896

R9-CA-Encina
#22484 Intake

SAN DIEGO GAS & ELECTRIC

ENCINA POWER PLANT

COOLING WATER INTAKE SYSTEM DEMONSTRATION

SDGE

VOLUME I

DECEMBER, 1980

10904 Intake
R9-CA-Encina

ENCINA POWER PLANT

COOLING WATER INTAKE SYSTEM DEMONSTRATION
(IN ACCORDANCE WITH SECTION 316(b) FEDERAL WATER POLLUTION CONTROL ACT AMENDMENT OF 1972)

PREPARED FOR:

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
SAN DIEGO REGION
SAN DIEGO, CALIFORNIA

PREPARED BY:

SAN DIEGO GAS & ELECTRIC

PROJECT MANAGER:

JOSEPH F. DIETZ

DECEMBER, 1980

SAN DIEGO GAS & ELECTRIC
101 ASH STREET
SAN DIEGO, CALIFORNIA 92112

TABLE OF CONTENTS

TABLE OF CONTENTS

000004

PAGE NUMBER

3.0
DESCRIPTION OF FACILITY AND EXISTING COOLING WATER INTAKE SYSTEM

4.0
MASTER DEMONSTRATION RATIONALE

PAGE NUMBER

PAG: NUMBER

PAGE NUMBER

7.0
FISH REMOVAL BY INTAKE SCREENS
(IMPINGEMENT STUDIES)

8.0
COOLING WATER SYSTEM
(ENTRAINMENT STUDY)

PAGE NUMBER

9.0
ENTRAINMENT MORTALITY

PAGE NUMBER

000011

PAGE NUMBER

10.0
ENVIRONMENTAL IMPACT ASSESSMENT

PAGE NUMBER

17.0
APPENDIX E: EVALUATION OF POTENTIAL MODIFICATIONS FOR MINIMIZATION OF IMPACTS

PAGE NUMBER

000016

TABLES AND FIGURES

LIST OF TABLES

000019

TABLE		PAGE NUMBER

000020

TABLE		PAGE NUMBER

000021

TABLE		PAGE NUMBER

TABLE PAGE NUMBER

000023

TABLE		PAGE NUMBER

TABLE PAGE NUMBER

000027

LIST OF FIGURES

FIGURE PAGE NUMBER

FIGURE PAGE NUMBER

FIGURE PAGE NUMBER

000031

FIGURE		PAGE NUMBER
7.5-5	Weekly mean total number of all fishes impinged at station 5 per 24-hour interval from 2-4-79 to 1-4-80	7-156
7.5-6	Weekly mean total weight of fishes impinged at station 5 per 24-hour interval from 2-4-79 to 1-4-80	7-157
7.5-7	Weekly mean total number of all fishes impinged at all stations per 24-hour interval from 2-4-79 to 1-4-80	7-158
7.5-8	Weekly mean total weight of all fishes impinged at all stations per 24-hour interval from 2-4-79 to 1-4-80	7-159
7.5-9	Weekly mean values of temperature and salinity for seawater entering the cooling water intake from 2-4-79 to 1-4-80	7-160
7.5-10	Weekly mean values for wave height (ft) and cloud cover (units of 1/10 cover) from 2-4-79 to 1-4-80	7-161
7.6-1	Comparisons of daytime and nighttime impingement for the period 2-4-79 to 1-4-80	7-162
7.8-1	Weekly mean flow rates during the period 2-4-79 to 1-4-80	7-163
7.8-2	Comparisons of weekly mean flow rates and impingement at station 1 from 2-4-79 to 1-4-80 .	7-164
7.8-3	Comparisons of weekly mean flow rates and impingement at station 4 from 2-4-79 to 1-4-80 .	7-165
7.8-4	Comparisons of weekly mean flow rates and impingement at station 5 from 2-4-79 to 1-4-80 .	7-166
7.8-5	Comparisons of weekly mean flow rates and total impingement from 2-4-79 to 1-4-80	7-167
7.11-1	Monthly mean volume of all material impinged at the bar rack per 24-hour interval from 2-4-79 to 1-4-80	7-168
7.11-2	Weekly mean total weight of plants impinged per 24-hour interval from 2-4-79 to 1-4-80 . . .	7-169

000032

FIGURE PAGE NUMBER

FIGURE PAGE NUMBER

FIGURE		PAGE NUMBER

000035

1.0

PURPOSE

The purpose of this report is to provide the 316(b) demonstration required by the California Regional Water Quality Control Board, San Diego Region (RWQCB-SD), under the Federal Water Pollution Control Act, as amended 1972, for the cooling water intake of the Encina Power Plant in Carlsbad, California, operated by the San Diego Gas & Electric Company (SDG&E).

1.1 GENERAL REGULATORY REQUIREMENTS REVIEW

The relevant regulatory requirements pertaining to cooling water intake technology have their basis in federal law. Initiated by the Federal Water Pollution Control Act (PL84-660) of 1956 and modified and amended by the Water Quality Act (PL89-234) of 1965, the Clean Water Restoration Act (PL89-753) of 1966, the Environmental Quality Improvement Act (PL91-224) of 1970, the Federal Water Pollution Control Act Amendments (PL92-500) of 1972, which entirely replaced the language of the previous Act, and subsequent amendments (PL93-207, 1973; PL93-243, 1974; PL93-592, 1975; PL94-238, 1976; PL94-558, 1976; PL95-95, 1977), this law, more popularly called the Clean Water Act, and hereinafter referred to as the Act, presents specific goals and policy:

- The objective of the Act is to restore and maintain the chemical, physical and biological integrity of the Nation's waters.

- In order to achieve that objective, "water quality which provides for the protection and propagation of fish, shellfish and wildlife and provides for recreation in and on the water . . .", is a goal, wherever attainable, by July 1, 1983.
- A further goal is that "the discharge of pollutants into the navigable waters be eliminated by 1985.

Title III of the Act (Standards and Enforcement), contains Sections 301 (Effluent Limitations), 306 (National Standards of Performance) and 316 (Thermal Discharges) which contain requirements relating to steam electric power plants:

- Section 301 sets July 1, 1983 as the deadline for achieving the best available technology economically achievable for point source discharges, which will result in reasonable progress toward the goal of eliminating the discharge of all pollutants.
- Section 306 charges the Administrator of the Environmental Protection Agency (EPA) with establishing standards of performance for steam electric power plants and other discharge source categories. This section further allows each state to develop and submit to the Administrator a procedure under state law for applying and enforcing standards for sources within that state.

- Section 316, in particular 316(b), states "Any standard established pursuant to Sections 301 or Section 306 of this Act, and applicable to a point source, shall require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact."

The State of California through its State Water Resources Control Board (SWRCB) is authorized by EPA to administer the enforcement of all of the above standards.

By its letter of September 30, 1977 the RWQCB-SD requested study proposals for 316(b) Intake Water Studies within 90 days. Study plans submitted by SDG&E, with their letter of December 21, 1977, were identified as tentative and subject to RWQCB-SD staff review. Discussion and revision of these preliminary plans proceeded throughout the period until SDG&E's letter of October 13, 1978 provided a revised 316(b) study plan for the Encina Power Plant. In its letter of November 17, 1978 RWQCB-SD acknowledged acceptance of this revised study plan. That plan was the basis of studies reported herein. The study approach has involved a year-long baseline study, a comprehensive review of alternate intake technologies, and environmental impact assessment of the intake technologies. In the conduct of these studies guidance has been sought and used wherever practicable from the following documents:

000038

- Recommendations for the Conduct of 316(b) Studies in California (SWRCB, April 1977).
- Guidance for the Assessment of Power Plant Entrainment Effects on Aquatic Life (SWRCB, June 1977).
- Development Document for Best Technology Available for the Location, Design, Construction, and Capacity of Cooling Water Intake Structures for Minimizing Adverse Environmental Impact (EPA, April 1976).
- Guidance for Evaluating the Adverse Impact of Cooling Water Intake Structures on the Aquatic Environment: Section 316(b), PL92-500 (EPA, May 1, 1977).

Data from this study and from other available sources have been analyzed to meet the demonstration objectives.

1.2 OBJECTIVES OF THE 316(b) DEMONSTRATION

The objective of the 316(b) demonstration is to determine whether the existing intake structure reflects the best available technology for minimizing adverse environmental impacts. This objective will be accomplished in part by evaluating the capability of various alternative intake technologies to minimize adverse environmental impacts.

2.0

INTRODUCTION

This section provides general background information and descriptive material relating to the power plant location a:ıd the demonstration document.

2.1 GENERAL BACKGROUND

Information which describes the location, the plant and its surroundings are incorporated in the following sections.

2.1.1 Geographic Location

The Encina Power Plant is located in the City of Ca:·lsbad on the southern California coastline, 81 miles south of :.os Angeles and 35 miles north of San Diego (Figure 2.1-1). At geographic coordinates 33°8.2'N; 117°20.2'W, the power plan. faces on the Gulf of Santa Catalina, a major offshore division of the eastern Pacific Ocean.

2.1.2 Site Description

The plant is specifically located on a site of 680 .:cres just eastward of Carlsbad Boulevard, which separates it :'rom the beach and shoreline (Figure 2.1-2). The coastline in th‹ site vicinity consists of a sandy beach backed by bluffs risi:.g to heights of 40 to 80 feet except between the inlet of the sea to Agua Hedionda Lagoon and the plant discharge (Figure :.1-2) where no bluffs occur. The ocean floor offshore consist: of a sandy bottom with scattered, flat, rocky reef out to wat‹r depths of about 50 feet. Most of the reef areas provide substrate for kelp stands (Figure 2.1-2). The undersea topography is reasonably uniform, sloping to about 10 fathoms (60 feet) in depth about 0.5 miles offshore of the power plant, and reaching 100 fathoms (600 feet) about 1.3 miles offshore where the generally parallel trending bathymetric contours are indented by the Carlsbad Canyon (undersea canyon). The offshore waters are a portion of that general water volume described by the Southern California Coastal Water Research Project as the Southern California Bight.

To the north and east of the plant site is the Agua Hedionda Lagoon system comprised of three segments identified as the outer, middle and upper lagoons. This system has average depths of 2-5 m and the segments vary in area from 26 hectares (66 acres) for the outer lagoon and 10 hectares (27 acres) for the middle lagoon to 120 hectares (297 acres) for the upper lagoon. Lagoon substrates consist of sand, sandy-mud and mud with scattered eelgrass beds (Figure 2.1-3).

The plant utilizes seawater with once-through cooling for its cooling water system. The cooling water intake structure is located on the southern portion of outer Agua Hedionda Lagoon and the discharge is through an across-the-beach channel into the surf zone of the Pacific Ocean (Figure 2.1-2).

2.1.3 Additional Stresses on the Water Body Segment

Proceeding both north and south from the Encina Pow:r Plant 11 other power plants and 13 sewage treatment plants dis:harge into the southern portion of the Southern California Bight between Los Angeles and the Mexican border (Figure 2.1-1 . The closest discharge, three miles to the north, is the Oceanside sewer outfall (5 MGD) which extends 8640 feet offshore into waters 120 feet deep. To the south, 1.5 miles, the sewer discharge of the Encina Water Pollution Control Facility (1+ MGD) extends 7800 feet offshore into water depths of 168 feet The next two closest discharging facilities are the San Elijo Water Pollution Control Facility (30 MGD) 8.3 miles to the southeast and the San Onofre Nuclear Generating Station (450 MW; 450 MGD, increasing to 2709 MW; 2790 MGD when Units 2 and 3 are completed) about 18 miles to the northwest. The largest power plant presently operational (Alamitos Steam Plant, 2071 MW; 1270 MGD) and the largest sewage treatment plant (White's Point, 371 MGD) are in the Los Angeles area some 80 miles to the northwest. The largest discharge to the south is from the Point Loma Waste Water Treatment Plant (108 MGD) some 28 miles distant.

Stresses on the waters of the Gulf of Santa Catalina, introduced by the various discharges would be those related to increased temperatures from the discharged cooling water and the constituents of the waters which remain after the primary and secondary treatment processes for sewage discharge. These stresses are both variable and transient, the major long term changes being related to deposition of sewer discharge constituents on the ocean bottom. Temperature increases are not cumulative. The natural forces--wind, waves, tides, currents and the assimilative capacity of the oceans--work continuously to dissipate the heat introduced by natural or man-made sources.

2.2 DESCRIPTION OF 316(b) DEMONSTRATION CONTENTS

A brief review of what is contained in this demonstration is provided in the following sections.

2.2.1 Facility Description

Section 3.0 provides, in reasonable detail, a description of the Encina Power Plant, its present intake structure, and the essential information on the plant's operation.

2.2.2 Master Demonstration Rationale

Section 4.0 of the demonstration presents the conclusions with respect to best available technology for the intake, based on the findings of the program.

2.2.3 Physical Environment

Included in Section 5.0 is a discussion of the existing physical setting--study area boundaries, general hydrography including current patterns--and analysis of offshore and lagoon circulation characteristics, particularly as they relate to source waters and their probability of entrainment.

2.2.4 Biological Environment

Section 6.0 reviews the historical biological characteristics of the study area, discusses the selection of critical species on which the biological studies are centered and describes in detail the biological findings within the source waters.

2.2.5 Impingement Study

Within Section 7.0 the findings of an intensive, twice daily (336 consecutive days) collection program which describes and evaluates the impingement of marine fishes and other organisms at the traveling screens and bar rack of the plant are detailed.

2.2.6 Entrainment Study

Those activities of the study which dealt with collections of plankton at the plant's intake structure, Section 8.0 are detailed in this portion of the demonstration.

2.2.7 Entrainment Survival

Seasonal studies of entrainment mortality, describing the influence of the cooling water system on plankton passing through it are presented in Section 9.0.

2.2.8 Environmental Impact Assessment

An analysis of the environmental impact of the present cooling water intake structure is presented in Section 10.0.

This analysis compares removal of fish by natural, commercial, and recreational activity to those removed by the plant.

2.2.9 Ecological Evaluation of Existing Intake System

The ecological significance of the intake location, design, construction and operation are presented in Section 11.0.

2.2.10 Alternate Technologies Available

Section 12.0 reviews and describes a number of alternate intake technologies and documents the selection of potential alternate intake technologies considered as possible at the Encina location. This section also reviews both the engineering and economic aspects of the potential alternate intake technologies.

2.2.11 Environmental Assessment of Alternate Technologies

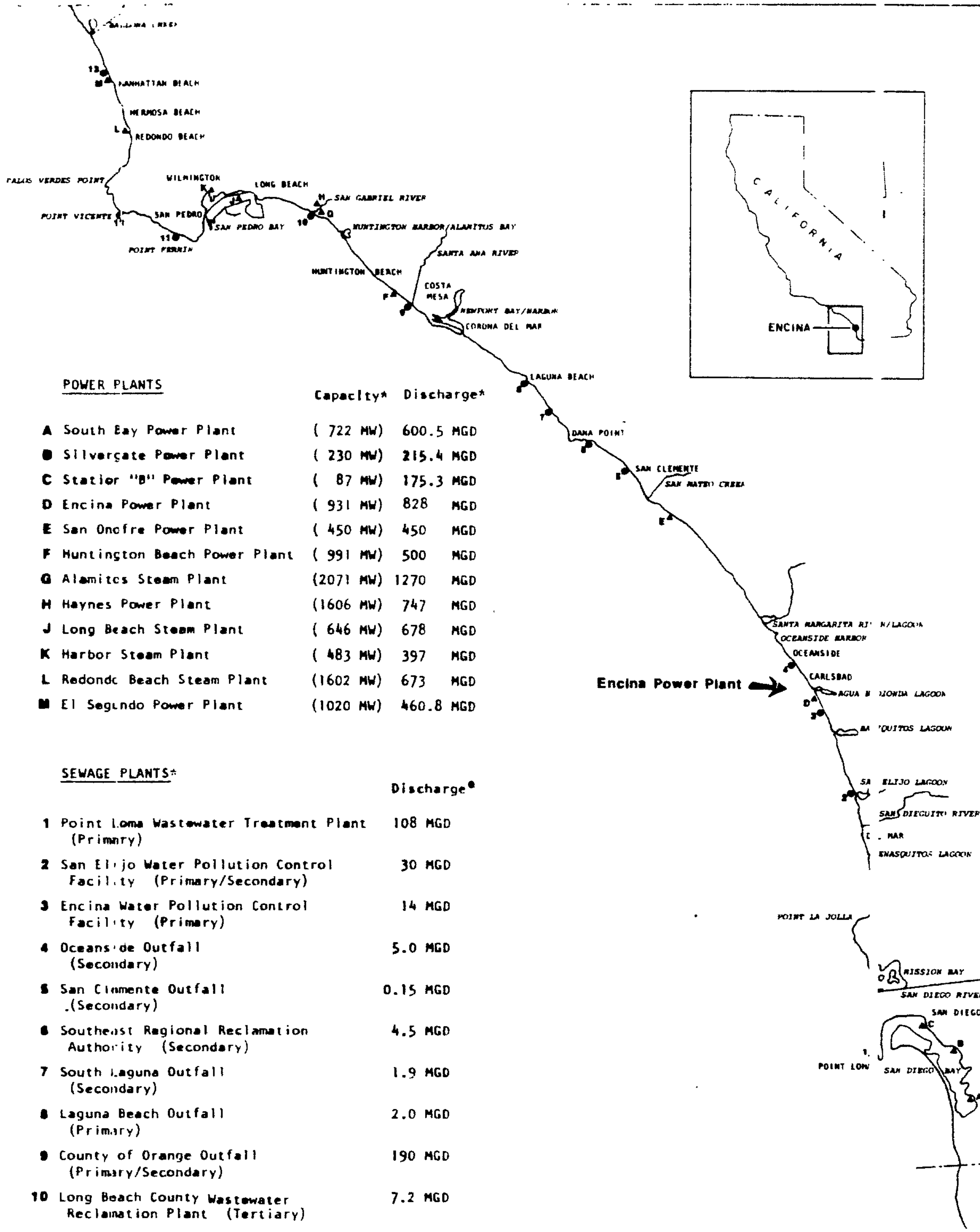
The ecological significance of each of the alternate technologies is reviewed in Section 13.0 and, through review of environmental benefits and cost/benefit analysis, the technologies are ranked as to applicability for the plant.

2.2.12 Bibliography

All literature referenced, or considered applicable to this demonstration, are presented alphabetically, by author, in Section 14.0.

2.2.13 Appendices

The essential data developed during the program and supporting documentation are all provided in Section 16.0.



POWER PLANTS

		Capacity*	Discharge*
A	South Bay Power Plant	(722 MW)	600.5 MGD
B	Silvergate Power Plant	(230 MW)	215.4 MGD
C	Station "B" Power Plant	(87 MW)	175.3 MGD
D	Encina Power Plant	(931 MW)	828 MGD
E	San Onofre Power Plant	(450 MW)	450 MGD
F	Huntington Beach Power Plant	(991 MW)	500 MGD
G	Alamitos Steam Plant	(2071 MW)	1270 MGD
H	Haynes Power Plant	(1606 MW)	747 MGD
J	Long Beach Steam Plant	(646 MW)	678 MGD
K	Harbor Steam Plant	(483 MW)	397 MGD
L	Redondo Beach Steam Plant	(1602 MW)	673 MGD
M	El Segundo Power Plant	(1020 MW)	460.8 MGD

SEWAGE PLANTS*

		Discharge*
1	Point Loma Wastewater Treatment Plant (Primary)	108 MGD
2	San Elijo Water Pollution Control Facility (Primary/Secondary)	30 MGD
3	Encina Water Pollution Control Facility (Primary)	14 MGD
4	Oceanside Outfall (Secondary)	5.0 MGD
5	San Clemente Outfall (Secondary)	0.15 MGD
6	Southeast Regional Reclamation Authority (Secondary)	4.5 MGD
7	South Laguna Outfall (Secondary)	1.9 MGD
8	Laguna Beach Outfall (Primary)	2.0 MGD
9	County of Orange Outfall (Primary/Secondary)	190 MGD
10	Long Beach County Wastewater Reclamation Plant (Tertiary)	7.2 MGD
11	Whites Point County Sanitation District of Los Angeles (Primary)	371.4 MGD
12	Marineland of the Pacific (Primary/Secondary)	2.9 MGD
13	City of Los Angeles, Hyperion (Primary/Secondary)	340 MGD

*Key

Capacity: MW = Megawatts
Discharge: MGD = Million Gallons Per Day
Sewage Plants: Type of treatment in parentheses

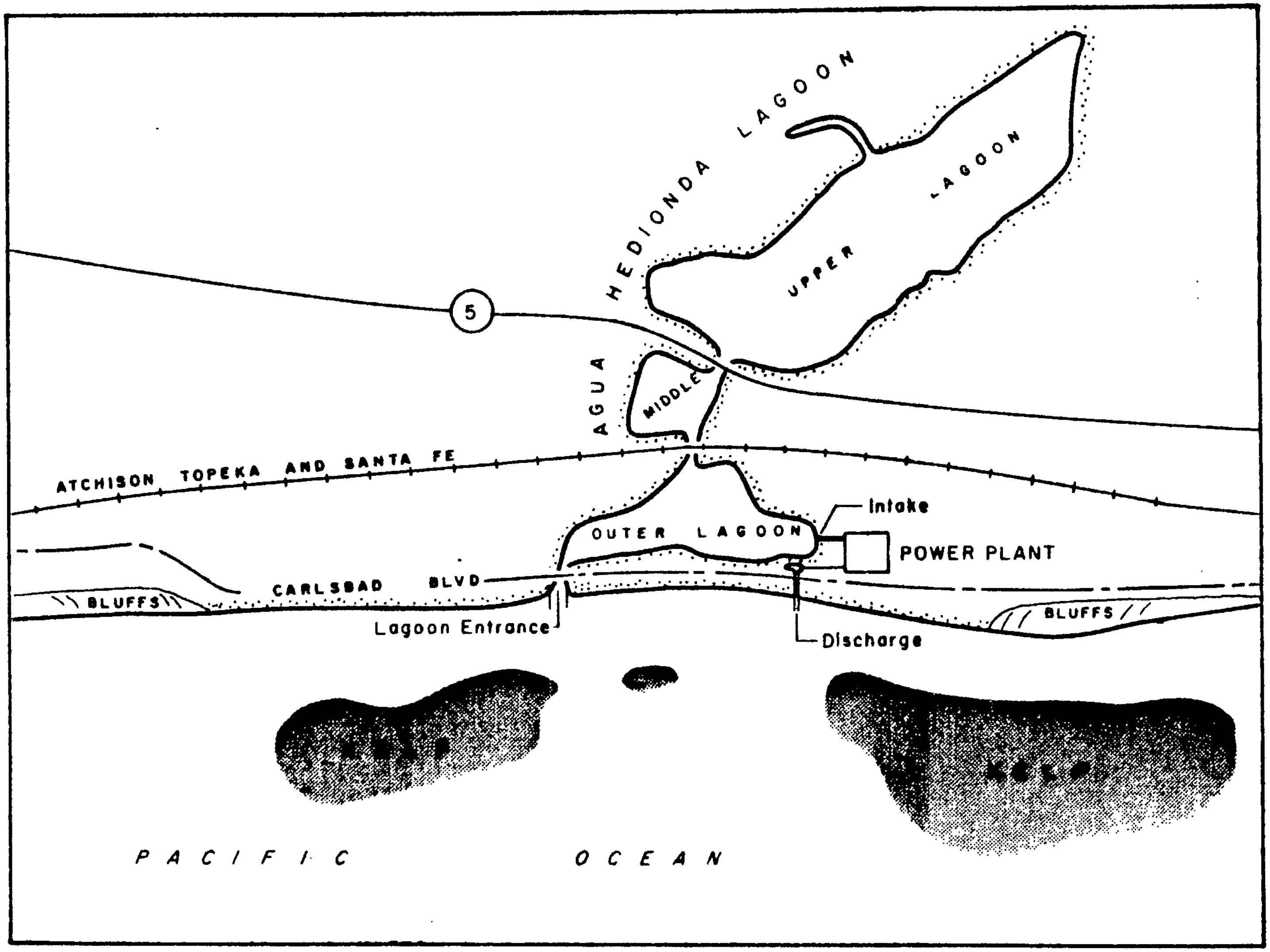
SAN DIEGO GAS & ELECTRIC COMPANY

Major southern California discharge sites.

Encina Power Plant - August 1 1980

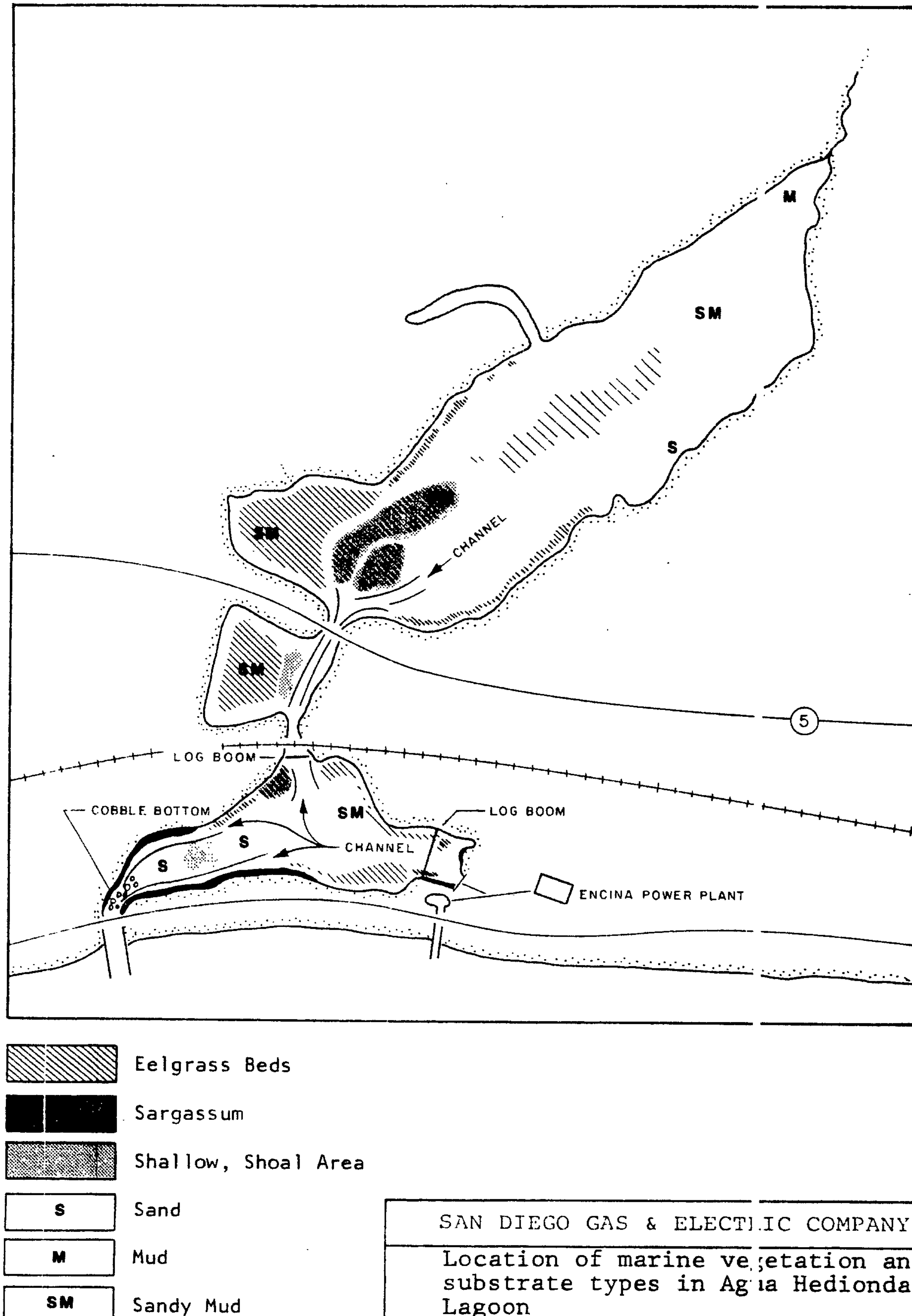
PREPARED BY: WOODWARD-CLYDE CONSULTANTS

FIGURE NO. 2-1



SAN DIEGO GAS & ELECTRIC COMPANY	
Location of the Encina Power Plant **Encina Power Plant - August 1, 1980**	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 2.1-2

000047



SAN DIEGO GAS & ELECTRIC COMPANY	
Location of marine vegetation and substrate types in Agua Hedionda Lagoon Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 2.1-3

3.0

DESCRIPTION OF FACILITY AND EXISTING COOLING WATER INTAKE SYSTEM

3.1 GENERAL DESCRIPTION

3.1.1 Power Plant

The San Diego Gas & Electric (SDG&E) Encina Power Plant is located in the southwest sector of the City of Carlsbad, California, adjacent to the Aqua Hedionda Lagoon on the Pacific Ocean (Figure 3.1-1). The general layout of the Encina Power Plant is shown in Figure 3.1-2. It is an oil and gas fueled power plant (except Unit 5 which is oil fueled only), consisting of five steam turbine generators and one gas turbine generator. The rated net capability is 937 mw, composed of: Unit 1, 100 mw; Unit 2, 102 mw; Unit 3, 108 mw; Unit 4, 287 mw; Unit 5, 320 mw; and the gas turbine, 20 mw.

Construction of the Encina Power Plant began in 195[illegible] and Unit 1 began commercial service in 1954. Unit 2 was placed in commercial service in 1956 and Unit 3, in 1958. No further plant expansion took place until the 20 mw gas turbine was installed in 1968. Unit 4 was completed and began commercial operation in June, 1973, and Unit 5 began commercial operation in November, 1978. There are no plans for major modifications in the capacity of this power plant in the near future.

The Units operate independently, but share a single once-through cooling intake and discharge system. Waste heat from the steam turbine generators is rejected to the ocean by the cooling water system. The system consists of the following principal components: (a) Agua Hedionda Lagoon (Figure 3.1-2), (b) the intake structure and two inlet tunnels (Figure 3.1-3), (c) the inlet screen structure (Figure 3.1-4), (d) four conveyance tunnels (branch tunnels 1-4) (Figure 3.1-5), (e) the five pump intakes, (f) the conveyance structure of pump intake 4, (g) the conveyance structure to pump intake 5, (h) the condensers, (i) the discharge tunnel, (j) the discharge pond, and (k) the discharge channel.

3.1.2 Location of Intake Structure With Respect To Source Water Body

The mouth of the Aqua Hedionda Lagoon is the beginning of the water intake system. The cooling water intake structure complex is located approximately 2200 feet from the ocean inlet to the lagoon. Variations in the water surface due to tide are from a low of -5.07 feet to a high of +4.83 feet (elevation 0 being mean sea level, msl).

3.1.3 Location of Intake Structure With Respect To Cooling Water System

The intake structure is located on the lagoon, about 525 feet in front of the generating units. A detailed illustration of the cooling water system is shown in Figure 3.1-5.

3.1.4 Intake Screening and Trash Removal System

Floating booms are situated in the lagoon in front of the circulating-water intake structure to retain large floating material washed in from the ocean. The mouth of the intake structure is 49 feet wide. As the water flows into the intake structure, it passes through trash racks (metal bars about 3 1/2 inch apart) which prevent passage of large debris (Figure 3.1-6). The tunnel tapers into two 12-foot wide intake tunnels. From these tunnels, the cooling water enters four six-foot wide conveyance tunnels. Cooling water for conveyance tunnels 1 and 2 passes through two vertical traveling screens to prevent fish, grass, kelp, and debris from entering pump intakes 1, 2, and 3. Conveyance tunnels 3 and 4 carry cooling water to intake 4 and intake 5, respectively. Traveling water screens are located at the intake of pump 4 (2) and the intake of pump 5 (3).

3.1.5 Cooling Water Data

3.1.5.1 Capacity (rated pump(s) flow(s)). Each pump intake consists of two circulating pump cells and one or two service pump cells. The rated capacities (nameplate) of the cooling water pumps for each unit are listed below:

Unit 1	-	48,000 gpm
Unit 2	-	48,000 gpm
Unit 3	-	48,000 gpm
Unit 4	-	200,000 gpm
Unit 5	-	208,000 gpm
Total		552,000 gpm

Separate salt water service pumps supply cooling water to heat exchangers, where heat is transferred from the service (fresh) water that cools the lubricating bearing oil and other auxiliary equipment. The capacities of the salt water service pumps are:

Units 1, 2	-	6,000 gpm (3,000 gpm, each)
Unit 3	-	6,000 gpm
Unit 4	-	13,000 gpm
Unit 5	-	18,200 gpm
Total		43,200 gpm

With all cooling water pumps operating (552,000 gpm) and all salt water heat exchangers operating (43,200 gpm), the total plant flow is 595,200 gpm or 857 mgd.

3.1.5.2 Velocities (Screen). The velocity of the water as it approaches the traveling water screens varies with unit operation, water level, and cleanness of the screens. Calculated maximum velocities, in feet per second, at high and low tides with 100 percent clean screens are presented in the table below:

Unit	High Tide (+4.83)	Low Tide (-5.07)
1	0.7 fps	1.2 fps
2	0.7 fps	1.2 fps
3	0.7 fps	1.2 fps
4	1.0 fps	1.6 fps
5	0.7 fps	1.1 fps

000052

3.1.5.3 Traveling Screens. The seven traveling screens remove debris which passes through the trash racks. The screens are conventional through-flow, vertically rotating, single entry, band-type screens, mounted in the screen wells of the intake channels. Each screen consists of a series of baskets or screen panels attached to a chain drive (Figure 3.1-4). Since the screens are designed to prevent the passage of particles large enough to clog the condenser tubes, the screening surface is made of 3/8-inch meshed stainless steel wire, with the exception of Unit 5 screens, which have 5/8-inch square openings.

Cooling water passes through the wire mesh screening surface and floating or suspended matter is retained on the screens. The screens rotate automatically when the debris buildup causes a predetermined pressure differential across the screen (or the difference in sea water level before and after the screen increases to a set level). As the screens revolve, the material is lifted from the intake water surface by the upward travel of the baskets. The screens travel 3 feet per minute, making one complete revolution in about 20 minutes. A screen wash system in the traveling screen structure provides water (sea water from the intake tunnels) to wash the debris from the traveling screen. At the head of the screen, matter is removed from the baskets by a 70-100 psi spray of water, which is evenly distributed over the entire basket width. The jet spray washes the material into a trough feeding into screen well baskets where it is accumulated for disposal.

3.1.5.4 Circulating Water Pumps. Each unit has two vertical submerged circulating (cooling) water pumps, one for each condenser half. Each pump is located in a pump structure, draws water in through the traveling water screen, and discharges to the condenser half. Circulating water pumps for Units 1, 2, and 3 rotate at 390 rpm; for Unit 4, at 254 rpm; and Unit 5, 271 rpm.

3.1.5.5 Condensers. The condenser is a shell-and-tube arrangement in which heat is transferred from the turbine exhaust steam to the circulating (cooling) water. Units 1, 2, and 3 have two-pass condensers (water enters the bottom, passes through the condenser twice, and exits the top). The tubing, made of No. 18 BWG aluminum brass, has a 30-foot length and a 1-inch outside diameter. Units 4 and 5 condensers are single-pass design. The tubing is No. 20 BWG copper-nickel with a 36-foot length and 1 1/8-inch outside diameter. The heat transfer area is 103,200 ft^2 and 105,000 ft^2 for Unit 4 and Unit 5, respectively.

Units 1 through 5 will transfer 4805 x 10^6 Btu/hr (approximate maximum limits) to 595,200 gpm of circulating water with a plant temperature rise of 17.9°F with all units operating at maximum load. (Individual and total heat loads for the Units are listed below.) The temperature rise may vary depending on the Units in service. A maximum of 20°F may be experienced under certain conditions.

Unit	Maximum Capability mw(net)	Maximum Calculated Cooling Water Thermal Load Btu/hr	Heat Load Salt Service Water Btu/hr
1	100	518×10^6	12×10^6
2	102	533×10^6	12×10^6
3	108	567×10^6	12×10^6
4	287	1464×10^6	29×10^6
5	320	1626×10^6	32×10^6
TOTAL	917	4708×10^6	97×10^6

Heated water discharges from the condensers through separate discharge pipes to a common discharge tunnel.

3.1.5.6 Discharge System. Cooling water from the condensers of all five units flows into a common discharge tunnel. The concrete discharge tunnel (15 feet wide) runs along the east side of the inlet conveyance tunnels, past the traveling screen structures, then crosses under the inlet tunnels and runs parallel to the west side (Figure 3.1-5). The cooling water flows into a discharge pond before traveling through box culverts under Carlsbad Boulevard into a riprap-lined channel, a surface jet discharge, into the Pacific Ocean. The coordinates of the plant discharge are 32°-57'-45" north latitude and 117°-16'-05" west longitude.

Approximately 120 feet from the discharge end, a gated tunnel is cross-connected to the intake channel to allow recirculation for periodic heat treating (Section 3.1.5.9).

000055

3.1.5.7 Chlorination. Intermittent chlorine treatment is used to minimize formation of slime, which occurs in the condenser tubes if control is not practiced. At the Encina Power Plant, sodium hypochlorite is manufactured on-site as needed. It is produced electrolytically from sodium chloride in the seawater. Seawater from the intake is pumped through each of the two hypochlorinators, which are comprised of electrolytic cell modules arranged in series. The hypochlorite produced is fed into a holding tank, where it is diluted with intake water. Then the sodium hypochlorite solution is injected, into the channel immediately upstream of the circulating and salt water service pump suctions for each unit. Each injection point is individually controlled.

Hypochlorination is conducted for about six minutes per injection point on a timed two-hour cycle several periods each day. The sodium hypochlorite is injected separately for each point, and no two points are injected at the same time. Hence, the flow of cooling water from the other units will result in minimal chlorine residual in the cooling water being discharged to the ocean. This rapid dilution is one of the environmental advantages of having multiple units on a single site with a common discharge.

3.1.5.8 Operation Procedure. During normal operation, one circulating water pump serves each half of the condenser, so when a unit is on the line, both pumps are in operation.

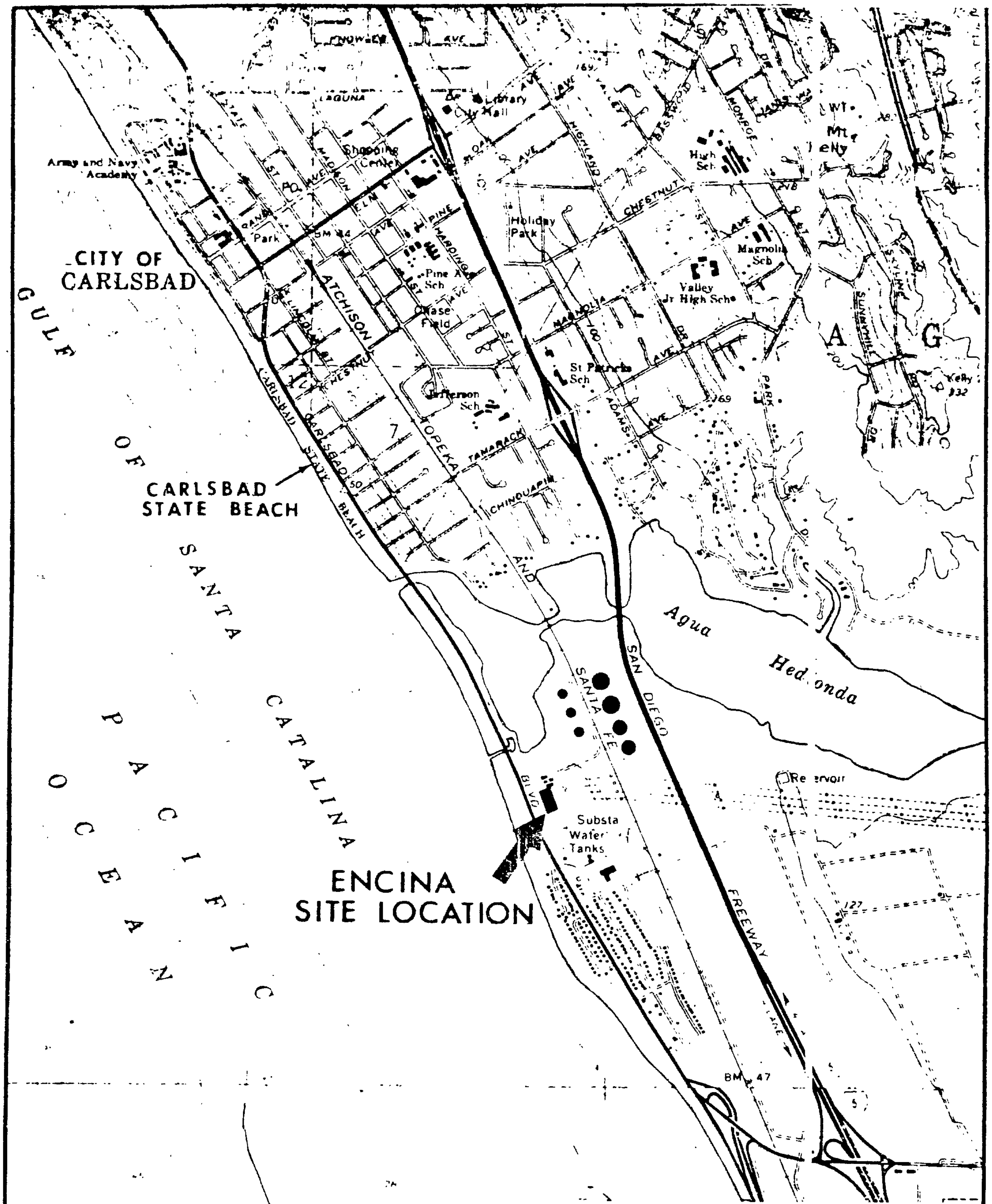
Traveling water screens normally are set on automatic, starting up when the differential pressure across the screen exceeds the set point (Section 3.1.5.3). At the beginning of each work shift (0700, 1500, and 2300 hours), the screens are turned on and the automatic start is checked to ascertain they are functioning properly.

Chlorine (sodium hypochlorite) treatment is conducted intermittently throughout the day, 12 injections per unit over a 24-hour period (Section 3.1.5.7).

The intake tunnels are thermally treated (tunnel recirculation) approximately every five weeks (Section 3.1.5.9).

3.1.5.9 Tunnel Recirculation. Encrusting organisms in the early stages of development, are small enough to pass through the trash racks and screens and enter the intake tunnels, attach themselves to the tunnel walls, traveling water screens, and other parts of the cooling-water system. If not removed, the encrusting organisms grow and accumulate at a rate of approximately 1000 yd^3 over a 6-month period. These accumulations restrict the flow of cooling water to and through the condensers, causing a rise in the condenser operating temperature and the temperature of the discharged circulating water. A thermal tunnel recirculation treatment process is used periodically (at approximately 5-week intervals) to prevent the encrusting organisms from developing to any significant size or quantity. The treatment kills the encrusting organisms, which release from the surfaces and wash through the condensers to the ocean with the circulating water discharge, reducing the need for maintenance outages for manual cleaning of the circulating water inlet tunnels and condensers. This practice also helps to maintain the lowest possible temperature rise across the condensers, thereby improving plant efficiency.

Thermal treatment is performed by restricting the flow of cooling water from the lagoon and recirculating the condenser discharge water through the conveyance tunnels and condensers until an inlet water temperature of approximately 105°F is attained. Maintaining a temperature of 105°F in the intake tunnels for approximately 2 hours has proved adequate in disposing of encrusting organisms. The total time required for the thermal treatment operation, including temperature buildup and cooldown, is approximately 6 hours.

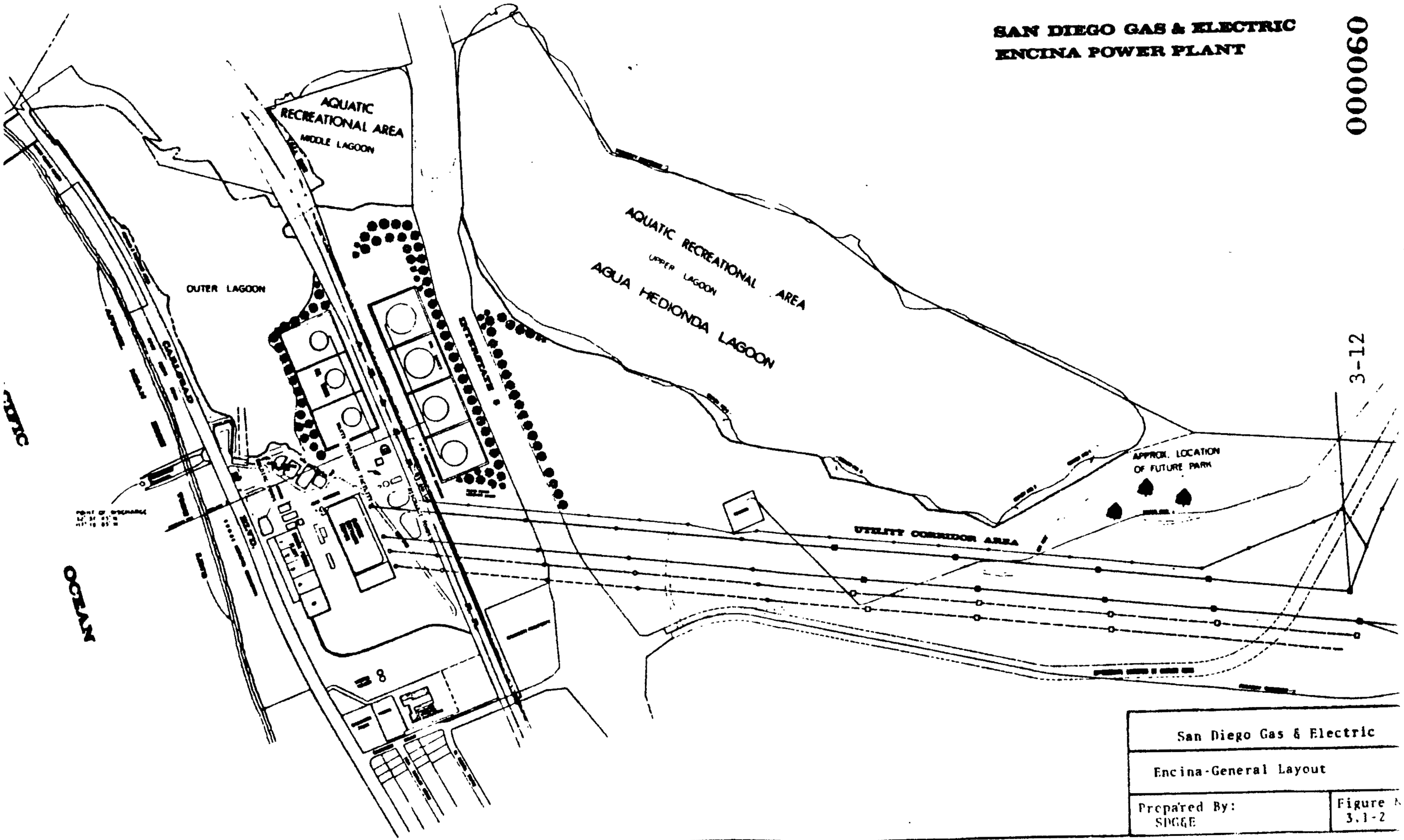


San Diego Gas & Electric

Encina Plant Location

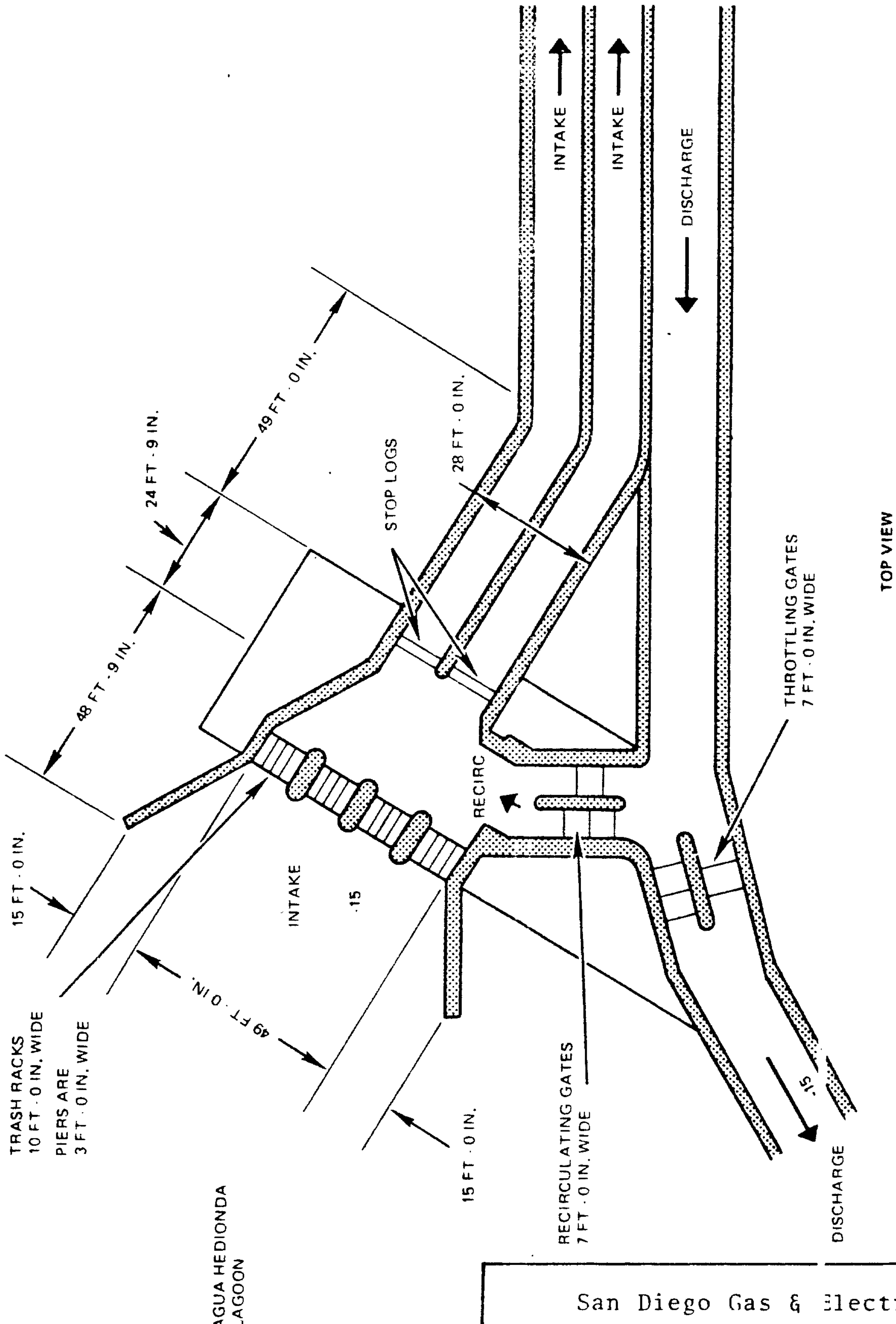
Prepared By: SDG&E

Figure No: 3.1-1

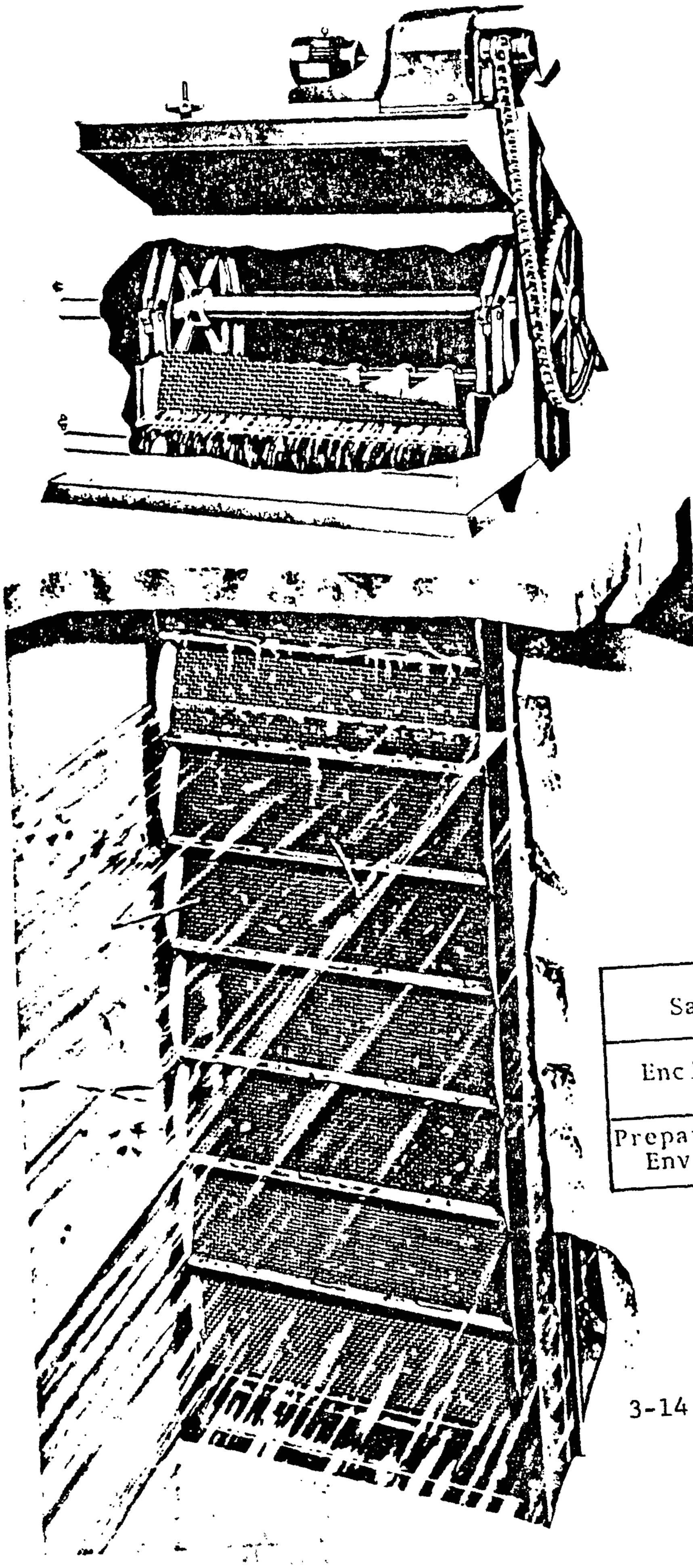


San Diego Gas & Electric	
Encina-General Layout	
Prepared By: SDG&E	Figure No. 3.1-2

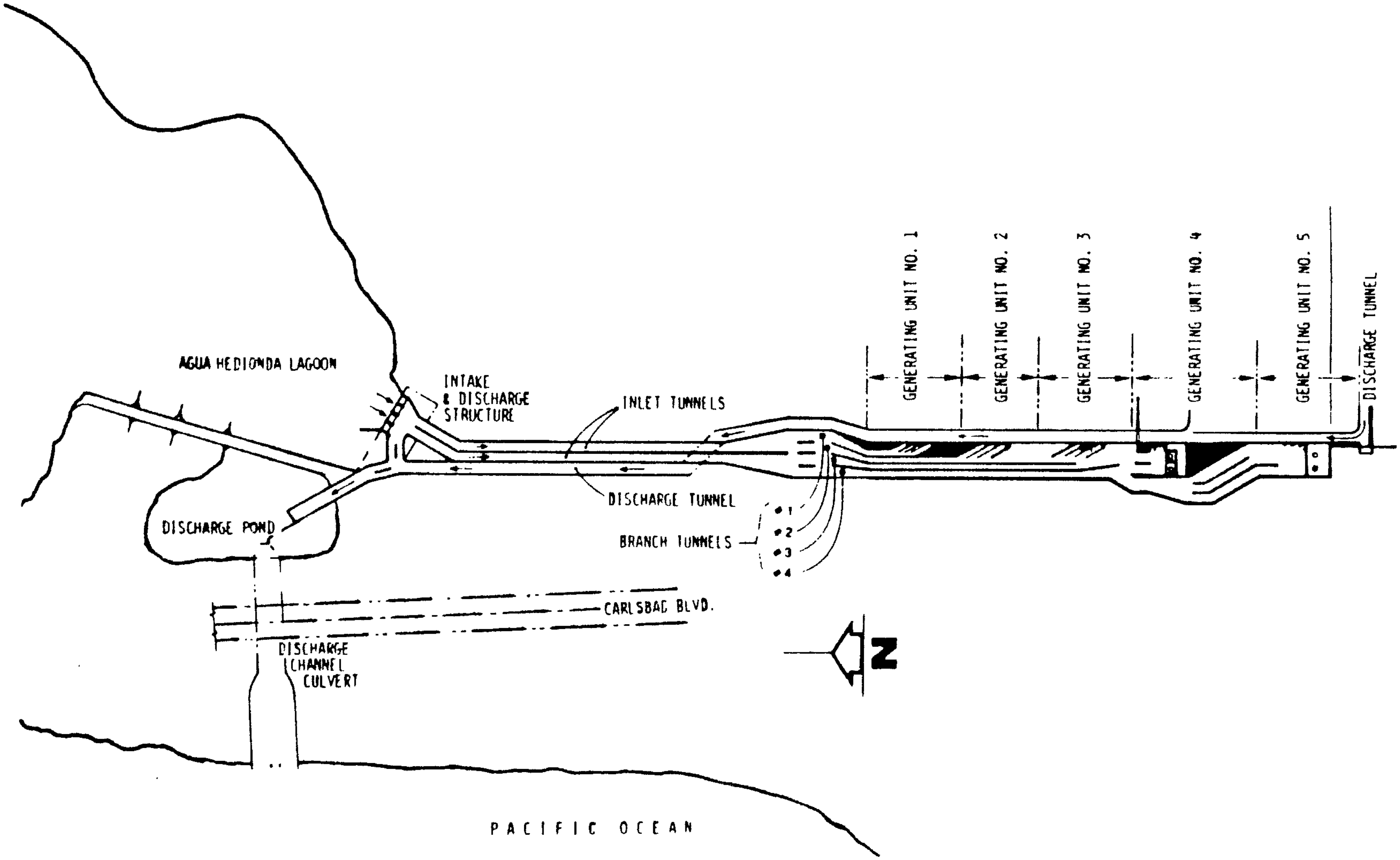
000060



San Diego Gas & Electric	
Encina Intake Structures	
Prepared By: SDG&E	Figure No: 3.1-3



San Diego Gas & Electric	
Encina Traveling Water Screen	
Prepared By: Envirex	Figure No: 3.1-4

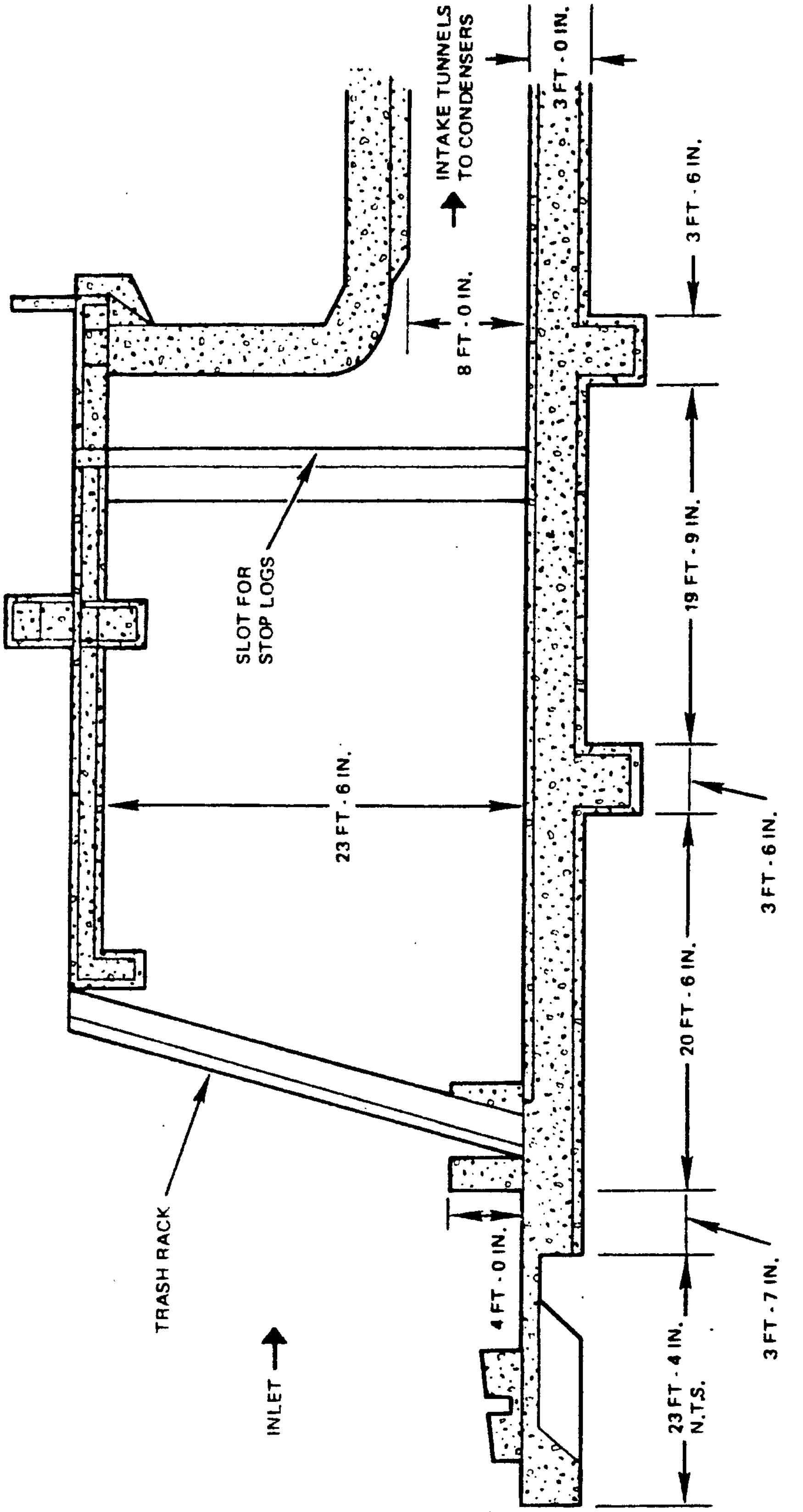


San Diego Gas & Electric

Encina Cooling Water System

Prepared By: Flour Power Systems, Inc.

Figure No: 3.1-5



San Diego Gas & Electric	
Encina Longitudinal Cross-Section of Intake Structure	
Prepared By: SDG&E	Figure No: 3.1-6

4.0

MASTER DEMONSTRATION RATIONALE

4.1 PURPOSE AND OBJECTIVES OF THE DEMONSTRATION

The purpose of this 316(b) Demonstration is to respond to the California Regional Water Quality Control Board - San Diego Region (RWQCB) requirements, under the Federal Water Pollution Control Act amendments of 1972,[a] regarding the impact of the cooling water intake of the Encina Power Plant. This section of the Act requires that the location, design, construction and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impact. The objective of this Demonstration is to determine whether the existing intake, as it is presently designed and operated, reflects BTA for minimizing adverse environmental impact or whether an alternative technology would be required.

The Environmental Protection Agency (EPA) and California State Water Resources Control Board (SWRCB) recognized that an evaluation of the impact of a power plant's intake structure could involve technical and scientific undertakings of considerable magnitude and difficulty (4-1 and 4-2). The State felt it very important, therefore, to allocate the level of effort required for a 316(b) Demonstration. The State further suggested

---

a. Federal Water Pollution Control Act, Amendments of 1972, 33 USC 1251, et seq, P.L. 92-500. Also known as the Clean Water Act.

that based on available information, although limited, provisional classifications be made of cooling water intake structures into potentially "High" and "Low" impact cases, with associated differences in the type of information needed to determine best intake technology (4-3). Table 4.1-1 presents the list of all California power plants and their designations by the State (California Department of Fish and Game) as "Low", "Intermediate", or "High" impact plants.

The primary focus of this Demonstration, therefore, is the evaluation of the impact of the Encina Power Plant cooling water intake with respect to its initial designation by the State as a "High" impact intake system. This Demonstration evaluated the appropriateness of the initial classification for the Encina Plant using data collected during extensive one-year entrainment and impingement studies and physical and biological studies of the source water body.

TABLE 4.1-1
REPRODUCED FROM 11 MARCH 1977 MEMORANDUM
FROM THE STATE WATER RESOURCES CONTROL BOARD†
(ATTACHMENT BY CALIFORNIA DEPARTMENT OF FISH AND GAME)

Power Plant Name	High fish mortality--over 30,000 pounds per year	Intake in area of very high value aquatic habitat	Intake volume very large--over 1500 cfs	Entrainment period long due to long conduits	Rare, endangered, threatened aquatic species	Intake volume relatively low--plant <100 MW capacity	High, intermediate, or low potential impact (overall)
South San Diego Bay		X					HIGH
Silver Gate							INT.
Broadway (Station B)						X	LOW
Encina		X					HIGH
San Onofre I	X			X			HIGH
San Onofre II & III	?		X	X			HIGH
Huntington Beach	X			X			HIGH
Haynes			X				INT.
Alamitos			X				INT.
Long Beach - T.I.							LOW
Harbor							LOW
Redondo	X		X	X			HIGH
El Segundo	X			X			HIGH
Scattergood	X			X			HIGH
Ormond Beach	X		X	X			HIGH
Mandalay							LOW
Diablo		X	X		††		HIGH

† See Appendix A (Section 16) for memorandum.

†† Sea Otter

TABLE 4.1-1 (Concluded)

Power Plant Name	High fish mortality--over 30,000 pounds per year	Intake in area of very high value aquatic habitat	Intake volume very large--over 1500 cfs	Entrainment period long due to long conduits	Rare, endangered, threatened aquatic species	Intake volume relatively low--plant <100 MW capacity	High, intermediate, or low potential impact (overall)
Morro Bay		X			††		HIGH
Moss Landing		X	X				HIGH
Potrero							INT.
Hunters Point							INT.
Pittsburg		X	X				HIGH
Contra Costa (Antioch)		X	X				HIGH
Oleum		X				X	INT.
Humboldt Bay		X					INT.

† See Appendix A (Section 16) for memorandum.

†† Sea Otter

000068

4.2 COOLING WATER INTAKE SYSTEM STUDIES

The State Water Resources Control Board (4-4) suggested in their 316(b) Guidelines that environmental consequences (impacts) of cooling water intakes are sensitive to the following factors.

- Population consequences of (1) impingement of adult and juvenile fish and (2) entrainment of planktonic[b] organisms.

The Electric Power Research Institute (EPRI), a nationally recognized research institute which sponsors research evaluating the environmental effects of power plant operation, has defined impingement and entrainment as follows (4-5).

- Impingement

  "As water passes through debris collecting screens at power plant intakes, fish are carried by the flow against the screen surface and held there by the water current. The terms impingement and entrapment have been applied to this process. In this document, impingement will refer to the entire process of entrapment within an intake structure and contact with the screen mesh."

- Entrainment

  "Entrainment is the process of passing aquatic life through power plant cooling systems with the water withdrawn from a source water body for cooling."

Year-long, extensive impingement and entrainment studies were conducted at the Encina Power Plant to determine the effect of withdrawing cooling water from Agua Hedionda Lagoon (Pacific Ocean).

---

b. Planktonic: Passively drifting or weakly swimming - unable to overcome even small current velocities.

4.2.1 Impingement Studies

The State 316(b) Guidelines recommend "...data should be collected over a period of at least one year for the purpose of characterizing seasonal differences." The rigorous sampling program performed for this Demonstration provided an accurate characterization of seasonal patterns and annual total losses of nekton[c]. Samples were collected daily for 336 days and the following population parameters studied: length frequency, age distribution, sex ratio, reproductive condition, and fecundity[d]. Impingement rates also were studied as a function of flow rate and diel[e] variations.

4.2.2 Thermal Treatment

Encrusting organisms in the early stages of development are small enough to pass through the trash racks and screens and enter the intake tunnels, attach themselves to the tunnel walls, traveling screens, etc. A thermal tunnel recirculation treatment process is used periodically (at approximately five week intervals) to prevent encrusting organisms from developing to any significant size or quantity. Thermal treatment is performed by restricting the flow of cooling water from the lagoon and recirculating the condenser discharge water through the conveyance

---

c. Nekton: adult and juvenile fishes.

d. Fecundity: fertility.

e. Diel: involving a 24-h period that usually includes a day and an adjoining night.

tunnels and condensers until an inlet water temperature of approximately 105 F is attained. Maintaining a temperature of 105 F in the intake tunnels for approximately two hours has proved adequate in disposing of encrusting organisms. During thermal treatments, all nekton species in the tunnel system are killed and collected by the traveling screens.

The fish species collected during the seven thermal treatments in 1979 were processed for length-frequency, weight, abundance, and identification.

4.2.3 Entrainment Studies

The objective of these studies was to estimate the annual entrainment of ichthyoplankton[f] and zooplankton[g]. Entrainment rates were estimated for each biweekly sampling period and flow-weighted to estimate annual entrainment. To further refine the annual entrainment estimates, two entrainment mortality studies were conducted during the summer and winter to examine high and low ambient water temperatures. Three potential sources of mortality were examined: thermal, mechanical, and chemical stresses.

---

f. Ichthyoplankton: passively drifting or weakly swimming fish eggs and larvae.

g. Zooplankton: passively drifting or weakly swimming invertebrates (e.g., copepods, mysids, and larval forms of crabs and shrimp).

000071

4.3 SOURCE WATER CHARACTERIZATION

The State Water Resources Control Board (4-6) suggested in their 316(b) guidelines that environmental consequences (impacts) of cooling water intakes are sensitive to the following factors.

- Amount of water entrained and size of water body
- Species' abundance and distribution patterns within the source waters

The physical and biological environment in the vicinity of Encina Power Plant was characterized with information gathered during field studies. This was done to provide the basis for evaluating the cooling water intake structure's environmental impact.

4.3.1 Physical Oceanography Description

The objective of this portion of the Demonstration was to ascertain the origin of the source waters affected by the intake system.

The physical oceanographic study area was divided into two broad categories: the near-field environment and the far-field environment. The near-field was defined as meeting the following four criteria simultaneously:

- A water parcel located in this field must have the opportunity to enter the power plant cooling tunnels,
- The above opportunity must be capable of being exercised within a 24-h period,

000072

- The field must be situated in a geographic area that is unchanged by natural water movements, and
- The 10 percent probability of entrainment isopleth must always be contained within this field.

For the purposes of this study, all of these criteria were met by the geographic area enclosed by the outer lagoon. The geographic boundaries of the outer Agua Hedionda Lagoon segment therefore constituted the near-field. The far-field was then defined as those remaining portions of the primary study area which are contiguous to the near-field. Geographically, these field areas consisted of the two inner lagoon segments of the Agua Hedionda System and the offshore coastal zone.

Organisms such as planktonic forms and ichthyolarvae located within about 1000 ft of the intake screens in the southern end of the near-field environment are under the direct influence of the intake system. Biological matter in the far-field may be transported into the near-field by currents, winds, tides, and wave action.

As suggested in the EPA Draft 316(b) Guidelines (4-7) isopleths[h] of entrainment probability were developed. Figure 4.2-1 presents a representative probability distribution derived from current meter and water property data taken over a complete tidal period in the outer lagoon segment. Probability isopleths

---

h. Isopleths: theoretical lines connecting points of like value, which in this case describe the various percentages of entrainment probability.

000073

for the offshore zone are shown in Figure 4.2-2. Information gained from such distributions is useful as a predictive tool, and as a means for determining the probable extent and configuration of the near-field affected area. The completeness of the plankton entrainment studies performed for this Demonstration, however, obviated the necessity to utilize probabilities of entrainment as a predictive tool.

4.3.2 Biological Oceanography Description

In order to assess impingement and entrainment impacts, data must be evaluated in terms of the important species which occur in the source water. For the purposes of this study, the term "critical species" was used to describe important taxa[i] which were employed ultimately as impact indicators. These critical taxa were examined in samples from the cooling water intake impingement and entrainment surveys, as well as field surveys.

Development of the critical taxa list was based on criteria designated by State and Federal 316(b) Guidelines (4-8, 4-9). Accordingly, taxa were selected through review of agency and academic literature, augmented by prior field experience in the vicinity of the Encina Power Plant. The critical species list approved by the State Water Resources Control Board for use within this Demonstration is presented in Table 4.3-1.

---

i. Taxa: groups of organisms.

TABLE 4.3-1
CONSIDERATIONS AND RATIONALE FOR DETERMINATION OF ORIGINALLY APPROVED CRITICAL SPECIES FOR 316(b) STUDIES AT ENCINA POWER PLANT
ENCINA POWER PLANT - NOVEMBER 17, 1978

Species	Representative of a balanced community	Commercially or recreationally valuable	Critical to structure and function of ecosystem	Food chain necessity	High potential for impingement or entrainment	Rationale for final disposition of critical determination
ADULT FISH						
Engraulidae						
Engraulis mordax (Northern Anchovy)	X	X	X	X	X	Common offshore and in lagoon at times; previously impinged.
Atherinidae						
Atherinops affinis (Topsmelt)	X	X	X	X	X	Common in source waters and kelp beds; previously impinged.
Serranidae						
Paralabrax clathratus (Kelp Bass)	X	X	X		X	Common in source waters; previously impinged.
Paralabrax maculatofasciatus (Spotted Sand Bass)	X	X			X	Common in source waters; previously impinged.
Paralabrax nebulifer (Barred Sand Bass)	X	X			X	Common in source waters; previously impinged.
Sciaenidae						
Cynoscion nobilis ([illegible])	X	X	X		X	Common near kelp and offshore; previously impinged.
Menticirrhus undulatus (California Corbina)	X	X			X	Common in surf and lagoon.

TABLE 4.3-1 (Continued)

Species	Representative of a balanced community	Commercially or recreationally valuable	Critical to structure and function of ecosystem	Food chain necessity	High potential for impingement or entrainment	Rationale for final disposition of critical determination
<u>Seriphus</u> <u>politus</u> (Queen Fish)	X			X	X	Common in source waters; previously impinged.
Embiotocidae						
<u>Amphistichus</u> <u>argenteus</u> (Barred Surfperch)	X	X	X		X	Common in surf; previously impinged.
<u>Hyperprosopon</u> <u>argenteum</u> (Walleye Surfperch)	X	X				Common in surf; kelp, lagoon; previously impinged.
Labridae						
<u>Pimelometopon</u> <u>pulchrum</u> (California Sheephead)	X	X				Common in source waters.
Mugilidae						
<u>Mugil</u> <u>cephalus</u> (Striped Mullet)	X				X	Common in source waters; previously impinged.
Bothidae						
<u>Citharichthys</u> <u>sordidus</u> (Pacific Sanddab)	X	X	X		X	Common in source waters.
<u>Paralichthys</u> <u>californicus</u> (California Halibut)	X	X	X		X	Common in source waters; previously impinged.
Pleuronectidae						
<u>Pleuronichthys</u> <u>verticalis</u> (Hornyhead turbot)	X					Common in source waters; previously impinged.

TABLE 4.3-1 (Concluded)

Species	Representative of a balanced community	Commercially or recreationally valuable	Critical to structure and function of ecosystem	Food chain necessity	High potential for impingement or entrainment	Rationale for final disposition of critical determination
Clinidae						
Heterostichus rostratus (Giant Kelpfish)	X				X	Common in kelp beds and lagoon grass beds; previously impinged.
ICHTHYOPLANKTON						
Engraulidae (Anchovies)						
Anchoa compressa	X		X	X	X	A major species or group in previous collections.
Engraulis mordax	X	X	X	X	X	
Cottidae (Sculpins)	X				X	
Serranidae (Sea Basses)	X	X	X		X	
Sciaenidae (Drums)	X	X	X	X	X	
Clinidae (Clinids)	X				X	
Gobiidae (Gobies)	X				X	
Coryphopterus nicholsi						
Bothidae (Lefteye Flounders)	X	X	X		X	
Citharichthys stigmaeus	X				X	
Paralichthys californicus	X	X			X	
Pleuronectidae (Righteye Flounders)	X	X	X		X	
Hysopsetta guttulata	X				X	
Atherinidae (Smelts, Grunion)	X	X	X			A major species or group in previous collections.
ZOOPLANKTON						
Acartia tonsa (Copepod).	X		X	X	X	A major species or group in previous collections.

4.3.2.1 Field Plankton Studies. Source water studies of ichthyoplankton and zooplankton were performed to characterize the temporal and spatial distributions of these organisms. Plankton are major components of the ecosystem in the vicinity of the Power Plant. Plankton distribution was studied with respect to factors which affect population fluctuations (tide, diel and vertical stratification). Distribution studies were necessary to separate "natural" fluctuations from those changes which could be attributed to the Plant's intake system. Parameters studied were plankton density and distribution.

The population(s) baselines, for the parameters just described, thus established the natural conditions for comparisons with entrainment data, in order to evaluate Plant impact on source water populations. The relationship between near-field and far-field source water populations was examined during the assessment of entrainment impact.

4.3.2.2 Field Nekton Studies. Source water nekton studies were conducted to characterize population distributions, both spatial and temporal, in the vicinity of the Encina Power Plant. Information was collected describing length frequency distribution, fecundity, biomass, age class distribution, sex ratio, and population abundance. These parameters were used to define population size.

The population(s) baselines, for the parameters just described, thus established the natural conditions for comparisons with impingement data, in order to evaluate Plant impact on source water populations.

4.4 ENVIRONMENTAL IMPACT ASSESSMENT

The effects of Encina's impingement and entrainment rates were assessed for impact through comparisons of plant-associated losses with source water population characteristics such as natural mortality, standing stock[j] abundance, and commercial fishing losses. All impacts were described as either significant or insignificant.

4.4.1 Impingement Impact

The biological impact of Encina's impingement losses was found to be insignificant through the assessment of the following three comparisons.

(1) Impingement Loss vs Source Water Resources

The average daily Plant removal was only 0.02 percent of the estimated standing stock. When compared to source water resources, therefore, the impact of impingement loss was found to be insignificant

(2) Impingement Loss vs Commercial Fishing Losses

The Power Plant removals only amounted to 0.05 percent of the commercial landings in the San Diego area annually. When compared to commercial fishing losses, the impact of annual impingement was found to be insignificant.

(3) Impingement Loss vs Natural Losses

Annual impingement losses compared to natural losses indicated the impact of impingement to be insignificant.

---

j. Standing Stock: The amount of living material per unit of water surface or volume, expressed in either units of weight or numbers of organisms. In the context of this study, standing stock was estimated using one year of data and was assumed to represent the amount of organisms present at any given time during that period.

000080

4.4.2 Entrainment Impact

Entrainment losses at Encina were assessed for impact through the three comparisons listed below using zooplankton, ichthyoplankton, and phytoplankton data.

(1) Near-Field vs Far-Field Density (to isolate any localized effect)

(2) Near-Field vs Entrainment Density (to indicate any selective entrainment effect)

(3) Entrainment Loss vs Source Water Resources

The results of these comparisons are summarized in Table 4.4-1. For all three taxonomic groups, the impact of entrainment is insignificant.

4.4.3 Combined Effects of Impingement and Entrainment

The impact from impingement and entrainment is compounded for those taxa, for example topsmelt and deepbody anchovy, which are susceptible to both. Even so, the average losses combined from impingement and entrainment were insignificant, amounting to about 0.24 percent of the estimated standing stock.

4.4.4 Impact Evaluation

An assessment of the impact of Plant-related effects (i.e., impingement, entrainment) on the adult fish, zooplankton ichthyoplankton, and phytoplankton populations in the vicinity of the Encina Power Plant indicated the following:

TABLE 4.4-1
ENTRAINMENT IMPACT MATRIX

Taxonomic Group	Near-Field vs Far-Field Density	Near-Field vs Entrainment Density	Entrainment Loss vs Source Water Resources
ZOOPLANKTON	No localized depletion of zooplankton was evident in the area within the influence of the Plant's intake.	Entrainment was shown to be non-selective (i.e., taxa are entrained in roughly the same proportions as they occur in the source water).	The average ratio of entrainment loss to standing stock resources within one day's travel time of the Power Plant was only 0.2 percent: Environmental impact is insignificant.
ICHTHYOPLANKTON	No discernible localized depletion of fish eggs or larvae was evident in the area within the influence of the Plant's intake.	No clear selective entrainment.	The average ratio of entrainment loss to standing stock resources within one day's travel time of the intake was 7.4 percent: Environmental impact is insignificant.
PHYTOPLANKTON	Not applicable.	Not applicable.	Estimated loss in source water productivity was insignificant: Environmental impact is insignificant.

000082

- The impact of Encina Power Plant impingement loss on the adult fish community in source waters is insignificant.
- The impact of Encina Power Plant entrainment on plankton resources in source waters is insignificant.
- The impact of the combined effects of fish removal and plankton entrainment by Encina Power Plant on source water populations is insignficant.

4.5 INTAKE TECHNOLOGIES FOR MINIMIZATION OF ADVERSE IMPACT

Environmental impact due to organism loss constitutes an "adverse environmental impact" only when it is of sufficient magnitude to damage and seriously disrupt the ecosystem. This distinction between "environmental impact" and "adverse environmental impact" is recognized in many contexts. For example, hunting and fishing laws are clearly premised on the difference between a mere loss of animals and loss in sufficient numbers to upset the ecological balance of the natural system which produces the animals and sustains their populations.

Section 316(b) of the Clean Water Act recognizes that a certain level of environmental impact is acceptable. In the Seabrook case, for example, the EPA Administrator stated the following after examining the data which indicated the plant was responsible for the entrainment and mortality of an estimated 100 billion softshell clam (*Mya arenaria*) larvae: "...I conclude that entrainment of *Mya* (larvae) will have an insignificant effect on the adult *Mya* population."[k]

---

k. Public Service of New Hampshire, Seabrook I. NPDES Appeal No. 76-7, Decision of the Administrator, 10 June 1977, page 41. In addition, the Administrator stated the following:

"...the mortality of *Mya* (*arenaria*) larvae from all sources related to the Seabrook operations would be approximately 1×10^{11}... Thus the larvae killed would be about 5% of the larvae in the neritic band in the vicinity of Seabrook. If it is assumed that destruction of *Mya* larvae would result in destruction of the same proportion of adult clams, the

In granting Seabrook its NPDES permit, the EPA Administrator thus recognized that the goal of Section 316(b) was for cooling water intake system technology to achieve an acceptable low level of adverse impact. If the intake system is already operating at an acceptable "low" impact level, therefore the system is considered to have BTA.

The State Guidelines suggest that the Demonstration documents where the present intake design includes features that contribute to minimizing adverse impacts. Furthermore, alternative technologies having the potential for achieving "low" impact were reviewed and analyzed, as required by the California State 316(b) Guidelines.

4.5.1 Evaluation of the Existing Intake System's Design Operation, and Location

The State Water Resources Control Board (4-10) suggested in their 316(b) Guidelines that environmental consequences impacts) of cooling water intakes are sensitive to the following factors.

---

k. Continued:
Seabrook operations would be expected to destroy approximately 5% of the standing crop of Mya in the Hampton Seabrook area..." (page 30, 31)

"Although the plant may kill considerable numbers of eggs and larvae, the total volume of water that will be subject to the plants' adverse effects is miniscule compared to the 54 square miles of coastal water adjacent to the plant, in which these ichthyoplankton may be expected to develop." (page 33)

- Design, operation and location of the intake

After reviewing the extensive sampling data collected during the operation of the Encina Power Plant, the following design aspects of the Encina intake system were found to contribute to minimizing adverse impacts.

- The withdrawal of cooling water from the entire water column is non-selective in terms of organism removal from the source water.
- Vertical traveling screens serve as a barrier and prevent fish from entering the cooling water system.
- The vertical traveling screens' mesh is large enough to prevent abrasive extrusion of entrained organisms.
- Intake location at the southern end of Outer Agua Hedionda Lagoon avoids direct impact on the greater population densities existent in offshore fish and plankton populations.
- Due to its specific location it allows lagoon species an opportunity to pass into the middle and upper lagoon segments on flood tide, or offshore on ebb tide rather than enter the intake system.
- Intake location has permitted the development of a viable marine habitat and nursery area for fish and invertebrate species.
- Intake location and design serves to separate the intake structure from the discharge and works to prevent re-entrainment of cooling waters and their biological constituents.

An evaluation of the individual components of the intake system and their effects on entrainment and impingement indicated the following.

- Condenser biofouling control via chlorination had no observed effect on entrainment or impingement losses.

- Condenser biofouling control via thermal treatment minimizes biofouling predation loss of entrained organisms.

- Impingement and entrainment losses are generally lower at lower rates of cooling water intake.

- Maintenance dredging operations in the outer lagoon segment serve as an attractant to fish species and result in greater impingement losses. However, this is limited to periods of 2 to 3 months duration, every 2 years.

4.5.2 Potential Alternative Intake Technologies for Minimization of Impacts

Potential alternative intake technologies reviewed for this Demonstration can be grouped into six broad categories based upon their mode of operation: (1) behavioral barriers, (2) diversion devices, (3) collection systems, (4) passive intakes, (5) fish-return systems, and (6) other alternatives. These categories are briefly described below.

(1) Behavioral barriers take advantage of the natural behavioral characteristics of fish. Since the success of these barriers depends solely on active fish avoidance responses, they are not designed to reduce entrainment.

(2) Diversion devices are physical structures designed to alter flow conditions at the intake in such a way that fish will be guided away from the main circulating water flow.

(3) Fish collection devices are designed to actively collect organisms entrapped within the intake screenwell.

(4) Passive intakes operate on the principle of achieving very low withdrawal velocities at the screening media and on locating the intake in a relatively high-velocity cross current. Organisms avoid the intake and get carried away with the cross current flow.

(5) Fish return systems are designed to return organisms collected at the intake to the source water with minimal mortality.

(6) Other alternatives considered were offshore intakes and flow reduction designs. Offshore intakes are designed to seek greater cooling water efficiency from deeper offshore waters, which may have lower densities of aquatic organisms than near-shore locations. Flow reduction systems are designed to reduce intake volume and velocities, seeking a reduction in the number of planktonic organisms entrained and adult fish impinged.

Further consideration of alternate technologies was unnecessary because the existing intake system was demonstrated to have "low" impact.

4.6 BEST TECHNOLOGY AVAILABLE

As previously discussed, the State Water Resources Control Board suggested in their 316(b) Guidelines that environmental consequences (impacts) of cooling water intakes are sensitive to three sets of factors. Each of the factors is reviewed in the paragraphs that follow to demonstrate the acceptable "low" level of adverse environmental impact which has been achieved by the Encina Power Plant cooling water intake system.

- Amount of Water Entrained and Size of Water Body

  It is shown in this Demonstration that Plant water use during a typical flood or ebb tidal phase is on the order of 600 acre-ft. The mean low water (MLW) volume of the Agua Hedionda Lagoon System is about 2500 acre-ft whereas the mean high water (MHW) volume is about 4000 acre-ft. Thus, as average percentage of lagoon volume entrained before replacement by lagoon tidal flushing is 24 percent at MLW and 15 percent at MHW. Considering the region between Dana Point to the north, the Mexican border to the south, and two miles offshore, coastal waters in an area of only 1.4 percent of this region have a maximum probability of less than 34 percent of even entering the Agua Hedionda Lagoon system. The waters in the remaining 98.6 percent of this offshore region have little or no probability of entering the lagoon system in a 24-h period.

- Species' Abundance and Distribution Patterns Within the Source Waters and Population Consequences of Entrainment and Impingement

  EPRI (4-11) concluded where intertrophic level[m] pathway changes are small, ecosystem stability will not be

---

m. Intertrophic Level: Between trophic levels. A trophic level is a successive stage in nourishment as represented by lines of the food chain. (Primary producers [algae] constitute the first trophic level, herbivorous zooplankton constitute the second level, and carnivorous organisms the third).

disrupted, and any resulting ecosystem effects will be reversable. Because entrainment and impingement loss to standing stock ratios were relatively small (Zooplankton - 0.2 percent, ichthyoplankton - 7.4 percent, and nekton - 0.02 percent), changes in intertrophic level pathways would be small as well. The environmental impact assessment performed for this Demonstration indicates that the impact of Plant entrainment and impingement is insignificant and does not upset the stability of this marine ecosystem.

- Design, Operation, and Location of the Intake

  The insignificant level of impact at all trophic levels demonstrates that the Plant intake, as presently designed and operated, is a "Low" impact system.

The low and insignificant level of impact demonstrates that the existing Encina Power Plant intake system represents the best technology available for this specific site to minimize adverse environmental impact.

000090

REFERENCES

4-1 U.S. Environmental Protection Agency. Guidance for Evaluating the Adverse Impact of Cooling Water Intake Structures on the Aquatic Environment: Section 316(b) PL 92-500. U.S. Environmental Protection Agency, Office of Water Enforcement, Washington, D.C., 1977.

4-2 California State Water Resources Control Board (SWRCB), Guidance Document for the Conduct of 316(b) Studies in California, SWRCB, Sacramento, Ca., 1977.

4-3 California State Water Resources Control Board (4-2).

4-4 California State Water Resources Control Board (4-2).

4-5 Electric Power Research Institute (EPRI), Methodology for Assessing Population and Ecosystem Level Effects Related to Intake of Cooling Waters, EPRI - "EA-1238," Palo Alto, Ca., 1979.

4-6 California State Water Resources Control Board (4-2).

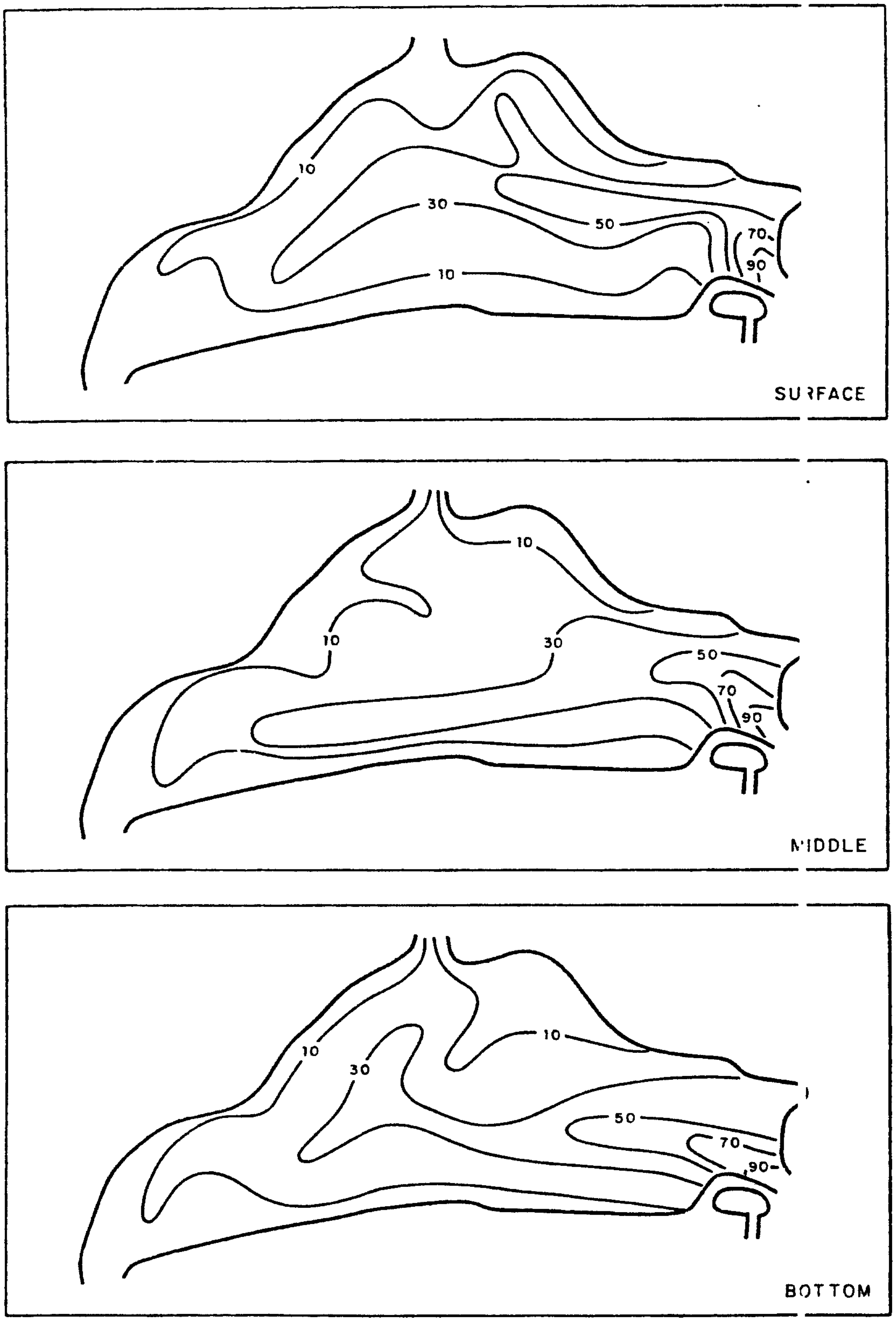
4-7 U.S. Environmental Protection Agency (4-1).

4-8 U.S. Environmental Protection Agency (4-1).

4-9 California State Water Resources Control Board (4-2).

4-10 California State Water Resources Control Board (4-2).

4-11 Electric Power Research Institute, (EPRI), Ecosystem Effects of Phytoplankton and Zooplankton Entrainment, EPRI - "EA-1038," Palo Alto, Ca., 1979.



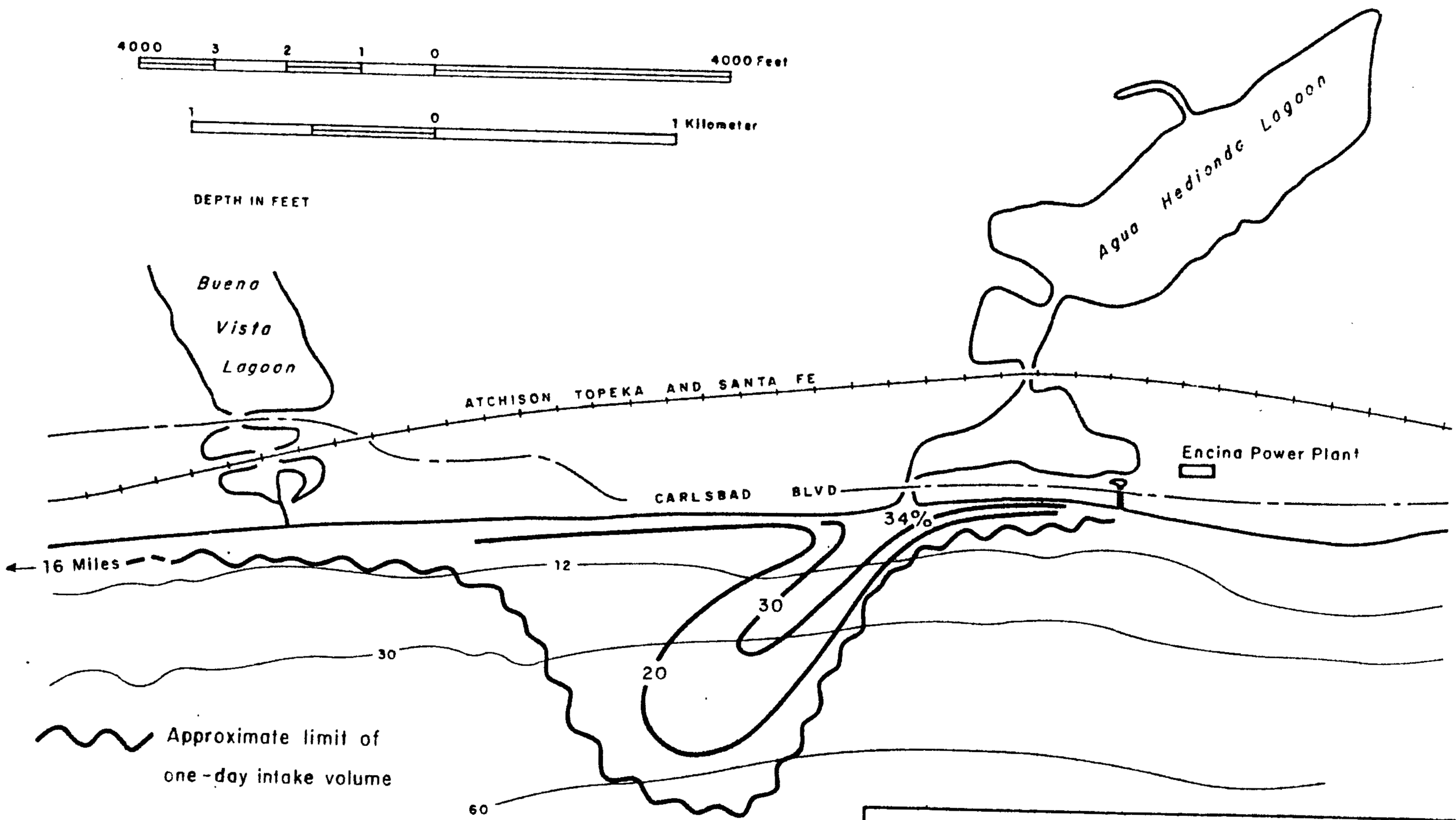
20 June 1979, Flood Tide

Time: 1300 - 1800

0 500 1000 Ft

0 100 200 300 M

SAN DIEGO GAS & ELECTRIC COMPANY	
Near-field entrainment probability Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 4.2-1



SAN DIEGO GAS & ELECTRIC COMPANY	
Offshore entrainment probability Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 4.2-2

5.0

PHYSICAL ENVIRONMENT: CIRCULATION CHARACTERISTICS AND SOURCE WATER INVOLVEMENT

5.1 ABSTRACT AND SUMMARY

In 1979, in accordance with a study plan approved by the California Regional Water Quality Control Board, San Diego Region (RWQCB-SD), a series of physical oceanopraphic surveys of the outer lagoon segment and offshore areas were conducted during each of the three dominant oceanographic seasons (Upwelling, Davidson, Oceanic). Data pertaining to:

- surface current structure,
- subsurface coastal currents,
- meteorological variability during the measurement periods,
- meteorological variability throughout the year,
- current patterns in the outer lagoon segment, and
- water property variations over diurnal periods

were collected and analyzed to trace the origins of water entering the cooling water tunnels of the power plant.

"Primary Study Area" measurements were considered in two parts -- the near-field and the far-field. Together both

fields comprise the primary study area defined in the RWQCB-SD study plan. As a result of early study results the near-field was defined as meeting the following four criteria simultaneously:

- a water parcel located in this field must have the opportunity to enter the power plant cooling tunnels,
- the above opportunity must be capable of being exercised within a 24-hour period,
- the field must be situated in a geographic area that is unchanged by natural water movements, and,
- the 10 percent probability of entrainment isopleth must always be contained within this field.

For the purposes of this study, all of these criteria were met by the geographic area enclosed by the outer lagoon, primary study area. The geographic boundries of the outer Agua Hedionda lagoon segment therefore constituted the near-field.

As a corollary, the far-field is then defined as those remaining portions of the primary study area which are contiguous to the near-field. Geographically, these field areas consisted of the two inner lagoon segments of the Agua Hedionda System and the offshore coastal zone.

Data analysis was also divided between two fields. The results of these analyses showed that although all source waters obviously passed through the outer lagoon segment (near-field), both the offshore region and the two inner lagoon segments (far-field) could act as source regions for the near-field volume.

Considering the region between Dana Point to the north, the Mexican border to the south, and two miles offshore, coastal waters in an area of only 2,560 acres, or 1.4 percent of this total region, have a maximum probability of less than 34 percent of even entering Agua Hedionda Lagoon system. The waters in the remaining 170,880 acres of this offshore region have little or no probability of entering the lagoon system in a 24-hour period. Further, once water has entered the lagoon system, plankton carried by these waters have a probability of greater than 50 percent of escaping power plant entrainment over more than half of the outer lagoon segment area. Thus the overall probability for plankton entrainment in the Encina Power Plant for waters in the Southern California Bight is extremely small.

Cooling water origins are closely related to the time frame under consideration. Over a period of several days, the ultimate source of water for the lagoon segments and power plant cooling water is the adjacent Pacific Ocean. Over a semi-diurnal tidal cycle, the cooling water origin alternates from the ocean to the inner lagoon segments depending upon tidal phase. As shown in Figure 5.4-11:

- During flooding tides, water entering the seaward entrance from the nearshore and littoral zones flows along the length of the outer lagoon segment to the cooling water tunnels and into the two inner lagoon segments.
- On the following ebb tide, water returning from the inner lagoon segments bifurcates at the middle lagoon segment entrance (in the outer lagoon segment) and supplies the cooling water demand as well as a return flow volume to the ocean.

Thus, on a time scale of about 10 to 15 hours, both the ocean and the inner lagoon segments serve as source regions for power plant cooling water. On an even shorter time scale, once an approximate 90-minute tidal phase lag in the outer lagoon segment has been taken into account, the inner lagoon segments are generally the main source water region during an ebb tide, and the ocean is the main source water region during a flood tide.

In the offshore zone, Figure 5.5-1 shows that the maximum extent of the one-day contribution to the intake volume extends about 1200 m (4000 ft) seaward and along the littoral zone for as far as 26 km (16 mi) upcoast and 0.8 km (0.5 mi) downcoast. Inflow speeds as high as 90 cm/sec (1.75 kt) were measured at the seaward entrance to the lagoon; return speeds were considerably slower at about 10 cm/sec (0.20 kt). Over a six-hour period with all five power plant units in operation, an order of magnitude estimate of the outer lagoon segment volume balance yielded the following values.

- During a flood tide, approximately 1600 acre-feet of water enters the seaward entrance of the outer lagoon segment. About half of this volume flows into the middle and upper lagoon segments while 200 acre-feet remains in the outer lagoon segment. A net volume of about 600 acre-feet therefore enters the cooling water tunnels to complete the flood tide volume balance.

- On an ebb tide, approximately 800 acre-feet of water returns from the middle and upper lagoon segments. About half of this volume exits to the ocean at the seaward entrance. The remaining 400 acre-feet combines with the approximate 200 acre-feet derived from the falling water level to provide the 600 acre-feet required by the power plant for cooling water.

Since the ambient water circulation patterns transport planktonic matter, a uniform distribution assumption allowed the potential for water entry into the cooling water tunnels to be characterized by isopleths of entrainment probability. Far-field entry and near-field entrainment probabilities were evaluated independently; each field was based on a maximum probability of 100 percent. A probability of 100 percent in the far-field implied entrance from the ocean into the outer lagoon segment; 100 percent probability in the near-field indicated flow into the cooling water tunnels.

In the far-field, offshore region, these isopleths are skewed at an approximate angle of 30 to 60 degrees with the coastline to reflect the more dominant southward transport in this near-shore zone. A probability of about 34 percent was calculated near the seaward entrance of the lagoon.

In the near-field, Figure 5.5-2 shows that the entrainment probabilities ranged from about 10 percent at the northern end of the outer lagoon segment to 100 percent probability at the immediate entrance to the cooling water tunnels. The current profile data shows that the draw-down effects of Units 1-5 operation could only be detected to a maximum distance of about 304 m (1000 ft) into the southern end of the outer lagoon segment. In all cases studied, this radius included the 70 percent isopleth for plankton entrainment. A noticeable shift of the probability isopleths toward the seaward entrance on flood tide (Figure 5.5-2) and toward the middle lagoon segment entrance on ebb tide was evident (Figure 5.5-3).

Directly in front of the trash racks leading to the cooling water tunnels, inflow speeds on the order of 45 cm/sec (0.80 kt) were measured on the deeper western side and speeds of about 26 cm/sec (0.50 kt) were measured on the eastern side.

5.2 METHODOLOGY SUMMARY

Determination of origins for the cooling waters entering the Encina Power Plant was divided between three seasonal field surveys and a detailed examination of the resulting measurements. Field surveys in both the coastal area off Carlsbad State Beach and in Agua Hedionda Lagoon were conducted on June 20-21, August 29-30, and November 14-15, 1979 to coincide with the approximate times of the varying oceanographic seasons off the southern California coast. During each of these seasons, the large scale offshore current patterns undergo significant changes in both speed and direction. Potentially, these changes in velocity can bring different populations of planktonic material into the nearshore zone and the subject lagoon segments

Source regions were categorized as either near-field or far-field. Geographically, the near-field area consisted of the outer or westernmost lagoon segment of the Agua Hedionda System. The far-field encompassed the area offshore and the inner two two lagoon segments. Both fields contribute to the one-day intake volume passing through the power plant.

Offshore current measurements consisted of:

- deploying subsurface, self-recording current meters on two single-point moorings located approximately 427 and 1036 m (1400 and 3400 ft), respectively, seaward of the intake entrance to the outer lagoon segment, and

- tracing the movement of surface drift blocks.

The current meter moorings remained on station for the entire month of the survey. Beach searches for drift blocks were conducted over a two-day period following each release. The month-long current meter records were computer processed for speed and direction distributions, component variations along shore and perpendicular to shore, and differences in current structure with increasing seaward distance from the outer lagoon segment entrance. The drift block data were reduced to provide estimates of surface trajectories, speeds, and dominant surface flow directions. Based on estimates of tidal volumes passing through the seaward entrance of the outer lagoon segment, an offshore, far-field region of potential flow into the lagoon segment was defined. Regions of potential inflow were assigned a probability of lagoon entry.

Within the outer lagoon segment, a series of approximately 20 sampling stations were established during each field survey. Continuous sampling of current and Conductivity, Temperature, Depth (CTD) profiles through the station network was completed for an entire tidal day. Streamline and isotach analyses of near-surface, mid-depth, and near-bottom current data were developed for different tidal phases. Directions of flow at each station and level were combined with distance from the cooling water intake to develop estimates of near-field entrainment probability.

Water temperature measurements in the offshore regime were combined with temperature and salinity data gathered in the lagoon to trace water origins. Water masses were identified by their temperature and salinity--although most of the variability appeared in the hourly temperature values rather than salinity.

Concurrent with the lagoon measurements, a self-recording weather station was deployed to record wind velocity and air temperature over the measurement periods. These data were digitized on an hourly basis for assistance in interpreting the oceanographic measurements.

Details of the particular procedures used in each study segment are presented in Appendix Section 16.2 Methodology (detailed).

5.3 EXISTING PHYSICAL SETTING

5.3.1 Study Area Boundaries

The Encina Power Plant of the San Diego Gas & Electric Company is located in San Diego County along the Pacific coast about 42 km (26 mi) north of the City of San Diego. This five unit, 937 net MW, fossil fuel power plant draws its intake cooling waters for once-through cooling from the westernmost lagoon segment of the Agua Hedionda System. The Agua Hedionda Lagoon System consists of three interconnected segments of a coastal lagoon situated at the seaward end of the Agua Hedionda Creek drainage basin; this basin extends eastward into the San Marcos Mountains.

The climate of the coastal area of San Diego County, including Agua Hedionda Lagoon, is characterized as subtropical and semi-arid with a strong oceanic influence. Diurnal and seasonal temperature changes are relatively slight and humidities are normally low. Considerable fog occurs along the coast. The fall and winter months are usually the foggiest. The proximity of the ocean produces a maritime climate characterized by relatively even temperatures throughout the year and generally predictable wind patterns (5-1).

The mean annual air temperature is about 17.2 C (63 F). Monthly mean temperatures range from a minimum of 12.7 C (55 F) to a maximum of 21.6 C (71 F). Temperature extremes range from a minimum of -1.6 C (29 F) in January to a maximum of 44 C (111 F) in September. Freezing temperatures are generally rare and maximum temperatures are usually associated with weather patterns known as "Santa Ana" winds.

The annual rainfall in this south coast area totals about 30.5 cm (12 in)--most of which occurs in winter. The rainiest month is typically January with 5.1 to 7.6 cm (2 to 3 in, respectively) of rain on the average; usually less than 2.5 cm (1 in) falls between May and October. The rain is primarily associated with cold fronts moving down the coast from the Gulf of Alaska or from the west when the subtropical high pressure system breaks down.

Winds in the study area are predominantly westerly and are classified as light to moderate; wind speeds less than 3.5 m/sec (8 kt) occur about 64 percent of the time. The usual wind pattern is the land-sea (east-west) breeze combination which is most pronounced in summer when thermal gradients between land and sea are greatest. Occasional strong winds of 27 to 29 m/sec (60 to 65 kt, respectively) are associated with winter storms and gales and occur only on the average of every 50 years. The Santa Ana winds blow from the east or northeast and tend to be less severe but locally gusty.

Agua Hedionda Lagoon receives approximately 3200 hours of sunshine per year (about 70 percent of the total possible); most of it is received in winter because of the summer night and early morning cloudiness which is typical of this California coastal climate.

The geographic boundaries of the study area are shown in the site map presented in Figure 5.3-1. From the seaward entrance of the outer lagoon segment, the area of interest ranges about 25.7 km (16 mi) upcoast, 3.2 km (2 mi) downcoast, 1.6 km (1 mi) offshore, and inland to the easternmost limit of the inner lagoon segment.

5.3.2 General Hydrography

5.3.2.1 Offshore Characteristics. By definition, plankton (Gr., wanderer) are the floating or drifting life forms of the pelagic division of the sea; these plants and animals are carried by the prevailing currents in which they reside. A study of the general nearshore and lagoon circulation characteristics and current structure was therefore completed in order to develop estimates for the probability of offshore waters (which carry plankton) entering the coastal lagoon system, passing through the system to the cooling water tunnels, and potentially entraining these planktonic species. Based on the wide degree of variability found in the plankton sampling data (see Section 6.4), a generally uniform distribution of planktonic forms was assumed. The basic objective of these measurements was to demonstrate which of the offshore waters entered the lagoon, the time scales of these motions, and the source from which cooling water for power plant operation originated.

Offshore, the California Current, a broad, sluggish, eddying eastern boundary current of the North Pacific Ocean, flows strongest during the summer and weakest and most meandering in the winter (5-2). This current flows southeast as an extension of the Japanese and Aleutian currents and generally dominates the circulation of the California coastline. In southern California, a northward moving surface countercurrent appears landward of the California current on a seasonal basis. During the period from about September to February, this Davidson Current dominates the coastal circulation; this is usually followed by a period of upwelling. Upwellings are generally strongest in southern California in May and June as a result of northerly or northwesterly wind stresses. Currents during this period are generally variable. South-southeasterly moving currents dominate the remainder of the year and characterize the Oceanic Season.

A recent paper by Tsuchiya (1980) (5-3) summarizes much of our present level of knowledge of inshore circulation patterns in the Southern California Bight area. Using a geostrophic analysis of CalCOFI (California Cooperative Oceanic Fisheries Investigations) data taken between 1974 and 1977, he showed that the general surface circulation was predominantly to the south-southeast in the months of April, March, and June and towards the north-northwest in September, October, and December. Although these types of results form a good background for description of the inshore circulation, direct application of these data for this particular purpose cannot be made because the cooling waters utilized by the power plant generally occur at distances even closer to shore. Tsuchiya's shallowest station was located in a water depth of about 55 m (180 ft).

In a general sense, nearshore currents between the surf zone and a seaward distance of approximately 1.6 to 8.0 km (1 to

5 mi, respectively) flow in a longshore direction with downcoast (southerly) movements recorded more frequently than upcoast (northerly) movements. Direction reversals are caused by tidal forces as well as longer term (3 to 4 days) forces thought to be the result of Rossby waves trapped on the continental shelf. Maximum longshore speeds are approximately 25 to 40 cm/sec (0.5 to 0.8 kt, respectively) with near slack currents occurring over periods as long as 1 to 2 hours. Mean current speeds are generally slow, averaging less than 10 cm/sec (0.19 kt).

Inshore of this current regime lies the littoral zone which extends several hundred meters seaward from the shoreline. The littoral drift system carries much of the sand from beaches to deeper waters offshore during the winter months, decreasing their widths, increasing their slope, and exposing much of the underlying cobble. A large portion of the source material for beaches comes from the Oceanside littoral cell and partly from dredging operations. The Oceanside littoral cell, which receives its sand supply from runoff of local rivers and erosion of the San Onofre Bluffs, transports the sediments along the coast by wave action and longshore currents. According to Inman and Frautschy (1966) (5-4), the rate of sand transport is estimated to be about 164,389 m^3/yr (215,000 yd^3/yr).

Wind waves impinging on the southern California shoreline can be categorized seasonally from several source regions. Swell comes to the Southern California Bight from storms in the

Aleutians, the Hawaiian area, the western North Pacific typhoon region, the tropical storms west of Mexico, and the pressure gradient around the Pacific high pressure cell in the North Pacific, as well as from the New Zealand area and the high latitude region of the South Pacific (5-5). Swell derived from northern hemisphere storms approaches the coast from the west in contrast with southern hemisphere swell which arrives from the south and the southwest. Swell from the northern hemisphere predominates during the winter and spring when the storm systems are more intense. Southerly swells occur during the summer and fall when hurricanes are present off southern Mexico and extra-tropical storms exist in the southern hemisphere. Typically, swell waves have periods of about 12 to 18 seconds; locally developed wind waves have shorter periods.

Wind waves formed locally come from the northwest, west, and southwest and south (5-6). They respond to northwest winds from the Pacific high pressure regions, winds of the Santa Catalina Eddy, and the offshore Santa Ana winds. The largest sea waves occur when cyclonic and tropical storms approach the southern California coast. The average maximum wave heights are 3 to 5 m (10 to 16 ft, respectively). Emery (1960) (5-7) notes the occasional occurrence of 6 to 8 m (19 to 26 ft, respectively) high waves.

In the nearshore zone, ambient surface water temperatures recorded over a 40-year period at the Scripps Institute of Oceanography pier, located 33.8 km (21 mi) downcoast of the Agua

Hedionda Lagoon, averaged 12.8 C (55 F) during the coldest months (January-April) and 20 C (68 F) during the warmest months (August-September). The mean surface temperature at Scripps Pier in 1979 was 16.8 C (62.3 F) with a maximum temperature of 23.2 C (73.8 F) recorded in September and a minimum temperature of 12.0 C (53.6 F) recorded in January and February.

Ambient water temperatures recorded off Carlsbad State Beach in 1979 show variations similar to those measured at the Scripps Pier. Between March 19 and April 20, the mean surface temperature was 15.1 C (59.3 F); from July 19 to August 16, the mean rose to 20.9 C (69.7 F); and from August 16 to September 18, the mean was 21.1 C (70.0 F).

Salinity is nearly constant throughout the nearshore zone (about 33-34 ppt), and varies little with time. The mean nearshore salinity is about 33.75 ppt with a standard deviation of only 0.10 ppt (5-8).

5.3.2.2 Agua Hedionda Lagoon. Agua Hedionda Lagoon is situated within the city limits of Carlsbad and is owned by SDG&E. It extends inland about 2.7 km (1.7 mi) and ranges from 174 to 177 m (570 to 2550 ft, respectively) in width. The lagoon is bounded by Carlsbad Boulevard to the west, downtown Carlsbad to the north, hillslopes and bluffs to the east, and cultivated fields, along with the Encina Power Plant, to the south. A trestle of the Atchison, Topeka and Santa Fe Railroad and Interstate 5 freeway cross the lagoon and divide it into three segments; the segments are referred to as the "outer", "middle", and "inner" lagoon segments. At the northwestern end of the outer lagoon segment, a seaward entrance about 46 m (150 ft) wide and 2.7 m (9 ft) deep formed by two 91 m (300 ft) long rock jetties allows a free exchange between the ocean and the lagoon system. The cross sectional area of this passage is about 78.4 m^2 (844 ft^2) at MLLW.

The lagoon system is kept open by a biennial maintenance dredging program. The lagoon segments were originally dredged to a mean depth of about 2.4 m (8 ft) in 1954. The operation required 247 days and 3,271,273 m^3 (4,279,000 yd^3) of material were dredged. Between 1954 and 1972, approximately 1.4 million m^3 (1.9 million yd^3) of sediment were removed. Practically all of the material from maintenance dredging was composed primarily of fine to very fine sand with small amounts of medium sand and fine particles such as silt and clay. This material was discharged west of Carlsbad Blvd. to restore the naturally eroded beach in front of the Encina Power Plant.

The outer lagoon segment is about 823 m (2700 ft) long from north to south and has a maximum width of about 311 m (1020 ft). It covers approximately 267,000 m^2 (66 acres) at MHW and has a present averaged dredged depth of about 4.6 m (15 ft). The most recent dredging of the lagoon segment was completed in April 1979. Much of the intertidal area has been lined with riprap to prevent erosion at exposed points. Elsewhere, the lagoon segment shoreline consists largely of fine sand with cobble patches. Floating booms have been installed near the southern end of the lagoon segment and between the jetties below the railroad trestle on the eastern bank of the outer lagoon segment. The entrance to the inner lagoon segments is located below this trestle. The cross-sectional area of the middle lagoon segment entrance is about 70 m^2 (750 ft^2) at MLLW. A bathymetric chart of the outer lagoon segment presenting contours of depth soundings in feet taken after the April dredging is presented in Figure 5.3-2.

The middle lagoon segment is the smallest section of Agua Hedionda Lagoon, almost square, with sides of about 300 m (980 ft) in length. The horizontal area is about 110,000 m^2 (27 acres) at MHW. Its southern and western banks consist mostly of crushed rocks and sand with no emergent or intertidal marsh vegetation. A clayey silt containing many clam shells makes up the northern edge while silty sand predominates on the eastern bank bordering Interstate 5. A small intermittent freshwater creek drains into this lagoon segment at the northwest corner. The only development of this lagoon segment is a YMCA-operated small boat house on the western shore which is used for recreational activities. The entrance to the upper lagoon segment is also lined with large boulders and contains pylons to support the freeway.

The inner lagoon segment is the largest of the three segments and extends about 1650 m (5400 ft) eastward from I-5; it occupies about 1,200,000 m^2 (295 acres) at MHW. The banks are occupied to the north by a private marina condominium complex and two private boat launching facilities. Bluffs rising to power plant lands that contain fuel tanks and leased agricultural crops occupy the banks to the south. The west bank rises to I-5. Agua Hedionda Creek empties into the upper lagoon segment at its east end. Also at this end, are the degraded remnants of a once extensive salt marsh with about 404,900 m^2 (100 acres) of mudflat and high marsh interspersed with salt flats and alluvial fan. Most of the limited amount of freshwater that enters the lagoon comes from Agua Hedionda Creek and its major tributary, Buena Creek.

The daily cycle of tides in Agua Hedionda Lagoon has two maxima and two minima; tidal height varies from below MLLW during extreme low tides to slightly more than 1.6 m (5.3 ft) during spring tides. The mean tide range is 1.1 m (3.7 ft); the mean tide level is 0.8 m (2.7 ft).

5.4 CURRENTS AND CIRCULATION PATTERNS

5.4.1 Coastal Zone

Circulation properties in the coastal zone are characterized in two regions. The nearshore region extends seaward to a distance of about 1.6 to 8.0 km (1 to 5 mi, respectively) and serves as a transition zone between shore processes and the larger scale circulation associated with open ocean flows. Immediately inshore of this zone, currents in the littoral region respond to wave-induced momentum, bottom topography, and local wind stresses. Because of the importance of this region in redistributing beach sediments, a number of field studies (e.g., 5-9 and 5-10) and explanations (e.g., 5-11 and 5-12) for the physical processes in this zone have been suggested. Generally, the littoral zone only extends offshore for several hundred meters (yards), or to the approximate limit of the breaker zone.

5.4.1.1 Nearshore Circulation. In June, August, and November 1979, two ENDECO Model 105 current meters were deployed at preselected mooring sites off the seaward entrance of the outer lagoon segment (see Section 16.2.1.2.1 for detailed methodology). Complete listings of the measured speeds and directions recorded at 30-minute intervals at a subsurface depth of approximately 3 m (10 ft) are presented in Section 16.3.1.1. These data can be summarized in several different forms to illustrate significant features of the nearshore circulation.

Table 5.4-1 presents speed and direction frequency distributions for the three measurement periods at the station closest to shore. Speed values are sorted into 5 cm/sec (0.09 kt) intervals; directions (in degrees true) are sorted into 16 separate bands. Totals in each interval and percentage of the record set are listed across the bottom and in the right-hand columns. A station average speed is appended in the lower left-hand corner of each distribution. A similar set of distributions for the mooring located at 1036 m (3400 ft) offshore is presented in Table 5.4-2. Comparison of the resultant frequencies in the tables shows the following:

- Current speeds in the nearshore area are relatively slow during all seasons. The highest speeds occur further offshore but are still comparatively slow for most oceanic phenomena. If 10 cm/sec (0.19 kt) is chosen as a typical current speed then at least half of all the measurements taken at the furthest offshore station do not exceed this limit; more than 90 percent of the speeds measured closer to shore are less than 10 cm/sec (0.19 kt). This decrease in speed with proximity to shore is also reflected in the station averages.
- Current directions at both stations show an upcoast/downcoast reversal at approximate tidal frequencies. Currents further offshore, however, exhibit a greater tendency for flow towards the south than currents

TABLE 5.4-1
NEAR-SHORE STATION
SPEED AND DIRECTION DISTRIBUTION
ENCINA POWER PLANT - AUGUST 1, 1980

RECORD PERIOD: 6- 6-79 TO 6-28-79

DIRECTIONS ARE TRUE

SPEEDS CM/S	0	22	45	67	90	112	135	157	180	202	225	247	270	292	315	337	360	TOTAL	PERCENT
0	19	18	53	44	35	41	43	47	30	39	33	9	22	36	52	114		635	60.36
5	24	10	18	25	28	27	9	9	9	13	12	12	13	12	24	104		349	33.17
10	4		1	2	5	1		1		3	9	9	7	1	1	10		54	5.13
15											4	5	2					11	1.05
20												3						3	0.29
25																			
30																			
35																			
TOTAL	47	28	72	71	68	69	52	57	39	55	58	38	44	49	77	228		1052	
PERCENT	4.47	2.66	6.84	6.75	6.46	6.56	4.94	5.42	3.71	5.23	5.51	3.61	4.18	4.66	7.32	21.67			100.00

STATION AVERAGE = 5.36 CM/S

TABLE 5.4-1 (Continued)
NEAR-SHORE STATION
SPEED AND DIRECTION DISTRIBUTION
ENCINA POWER PLANT - AUGUST 1, 1980

RECORD PERIOD: 8- 6-79 TO 8-31-79

DIRECTIONS ARE TRUE

SPEEDS CM/S	0	22	45	67	90	112	135	157	180	202	225	247	270	292	315	337	360	TOTAL	PERCENT
0	35	10	19	22	13	12	16	24	31	23	14	6	13	10	16	85		349	29,25
5	107	36	44	51	33	40	15	42	43	95	43	30	21	13	22	93		728	61,02
10	19	5	2	3	2	5	3	3	2	6	17	12	11	1		6		97	8,13
15	2										3	7	2					14	1,17
20											1	4						5	0,42
25																			
30																			
35																			
TOTAL	163	51	65	76	48	57	34	69	76	124	78	59	47	24	38	184		1193	
PERCENT	13,66	4,27	5,45	6,37	4,02	4,78	2,85	5,78	6,37	10,39	6,54	4,95	3,94	2,01	3,19	15,42			100,00

STATION AVERAGE = 7,00 CM/S

000116

TABLE 5.4-1 (Concluded)
NEAR-SHORE STATION
SPEED AND DIRECTION DISTRIBUTION
ENCINA POWER PLANT - AUGUST 1, 1980

RECORD PERIOD: 11- 2-79 TO 11-30-79

DIRECTIONS ARE TRUE

SPEEDS CM/S	0	22	45	67	90	112	135	157	180	202	225	247	270	292	315	337	360	TOTAL	PERCENT
0																			
	60	33	63	49	59	71	56	72	71	61	45	19	25	14	30	223		951	71,08
5																			
	50	23	19	21	22	23	20	17	12	11	22	7	9	2	4	87		349	26,08
10																			
	9	4					1	2		1	3	4	3	2		1	4	34	2,54
15																			
												2	2					4	0,30
20																			
25																			
30																			
35																			
40																			
TOTAL	119	60	82	70	81	95	78	89	84	75	73	31	36	16	35	314		1338	
PERCENT	8,89	4,48	6,13	5,23	6,05	7,10	5,83	6,65	6,28	5,61	5,46	2,32	2,69	1,20	2,62	23,47			100,00

STATION AVERAGE = 4.66 CM/S

000117

TABLE 5.4-2
OFF-SHORE STATION
SPEED AND DIRECTION DISTRIBUTION
ENCINA POWER PLANT - AUGUST 1, 1980

RECORD PERIOD: 6- 6-79 TO 6-28-79

DIRECTIONS ARE TRUE

SPEEDS CM/S	0	22	45	67	90	112	135	157	180	202	225	247	270	292	315	337	360	TOTAL	PERCENT
0																			
5	1	1	5	9	8	7	15	7	5	11	4	5	6	1	8	8		101	9.60
10	17	9	18	16	15	26	38	52	35	25	19	9	25	31	32	71		438	41.63
15	18	7	11	8	5	13	32	55	38	28	5	5	7	5	22	80		339	32.22
20	14	5				1	21	29	19	3			1	1		19		113	10.74
25	2						8	14	10	1						10		45	4.28
30							3	10	1									14	1.33
35								2										2	0.19
TOTAL	52	22	34	33	28	47	117	169	108	68	28	19	39	38	62	188		1052	
PERCENT	4.94	2.09	3.23	3.14	2.66	4.47	11.12	16.06	10.27	6.46	2.66	1.81	3.71	3.61	5.89	17.87			100.00

STATION AVERAGE = 11.14 CM/S

TABLE 5.4-2 (Continued)
OFF-SHORE STATION
SPEED AND DIRECTION DISTRIBUTION
ENCINA POWER PLANT - AUGUST 1, 1980

RECORD PERIOD: 8- 6-79 TO 8-31-79

DIRECTIONS ARE TRUE

SPEEDS CM/S	0	22	45	67	90	112	135	157	180	202	225	247	270	292	315	337	360	TOTAL	PERCENT
0																			
5		13	6	12	14	16	12	17	17	25	36	12	5	17	13	23	129	367	30,76
10		22	13	12	6	13	18	33	66	53	30	6	5	4	7	17	99	404	33,86
15		29	2	2		4	11	32	72	35	8		1	1		2	46	245	20,54
20		21					2	14	39	20	3						19	118	9,89
25		6					1	3	16	8							3	37	3,10
30		1						2	7	6							4	20	1,68
35																	2	2	0,17
TOTAL		92	21	26	20	33	44	101	217	147	77	18	11	22	20	42	302	1193	
PERCENT		7,71	1,76	2,18	1,68	2,77	3,69	8,47	18,19	12,32	6,45	1,51	0,92	1,84	1,68	3,52	25,31		100,00

STATION AVERAGE = 9,25 CM/S

000119

TABLE 5.4-2 (Concluded)
OFF-SHORE STATION
SPEED AND DIRECTION DISTRIBUTION
ENCINA POWER PLANT - AUGUST 1, 1980

RECORD PERIOD: 11- 2-79 TO 11-30-79

DIRECTIONS ARE TRUE

SPEEDS CM/S	0	22	45	67	90	112	135	157	180	202	225	247	270	292	315	337	360	TOTAL	PERCENT
0	57	13	20	21	31	33	32	35	44	41	19	13	6	16	23	70		474	35,45
5	98	7		6	8	16	17	48	70	52	31	10	4	3	7	45		422	31,56
10	65					2	21	34	53	29	3					13		220	16,45
15	41						6	18	24	5		1				3		98	7,33
20	24	1					11	11	17	1								65	4,86
25	13						3	9	14									39	2,92
30	3						1	8	4									16	1,20
35								3										3	0,22
40																			
TOTAL	301	21	20	27	39	51	91	166	226	128	53	24	10	19	30	131		1337	
PERCENT	22,51	1,57	1,50	2,02	2,92	3,81	6,81	12,42	16,90	9,57	3,96	1,80	0,75	1,42	2,24	9,80			100,00

STATION AVERAGE = 9.56 CM/S

closer to shore. This particular feature is demonstrated best by a histogram plot of the tabulated frequencies. The left-hand column of Figure 5.4-1 presents comparative histograms of the directional distributions. The right-hand column presents comparative histograms of the speed distributions. A light line is used to represent the offshore data; a heavy line is used to represent the inshore data. Note that the light graph always indicates higher frequencies around 180 degrees than the heavy graph; this indicates that southerly directed flows are more common in the offshore portion of the nearshore zone than in the inshore area. Similarly, higher frequencies indicated by the light graph (over the heavy graph) at speeds in excess of 10 cm/sec (0.19 kt) in the right-hand column further support the contention that higher speeds are more predominant further offshore.

- Another feature of the directional distribution that can be illustrated best with the assistance of an auxiliary figure is that a wider variety of directional flows is present closer to shore. That is, the current roses in the right-hand column of Figure 5.4-2 (inshore station) show a higher frequency of east-west flows than the current roses in the left-hand column (offshore station). This particular point can be examined closer by resolving the vector time series into components directed parallel (upcoast/downcoast) and perpendicular to the coastline. A coastal inclination of 36 degrees west of north was used for the component calculations. Time series plots of the resulting component variability for the June, August, and November measurement periods are presented in Figures 5.4-3, 5.4-4, and 5.4-5, respectively. Examining each of these graphs, a compilation of the probability for flow in each of the four component (i.e., upcoast, downcoast, onshore, and offshore) directions at each station was developed; these values are listed in Table 5.4-3. Basically, comparison of the onshore and offshore elements of the table indicate that more water flows into the outer lagoon segment from a distance of 426 m (1400 ft) offshore than at a distance of 1036 m (3400 ft). If the trend in the onshore component is now assumed to be stationary under linear extrapolation toward shore, then it appears that 34.4 percent of the time, water at the shoreline enters the lagoon segment and only 15.6 percent exits. In other words, on a monthly basis, more water enters the seaward

TABLE 5.4-3
PROBABILITY (PERCENT) OF COMPONENT
CURRENT FLOW OCCURRENCE
ENCINA POWER PLANT
AUGUST 1, 1980

Station	Direction	June 6-28	Aug. 6-31	Nov. 2-30
Offshore	Upcoast	21.5	22.5	20.0
	Downcoast	28.5	27.5	30.0
	Onshore	22.0	25.5	23.5
	Offshore	28.0	24.5	26.5
Inshore	Upcoast	27.0	27.0	26.0
	Downcoast	23.0	23.0	24.0
	Onshore	28.5	28.5	33.0
	Offshore	21.5	21.5	17.0

entrance of the lagoon than leaves. This general type of conclusion is also supported by the estimated volume exchange presented in Section 5.4.3

Still further information pertaining to the dominant direction of nearshore zone water entry into the lagoon entrance can be obtained by examining the surface drift block results Table 5.4-4 summarizes the release, recovery, and calculated speed information developed from application of this Lagrangian technique. Figure 5.4-6 presents a schematic of the resultant trajectories from release to recovery, or offshore sighting. Note that in all cases except one in November, all resultant trajectories are directed southeastward along the coast at an angle between 30 and 60 degrees with the coastline. Extrapolating seaward from the lagoon entrance, it appears that nearshore zone surface water in directions from 30 to 60 degrees probably contribute most to waters entering the outer lagoon segment on a flood tide.

Another feature of surface circulation that can be seen by comparing the resultant drift block speeds to the winds recorded during their deployment is the effect of winds on surface currents. Since the drift blocks were pre-soaked to simulate seawater density, a reasonable degree of coupling with the surface layer was probably achieved. Previous usage of identical drifters (5-13) supports this contention. Hence, an appreciable percentage of the observed variability in the calculated speeds is probably due to wind-induced changes.

Table 5.4-4

SURFACE DRIFTER RELEASE STATISTICS
ENCINA POWER PLANT - AUGUST 1, 1980

Release				Recovery				
Date	Time	Location	Number	Date	Time	Location	Number	Resultant Speed (cm/sec)
June 19	1100	Station A-50	100				0	
	1103	Half-way bet. current meter moorings	100	June 19	1420	Transect O	1	8.1
	1105	Station 4	100	June 19	1405	Transect X	99	11.1
August 28	0630	50-ft isobath off Buena Vista Lagoon	100				0	
	0640	Station A-50	100				0	
	0645	Half-way bet. current meter moorings	100				0	
November 14	1212	Station S	100	Nov. 15	1500	C-40*	1	0.7
	1220	Half-way bet. current meter moorings	100	Nov. 15	1306	Transect C	68	1.2
				Nov. 15	1600	Transect [illegible]	1	1.1
				Nov. 15	1600	Transect C	1	1.[illegible]
				Nov. 15	1306	Transect P	6	1.0
				Nov. 15	1306	Transect H	4	1.0
	1228	Station A-50	100	Nov. 15	1500	C-10*	2	2.2
				Nov. 15	1500	B-30*	1	1.3
				Nov. 15	1430	Transect C	1	2.3

*sighted offshore by work-boat in area.

000125

Summary graphs of air temperature, wind direction, and wind speed including the three measurement periods are presented in Figures 5.4-7, 5.4-8 and 5.4-9. Periods of drift block deployments are indicated by the vertical lines. Each of the graphs illustrates the classical sea breeze effect mentioned earlier. During the June deployment, winds were directed onshore at about 4.2 m/sec (9.5 mph) (see Figure 5.4-7). The surface drifters recovered at beach transects O and X yield speeds on the order of 2 percent of the wind speed. Usually, objects on the sea surface drift on the order of 1 to 3 percent of the wind speed (5-14) so that the observed results are quite reasonable In August, however, none of the 300 released surface drifters were recovered. The wind direction graph in Figure 5.4-8 provides a reasonable explanation. Although the tidal current was flooding, the wind was directed offshore. In spite of the fact that the wind speeds were extremely slow, the directional factor was probably sufficient to keep the drifters offshore for the ensuing beach search period. Wind effects are also evident in the November recovery data. Note the extremely slow resultant speeds in Table 5.4-4 for November, and the long deployment period in Figure 5.4-9. These results imply that the drifters probably meandered back and forth before final recovery on the beach. In other words, water masses in the nearshore zone probably do not head directly shoreward (as might be construed from the resultant trajectories in Figure 5.4-6), but meander back and forth and ultimately reach shore or the lagoon entrance.

5.4.1.2 Littoral Circulation. As gravity waves travel shoreward, they undergo a series of changes in height and direction caused by refraction, shoaling, bottom friction, and percolation. Within several hundred meters (yards) of shore, these changes establish a littoral current which travels along the shore and is capable of transporting significant volumes of beach sediment. The particular types of patterns established depend upon wave incidence angle, tidal phase, and surf zone topography. Circulatory currents are associated with normal-wave incidence; meandering currents are associated with oblique-wave incidence (5-15).

Because of the different physical mechanisms involved, littoral currents are considered apart from the general near-shore currents discussed above. A number of qualitative (e.g., 5-16) and quantitative (e.g., 5-17) studies of coastal dynamics are discussed in the literature. For the present purposes, however, the data presented by Szuwalski (1970) (5-18) for Carlsbad Beach appear to be sufficient to demonstrate the probable extent of the littoral source region. According to the Littoral Environmental Observation (LEO) program data presented by Szuwalski for Carlsbad Beach, upcoast current speeds average about 21 cm/sec (0.40 kt). Downcoast currents are less frequent but generally occur at slightly higher speeds (about 30 cm/sec, or 0.58 kt).

5.4.2 Agua Hedionda Lagoon

Analytical techniques for studying the dynamics of bays and inlets have been used by numerous investigators for various sites throughout the world; perhaps the best known of these studies is that reported by Keulegan (1951) (5-19). Many of the principles developed by Keulegan have been modified for other inlet dynamics studies (e.g., 5-20). Analytical descriptions of tidal flows including terms for non-linear friction, varying inertial forces, cross-sectional and surface areas are generally available in the literature.

For the purposes of demonstrating source water origins, however, a more site-oriented definition can be given through an empirical approach using data taken at the specific study site in question. Detailed examination of such data can then be site specific and address only those questions which are unique to that particular study area. Analysis of the current measurements taken in 1979 in the outer Agua Hedionda Lagoon segment showed a complex, tidally dominated flow structure. Regions of rapid accelerations and decelerations were found in close proximity to regions of horizontal flow convergence and divergence, vertical shears, and semi-permanent eddies where local sediment deposition and bottom build-up were enhanced. During each ebb and flood tidal period, a fairly consistent flow pattern appeared to develop after an approximate lag time of about 90 minutes with the astronomical tide change. Because of natural variations in wind, wave, and tidal conditions, however, the actual circulation patterns from tide to tide (see Section 16.3.15) generally appeared to be different. The over all features of the circulation patterns, however, appeared to be consistent.

As a means of demonstrating the outer lagoon segment phase shift with the data set, consider only the current speed and direction measurements taken at the middle lagoon segment entrance during times of flood tide. Similar data taken at the seaward entrance are not as useful for this purpose because they are contaminated by wave motions and thus show a greater amount of variability. Likewise, ebb tide data were not used because relatively more measurements were available during flood tides. Conceptually, it should be expected that water will flow out of the outer lagoon segment into the middle and inner lagoon segments during a flood tide. Conversely, during an ebb tide, flow into the outer lagoon segment should be expected. To test this concept, the time difference between the time of astronomical tide change and each current measurement at the middle lagoon segment entrance (abbreviated as Δt) was calculated and plotted against the current direction. Figure 5.4-10 presents the results of this calculation. At the measurement station, (magnetic) directions between about 30 and 100 degrees were out of the outer lagoon segment; directions between 100 and 275 degrees were directed into the lagoon segment. Using the dashed horizontal line as a guide, note that approximately 90 minutes elapse after the astronomical tidal change before flow begins out of the lagoon segment. A lag on this order also appears to be consistent with the other data taken in the lagoon. Further, over the three lagoon segment measurement periods, if a total of 15 complete passes through the station closest to the seaward and middle lagoon segment entrances are now tabulated with respect to flow direction and time of measurement, then the following distribution results:

Tidal Phase	Flow Dir	Seaward Entrance $\Delta t > 90$ min	Seaward Entrance $\Delta t < 90$ min	Middle Lagoon Segment Entrance $\Delta t > 90$ min	Middle Lagoon Segment Entrance $\Delta t < 90$ min
Flood	in	7	1	0	3
	out	0	0	7	0
Ebb	in	2	2	5	0
	out	3	0	0	0

In the second column, "in" refers to flow "into the outer lagoon segment" and "out" refers to flow "out of the outer lagoon segment." The distribution of observations agrees with the concept that once the phase shift is taken into account, currents flow into the seaward entrance at flood tide, out at ebb tide; and, at the middle lagoon segment entrance, flow out at flood tide and into the outer lagoon segment at ebb tide.

Allowing for the approximate hour and a half phase shift, circulation patterns in the outer lagoon segment are shown in schematic form in Figure 5.4-11. The arrows depict streamlines of flow averaged over the tidal period.

On a flood tide (Figure 5.4-11a), currents at the seaward entrance attain speeds as high as 90 cm/sec (1.75 kt)[a]; most of this inflow has been observed to concentrate in the southern half of the entrance. After passing under the bridge (Carlsbad Boulevard), currents flow across the lagoon segment, swing clockwise along the northwest bank, and then divide into three main components. One component continues the general clockwise rotation to form a semi-permanent eddy in the northern part of the lagoon segment. The ensuing deposition of sediment from this eddy is probably a primary cause for the bottom build-up which develops in this area and must be removed during the biennial dredging. A second component flows southward across the length of the lagoon segment to the generally slow speed region near the southern end. Speeds at this end are usually less than 5 cm/sec (0.09 kt). The third component turns into the middle lagoon segment entrance. At the log boom to the entrance, maximum speeds of 80 cm/sec (1.5 kt) have been measured during flood tide; average speeds are usually less than 50 cm/sec (1 kt).

On an ebb tide, currents coming out of the inner lagoon segments bifurcate at the entrance and flow toward the northern and southern ends. Speeds at the entrance have been measured to more than 50 cm/sec (1 kt) but diminish rapidly within the

---

a. Current measurements in November 1979 indicated speeds of 90 cm/sec (1.75 kt); unconfirmed reports suggest speeds in excess of 103 cm/sec (2 kt).

first 152 m (500 ft) across the lagoon segment. Flows exiting to the ocean only achieve speeds on the order of 10 cm/sec (0.19 kt). Flows directed toward the southern end again enter a slow region where speeds are only on the order of 5 cm/sec (0.09 kt).

The analyzed distributions upon which these generalized flow patterns were developed are presented in Section 16.3.1.5. The analyses are drawn for near-surface, mid-depth, and near-bottom measurements at tidal stages corresponding to changes in the nearshore zone. Note that each of these circulation patterns appear to represent some form of mixture of the generalized features in Figure 5.4-11. This is a result of including measurements taken over the tidal phase lag in the averaging time of the diagram. A tidal curve with marked measurement period is inset into each figure. Also, note that there are considerable differences between flow patterns at different depths at the same time; this is an indication of vertical current shearing and multi-level water mixing occurring throughout the lagoon segment.

Still another independent demonstration of water mass origins can be obtained by tracing the temperature and salinity characteristics of the cooling water entering the power plant tunnels. In the oceans, neither temperature nor salinity alone are conservative enough to be used as a tracer element. The combination of temperature and salinity, however, has proven to be a very useful water mass tracing tool in physical oceanography since first suggested by Helland-Hansen in 1916 (5-21). In this particular application, data taken offshore and measurements in the outer lagoon segment show that salinity varies by less than one ppt throughout the study area; this implies that most of the tracing according to such a technique must be made in terms of temperature.

Temperature variations at the southern end of the outer lagoon segment are normally quite small and only show slight variations from hour to hour. In late September 1979, however, temperature recordings showed some relatively rapid changes which can be used in this particular context to demonstrate further the origins of cooling water sources. The broad solid graph in the upper portion of Figure 5.4-12 shows the variations in temperature of water entering the Encina Power Plant cooling water tunnels between September 24 and 30. Temperatures were measured with a fast response Powers Model TC 101 thermal probe mounted at the boat dock immediately in front of the trash racks leading to the tunnels. For comparison purposes, the lighter solid and dashed graphs depict the variations in temperature at a measurement station located immediately offshore and north of the seaward entrance. Data were taken at a near-surface (i.e., 0.3 to 1 m below the surface) and mid-water depth (i.e., 3 to 4 m below the surface). The data were recorded with Peabody-Ryan Model J-90 thermographs at California coordinates N 357,688, E 1,663, 872. The broad solid graph in the lower depiction shows the change in tidal height after a 90 minute phase shift of the entire graph. Note the close correspondence between minima in the upper temperature trace and maxima in the shifted tidal curve. The calculated correlation coefficient between the solid graphs is r = 0.77. Physically, this high degree of correlation means that after a flood tide, water reaching the cooling water tunnels is derived mainly from the seaward entrance. In view of the fact that the minima in the upper solid temperature trace are generally closer to the offshore (dashed) mid-depth graph than the surface temperature graph, the flood tide source waters are probably of mid-depth origin. In addition, the match between minima in the shifted tidal curve and maxima in the temperature curve implies that waters entering the cooling water tunnels after an ebb tide are derived mainly from the inner lagoon segments. Since the total surface area of the lagoon system is about 1.4×10^5 m^2 (350 acres) and at 30 degrees latitude, approximately 360 g cal/cm^2/day are received from insolation effects (5-22), it is possible to calculate a temperature increase of as much as 3.6 C per day in the upper meter (3 ft). Thus, to an approximate order of magnitude, a combination of insolation, residence time, depth, and cloudiness can explain the noted increases in temperature.

5.4.3 Water Volumes

An approximation of the order of magnitude volumes can be obtained by using the measured currents, dimensions of the entrances, and average tidal height values. First an estimate for the tidal prism of the outer lagoon segment can be obtained by first noting that the MHW surface area is about 2.7×10^5 m^2 (66 acres)[b]. Bradshaw's (1976) (5-23) study suggests that the MLW surface area is less than the MHW value by about 20 percent, or to 21×10^5 m^2 (52 acres). If the lagoon segment area is then approximated to be twice as long as it is wide and the mean NOS (1979 (5-24) tide range of 1.1 m (3.7 ft) is accepted, then the mean volume change from MLW to MHW, or tidal prism, can be calculated to be approximately 2.5×10^5 m^3 (200 acre ft).

Next, using averages of the current measurements taken at the seaward and middle lagoon segment entrances, integrating the speeds over the duration of the tidal phases, and accounting for the cross-sectional areas of the entrance[c], exchange volumes over tidal phases were calculated.

A third factor to consider in the lagoon segment water balance is, of course, the use of cooling water by the Encina Power Plant. The volume demand from this source varies in

---

b. Based on topographic map provided by SDG&E with final depth soundings as of April 1979.

c. At MLLW, the mean cross-sectional areas of the seaward and middle lagoon entrances are 844 and 750 ft^2, respectively. Depth soundings were taken on July 19, 1979.

accordance with the number of units and pumps in operation, and the general requirement for cooling the condensers. Over a six-hour period, constant flow rates (in million gallons/day, mgd) in different operating modes provide different water intake volumes. For example,

Operating Condition	Rate (mgd)	Six-hour Volume $10^6 m^3$	(acre-ft)
Maximum flow	1149.8	1.0	(880)
Units 1-5	828	0.7	(633)
Units 1, 2, 4, 5 operative	524	0.5	(402)
Units 1, 2, 3, 4	360	0.3	(276)
Units 1, 2, 3	153	0.1	(117)

Compiling these results and assuming operation of Units 1-5, the orders of magnitude volumes exchanged in a six-hour period in outer Agua Hedionda Lagoon are probably something like the following.

Tidal Phase	Volume Through Seaward Entrance $10^6 m^3$	(acre-ft)	Volume Through Middle Lagoon Segment Entrance $10^6 m^3$	(acre-ft)	Tidal Prism $10^6 m^3$	(acre-ft)	Cooling Water Intake $10^6 m^3$	(acre-ft)
Flood	2.00	(1600)	1.00	(800)	0.25	(200)	0.75	(600)
Ebb	0.50	(400)	1.00	(800)	0.25	(200)	0.75	(600)

During a flood tide, approximately 1600 acre-ft of water enters the seaward entrance of the outer lagoon segment. About half of this volume flows into the middle and upper lagoon segments, while 200 acre-ft remains in the outer lagoon segment. A net volume of about 600 acre-ft therefore enters the cooling water tunnels to complete the flood tide volume balance.

On an ebb tide, approximately 800 acre-ft of water returns from the middle and upper lagoon segments. About half of this volume exits to the ocean at the seaward entrance. The remaining 400 acre-ft combines with the approximate 200 acre-ft derived from the falling water level to provide the 600 acre-ft required by the power plant for cooling water.

5.5 ENTRAINMENT PROBABILITY

5.5.1 Far-Field

Since there are two flood tides in the tidal day, a total volume on the order of 4.0×10^6 m^3 (3200 acre-ft) must enter the outer lagoon segment per day. Based on the results discussed in Section 5.4.1.1, if an offshore water parcel has about one chance in three of entering the lagoon, then a total offshore volume of 12.0×10^6 m^3 (9600 acre-ft) must be considered. Additionally, this volume must be composed of both littoral and nearshore waters. Inasmuch as temperature measurements in the lagoon segment generally do not indicate heating effects caused by discharge recirculation, the average southern limit of the downcoast littoral volume must be located north of the discharge jetty. To the north, an average littoral speed of 30 cm/sec (0.5 kt) places the 24-hr reach of the littoral extent at 26 km (16 mi) upcoast. The total volume of the one-day littoral source region is therefore 2.0×10^6 m^3 (1700 acre-ft). The remaining 10.0×10^6 m^3 (7900 acre-ft) must be drawn from a nearshore region that is situated in the nearshore zone inclined to the coast by 30 to 60 degrees upcoast. A schematic of the probable extent of this one-day source region is presented in Figure 5.5-1. At the seaward entrance, a water parcel has a 34 percent probability of entering the lagoon; offshore probabilities must decrease with distance to the volume limit where the probability for one-day entry is zero.

5.5.2 Near-Field

Within the outer lagoon segment, a more quantitative approach can be taken to estimate entrainment probabilities. There are two physical parameters that can be used to define entrainment probability -- 1) distance from the power plant tunnel entrances, and 2) direction of flow. Speed is not considered to be an important parameter because entrance into the cooling water tunnel at any speed will not occur unless it is heading in an appropriate direction.

At each sampling station depth during each tidal phase, the direction of the measured current was assigned a probabilistic value between 0 and 100 percent in accordance with its heading towards the cooling water tunnels. That is, 100 percent was assigned to a vector heading directed at the entrance; an 0 was assigned to a direction opposite. Intermediate directions were assigned values between the two extremes. No distinctions between deviations to the right or left were made. At each sampling station, the distance from the tunnel entrance was also assigned a probability value from 0 to 100 percent. A value of 0 was assigned to points removed from the tunnel entrance by the maximum length of the outer lagoon segment (about 823 m or 2700 ft). By assuming that both probability distributions were independent, a multiplication of the direction and distance probabilities yielded estimates for the joint entrainment probability.

Figures 5.5-2 through 5.5-7 present the results of contouring the potential entrainment probability results for the

June, August, and November data sets, respectively. Each figure has been drawn for flood tide and ebb tide at near-surface, middle, and near-bottom depths. Isopleth probability values are labeled in percent. Unit 3 was inoperative in the June data sets.

The independence of probabilities assumption is probably valid over most of the near-field region. In the area directly in front of the cooling water tunnels where the draw-down of the operating units is evident, the higher percentage isopleth locations in the figures may be an underestimate of the actual area where the higher probability of entrainment would occur. In either case, however, the relative locations of the lower value isopleths would remain unchanged.

Several features of the results are common between months. First, the basic shapes of the seasonal distributions at each depth are similar. This result agrees with the current data which suggest that the underlying flood and ebb tide flow patterns in the outer lagoon segment do not undergo pronounced changes from season to season. The pattern changes from surface to bottom during any particular tidal phase are again an indication of the vertical variability discussed in Section 5.4.2.

A second feature to note is that the 10 percent isopleth is consistently found near the northern and eastern extremities of the lagoon segment. Interpreted in another sense, this type of distribution permits planktonic matter a 90 percent probability of escaping entrainment. In other words, not all of the plankton drifting into the lagoon system can be entrained; a certain population must also return to the ocean on each ebb tide.

By noting the consecutive positions of the 50 percent isopleth, it can also be noted that planktonic material has a more than even chance of not being entrained over most of the area of the lagoon segment. Further, the 70 and 90 percent isopleths are usually located well within the southern third of the lagoon segment.

Finally, the isopleths shift toward the seaward entrance on a flood tide, and toward the middle lagoon segment entrance on an ebb tide. Again, this result agrees with the schematic current flow patterns presented earlier in Figure 5.4-11.

5.5.3 Intake Effects

Using 70 percent entrainment probability isopleths to define intake effects, Figures 5.5-2 through 5.5-7 show that the maximum extent of the intake effect is about 304 m (1000 ft) into the southern end of the outer lagoon segment. Referring to the current data in Section 16.3.1.5, this radius also agrees with station data which show predominant current flows in directions other than towards the intake tunnels.

In front of the trash racks leading to the cooling water tunnels, higher inflow speeds appeared on the deeper western side. Maximum speeds on this side are on the order of 45 cm/sec (0.80 kt); speeds on the eastern side are about 26 cm/sec (0.50 kt).

5.6 DISCUSSION

Analysis of the data taken during the three field measurement periods in 1979 presents a basic picture of source water involvement during the predominant "dry" season in southern California. During periods of seasonal rainfall such as January or February, drainage of Agua Hedionda and Buena Creeks may result in fresh water additions of as great as 6787 mgd (10,500 cfs) (5-25); this addition is on the order of 8.5 times the mean flow rate of Units 1-5. Lagoon salinities may then drop to as low as 20 ppt and different circulation patterns and volume balances may become established. The present data do not address such an occurrence.

Over periods of several days, the main source for Encina Power Plant cooling water during all seasons is the adjacent coastal zone of the Pacific Ocean. During flooding tides, waters entering the seaward entrance from the nearshore and littoral zones flow along the length of the outer lagoon segment to the cooling water tunnels and into the inner lagoon segments. On the following ebb tide, waters returning from the inner lagoon segments bifurcate at the middle lagoon segment entrance and supply the cooling water demand with one branch and return flow to the ocean with the other. Both the ocean and the inner lagoon segments can therefore be considered to be source regions for power plant cooling water over periods of a tidal cycle.

References

5-1 Woodward-Envicon, Inc., Environmental Impact of Maintenance Dredging of Agua Hedionda Lagoon and Dredge Spoil Disposal. San Diego, CA, March, 1974, p. 2-79.

5-2 Maloney, N. J. and Chan, K. M., "Physical Oceanography," A Summary of Knowledge of the Southern California Coastal Zone and Offshore Areas, 1, (1974), p. 3-1.

5-3 Tsuchiya, M., "Inshore Circulation in the Southern California Bight , 1974-1977", Deep-Sea Research, 27A, (1980), p. 99.

5-4 Inman, D. L. and Frautschy, J. D., Littoral Processes and the Development of Shorelines, ASCE Coastal Engr. Proc. of Santa Barbara Specialty Conference, New York, N.Y., 1966, p. 511.

5-5 Marine Advisers, Inc., A Statistical Summary of Ocean Wave Characteristics in Southern California Waters, La Jolla, CA, 1961.

5-6 Marine Advisers, Inc., (5-5).

5-7 Emery, K. O., The Sea Off Southern California, John Wiley & Sons, Inc., New York, N.Y., 1960.

5-8 Southern California Coastal Water Research Project, The Ecology of the Southern California Bight: Implications for Water Quality Management, SCCWRP-TR104, EL Segundo, CA, 1973.

5-9 Shepard, F. P. and Inman, D. L., "Nearshore Water Circulation related to Bottom Topography and Wave Refraction, "Eos Trans. AGU 31(2), 1950, p. 196.

5-10 Sonu, C. J., "Tethered Ballons for Study of Coastal Dynamics," Proc. Symp. Earth Observ. Balloons, 1969, p. 91.

5-11 Longuet-Higgins, M. S. and R. W. Stewart, "Radiation Stress and Mass Transport in Gravity Waves with Application to Surf Beats," J. Fluid Mech. 13, (1962), p. 481.

5-12 Longuet-Higgins, M. S. and R. W. Stewart, "Radiation Stress in Water Waves, A Physical Discussion with Applications," Deep-Sea Research 11(4), (1964), p. 529.

5-13 PBQ&D, Inc., Southwest Ocean Outfall, Predesign Oceanographic Study, San Francisco, CA, 1978, p. I-91.

5-14 Defant, A., Physical Oceanography, 1, Pergamon Press, New York, NY, 1961, p. 418.

5-15 Sonu, C. J., "Field Observations of Nearshore Circulation and Meandering Currents," J. G. R. 77(18), (1972), p. 3232.

5-16 Evans, O. F., "Mass Transportation of Sediments on Subaqueous Terraces," J. Geol. 47, (1939), p. 325.

5-17 Sonu, C. J., (5-15), p. 3233 to above.

5-18 Szuwalski, A., Littoral Environment Observation Program in California, U. S. Army Corps of Engr. - 2-70, Coastal Engr. Res. Center, 1970, p. C-4.

5-19 Keulegan, G. H., Third Progress Report on Tidal Flow in Entrances, National Bureau of Standards, - 1146, 1951.

5-20 King, Jr., D. B., The Dynamics of Inlets and Bays, Coastal and Engineering Laboratory, Univ. of Florida - TR22, 1974.

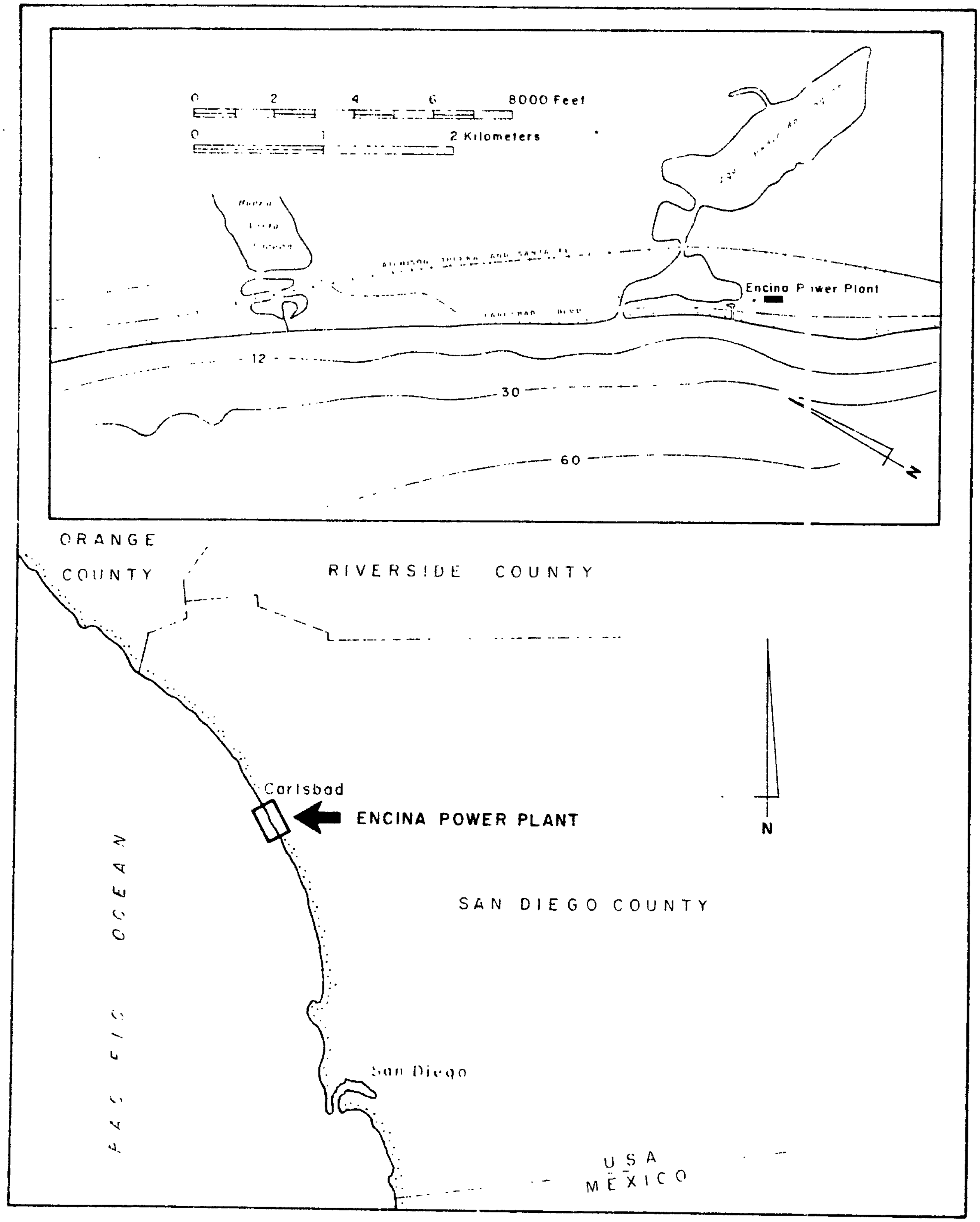
5-21 Neumann, G. and W. J. Pierson, Jr., Principles of Physical Oceanography, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1966, p. 400.

5-22 Defant, A., (5-14), p. 94 to above.

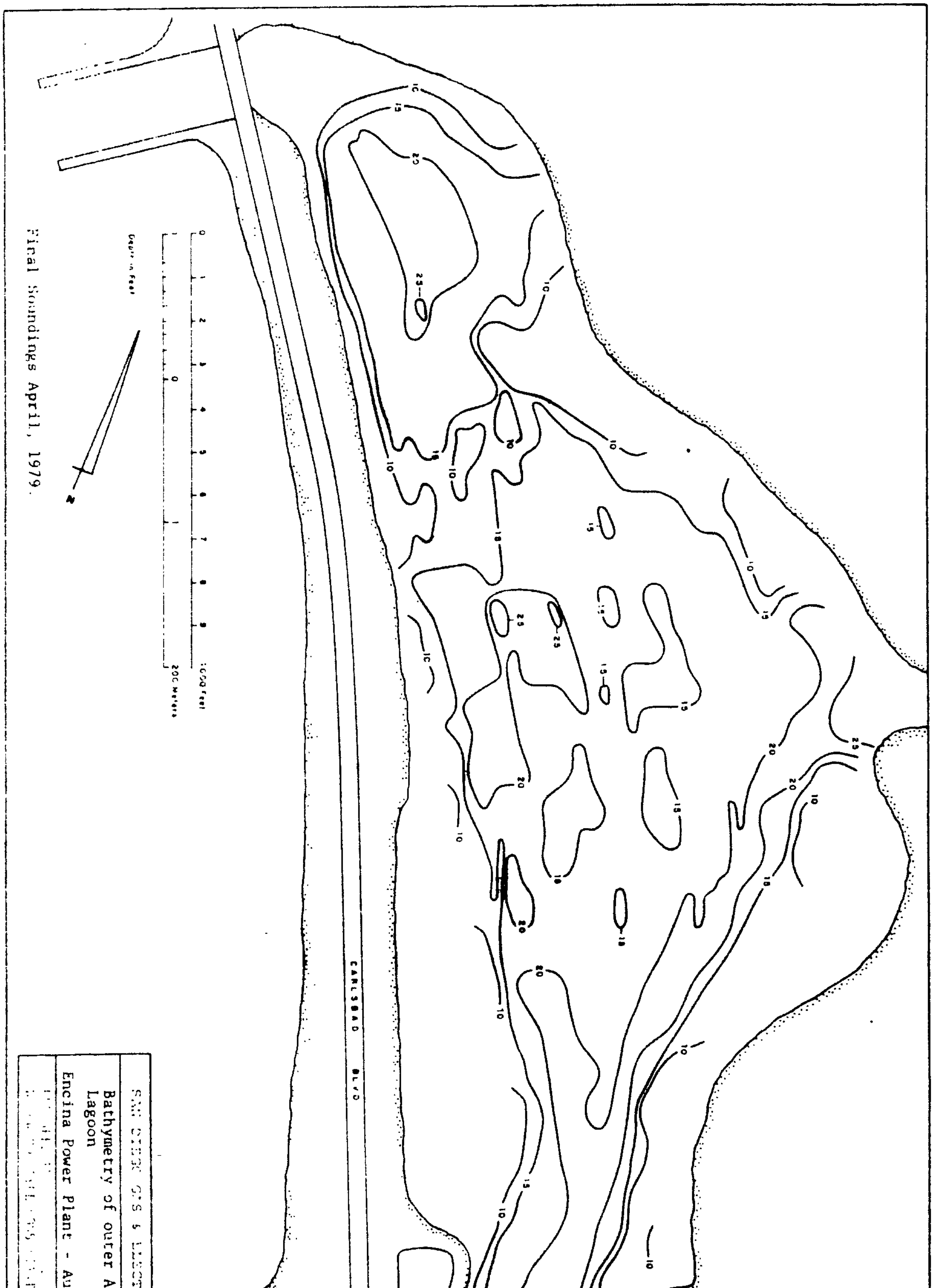
5-23 Bradshaw, J., B. Browning, K. Smith, and J. Speth, The Natural Resources of Agua Hedionda Lagoon, U. S. Fish and Wildlife Service, Coastal Wetland Series No. 16, 1976, p. 13.

5-24 National Ocean Survey, Tide Tables, West Coast of North and South America, 1979, p. 171.

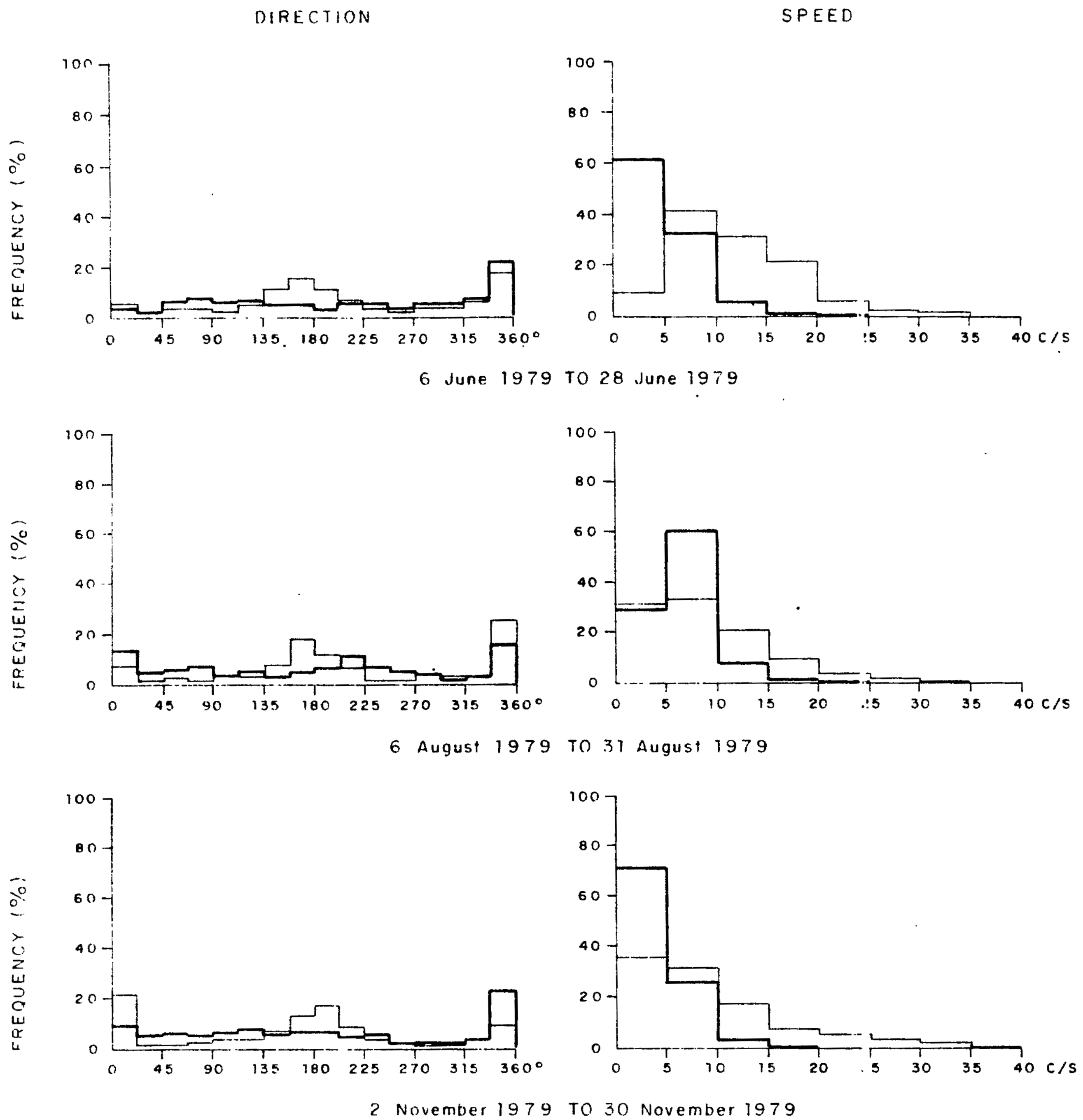
5-25 Bradshaw, J., B. Browning, K. Smith, and J. Speth, (5-23), p. 21 to above.



SAN DIEGO GAS & ELECTRIC COMPANY	
Site map Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 5.3-1


Final Soundings April, 1979.
CARLSBAD BLVD
Bathymetry of outer Agua Hedionda Lagoon
Encina Power Plant - August 1, 1980
5.3-2

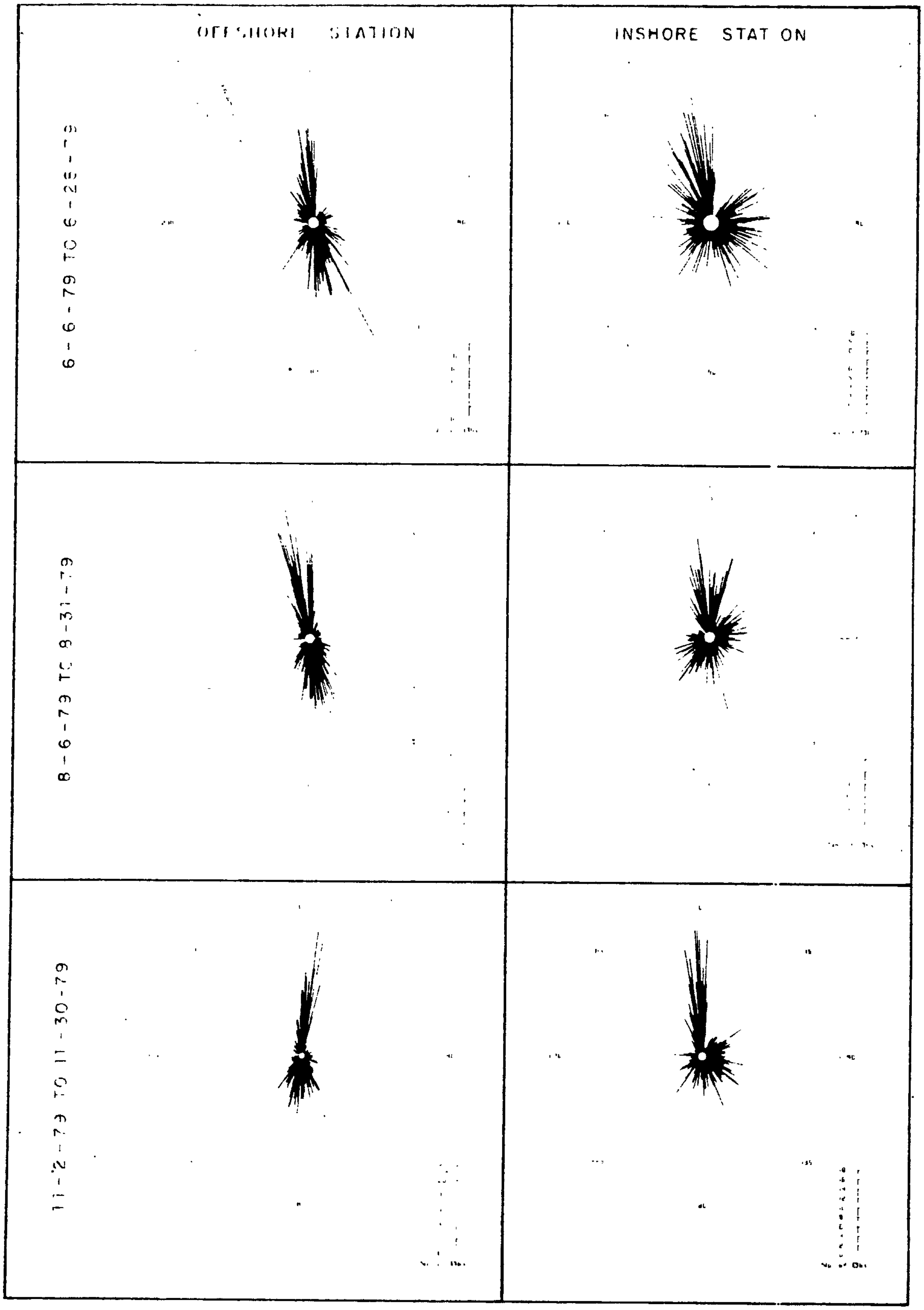
000147



Closest to Shore ———

Offshore — — - - - - - —

SAN DIEGO GAS & ELECTRIC COMPANY	
Histograms of current speeds and directions Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 5.4-1



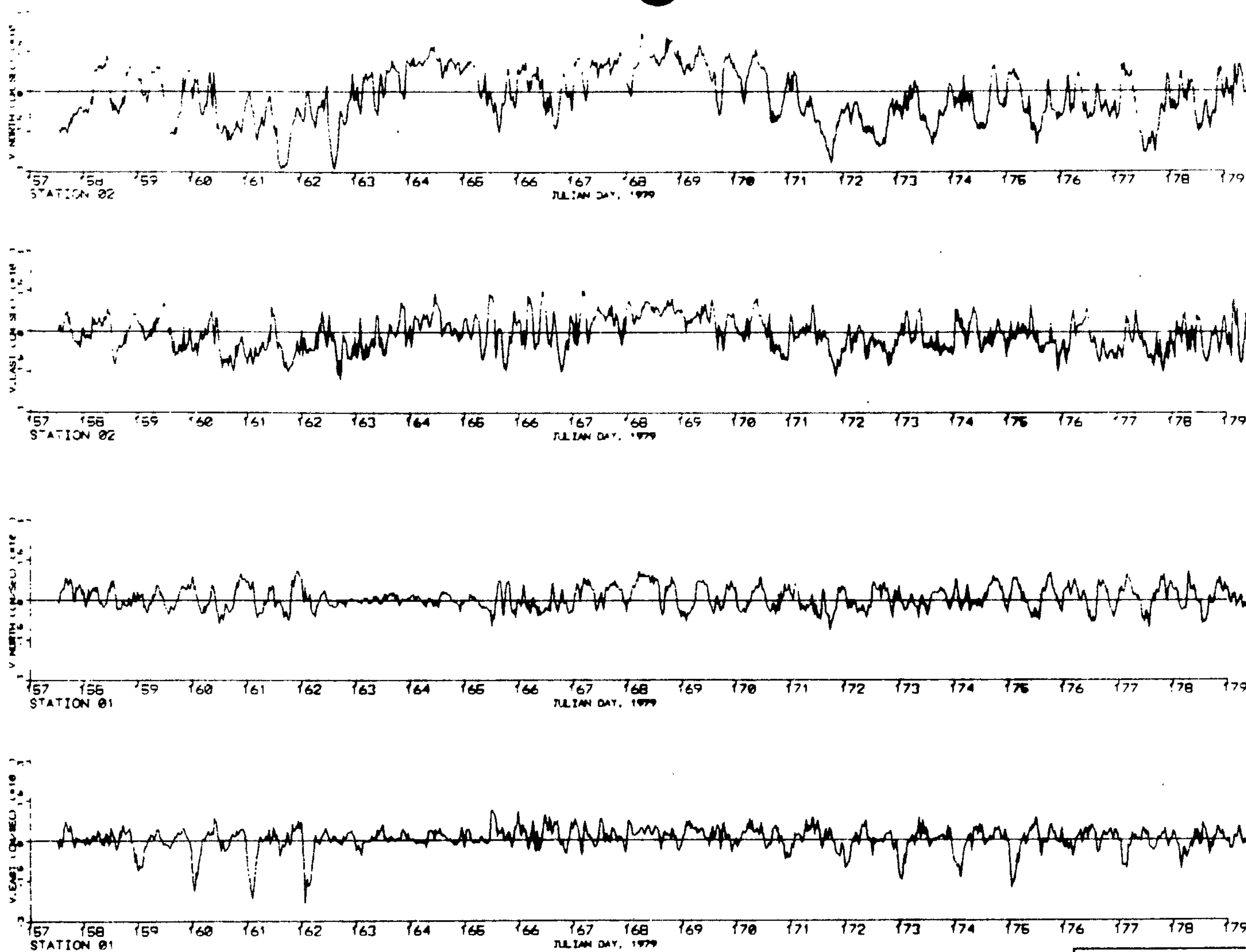
SAN DIEGO GAS & ELECTRIC COMPANY

Offshore current roses

Encina Power Plant - August 1, 1980

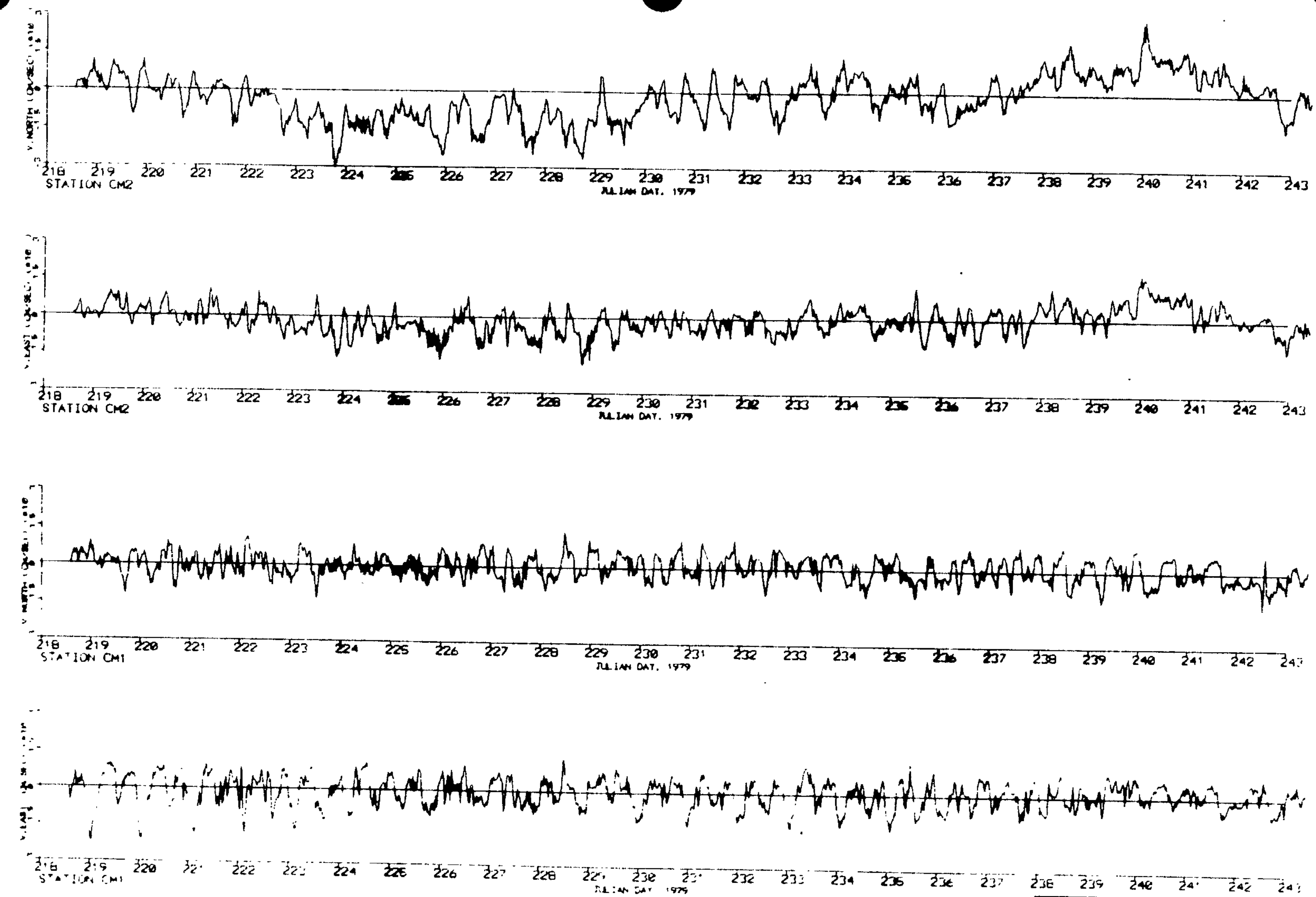
PREPARED BY:
WOODWARD-CLYDE CONSULTANTS

FIGURE NO.
5.4-2



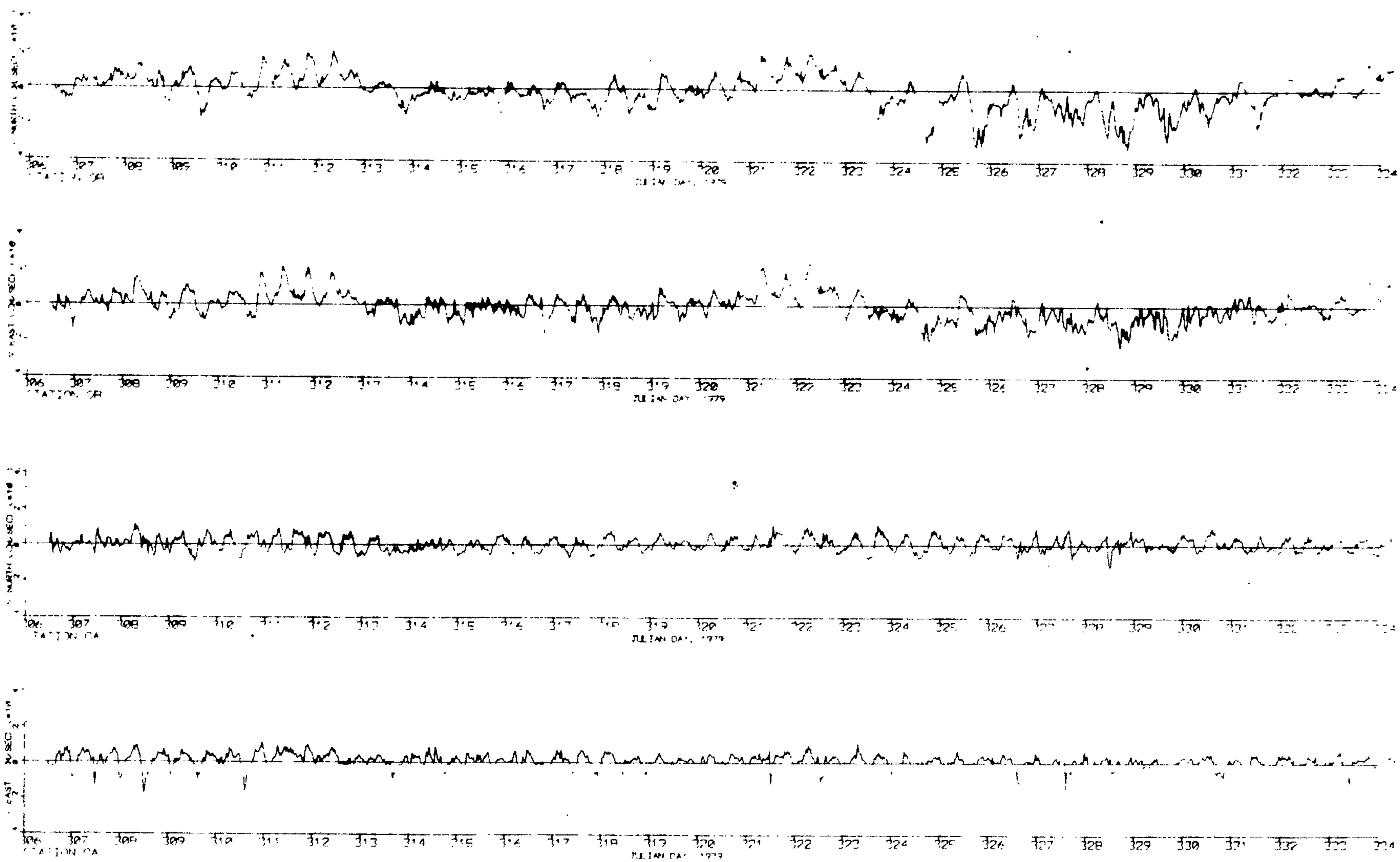
ENCINA 316 [B] INTAKE ENVIRONMENTAL STUDY

SAN DIEGO GAS & ELECTRIC COMPANY	
Offshore current components for June, 1979	
Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 5.4-3



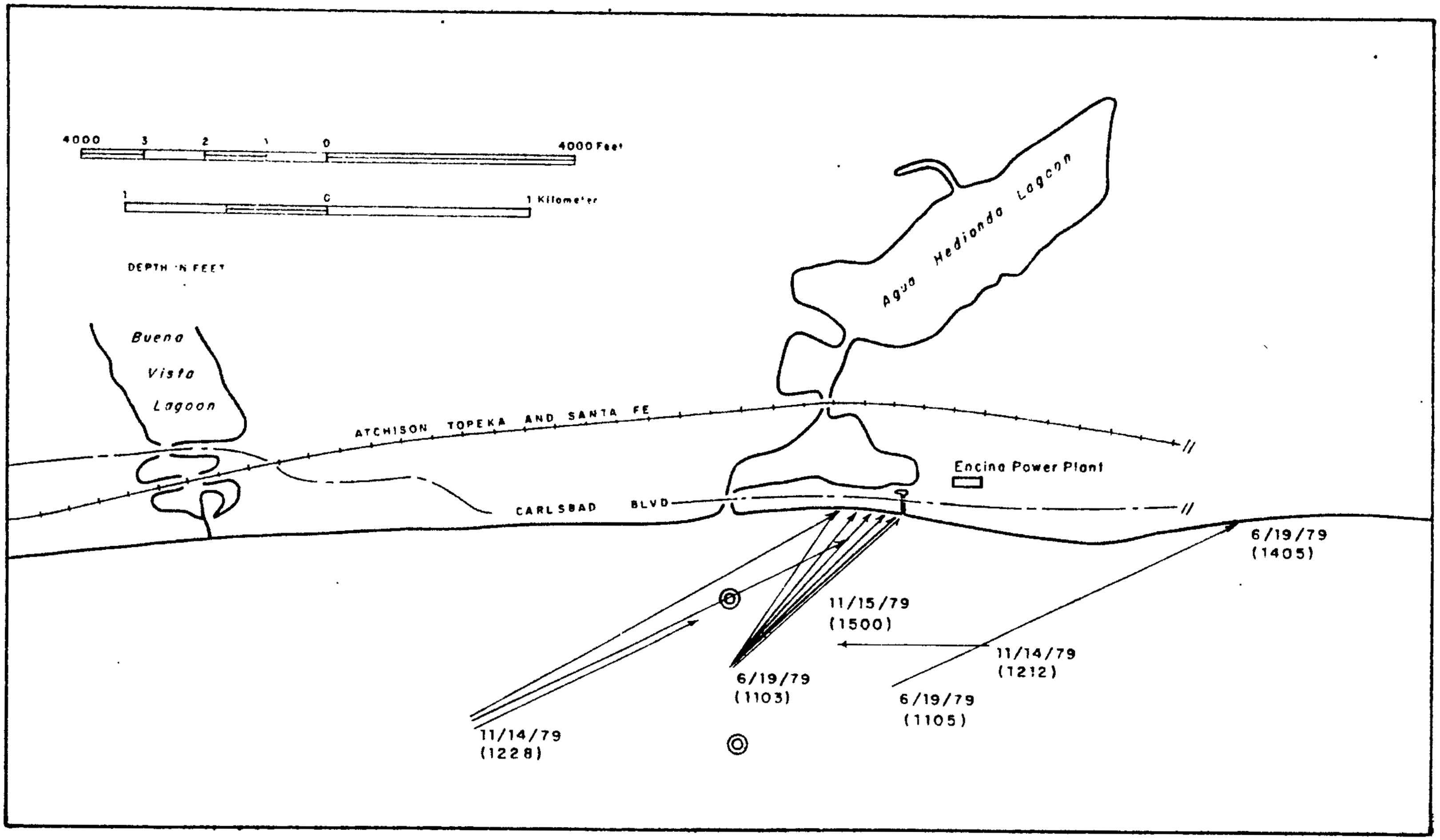
ENCINA UNIT 6 INTAKE ENVIRONMENTAL STUDY

SAN DIEGO GAS & ELECTRIC COMPANY	
Offshore current components for August, 1979	
Encina Power Plant - August 1, 1980	
	FIGURE NO. 5.4-4



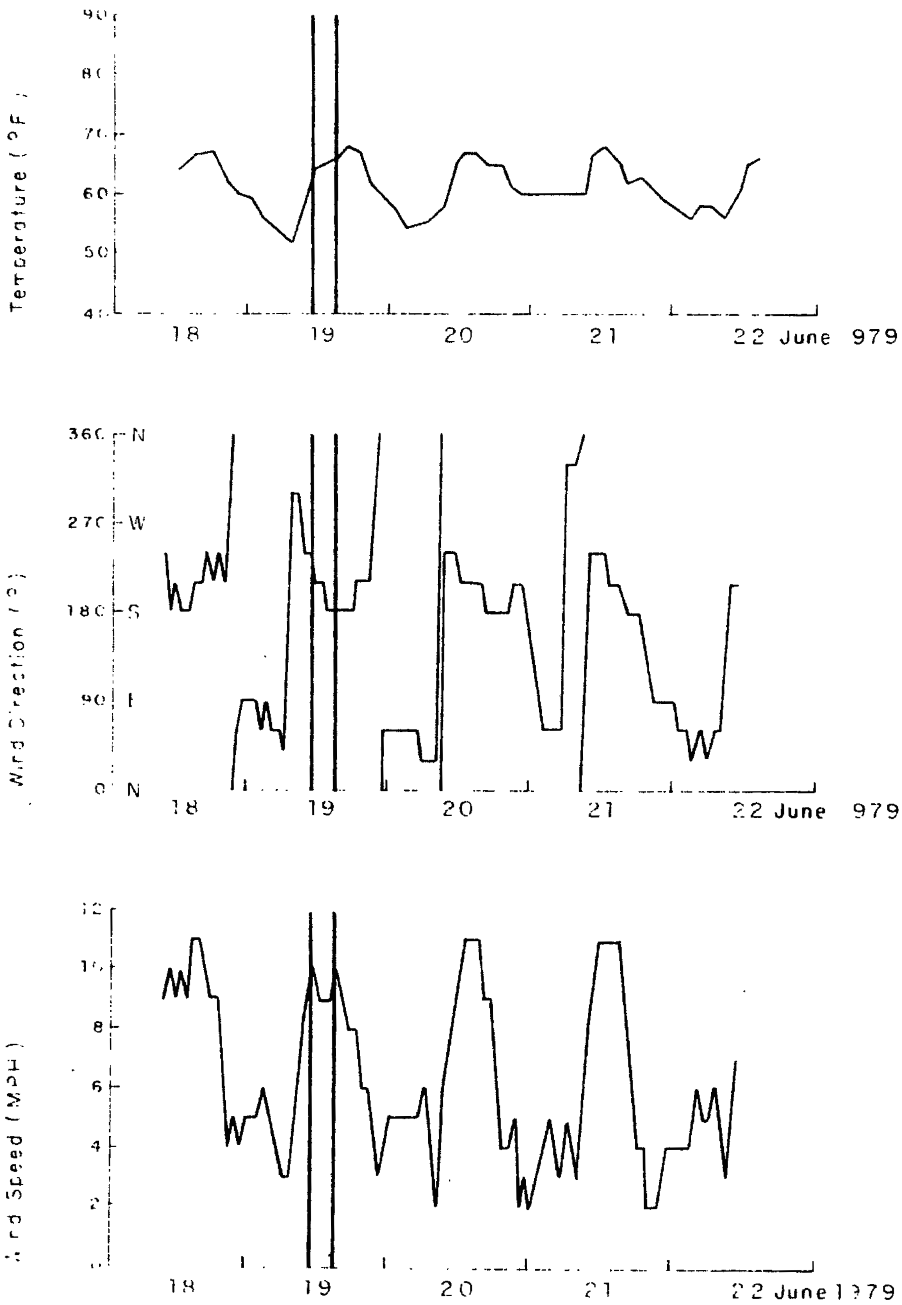
ENCINA 316 (B) INTAKE ENVIRONMENTAL STUDY

SAN DIEGO GAS & ELECTRIC COMPANY	
Offshore current components for November, 1979	
Encina Power Plant - August 1, 1980	
PREPARED BY WOODWARD-CLYDE CONSULTANTS	FIGURE 5.4-5

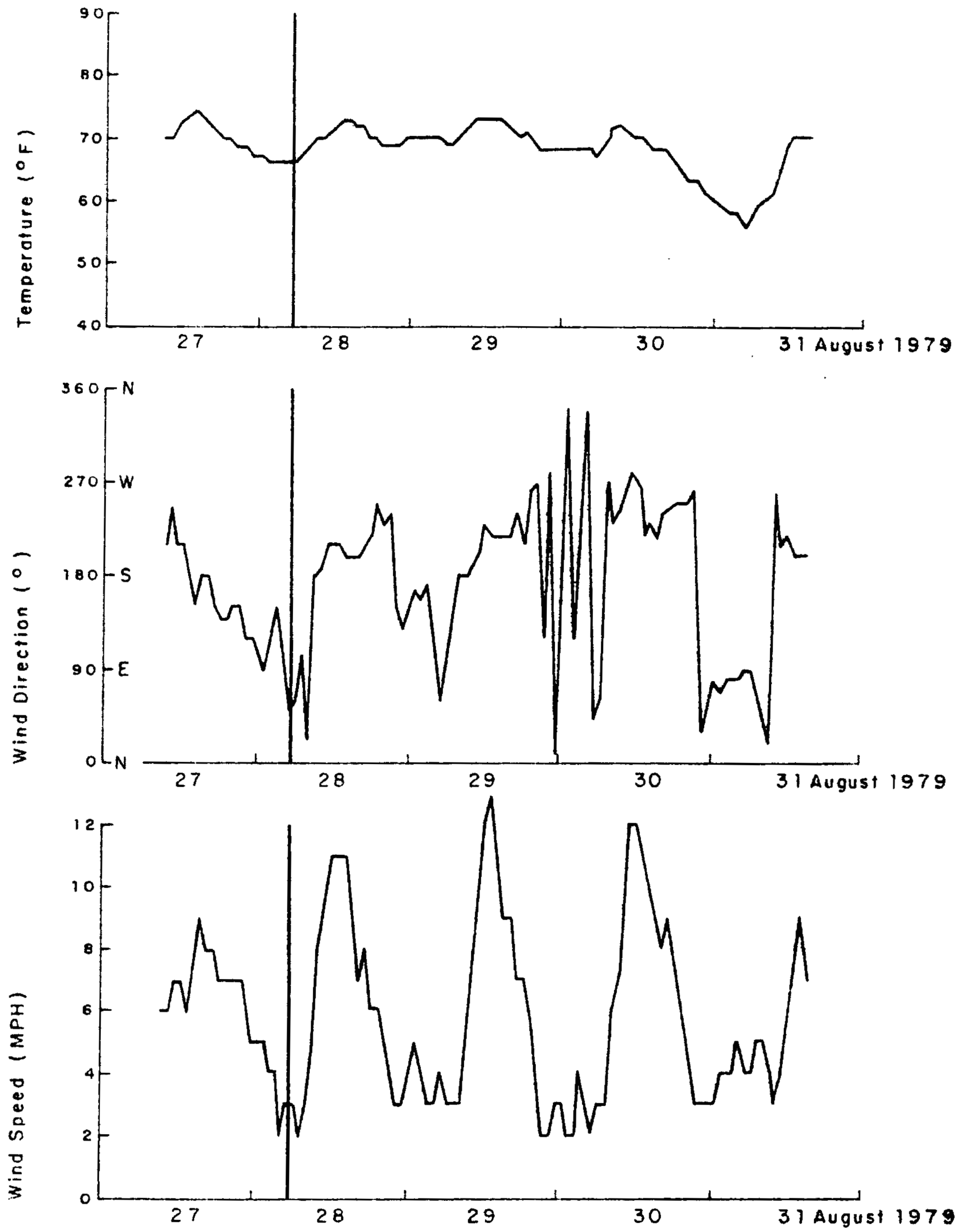


◎ Current Meter Station

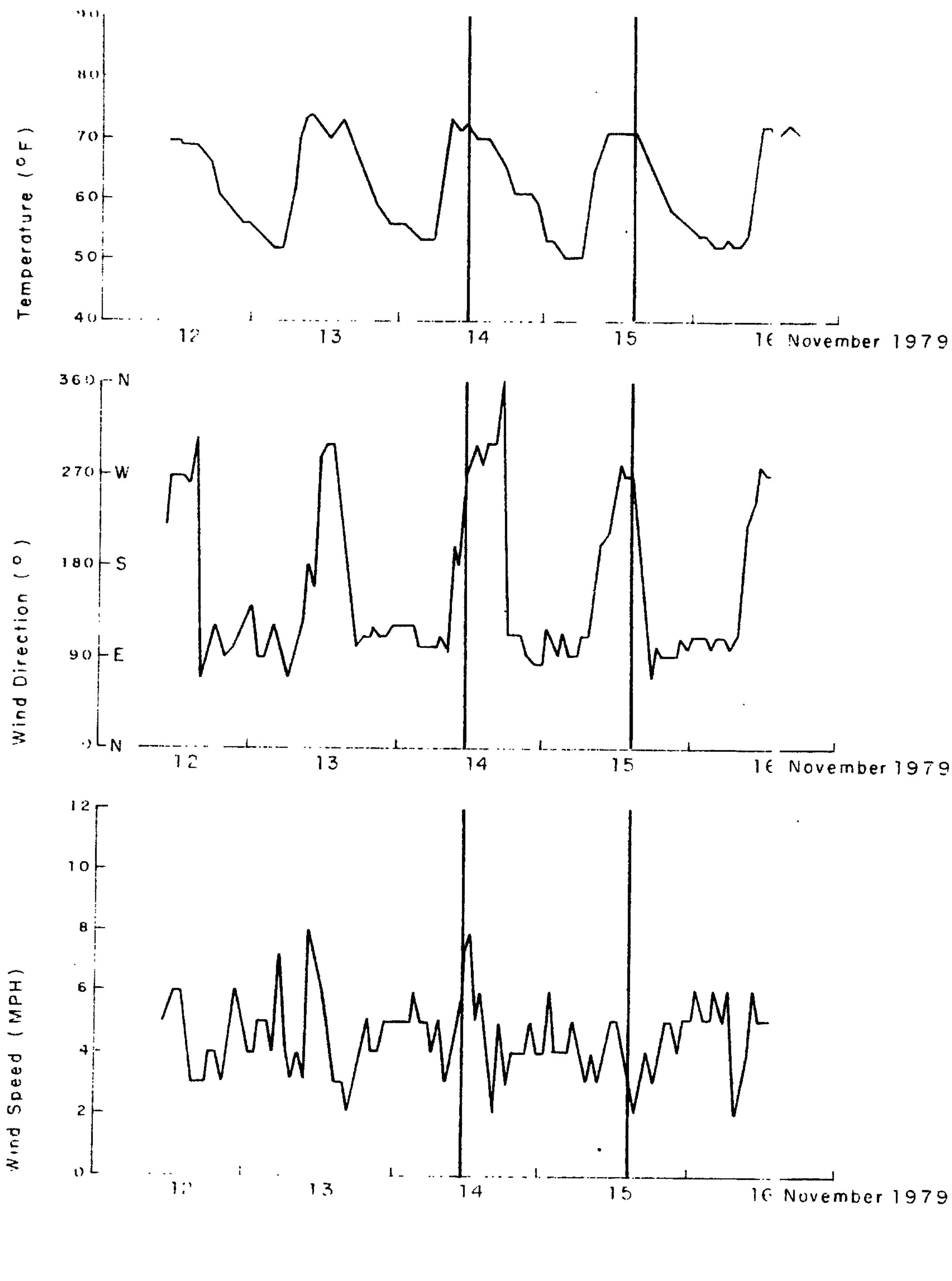
SAN DIEGO GAS & ELECTRIC COMPANY	
Drift block trajectories Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 5.4-6



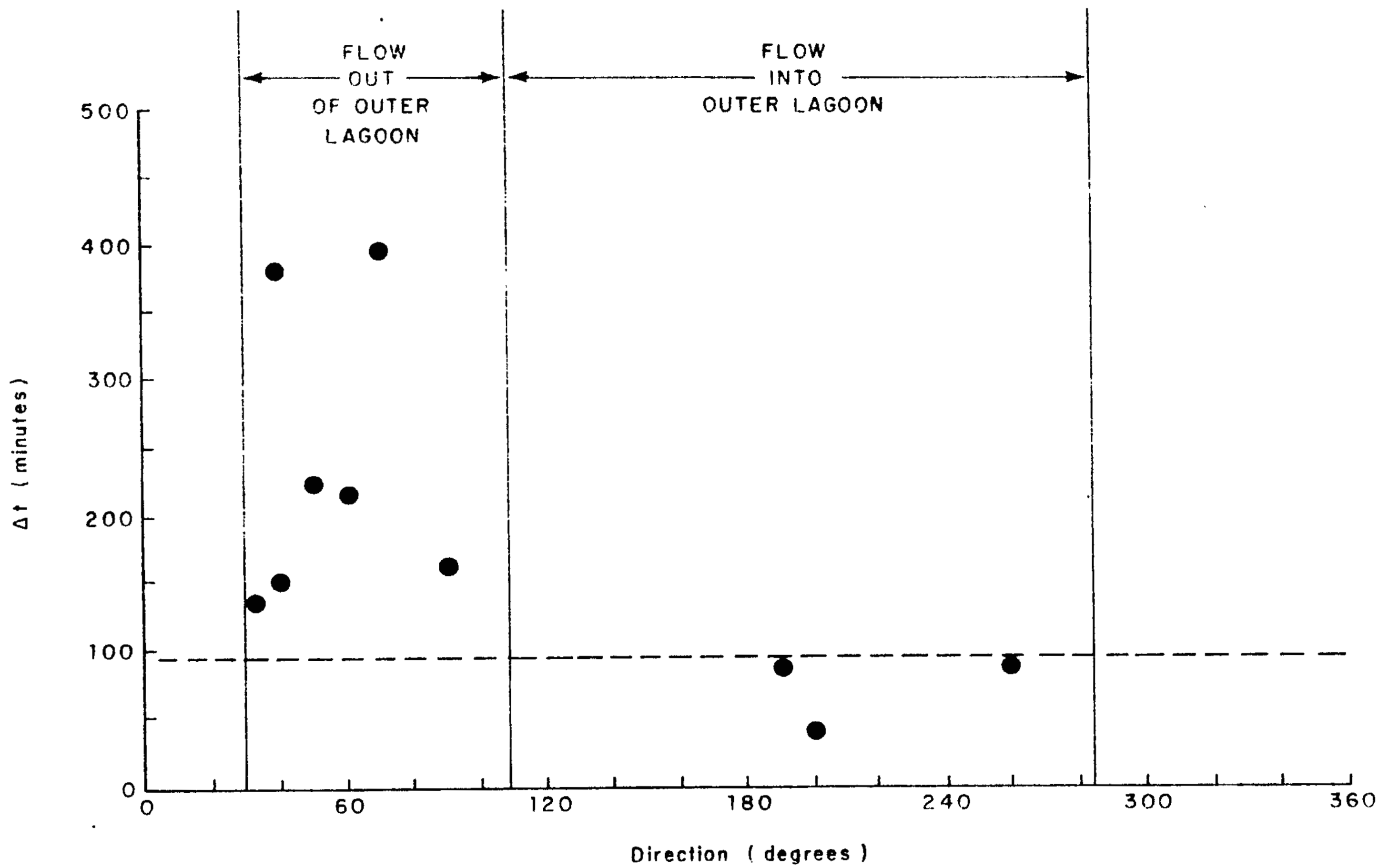
SAN DIEGO GAS & ELECTRIC COMPANY	
Air temperature and wind data during June survey Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 5.4-7



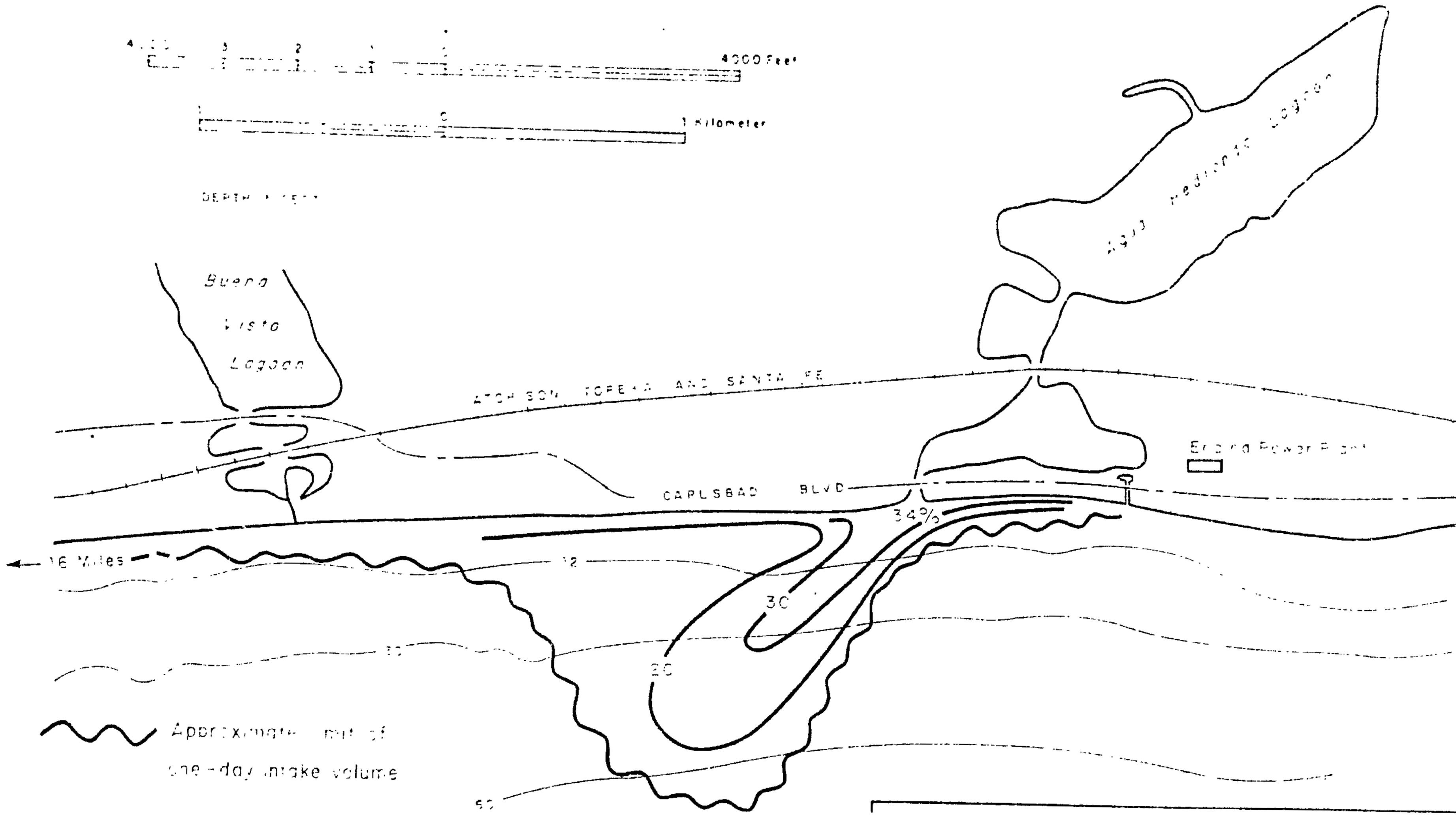
SAN DIEGO GAS & ELECTRIC COMPANY	
Air temperature and wind data during August survey Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 5.4-8



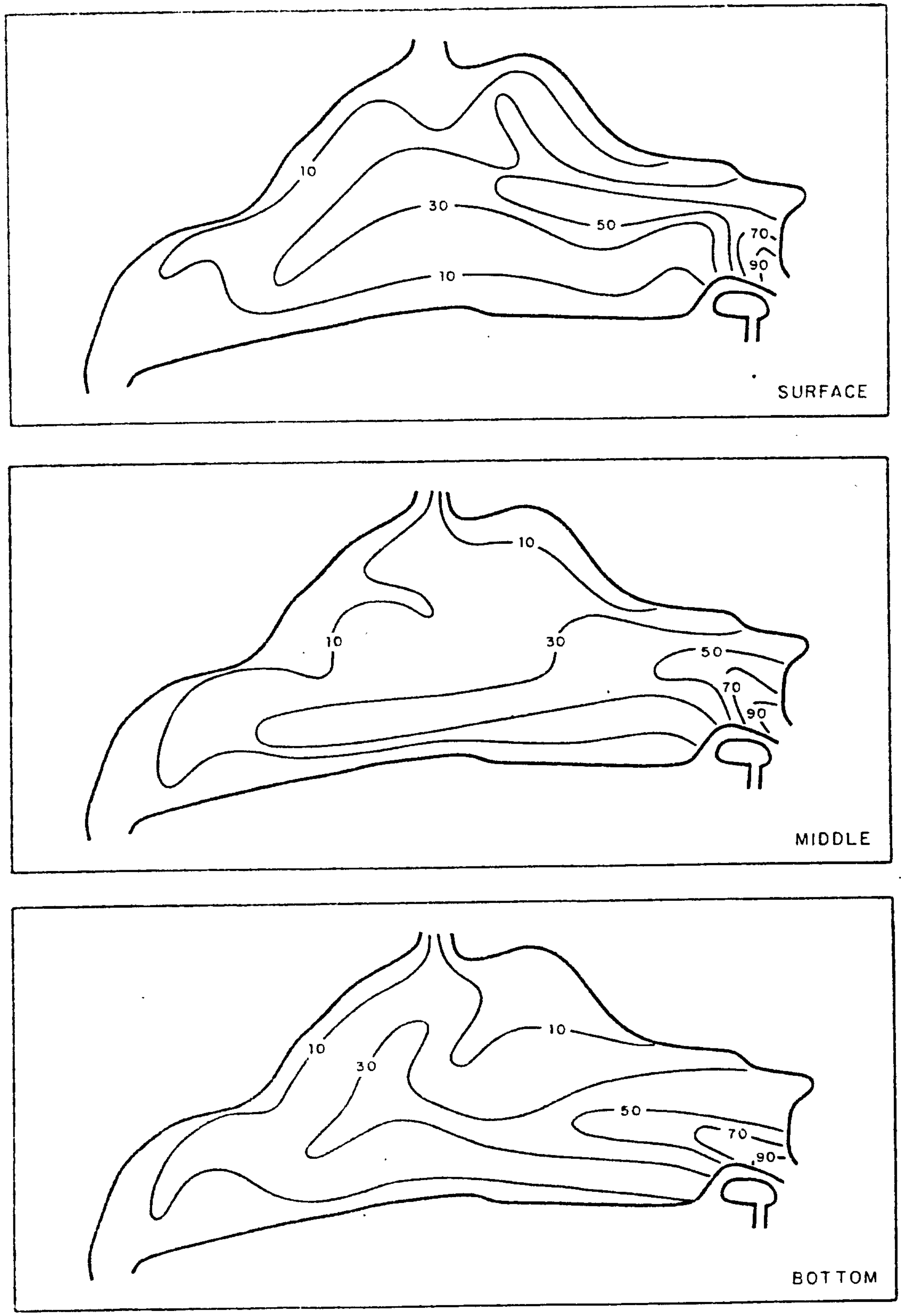
SAN DIEGO GAS & ELECTRIC COMPANY	
Air temperature and wind data during November survey Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 5.4-9



SAN DIEGO GAS & ELECTRIC COMPANY	
Middle lagoon entrance flows Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 5.4-10



SAN DIEGO GAS & ELECTRIC COMPANY	
Offshore entrainment probability Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 5.5-1



'0 June 1979, Flood Tide

Time: 1300 - 1800

0 500 1000 Ft

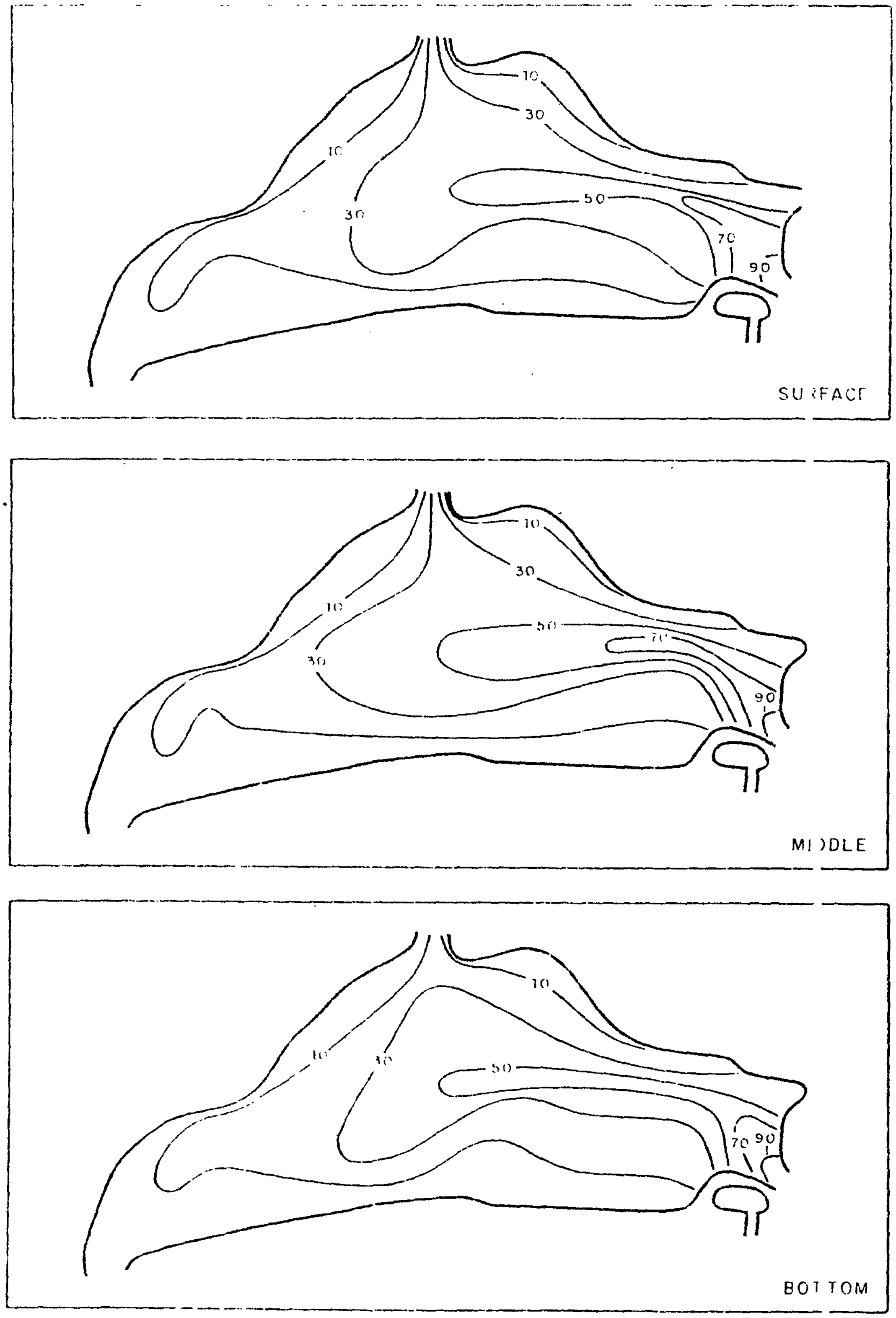
0 100 200 300 M

SAN DIEGO GAS & ELECTRIC COMPANY

Near-field entrainment probability
Encina Power Plant - August 1, 1980

PREPARED BY:
WOODWARD-CLYDE CONSULTANTS

FIGURE NO.
5.5-2



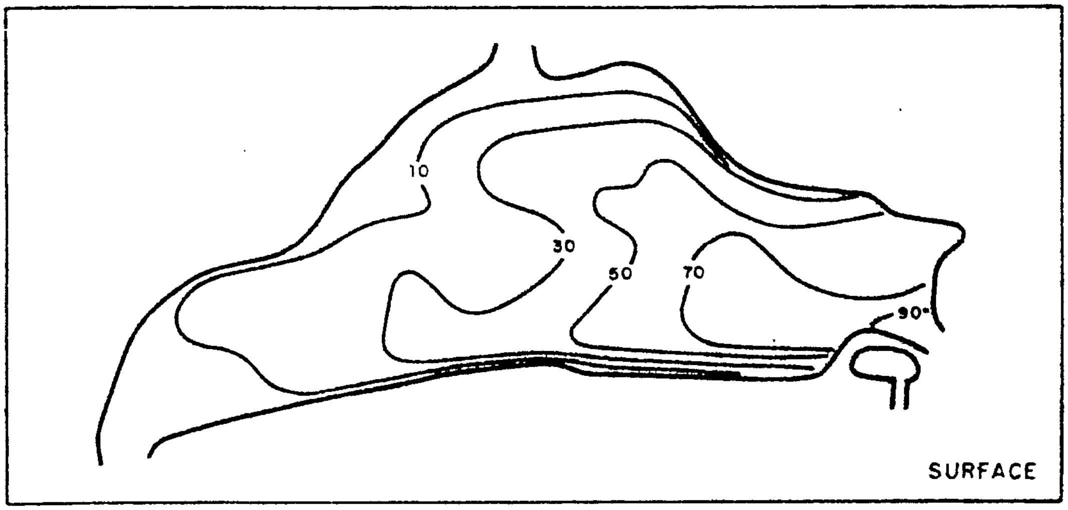
20 June 1979, Ebb Tide

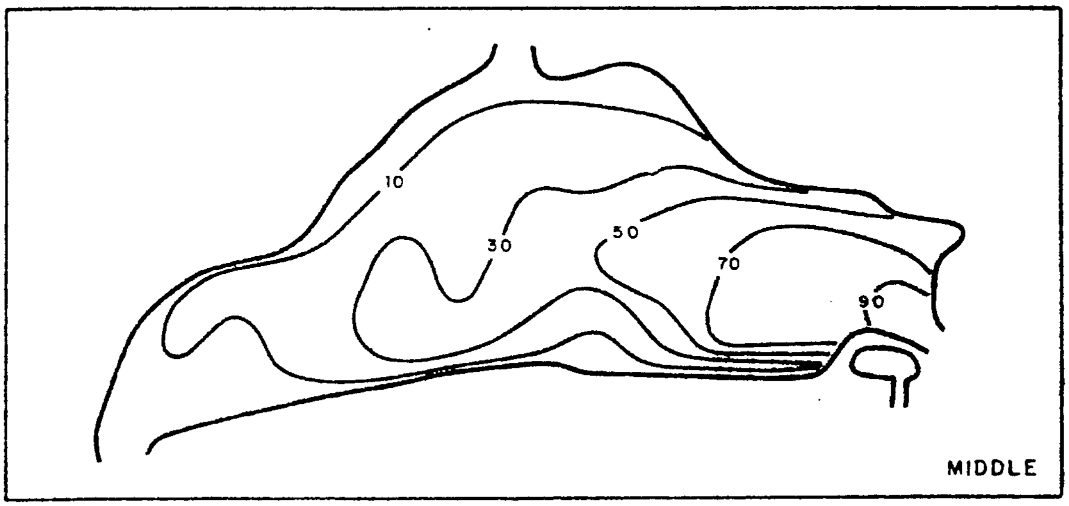
Time: 2100 2400

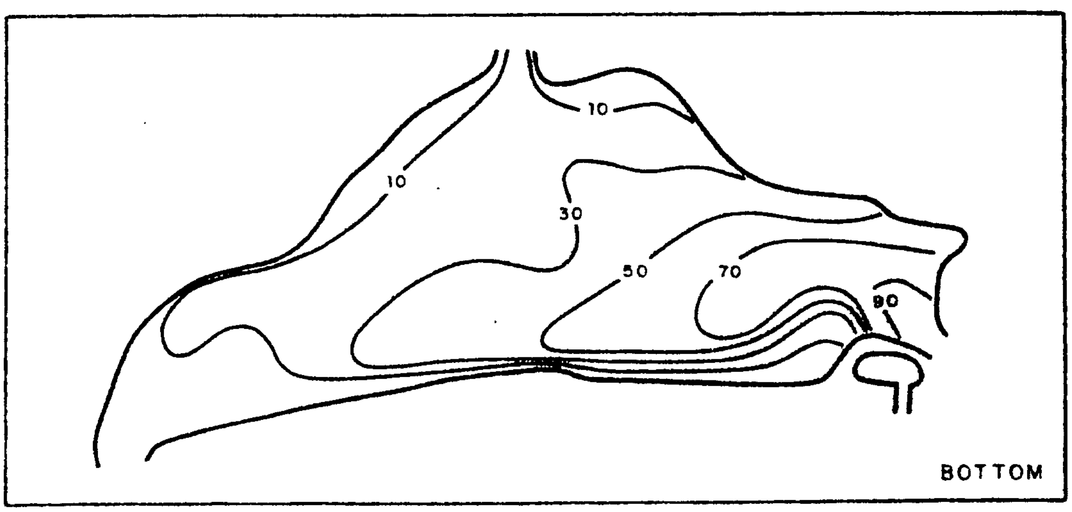
0 500 1000 FT

0 100 200 400 M

SAN DIEGO GAS & ELECTRIC COMPANY	
Near-field entrainment probability Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 5.5-3

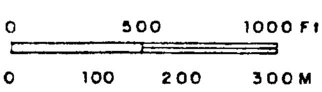




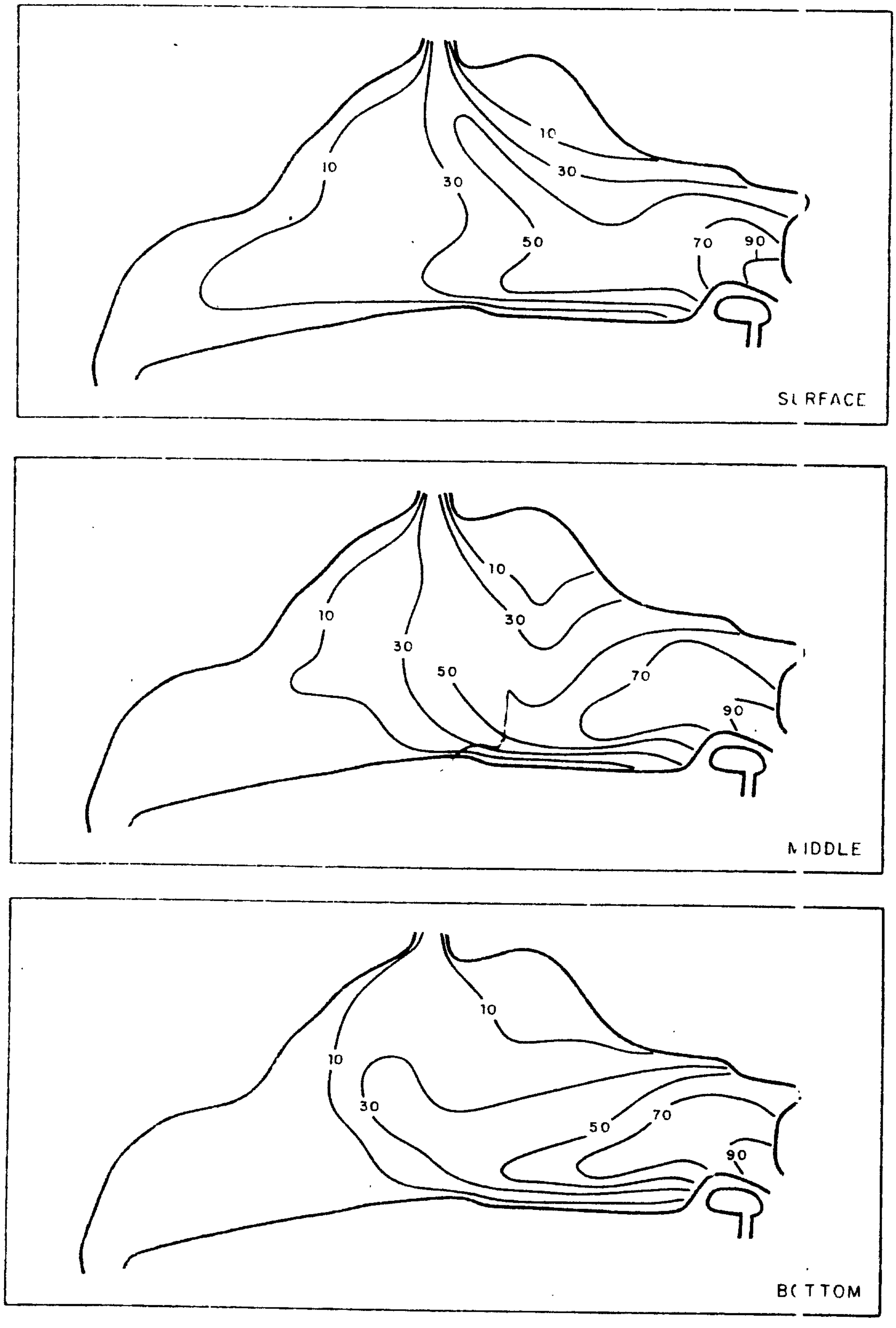


29 August 1979, Flood Tide

Time: 0700 - 1100



SAN DIEGO GAS & ELECTRIC COMPANY	
Near-field entrainment probability Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 5.5-4



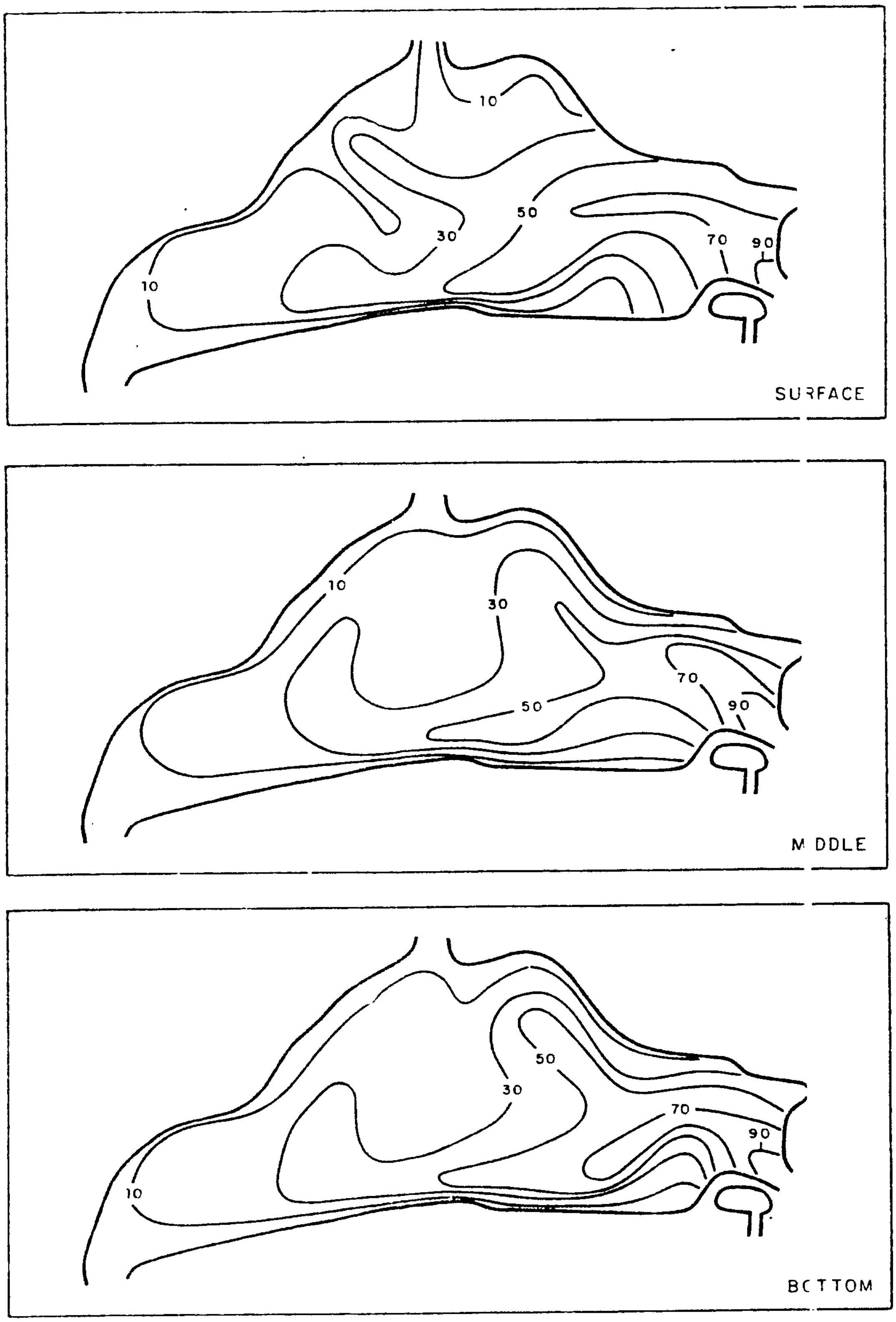
29 August 1979, Ebb Tide

Time: 1500-1900

0 500 1000 Ft

0 100 200 300 M

SAN DIEGO GAS & ELECTRIC COMPANY	
Near-field entrainment probability Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 5.5-5



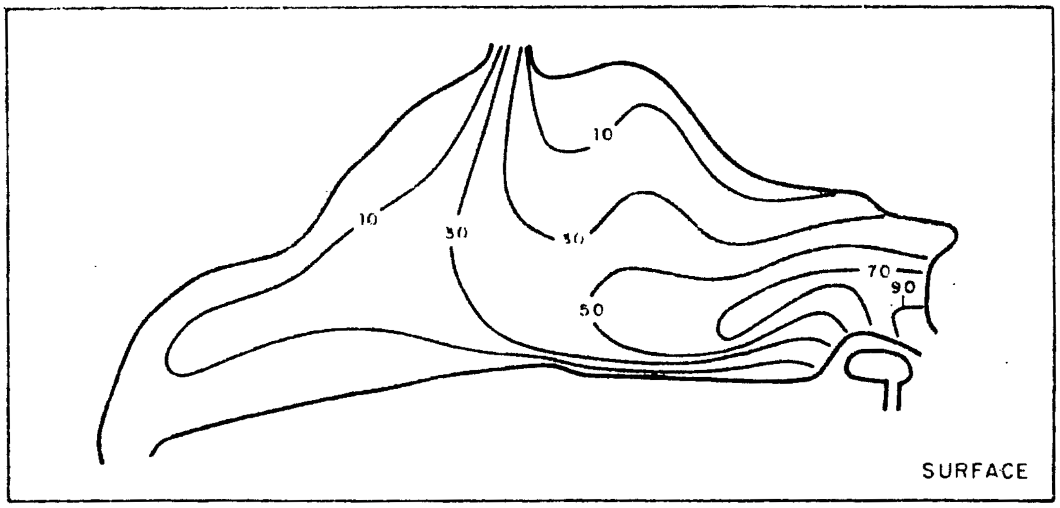
14 November 1979, Flood Tide

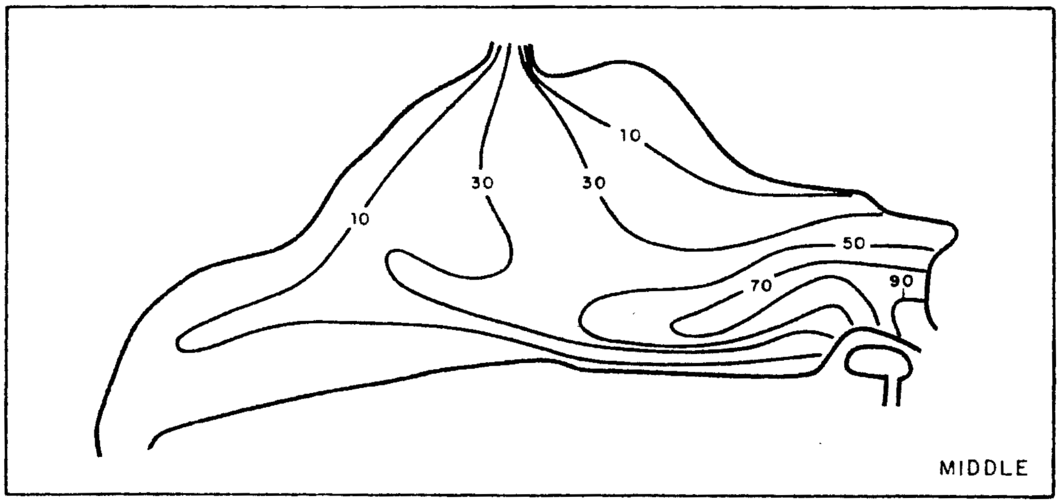
Time: 1400 - 1700

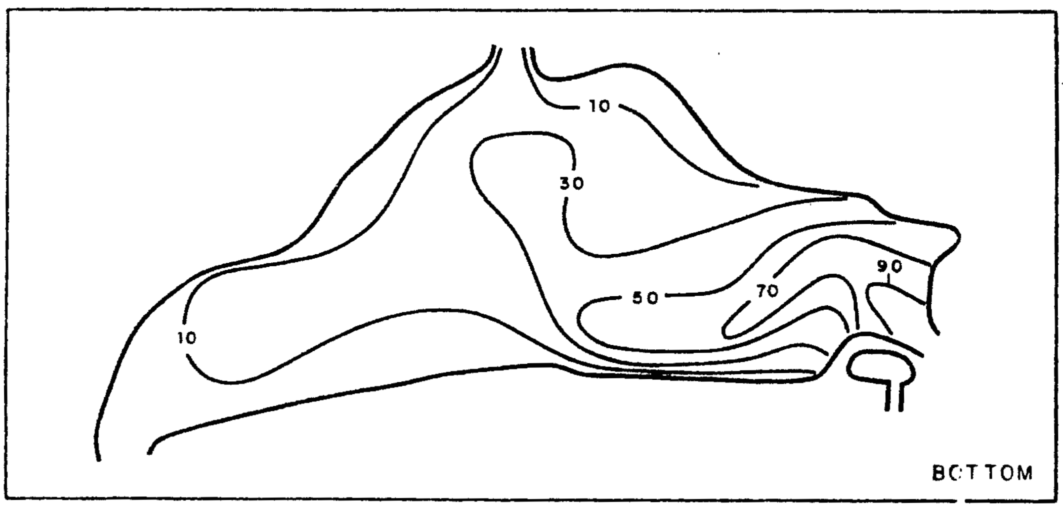
0 500 1000 Ft

0 100 200 300 M

SAN DIEGO GAS & ELECTRIC COMPANY	
Near-field entrainment probability Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 5.5-6

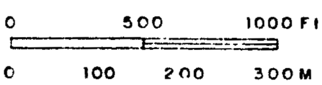






14 November 1979, Ebb Tide

Time: 2000-2400



SAN DIEGO GAS & ELECTRIC COMPANY	
Near-field entrainment probability Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 5.5-7

6.0

BIOLOGICAL ENVIRONMENT: ABUNDANCE AND DISTRIBUTION OF CRITICAL AND NON-CRITICAL SPECIES IN STUDY AREA

6.1 ABSTRACT AND SUMMARY

The abundance and distribution of critical and non-critical species was examined in a year-long study conducted at the Encina Power Plant located on the southern California coastline 35 miles north of San Diego. Cooling water is taken in from a coastal lagoon (Agua Hedionda Lagoon) and discharged into the surf zone of the Pacific Ocean. Habitats occurring in the vicinity include sandy beach, rocky reef, kelp beds, and lagoon. Of the 550 fish species occurring along California's coastline, 254 are expected to occur in the vicinity of the Encina Power Plant (6-1).

With the construction of the Encina Power Plant in 1952, Agua Hedionda Lagoon was dredged to increase the water area and to provide an adequate tidal prism for condenser cooling water. Permanent tidal flushing in the lagoon was established. Prior to this time, frequent closings of the lagoon mouth were reported as early as 1887. Forty-nine fish species have been reported from Agua Hedionda Lagoon in studies by other authors (6-2).

A number of factors, such as temperature, upwelling, commercial fishing pressure, food availability and spawning behavior affect seasonal patterns of fish. Many species move

offshore in winter and inshore in summer months. A number move inshore for spawning. Others spawn offshore. Lagoon and bay areas and estuarine regions can serve as feeding and spawning grounds for some species. They also represent important nursery areas for the young of many marine species. Shallow water habitats in these environments such as marshes and eel grass beds provide food supplies and shelter for developing larvae and juveniles.

Critical species (16 fish, 11 ichthyoplankton, and one zooplankton) were selected, based on six criteria and approved by the RWQCB-SDR for detailed study during the program (Table 6.3-1). After field studies were initiated some additional species were treated in the same way as critical species (Table 6.3-2). These species were frequently found during the sampling program. Criteria used in selecting critical species included:

- Representative of a balanced community
- Commercially or recreationally valuable
- Critical to structure and function of ecosystem
- Food chain necessity
- High potential for impingement or entrainment
- Threatened or endangered species.

Records of fishes impinged at the Encina Power Plant from 1972 through 1978 (based on eight-hour samples several times per month) were reviewed in evaluating those species with high potential for impingement. Not all criteria were necessarily applied in order to place a species on the critical species list.

Life history data for the critical species (Section 6.3.4) was used in the several analyses undertaken in the entire study.

6.2 EXISTING ENVIRONMENTAL SETTING

6.2.1 Historical Information

6.2.1.1 Inventory of Offshore Species. Approximately 550 species of marine fishes representing 144 families occur along the 1000 miles of California coastline (6-3).

A number of these are confined to specific regions or water depths. Those species (254) expected to occur in the vicinity of the Encina Power Plant in southern California are shown in Table 6.2-1. A number of these species are more common in deeper offshore waters and as such are not apt to be caught in the study area for this program. The habitats occurring in the vicinity of the Power Plant (sandy beach, rocky reef, kelp beds, and lagoon) are such that inshore sandy bottom species, kelp bed fishes, surf zone species and those favoring embayments and lagoons are the species most likely to be collected in the study area. In addition, the habitats preferred by a number of species are such that they are not likely to be captured with the sampling gear although they may be present in the area.

6.2.1.2 Inventory of Agua Hedionda Lagoon Species. Agua Hedionda Lagoon is a coastal lagoon within the limits of the City of Carlsbad. It is divided into three sections (Figures 2.1-2 and 2.1-3), each connected by narrow channels. The outer lagoon occupies 26.7 hectares and is open to the ocean on the northwest corner through two rip-rap jetties. It is fringed with eelgrass

Table 6.2-1
FISHES EXPECTED TO OCCUR
IN THE VICINITY OF THE ENCINA POWER PLANT
AUGUST 1, 1980

Heterodontidae
Heterodontus francisci
(Horn shark)

Squalidae
Squalus acanthias
(Spiny dogfish)

Squatinidae
Squatina californica
(Pacific angel shark)

Alopiidae
Alopias vulpinus
(Common thresher)

Scyliorhinidae
Cephaloscyllium ventriosum
(Swell shark)

Lamnidae
Isurus oxyrinchus
(Bonito shark)

Carcharhinidae
Triakis semifasciata
(Leopard shark)

Mustelus californicus
(Gray smoothhound)

Mustelus henlei
(Brown smoothhound)

Galeorhinus zyopterus
(Soupfin shark)

Prionace glauca
(Blue shark)

Rhizoprionodon longurio
(Pacific sharpnose shark)

Torpedinidae
Torpedo californica
(Pacific electric ray)

Platyrhinidae
Platyrhinoidis triseriata
(Thornback)

Rhinobatidae
Rhinobatos productus
(Shovelnose guitarfish)

Rajidae
Raja binoculata
(Big skate)

Raja inornata
(California skate)

Raja rhina
(Longnose skate)

Myliobatididae
Myliobatis californica
(Bat ray)

Dasyatididae
Urolophus halleri
(Round stingray)

Gymnura marmorata
(California butterfly ray)

Dasyatis dipterura
(Diamond stingray)

Albulidae
Albula vulpes
(Bonefish)

Muraenidae
Gymnothorax mordax
(California moray)

Ophichthidae
Myrophis vafer
(Pacific worm eel)

Ophichthus zophochir
(Yellow snake eel)

Ophichthus triserialis
(Spotted snake eel)

Clupeidae

Dorosoma petenense
(Threadfin shad)

Opisthonema medirastre
(Middling thread herring)

Etrumeus teres
(Round herring)

Clupea harengus
(Pacific herring)

Sardinops sagax caeruleus
(Pacific sardine)

Alosa sapidissima
(American shad)

Harengula thrissina
(Flatiron herring)

Engraulidae

Engraulis mordax
(Northern anchovy)

Anchoa compressa
(Deepbody anchovy)

Anchoa delicatissima
(Slough anchovy)

Salmonidae

Oncorhynchus tshawytscha
(King salmon)

Oncorhynchus kisutch
(Silver salmon)

Argentinidae

Argentina sialis
(Pacific argentine)

Synodontidae

Synodus lucioceps
(California lizardfish)

Batrachoididae

Porichthys myriaster
(Speckled midshipman)

Porichthys notatus
(Plainfin midshipman)

Ophidiidae

Chilara taylori
(Spotted cusk-eel)

Otophidium scrippsi
(Basketweave cusk-eel)

Brotulidae

Brosmophycis marginata
(Red brotula)

Gobiesocidae

Gobiesox papillifer
(Bearded clingfish)

Gobiesox rhessodon
(California clingfish)

Rimicola eigenmanni
(Slender clingfish)

Rimicola miscarum
(Kelp clingfish)

Merlucciidae

Merluccius productus
(Pacific hake)

Gadidae

Microgadus proximus
(Pacific tomcod)

Zoarcidae

Lycodopsis pacifica
(Blackbelly eelpout)

Exocoetidae

Fodiator acutus
(Sharpchin flyingfish)

Cypselurus heterurus
(Blotchwing flyingfish)

Cypselurus californicus
(California flyingfish)

Belonidae

Strongylura exilis
(California needlefish)

Table 6.2-1 (Continued)

Scomberesacidae
Cololabis saira
(Pacific saury)

Cuprinodontidae
Fundulus parvipinnis
(California killifish)

Atherinidae
Leuresthes tenuis
(California grunion)

Atherinopsis californiensis
(Jacksmelt)

Atherinops affinis
(Topsmelt)

Syngnathidae
Syngnathus californiensis
(Kelp pipefish)

Syngnathus leptorhynchus
(Bay pipefish)

Syngnathus arctus
(Snubnose pipefish)

Syngnathus auliscus
(Barred pipefish)

Scorpaenidae
Scorpaena guttata
(Sculpin or Spotted scorpionfish)

Scorpaenodes xyris
(Rainbow scorpionfish)

Sebastes vexillaris
(Whitebelly rockfish)

Sebastes dallii
(Calico rockfish)

Sebastes serriceps
(Treefish)

Sebastes chrysomelas
(Black-and-yellow rockfish)

Sebastes carnatus
(Gopher rockfish)

Sebastes auriculatus
(Brown rockfish)

Sebastes rastrelliger
(Grass rockfish)

Sebastes atrovirens
(Kelp rockfish)

Sebastes mystinus
(Blue rockfish)

Sebastes hopkinsi
(Squarespot rockfish)

Sebastes ovalis
(Speckled rockfish)

Sebastes entomelas
(Widow rockfish)

Sebastes flavidus
(Yellowtail rockfish)

Sebastes serranoides
(Olive rockfish)

Sebastes constellatus
(Starry rockfish)

Sebastes rosaceus
(Rosy rockfish)

Sebastes umbrosus
(Honeycomb rockfish)

Sebastes ensifer
(Swordspine rockfish)

Sebastes eos
(Pink rockfish)

Sebastes rosenblatti
(Greenblotched rockfish)

Sebastes jordani
(Shortbelly rockfish)

Sebastes rubrivinctus
(Flag rockfish)

Sebastes paucispinis
(Bocaccio)

Sebastes goodei
(Chilipepper)

Table 6.2-1 (Continued)

Sebastes ruberrimus
(Yelloweye rockfish)

Sebastes levis
(Cowcod)

Sebastes rufus
(Bank rockfish)

Sebastes alutus
(Pacific ocean perch)

Sebastes pinniger
(Canary rockfish)

Sebastes saxicola
(Stripetail rockfish)

Sebastes semicinctus
(Halfbanded rockfish)

Sebastes wilsoni
(Pygmy rockfish)

Triglidae
Prionotus stephanophrys
(Lumptail searobin)

Anoplopomatidae
Anoplopoma fimbria
(Sablefish)

Zanlolepididae
Zaniolepis frenata
(Shortspine combfish)

Zaniolepis latipinnis
(Longspine combfish)

Hexogrammidae
Oxylebius pictus
(Painted greenling)

Ophiodon elongatus
(Lingcod)

Hexagrammos decagrammus
(Kelp greenling)

Cottidae
Rhamphocottus richardsonii
(Grunt sculpin)

Scorpaenichthys marmoratus
(Cabezon)

Leptocottus armatus
(Staghorn sculpin)

Icelinus quadriseriatus
(Yellowchin sculpin)

Icelinus oculatus
(Frogmouth sculpin)

Icelinus burchami
(Dusky sculpin)

Icelinus filamentosus
(Threadfin sculpin)

Icelinus tenuis
(Spotfin sculpin)

Icelinus cavifrons
(Pithead sculpin)

Chitonotus pugetensis
(Roughback sculpin)

Orthonopias triacis
(Snubnose sculpin)

Artedius corallinus
(Coralline sculpin)

Artedius lateralis
(Smoothhead sculpin)

Artedius notospilotus
(Bonyhead sculpin)

Artedius creaseri
(Roughcheek sculpin)

Oligocottus snyderi
(Fluffy sculpin)

Oligocottus rubellio
(Rosy sculpin)

Leiocottus hirundo
(Lavender sculpin)

Clinocottus analis
(Wooly sculpin)

Clinocottus embryum
(Calico sculpin)

Table 6.2-1 (Continued)

Clinocottus recalvus
(Bald sculpin)

Agonidae
Stellerina xyosterna
(Pricklebreast poacher)

Agonopsis sterletus
(Southern spearnose)

Odontopyxis trispinosa
(Pygmy poacher)

Asterotheca pentacantha
(Bigeye starnose)

Xeneretmus ritteri
(Flagfin poacher)

Xeneretmus triacanthus
(Bluespotted poacher)

Xeneretmus latifrons
(Blackedge poacher)

Liparididae
Liparis mucosus
(Slimy snailfish)

Serranidae
Stereolepis gigas
(Giant sea bass)

Mycteroperca xenarcha
(Broomtail grouper)

Mycteroperca jordani
(Gulf grouper)

Hemanthias peruanus
(Splittail bass)

Epinephelus analogus
(Spotted cabrilla)

Epinephelus niveatus
(Snowy grouper)

Paralabrax clathratus
(Kelp bass)

Paralabrax maculatofasciatus
(Spotted sand bass)

Paralabrax nebulifer
(Barred sandbass)

Branchiosteigidae
Caulolatilus princeps
(Ocean whitefish)

Echeneididae
Remora remora
(Remora)

Carangidae
Trachurus symmetricus
(Jack mackerel)

Decapterus hypodus
(Mexican scad)

Naucrates ductor
(Pilotfish)

Seriola dorsalis
(Yellowtail)

Seriola colburni
(Pacific amberjack)

Oligoplites saurus
(Leatherjacket)

Chloroscombrus orqueta
(Pacific bumper)

Caranx caballus
(Green jack)

Coryphaenidae
Coryphaena hippurus
(Dolphinfish)

Pristipomalidae
Xenistius californiensis
(Salema)

Anisotremus davidsonii
(Sargo)

Mullidae
Mulloidichthys dentatus
(Mexican goatfish)

Table 6.2-1 (Continued)

Sciaenidae
- *Seriphus politus* (Queenfish)
- *Cynoscion nobilis* (White seabass)
- *Cynoscion xanthulus* (Orangemouth corvina)
- *Cynoscion parvipinnis* (Shortfin corvina)
- *Menticirrhus undulatus* (California corbina)
- *Genyonemus lineatus* (White croaker)
- *Roncador stearnsi* (Spotfin croaker)
- *Cheilotrema saturnum* (Black croaker)

Girellidae
- *Girella nigricans* (Opaleye)

Kyphosidae
- *Hermosilla azurea* (Zebraperch)

Scorpididae
- *Medialuna californiensis* (Halfmoon)

Embiotocidae
- *Rhacochilus toxotes* (Rubberlip surfperch)
- *Embiotoca jacksoni* (Black surfperch)
- *Amphistichus argenteus* (Barred surfperch)
- *Amphistichus koelzi* (Calico surfperch)
- *Hyperprosopon anale* (Spotfin surfperch)
- *Hyperprosopon argenteum* (Walleye surfperch)
- *Hyperprosopon ellipticum* (Silver surfperch)
- *Cymatogaster aggregata* (Shiner surfperch)
- *Hypsurus caryi* (Rainbow surfperch)
- *Brachyistius frenatus* (Kelp surfperch)
- *Micrometrus minimus* (Dwarf surfperch)
- *Micrometrus aurora* (Reef surfperch)
- *Damalichthys vacca* (Pile surfperch)
- *Phanerodon furcatus* (White surfperch)
- *Phanerodon atripes* (Sharpnose surfperch)

Pomacentridae
- *Hypsypops rubicundus* (Garibaldi)
- *Chromis punctipinnis* (Blacksmith)

Mugilidae
- *Mugil cephalus* (Striped mullet)

Sphyraenidae
- *Sphyraena argentea* (California barracuda)

Labridae
- *Pimelometopon pulchrum* (California sheephead)
- *Oxyjulis californica* (Senorita)
- *Halichoeres semicinctus* (Rock wrasse)

Table 6.2-1 (Continued)

Anarhichadidae
Anarrhichthys ocellatus
(Wolf-eel)

Blenniidae
Hypsoblennius gentilis
(Bay blenny)

Hypsoblennius gilberti
(Rockpool blenny)

Hypsoblennius jenkinsi
(Mussel blenny)

Clinidae
Paraclinus integripinnis
(Reef finspot)

Chaenopsis alepidota
(Orangethroat pikeblenny)

Neoclinus stephensae
(Yellowfin fringehead)

Neoclinus uninotatus
(Onespot fringehead)

Neoclinus blanchardi
(Sarcastic fringehead)

Alloclinus holderi
(Island kelpfish)

Cryptotrema corallinum
(Deepwater blenny)

Heterostichus rostratus
(Giant kelpfish)

Gibbonsia metzi
(Striped kelpfish)

Gibbonsia elegans
(Spotted kelpfish)

Gibbonsia montereyensis
(Crevice kelpfish)

Gibbonsia erythra
(Scarlet kelpfish)

Cebidichthyidae
Cebidichthys violaceus
(Monkeyface-eel)

Stichaeidae
Xiphister atropurpureus
(Black prickleback)

Xiphister mucosus
(Rock prickleback)

Stichaeopsis sp
(Masked prickleback)

Pholididae
Ulvicola sanctaerosae
(Kelp gunnel)

Xererpes fucorum
(Rockweed gunnel)

Gobiidae
Coryphopterus nicholsii
(Blackeye goby)

Lythrypnus dalli
(Bluebanded goby)

Lythrypnus zebra
(Zebra goby)

Typhlogobius californiensis
(Blind goby)

Lethops connectens
(Kelp goby)

Gobionellus longicaudus
(Longtail goby)

Gillichthys mirabilis
(Longjaw mudsucker)

Lepidogobius lepidus
(Bay goby)

Ilypnus gilberti
(Cheekspot goby)

Clevelandia ios
(Arrow goby)

Quietula y-cauda
(Shadow goby)

Scombridae
Scomber japonicus
(Pacific mackerel)

Table 6.2-1 (Concluded)

Auxis thazard
(Frigate mackerel)

Auxis rochei
(Bullet mackerel)

Scomberomorus sierra
(Sierra)

Scomberomorus concolor
(Monterey Spanish mackerel)

Euthynnus pelamis
(Skipjack)

Sarda chiliensis
(Pacific bonito)

Thunnus alalunga
(Albacore)

Thunnus thynnus
(Bluefin tuna)

Thussus albacares
(Yellowfin tuna)

Xiphiidae
Xiphias gladius
(Swordfish)

Istiophoridae
Tetrapturus audax
(Striped marlin)

Centrolophidae
Icichthys lockingtoni
(Medusafish)

Stromateidae
Peprilus simillimus
(Pacific butterfish)

Cynoglossidae
Symphurus atricauda
(California tonguefish)

Bothidae
Paralichthys californicus
(California halibut)

Xystreurys liolepis
(Fantail sole)

Hippoglossina stomata
(Bigmouth sole)

Citharichthys xanthostigma
(Longfin sanddab)

Citharichthys sordidus
(Pacific sanddab)

Citharichthys stigmaeus
(Speckled sanddab)

Pleuronectidae
Pleuronichthys decurrens
(Curlfin turbot)

Pleuronichthys verticalis
(Hornyhead turbot)

Pleuronichthys ritteri
(Spotted turbot)

Pleuronichthys coenosus
(C-O turbot)

Hypsopsetta guttulata
(Diamond turbot)

Parophrys vetulus
(English sole)

Microstomus pacificus
(Dover sole)

Molidae
Mola mola
(Common mola)

beds (Zostera marina) on the eastern and southwestern edges. The middle lagoon is 10.9 hectares in size, and eelgrass beds occupy approximately 75 percent of its areal extent. The upper (inner) lagoon is the largest of the three sections, encompassing 120.2 hectares. Quite extensive eelgrass beds exist in the northwest end, while the extreme eastern end is dominated by a mixture of degraded salt marsh, mud flats, salt flats, and alluvial fan. The freshwater entering the upper end of the lagoon comes from the 7500 hectare watershed of Buena Creek and Agua Hedionda Creek. Since this flow is minimal, the lagoon is essentially a marine rather than estuarine environment.

The first accurate map of the area, made by the Coast and Geodetic Survey 1887-1888, shows the mouth of the lagoon closed. Subsequent surveys in 1898 and 1915 also show the mouth closed. In 1910 the coast highway was constructed with a 7.6 meter wide wooden bridge to span the mouth of the lagoon. In 1916 the highway was paved and the bridge replaced with a 22.9 meter wide concrete span. The mouth of the lagoon was scoured open in 1927 as a result of heavy rains, and remained open until 1932 when, to make way for a new bridge, the old one was dynamited into the mouth of the lagoon, closing it once again. The entrance was reopened in 1948 by local residents. The entire lagoon (all three sections) was dredged in 1952-1954 to create an adequate tidal prism to provide condenser cooling water for the San Diego Gas & Electric Encina Power Plant. Establishment of two rip-rap channels was also completed in conjunction with the dredging operation in late 1953 and early 1954. One channel was built at the northwest end of the outer lagoon so as to allow free movement of ocean water into the lagoon; and the other was positioned in the southwest corner to facilitate the discharging of heated power plant cooling water back into the ocean. Due to deposition of sand, maintenance dredging is performed, in the outer lagoon only, at about two year intervals.

Table 6.2-2 lists species of fish (49) which have been reported from Agua Hedionda Lagoon by other workers. Previously noted invertebrate species are shown in Table 6.2-3.

6.2.1.3 Seasonal Patterns. There are many factors which affect the migration patterns and distributions of nearshore fishes. Among these are temperature, upwelling, commercial fishing pressure, food availability and spawning behavior (6-7). Most of these factors are closely related and often difficult to examine separately. Upwelling, for example, reduces water temperatures. At the same time, nutrient levels in the surface waters are increased, resulting in periods of increased primary production. This increases the food availability. Temperature, itself, often serves as a triggering mechanism for spawning activities of marine fish. Commercial fishing pressure can affect the abundance and distribution of fish and food availability. All of the above factors, whether acting alone or synergistically, can affect the actual distribution of fish.

Temperature is an important regulating factor of fish distribution and movement. Different fish species have specific

TABLE 6.2-2
LIST OF FISH REPORTED FROM AGUA HEDIONDA LAGOON†
ENCINA POWER PLANT - AUGUST 1, 1980

CHONDRICHTHYES - cartilaginous fishes

Heterodontiformes
Heterodontidae - bullhead sharks
Heterodontus francisci - horn shark

Squaliformes
Carcharhinidae - requiem sharks
Triakis semifasciata - leopard shark
Mustelus californicus - gray smoothhound
Mustelus henlei - brown smoothhound

Rajiformes
Rhinobatidae - guitarfishes
Platyrhinoidis triseriata - thornback
Rhinobatos productus - shovelnose guitarfish

Dasyatidae - stingrays
Dasyatis dipterura - diamond stingray
Gymnura marmorata - California butterfly ray
Urolophus halleri - round stingray

Myliobatidae - eagle rays
Myliobatis californica - bat ray

OSTEICHTHYES - bony fishes

Clupeiformes
Clupeidae - herrings
Sardinops sagax caeruleus - Pacific sardine

Engraulidae - anchovies
Anchoa delicatissima - slough anchovy
Engraulis mordax - northern anchovy

Batrachoidiformes
Batrachoididae - toadfishes
Porichthys myriaster - specklefin midshipman
Porichthys notatus - plainfin midshipman

†Bradshaw et al. (1976) (6-4)

TABLE 6.2-2 (Continued)

OSTEICHTHYES (continued)

Atheriniformes

Belonidae - needlefishes

Strongylura exilis - California needlefish

Cyprinodontidae - killifishes

Fundulus parvipinnus - California killifish

Poeciliidae - livebearers

Gambusia affinis - mosquitofish

Atherinidae - silversides

Atherinopsis affinis - topsmelt

Gasterosteiformes

Syngnathidae - pipefishes and seahorses

Syngnathus auliscus - barred pipefish

Syngnathus griseolineatus - bay pipefish

Perciformes

Serranidae - sea basses

Paralabrax clathratus - kelp bass

Paralabrax maculatofasciatus - spotted sand bass

Paralabrax nebulifer - barred sand bass

Carangidae - jacks and pompanos

Seriola dorsalis - yellowtail

Trachurus symmetricus - jack mackerel

Trachinotis sp - pompano

Pomadasyidae - grunts

Anisotremus davidsoni - sargo

Sciaenidae - drums

Cynoscion nobilis - white seabass

Menticirrhus undulatus - California corbina

Roncador stearnsi - spotfin croaker

Seriphus politus - queenfish

Umbrina roncador - yellowfin croaker

Kyphosidae - sea chubs

Girella nigricans - opaleye

Hermosilla azurea - zebraperch

Embiotocidae - surfperches

Hyperprosopon argenteum - walleye surfperch

TABLE 6.2-2 (Concluded)

OSTEICHTHYES (continued)

Pomacentridae - damselfishes
Chromis punctipinnus - blacksmith

Mugilidae - mullets
Mugil cephalus - striped mullet

Sphyraenidae - barracudas
Sphyraena argentea - Pacific barracuda

Blenniidae - combtooth blennies
Hypsoblennius gentilis - bay blenny

Gobiidae - gobies
Clevelandia ios - arrow goby
Gillichthys mirabilis - longjaw mudsucker

Scombridae - mackerels and tunas
Sarda chiliensis - Pacific bonito

Scorpaenidae - scorpionfishes
Scorpaena guttata - California scorpionfish
Sebastes atrovirens - kelp rockfish

Cottidae - sculpins
Leptocottus armatus - Pacific staghorn sculpin

Pleuronectiformes
Bothidae - lefteye flounders
Paralichthys californicus - California halibut

Pleuronectidae - righteye flounders
Hypsopsetta guttulata - Diamond turbot

Cynoglossidae - tonguefishes
Symphurus atricauda - California tonguefish

TABLE 6.2-3
LIST OF INVERTEBRATES TAKEN FROM AGUA HEDIONDA LAGOON†,††
ENCINA POWER PLANT - AUGUST 1, 1980

ARTHROPODA

Crustacea
Thoracica
Chthamalidae - small acorn barnacles
Chthamalus fissus - small acorn barnacle

Balanidae - acorn barnacles
Balanus glandula - Pacific acorn barnacle
Balanus cariosus - acorn barnacle

Tetraclitinae
Tetraclita squamosa

Nebaliacea
Nebalia pugettensis

Cumacea
Lampropidae
Oxyurostylis pacifica

Tanaidacea
Tanaidae
Tanais normanii

Isopoda
Sphaeromatidae
Paracerceis sculpta
Gnorimosphaeroma sp

Aegidae
Rocinela aries

Jaeropsidae
Jaeropsis concava

Bopyridae
Phyllodurus abdominalis

Ligiidae
Ligia occidentalis

† Bradshaw et al. (1976) (6-5)
††Miller (1966) (6-6)

TABLE 6.2-3 (Continued)

Crustacea (continued)
  Amphipoda
    Ampithoidae
      Ampithoe plumosa
      Ampithoe pollex
      Ampithoe longimana

    Aoridae
      Rudilemboides stenopropodus
      Amphideutopus sp

    Corophiidae
      Corophium acherusicum
      Erichthonius brasiliensis

    Eusiridae
      Pontogeneia minuta

    Gammaridae
      Maera sp

    Hyalidae
      Hyale sp
      Hyale rubra frequens

    Ischyroceridae
      Jassa falcata

    Leucothoidae
      Leucothoe alata

    Oedicerotidae
      Monoculodes hartmanae

    Podoceridae
      Podocerus fulanus

    Stenothoidae
      Stenothoe valida

    Talitridae
      Orchestoidea californiana

    Caprellidae
      Caprella equilibra
      Caprella californica

TABLE 6.2-3 (Continued)

Crustacea (continued)
  Decapoda
    Alpheidae
      Betaeus longidactylus - long fingered shrimp

    Callianassidae - ghost shrimps
      Callianassa californiensis - red ghost shrimp

    Porcellanidae - porcelain crabs
      Petrolisthes cinctipes - porcelain crab

    Cancridae - cancer crabs
      Cancer productus - red crab

    Goneplacidae - burrowing crabs
      Speocarcinus californiensis

    Pinnotheridae - pea crabs
      Scleroplax granulata

    Grapsidae - shore crabs
      Pachygrapsus crassipes - striped shore crab
      Hemigrapsus nudus - purple shore crab
      Hemigrapsus oregonensis - yellow shore crab

    Ocypodidae - fiddler crabs
      Uca crenulata - fiddler crab

ANNELIDA

  Polychaeta
    Polynoidae
      Halosydna tuberculifer
      Lagisca lamellifera

    Amphinomidae
      Eurythoe complanata

    Phyllodocidae
      Eulalia aviculiseta
      Eulalia quadrioculata

    Hesionidae
      Ophiodromus pugettensis

TABLE 6.2-3 (Continued)

Polychaeta (continued)

Syllidae
- *Pionosyllis* sp
- *Pionosyllis gigantea*
- *Typosyllis* sp

Neridae
- *Nereis latescens*
- *Platynereis bicanaliculata*

Nepthyidae
- *Nephtys californiensis*

Glyceridae
- *Glycera* sp
- *Glycera convoluta*
- *Hemipodus borealis*

Goniadidae
- *Goniada littorea*

Lumbrineridae
- *Lumbrineris erecta*
- *Lumbrineris minima*

Dorvilleidae
- *Dorvillea articulata*

Orbiniidae
- *Haploscoloplos elongatus*

Paraonidae
- *Paraonis gracilis*

Spionidae
- *Nerinides acuta*
- *Nerinides maculata*
- *Polydora ligni*
- *Prionospio cirrifera*
- *Prionospio heterobranchia newportensis*
- *Prionospio malmgreni*
- *Prionospio pinnata*
- *Prionospio pygmaeus*

Magelonidae
- *Magelona californica*

TABLE 6.2-3 (Continued)

Polychaeta (continued)
Cirratulidae
Chaetozone corona

Flabelligeridae
Pherusa capulata

Opheliidae
Armandia bioculata

Capitellidae
Anotomastus gordiodes
Capitita ambiseta
Heteromastus filiformis
Notomastus tenuis

Oweniidae
Owenia collaris

Sabellariidae
Phragmatopoma californica

Terrebellidae
Artacamella hancocki

Sabellidae
Euchone limnicola

Serpulidae
Spirorbis borealis

MOLLUSCA

Gastropoda
Fissurellidae - keyhole limpets
Lucapinella callomarginata - hard-edged keyhole limpet

Acmaeidae - limpets
Collisella pelta - shield limpet
Collisella digitalis - finger limpet
Collisella scabra - rough limpet
Collisella conus - test's limpet
Collisella limatula - file limpet
Collisella strigatella
Collisella asmi - black limpet
Notoacmea incessa - seaweed limpet

TABLE 6.2-3 (Continued)

Gastropoda (continued)

Acmaeidae (continued)

Notoacmea fenestrata - fenestrate limpet
Notoacmea persona - mask limpet

Trochidae - pearlly top shells

Tegula funebralis - black top
Tegula gallina - speckled top

Phasianellidae - pheasant shells

Tricolia pulloides - small pheasant

Littorinidae - periwinkles

Littorina planaxis - flat periwinkle
Littorina scutalata - checkered periwinkle

Lacunidae - chink shells

Lacuna unifasciata - one-banded lacuna

Caecidae

Caecum californicum - caecum snail

Vitrinellidae

Teinostoma supravallatum

Vermetidae - worm shells

Serpulorbis squamigerus

Potamididae - horned shells

Cerithidea californica - California horn shell

Epitoniidae - wentletraps

Epitonium cooperi - Cooper's wentletrap

Calyptraeidae - slipper shell

Crepidula nummaria - white slipper shell
Crepidula excavata - excavated slipper shell
Crepidula onyx - onyx slipper shell
Crepidula coei
Crepipatella lingulata - half slipper shell

Naticidae - moon shells

Neverita reclusiana - Recluz's moon shell
Polinices lewisii - Lewis' moon shell

TABLE 6.2-3 (Continued)

Gastropoda (continued)

Muricidae - rock shells
- *Ocenebra gracillima*
- *Pteropurpura festiva* - festive murex
- *Roperia poulsoni* - Poulson's rock shell

Thaididae - dye shells
- *Acanthina spirata* - angular unicorn

Neptuneidae
- *Kelletia kelletii* - Kellet's whelk

Columbellidae - dove shells
- *Mitrella carinata* - keeled dove shell
- *Mitrella gausapata*

Nassariidae - dog whelks
- *Nassarius tegulus* - mud dog whelk
- *Nassarius fossatus* - channeled dog whelk
- *Nassarius mendicus* - lean dog whelk

Olividae - olive shells
- *Olivella biplicata* - purple olive
- *Olivella baetica* - beatic olive

Conidae - cone shells
- *Conus californicus* - California cone

Acteonidae - small bubble shells
- *Rictaxis punctocaelatus*

Bullidae - true bubble shells
- *Bulla gouldiana* - Gould's bubble

Atyidae - paper bubble shells
- *Haminoea virescens* - green paper bubble
- *Haminoea vesicula* - blister paper bubble

Acteocinidae - glassy bubble shells
- *Acteocina* sp

Aplysiidae - sea slugs
- *Phyllaplysia taylori* - eel grass slug

Melampidae - marsh snails
- *Melampus olivaceus* - salt-marsh snail

TABLE 6.2-3 (Continued)

Pelecypoda

Mytilidae - mussels
- *Modiolus neglectus*
- *Mytilus edulis* - bay mussel
- *Mytilus californianus* - California mussel

Ostreidae - oysters
- *Ostrea lurida* - California oyster

Pectinidae - scallops
- *Argopecten aequisulcatus*
- *Leptopecten latiauratus* - kelp-weed scallop

Limidae - file shells
- *Lima hemphilli* - Hemphill's file

Kelliidae - kellys
- *Kellia suborbicularis* - kelly shell

Chamidae - chamas
- *Chama pellucida* - agate jewel box
- *Pseudochama exogyra* - reversed jewel box

Cardiidae - cockles
- *Trachycardium quadragenarium* - giant Pacific cockle
- *Laevicardium substriatum* - little egg cockle

Veneridae - venus clams
- *Saxidomus nuttalli* - Washington clam
- *Tapes japonica* - Japanese littleneck
- *Chione undatella* - frilled California venus
- *Chione californiensis* - California venus
- *Chione fluctifraga* - smooth California venus
- *Protothaca laciniata* - folded littleneck
- *Protothaca staminea* - Pacific littleneck

Petricolidae - rock dwellers
- *Petricola californiensis* - California rock dweller

Cooperellidae
- *Cooperella subdiaphana*

Mactridae - surf clams
- *Mactra californica* - California surf clam
- *Tresus nuttalli* - gaper

Pelecypoda (continued)

Tellinidae - tellins

Leporimetis obesa
Macoma nasuta - bent-nosed macoma
Macoma secta - white sand macoma
Macoma inquinata
Tellina carpenteri - Carpenter's tellin
Tellina meropsis

Donacidae - bean clams

Donax gouldii - little bean clam

Psammobiidae - garis

Heterodonax bimaculatus - false donax
Nuttallia nuttalli - purple clam
Tagelus californianus - jackknife clam
Tagelus subteres

Semelidae - semeles

Semele decisa - bark semele
Semele rubropicta - rose-petal semele

Solenidae - razor clams

Solen rosaceus - rosy razor clam

Myidae - soft-shelled clams

Cryptomya californica - California soft-shelled clam

Hiatellidae - giant clams

Hiatella arctica - Arctic rock borer

Pholadidae - piddocks

Barnea subtruncata - Pacific piddock
Zirfaea pilsbryi - Pillsbry's piddock

Lyonsiidae - paper shells

Lyonsia californica - California lyonsia

Thraciidae - thracias

Tracia diegensis

TABLE 6.2-3 (Concluded)

Polyplacophora

Ischnochitonidae

Ischnochiton conspicuus - conspicuous chiton

Lepidochitona keepiana

Mopaliidae

Mopalia acuta

Mopalia muscosa - mossy chiton

PHORONIDA

Phoronis vancouverensis

NEMERTEA

Unidentified Nemertean

ranges of thermal tolerance, outside of which they cannot survive. Within these ranges, each species exhibits certain temperature preferences, which they actively seek to remain within. Changes in temperature, thus, can cause localized and long-term movements of fish populations.

Distributions of pelagic and demersal fishes of the California Bight region can be greatly influenced by upwelling, which often occurs during the summer months. Fish will generally avoid the upwelling water which is usually cold and low in oxygen. Demersal species move inshore toward lagoons and bays, while pelagic fish escape to offshore waters (6-8).

The effects of commercial fishing pressure on fish distribution may or may not be evident, depending upon the extent of fishing activity. However, if excessive, this factor can greatly reduce the populations of fish within an area.

Food availability is an important influence on fish distribution and migration. The northern anchovy (*Engraulis mordax*) for example, migrates inshore for the summer and offshore during the winter (6-9). This migration has been observed to closely follow an increased production of *Acartia tonsa*, a copepod which constitutes a major portion of the anchovy's diet (6-10). Such migration patterns, largely dependent upon food supply, appear common among planktivorous fish species. Bottom feeding (demersal) fish such as the sheephead (*Pimelometopon pulchrum*), barred sandbass (*Paralabrax nebulifer*) and speckled sanddab

(Citharichthys stigmaeus) do not exhibit such food-dependent movements (6-11, 6-12 and 6-13).

A number of species of fish undergo regular seasonal migrations which are directly related to spawning activity. Many sciaenids, such as the queenfish (Seriphus politus), yellowfin croaker (Umbrina roncador), white seabass (Cynoscion nobilis) and spotfin croaker (Roncador stearnsi), appear to migrate inshore during the summer for mating purposes (6-14 and 6-15). The California halibut (Paralichthys californicus) displays an inshore movement for spawning during the spring and summer months (6-16). Two viviparous fish species, the shiner surfperch (Cymatogaster aggregata) and round stingray (Urolophus halleri), also migrate into shallow coastal waters for breeding and nursing. The shiner begins spawning in spring and leaves by late summer, after giving birth (6-17). The round stingray moves shoreward in June to breed, moves offshore afterwards and then returns again in September to give birth (6-18).

6.2.1.4 Lagoon Utilization. Large inshore nurseries such as those found on the Atlantic and Gulf of Mexico coastlines are absent from the California coast (6-19). The smaller California bays and estuaries are utilized by fish, however, in a similar manner. These inshore waters serve as feeding and spawning grounds for a number of species. Such estuarine regions also represent important nursery areas for the young of many marine species. At very early stages, young fish and invertebrates migrate into shallow areas, where they undergo periods of rapid development. There, shallow water environments such as eelgrass beds, marshes, etc. provide ample food supplies and shelter for the developing larvae and juveniles. Upon reaching specific stages of maturity, individuals of certain species migrate to deeper water regions, while others may remain as residents. Inshore waters, then, serve as a region if importance for both resident and transient populations.

An examination of the fish composition of 13 selected California bays and lagoons between Humboldt Bay and the Tijuana Estuary revealed that 51 percent (224 species) of the 439 California coastal fish species occurred in these estuaries (6-20). The investigators compared seven variables (mean annual temperature, latitude, bay mouth width, water surface area, distance to the nearest neighboring bay, mean annual rainfall and diurnal tidal range) using multivariate analysis and found bay mouth width responsible for the greatest differences in fish species diversity. In this context it is useful to visualize the lagoons as being peninsulas of the ocean, with inlet size controlling access to and from the source waters. Lagoons having greater mouth width and/or those located closer to oceanic waters usually have larger fish populations (6-21). When mouth width was excluded from the analysis, embayment surface area was found to contribute significantly to diversity. Of the 13 bays studied, the four largest contained the largest number of fish species (6-22).

Agua Hedionda Lagoon's fish diversity compares favorably with those of other embayments examined by Horn and Allen (1976) (6-23). Agua Hedionda Lagoon was reported to have 55 fish species within a 120 hectare subtidal area (6-24). In this study, additional collections at the adjacent cooling water intake system within the Power Plant along with lagoon collections yielded 79 fish species. Other bays examined by Horn and Allen (1976) (6-25) were: Anaheim Bay with 59 species in 53.0 hectares, Alamitos Bay with 43 species in 67.2 hectares, Elkhorn Slough with 69 species in 87.4 hectares, Bolinas Lagoon with 41 species in 109.3 hectares, and Newport Bay with 78 species in 175.2 hectares. A positive linear logarithmic relationship of surface area to fish species diversity was indicated for all 13 embayments.

Agua Hedionda Lagoon is primarily a marine lagoon with seasonal freshwater influence during heavy rains from December through April (6-26). The southern end of the upper lagoon is probably most influenced by runoff from Agua Hedionda Creek. Euryhaline species such as the California killifish (*Fundulus parvipinnis*), western mosquitofish (*Gambusia affinis*), and striped mullet (*Mugil cephalus*) have been reported to occur in the upper portion of the lagoon (6-27). These waters may provide a necessary gradation from fresh to brackish water for some winter spawning teleosts which require variable salinities for normal egg and larval development.

The lagoon environment offers calmer waters and higher productivity than adjacent coastal areas. It contains several specialized habitats which are ideal for early stages of fish and invertebrate development. Zostera marina beds, sand, mud, and rocky areas each provide useful habitats for select species throughout the year. Figure 2.1-3 shows the extent of the various habitats in Agua Hedionda Lagoon.

Utilization of the lagoon is variable for different species. There are permanent residents that utilize particular habitats in the lagoon for resting, feeding and spawning throughout their lifetime. There are transient species whose adults use the lagoon for spawning seasonally and whose young subsequently utilize the area as a nursery ground.

The roles of particular fish species expected to utilize Agua Hedionda Lagoon have been summarized in Table 6.2-4. Emphasis has been given to both those fish designated as critical species (Section 6.3) and those species which have been indicated to be most abundant within the lagoon. Expected seasonal occurrence, developmental stage and major habitat utilized have been included.

Plankton populations within Agua Hedionda Lagoon have also been previously examined. Bradshaw et al. (1976) found zooplankton composition to be fairly uniform throughout the three sections of the lagoon (6-28). Density and distribution of zooplankton may be more closely influenced by tidal cycles than any other factors in this type of water system (6-29).

TABLE 6.2-4
PROJECTED USE OF AGUA HEDIONDA LAGOON BY CRITICAL AND HIGHLY ABUNDANT FISH SPECIES
ENÇINA POWER PLANT - AUGUST 1, 1980

Projected Use	Species	Spawning Season	Early Development	Primary Habitat
Resident	Striped mullet *Mugil cephalus* (6-30 through 6-34)	Winter	Pelagic eggs. Reported to spawn offshore as well as inshore. At size of 25 mm (total length) larvae move shoreward where they become abundant in shallow waters. Larvae become benthic feeders at this size, feeding upon filamentous green and blue-green algae.	Throughout lagoon and along coast.
Resident	Topsmelt *Atherinops affinis* (6-35 and 6-36)	Spring and Winter	Filamentous eggs attached to algae and *Zostera*. Larvae generally in upper 50 mm of the water column.	Throughout lagoon, with greatest densities around *Zostera marina* beds.
Resident	Staghorn sculpin *Leptocottus armatus* (6-37)	Winter	Demersal eggs, hatching in 9 to 14 days. Larvae become pelagic one month before settling.	Sandy substrates.
Resident	Bay pipefish *Syngnathus griseolineatus* (6-38 and 6-39)	May-June	Eggs are carried by the male for 2 to 3 weeks before young are released.	*Zostera marina* beds.
Resident	Spotted sand bass *Paralabrax maculatofaciatus* (6-40, 6-41 and 6-42)	Spring-Summer	Pelagic eggs. Larvae and juveniles inhabit *Zostera* beds.	*Zostera marina* beds, kelp beds, and nearby sandy areas.
Resident	Giant kelpfish *Heterostichus rostratus* (6-43 and 6-44)	March-July	Filamentous eggs attached to *Zostera*.	*Zostera marina* beds.
Resident	Opaleye *Girella nigricans* (6-45 and 6-46)	April-June	Pelagic eggs. Juveniles move into shallow waters and tidepools.	*Zostera marina* beds, rip-rap and rocky substrates.

TABLE 6.2-4 (Continued)

Projected Use	Species	Spawning Season	Early Development	Primary Habitat
Resident	Blackeye goby *Coryphopterus nicholsii* (6-47)	Spring-Summer	Demersal eggs spawned under rocks.	Rip-rap.
Resident	White surfperch *Phanerodon furcatus* (6-48 and 6-49)	May-June	Viviparous	Quiet waters around rock and sand.
Resident	Round stingray *Urolophus halleri* (6-50)	September	Viviparous. Young prefer water less than 3.3 m deep.	Protected sand and mud substrates.
Resident	Diamond turbot *Hysopsetta guttulata* (6-51 and 6-52)	Early Spring	Pelagic eggs and early larvae.	Sandy substrates, especially deeper channels.
Resident	Slough anchovy *Anchoa delicatissima* (6-53)	Spring and Summer	Pelagic eggs and larvae.	Throughout the lagoon.
Resident	Deepbody anchovy *Anchoa compressa* (6-54, 6-55 and 6-56)	Spring and Summer	Pelagic eggs and larvae.	Throughout the lagoon.
Seasonal Spawner	Jacksmelt *Atherinopsis californiensis* (6-57)	Winter	Filamentous eggs attached to algae and *Zostera*.	Adults can occur throughout the lagoon, eggs in algae and *Zostera marina* beds.
Seasonal Spawner	California halibut *Paralichthys californicus* (6-58 and 6-59)	February-July	Eggs are pelagic. Larvae probably settle quickly after hatching. Little movement of juveniles from a particular area until they begin moving offshore at a size of about 200 mm total length.	Sandy sediments.

TABLE 6.2-4 (Continued)

Projected Use	Species	Spawning Season	Early Development	Primary Habitat
Seasonal Spawner	Shiner surfperch *Cymatogaster aggregata* (6-60)	Summer	Viviparous. Males mature at birth.	*Zostera marina* beds in summer (offshore rest of the year).
Seasonal Spawner	Queenfish *Seriphus politus* (6-61 and 6-62)	Spring-Summer	Pelagic eggs.	Shallow sandy bottoms. Move offshore in winter.
Seasonal Spawner	Spotfin croaker *Roncador stearnsi* (6-63, 6-64 and 6-65)	Summer	Pelagic eggs.	Shallow sandy bottoms. Move offshore in winter.
Seasonal Spawner	Yellowfin croaker *Umbrina roncador* (6-66 and 6-67)	Summer	Pelagic eggs.	Over sandy bottoms near rocks.
Adults that frequent the lagoon.	California corbina *Menticirrhus lineatus* (6-68 and 6-69)	Summer in offshore areas.	Pelagic eggs. Larvae and juveniles larger than 25 mm TL move into the surf zone.	Sandy bottoms in surf zone and in shallow bays.
Adults that frequent the lagoon.	White croaker *Genyonemus lineatus* (6-70, 6-71 and 6-72)	October-April in offshore areas.	Pelagic eggs.	Sandy bottoms.
Species which utilize the lagoon as a nursery area.	Kelp bass *Paralabrax clathratus* (6-73 and 6-74)	May-August in kelp beds offshore.	Young move into shallow algae and *Zostera* beds in fall and winter at a size of about 25-50 mm TL.	Young utilize *Zostera marina* and *Sargassum* in the lagoons.
Species which utilize the lagoon as nursery area.	Barred sand bass *Paralabrax nebulifer* (6-75 and 6-76)	Spring-Summer in kelp beds offshore.	Larvae and juveniles move inshore to bays in fall and winter.	Juveniles utilize *Zostera marina* beds.

TABLE 6.2-4 (Concluded)

Projected Use	Species	Spawning Season	Early Development	Primary Habitat
Species which utilize the lagoon as a nursery area.	White seabass Cynoscion nobilis (6-77 and 6-78)	March-August inshore.	Juveniles found in shallow waters and embayments during spring and summer.	Some juveniles in lagoon in summer.
Species which utilize the lagoon as a nursery area.	Pacific sanddab Citharichthys sordidus (6-79 through 6-81)	Possibly year-round.	Pelagic eggs.	Sandy and mud bottoms. Shallow and deep waters in winter, shallow waters in summer.
Species which utilize the lagoon as a nursery area.	Speckled sanddab Citharichthys stigmaeus (6-82 and 6-83)	Possibly year-round.	Pelagic eggs, followed by long larval period.	Prefer sand or mud bottoms at depths from 3-60 m.
Adventitious visitors	California barracuda Sphyraena argentea (6-84)	April-Sept. Primarily May-July offshore.	Pelagic eggs spawned offshore. Schooling fish. Young enter bays and lagoons.	Young fish feeding throughout lagoon.
Adventitious visitors	California needlefish Strongylura exilus (6-85)	----	Demersal eggs. Common from central Baja California south. Present in lagoon in summer.	Feeding through lagoon.
Adventitious visitors	Northern anchovy Engraulis mordax (6-86)	Year-round with February-March peak in nearshore areas.	Juveniles may frequent lagoons, but adults are pelagic offshore.	Feeding throughout lagoon.

6.3 CRITICAL SPECIES

6.3.1 Definition of Critical and Non-Critical

Over 90 species of fish (over 100,000 individuals) were collected during the study. It was not feasible to collect detailed data on all species captured. Therefore, selected species ("critical species") which would be representative of the fish populations in the vicinity were chosen for detailed study. Criteria used in selecting "critical species" included:

- Representative of a balanced community
- Commercially or recreationally valuable
- Critical to structure and function of ecosystem
- Food chain necessity
- High potential for impingement or entrainment
- Threatened or endangered species.

All other species not identified as critical were treated as non-critical.

6.3.2 Species List

The selected "critical species" were submitted to the Regional and State Water Quality Control Boards for review and approval prior to initiation of the study. The approved list is shown in Table 6.3-1.

6.3.3 Species List Additions

The "critical species" list was reviewed during the study and following completion of field collections to evaluate the need for additions to or deletions from the list based on

TABLE 6.3-1
CONSIDERATIONS AND RATIONALE FOR DETERMINATION OF ORIGINALLY APPROVED CRITICAL SPECIES FOR 316(b) STUDIES AT ENCINA POWER PLANT
ENCINA POWER PLANT - NOVEMBER 17, 1978

Species	Representative of a balanced community	Commercially or recreationally valuable	Critical to structure and function of ecosystem	Food chain necessity	High potential for impingement or entrainment	Rationale for final disposition of critical determination
ADULT FISH						
Engraulidae						
Engraulis mordax (Northern Anchovy)	X	X	X	X	X	Common offshore and in lagoon at times; previously impinged.
Atherinidae						
Atherinops affinis (Topsmelt)	X	X	X	X	X	Common in source waters and kelp beds; previously impinged.
Serranidae						
Paralabrax clathratus (Kelp Bass)	X	X	X		X	Common in source waters; previously impinged.
Paralabrax maculatofasciatus (Spotted Sand Bass)	X	X			X	Common in source waters; previously impinged.
Paralabrax nebulifer (Barred Sand Bass)	X	X			X	Common in source waters; previously impinged.
Sciaenidae						
Cynoscion nobilis (White Seabass)	X	X	X		X	Common near kelp and offshore; previously impinged.
Menticirrhus undulatus (California Corbina)	X	X			X	Common in surf and lagoon.

TABLE 6.3-1 (Continued)

Species	Representative of a balanced community	Commercially or recreationally valuable	Critical to structure and function of ecosystem	Food chain necessity	High potential for impingement or entrainment	Rationale for final disposition of critical determination
Seriphus politus (Queen Fish)	X			X	X	Common in source waters; previously impinged.
Embiotocidae						
Amphistichus argenteus (Barred Surfperch)	X	X	X		X	Common in surf. previously impinged.
Hyperprosopon argenteum (Walleye Surfperch)	X	X				Common in surf, kelp, lagoon; previously impinged.
Labridae						
Pimelometopon pulchrum (California Sheephead)	X	X				Common in source waters.
Mugilidae						
Mugil cephalus (Striped Mullet)	X				X	Common in source waters; previously impinged.
Bothidae						
Citharichthys sordidus (Pacific Sanddab)	X	X	X		X	Common in source waters.
Paralichthys californicus (California Halibut)	X	X	X		X	Common in source waters; previously impinged.
Pleuronectidae						
Pleuronichthys verticalis (Hornyhead turbot)	X					Common in source waters; previously impihged.

TABLE 6.3-1 (Concluded)

Species	Representative of a balanced community	Commercially or recreationally valuable	Critical to structure and function of ecosystem	Food chain necessity	High potential for impingement or entrainment	Rationale for final disposition of critical determination
Clinidae						
Heterostichus rostratus (Giant Kelpfish)	X				X	Common in kelp beds and lagoon grass beds; previously impinged.
ICHTHYOPLANKTON						
Engraulidae (Anchovies)						
Anchoa compressa	X		X	X	X	A major species or group in previous collections.
Engraulis mordax	X	X	X	X	X	
Cottidae (Sculpins)	X				X	
Serranidae (Sea Basses)	X	X	X		X	
Sciaenidae (Drums)	X	X	X	X	X	
Clinidae (Clinids)	X				X	
Gobiidae (Gobies)	X				X	
Coryphopterus nicholsi						
Bothidae (Lefteye Flounders)	X	X	X		X	
Citharichthys stigmaeus	X				X	
Paralichthys californicus	X	X			X	
Pleuronectidae (Righteye Flounders)	X	X	X		X	
Hypsopsetta guttulata	X				X	A major species or group in previous collections.
Atherinidae (Smelts, Grunion)	X	X	X			
ZOOPLANKTON						
Acartia tonsa (Copepod)	X		X	X	X	A major species or group in previous collections.

findings during the study. It was decided not to delete or add any species to the approved list, although very few individuals of some species were collected. However, certain species which were not on the list were captured in fairly large numbers during the study, and they were treated in the same manner as critical species with regard to data collected and presented in this report. Table 6.3-2 lists the additional species that have been treated as "critical" for this report and a justification for such designation. In light of the State Water Quality Control Board approval of only one zooplankton species (Acartia tonsa) on the critical list, we have added some general categories (Table 6.3-3) which were utilized to compile the basic types of zooplankters captured in collections in addition to Acartia tonsa. Data on these groups were compiled from all plankton collections taken from offshore, in the lagoons, in entrainment and entrainment mortality studies.

6.3.4 Life Histories of Critical Species

6.3.4.1 Invertebrate Zooplankton

6.3.4.1.1 Copepod (Acartia tonsa). Acartia tonsa is a major food source for many larval and small-sized fish that inhabit estuaries and bays at some point in their life cycle (6-87).

The seasonal distribution of A. tonsa in southern California is similar to that found along the colder Atlantic coast of the United States (6-88). However, in southern

TABLE 6.3-2
ADDITIONAL SPECIES TREATED AS CRITICAL FOR THIS REPORT
ENCINA POWER PLANT - AUGUST 1, 1980

	CRITERIA			
	Commercially or Recreationally Valuable	Food Chain Necessity	Abundant in Study Area	Frequently Impinged
SPECIES NAME				
Dasyatidae				
Urolophus halleri (round stingray)			X	X
Engraulidae				
Anchoa compressa (deepbody anchovy)		X	X	X
Anchoa delicatissima (slough anchovy)		X	X	
Atherinidae				
Leuresthes tenuis (California grunion)	X	X	X	X
Sciaenidae				
Genyonemus lineatus (white croaker)		X	X	X
Roncador stearnsi (spotfin croaker)	X		X	
Embiotocidae				
Cymatogaster aggregata (shiner perch)		X	X	X

TABLE 6.3-2 (Concluded)

	Criteria			
	Commercially or Recreationally Valuable	Food Chain Necessity	Abundant in Study Area	Frequently Impinged
SPECIES NAME				
Scorpaenidae				
Scorpaena guttata (sculpin, scorpionfish)	X		X	
Cottidae				
Leptocottus armatus (staghorn sculpin)			X	
Bothidae				
Citharichthys stigmaeus (speckled sanddab)		X	X	
Pleuronectidae				
Hypsopsetta guttulata (diamond turbot)			X	X

Table 6.3-3
GROUPS OF ZOOPLANKTON SPECIES UTILIZED
FOR DATA COMPILATION FOR THE STUDY
ENCINA POWER PLANT - AUGUST 1, 1980

Species	Plankton Collections	Entrainment	Entrainment Mortality
Acartia tonsa	x	x	x
Other Copepods	x	x	x
Decapod Larvae	x	x	x
Other Crustacea	x	x	x
Other Zooplankton	x	x	x
Chaetognaths	x	x	x (Sept.)
Mysidacea	x	x	x (Dec.)

California, this species does not completely disappear during winter. Populations attain a peak abundance in summer but decline to low winter levels, possibly due to the effects of lower temperatures on early life stages (6-89). The average female sheds about 44 eggs per day and produces two broods in its lifetime (6-90). The second brood is generally of less magnitude than the first (6-91). Over 1200 eggs are produced per female during its life cycle (6-92). In warm water areas, _A. tonsa_ is present in bays and lagoons throughout the year and may produce as many as 11 generations per year. The time interval between generations varies from four to seven weeks depending upon the temperature (6-93). Eggs may or may not have spines and are granular with a gold-yellow or green-yellow color. The average diameter of the eggs is approximately 80 microns. Although eggs of _A. tonsa_ in colder areas can become dormant during the winter, those in southern California do not exhibit a significant ability to do so (6-94). There are six naupliar and six copepodid life stages in the development of _A. tonsa_. Eggs and nauplii develop fastest in estuarine waters of 25.5 C. Growth rates are largely dependent upon temperature. However, high population densities can also slow growth by reducing food availability (6-95). In size, females may attain a maximum length of 1.5 mm. Males are somewhat smaller, seldom exceeding 1.0 mm in length (6-96).

Acartia tonsa thrives in lagoons and bays on both the Pacific and Atlantic coasts. It has been found from Port Jackson, New South Wales to the west coast of South America between Valparaiso and Callao. In the Americas, it has been reported in Jamaica Bay, NY, Plymouth Harbor, Charlestown Pond and Narragansett Bay (6-97). It was first reported from San Diego Bay in 1907 and later from San Francisco Bay in 1924 (6-98). Its distribution within bays and lagoons is largely dependent upon the tides. At low tide, *A. tonsa* adults concentrate in the centers of channels but later move upstream and spread out during incoming tides (6-99).

6.3.4.2 Fish

6.3.4.2.1 Round Stingray (*Urolophus halleri*). The round stingray supports no significant commercial fishery. They will take almost any of the baits used in surf and bay fishing and are frequently caught by sportsmen when fishing for other species (6-100). Stingrays are generally considered a nuisance by bathers and will frequently sting when stepped on (6-101).

A marked relationship exists between the size of round stingrays and their movements. Both the depth of occurrence and extent of migrations increase with growth.

Round stingray apparently have two breeding seasons each year. Most males and females mate during the late spring and early summer. Soon afterward, small embryos are formed within the females. Gestation takes about three months, with young being released by fall. Some males, however, may mate with females during the fall. These females apparently store the sperm for approximately three months until ovulation and subsequent fertilization occur, later during winter.

Most females bear live young every year (6-102). Each female may give birth to as many as eight young, but the average number is three (6-103). Newborn rays are relatively large, with disc width averaging 75 mm (3 in.), and capable of protecting themselves (6-104).

Round stingrays possess a poisonous spine located near the base of their tail. However, larger and older fish often lose their integumentary sheath and venom glands, preventing them from inflicting more than mechanical injury (6-105).

Stingrays feed upon crustaceans, worms and mollusks. These are dredged from the bottom by suction, which is created by the movement of their wings (6-106).

In size, stingrays longer than 381 mm (15 in.) are uncommon. However, specimens measuring greater than 508 mm (20 in.) in length have been recorded (6-107). Both males and females reach maturity at an age of 2.6 years (6-108).

In distribution, round stingrays range from Parama Bay to Humboldt Bay, including the Gulf of California. They are very common off southern and Baja California on shallow sandy and mud bottoms (6-109). Most of the population is found between 1 m (3 ft) and 15 m (50 ft) (6-110). The most common depth of occurrence is 4.5 m (15 ft) (6-111).

6.3.4.2.2 Northern Anchovy (*Engraulis mordax*). The northern anchovy is a relatively unimportant sportfish but has been reported to be taken by fishermen around jetties and piers (6-112). Commercially, anchovies are important as bait, canned pet and human food, and processed fish meal or oil. From 1952 to 1957, the commercial catch of anchovies ranged from 18,400,000 to 38,900,000 Kg annually (6-113). In 1976, landings totaled 113,325,064 Kg (124,919 tons) (6-114).

The northern anchovy is the mainstay of the live bait fishery from San Francisco to San Diego, comprising 98 percent of the total landings. From 1950 to 1966 the live bait catches have varied from 3,628,739 Kg (4000 tons) to 6,350,293 Kg (7000 tons) annually and produced an estimated average 1.5 million dollars per year (6-115). Landings for live bait totaled 6,202,422 Kg in 1976 (6-116).

During the fall and winter, schools of northern anchovy migrate offshore. Younger anchovy return to inshore areas in spring. Older adults, however, generally remain offshore, being less tolerant to higher inshore temperatures than juveniles (6-117). The major spawning season in southern California is in February and March (6-118) but the season does vary depending upon temperature and food availability (6-119). The average female will release 20,000 to 30,000 eggs per season (6-120). The clear and ovoid eggs are neutrally buoyant and range in size from 1.23 to 1.55 mm in length and 0.65 to 0.82 mm in width. Larvae hatch in two to four days and after 36 hours begin to feed on plankton comprised primarily of unarmored dinoflagellates (6-121). Larval anchovies begin to resemble adults when they reach a length of 25 mm. The adults are indiscriminant filter and particulate feeders, but have also been observed feeding on larval fish (6-122).

Northern anchovy do not typically have a long life span. Most fish taken by commercial boats range from two to three years old (6-123); however, the maximum reported age is seven years. Recent studies have shown that the average size of the northern anchovy, in relation to its age, has decreased since 1952. This decrease appears to be due to a dramatic increase in the anchovy population, an occurrence which has caused increased competition among individuals (6-124). Most northern anchovies reach maturity by the end of their second year (6-125). Some are mature after 12 months of age.

In distribution, the northern anchovy ranges from Queen Charlotte Islands, British Columbia, to Cape San Lucas, Baja California. They are most commonly found in coastal waters from San Francisco to Magdalena Bay (6-126).

6.3.4.2.3 Deepbody Anchovy (Anchoa compressa). The deepbody anchovy has little commercial value. It dies shortly after capture so it is not useful as a live bait fish (6-127).

Nearly mature eggs are found in the ovaries of female deepbody anchovies during most of the year; however, successful spawning is confined to spring or summer. The adults and juveniles are planktonic filter feeders but they have been observed selectively feeding on micro-organisms. The maximum reported size for the deepbody is 165 mm TL and the maximum age is seven years (6-128).

The deepbody's distribution range is from Morro Bay, California, to Todos Santos Bay, Baja California (6-129). It is found in abundant numbers in bays and estuaries during the summer and early fall (6-130).

6.3.4.2.4 Slough Anchovy (Anchoa delicatissima). The slough anchovy is often caught with Engraulis mordax in commercial hauls and is used as a live and dead bait fish (6-131). Although not a sportfish, it is a desirable food fish, being meatier and tastier than the deepbody anchovy (6-132).

In southern California, the slough anchovy is a resident of bays and lagoons throughout the year. However, abundances generally decline during the winter months. Adults and juveniles are nonselective planktonivores. In size, individuals as large as 100 mm FL have been reported (6-133).

Little is known about the spawning habits of this species.

The slough anchovy ranges from Belmont Shores (Long Beach), California, to Magdalena Bay, Baja California. It is found in estuaries, bays and occasionally in coastal areas just outside of bays (6-134).

6.3.4.2.5 California Grunion (*Leuresthes tenuis*). Grunion are not abundant enough to be a commercially valuable fish; however, some are incidentally taken as a minor portion of the commercial smelt catch (6-135 and 6-136). They are an important sportfish taken by hand during spawning runs. Spawning occurs during three or four consecutive nights at the extreme high tides following each full or new moon. They spawn from late February through early September. Each female buries herself to her pectoral fins and deposits eggs in the sand at the high tide mark. The male fertilizes the eggs during spawning. Females produce between 1000 and 3000 eggs every ten days during the spawning period (6-137). The eggs are spherical, 1.5 to 1.6 mm in diameter, and are a semi-transparent yellow-green color (6-138). They require approximately ten days to hatch, when the next series of high tides uncovers them (6-139). The newly hatched larvae are large (6.5 to 6.75 mm long) and possess a large yolk sac and oil globule (6-140). The grunion feed on macroscopic and microscopic plankton (6-141). Growth is very rapid during the first year and year-old grunion attain a length of 125 mm. The life expectancy for the grunion varies from two to three years, but a few specimens live to be four years old. The maximum size for grunion is about 175 mm (6-142).

The grunion ranges from Monterey Bay to Bahia Magdalena, Baja California; however, its presence in Baja is limited, due to the lack of suitable beach habitat (6-143). They are seldom captured more than a mile offshore and usually stay just beyond the surf zone (6-144).

6.3.4.2.6 Topsmelt (*Atherinops affinis*). Topsmelt are often captured by pier fishermen using hook and line and by commercial fishermen using lamperas, or similar encircling nets. The combined commercial catch of topsmelt and jacksmelt seldom exceeds 226,750 Kg (500,000 lb) per year. About 25 percent of the 320,000 topsmelt and jacksmelt caught by sportsfishermen each year are topsmelt (6-145). In California waters, the 1976 commercial catch for smelt (topsmelt and jacksmelt) was 5,098 Kg (11,256 lb) (6-146).

Four subspecies of topsmelt, generally separated by the habitat they occupy, are recognized in California (6-147). Spawning usually occurs in shallow water from late winter and spring through late summer and early fall (6-148, 6-149, and 6-150). The relatively large eggs are equipped with short adhesive filaments which attach to bits of algae and seaweed (6-151). Larvae and young occupy the bays and the upper 50 mm (2 in.) of the kelp canopy, where they feed upon small crustaceans (6-152). Juveniles predominate from summer through fall, occupying the open spaces of the surface in kelp forests and the intertidal areas of shallow rocky reefs (6-153). Algae and kelpfly larvae have been reported from the stomachs of juveniles, but adults feed almost exclusively on planktonic crustaceans within 3 to 4.5 m (10 to 15 ft) of the surface (6-154).

Topsmelt are reported to grow from 64 to 102 mm (2.5 to 4 in.) during their first year, and about 51, 38 and 19 mm during the second, third and fourth years, respectively. Females are usually larger and more abundant than males, reaching lengths of 368 mm (15 in.). The maximum age attained is generally seven to eight years (6-155). Some topsmelt reach maturity after two years but all mature by the third year (6-156).

The distribution of topsmelt ranges from Sooke Harbor, Vancouver Island, to the Gulf of California. They generally occur in large schools year-round (6-157). Although found from the surface to depths of 9 m (30 ft), topsmelt usually occupy the upper 1 m of the water column (6-158). They are also common in inshore waters, bays and estuaries and have been reported from brackish and fresh water (6-159 and 6-160).

6.3.4.2.7 Sculpin (*Scorpaena guttata*). Although common throughout the year, this popular sportsfish is taken in peak numbers during the spring and summer (6-161 and 6-162). It ranked as one of the top ten species taken by private and party boats in southern California from 1963 through 1966 (6-163). In 1978, 44,744 sculpin were landed by California party boats (6-164). The commercial catch is primarily taken on set lines and averages about 45,000 Kg (99,000 lb) per year (6-165). In 1976, 15,000 Kg (34,000 lb) were taken from California waters and 63,000 Kg (139,000 lb) from Mexican waters (landed in California) (6-166).

Sculpin appear to migrate and congregate in groups at certain locations, often remaining for days, weeks or months before dwindling or disappearing (6-167). Spawning occurs at night from April through August (6-168). The fertilized egg masses are buoyant and rise to the surface in a bilobed gelatinous mass (6-169). Larvae hatch in approximately 2.5 days (6-170). Sculpin feed upon a variety of organisms including crabs, squid, fish and shrimp (6-171). Because of their venomous spines, they are not scared easily. Wounds from these spines can be extremely painful. Sculpin reach maturity at three to four years of age at a length of about 219 mm SL. Individuals may grow to over 400 mm SL (6-172).

In distribution, the sculpin extends from the Gulf of California to Santa Cruz, including Guadalupe Island (6-173). They range from shallow tidepools inshore out to depths as great as 183 m (6-174). However, sculpin are most common in waters of less than 30 m depth, over relatively bare rocky bottoms (6-175).

6.3.4.2.8 Staghorn Sculpin (*Leptocottus armatus*). The staghorn sculpin has little recreational or commercial value but has been reported to be taken by anglers from piers and jetties (6-176).

Most staghorn sculpin spend their entire life span in saltwater; however, some larvae and juveniles have been found in freshwater. The adult fish spawn in marine waters, offshore or in bays, from October through March. Individual fish will spawn only once during this season. After mating, each female reportedly moves into brackish lagoons (those having salinities of about 28 ppt) to lay approximately 5000 eggs in a sticky demersal cluster. These eggs require from 9 to 14 days to hatch at 15 C. Some newly hatched larvae migrate up rivers past the limits of tidal influence. At three months of age most of the young return to the estuaries, although some fish as old as two years have been found in freshwater streams (6-177). The diet of juvenile staghorn sculpin consists primarily of tubiculous amphipods, polychaetes, insect larvae and other invertebrates. Adults feed upon small shrimp, ghost shrimp and small fishes (6-178). The maximum size for these sculpins is just under 305 mm and the maximum age is 5 years (6-179). Staghorns reach maturity by the end of their first year at a length of about 120 mm (6-180).

The staghorn sculpin ranges from Kodiak Island, Alaska, to San Quentin Bay, Baja California, and is one of the most widely distributed cottids on the Pacific coast (6-181). It has been reported from depths out to 155 m, but is seldom found below 18 m (6-182).

6.3.4.2.9 Kelp Bass (*Paralabrax clathratus*). The kelp bass was the most important fish caught by sportsmen on party boats during 1964 (6-183). Off of San Diego, the Point Loma kelp beds alone yielded an estimated annual 9.5 Kg per acre for this species (6-184). In southern California, more kelp bass are landed each year than yellowtail, albacore and white seabass combined (6-185). In 1978, 344,917 fish were landed on party boats alone (6-186).

Large-scale migrations of the kelp bass have not been observed, and different kelp stands appear to contain local resident populations (6-187). However, adults will move into areas of low species density (6-188). Larger kelp bass become reproductive earlier in the season than smaller fish and can be found in reproductive condition from April through December. The majority of spawning takes place from July through September. Spawning kelp bass generally congregate in large groups in deep water kelp stands (6-189). The eggs are pelagic and subsequent larvae (25 to 50 mm TL) are found inshore from summer until late December (6-190).

Kelp bass grow slowly but may live up to 32 years and reach a maximum size of 640 mm TL (6-191). Most reach maturity at a size of about 254 mm and an age of two years (6-192 and 6-193). The adult's diet consists of fish and cephalopods. Juveniles, however, feed upon demersal crustacea (6-194).

Kelp bass range from Monterey Bay, California, to Point Abreojos, Baja California, but are considered uncommon north of Point Conception (6-195).

6.3.4.2.10 Spotted Sand Bass (Paralabrax maculatofasciatus). The commercial fishery for Paralabrax sp was halted in 1947 in California. Approximately 12,000 are taken by sportsfishermen each year, exclusive of the sportboat fishery catch (6-196).

Spawning occurs during the spring and early summer (6-197). The spotted sand bass has pelagic eggs. Young bass utilize bays and lagoons as nursery grounds (6-198). Individuals may grow to a maximum size of approximately 40 cm and a weight of 2.7 kg. Fish as old as 15 years have been reported (6-199).

The spotted sand bass ranges from San Francisco to Mazatlan, Mexico, although they have not been numerous in waters north of Monterey Bay since 1880 (6-200). They inhabit bays and lagoons almost exclusively and are most common at depths from 1 to 9 m. These fish are generally found on flat sand bottoms associated with Zostera (eelgrass) (6-201, 6-202, and 6-203).

6.3.4.2.11 Barred Sand Bass (Paralabrax nebulifer). Commercial fishing for all sand bass (Paralabrax sp) was halted in 1947 (6-204). However, sand bass are still popular sportsfish and are taken in large numbers on party boats each year (6-205). Barred sand bass make up only a small portion of the total sand bass landings (6-206). In 1978, 110,377 individuals were taken by California party boats (6-207).

Barred sand bass have been observed at local areas by divers throughout the year and do not appear to migrate (6-208). The spawning season runs from April to October. However, most fish spawn in July and September during the warmer months of the year (6-209). The eggs, like those of other sand bass, are pelagic. Juveniles are common around the entrances of bays in eelgrass beds during fall and winter (6-210). Adult barred sand bass feed mainly upon shrimp, crabs, ophiuroids and small fish (6-211). Individuals reach maturity at a length of about 240 mm (6-212). Fish as large as 660 mm have been reported (6-213).

In distribution, these sand bass are found from Monterey Bay, California, to Magdalena Bay, Baja California (6-214 and 6-215). They are bottom fish generally found inhabiting sandy areas around rocks at depths from 3 to 40 m (6-216).

6.3.4.2.12 Queenfish (*Seriphus politus*). Queenfish have little commercial value. They are small fish and difficult to catch in commercially profitable quantities (6-217). In 1976, 5888 Kg (12,914 lb) were landed in California waters (6-218). In a typical catch of queenfish and white croaker, the queenfish comprised only 1 percent of the marketable catch. To the sport fishermen, the queenfish are valued as live bait. They are hardy, available during most of the year, able to live in small receptacles for extended periods, and being bottom fish, they remain near the bottom while hooked (6-219).

The queenfish have been observed to migrate seaward, into deep water, at night (6-220). During the winter they move offshore becoming less available to anglers (6-221). Ripe adults have been collected during midsummer and young appear in late summer and fall. The queenfish enters spawning condition in April and spawns into August (6-222, 6-223, and 6-224). Their ovaries contain various types of oocytes, which is common among fish with long breeding seasons and multiple spawnings (6-225). The eggs are pelagic, giving birth to tiny young in late summer and fall (6-226). The queenfish frequently associates with other fish, especially the white croaker (6-227). They feed on small shrimp, fish and worms. Individuals generally mature at a body length of about 170 to 220 mm (6-228).

Distribution of the queenfish extends from Yaquina Bay, Oregon, to Uncle Sam Bank, Baja California (6-229), but they are more common south of Point Conception. They prefer shallow water and sandy bottoms and are common in bays and sloughs, swimming in small dense schools.

6.3.4.2.13 White Seabass (*Cynoscion nobilis*). Commercial fishing for white seabass using round haul or encircling nets, was outlawed in California in 1940. Since that time, commercial landings have been taken primarily using gill nets (6-230). From 1920 to 1970, the average commercial catch has been about 450,000 Kg per year (6-231). In 1976, 90,000 Kg (198,000 lb) were landed from California waters and 390,000 Kg (860,000 lb) from Mexican waters (6-232). The commercial fishing activities usually extend from Morro Bay to Baja California. Much of the California catch, however, is taken from waters off Santa Catalina and San Clemente Islands (6-233). The white seabass is also a popular sportfish taken by skiff fishermen, scuba divers and other anglers. In 1978, 432 seabass were landed by party boats in California (6-234).

From existing data, white seabass appear to spawn from March through August (6-235). During this period adult fish congregate around coastal kelp beds and areas of rocky relief. Seabass eggs being pelagic, larval fish and young are commonly found in bays and in the surf zone during late summer and fall (6-236 and 6-237).

A record size of 37 Kg was recorded for this species, but individuals larger than 27 Kg are rare (6-238, 6-239, and 6-240). Many fish live to 20 years or older. The males mature about a year before the females, at an age of 3 to 4 years and a size of about 550 mm.

White seabass are distributed from Juneau, Alaska, to the Gulf of California but are most common south of San Francisco. Adults occur from surf zone offshore to areas as deep as 122 m. However, they are more typically found at depths of 15 to 23 m around kelp beds, over rocky or sandy bottoms (6-241, 6-242, and 6-243). Adult seabass generally occur in loose schools around kelp beds. They have been observed entering rivers on occasion (6-244).

6.3.4.2.14 California Corbina (*Menticirrhus undulatus*). Commercial fishing for corbina has been outlawed since 1909 and the sale or purchase of them illegal since 1915 (6-245). However, they are a highly prized and sought after sportsfish, especially by the surf fishermen. They are taken year-round along southern California's sandy beaches, but fishing is best from July through September (6-246). Baxter (1974) found that soft-shelled sandcrabs are the preferred bait, although fishermen also have good success with bloodworms, mussels, clams and pileworms (6-247). In 1960, the corbina comprised 17 percent of the total surf fishing catch in southern California (6-248). In 1964, it was considered to be the most important surf fish caught by sportsfishermen (6-249).

California corbina move offshore into deeper water in the summer months during spawning (6-250 and 6-251). Tagging studies have indicated movements of up to 82 km (6-252). Corbina are summer spawners, with the heaviest activity taking place during July and August (6-253, 6-254, and 6-255). Once the pelagic eggs hatch, young show very high growth rates for the first two years, especially during the summer months (6-256). The species is reported to feed in very shallow water, scooping up mouthfuls of sand and feeding upon small crustaceans (6-257). Analysis of stomach contents have shown that they feed upon mysids, amphipods, bean clams and sand crabs (6-258). Males mature at two years of age and at a length of about 250 mm. Females mature at three years and a length of about 300 mm (6-259). The largest reported fish was 710 mm long, weighed 3.2 Kg, and was approximately 8 years old.

The corbina commonly ranges from Point Conception to the Mexican border, although stragglers may occur as far north as San Francisco and as far south as the Gulf of California (6-260 and 6-261). They are commonly found in the water column from the surface down to 14 m (6-262). Fish are often observed in aggregations of from two to five individuals, although occasional schools of hundreds have been noted (6-263).

6.3.4.2.15 White Croaker (*Genyonemus lineatus*). By virtue of its relatively great abundance in California waters, the white croaker is a species of significant commercial interest (6-264). Commercial catches are made primarily using round haul nets. In recent years, however, landings have declined. Total commercial catch has dropped since 1952 from close to 1,000,000 Kg to an average of 230,000 Kg per year (6-265). In 1976, 227,000 Kg (497,000 lb) were landed from California waters (6-266). As a sportfish, the white croaker is also significant. It was considered to be the most important fish taken by sportfishermen in California bays and lagoons during 1965 (6-267). In 1978, over 17,000 fish were landed on California party boats alone (6-268).

Although present year-round, the white croaker seems to be more common during the summer months (6-269). Spawning occurs from October through April and may continue sporadically into the summer (6-270 and 6-271). The croaker's diet consists of live or dead fish, squid, shrimp, octopi, worms and other items. White croakers reach maturity and spawn for the first time during spring of their second or third year (6-272). Individuals vary from 130 to 150 mm in length at this time. They grow to a maximum of 510 mm in length and 1 Kg in weight. White croakers may live to be 15 years old or more (6-273).

In distribution, the white croaker ranges from Magdalena Bay, Baja California, to Vancouver Island, British Columbia (6-274, 6-275, and 6-276). However, it is not common in waters north of San Francisco (6-277). The croakers are usually found in loose schools at or near the bottom in sandy areas (6-278). They are common both in the surf zone as well as in shallow bays and lagoons. Normally, these fish inhabit waters from 3 to 30 m deep.

6.3.4.2.16 Spotfin Croaker (*Roncador stearnsi*). Although commercial use of spotfin croaker has been outlawed since 1909, their importance as a recreational fish has increased because of their beauty, fine fighting spirit and delicate taste (6-279). They are taken along the shoreline, in bays, off jetties and piers and occasionally by spear fishermen (6-280 and 6-281).

Skogsberg (1939) observed that spotfin croaker appear to be seasonal in occurrence and show at least a limited migration by moving into deeper waters during the cooler seasons (6-282). The presence of spent females in late summer and young during the fall indicates a summer spawning season for this species (6-283, 6-284, and 6-285). The croaker eggs are pelagic (6-286). After hatching, the young spread throughout the surf zone, where they apparently reside. Their food consists primarily of polychaetes, clams, crabs and various small crustaceans (6-287). The spotfin is unique among croakers in that they are able to crush and ingest heavily shelled food (6-288). They do not appear to reach sexual maturity until the beginning of their third growth year, at a length of about 230 mm (6-289 and 6-290). Annual growth during their first two years is rapid (100 mm/yr) although net weight gain is greatest in the third growth year (6-291). Temperature appears to be a key factor influencing their growth.

000228

Their distribution ranges from Point Conception to Maddalena Bay, Baja California, but sightings north of Los Angeles are not common (6-292, 6-293, and 6-294). The spotfin croaker is a shallow-water fish, preferring sandy beaches, sloughs and bays and appears not to exceed depths of 6 to 9 m (6-295). They may swim in small schools of up to 50 individuals but generally only two or three are found together (6-296).

6.3.4.2.17 Barred Surfperch (Amphistichus argenteus). South of Point Arguello, California, barred surfperch have been reserved exclusively for sportfishing since 1953. In this region, from 1963 to 1965, anglers landed an average of 114,000 individuals per year (6-297). In 1965 they were considered to be the most important surf fish taken on the open coast by sportfishermen (6-298). The predominant California commercial fishing areas are between Point Mugu and Pismo Beach. All of the commercial catch is sold as fresh fish.

General migratory patterns for this species have not been substantiated. However, tagging studies have shown that individuals may move considerable distances along the coastline (57 km in 48 days) (6-299).

Like the other surfperches, the barred surfperch is viviparous, giving birth to live young. Mating occurs from November through January, with the older females usually mating during the earlier parts of the season (6-30().

Following a gestation period of five months, the young are released at sizes ranging from 42 to 53 mm. The average number of young released per female is 33.4 fish, but the number of young varies directly with the female's size (6-301). The surfperch's diet consists mainly of sand crabs (93 percent), but razor clams, bean clams, mussels, crabs and small fish are also consumed (6-302). Males mature at some time during their first year, but females usually do not mature until after their second year (6-303). A typical specimen averages about 128 mm in length by the end of its first year. Maximum individual sizes on record are a 305 mm long male (6 years old) and a 430 mm long female (9 years old) (6-304 and 6-305).

Barred surfperch are typically found in breaking surf over sandy bottoms. Their range extends from Bodega Bay, California, to Playa Maria Bay, Baja California.

6.3.4.2.18 Walleye Surfperch (*Hyperprosopon argenteum*). The walleye surfperch is one of the two most important surfperch caught in California (6-306, 6-307, 6-308, 6-309, and 6-310). They are taken commercially with round haul nets, gill nets and beach seines. They are sold mostly on the fresh fish markets, but some are used as cut bait by commercial long line fishermen (6-311). In 1976, the total California commercial perch catch (comprised of various species) was 64,000 Kg (141,000 lb) (6-312).

Schools of walleye surfperch dissipate into small mating groups during the period from October through December (6-313). Each group consists of 4 to 10 females accompanied by one male (6-314). Following a five or six month gestation period, each female releases from 5 to 12 live young (about 40 mm TL) (6-315 and 6-316). Walleye reach maturity by the end of their first winter (6-317). One year old fish measure from 90 to 120 mm TL, while six year old individuals vary from 150 to 180 mm (6-318). The maximum recorded age for a male or female is six years. In general, the surfperch are considered to be nocturnal predators, feeding upon large zooplankton and small crustaceans (6-319).

The walleye surfperch is widely distributed from Vancouver Island, British Columbia, to Santa Rosalia Bay, Baja California (6-320 and 6-321). They usually occur over sand patches and among rocks within the surf zone. Often these fish aggregate in dense schools (2 to 2.5 m thick) comprised of several hundred to several thousand individuals (6-322).

6.3.4.2.19 Shiner Surfperch (*Cymatogaster aggregata*). In California, the shiner surfperch is of little commercial value. To a minor extent, it is occasionally taken as a bait fish (6-323). As a sportfish, it is caught by anglers on piers and other structures, but its small size makes it of little recreational importance.

The migration patterns of the shiner are generally associated with its breeding cycle. The species is a viviparous annual breeder and mates inshore during the spring and early summer (6-324 and 6-325). In spring, adult females enter the bays to give birth and to mate. Males migrate to the breeding areas during spring and summer. After breeding has been concluded near the end of summer, almost all adult shiners move out of the bays to ocean areas (6-326). Sperm is apparently stored by the female surfperch until fall or early winter, when the eggs undergo fertilization. Embryos are retained until the following June or July when they are released in the inshore breeding areas (6-327). Males are born mature, and females become mature shortly after birth (6-328). Newborn fish first mate during the several months following their birth. They grow rapidly, reaching adult size during their first year. The maximum reported length and age for an individual is 178 mm TL and 4 years, respectively (6-329).

The shiner surfperch is an omnivore which feeds by picking around structures and eelgrass beds. Animals reported from gut analysis of this fish include amphipods, annelids and fish eggs (6-330).

The shiner surfperch ranges from Port Wrangle, Alaska, to Ensenada, Mexico, making it the most widely distributed surfperch on the west coast (6-331). Although a euryhaline species occasionally observed in freshwater, the shiner is generally found around pilings, docks, eelgrass beds, shallow bay areas and the surf zone.

6.3.4.2.20 Striped Mullet (*Mugil cephalus*). The striped mullet is of only minor commercial and recreational importance on the California coast, although it may be considered a good food fish in other areas (6-332). During 1976, only 1,360 Kg (3000 lb) were landed commercially in California (6-333).

Striped mullet exhibit definite patterns with respect to seasonal distribution. They move offshore in winter, often against the prevailing currents, to spawn in waters that may be as deep as 1500 m (6-334 and 6-335). Fertilization is accomplished externally, ova and sperm shed freely into the water (6-336). The pelagic eggs hatch in about two days and the resulting larvae drift from the spawning grounds with the prevailing currents. At a length of just over 25 mm, young commence moving shoreward into bays and estuaries (6-337). Larger young (50 to 130 mm) become abundant in shallow water, schooling in estuaries and the lower freshwater zones. By mid-summer, juveniles may travel considerable distances up river systems or even migrate to sea and travel along the coast to other inshore systems (6-338). Mullet regularly ascend sluggish rivers and may be able to complete their entire life cycle in freshwater (6-339). In general, however, striped mullet can be found nearshore in the surf zone and coastal areas throughout much of the year.

Age and size at maturity vary considerably, depending upon geographic location (6-340). Males (230 to 530 mm FL) mature at ages from 1 to 7 years, females (240 to 614 mm FL) from 2 to 8 years.

Mullet undergo marked changes in feeding habits with development. The diet of larvae and young is essentially carnivorous, consisting primarily of copepods and other zooplankton (6-341). By the time they have reached a length of about 55 mm, young mullet have undergone a transition to a benthic grazing habit, which is characteristic of the adult fish. Organic detritus, bacteria, macroinvertebrates and algae make up most of this diet (6-342 and 6-343).

The striped mullet is world-wide in distribution. It has been found in all warm seas along continents from approximately 42 degrees north to 42 degrees south latitude (6-344 and 6-345). Mullet have been reported in waters ranging from 0 to 75 ppt salinity but prefer temperatures above 16 C.

6.3.4.2.21 California Sheephead (*Pimelometopon pulchrum*). The commercial fishery for the California sheephead has declined in recent years, reflecting a lack of consumer demand. Landings have decreased from 45,360 Kg (100,000 lb) in 1948 to less than 3175 Kg (7000 lb) in 1956 (6-346). In 1976, the commercial catch amounted to only 3623 Kg (6-347). Recreational interest in this species has been significant. California party boat fishermen caught an average of 15,000 fish per year during the period from 1950 to 1970 (6-348).

A peak catch of 53,000 fish was recorded in 1966. In 1978, 34,409 sheephead were landed on party boats (6-349).

No seasonal movements have been reported for the sheephead. Limbaugh (1955) reported sheephead to be solitary wanderers, never remaining long in one place (6-350). Fitch (1958), however, based on reports from skindivers, claimed that it was safe to assume that sheephead travel very little, particularly as adults (6-351).

California sheephead probably first spawn at four or five years of age at a length of about 200 mm SL. Most function as females for the first four years. At a length of about 310 mm some fish may undergo a sexual transformation (6-352). Warner (1975) suggests that spawning occurs a number of times during a single breeding season, probably occurring in July, August and September (6-353). The eggs are pelagic and are believed to be free-floating (6-354 and 6-355). Young sheephead (about 13 mm) are common from late May through December. They live close to rocks and around beds of gorgonian corals (sea fans), and at depths from 3 m (9.8 ft) to well below 30 m (98 ft) (6-356 and 6-357). At two years of age sheephead are from 152 to 203 mm (6 to 8 in.) long. Individuals can grow to total lengths of over 800 mm (31.5 in.). The oldest sheephead recorded was a 53 year old male (6-358).

Adult sheephead feed upon a variety of organisms, including sea urchins, mussels, crabs, snails, squid, bryozoans, sand dollars and sea cucumbers (6-359).

In distribution, the California sheephead ranges from Cape San Lucas, Baja California, to Monterey, California (6-360). They are generally confined to temperate waters (6-361). In southern California, the species is commonly found among rocky shores and kelp beds at depths between 5 and 50 m (6-362).

6.3.4.2.22 Giant Kelpfish (*Heterostichus rostratus*). Although taken by commercial fishermen in offshore kelp beds, giant kelpfish are of only minor commercial and recreational importance (6-363). Spawning occurs from March through July. The eggs are laid on various plants, including sargassum, kelp and surfgrass, being attached by means of adhesive threads. Males generally remain around the eggs to guard them from predators (6-364). Transparent post-larvae begin to appear from April through August, usually in shallow water at depths from 1.5 to 9 m (5 to 30 ft). Young kelpfish school until they begin to assume adult coloration patterns at a length of about 64 mm (2.5 in.). Adults are usually solitary in habit, living close among the seaweeds (6-365).

Giant kelpfish are the largest of the clinoid blennies on the California coast, reaching lengths of 610 mm (24 in.)

(6-366). Their diet consists mainly of small crustaceans, but small fish and mollusks may also be eaten (6-367).

In distribution, giant kelpfish range from British Columbia to Cape San Lucas, Baja California. They are generally concentrated in shallow water, out to depths of 30.5 m (100 ft) (6-368). Kelpfish are common in algae, kelp beds, rocky tidepools and eelgrass beds in bays and lagoons (6-369).

6.3.4.2.23 California Halibut (*Paralichthys californicus*). The California halibut is valuable to both the commercial and recreational fisheries. It is an excellent food fish. The greatest recorded commercial catch of just over 2,000,000 Kg (4,500,000 lb) was made in 1919 (6-370). Since then, landings have fluctuated greatly, dropping to as low as seven percent of this peak catch during some years. In 1976, landings amounted to 284,000 Kg (627,000 lb) in California (6-371). Most commercial fishing is done with trammel nets and otter trawls, in water at depths greater than 18.2 m (60 ft). Since WWII, party boat anglers have made annual sport catches ranging from 10,000 to 150,000 individuals (6-372). In 1964, this species was ranked as the second most important sportfish taken by party boats (6-373). In 1978, 5400 fish were landed by California party boats (6-374).

In spring, mature halibut migrate from deeper offshore water to shallow areas near the coast to spawn (6-375).

After spawning they return to deeper water leaving the young behind. Other than this seasonal spawning migration, they move very little. Of more than 12,000 fish tagged during a survey conducted over several years, only about 10 percent of those recovered had traveled more than a mile from the point of release (6-376). The California halibut is oviparous and spawns in water 6 to 20 m deep from about February to July (6-377). Eggs are pelagic. East Coast species of the genus are reported to take up a bottom dwelling existence almost immediately (6-378). When they reach a length of approximately 200 mm (8 in.), which coincides with the maturation of the males, they emigrate to deeper water (6-379). Male halibut are mature in two to three years, while the females do not spawn until four to five years of age (6-380). Females grow faster and attain larger sizes than males. Almost all fish over 13 Kg (30 lb) are females, with the record individual measuring 1500 mm (5 ft) in length and weighing 32.4 Kg (71 lb) (6-381). They are reported to attain ages of at least 30 years (6-382).

California halibut occur from the Quillayute River, British Columbia, to Magdalena Bay, Baja California, but are uncommon north of San Francisco. They inhabit depths to 180 m and are commonly found in bays and estuaries along the central and southern California coast (6-383).

6.3.4.2.24 Pacific Sanddab (Citharichthys sordidus). Both the speckled and Pacific sanddabs are included in the commercial catch statistics, yet the Pacific sanddab comprises most of the combined catch (6-384). They are an important fish in the fresh fish markets, especially in the San Francisco area. Commercial landings of sanddabs in California have fluctuated between 226,796 and 907,184 Kg since 1917. Only a small percentage of these were taken in southern California waters (6-385, 6-386, 6-387, 6-388, and 6-389). In 1976, 586,124 Kg (1,293,872 lb) were landed in California (6-390).

Pacific sanddabs occur in water from 18 to 180 m deep. Pinkas (1977) observed that commercial catches are not seasonal and reported that C. sordidus does not undergo any major seasonal migrations (6-391). Pearcy (1978), however, reported the sanddab to be more abundant in shallow water during the summer months (6-392).

Spawning begins in July and continues through September. Evidence indicates that females probably spawn more than once during this period (6-393 and 6-394). Mature eggs are spherical (0.5 to 0.6 mm diameter) and transparent, containing a single oil globule (6-395). Pacific sanddab mature in two to three years at a length of about 165 mm (6-396, 6-397, and 6-398). Females are typically larger than males. Individuals may grow to 400 mm and 1 Kg in 8 to 10 years. Sanddabs feed on pelagic crustaceans and do not

000239

appear to exhibit benthic feeding habits. These fish generally feed in the water column at night (6-399).

Pacific sanddab range from northwestern Alaska to Baja California. They are most abundant in central California, from Bodego Bay to Monterey Bay (6-400 and 6-401). These fish prefer sandy or muddy bottoms.

6.3.4.2.25 Speckled Sanddab (*Citharichthys stigmaeus*). The speckled sanddab is not an important sport or commerical food fish because of its small size (6-402).

The adults appear to be randomly distributed throughout its range during the entire year and exhibit no large-scale migrations. The spawning season begins in April and declines in September. Warm water may trigger the spawning process. The number of eggs spawned per female ranges from 4200 to 30,800, depending on the size of the female. The average female may spawn as many as three times in a season. Eggs are pelagic, transparent and contain a single oil globule. The larvae can occur from the surface to 90 m but most are found from 25 to 50 m deep (6-403). Many young larvae occur several kilometers offshore but these may be carried to sea by currents and may be lost to the population (6-404). The larvae have a relatively long pelagic period. Major recruitment into the settled speckled sanddab population is from May to October. The adults feed on a variety of prey species consisting of mostly crustacea and larval fishes. The average life span is 36 to 42 months and their size ranges from 25 to 150 mm. Individuals larger than 130 mm are rare. Most speckled sanddabs are sexually mature in the second year of life when the females reach a length of 70 to 80 mm (6-405).

Speckled sanddab range from Montague Island, Alaska, to Magdalena Bay, Baja California. Although reported from sand or mud bottoms at depths from 3 to 370 m, they are seldom taken below 60 m (6-406). Young juveniles (<1 year old) are most common at depths from 15 to 25 m (6-407).

6.3.4.2.26 Hornyhead Turbot (*Pleuronichthys verticalis*). Only since the 1950's have turbot been marketed commercially in any quantity, and then primarily as mink food (6-408). The low commercial turbot catch is due to their limited accessibility. They primarily inhabit shallow water within 4.8 km of shore, where commercial trawling is prohibited (6-409). In 1976, 13,400 Kg (29,590 lb) of turbot were landed in California (6-410). Although their flesh is tasty and firm, they are not sought after by sportfishermen because of their small size.

The hornyhead turbot has an extended spawning period from March to August (6-411). Their eggs are pelagic, spherical and average 1.07 mm in diameter. Hatching occurs approximately 110 hours after fertilization, and the newly hatched larvae are about 3.2 mm long (6-412).

Females are usually more numerous and larger than males (6-413). The largest specimen on record measured 370 mm in length (6-414).

Hornyhead turbot are found from Point Reyes, California, to Magdalena Bay, Baja California (6-415). They are primarily a shallow water fish, although individuals have been taken in waters as deep as 187 m.

6.3.4.2.27 Diamond Turbot (*Hypsopsetta guttulata*). Turbot are of only minor importance to the California commercial fishing industry. They are primarily considered as incidental catch in normal fishing operations. Reported catches consist of the combined landings of diamond, spotted, hornyhead, C-O and curlfin turbots. From 1973 to 1975 an average of only 12,000 Kg were taken annually (6-416, 6-417, and 6-418). In 1976, 13,400 Kg of turbot were landed in California (6-419). Diamond turbot are, however, an important recreational species. In California bays and sloughs, they are one of the most often caught fish by anglers. Mission Bay (San Diego) and Newport Bay (Newport Beach) yield very high catches year-round (6-420).

Diamond turbot probably do not make any significant seasonal migrations, indicated by their year-round abundance in sloughs, bays and calm coastal waters. Spawning occurs in early spring, when pelagic eggs are released (6-421). Small yolk-sac larvae (2.2 mm long) are pelagic for the first few days, but they soon move toward the bottom to adopt a benthic habit. These fish mature at two to three years of age and grow to a maximum size of 460 mm and 1.8 Kg (6-422). Diamond turbot feed nocturnally on various benthic invertebrates. Clams and polychaetes have been reported as primary food sources for this species (6-423 and 6-424).

Diamond turbot range from Cape Mendocino, California, to Cape San Lucas, Baja California. They occur at water depths out to 45 m but are most abundant at depths of less than 18 m (6-425, 6-426, and 6-427).

6.4 PLANKTON

Monthly plankton collections were made in both the near-field and far-field during the year long study to evaluate the abundance and distribution of critical species.

6.4.1 Abstract and Summary

Monthly plankton collections were made for a year offshore at five sampling stations using 505μ and 335μ nets attached to a 61 cm bongo net system. Collections were made monthly in the middle and upper Agua Hedionda Lagoon segments and every two weeks in the outer Agua Hedionda Lagoon segment for a year using half-meter plankton nets (505μ and 335μ). Data for each mesh size is considered separately.

Two mesh sizes, 505μ and 335μ, were used in all phases of plankton studies. The 505μ nets were employed in order to allow comparison of the results of the present study with previous environmental studies at Encina and with California Cooperative Oceanic Fisheries Investigations (CALCOFI). The 335μ nets were used in order to capture small plankton forms (e.g., *Acartia tonsa*) and to allow comparisons with other study results. Data derived from the two meshes represent independent estimates of plankton abundances and are not directly comparable. While this resulted in different estimates of species abundances (the smaller mesh net generally giving a greater abundance estimate because more organisms were captured in the smaller mesh) it will contribute data for comparison with any future research.

Ichthyoplankton (fish eggs and larvae) and other zooplankton were examined from all samples. One invertebrate copepod species (Acartia tonsa) and nine groups of ichthyoplankton (Engraulidae - anchovies, Atherinidae - smelt, Cottidae - sculpin, Serranidae - sea basses, Sciaenidae - croakers, Clinidae - kelpfish, Gobiidae - gobies, Bothidae - flatfish, Pleuronectidae - flatfish) were examined in detail.

Collections from the lagoon and offshore captured 123 invertebrate and 71 ichthyoplankton taxa.

Invertebrate species comprised the vast majority of the plankton collections consisting of 85 (505μ) and 98 (335μ) percent of the total catch. Offshore, invertebrates comprised 95 (505μ) and 99 (335μ) percent of the catch, while in the lagoon they comprised 63 (505μ) and 94 (335μ) percent. Average densities of invertebrate species offshore were 8,750 (505μ mesh) and 130,906 (335μ mesh) individuals per 100 m^3 of water. In the lagoon invertebrate densities were 1,016 (505μ mesh) and 30,558 (335μ mesh) individuals per 100 m^3 of water.

Copepods were the most abundant invertebrate zooplankton species comprising 52 (505μ) and 78 (335μ) percent of the total plankton catch. They comprised 71 (505μ) and 80 (335μ) percent of the total plankton catch offshore and 10 (505μ) and 74 (335μ) percent of the total catch in the lagoon. All the major invertebrate zooplankton groups (Table 6.4-8) were captured offshore and in the lagoon.

Ichthyoplankton species comprised 15 (505μ) and 2 (335μ) percent of the total plankton catch. Offshore they comprised five (505μ) and one (335μ) percent of the catch, while in the lagoon they comprised 37 (505μ) and 6 (335μ) percent of the catch. Offshore ichthyoplankton densities were 474 (505μ) and 728 (335μ) per 100 m^3 of water, while in the lagoon they were 700 (505μ) and 1,974 (335μ) per 100 m^3 of water. Anchovy (Engraulidae) densities were 403 (505μ) and 1,592 (335μ) larvae and/or eggs per 100 m^3 in the lagoon catches. If anchovies are removed from catches, lagoon densities were 297 (505μ) and 383 (335μ) per 100 m^3 while offshore densities were 423 (505μ) and 718 (335μ) per 100 m^3. Greater densities of all species other than anchovies occurred offshore, and the offshore population included a greater variety of species.

Anchovies were the most abundant ichthyoplankton species comprising seven (505μ) and one (335μ) percent of the total plankton catch. Anchovies (Engraulidae) ranked number one in the lagoon collections comprising 24 (505μ) and 5 (335μ) percent of the catch. Offshore, anchovies ranked number four, comprising 0.1 (505μ) and 0.04 (335μ) percent of the total plankton catch. Croakers (Sciaenidae) ranked number one offshore, comprising four (505μ) and 0.4 (335μ) percent of the total plankton catch.

Estimates of average instantaneous plankton numbers present in Agua Hedionda Lagoon ($4x10^6$ m^3 water volume) were $5.5x10^7$ with 505μ samples and $2.4x10^9$ with 335μ samples. Estimates of instantaneous plankton numbers present for the offshore zone ($12x10^6$ m^3 water volume) were $6.8x10^8$ for 505μ samples and $3.1x10^{10}$ for 335μ samples. These abundances are consistent with other studies conducted on plankton in southern California waters.

Spatial distributions were described for critical plankton species both offshore and in the lagoon. A number of the species (Acartia tonsa, Engraulidae, Atherinidae, Sciaenidae, Clinidae, and Gobiidae) were widespread and captured at all offshore and lagoon stations. Three groups (Serranidae, Bothidae, Pleuronectidae) were more widespread at offshore stations than in the lagoon. The Cottids were sparsely scattered offshore and in the lagoon.

Temporal plankton distributions were variable depending on species. A number of the groups studied (Acartia tonsa, Sciaenidae, and Clinidae) were collected throughout the year. Others were collected during only part of the year.

Seasonal peaks in invertebrate populations occurred in spring, fall and winter offshore and in spring-early summer, fall and winter in the lagoon (examples shown in Figures 6.4-4 and 6.4-5). Seasonal peaks in ichthyoplankton abundances occurred in spring, summer and fall offshore, and in spring and summer in the lagoon (examples shown in Figures 6.4-12 and 6.4-14). Ichthyoplankton numbers were dominated by eggs.

Overall plankton abundances were greater offshore than in the lagoon and most all lagoon species appeared to be originating offshore with the exception of a few lagoon species such as gobies and anchovies (Anchoa sp.).

6.4.2 Methodology

Monthly studies of plankton in the vicinity of the Encina Power Plant were conducted at five offshore and six lagoon stations (Figure 6.4-1). Offshore plankton was sampled using a bongo net system, equipped with 505μ and 335μ mesh nets (Figure 6.4-2). Restrictions imposed by limited working area and practicable boat size necessitated the use of smaller sampling gear for lagoon collections. Lagoon samples were obtained using paired 0.5 m diameter plankton nets (one 505μ mesh; the other, 335μ mesh).

Plankton sampling was generally performed during the daylight hours. However, some night collections were also taken. All plankton specimens were preserved for subsequent laboratory analysis (Appendix B, Section 16.2.6). Detailed methodologies for all plankton collections and processing are given in Appendix B.

6.4.3 Rank Order - Abundance

Rank orders were compiled for plankton abundance for offshore and for the lagoon. The data was compiled separately for the 505μ and 335μ mesh nets as the smaller mesh caught more of many organisms (Tables 6.4-1 and 6.4-2). Zooplankton species ranked as most abundant in nearly all samples. Copepods predominated with *Acartia tonsa* being very abundant both offshore and in the lagoon (Tables 6.4-1 through 6.4-6). Copepods, decapods, and other crustaceans also ranked high on the list (Tables 6.4-1 and 6.4-2). *Acartia tonsa* comprised 67 percent of the

TABLE 6.4-1
RANK ORDER OF OFFSHORE AND LAGOON PLANKTON SPECIES CAPTURED IN 505μ NETS FROM JANUARY THROUGH DECEMBER, 1979 AT THE ENCINA POWER PLANT

SPECIES NAME	COMMON NAME	# PER 10C M3	PERCENT OF TOTAL	RANK
SUBCLASS COPEPODA		1644.429	39.73	1
OTHER CRUSTACEANS		537.554	12.99	2
ACARTIA TONSA		533.295	12.88	3
ORDER DECAPODA		375.005	9.06	4
FAMILY ENGRAULIDAE		280.365	6.77	5
OTHER ZOOPLANKTON		256.471	6.20	6
FAMILY SCIAENIDAE		220.604	5.33	7
PHYLUM CHAETOGNATHA		105.038	2.54	8
ORDER MYSIDACEA		92.613	2.24	9
CITHARICHTHYS SP.		36.599	.93	10
UNID.FISH EGGS		19.048	.46	11
FAMILY GOBIIDAE		8.186	.20	12
FAMILY ATHERINIDAE		7.118	.17	13
ANCHOA SP.		4.191	.10	14
FAMILY LABRIDAE		3.329	.08	15
FAMILY SERRANIDAE		2.415	.06	16
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT	1.622	.04	17
MUGIL CEPHALUS	STRIPED MULLET	1.563	.04	18
PLEURONICHTHYS RITTERI	SPOTTED TURBOT	1.492	.04	19
FAMILY CLINIDAE		1.327	.03	20
HYPSOBLENNIUS SP.		.610	.01	21
SPHYRAENA ARGENTEA	CALIFORNIA BARRACUDA	.562	.01	22
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT	.478	.01	23
TRACHURUS SYMMETRICUS	JACK MACKEREL	.466	.01	24
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT	.418	.01	25
GENYONEMUS LINEATUS	WHITE CROAKER	.403	.01	26
PARALICHTHYS SP.		.235	.01	27
ANISOTREMUS DAVIDSONII	SARGO	.226	.01	28
SYNODUS LUCIOCEPS	CALIFORNIA LIZARDFISH	.190	.00	29
PLEURONICHTHYS COENOSUS	C-O TURBOT	.154	.00	30
FAMILY XIPHIIDAE		.149	.00	31
PLEURONICHTHYS SP.		.110	.00	32
SYNGNATHUS SP.		.108	.00	33
GIRELLA NIGRICANS	OPALEYE	.107	.00	34
PAROPHRYS VETULUS	ENGLISH SOLE	.101	.00	35
SERIPHUS POLITUS	QUEENFISH	.098	.00	36
CORYPHOPTERUS NICHOLSII	BLACKEYE GOBY	.095	.00	37
RONCADOR STEARNSII	SPOTFIN CROAKER	.087	.00	38
UMBRINA/CHEILOTREMA COMPLEX		.067	.00	39
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA	.059	.00	40
SYNGNATHUS LEPTORHYNCHUS	BAY PIPEFISH	.057	.00	41
FAMILY CLUPEIDAE		.054	.00	42
FAMILY COTTIDAE		.041	.00	43
GOBIIDAE TYPE A		.033	.00	44
SARDINOPS SAGAX CAERULEUS	PACIFIC SARDINE	.030	.00	45
SEBASTES SP.		.025	.00	46
FAMILY GOBIESOCIDAE		.022	.00	47

TABLE 6.4-1 (Concluded)

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
PARALABRAX CLATHRATUS	KELP BASS	.015	.00	48
PIMELOMETOPON PULCHRUM	CALIFORNIA SHEEPHEAD	.014	.00	49
ANCHOA DELICATISSIMA	SLOUGH ANCHOVY	.014	.00	50
TYPHLOGOBIUS CALIFORNIENSIS	BLIND GOBY	.014	.00	51
ATHERINOPS AFFINIS	TOPSMELT	.012	.00	52
ENGRAULIS MORDAX	NORTHERN ANCHOVY	.011	.00	53
CHROMIS PUNCTIPINNIS	BLACKSMITH	.009	.00	54
FAMILY EXOCOETIDAE		.005	.00	55
COTTIDAE TYPE 7		.005	.00	56
HIPPOGLOSSINA STOMATA	BIGMOUTH SOLE	.004	.00	57
CHEILOTREMA SATURNUM	BLACK CROAKER	.004	.00	58
TRIPHOTURUS MEXICANUS	MEXICAN LAMPFISH	.004	.00	59
ILYPNUS GILBERTI	CHEEKSPOT GOBY	.004	.00	60
ORDER ANGUILLIFORMES		.003	.00	61
LEPIDOGOBIUS LEPIDUS	BAY GOBY	.003	.00	62
PEPRILUS SIMILLIMUS	PACIFIC BUTTERFISH	.003	.00	63
PLEURONICHTHYS DECURRENS	CURLFIN TURBOT	.002	.00	64
PARALABRAX SP.		.001	.00	65
TOTAL		4139.297	100.00	

TABLE 6.4-2

RANK ORDER OF OFFSHORE AND LAGOON PLANKTON SPECIES CAPTURED IN 335μ NETS FROM JANUARY THROUGH DECEMBER, 1979 AT THE ENCINA POWER PLANT

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
ACARTIA TONSA		52112.402	67.74	1
OTHER CRUSTACEANS		8226.250	10.69	2
SUBCLASS COPEPODA		8013.289	10.42	3
OTHER ZOOPLANKTON		3912.264	5.09	4
ORDER DECAPODA		2483.522	3.23	5
FAMILY ENGRAULIDAE		952.756	1.24	6
PHYLUM CHAETOGNATHA		523.078	.68	7
FAMILY SCIAENIDAE		341.704	.44	8
ORDER MYSIDACEA		179.746	.23	9
CITHARICHTHYS SP.		73.272	.10	10
UNID.FISH EGGS		33.810	.04	11
FAMILY GOBIIDAE		29.281	.04	12
FAMILY ATHERINIDAE		8.345	.01	13
FAMILY LABRIDAE		6.450	.01	14
HYPSOBLENNIUS SP.		6.125	.01	15
FAMILY SERRANIDAE		5.114	.01	16
SEBASTES SP.		2.857	.00	17
TRACHURUS SYMMETRICUS	JACK MACKEREL	2.089	.00	18
FAMILY CLINIDAE		1.646	.00	19
MUGIL CEPHALUS	STRIPED MULLET	1.500	.00	20
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT	1.168	.00	21
SARDINOPS SAGAX CAERULEUS	PACIFIC SARDINE	1.129	.00	22
PARALICHTHYS SP.		1.001	.00	23
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT	.970	.00	24
PLEURONICHTHYS RITTERI	SPOTTED TURBOT	.959	.00	25
PLEURONICHTHYS SP.		.930	.00	26
GIRELLA NIGRICANS	OPALEYE	.861	.00	27
SPHYRAENA ARGENTEA	CALIFORNIA BARRACUDA	.818	.00	28
FAMILY CLUPEIDAE		.698	.00	29
ANISOTREMUS DAVIDSONII	SARGO	.625	.00	30
SYNODUS LUCIOCEPS	CALIFORNIA LIZARDFISH	.414	.00	31
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA	.395	.00	32
ANCHOA SP.		.205	.00	33
FAMILY HEMIRAMPHIDAE		.180	.00	34
PARALABRAX CLATHRATUS	KELP BASS	.163	.00	35
GENYONEMUS LINEATUS	WHITE CROAKER	.135	.00	36
PLEURONICHTHYS COENOSUS	C-O TURBOT	.132	.00	37
SERIPHUS POLITUS	QUEENFISH	.121	.00	38
HETEROSTICHUS ROSTRATUS	GIANT KELPFISH	.108	.00	39
SYNGNATHUS SP.		.106	.00	40
FAMILY COTTIDAE		.101	.00	41
TYPHLOGOBIUS CALIFORNIENSIS	BLIND GOBY	.097	.00	42
CORYPHOPTERUS NICHOLSII	BLACKEYE GOBY	.096	.00	43
GOBIIDAE TYPE A		[illegible]	.00	44
FAMILY GOBIESOCIDAE		.075	.00	45
ENGRAULIS MORDAX	NORTHERN ANCHOVY	.066	.00	46
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT	.063	.00	47

TABLE 6.4-2 (Concluded)

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
PARALABRAX SP.		.044	.00	48
UMBRINA/CHEILOTREMA COMPLEX		.038	.00	49
FAMILY SYNGNATHIDAE		.027	.00	50
CYNOSCION NOBILIS	WHITE SEABASS	.022	.00	51
CHROMIS PUNCTIPINNIS	BLACKSMITH	.021	.00	52
CHEILOTREMA SATURNUM	BLACK CROAKER	.018	.00	53
HYPSYPOPS RUBICUNDUS	GARIBALDI	.017	.00	54
ORDER TETRAODONTIFORMES		.016	.00	55
CITHARICHTHYS STIGMAEUS	SPECKLED SANDDAB	.015	.00	56
SYNGNATHUS LEPTORHYNCHUS	BAY PIPEFISH	.009	.00	57
PLEURONICHTHYS DECURRENS	CURLFIN TURBOT	.007	.00	58
COTTIDAE TYPE 1		.006	.00	59
RONCADOR STEARNSII	SPOTFIN CROAKER	.004	.00	60
FAMILY EXOCOETIDAE		.003	.00	61
GOBIESOX PAPILLIFER	BEARDED CLINGFISH	.002	.00	62
TRIPHOTURUS MEXICANUS	MEXICAN LAMPFISH	.002	.00	63
CETENGRAULIS SP.		.001	.00	64
TOTAL		76926.188	100.00	

000253

TABLE 6.4-3
RANK ORDER OF OFFSHORE PLANKTON SPECIES CAPTURED IN 505μ NETS FROM JANUARY THROUGH DECEMBER, 1979 AT THE ENCINA POWER PLANT

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
SUBCLASS COPEPODA		4775.844	51.78	1
ACARTIA TONSA		1759.635	19.08	2
OTHER CRUSTACEANS		884.484	9.59	3
OTHER ZOOPLANKTON		591.651	6.41	4
ORDER DECAPODA		441.314	4.78	5
FAMILY SCIAENIDAE		335.230	3.63	6
PHYLUM CHAETOGNATHA		267.783	2.90	7
CITHARICHTHYS SP.		56.295	.61	8
ORDER MYSIDACEA		33.462	.36	9
UNID.FISH EGGS		33.024	.36	10
FAMILY ENGRAULIDAE		10.207	.11	11
FAMILY SERRANIDAE		6.399	.07	12
FAMILY LABRIDAE		4.848	.05	13
MUGIL CEPHALUS	STRIPED MULLET	4.374	.05	14
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT	4.049	.04	15
PLEURONICHTHYS RITTERI	SPOTTED TURBOT	1.951	.02	16
SPHYRAENA ARGENTEA	CALIFORNIA BARRACUDA	1.645	.02	17
TRACHURUS SYMMETRICUS	JACK MACKEREL	1.298	.01	18
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT	1.247	.01	19
HYPSOBLENNIUS SP.		1.205	.01	20
GENYONEMUS LINEATUS	WHITE CROAKER	1.098	.01	21
FAMILY CLINIDAE		1.093	.01	22
FAMILY GOBIIDAE		.736	.01	23
ANISOTREMUS DAVIDSONII	SARGO	.652	.01	24
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT	.566	.01	25
SYNODUS LUCIOCEPS	CALIFORNIA LIZARDFISH	.559	.01	26
FAMILY ATHERINIDAE		.553	.01	27
PLEURONICHTHYS COENOSUS	C-O TURBOT	.458	.00	28
FAMILY XIPHIIDAE		.434	.00	29
PAROPHRYS VETULUS	ENGLISH SOLE	.293	.00	30
SERIPHUS POLITUS	QUEENFISH	.274	.00	31
RONCADOR STEARNSII	SPOTFIN CROAKER	.255	.00	32
PLEURONICHTHYS SP.		.220	.00	33
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA	.173	.00	34
FAMILY CLUPEIDAE		.157	.00	35
CORYPHOPTERUS NICHOLSII	BLACKEYE GOBY	.145	.00	36
GIRELLA NIGRICANS	OPALEYE	.098	.00	37
SARDINOPS SAGAX CAERULEUS	PACIFIC SARDINE	.083	.00	38
SEBASTES SP.		.074	.00	39
PARALABRAX CLATHRATUS	KELP BASS	.044	.00	40
FAMILY GOBIESOCIDAE		.027	.00	41
CHROMIS PUNCTIPINNIS	BLACKSMITH	.025	.00	42
SYNGNATHUS SP.		.023	.00	43
HIPPOGLOSSINA STOMATA	BIGMOUTH SOLE	.012	.00	44
CHEILOTREMA SATURNUM	BLACK CROAKER	.012	.00	45
FAMILY COTTIDAE		.011	.00	46
TRIPHOTURUS MEXICANUS	MEXICAN LAMPFISH	.011	.00	47

TABLE 6.4-3 (Concluded)

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
PLEURONICHTHYS DECURRENS	CURLFIN TURBOT	.011	.00	48
ORDER ANGUILLIFORMES		.010	.00	49
UMBRINA/CHEILOTREMA COMPLEX		.010	.00	50
PEPRILUS SIMILLIMUS	PACIFIC BUTTERFISH	.007	.00	51
ENGRAULIS MORDAX	NORTHERN ANCHOVY	.005	.00	52
ANCHOA SP.		.004	.00	53
PARALABRAX SP.		.004	.00	54
TYPHLOGOBIUS CALIFORNIENSIS	BLIND GOBY	.004	.00	55
TOTAL		9224.082	100.00	

TABLE 6.4-4
RANK ORDER OF OFFSHORE PLANKTON SPECIES CAPTURED IN 335μ NETS FROM JANUARY THROUGH DECEMBER, 1979 AT THE ENCINA POWER PLANT

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
ACARTIA TONSA		89413.188	67.93	1
SUBCLASS COPEPODA		15696.090	11.92	2
OTHER CRUSTACEANS		14968.313	11.37	3
OTHER ZOOPLANKTON		7935.020	6.03	4
ORDER DECAPODA		1868.352	1.42	5
PHYLUM CHAETOGNATHA		896.021	.68	6
FAMILY SCIAENIDAE		472.819	.36	7
ORDER MYSIDACEA		128.114	.10	8
CITHARICHTHYS SP.		95.636	.07	9
UNID.FISH EGGS		55.987	.04	10
FAMILY ENGRAULIDAE		51.685	.04	11
FAMILY SERRANIDAE		9.252	.01	12
HYPSOBLENNIUS SP.		4.846	.00	13
FAMILY LABRIDAE		4.814	.00	14
TRACHURUS SYMMETRICUS	JACK MACKEREL	4.448	.00	15
MUGIL CEPHALUS	STRIPED MULLET	3.137	.00	16
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT	2.711	.00	17
FAMILY GOBIIDAE		2.939	.00	18
SARDINOPS SAGAX CAERULEUS	PACIFIC SARDINE	2.463	.00	19
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT	2.122	.00	20
PLEURONICHTHYS SP.		2.005	.00	21
GIRELLA NIGRICANS	OPALEYE	1.860	.00	22
FAMILY CLINIDAE		1.795	.00	23
SPHYRAENA ARGENTEA	CALIFORNIA BARRACUDA	1.784	.00	24
FAMILY CLUPEIDAE		1.509	.00	25
ANISOTREMUS DAVIDSONII	SARGO	1.371	.00	26
PLEURONICHTHYS RITTERI	SPOTTED TURBOT	1.190	.00	27
SYNODUS LUCIOCEPS	CALIFORNIA LIZARDFISH	.904	.00	28
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA	.672	.00	29
FAMILY HEMIRAMPHIDAE		.393	.00	30
PARALABRAX CLATHRATUS	KELP BASS	.355	.00	31
FAMILY ATHERINIDAE		.352	.00	32
GENYONEMUS LINEATUS	WHITE CROAKER	.294	.00	33
SERIPHUS POLITUS	QUEENFISH	.264	.00	34
PLEURONICHTHYS COENOSUS	C-O TURBOT	.229	.00	35
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT	.180	.00	36
FAMILY GOBIESOCIDAE		.146	.00	37
ENGRAULIS MORDAX	NORTHERN ANCHOVY	.143	.00	38
PARALABRAX SP.		.096	.00	39
FAMILY COTTIDAE		.079	.00	40
ORDER TETRAODONTIFORMES		.066	.00	41
ANCHOA SP.		.061	.00	42
CHEILOTREMA SATURNUM	BLACK CROAKER	.040	.00	43
UMBRINA/CHEILOTREMA COMPLEX		.037	.00	132
PLEURONICHTHYS DECURRENS	CURLFIN TURBOT	.027	.00	45
CYNOSCION NOBILIS	WHITE SEABASS	.021	.00	46
CORYPHOPTERUS NICHOLSII	BLACKEYE GOBY	.013	.00	47

000256

TABLE 6.4-4 (Concluded)

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
RONCADOR STEARNSII	SPOTFIN CROAKER	.010	.00	48
FAMILY EXOCOETIDAE		.007	.00	49
GOBIESOX PAPILLIFER	BEARDED CLINGFISH	.005	.00	50
HETEROSTICHUS ROSTRATUS	GIANT KELPFISH	.005	.00	51
TRIPHOTURUS MEXICANUS	MEXICAN LAMPFISH	.004	.00	52
CETENGRAULIS SP.		.003	.00	53
TOTAL		131634.563	100.00	

TABLE 6.4-5
RANK ORDER OF LAGOON PLANKTON SPECIES CAPTURED IN 505μ
NETS FROM JANUARY THROUGH DECEMBER, 1979 AT THE ENCINA POWER PLANT

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
FAMILY ENGRAULIDAE		403.796	23.52	1
OTHER CRUSTACEANS		351.865	20.50	2
ORDER DECAPODA		328.815	19.16	3
FAMILY SCIAENIDAE		154.394	8.99	4
SUBCLASS COPEPODA		131.206	7.64	5
ORDER MYSIDACEA		118.409	6.90	6
OTHER ZOOPLANKTON		88.272	5.14	7
ACARTIA TONSA		39.837	2.32	8
CITHARICHTHYS SP.		30.566	1.78	9
PHYLUM CHAETOGNATHA		22.053	1.29	10
FAMILY GOBIIDAE		11.842	.69	11
UNID.FISH EGGS		11.460	.67	12
FAMILY ATHERINIDAE		10.148	.59	13
ANCHOA SP.		6.109	.36	14
FAMILY LABRIDAE		2.430	.14	15
FAMILY CLINIDAE		1.390	.08	16
PLEURONICHTHYS RITTERI	SPOTTED TURBOT	1.230	.07	17
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT	.385	.02	18
PARALICHTHYS SP.		.343	.02	19
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT	.339	.02	20
FAMILY SERRANIDAE		.324	.02	21
HYPSOBLENNIUS SP.		.259	.02	22
SYNGNATHUS SP.		.147	.01	23
GIRELLA NIGRICANS	OPALEYE	.111	.01	24
MUGIL CEPHALUS	STRIPED MULLET	.093	.01	25
UMBRINA/CHEILOTREMA COMPLEX		.093	.01	26
SYNGNATHUS LEPTORHYNCHUS	BAY PIPEFISH	.084	.00	27
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT	.073	.00	28
CORYPHOPTERUS NICHOLSII	BLACKEYE GOBY	.065	.00	29
FAMILY COTTIDAE		.054	.00	30
PLEURONICHTHYS SP.		.050	.00	31
GOBIIDAE TYPE A		.042	.00	32
GENYONEMUS LINEATUS	WHITE CROAKER	.039	.00	33
TRACHURUS SYMMETRICUS	JACK MACKEREL	.031	.00	34
TYPHLOGOBIUS CALIFORNIENSIS	BLIND GOBY	.022	.00	35
PLEURONICHTHYS COENOSUS	C-O TURBOT	.021	.00	36
PIMELOMETOPON PULCHRUM	CALIFORNIA SHEEPHEAD	.021	.00	37
ANCHOA DELICATISSIMA	SLOUGH ANCHOVY	.021	.00	38
ATHERINOPS AFFINIS	TOPSMELT	.018	.00	39
FAMILY GOBIESOCIDAE		.016	.00	40
ENGRAULIS MORDAX	NORTHERN ANCHOVY	.014	.00	41
FAMILY EXOCOETIDAE		.008	.00	42
COTTIDAE TYPE 7		.007	.00	43
SERIPHUS POLITUS	QUEENFISH	.006	.00	44
ILYPNUS GILBERTI	CHEEKSPOT GOBY	.005	.00	45
LEPIDOGOBIUS LEPIDUS	BAY GOBY	.004	.00	46

TABLE 6.4-5 (Concluded)

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
TOTAL		1716.561	100.00	

TABLE 6.4-6
RANK ORDER OF LAGOON PLANKTON SPECIES CAPTURED IN 335µ
NETS FROM JANUARY THROUGH DECEMBER, 1979 AT THE ENCINA POWER PLANT

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
ACARTIA TONSA		21956.965	67.49	1
ORDER DECAPODA		2823.086	8.68	2
OTHER CRUSTACEANS		2414.048	7.42	3
SUBCLASS COPEPODA		2083.571	6.40	4
FAMILY ENGRAULIDAE		1592.734	4.90	5
OTHER ZOOPLANKTON		840.578	2.58	6
PHYLUM CHAETOGNATHA		228.615	.70	7
ORDER MYSIDACEA		214.792	.66	8
FAMILY SCIAENIDAE		214.755	.66	9
CITHARICHTHYS SP.		58.495	.18	10
FAMILY GOBIIDAE		49.723	.15	11
UNID.FISH EGGS		14.620	.04	12
FAMILY ATHERINIDAE		14.137	.04	13
FAMILY LABRIDAE		7.275	.02	14
HYPSOBLENNIUS SP.		6.722	.02	15
SEBASTES SP.		4.698	.02	16
FAMILY CLINIDAE		1.886	.01	17
PARALICHTHYS SP.		1.716	.01	18
FAMILY SERRANIDAE		1.507	.00	19
PLEURONICHTHYS RITTERI	SPOTTED TURBOT	.746	.00	20
ANCHOA SP.		.311	.00	21
SYNGNATHUS SP.		.181	.00	22
HETEROSTICHUS ROSTRATUS	GIANT KELPFISH	.181	.00	23
TYPHLOGOBIUS CALIFORNIENSIS	BLIND GOBY	.167	.00	24
CORYPHOPTERUS NICHOLSII	BLACKEYE GOBY	.154	.00	25
GOBIIDAE TYPE A		.140	.00	26
MUGIL CEPHALUS	STRIPED MULLET	.113	.00	27
FAMILY COTTIDAE		.111	.00	28
TRACHURUS SYMMETRICUS	JACK MACKEREL	.087	.00	29
PLEURONICHTHYS COENOSUS	C-O TURBOT	.066	.00	30
FAMILY SYNGNATHIDAE		.046	.00	31
UMBRINA/CHEILOTREMA COMPLEX		.039	.00	32
HYPSYPOPS RUBICUNDUS	GARIBALDI	.029	.00	33
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT	.026	.00	34
CYNOSCION NOBILIS	WHITE SEABASS	.022	.00	35
PLEURONICHTHYS SP.		.019	.00	36
SYNGNATHUS LEPTORHYNCHUS	BAY PIPEFISH	.015	.00	37
FAMILY GOBIESOCIDAE		.014	.00	38
GIRELLA NIGRICANS	OPALEYE	.014	.00	39
COTTIDAE TYPE 1		.011	.00	40
CHROMIS PUNCTIPINNIS	BLACKSMITH	.011	.00	41
FAMILY CLUPEIDAE		.010	.00	42
TOTAL		32532.746	100.00	

total plankton catch in the 335μ mesh nets from offshore and the lagoon, and 12 percent of the total catch with 505μ mesh nets. In 505μ mesh nets, other copepods, other than Acartia tonsa, ranked number one comprising 39 percent of the total catch. Combined, all copepods, including Acartia tonsa, comprised 52.5 percent of the total offshore and lagoon 505μ mesh net catches and 78 percent of the 335μ mesh net catches. Generally speaking, plankton abundances were four to five times greater offshore than in the lagoon (Tables 6.4-3 through 6.4-6). The smaller mesh net (335μ) caught approximately ten times the number of organisms as the 505μ mesh net, although the species makeup of the catches was similar. This increase in 335μ mesh net catches was greatly influenced by Acartia tonsa catches which were 100 times greater in the 335μ nets than in the 505μ net catches (Tables 6.4-1 and 6.4-2). This is to be expected as many Acartia tonsa can pass through the 505μ net. A qualitative analysis was made of zooplankton collections to identify individual species within the major groupings. The taxonomic breakdown of the major groupings studied is given in Table 6.4-7.

Ichthyoplankton rank orders (Table 6.4-1) for 505μ mesh nets identified anchovies (Engraulidae) as most abundant followed by croakers (Sciaenidae), sanddabs (Citharichthys sp), gobies (Gobiidae), and smelt (Atherinidae). These same rankings were generally borne out in the 335μ mesh net collections (Table 6.4-2). Anchovies (Engraulidae) ranked number one in lagoon collections but were number four offshore. Croakers (Sciaenidae)

TABLE 6.4-7
SPECIES LIST OF ZOOPLANKTON TAXA COMPRISING
THE MAJOR ZOOPLANKTON GROUPS† EXAMINED
ENCINA POWER PLANT - AUGUST 1, 1980

OTHER COPEPODS INCLUDE:

CALANOIDA

Acartia negligens
Calanus sp
Eucalanus sp
Labidocera sp
Lucicutia sp
Pleuromamma cf robusta
Rhincalanus spp
Temora discaudata
Tortanus discaudatus
cf Valdiviella sp
Unidentified Calanoid Copepods

CYCLOPOIDA

Oithona sp
Unidentified Cyclopoid Copepods

HARPACTICOIDA

Corycaeus sp
Unidentified Harpacticoid Copepods

OTHER COPEPODS

Porcellidium sarsi
Caligus clemensi

MYSIDS INCLUDE:

Mysidacea

Meterythrops robusta
Neomysis sp
Acanthomysis sp
Unidentified Mysidacea

† See Table 6.3-3

TABLE 6.4-7 (Continued)

DECAPOD LARVAE INCLUDE:

NATANTIA

Hippolytid mysis
Hippolyte californiensis
Penaeid shrimp
Sergestid mysis
Unidentified Natantia mysis

REPTANTIA, ANOMURA

Blepharipoda occidentalis zoea
Callianassid mysis
Pagurid zoea & megalops
Porcellanid zoea
Unidentified Anomuran zoea

REPTANTIA, BRACHYURA

Canceridae zoea
Grapsidae zoea
Majidae zoea
Pinnotherid zoea
Xanthid zoea
Unidentified Brachyuran zoea

OTHER CRUSTACEA INCLUDE:

OSTRACODA

Cyprinidae
Unidentified Ostracods

CIRRIPEDIA

Cirripedia nauplius & cypis

CLADOCERA

Daphnia sp A
Daphnia sp B
Evadne sp A

EUPHAUSIACEA

TABLE 6.4-7 (Continued)

OTHER CRUSTACEA (continued)

CUMACEA

Cumella sp A
Lampropidae
Oxyurostylis pacifica
Unidentified Cumaceans

ISOPODA

Synidotea hartfordi
Idotea fewkesi
Idotea cf *gracillima*
Idotea resecata
Sphaeromatidae
Paracerceis galliana
Cryptoniscidae

AMPHIPODA

Gitanopsis vilordes
Aoridae
Rudilemboides stenopropodus
Corophium sp
Ericthonius brasiliensis
Atylus tridens
Gammaridae
Megaluropus longimerus
Photis sp
Ischyraceridae
Ischyrocerus sp
Lysianassidae
Oedicerotidae
Monoculoides hartmanae
Synchelidium sp
Parapleustes sp
Podecerus sp
Podocerus brasiliensis
Stenothoidae
Talitridae
Tironidae
Unidentified Gammaridae Amphipods
Caprellidae
Caprella sp A
Caprella equilibra
Caprella californica

TABLE 6.4-7 (Continued)

OTHER ZOOPLANKTON INCLUDE:

POLYCHAETE

Polynoidae
Amphinomidae
Phyllodocidae
Tomopteris sp
Syllidae
Nereidae
Spionidae
Apoprionospio pygmaea
Magelona sp
Armandia bioculata
Terebellidae
Spirorbis sp
Unidentified Polychaete Trochophores

MOLLUSCA

Acmaeidae
Tricolia sp
Cypraea spadacea
Mitrella sp
Mitrella cardinata
Navanax inermis
Unidentified Gastropoda Veligers
Mytilidae
Modiolus sp
Ischadium demissa
Leptopecten Latiauritus
Laevicardium substratum
Cooperellidae
Tellina sp
Macoma sp

OTHERS

Hydrozoa
Siphonophora
Platyhelminthes
Cyphonautes larvae for Membranipora
Actinotroch
Echinodermata
Echinopluteus
Asteropluteus

TABLE 6.4-7 (Concluded)

OTHERS (continued)

- Ophiopluteus
- Thaliacea
- Oikopleura
- Tadpole larvae of Ascidian

CHAETOGNATHS WERE NOT IDENTIFIED

were the number one ichthyoplankton species offshore (Tables 6.4-3 and 6.4-4). Average plankton abundances were compiled for all groups for offshore and for the lagoon by compiling an average of the year's collections (Table 6.4-8). The basic data for all plankton collections for the various sample areas are given in Appendix Tables 16.3-1 through 16.3-8 by month and species.

6.4.4 Invertebrate Zooplankton

The only designated critical zooplankton species was the copepod, Acartia tonsa. Other groupings of zooplankton species were studied and are discussed in Section 6.4.6.

6.4.4.1 Acartia tonsa. The calanoid copepod, Acartia tonsa, is widespread throughout the Pacific and Atlantic oceans and is a major food source for many larval fish.

6.4.4.1.1 Temporal Distribution - Offshore. Diel distribution of Acartia tonsa at offshore stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for either 335μ mesh or 505μ mesh nets between day and night sampling at offshore stations. Temporal distribution offshore was examined utilizing hierarchical analysis (Section 16.2.7). The data was compiled separately for the two mesh sizes (505μ and 335μ) of plankton nets. Acartia tonsa was captured every month of the year offshore (Appendix Tables 16.3-9 and 16.3-10)

Table 6.4-8
AVERAGE ABUNDANCES OF PLANKTON GROUPS COLLECTED
IN AGUA HEDIONDA LAGOON AND OFFSHORE AREAS†
ENCINA POWER PLANT - AUGUST 1, 1980

Plankton Group	335µ Mesh Estimates		505µ Mesh Estimates	
	Lagoon	Offshore	Lagoon	Offshore
Fish eggs	6.6×10^{7}	8.4×10^{7}	2.6×10^{7}	1.3×10^{7}
Fish larvae	8.4×10^{6}	3.2×10^{6}	9.0×10^{5}	1.6×10^{5}
Total Ichthyoplankton	7.5×10^{7}	8.7×10^{7}	2.7×10^{7}	1.3×10^{7}
Other crustacea	6.7×10^{7}	1.8×10^{9}	8.3×10^{6}	5.3×10^{7}
Copepods	9.1×10^{7}	1.9×10^{9}	4.4×10^{6}	4.7×10^{8}
Acartia tonsa	1.4×10^{9}	1.1×10^{10}	1.1×10^{6}	8.3×10^{7}
Mysids	4.6×10^{6}	1.5×10^{7}	2.5×10^{6}	3.3×10^{5}
Decapods	1.0×10^{8}	1.2×10^{8}	8.8×10^{6}	3.0×10^{7}
Chaetognaths	9.9×10^{6}	1.0×10^{8}	6.6×10^{5}	4.3×10^{6}
Other zooplankton	3.9×10^{7}	9.5×10^{8}	2.4×10^{6}	2.9×10^{7}
Total Invertebrates	5.7×10^{8}	1.6×10^{10}	2.8×10^{7}	6.7×10^{8}
TOTAL PLANKTON	2.4×10^{9}	3.1×10^{10}	5.5×10^{7}	6.8×10^{8}

† Offshore zone (12×10^{6} m^{3} volume) - See Section 5.0.

000268

TABLE 6.4-9
SUMMARY OF STATISTICAL ANALYSES
OF DIURNAL PLANKTON ABUNDANCES
ENCINA POWER PLANT - AUGUST 1, 1980

Species	Offshore		Outer Lagoon		Middle & Inner Lagoon	
	335μ	505μ	335μ	505μ	335μ	505μ
Fish spp.	NS	NS	NS	S ††	S ††	NS
Other zooplankton	NS	NS	NS	NS	NS	NS
Other crustaceans	NS	NS	S ††	S ††	S ††	NS
Copepoda	NS	NS	S ††	S ††	NS	NS
Acartia tonsa	S †	NS	S ††	S ††	S ††	NS
Mysidacea	NS	S ††	S ††	S ††	NS	NS
Decapoda	NS	NS	S ††	S ††	NS	NS
Chaetognatha	S ††	S ††	NS	S ††	NS	S ††

NS = Not significant (Mann-Whitney U-test)
S = Significant (Mann-Whitney U-test)
† = Significant during daytime
†† = Significant during nighttime

indicating year-round abundance. Peak abundances occurred in spring and fall (Figures 6.4-3 and 6.4-4). The greatest abundance for all sampling periods offshore occurred in March when the 335μ mesh net yielded abundance estimates for A. tonsa of 412,548/100 m^3 (Appendix Table 16.3-1).

6.4.4.1.2 Spatial Distribution - Offshore. *Acartia tonsa* distribution was widespread offshore. They were captured in large numbers at all offshore stations. Abundance was greater offshore than in the lagoon, but copepods were abundant everywhere (Appendix Tables 16.3-11 and 16.3-12).

6.4.4.1.3 Temporal Distribution - Lagoon. Diel distribution of *Acartia tonsa* was examined in October from day and night sampling in the lagoon. Significant differences were found in all tests for the two mesh sizes except for 505μ mesh samples in the middle and upper lagoon (Table 6.4-9). Nighttime samples consisted of more *A. tonsa* than daytime samples.

Monthly collections in the lagoon captured *A. tonsa* every month of the year. Peak abundances occurred in spring and fall (Appendix Tables 16.3-13 and 16.3-14; Figures 6.4-5 through 6.4-10). The greatest abundance occurred in the upper lagoon in June (232,496/100 m^3) (Figure 6.4-10). Abundances were greatest in the 335μ mesh net catches as previously discussed (Appendix Tables 16.3-3 through 16.3-8).

000270

6.4.4.1.4 Spatial Distribution - Lagoon. *Acartia tonsa* was captured in all three sections of Agua Hedionda Lagoon. All concentrations of *A. tonsa* in the three sections of the lagoon were quite large and are indicative of the widespread distribution and abundance of this species throughout the study area. The outer area of the lagoon contributed the intermediate average abundance level (11,095/100 m^3) for *A. tonsa*. The middle area had the lowest average abundance (4962/100 m^3) and the upper area had the greatest average abundance (46,746/100 m^3) levels (Appendix Tables 16.3-3, 16.3-5, and 16.3-7).

Vertical distribution of plankton organisms in the lagoon was examined by sampling at 5, 10 and 15 foot depths on several dates. The results of each taxonomic group were compared using the Kruskal-Wallis non-parametric test (6-428). The results of these tests on the vertical distribution of plankton organisms in the lagoon showed that at the 95 percent confidence interval level, there were no significant differences between catches of all plankton groups with depth (Table 6.4-10). The shallow depths of the lagoon and the tidal mixing appear to provide a homogenous mixture of plankton in lagoon waters.

6.4.5 Ichthyoplankton (Fish Eggs and Larvae)

Individuals of nine major families of fish species were designated as critical species for ichthyoplankton studies. These groups included six identified species from four families

TABLE 6.4-10
RESULTS OF KRUSKAL-WALLIS TEST (H) TO DETERMINE
IF THERE WAS A SIGNIFICANT (SIG) DIFFERENCE (=0.05) IN
PLANKTON VERTICAL DISTRIBUTION IN AQUA HEDIONDA LAGOON
ENCINA POWER PLANT - AUGUST 1, 1980

	335μ net		505μ net	
Taxonomic Group	(H)	(SIG)	(H)	(SIG)
Fish	0.13	No	-3.05	No
Fish eggs	2.6	No	0.94	No
Acartia tonsa	2.065	No	1.815	No
Other copepods	1.14	No	1.22	No
Chaetognaths	1.021	No	1.858	No
Mysidacea	5.901	No	2.725	No
Decapods	0.615	No	1.86	No
Other crustacea	1.693	No	0.05	No
Other zooplankton	0.09	No	2.175	No

000272

and the remaining families were treated as groups. In many cases, it is difficult to identify eggs and young larvae to lower taxonomic levels than family. The nine families are discussed below.

6.4.5.1 Engraulidae. Three major species of engraulids are common in the area and were examined in the study: northern anchovy (Engraulis mordax), deepbody anchovy (Anchoa compressa), and slough anchovy (Anchoa delicatissima).

6.4.5.1.1 Temporal Distribution - Offshore. Diel distribution of ichthyoplankton species at offshore stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for either 335μ mesh or 505μ mesh nets between day and night sampling at offshore stations.

Engraulid eggs were collected offshore during all months except February, August and September, indicating spawning occurs during most of the year (Appendix Tables 16.3-15 and 16.3-16). Larvae were collected during all months except October, November and December (Appendix Tables 16.3-17 and 16.3-18). Anchoa sp eggs were only collected in May offshore.

Seasonally, eggs were most abundant in spring (April-June). Larvae were most abundant in winter and early

000273

spring (January through April). Eggs and larvae were not taken in late fall (October, November, December) months (Appendix Tables 16.3-15 through 16.3-18). This is the time of year when anchovies migrate offshore (Section 6.3.4.2), which could explain their absence from samples in late fall. If spawning did occur during this time, it may have taken place outside the study area.

6.4.5.1.2 Spatial Distribution - Offshore. Anchovy eggs and larvae were taken at all offshore stations (Appendix Tables 16.3-19 through 16.3-22). *Anchoa* sp eggs were taken at the nearshore stations (C-25, G-25; Figure 6.4-1). *Engraulis mordax* eggs were taken at all offshore stations, as were engraulid larvae. This is commensurate with the widespread distribution and abundance of anchovies offshore.

6.4.5.1.3 Temporal Distribution - Lagoon. Diel distribution of ichthyoplankton species at lagoon stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for outer lagoon 335μ or middle and upper lagoon 505μ mesh nets between day and night sampling. However, significant differences were found in the outer lagoon with 505μ mesh and in the upper and middle lagoon with 335μ mesh nets. Where significant

000274

differences were found, the nighttime samples captured more than the daytime samples.

Eggs were collected in the lagoon from March through August (Appendix Tables 16.3-23 and 16.3-24). Larvae were collected from January through July (Appendix Tables 16.3-25 and 16.3-26). No eggs or larvae were taken during fall and winter. The deepbody (A. compressa) and slough (A. delicatissima) anchovies were most common in the lagoon. The deepbody spawns in spring and summer (Section 6.3.4.2) which would coincide with temporal distribution in the lagoon. Peak abundances occurred in May and June (Appendix Tables 16.3-3 through 16.3-8). In addition, some Engraulis mordax species were taken. Movement of E. mordax into the lagoon from offshore could explain the presence of anchovy larvae in early spring.

6.4.5.1.4 Spatial Distribution - Lagoon. Anchovy eggs and larvae were collected at all stations in the outer lagoon. They were most abundant at the station (AHL 3) connecting the outer area with the other portions of the lagoon (Figure 6.4-1).

Anchovy eggs were collected in the middle lagoon, but no larvae were captured in plankton collections in the middle lagoon (Appendix Tables 16.3-19 through 16.3-22).

In the upper lagoon, anchovy eggs and larvae were collected at both stations. Anchoa sp eggs were abundant in the upper lagoon (Appendix Tables 16.3-19 through 15.3-22).

Vertical distribution within the lagoon was difficult to examine due to shallow depths in many portions of the study area. The extent of vertical distribution was examined in the deeper areas of the outer lagoon and found to be insignificant, indicating no vertical stratification of species within the lagoon water column (see Section 6.4.4.1.4).

6.4.5.2 Atherinidae. Atherinid species common in the study area include California grunion (Leuresthes tenuis), topsmelt (Atherinops affinis), and jacksmelt (Atherinopsis californiensis). Grunion bury their eggs in the sand in the intertidal zone; therefore, only their larvae would be available to plankton collections. Topsmelt eggs attach to kelp and algae as do jacksmelt, so these were not expected to be captured.

6.4.5.2.1 Temporal Distribution - Offshore. No Atherinid eggs were collected offshore during the year (Appendix Tables 16.3-15 and 16.3-16). Diel distribution of ichthyoplankton species at offshore stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for either 335μ mesh or 505μ mesh nets between day and night sampling at offshore stations.

Atherinid larvae were collected offshore from January through June and in November. None were taken from July through October, or in December (Appendix Tables 16.3-17 and 16.3-18). This coincides with the reported winter-spring spawning period.

Capture of larvae in winter and spring and lack of any captures in summer and fall probably indicates growth of larvae to a size able to avoid plankton nets by summer. This could also indicate movement inshore or into the lagoon, or in the case of smelt species, perhaps movement to the kelp beds (a favorite habitat) for protection. This would make them unavailable to plankton tows in open water.

6.4.5.2.2 Spatial Distribution - Offshore. Atherinid eggs were not taken (see Section 6.4.5.2), but larvae were taken at all offshore stations (Appendix Tables 16.3-19 through 16.3-22). They were equally abundant at all stations, demonstrating their widespread distribution and abundance in the study area.

6.4.5.2.3 Temporal Distribution - Lagoon. Diel distribution of ichthyoplankton species at lagoon stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for outer lagoon 335μ mesh or middle and upper lagoon 505μ mesh nets between day and night sampling. However, significant differences were found in the outer lagoon with 505μ mesh and in the upper

000277

and middle lagoon with 335μ mesh nets. Where significant differences were found, the nighttime samples captured more than the daytime samples. The differences that were observed on two occasions (Table 6.4-9) in this study between day and night collections are most likely attributable to patchiness, net avoidance in daytime versus night, and perhaps a concentration of fish larvae near the surface (sampling zone) at night.

Atherinid larvae were collected in the lagoon during all months except August and September (Appendix Tables 16.3-25 and 16.3-26). They appear to be year-round residents within the lagoon, with peak abundances in spring and early summer.

6.4.5.2.4 Spatial Distribution - Lagoon. Atherinids were collected at all stations in the outer lagoon. Topsmelt were identified from two stations (AHL-1, AHL-3). Due to similarity of appearance of the atherinid species, smaller-sized larvae cannot always be identified to species.

Atherinids were collected from the middle lagoon and from both stations in the upper lagoon. They were widespread within the lagoon system. They probably spawn in the lagoon, attaching eggs in the eelgrass beds.

Vertical distribution within the lagoon was difficult to examine due to shallow depths in many portions of the study area. The extent of vertical distribution was examined in the deeper areas of the outer lagoon and found to be insignificant, indicating no vertical stratification of species within the lagoon water column (see Section 6.4.4.1.4).

6.4.5.3 Cottidae. Two cottid species were collected in nekton collections. Staghorn sculpin (*Leptocottus armatus*) and cabezon (*Scorpaenichthys marmoratus*). Identification of cottid larvae is difficult. A number of different types are recognized, but their species identification is unknown. Two types of cottid larvae were identified in plankton collections (cottid type 1 and cottid type 7; unpublished key). Others were included under Family Cottidae.

6.4.5.3.1 Temporal Distribution - Offshore. Diel distribution of ichthyoplankton species at offshore stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for either 335μ mesh or 505μ mesh nets between day and night sampling at offshore stations.

No cottid eggs were taken in collections. Most cottid species have demersal and/or adhesive eggs, so they would not be expected to be captured in plankton nets. Cottid larvae were collected in February, March, May, August, September and December (Appendix Tables 16.3-17 and 16.3-18), indicating presence of some type of cottid larvae during all seasons offshore (Appendix Tables 16.3-1 and 16.3-2). They were most abundant in August and September.

6.4.5.3.2 Spatial Distribution - Offshore. Cottid larvae were only collected at three stations offshore (C-25, G-25 and A-50). None were collected at station A-25 or F-50. Cottid larvae ranked in the lowest 20 percent in terms of abundance for plankton species offshore (Tables 6.4-3 and 6.4-4). In light of the small numbers taken, their limited distribution offshore is not unusual.

6.4.5.3.3 Temporal Distribution - Lagoon. Diel distribution of ichthyoplankton species at lagoon stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for outer lagoon 335μ mesh or middle and upper lagoon 505μ mesh nets between day and night sampling. However, significant differences were found in the outer lagoon with 505μ mesh and in the upper and middle lagoon with 335μ mesh nets. Where significant differences were found, the night samples captured more than the daytime samples. The differences that were observed on two occasions (Table 6.4-9) in this study between day and night collections are most likely attributable to patchiness, avoidance in daytime versus night and

000280

perhaps a concentration of fish larvae near the surface (sampling zone) at night.

Cottid larvae were captured in the lagoon from March through July and during September and December. Spring and fall collections would indicate both spring and summer spawning. Peak abundances occurred in June and July (Appendix Tables 16.3-3 through 16.3-8).

6.4.5.3.4 Spatial Distribution - Lagoon. Cottids were most abundant in the outer lagoon (Appendix Tables 16.3-3 through 16.3-8). They were captured at all stations in the outer lagoon. No cottid larvae were collected in the middle lagoon. Cottids were collected from one station in the upper lagoon (Appendix Table 16.3-21), where they were fairly abundant.

Vertical distribution within the lagoon was difficult to examine due to shallow depth in many portions of the study area. The extent of vertical distribution was examined in the deeper areas of the outer lagoon and found to be insignificant, indicating no vertical stratification of species within the lagoon water column (see Section 6.4.4.1.4).

6.4.5.4 Serranidae. Several Serranid species were common in nekton collections in the study area. These included: kelp bass (*Paralabrax clathratus*), spotted sand bass (*Paralabrax maculatofasciatus*), and barred sand bass (*Paralabrax nebulifer*).

6.4.5.4.1 Temporal Distribution - Offshore. Diel distribution of ichthyoplankton species at offshore stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for either 335μ mesh or 505μ mesh nets between day and night sampling at offshore stations.

Kelp bass was identified in plankton samples offshore. Some additional serranid larvae were identified as *Paralabrax* sp, others could just be identified to family. Serranid eggs were collected in March, August, September and October. Larvae were taken in May, July, August, September, October and November. This coincides with reported spawning times and presence of larvae (6-429, 6-430, 6-431, and 6-432). Eggs were present in spring and fall, and larvae in summer and fall.

6.4.5.4.2 Spatial Distribution - Offshore. Serranid eggs were taken at all offshore stations. They were most abundant at the deeper stations (A-50, F-50) which is to be expected since serranids spawn in deeper waters (Appendix Tables 16.3-19 and 16.3-20). Larvae were also collected at all offshore stations (Appendix Tables 16.3-21 and 16.3-22). Serranid larvae were generally more abundant at the deeper stations also, although kelp bass larvae were more abundant at the shallow station A-25 (Appendix Tables 16.3-21 and 16.3-22). Larvae are reported to move inshore (6-433).

6.4.5.4.3 Temporal Distribution - Lagoon. Diel distribution of ichthyoplankton species at lagoon stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for outer lagoon 335μ mesh or middle and upper lagoon 505μ mesh nets between day and night sampling. However, significant differences were found in the outer lagoon with 505μ mesh and in the upper and middle lagoon with 335μ mesh nets. Where significant differences were found, the nighttime samples captured more than the daytime samples. The differences that were observed on two occasions (Table 6.4-9) in this study between day and night collections are most likely attributable to patchiness, avoidance in daytime versus night, and perhaps a concentration of fish larvae near the surface (sampling zone) at night.

Serranid eggs were only collected in the lagoon in March. Larvae were only taken in September. The appearance of eggs in spring could be from spotted sand bass which inhabit the lagoon and are spring spawners. Fall larvae could be from any of the serranid species in the area.

6.4.5.4.4 Spatial Distribution - Lagoon. In the outer lagoon, serranid eggs were collected at all stations, but larvae were only taken at station AHL-3. Eggs were collected at the middle lagoon station, but no larvae were taken. No serranid eggs or larvae were taken in the upper lagoon. However, juvenile serranids were common in the lagoon, apparently migrating in from offshore spawning.

Vertical distribution within the lagoon was difficult to examine due to shallow depths in many portions of the study area. The extent of vertical distribution was examined in the deeper areas of the outer lagoon and found to be insignificant, indicating no vertical stratification of species within the lagoon water column (see Section 6.4.4.1.4).

6.4.5.5 Sciaenidae. Various sciaenid (croaker) species occur in the study area. Common croakers collected in the study include: white seabass (*Cynoscion nobilis*), white croaker (*Genyonemus lineatus*), California corbina (*Menticirrhus undulatus*), spotfin croaker (*Roncador stearnsi*), queenfish (*Seriphus politus*), and yellowfin croaker (*Umbrina roncador*). In addition, some black croaker (*Cheilotrema saturnum*) were also collected during a few sample periods. The Family Sciaenidae comprises more species that were common in the study area than most other family groupings examined.

6.4.5.5.1 Temporal Distribution - Offshore. Diel distribution of ichthyoplankton species at offshore stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for either 335μ mesh or 505μ mesh nets between day and night sampling at offshore stations.

Sciaenidae eggs were collected offshore during every month of the year (Appendix Tables 16.3-15 and 16.3-16). They were most abundant during summer (June-August). This is in line with reported summer (April-August) spawnings for many sciaenid species (queenfish, white seabass, California corbina, spotfin croaker).

Five species of sciaenid larvae were identified from offshore collections: queenfish, spotfin croaker, white croaker, black croaker, California corbina, and white seabass. One or more species were taken during almost every month of the year (Appendix Tables 16.3-17 and 16.3-18). Queenfish were taken in January, April, and July through September. Spotfin croaker were collected in January, February, May, August and September. White croaker were collected in January, February, April through July, and October.

Black croaker were only collected in July. California corbina were taken from July through September and in

000285

December. White seabass were only captured in June. Sciaenids were the top ranked fish species taken in offshore plankton collections. They were taken in all seasons, but were most common in summer.

6.4.5.5.2 Spatial Distribution - Offshore. Sciaenid eggs and larvae were taken at every sampling station (Appendix Tables 16.3-19 through 16.3-22), indicating widespread offshore distribution.

6.4.5.5.3 Temporal Distribution - Lagoon. Diel distribution of ichthyoplankton species at lagoon stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for outer lagoon 335μ mesh or middle and upper lagoon 505μ mesh nets between day and night sampling. However, significant differences were found in the outer lagoon with 505μ mesh and in the upper and middle lagoon with 335μ mesh nets. Where significant differences were found, the night samples captured more than the daytime samples. The differences that were observed on two occasions (Table 6.4-9) in this study between day and night collections are most likely attributable to patchiness, avoidance in daytime versus night, and perhaps a concentration of fish larvae near the surface (sampling zone) at night.

Sciaenid eggs were collected in the lagoon during every month of the year (Appendix Tables 16.3-23 and 16.3-24). Larvae were captured from January through May and July through September (Appendix Tables 16.3-25 and 16.3-26). The presence of sciaenid eggs and larvae in the lagoon during all seasons corresponds with similar distributions offshore.

6.4.5.5.4 Spatial Distribution - Lagoon. Sciaenid eggs were most abundant in the outer lagoon, but were collected at all stations in the outer, middle and upper lagoon. Sciaenid larvae were collected at all lagoon stations, but some species were only taken at certain stations (Appendix Tables 16.3-21 and 16.3-22). White croakers were only taken in the outer and upper lagoon. California corbina larvae, although widespread offshore, were not taken in the lagoon. Spotfin croaker larvae also were not taken in the lagoon. Queenfish were taken only in the outer lagoon. White sea-bass were taken only in the outer lagoon. Larvae that could only be identified to family (Sciaenidae) were taken in all three portions of the lagoon (outer, middle, upper).

Vertical distribution within the lagoon was difficult to examine due to shallow depths in many portions of the study area. The extent of vertical distribution was examined in the deeper areas of the outer lagoon and found to be insignificant, indicating no vertical stratification of species within the lagoon water column (see Section 6.4.4.1.4).

6.4.5.6 Clinidae. Common clinids in the study area include the giant kelpfish (*Heterostichus rostratus*) and the striped kelpfish (*Gibbonsia metzi*). There are other species in the family that occur in the region, such as reef finspot (*Paraclinus integripinnis*), but the two species above are the most common.

6.4.5.6.1 Temporal Distribution - Offshore. Diel distribution of ichthyoplankton species at offshore stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for either 335μ mesh or 505μ mesh nets between day and night sampling at offshore stations.

No clinid eggs were collected offshore. Kelpfish species attach their eggs to kelp and seagrass with adhesive threads; therefore, they would not be expected to be captured in plankton nets. Larvae were collected offshore during every month but December. They were most abundant in spring and into summer (Appendix Tables 16.3-17 and 16.3-18).

000288

6.4.5.6.2 Spatial Distribution - Offshore. Clinid larvae were collected at offshore stations. They were least common at station A-50; but were very abundant at the other four stations in the vicinity of kelp beds (Appendix Tables 16.3-21 and 16.3-22).

6.4.5.6.3 Temporal Distribution - Lagoon. Diel distribution of ichthyoplankton species at lagoon stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for outer lagoon 335μ mesh or middle and upper lagoon 505μ mesh nets between day and night sampling. However, significant differences were found in the outer lagoon with 505μ mesh and in the upper and middle lagoon with 335μ mesh nets. Where significant differences were found, the night samples captured more than the daytime samples. The differences that were observed on two occasions (Table 6.4-9) in this study between day and night collections are most likely attributable to patchiness, avoidance in daytime versus night, and perhaps a concentration of fish larvae near the surface (sampling zone) at night.

Clinid larvae were captured during every month in the lagoon. Peak abundances occurred in July and November, December and January. The winter peak in numbers in the

000289

lagoon could be due to young larvae seeking refuge in the lagoon grass beds during winter stormy periods offshore.

6.4.5.6.4 Spatial Distribution - Lagoon. Clinid larvae were widespread in the lagoon. They were captured at all stations in the outer, middle and upper lagoon. All three sections of the lagoon have eelgrass beds which are a habitat frequented by kelpfish.

Vertical distribution within the lagoon was difficult to examine due to shallow depths in many portions of the study area. The extent of vertical distribution was examined in the deeper areas of the outer lagoon and found to be insignificant, indicating no vertical stratification of species within the lagoon water column (see Section 6.4.4.1.4).

6.4.5.7 Gobiidae. Common gobies in the study area include: blackeye goby (*Coryphopterus nicholsi*), cheekspot goby (*Ilypnus gilberti*), shadow goby (*Quietula y-cauda*), bay goby (*Lepidogobius lepidus*), and blind goby (*Typhlogobius californiensis*). Most gobies have demersal and/or adhesive eggs. They are sedentary fishes, frequently lying partly buried in the sand (6-434) and as such, eggs are not normally collected in plankton tows.

6.4.5.7.1 Temporal Distribution - Offshore. Diel distribution of ichthyoplankton species at offshore stations was examined by day and night sampling in October. A Mann-

Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for either 335μ mesh or 505μ mesh nets between day and night sampling at offshore stations.

No goby eggs were collected in offshore plankton tows. Goby larvae were collected offshore during every month of the year. Two species could be identified in collections offshore, blackeye goby and blind goby; others could only be identified to family. Blackeye and blind gobies were most common offshore in May. Seasonal peaks in abundance for goby species occurred in late spring, summer and fall (Appendix Tables 16.3-17 and 16.3-18).

6.4.5.7.2 Spatial Distribution - Offshore. Goby larvae were caught at all offshore stations (Appendix Tables 16.3-21 and 16.3-22). Blackeye gobies were only taken at station A-25 and blind gobies were only taken at station C-25.

6.4.5.7.3 Temporal Distribution - Lagoon. Diel distribution of ichthyoplankton species at lagoon stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for outer lagoon 335μ mesh or middle and upper lagoon 505μ mesh nets between day and night sampling. However, significant differences were found in the outer lagoon with 505μ mesh and in the upper and middle lagoon with 335μ mesh nets. Where significant differences were found, the nighttime samples captured more than the daytime samples. The differences that were observed on two occasions (Table 6.4-9) in this study between day and night collections are most likely attributable to patchiness, avoidance in daytime versus night, and perhaps a concentration of fish larvae near the surface (sampling zones) at night.

No goby eggs were taken in lagoon collections. Goby larvae were collected during every month of the year in the lagoon. Peak abundances occurred from March through June for most groups. Species identified from lagoon collections included: blind goby, blackeye goby, bay goby, and checkspot goby. Blind gobies were taken in May, June and November. Blackeye gobies were collected in May, June, and July. Bay gobies were collected in April. Checkspot gobies were taken in December. The peak abundances for most species in summer and fall coincide with reported spawning times for certain species (6-435).

6.4.5.7.4 Spatial Distribution - Lagoon. Goby larvae were collected at all lagoon sampling stations in all three sections of the lagoon. Blackeye, blind, checkspot, and bay goby were collected from the outer lagoon. Only unidentified species were taken in the middle lagoon. Blind and blackeye gobies were identified from the upper lagoon.

Vertical distribution within the lagoon was difficult to examine due to shallow depths in many portions of the study area. The extent of vertical distribution was examined in the deeper areas of the outer lagoon and found to be insignificant, indicating no vertical stratification of species within the lagoon water column (see Section 6.4.4.1.4).

6.4.5.8 Bothidae. The bothid (left-eyed) flounders comprise fewer species than the right-eyed group (Pleuronectidae) in California waters. Common bothids in the study area include: Pacific sanddab (*Citharichthys sordidus*), speckled sanddab (*C. stigmaeus*), longfin sanddab (*C. xanthostigma*), bigmouth sole (*Hippoglossina stomata*), California halibut (*Paralichthys californicus*), and fantail sole (*Xystreurys liolepis*). The major species collected in plankton studies were sanddabs (*Citharichthys* sp) and California halibut.

6.4.5.8.1 Temporal Distribution - Offshore. Diel distribution of ichthyoplankton species at offshore stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for either 335μ mesh or 505μ mesh nets between day and night sampling at offshore stations.

Eggs from three bothid species were collected offshore. California halibut eggs were collected from January through March and in June and September. California halibut are reported to spawn from February to July (6-436). Sanddab (Citharichthys sp) eggs were collected during every month of the year offshore. Sanddab spawning is reported from April to September for two of the three species (6-437 and 6-438). Bigmouth sole eggs were collected in October. Only sanddab (Citharichthys sp) and California halibut larvae were collected offshore. Sanddab larvae were only collected in September (Appendix Tables 16.3-17 and 16.3-18). California halibut larvae were collected from January through April and in September and November. The seasonal collections in fall for sanddabs and in spring for California halibut correspond with reported spawning periods (6-439, 6-440, and 6-441).

6.4.5.8.2 Spatial Distribution - Offshore. California halibut eggs were collected at all offshore stations. The California halibut migrates inshore to waters 6 to 20 m deep to spawn (6-442), so eggs were expected to be common in the study area, as was the case. Sanddab eggs (Citharichthys sp) were very common at all sampling stations offshore. This species is very abundant in the region and eggs were collected at all stations (Appendix Tables 16.3-19 and

16.3-20). Eggs of the bigmouth sole were only collected at station C-25. California halibut larvae were collected at all stations offshore (Appendix Tables 16.3-21 and 16.3-22). Sanddab larvae (Citharichthys sp) were only collected at two stations offshore (G-25, F-50), even though eggs were abundant everywhere. Fitch and Lavenberg (1973) report that sanddab larvae have a relatively long pelagic period and that many young larvae occur several kilometers offshore, which is beyond the study area for our collections (6-443). This may be the cause of the sparse distribution of larvae in this study area.

6.4.5.8.3 Temporal Distribution - Lagoon. Diel distribution of ichthyoplankton species at lagoon stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for outer lagoon 335μ mesh or middle and upper lagoon 505μ mesh nets between day and night sampling. However, significant differences were found in the outer lagoon with 505μ mesh and in the upper and middle lagoon with 335μ mesh nets. Where significant differences were found, the nighttime samples captured more than the daytime samples. The differences that were observed on two occasions (Table 6.4-9) in this study between day and night collections are most likely attributable to patchiness, avoidance in daytime versus night, and perhaps a concentration of fish larvae near the surface (sampling zone) at night.

Monthly collections in the lagoon captured sanddab (Citharichthys sp) eggs during every month of the year. California halibut eggs were collected in the lagoon from January through March and in July and September. Sanddab larvae were collected in the lagoon in September. California halibut larvae were collected in the lagoon in February. It appears that larvae of these species drift into the lagoon at times, but are more common offshore. The seasonal appearance of sanddab larvae in fall and halibut larvae in spring coincides with their seasonal abundances offshore.

6.4.5.8.4 Spatial Distribution - Lagoon. Sanddab eggs were collected at all lagoon stations in the outer, middle, and upper lagoon. Sanddab larvae were only collected in the outer lagoon. California halibut eggs were collected in the outer and upper lagoon. None were taken in the middle lagoon. Halibut larvae were only taken in the outer lagoon.

Vertical distribution within the lagoon was difficult to examine due to shallow depths in many portions of the study area. The extent of vertical distribution was examined in the deeper areas of the outer lagoon and found to be insignificant, indicating no vertical stratification of species within the lagoon water column (see Section 6.4.4.1.4).

000296

6.4.5.9 Pleuronectidae. The right-handed flatfish (Pleuronectidae) common in the study area include: diamond turbot (*Hypsopsetta guttulata*), English sole (*Parophrys vetulus*), C-O sole (*Pleuronichthys coenosus*), spotted turbot (*Pleuronichthys ritteri*), hornyhead turbot (*Pleuronichthys verticalis*), and curlfin sole (*Pleuronichthys decurrens*).

6.4.5.9.1 Temporal Distribution - Offshore. Diel distribution of ichthyoplankton species at offshore stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for either 335μ mesh or 505μ mesh nets between day and night sampling at offshore stations.

Eggs of six Pleuronectid species were collected offshore. English sole eggs were collected in September. Spotted turbot eggs were collected during every month of the year except July. Hornyhead turbot eggs were collected during every month of the year. C-O sole eggs were collected in March, May, and August through December. Diamond turbot eggs were collected in November and February. Curlfin sole eggs were collected in November

Larvae of three Pleuronectid species were collected offshore. Diamond turbot larvae were collected in February, April, May and September through November. Hornyhead turbot larvae were collected in October, January, February, and May. Curlfin sole larvae were collected in November.

In general, some form of Pleuronectid eggs were present offshore during all seasons and larvae were present during spring and fall.

6.4.5.9.2 Spatial Distribution - Offshore. Spotted and hornyhead turbot and C-O sole eggs were collected at all offshore stations, indicating widespread distribution. Diamond turbot eggs were collected at all stations except one (C-25). Curlfin turbot and English sole eggs were only collected at one station (A-25) offshore (Appendix Tables 16.3-19 and 16.3-20).

Diamond turbot larvae were collected at all offshore stations. Spotted turbot were collected at three (F-50, C-25, G-25) of the five offshore stations. Curlfin sole larvae were collected at one station (F-50) offshore. No other Pleuronectid larvae were captured offshore.

6.4.5.9.3 Temporal Distribution - Lagoon. Diel distribution of ichthyoplankton species at lagoon stations was examined by day and night sampling in October. A Mann-Whitney U-test was utilized to examine any significant differences between day and night sampling. No significant differences were found (Table 6.4-9) for outer lagoon 335μ mesh or middle and upper lagoon 505μ mesh nets between day and night sampling. However, significant differences were found in the outer lagoon with 505μ mesh and in the upper and middle lagoon with 335μ mesh nets. Where significant differences were found, the nighttime samples captured more than the daytime samples. The differences that were observed on two occasions (Table 6.4-9) in this study between day and night collections are most likely attributable to patchiness, avoidance in daytime versus night, and perhaps a concentration of fish larvae near the surface (sampling zone) at night.

Four species of Pleuronectid eggs were collected in the lagoon. Diamond turbot eggs were collected in January and March. Spotted turbot eggs were collected in all months except August and November. Hornyhead turbot eggs were collected from January through July and in October and December. C-O sole eggs were collected in August, October and December.

Pleuronectid larvae in the lagoon were not very common. Diamond turbot larvae were collected in February and March and hornyhead turbot were collected in April.

Pleuronectid eggs were collected in all seasons, but larvae were only collected in the spring.

6.4.5.9.4 <u>Spatial Distribution - Lagoon</u>. Spotted turbot and hornyhead turbot eggs were captured at all stations in in all three portions of the lagoon. C-O sole and diamond turbot eggs were only collected in the outer lagoon (Appendix Tables 16.3-19 and 16.3-20).

Hornyhead turbot larvae were only collected in the outer lagoon. Diamond turbot larvae were collected in the outer and middle lagoons.

Vertical distribution within the lagoon was difficult to examine due to shallow depths in many portions of the study area. The extent of vertical distribution was examined in the deeper areas of the outer lagoon and found to be insignificant, indicating no vertical stratification of species within the lagoon water column (see Section 6.4.4.1.4).

6.4.6 Non-Critical Species

The only critical invertebrate species was the copepod, *Acartia tonsa*. Many other invertebrate species were captured in this study, although copepods were the most abundant species. The major groups of zooplankton species collected were examined to determine species make-up. A total of 123 invertebrate taxa were identified in samples (Table 6.4-7). Many of these were common in collections both offshore and in the lagoon.

Non-critical ichthyoplankton species were comprised of 21 different taxa for fish larvae and 11 different taxa (Table 6.4-11) for fish eggs. All of the non-critical species captured were species common or expected to occur in the study area. Temporal and spatial distribution of these species both offshore and in the lagoon is shown in Appendix Tables 16.3-9 through 16.3-26.

TABLE 6.4-11
NON-CRITICAL ICHTHYOPLANKTON TAXA CAPTURED
IN PLANKTON COLLECTIONS OFFSHORE AND/OR IN THE LAGOON
ENCINA POWER PLANT - AUGUST 1, 1980

Scientific Name	Common Name
Fish Larvae	
Anguilliformes	Eels
Anisotremus davidsonii	Sargo
Chromis punctipinnis	Blacksmith
Clupeidae	Herrings
Exocoetidae	Flyingfishes
Gobiesocidae	Clingfishes
Gobiesox papillifer	Bearded clingfish
Hypsoblennius sp.	Blenny
Hypsypops rubicundus	Garibaldi
Labridae	Wrasses
Mugil cephalus	Striped mullet
Peprilus simillimus	Pacific butterfish
Sardinops sagax caeruleus	Pacific sardine
Sebastes sp.	Rockfish
Sphyraena argentea	Pacific barracuda
Syngnathus leptorhynchus	Bay pipefish
Syngnathus sp.	Pipefish
Synodus lucioceps	California lizardfish
Trachurus symmetricus	Jack mackerel
Triphoturus mexicanus	Mexican lampfish
Xiphidae	Swordfish
Fish Eggs	
Cetengraulis sp.	Anchoveta
Girella nigricans	Opaleye
Hemiramphidae	Halfbeaks
Labridae	Wrasses
Mugil cephalus	Striped mullet
Pimelometopon pulchrum	California sheephead
Sebastes sp.	Rockfish
Sphyraena argentea	Pacific barracuda
Synodus lucioceps	California lizardfish
Tetradontiformes	Boxfish, Puffers, Parrotfish
Trachurus symmetricus	Jack mackerel

Abundances per unit volume for various sample periods and areas is given in Appendix Tables 16.3-1 through 16.3-8.

6.4.7 Comparisons of Lagoon and Offshore

With regard to species make-up for invertebrates there were no noticeable differences between the lagoon and offshore. The same major species groups were caught at all stations in both areas (Appendix Tables 16.3-11 and 16.3-12). However, abundances were significantly greater offshore than in the lagoon (Tables 6.4-3 through 6.4-6) indicating that the offshore waters were the source for lagoon invertebrate populations or that conditions were more favorable offshore for invertebrate production, or both.

Ichthyoplankton species were more diverse offshore than in the lagoon. A greater variety of species were collected offshore and they were more abundant offshore (Tables 6.4-3 through 6.4-6), indicating that most species spawn offshore rather than in the lagoon, however, a number of species drift into the lagoon. Some of the gobies were more abundant in the lagoon, indicating that some of these species may spawn in the lagoon. Another species that was more abundant in the lagoon was the anchovy (Engraulidae). Anchoa species are lagoon residents and spawn in the lagoon, so this group of anchovies was significantly more abundant in the lagoon. The northern anchovy (Engraulis mordax) spawns offshore and was not abundant in the lagoon.

It appears that the source waters for most lagoon planktonic organisms was offshore waters except for a few minor lagoon residents that spawn in the lagoon. Most lagoon species could be replaced from offshore sources, were they to be extirpated.

6.4.8 Seasonal Distribution

Offshore plankton distribution varied seasonally. Invertebrate species showed peak abundances in spring and fall in 335μ mesh collections (Figure 6.4-4), and high levels during fall and winter in 505μ mesh collections (Figure 6.4-3). The 335μ mesh data probably better approximates the seasonal picture for invertebrates as the 505μ mesh net does not capture all species.

Ichthyoplankton offshore showed seasonal peaks in spring and summer with 335μ mesh net collections (Figure 6.4-11) and peaks in summer and fall with 505μ mesh net collections (Figure 6.4-12). Eggs comprised the major percentage of the catch in most periods. Many species are spring and summer spawners and contribute to the observed peak levels in spring, summer and fall.

Lagoon invertebrate species showed peaks in abundances in spring, early summer, and early fall (Figures 6.4-5 and 6.4-6) in the outer lagoon where sampling was bimonthly. In the middle and upper lagoon there was a peak in invertebrate levels in June, September, November, and January (Figures 6.4-7 through 6.4-10). These peaks fluctuated greatly, making it difficult to determine definite seasonal patterns. Sampling was conducted monthly, so some changes and/or fluctuations were probably missed due to the rapid turnover of many plankton species.

Ichthyoplankton in the outer lagoon exhibited definite peaks in late spring to early summer (May through June) and some smaller increases in fall (September) and spring (March) collections (Figures 6.4-13 and 6.4-14). Data for the middle and upper lagoon also showed peak abundances in late spring to early summer (May through June) collections (Figures 6.4-15 through 6.4-18). These ichthyoplankton peaks were all due to heavy spawning in spring and summer by many species.

Abundances for plankton groups were greater offshore than in the lagoon.

6.5 NEKTON

Monthly nekton collections were made in both the near-field and far-field during the year long study to evaluate the abundance and distribution of critical species.

6.5.1 Abstract and Summary

A one-year study was conducted to examine the abundance and distribution of nekton species in the vicinity of the Encina Power Plant. Monthly sampling was conducted using otter trawls, beach seines and gill nets at both offshore and lagoon sites.

Nekton collections yielded a total of 63,712 specimens (63,456 fish and 256 invertebrates). Ninety-one species of fish and 17 species of invertebrates were taken. Ninety-six percent of the total catch was comprised of the critically treated species studied (Tables 6.3-1 and 6.3-2 and Figure 6.5-1).

The ten most abundant species collected, listed in order of decreasing abundance, were California grunion, topsmelt, deep-body anchovy, slough anchovy, northern anchovy, queenfish, walleye surfperch, speckled sanddab, shiner surfperch and California halibut. Forty-nine percent of the entire nekton landings were California grunion predominately captured from the surf zone collections during the fall.

Non-critical species (using the concept that 96 percent of the species were treated as critical) accounted for only four percent (2,814 specimens) of the total nekton catch. Included

000305

within this category were 64 fish species and 17 invertebrate species.

Hierarchical analysis of nekton landings revealed three distinctly different populations, one in the lagoon, one offshore and one in the surf zone environment. Figure 6.5-15 summarizes the distribution of the three nekton population types. Lagoon populations (type A) were more closely related to offshore populations (type B) than to those of the surf zone (type C).

Instantaneous population estimates of demersal fish were calculated, based upon trawl and seine landings. Minimum average estimates were presented for upper, middle and outer segments of Agua Hedionda Lagoon (590,211 individuals) and for a defined coastal area (which included all sampling stations) (Figure 6.5-16) (467,967 individuals). Fish densities were found to be greatest in the upper lagoon segment, least in the outer lagoon segment. Approximately 78 percent of the total estimated lagoon population was contributed by the upper lagoon (which constitutes 76 percent of the total lagoon surface area). Only 12 percent of the total lagoon fish population was indicated for the outer lagoon area (which constitutes 17 percent of the lagoon surface area).

Nekton populations exhibited definite seasonal fluctuations, both in species composition and abundance. Nekton were most abundant during the fall and least abundant during the spring (Figure 6.5-17). Minimum and maximum species diversities occurred during the winter and fall, respectively. Seasonal fluctuations of individual critical species populations were also evident. However, 19 of the 27 critically treated species were taken during every month, indicating that they represented primarily year-round residents of the study area (Figure 6.4-1).

6.5.2 Methodology

Monthly studies of fishes in the vicinity of the Power Plant were conducted offshore and in each of the three sections of Agua Hedionda Lagoon during the period from January through December, 1979. Otter trawls, bag seines and gill nets were used in nekton collections.

Trawl collections were conducted at four offshore and five Agua Hedionda Lagoon locations (Figure 6.4-1). A 7.9 m (26 ft) and 4.9 m (16 ft) Marinovich otter trawl (1.5 cm stretch mesh) were utilized in offshore and lagoon collections, respectively.

Bag seine (1.27 cm stretch mesh) collections were obtained monthly at four coastline (surf zone) and three lagoon sites (Figure 6.4-1). Coastline samples were taken with a 50 m (164 ft) seine; lagoon samples with an 18 m (59 ft) seine.

Variable-mesh sinking gill nets 55 m (180 ft) long were used to sample demersal fish species at four offshore and three lagoon stations (Figure 6.4-1).

Nekton sampling was generally performed during the daylight hours. However, some night collections were also conducted. Nekton species were processed in the field or laboratory.

Detailed methodologies for all nekton collections and processing are given in Appendix B (Section 16.2.2).

6.5.3 Rank Order - Abundance

Nekton collections yielded a total of 63,712 specimens. Primary consideration has been given to fishes, which constituted 63,456 individuals (91 species). Invertebrates represented only a minor portion of the total catch (256 individuals of 17 species).

Appendix Table 16.3-27 (Section 16.3.2) shows the rank order of total nekton species abundance for the entire one-year study. Appendix Tables 16.3-28, 16.3-29, 16.3-30, 16.3-31 and 16.3-32 (Section 16.3.2) rank total nekton abundances in the offshore area, entire lagoon system, outer lagoon, middle lagoon and upper lagoon, respectively. Total catch data for the top ten most abundant species has been summarized in Table 6.5-1. These ten species, all treated as "critical", accounted for 91 percent of the total nekton landings. California grunion was the most abundant species captured during the entire study. It accounted for nearly half of the total nekton abundance. Although most common in coastline areas, it was taken in abundance in the outer and middle Agua Hedionda Lagoons. Another atherinid, the topsmelt, was the second most abundant species. It was found to be common both offshore and within the lagoon system. Deepbody and slough anchovies, ranking third and fourth in overall abundance, were taken primarily in the upper lagoon waters. Northern

TABLE 6.5-1
SUMMARY OF TOTAL CATCH DATA FOR THE TEN MOST
ABUNDANT NEKTON SPECIES
ENCINA POWER PLANT - AUGUST 1, 1980

Species	Number Caught	Rank	% Total Nekton Abundance
California grunion	31,293	1	49
Topsmelt	10,597	2	17
Deepbody anchovy	4,409	3	7
Slough anchovy	3,906	4	6
Northern anchovy	1,894	5	3
Queenfish	1,662	6	3
Walleye surfperch	1,358	7	2
Speckled sanddab	1,057	8	2
Shiner surfperch	896	9	1
California halibut	741	10	1

anchovies, however, were relatively numerous offshore and in the upper lagoon. Of the remaining "top ten" species, queenfish, walleye surfperch and speckled sanddab generally ranked in greater abundances in the offshore areas. Shiner surfperch and California halibut were taken in greater numbers within the inshore lagoon waters.

6.5.4 Critical Species

Critically treated species (Section 6.3) contributed 96 percent (60,898 individuals) of the entire 1979 nekton catch (Figure 6.5-1). In terms of total abundance, 23 of the 27 total critically treated species ranked in the top 30 abundance rankings (Appendix Table 16.3-27). Of the remaining species, white seabass, Pacific sanddab and California sheephead were relatively uncommon. The following accounts summarize pertinent information concerning each of the critical species captured during the nekton study.

6.5.4.1 *Urolophus halleri* (round stingray). Round stingray ranked twenty-third in overall abundance, with a total of 134 individuals captured during the nekton study. Although taken during every month, this species appeared to be most abundant during the winter months. Peak Abundances were observed during January (27 fish), February (15 fish) and March (32 fish) (Appendix Table 16.3-33). Few stingray were noted during the May-October period.

The majority (118 fish) of round stingray were captured from lagoon waters. Although relatively common throughout the lagoon system, greatest abundances were indicated within the middle lagoon (52 fish) and lowest, in the outer lagoon (24 fish). Only 16 specimens were obtained from the surf and offshore areas. Monthly abundance levels for these catches were never sufficient enough to observe specific trends. However, the catch does appear to indicate a preference for the shallower (25-foot depth) stations offshore.

Individuals captured ranged in size from 80 to 290 mm standard length. The average standard length for all stingray taken was 173 mm. However, specimens from offshore areas (average standard length 210 mm) were generally larger than those obtained from the lagoons (average standard length 168 mm). A length-frequency distribution for the entire round stingray catch is shown in Figure 6.5-2.

Spawning reportedly begins in April with young being born from June through November (6-444). At birth individuals are approximately 100 mm long (total length). Newly hatched stingray were not observed during the nekton collection program. However, a single adult, carrying well-developed young, was noted during September impingement sampling at the Power Plant (Section 7.10). Small juveniles were taken throughout the winter and spring in the shallow lagoon waters.

6.5.4.2 *Engraulis mordax* (northern anchovy). Northern anchovy ranked fifth in overall abundance with 1894 specimens taken. Although captured during every month, a large abundance peak

(1024 fish) was observed during July. Relatively low abundances were noted during January, February, April, November and December collections.

The anchovy was most abundant in offshore areas (1677 fish), with greater numbers being taken from shallower stations (25-foot depth and surf-zone). Few specimens were collected from the outer (4 fish) and middle (0 fish) lagoons. However, this species appeared to be moderately abundant in the upper lagoon, with 213 individuals collected during the study. While offshore seasonal distribution follows a pattern similar to that discussed above, the data may suggest a somewhat different pattern within the inshore lagoon areas. There, the anchovy was only collected during January, May, July, September, October and December. A peak abundance was observed to occur during October (170 individuals).

Northern anchovy averaged 85 mm in total length, with individuals ranging in size from 30 to 170 mm (Figure 6.5-2). Offshore fish (average total length 87 mm) were slightly larger than those found within the lagoons (average total length 70 mm). Juveniles, however, were collected from both areas.

Plankton data (Section 6.4.5.1) revealed spawning activity during October, December, and March, when eggs were collected from both offshore and lagoon areas. Females bearing eggs were also noted during impingement collections (Section 7.10) in November, March and April. These findings appear to be in agreement with those of Lasker and Smith (6-445) and Brewer (6-446).

6.5.4.3 *Anchoa compressa* (deepbody anchovy)

Deepbody anchovy was the third most abundant fish captured (4409 taken). It was taken every month of the year except during January. These anchovies were generally most abundant during the summer and fall, when 2000 and 1867 individuals were captured, respectively. The greatest peak abundance was observed to occur during August, when 1103 specimens were collected. Few deepbody anchovies were obtained during the winter months.

By far the majority of fish collected were taken from the upper Agua Hedionda Lagoon (4108 fish). Although relatively numerous in the middle lagoon, few were indicated in the outer lagoon. Only a relatively small number were collected offshore (77 fish) and these were only found at the shallower stations (25-foot depth and surf zone). Offshore, specimens were only captured during the February-June period and August.

Individuals captured averaged 92 mm in total length. However, fish ranging in size from 32 to 157 mm were collected during the study (Figure 6.5-3). Anchovies netted from offshore areas (average total length 113 mm) were much larger than those netted within the lagoons (average total length 71 mm).

Deepbody anchovies reportedly spawn during the spring and summer months (6-447). Data collected during the present studies support the observations of previous workers. Developing females with eggs were collected from January through August in impingement samples (Section 7.10) taken at the Power Plant. Ripe females were captured during June. Although this species could not be specifically identified in plankton samples (Section 6.4.5.1), specimens of Anchoa sp were captured in all areas during the spring and summer.

6.5.4.4 *Anchoa delicatissima* (slough anchovy). With 3906 individuals collected, the slough anchovy ranked as the fourth most abundant nekton species collected during 1979. Specimens were obtained during every monthly collection except January and April. The majority of anchovies were observed during the fall when peak abundances occurred in September (1520 fish), October (1120 fish), and November (1009 fish).

Nearly 99 percent of the slough anchovies were obtained from collections within Agua Hedionda Lagoon. The majority (3847 fish) were captured in the upper lagoon. Few were observed within the outer and middle lagoon areas. Offshore specimens (44 individuals) were only taken from the surf zone, during February and June collections.

The slough anchovy was usually the smallest anchovy species collected during the study program. In total length, individuals ranged from 29 to 98 mm, having an average length of 71 mm (Figure 6.5-3).

Little information is available in the literature concerning the spawning season of this species. Larval specimens were collected both offshore and in the lagoons in March plankton samples (Section 6.4.5.1). This data indicates at least a late winter-early spring spawning period in the vicinity of the Encina Power Plant.

6.5.4.5 *Leuresthes tenuis* (California grunion). The California grunion was the most abundant nekton species captured during the entire study (31,293 specimens). Although the fish were taken during every month except March, they were most abundant during the fall, when 21,743 were collected. Peak abundances were observed during September (8,168 fish) and November (11,929 fish) collections.

In terms of spatial distribution, 97 percent of the individuals were obtained from samples taken in the surf zone. None were taken farther offshore. Within the Agua Hedionda Lagoon system, grunion ranked fifth in terms of total abundance (784 specimens). Abundances were greatest in the middle (483 fish) and outer (277 fish) lagoons. Relatively few were taken from the upper lagoon waters. Most of the lagoon grunion were collected within the August-December period. During the rest of the year, only 12 individuals were captured, all during April collections.

Specimens ranged in size from 40 to 196 mm, with an average total length of 96 mm (Figure 6.5-4). Surf zone fish (average total length 102 mm) were generally larger than those captured within Agua Hedionda Lagoon (average total length 77 mm).

California grunion reportedly spawn from late winter through early fall (4-448, 4-449). Data from the present studies indicate the occurrence of spawning during this period. Ripe females were taken during impingement collections within the Power Plant (Section 7.10) in April, May and June. Spent females were observed in September collections. Plankton data results are relatively inconclusive with respect to this species (Section 6.4.5.2). No specifically identified grunion larvae are reported in the plankton data. Taxonomic problems did not allow positive identification below the family level. Atherinidae larvae were collected from both offshore and lagoon areas during the January-July and October-December periods.

6.5.4.6 *Atherinops affinis* (topsmelt). Topsmelt ranked as the second most abundant species captured (10,597 individuals). Speciments were obtained throughout the year. Although a maximum abundance was indicated in December (2063 specimens), topsmelt were consistenly taken in large numbers during the summer and winter months. Spring appeared to be the season of least abundance.

This atherinid was abundant in both offshore (2333 specimens) and lagoon (8264 specimens) areas. Most of the offshore specimens were taken from the surf zone. Within the lagoon system, greatest numbers were captured in the middle lagoon (4843 fish). However, topsmelt were common in all lagoon areas.

In size, topsmelt ranged from 5 to 383 mm. Having an average total length of 127 mm, this species was a consideraly larger atherinid than the grunion. A length-frequency distribution for total topsmelt nekton catch is presented in Figure 6.5-4. Few fish smaller than 50 mm or larger than 200 mm were captured during the 1979 investigation.

Previous investigators report an extensive spawning season, running from late winter through early fall (6-450, 6-451). Data from the present studies show no evidence to the contrary. Ripe females were noted during February, March and April impingement collections (Section 7.10). Also during February, nekton collections within the lagoons yielded recently hatched (5 mm total length) individuals. Small juveniles were generally taken throughout most of the year. In addition, planktonic atherinid larvae were consistenly collected both offshore and from the lagoons during the January-July and October-December periods.

6.5.4.7 *Scorpaena guttata* (sculpin). Relatively few sculpin (99 specimens) were captured during the nekton study. This species ranked only twenty-ninth in overall abundance. Specimens were obtained during each month; however, numbers were generally quite low. The periods of greatest abundance occurred during October and November when 17 and 19 fish were captured, respectively.

In terms of spatial distribution, only one sculpin was captured from Agua Hedionda Lagoon. The remaining catch was obtained from offshore stations. The sculpin appeared to be equally common offshore at both 25 and 50-foot depths. No specimens were taken from the surf zone.

Specimens ranging from 84 to 305 mm were taken, having an average total length of 197 mm (Figure 6.5-5).

No information was revealed concerning spawning activity of the sculpin. No eggs or larvae were present in plankton collections (Section 6.4.5). David (6-452) reported that spawning takes place from April through August for this species.

6.5.4.8 *Leptocottus armatus* (staghorn sculpin). Staghorn sculpin ranked thirty-fourth in terms of overall abundance, with only 77 individuals captured during 1979. These sculpin were collected during every monthly collection. Although abundances were quite low for this species, definite seasonal/spatial patterns were evident. Within the lagoon system this species was most common during the January-June period. Few were taken during the remainder of the year. Offshore, however, no individuals were obtained during the January-June period. The greatest abundances in this region were noted during the October-December period. In all, 25 staghorn sculpin were found offshore, 52 within the lagoons. This species appeared to be least abundant in the outer lagoon waters.

Staghorn sculpin captured in nekton collections averaged 107 mm in total length. Individuals, however, varied considerably in this respect, ranging from 17 to 195 mm (Figure 6.5-5). Lagoon specimens were usually much smaller than those taken from offshore areas.

Very little information was obtained concerning spawning activities of the staghorn sculpin. No eggs or positively identified larvae were taken in plankton collections (Section 6.4.5.3). Newly hatched young, however, were netted from the lagoons during January and February nekton collections. The data suggest at least a winter spawning season exists for this sculpin. These findings are in agreement with those of Fitch and Lavenberg

(6-453), who reported the occurrence of spawning during the period from October through March.

6.5.4.9 *Paralabrax clathratus* (kelp bass). Kelp bass ranked as the fifteenth most abundant nekton species collected (259 specimens). This serranid was captured each month, except February, and exhibited a peak in abundance during the October collections (120 fish). Few specimens were obtained from offshore areas. This is probably a result of sampling bias since the fish's major habitat, the kelp beds, could not be sampled by the methods used. No fish were found to be present within the surf zone. Within the lagoon system, kelp bass were relatively abundant. Greatest numbers were taken from the middle lagoon (133 fish), smallest, from the upper lagoon (36 fish). The data indicate this species is more common inshore during the August-December period.

Individuals ranged in size from 12 to 315 mm, having an average total length of 105 mm (Figure 6.5-6). Kelp bass taken offshore were generally larger than those taken within the lagoons. Most offshore specimens were mature or nearly so, while both young and adults were common in Agua Hedionda Lagoon. Young juveniles (<40 mm total length) were abundant within the lagoons during the period from August through December, apparently utilizing the area as a nursery grounds.

Larval kelp bass were taken in both offshore and lagoon areas during July and September plankton collections (Section 6.4.5.4). These data are in close agreement with spawning seasons reported by previous investigators. Collyer and Young (6-454) claimed that most kelp bass spawn during July, August and September.

6.5.4.10 *Paralabrax maculatofasciatus* (spotted sand bass). Spotted sand bass ranked twenty-first in terms of overall abundance, with 164 fish collected. This species was captured throughout the year at relatively low levels. Greatest numbers were taken during March (29 fish) and January (21 fish) collections. All specimens were obtained from the lagoon stations. None were taken offshore or in the surf zone. Slightly greater catches were observed in the middle lagoon area.

Specimens ranging in size from 27 to 440 mm were collected (Figure 6.5-7). Average total length for the spotted sand bass was 225 mm.

No specifically identified eggs or larvae were collected for this species (Section 6.4.5.4). However, Paralabrax sp larvae were taken in July and September plankton collections. Small juvenile spotted sand bass were captured from Agua Hedionda Lagoon in October and November. Other investigators have reported spawning during the spring and early summer (6-455).

6.5.4.11 *Paralabrax nebulifer* (barred sand bass). In all, 89 barred sand bass were collected during the nekton sampling program. Specimens were obtained in all but the February samples. The largest landings were obtained during March (17 fish), June (19 fish), August (12 fish) and September (12 fish). Few fish were collected during the winter months. Greater numbers of this bass were taken in the lagoons (56 fish) than offshore (33 fish). The species appeared to be more or less evenly distributed between the three lagoons. Offshore distribution patterns were not evident. However, the species was never captured within the surf zone.

Barred sand bass averaged 187 mm in total length, with individuals falling within the 26 to 413 mm size range (Figure 6.5-6). All offshore specimens were mature adults, while both small juveniles and adults were present in lagoon areas.

No barred sand bass eggs or larvae were identified in plankton samples (Section 6.4.5.4), although larvae identified as Paralabrax sp were noted during July and September. Small juveniles were also present in lagoon areas during June and August. The data, as such, would indicate a spring/summer spawning season for this bass. Collyer and Young (6-456) reported similar findings, noting spawning activity from April through September.

6.5.4.12 *Seriphus politus* (queenfish). Queenfish were the sixth most abundant species captured (1662 specimens) during the program. This species was present in samples every month during the year. Peak abundances were noted during March (468 fish), May (242 fish) and September (381 fish). Landings during the winter months were generally quite low. Queenfish were taken in much larger numbers from offshore areas (1464 fish) than in the lagoons (198 fish). Offshore, the fish was common in all areas, including the surf zone. Within the lagoons, this sciaenid was much more abundant in the upper lagoon area (176 fish). Few specimens were obtained from the outer and middle lagoon nekton collections. They were, however, collected in impingement samples from the outer lagoon (Section 7.0).

Specimens ranged in size from 26 to 276 mm, yielding an average total length of 140 mm (Figure 6.5-8). Although both offshore and lagoon catches contained fishes within a similar size range, smaller juveniles comprised a much greater proportion of the lagoon nekton catch. Small juveniles (<75 mm) were relatively abundant during the summer months.

Larval queenfish were present in both lagoon and offshore areas during January, April, July, August and September (Section 6.4.5.5). Other investigators have previously reported spawning to occur from April through August (6-457, 6-458). Our data suggest a more extended spawning period, with a possible second spawning season during winter.

6.5.4.13 *Cynoscion nobilis* (white seabass). Only 15 white seabass were captured during the entire nekton program. At least one fish was captured each month, except during January, April and October. In the lagoons, six specimens were taken; offshore, only nine were taken. Landings were too small to observe any seasonal or spatial distribution patterns.

Individual seabass ranged from 79 to 500 mm in total length (Figure 6.5-7). The average total length for all specimens was 259 mm. No mature adults were captured.

Larval white seabass were collected both offshore and in the lagoons during June and September plankton collections (Section 6.4.5.5). These data are consistent with the findings of Thomas (6-459), who reported spawning activity from March through August.

6.5.4.14 *Menticirrhus undulatus* (California corbina). With 558 specimens captured, the California corbina ranked eleventh in overall abundance. This species was observed to occur every month of the year in the study area. The sciaenid appeared to be most abundant during the fall. Peak abundances were observed during September (104 specimens) and November (144 specimens). Abundances were reduced during the late winter and spring months. Relatively few corbina were taken within the lagoon system (18 fish). The majority of fish were landed from the surf zone collections (498 fish).

With an average total length of 208 mm, corbina specimens ranged in size from 50 to 695 mm (Figure 6.5-8). Small juveniles were abundant during the late summer and early fall.

Larvae were captured during July, August and September, indicating a summer spawning season (Section 6.4.5.5). Fitch and Lavenberg (6-460) and Feder et al. (6-461) report similar findings for this species.

6.5.4.15 *Genyonemus lineatus* (white croaker). White croaker was the twelfth most abundant fish captured in the study. In all, 462 specimens were taken. Individuals were observed in collections each month, however, abundance was generally greater during the spring and summer. Maximum numbers were obtained during March (173 fish) and April (109 fish) landings. Although common in the outer and upper lagoons, approximately 72 percent of the total landings were from offshore areas. Only one specimen was collected in the middle lagoon and four in the surf zone.

White croaker specimens varied from 24 to 253 mm in total length (Figure 6.5-9). The average total length for all individuals examined was 126 mm. Although fish of all sizes were captured from offshore areas, lagoon specimens were all very young juveniles (24 to 74 mm total length). Young-of-the-year were common during March, April, May and June.

Larval croaker were noted during six months: January, February, April, May, June, and July (Section 6.4.5.5). Maxwell (6-462) and Goldberg (6-463) also reported similar results, showing that spawning occurred throughout most of the year.

6.5.4.16 *Roncador stearnsi* (spotfin croaker). One hundred eleven spotfin croakers were captured in the sampling program. This species ranked as the twenty-seventh most abundant fish taken and was represented in every monthly collection. In general, this sciaenid was more numerous during the summer months. Maximum abundances were observed during June (21 specimens), July (19 specimens) and August (29 specimens). Minimum landings were noted during the winter.

Catch data indicate the spotfin croaker is primarily an inshore species. Only one fish was taken from the offshore area,

000324

and this was collected at a 25-foot depth station. Eight croakers were also obtained from the surf zone. In all, 102 specimens were captured within Agua Hedionda Lagoon. The fish was common in the outer and upper lagoons. Few, however, were taken from the middle lagoon area.

In length, individuals ranged from 180 to 690 mm (Figure 6.5-9). The average total length was relatively large (375 mm), with most specimens being mature adults. No early-state juveniles were captured from either offshore or lagoon areas. Larvae, however, were taken in both areas during January, February, May, August and September (Section 6.4.5.5). These data suggest a more extensive spawning than reported by other workers. Skogsberg (6-464) claimed the spotfin to be a summer spawner. Our data suggests the possible existence of an additional winter spawning period.

6.5.4.17 *Amphistichus argenteus* (barred surfperch). The barred surfperch was the fourteenth most abundant nekton species captured. Of the 429 total specimens, none were taken from lagoon waters. The majority of fish collected (416 specimens) were obtained from surf zone collections. None were captured farther offshore than the 25-foot depth zone. This surfperch was present in every monthly collection. Maximum landings were observed during November, when 240 fish were captured. Minimum catches were noted during March (2 specimens).

Barred surfperch ranged in size from 63 to 310 mm and yielded an average total length of 144 mm (Figure 6.5-10). Very young specimens (60 to 80 mm) were captured during May collections. No specific data on spawning, however, was obtained during the program. Triplett (6-465) reported that mating occurs from November through January. As is true of other surfperches, this fish is viviparous and live young are released following a five month gestation period.

6.5.4.18 *Hyperprosopon argenteum* (walleye surfperch). This species ranked as the seventh most abundant fish captured in the entire nekton program (1358 specimens). Walleye surfperch were taken during every month, primarily from the surf zone. Although 124 fish were captured in Agua Hedionda Lagoon, few were collected from the middle and upper lagoon waters. Offshore collections showed this fish to be common throughout the offshore study area. Maximum abundance was noted during November, when 943 fish were taken. Smaller abundance peaks occurred during June (119 specimens) and July (129 specimens).

Walleye surfperch captured varied from 48 to 210 mm in total length (Figure 6.5-10). The average size for all specimens was 126 mm. No differences in size distribution were noted between offshore and lagoon areas. Adults and juveniles were taken in both regions.

Females bearing young were captured in April and May. Recently born juveniles were abundant during May, June and July.

000326

These findings are consistent with a reported October-December mating season followed by a five to six month gestation period (6-466, 6-467).

6.5.4.19 *Cymatogaster aggregata* (shiner surfperch). The shiner surfperch was captured during every monthly collection and taken from all general sampling areas. In all, 896 fish were collected, making this surfperch the ninth most abundant nekton species captured. Overall abundances were greatest during spring and summer, lowest during winter. The majority of fish were netted from the lagoon environments. Middle lagoon collections yielded the largest catch (609 fish), while only 14 surfperch were obtained from the outer lagoon. Two hundred three surfperch were landed from the upper lagoon waters. Offshore catches were inconsistent and at relatively low levels. Fish were not captured there or in the surf zone during the winter months.

Specimens ranged in size from 35 to 166 mm, having an average total length of 106 mm (Figure 6.5-11). Young juveniles (35 to 75 mm) were common during April, May and June. Females bearing young were also taken from inshore areas during April and May. According to other investigators, shiners mate offshore during spring and summer, with most young being released by June and July (6-468, 6-469).

6.5.4.20 *Mugil cephalus* (striped mullet). With 231 individuals captured, this species ranked seventeenth in total nekton abundance. Striped mullet were evident during each monthly collection, but appeared to be most numerous during the fall/winter period. Maximum landings were recorded during December when 72 fish were taken.

No mullet were captured at the offshore stations, and only 20 were taken from the surf zone. Most striped mullet were collected from the inshore lagoon waters. The fish appeared to be somewhat less abundant in the outer lagoon catches, with only 21 specimens obtained. Collections in the middle and upper lagoons were 91 and 99 fish, respectively.

Striped mullet averaged 418 mm in total length, with specimens ranging from 28 to 650 mm (Figure 6.5-11). Young (25 to 30 mm) were taken only during December nekton collections from the lagoons. Eggs, however, were reported from both offshore and lagoon areas during September through December and during February (Section 6.4.5). These data indicate a somewhat extensive spawning season, through the fall and winter months.

6.5.4.21 *Pimelometopon pulchrum* (California sheephead). Only three California sheephead were captured during the entire sampling program. One fish was captured in September, the other two, during November. All three fish were captured at offshore station F-50. It is not surprising that this species was not taken in great abundance, since its primary habitats, kelp beds and rocky-reef areas, were not specifically sampled during this program. Data was insufficient to examine specific temporal/spatial patterns.

The three specimens measured 205, 230 and 290 mm in total length, respectively. Eggs were noted occurring only during the April plankton collections, suggesting a spring spawning (Section 6.4.5).

6.5.4.22 *Heterostichus rostratus* (giant kelpfish). During the nekton sampling program, 156 giant kelpfish were collected. The fish were taken during every monthly collection. Seasonal fluctuations in abundance were not marked enough to exhibit any definite patterns. The majority of kelpfish were captured from Agua Hedionda Lagoon. Greatest numbers were obtained from the middle lagoon (85 fish) and the least, from the upper lagoon (17 fish). Only one specimen was taken from the surf zone and four were collected offshore at station C-25.

Specimens ranged in size from 28 to 274 mm, yielding an average total length of 118 mm (Figure 6.5-12). Young (25 to 75 mm) were taken from February through July, only in lagoon areas. Larvae were collected offshore during February and both offshore and from the lagoons during June (Section 6.4.5.6), suggesting a late winter and early summer spawning. Previous investigators reported that spawning occurs during the March-July period (6-470, 6-471).

6.5.4.23 *Paralichthys californicus* (California halibut). California halibut ranked tenth in overall abundance, with 741 specimens during the 1979 collections. Halibut were captured during every month of the year. Summer and fall total landings were only slightly larger than those obtained during spring. Winter landings were reduced relative to other seasons. The single largest monthly halibut catch, however, occurred during March, when 94 fish were taken.

Greater numbers of California halibut were captured from the lagoons (501 fish) than from offshore (240 fish) waters. Offshore, the halibut appeared to be most abundant at the 25-foot depth locations. Within Agua Hedionda Lagoon, this fish was found to be much more abundant in the upper lagoon (342 fish) and least abundant in the middle lagoon (45 fish).

Differences in seasonal abundance patterns were noted between offshore and lagoon areas. Offshore, halibut abundances appeared to be much greater during the fall. Minimum abundances were indicated during the winter months. In the lagoons, however, the halibut catches were greatest during spring and summer. Minimum total seasonal landings occurred during the fall within the inshore system.

Halibut specimens ranged in size from 8 to 690 mm total length (Figure 6.5-12). Lagoon fish (151 mm average length) were considerably smaller than those taken offshore (266 mm average length). Juveniles (<55 mm total length) were common inshore during the January through June period. A few juveniles were also captured during September and November collections.

Ichthyoplankton data (Section 6.4.5.8) indicate spawning activity during winter, spring and summer. These findings are consistent with those of Frey (6-472).

6.5.4.24 *Citharichthys sordidus* (Pacific sanddab). Only 13 Pacific sanddab were captured during the nekton sampling program. All were taken from offshore sites during January, March, June and October collections. Maximum numbers were noted during March, when nine sanddabs were collected. Extremely low abundances in the nekton landings prevent conclusions concerning seasonal/temporal distribution patterns for this species.

Specimens ranged in size from 42 to 182 mm, yielding an average total length of 99 mm.

No specific information was obtained concerning spawning seasons for this species.

6.5.4.25 *Citharichthys stigmaeus* (speckled sanddab). The speckled sanddab was the most abundant flatfish captured during 1979. With 1057 individuals landed, this species ranked eighth in total nekton abundance. Although present year-round, the sanddab was found to be most abundant during the fall. Abundance maximums were noted during October and November when 201 and 232 fish were netted, respectively. Minimum abundances occurred during the winter months.

Speckled sanddab appeared to be a primarily offshore species, with only two specimens being taken from Agua Hedionda Lagoon. All offshore sanddabs were taken at 25 and 50-foot station depths in approximately equal abundance. However, greater numbers were landed upcoast from the Power Plant's discharge (stations A-50 and C-25) than downcoast (stations F-50 and G-25).

Individuals varied from 40 to 180 mm in total length (Figure 6.5-13). Average total length for nekton specimens captured was 102 mm. Juvenile sanddabs (<80 mm) were taken during January, February, June, July and September through December. No eggs were specifically identified for this species (Section 6.4.5.8). Larvae, however, were collected during September, indicating summer spawning. Fitch and Lavenberg (6-473) have reported spawning to occur for this species from April through September.

6.5.4.26 *Pleuronichthys verticalis* (hornyhead turbot). Hornyhead turbot were captured during every monthly nekton collection performed in the 1979 study. In all, 172 individuals were captured, primarily from offshore areas. Only four specimens were obtained in Agua Hedionda Lagoon collections. Temporal abundance remained essentially unchanged during the spring, summer and fall. Winter catches, howevever, dropped to low levels. January and February landings were three and two individuals, respectively. Hornyhead turbot appeared to be equally abundant at all offshore stations. No depth-related differences in distribution were noted in this region.

Specimens ranged from 40 to 304 mm, yielding an average total length of 203 mm (Figure 6.5-13). Small juveniles (<100 mm) were only taken during May collections. Eggs were obtained year-round in ichthyoplankton collections (Section 6.4.5.9),

000332

indicating a year-round spawning for the hornyhead turbot. Budd (6-469), however, reported the occurrence of spawning only during the March through August period.

6.5.4.27 *Hypsopsetta guttulata* (diamond turbot). One hundred thirteen diamond turbot were captured in the nekton collections. Individuals were taken during every monthly collection. No seasonal differences in abundance were evident from the data. In terms of spatial distribution, greater numbers were taken from lagoon waters (92 specimens) than from offshore (21 specimens). Within the lagoon system, the turbot appeared to be much more abundant in the upper lagoon areas. Offshore, the species was more numerous at the shallower stations (25-foot depths). No individuals were captured from the surf zone.

Diamond turbot specimens ranged from 6 to 369 mm and averaged 196 mm in total length (Figure 6.5-14). Small juveniles were captured only during January, March, June, July and August; and then in only minor abundances. Plankton data indicate spawning during the October-March period (Section 6.4.5.9). Sumida et al. (6-475), however, only reported spawning activity for this species during the spring.

6.5.5 Non-Critical Species

Non-critical species accounted for only four percent (2814 specimens) of the total 1979 nekton catch (Figure 6.5-1). Included within the non-critical category were 64 fish species (2558 specimens) and 17 invertebrate species (256 specimens). In terms of relative abundance, the most numerous of these were the yellowfin croaker (435 specimens), opaleye (247 specimens), white surfperch (199 specimens), longfin sanddab (187 specimens) and salema (130 specimens). Due to their relatively minor contribution to the nekton catch and for reasons outlined in Section 6.3, these species will not be specifically analyzed in further detail.

6.5.6 Collections by Various Gear

Total nekton catches by beach seines, gill nets and otter trawls are shown in Table 6.5-2. Total numbers of fish species taken by each gear type are presented in Table 6.5-3. Offshore and lagoon contributions have also been included. All fish captured and location of capture for all gear types combined are shown in Table 6.5-4. Despite bias inherent to each sampling technique, 17 of the 27 total critically treated nekton species were taken by all three types of gear.

Differences in abundance among different gear types and sampling areas shown do not necessarily reflect actual population differences. Limitations which must be considered in analyzing such data include specific gear selectively and highly nonrandom nekton distributions (6-476). Different types of gear sample different portions of the nekton population. Selectivity of each gear type can vary appreciably with respect to fish size, age, sex and species. Closely tied to this are behavioral factors which affect nekton distribution. Different species, age groups, etc. may exhibit distinctive solitary or schooling habits and migrations.

TABLE 6.5-2
TOTAL NEKTON ABUNDANCES BY SAMPLING GEAR
ENCINA POWER PLANT - AUGUST 1, 1980

Sampling Gear	Location	Number of Fish Captured During 1979
Beach Seine	Lagoon	14,342
	Offshore	36,069
		Total - 50,411
Gill Net	Lagoon	4,676
	Offshore	1,575
		Total - 6,251
Otter Trawl	Lagoon	2,378
	Offshore	4,672
		Total - 7,050

000335

TABLE 6.5-3
TOTAL NUMBER OF FISH SPECIES BY SAMPLING GEAR
ENCINA POWER PLANT - AUGUST 1, 1980

Sampling Gear	Location	Number of Species Collected	Total Number of Species Captured
Beach Seine			49
	Lagoon	39	
	Offshore	25	
Gill Net			55
	Lagoon	31	
	Offshore	47	
Otter Trawl			61
	Lagoon	35	
	Offshore	49	

TABLE 6.5-4
LIST OF ALL FISH SPECIES AND LOCATION
OF CAPTURE(S) FOR ENCINA 316(b) STUDY
ENCINA POWER PLANT - OCTOBER 1, 1980

Scientific Name	Common Name	Location of Capture				
		Offshore	Lagoons	Impingement	Heat Treat	Plankton
Alloclinus holderi	Island kelpfish			X		
Alopias vulpinus	Common thresher	X				
Amphistichus argenteus	Barred surfperch	X		X	X	
Anchoa compressa	Deepbody anchovy	X	X	X	X	
Anchoa delicatissima	Slough anchovy	X	X	X	X	X
Anchoa sp						X
Anguilliformes						X
Anisotremus davidsonii	Sargo	X	X	X	X	X
Atherinidae			X		X	X
Atherinops affinis	Topsmelt	X	X	X	X	X
Atherinopsis californiensis	Jacksmelt	X	X	X	X	
Blenniidae						X
Brachyistius frenatus	Kelp surfperch			X	X	
Caulolatilus princeps	Ocean whitefish	X				
Cetengraulis sp						X
Cheilotrema saturnum	Black Croaker	X	X		X	X
Chromis punctipinnis	Blacksmith	X		X	X	X
Citharichthys sordidus	Pacific sanddab	X				
Citharichthys sp						X
Citharichthys stigmaeus	Speckled sanddab	X	X	X		X
Citharichthys xanthostigma	Longfin sanddab	X		X		
Clinidae						X
Clinocottus analis	Wooly sculpin				X	
Clupea harengus	Pacific herring	X		X		

TABLE 6.5-4 (Continued)

Scientific Name	Common Name	Location of Capture: Offshore	Lagoons	Impingement	Heat Treat	Plankton
Clupeidae						X
Cololabis saira	Pacific saury					X
Coryphopterus nicholsii	Blackeye goby					X
Cottidae						X
Cottidae Type 1						X
Cottidae Type 7						X
Cymatogaster aggregata	Shiner surfperch	X	X	X	X	
Cymatogaster gracilis	Island surfperch			X		
Cynoscion nobilis	White seabass	X	X	X	X	X
Cypselurus californicus	California flying fish			X		
Damalichthys vacca	Pile surfperch	X	X	X	X	
Decapterus hypodus	Mexican scad	X		X		
Dorosoma petenense	Threadfin shad		X	X	X	
Embiotoca jacksoni	Black surfperch	X	X	X	X	
Embiotocidae		X				
Engraulidae		X	X			X
Engraulis mordax	Northern anchovy	X	X	X	X	X
Epinephelus niveatus	Snowy grouper	X				
Exocoetidae						X
Fundulus parvipinnis	California killifish		X	X	X	
Genyonemus lineatus	White croaker	X	X	X	X	X
Gibbonsia elegans	Spotted kelpfish	X			X	
Gibbonsia metzi	Striped kelpfish		X	X	X	
Gibbonsia montereyensis	Crevice kelpfish					X
Gillichthys mirabilis	Longjaw mudsucker		X			

TABLE 6.5-4 (Continued)

Scientific Name	Common Name	Location of Capture: Offshore	Lagoons	Impingement	Heat Treat	Plankton
Girella nigricans	Opaleye		X	X	X	X
Gobiesocidae						X
Gobiesox papillifer	Bearded clingfish					X
Gobiidae						X
Gobiidae Type A						X
Gobionellus longicaudus	Longtail goby		X			
Gymnothorax mordax	Moray eel			X	X	
Gymnura marmorata	California butterfly ray	X	X	X	X	
Halichoeres semicinctus	Rock wrasse	X			X	
Hemiramphidae						X
Hermosilla azurea	Zebra perch	X	X	X	X	
Heterodontus francisci	Horn shark	X	X	X		
Heterostichus rostratus	Giant kelpfish	X	X	X	X	X
Hyperprosopon argenteum	Walleye surfperch	X	X	X	X	
Hyperprosopon ellipticum	Silver surfperch	X				
Hippoglossina stomata	Bigmouth sole	X				X
Hypsoblennius gentilis	Bay blenny		X		X	X
Hypsoblennius gilberti	Rockpool blenny		X	X	X	
Hypsoblennius jenkinsi	Mussel blenny		X	X	X	
Hypsoblennius sp					X	X
Hypsopsetta guttulata	Diamond turbot	X	X	X	X	X
Hypsypops rubicundus	Garibaldi			X	X	X
Ictalurus melas (freshwater)	Black bullhead				X	
Ilyphus gilberti	Cheekspot goby		X			X
Labridae						X

TABLE 6.5-4 (Continued)

Scientific Name	Common Name	Location of Capture: Offshore	Lagoons	Impingement	Heat Treat	Plankton
Lepidogobius lepidus	Bay goby					X
Leptocottus armatus	Staghorn sculpin	X	X	X	X	
Leuresthes tenuis	California grunion	X	X	X	X	
Medialuna californiensis	Halfmoon			X	X	
Menticirrhus undulatus	California corbina	X	X	X	X	X
Micrometrus minimus	Dwarf surfperch	X		X	X	
Mugil cephalus	Striped mullet	X	X	X	X	X
Mustelus californicus	Gray smoothhound		X	X	X	
Mustelus henlei	Brown smoothhound				X	
Myliobatis californica	Bat ray	X	X	X	X	
Oligocottus rubellio	Rosy sculpin			X		
Ophichthus zophochir	Yellow snake eel			X	X	
Otophidium scrippsi	Basketweave cusk-eel	X				
Oxyjulis californica	Sẽnorita				X	
Oxylebius pictus	Painted greenling				X	
Paraclinus integripinnis	Reef finspot		X			
Paralabrax clathratus	Kelp bass	X	X	X	X	X
Paralabrax maculatofasciatus	Spotted sand bass		X	X	X	
Paralabrax nebulifer	Barred sand bass	X	X	X	X	
Paralabrax sp						X
Paralichthys californicus	California halibut	X	X	X	X	X
Paralichthys sp						X
Parophrys vetulus	English sole	X				X
Peprilus simillimus	Pacific butterfish	X		X	X	X
Phanerodon furcatus	White surfperch	X	X	X	X	
Pimelometopon pulchrum	California sheephead	X				X

TABLE 6.5-4 (Continued)

Scientific Name	Common Name	Location of Capture: Offshore	Lagoons	Impingement	Heat Treat	Plankton
Platyrhinoidis triseriata	Thornback ray	X		X	X	
Pleuronichthys coenosus	C-O turbot	X				X
Pleuronichthys decurrens	Curlfin turbot	X				X
Pleuronichthys ritteri	Spotted turbot	X	X	X		X
Pleuronichthys sp						X
Pleuronichthys verticalis	Hornyhead turbot	X	X		X	X
Porichthys notatus	Plainfin midshipman			X		
Porichthys myriaster	Specklefin midshipman	X	X	X	X	
Quietula y-cauda	Shadow goby		X			
Raja binoculata	Big skate	X				
Raja inornata	California skate	X				
Rhacochilus toxotes	Rubberlip surfperch	X		X		
Rhinobatos productus	Shovelnose guitarfish	X		X		
Roncador stearnsii	Spotfin croaker	X	X	X	X	X
Sarda chiliensis	Pacific bonito	X		X	X	
Sardinops sagax caeruleus	Pacific sardine	X				X
Sciaenidae		X				X
Scomber japonicus	Pacific mackerel	X			X	
Scomberomorus concolor	Monterey spanish mackerel			X	X	
Scorpaena guttata	Sculpin/spotted scorpionfish	X	X	X	X	
Scorpaenighthys marmoratus	Cabezon		X			
Sebastes paucispinis	Bocaccio				X	
Sebastes rastrelliger	Grass rockfish				X	
Sebastes serranoides	Olive rockfish	X				
Sebastes sp						X

000341

TABLE 6.5-4 (Concluded)

Scientific Name	Common Name	Location of Capture: Offshore	Lagoons	Impingement	Heat Treat	Plankton
Seriphus politus	Queenfish	X	X	X	X	X
Serranidae						X
Sphyraena argentea	California barracuda	X	X	X	X	X
Squalus acanthias	Spiny dogfish	X			X	
Squatina californica	Pacific angel shark	X		X		
Strongylura exilis	California needlefish	X		X	X	
Symphurus atricauda	California tonguefish	X	X	X	X	X
Syngnathus californiensis	Kelp pipefish	X		X		
Syngnathus leptorhynchus	Bay pipefish	X	X	X	X	X
Syngnathus sp						X
Synodus lucioceps	California lizardfish	X				X
Tetraodontiformes						X
Torpedo californica	Pacific electric ray			X	X	
Trachurus symmetricus	Jack mackerel	X		X	X	X
Triakis semifasciata	Leopard shark			X		
Triphoturus mexicanus	Mexican lampfish					X
Typhlogobius californiensis	Blind goby					X
Typhlogobius sp						X
Umbrina/Cheilotrema complex						X
Umbrina roncador	Yellowfin croaker	X	X	X	X	
Unidentified fish eggs						X
Urolophus halleri	Round stingray	X	X	X	X	
Xenistius californiensis	Salema	X	X	X	X	
Xiphiidae						X
Xystreurys liolepis	Fantail sole	X		X		

TOTAL SPECIES: 125

There are additional considerations to be taken into account when examining the data presented in Tables 6.5-2 and 6.5-3. Shorter beach seines and otter trawls were used to sample lagoon populations than were used offshore (Appendix Section 16.2.2). Also, the total numbers listed do not reflect differences in the number of stations sampled by each gear type. All of the above limitations impose a degree of bias to the data which must be considered in the analysis of nekton data obtained during the study.

6.5.7 Comparisons of Lagoon and Offshore

A total of 69 fish species (6038 individuals) were collected at offshore trawl and gill net stations during the study. Of the total nekton catch, 31 fish species were unique to the offshore locations (Table 6.5-5). Only two of these, the Pacific sanddab (Citharichthys sordidus) and California sheephead (Pimelometopon pulchrum), were designated "critical species".

Hierarchical classification (dendrograms and two-way tables) was used in comparing total nekton catch at all sites sampled (Appendix Figures 16.3-17 and 16.3-18 and Appendix Table 16.3-34). Nekton landings at the four offshore sites (excluding surf zone) differed somewhat from one another. Station F-50 was the most unique of the offshore locations. This was to be expected since the bottom at this station differed from that at the other stations sampled. Trawls at station F-50 often snagged on submerged rocky-reef areas. Sea fans and sea whips, characteristic of this type of substrate, were often abundant in trawl samples

TABLE 6.5-5
NEKTON SPECIES UNIQUE TO OFFSHORE TRAWL
AND GILL NET STATIONS
ENCINA POWER PLANT - AUGUST 1, 1980

SCIENTIFIC NAME	COMMON NAME
Squalus acanthias	Spiny dogfish
Squatina californica	Pacific angel shark
Alopias vulpinus	Common thresher
Platyrhinoidis triseriata	Thornback
Rhinobatos productus	Shovelnose guitarfish
Raja binoculata	Big skate
Raja inornata	California skate
Sardinops sagax caeruleus	Pacific sardine
Synodus lucioceps	California lizardfish
Otophidium scrippsi	Basketweave cusk-eel
Sebastes serranoides	Olive rockfish
Epinephelus niveatus	Snowy grouper
Caulolatilus princeps	Ocean whitefish
Trachurus symmetricus	Jack mackerel
Decapterus hypodus	Mexican scad
Rhacochilus toxotes	Rubberlip surfperch
Hyperprosopon ellipticum	Silver surfperch
Chromis punctipinnis	Blacksmith
Pimelometopon pulchrum †	California sheephead
Halichoeres semicinctus	Rock wrasse
Gibbonsia elegans	Spotted kelpfish
Scomber japonicus	Pacific mackerel
Sarda chiliensis	Pacific bonito
Peprilus simillimus	Pacific butterfish
Xystreurys liolepis	Fantail sole
Hippoglossina stomata	Bigmouth sole
Citharichthys xanthostigma	Longfin sanddab
Citharichthys sordidus †	Pacific sanddab
Pleuronichthys decurrens	Curlfin turbot
Pleuronichthys coenosus	C-O turbot
Parophrys vetulus	English sole

† Denotes critically treated species.

at station F-50. Accordingly, a number of fish species were taken at station F-50 that were not captured at other stations. Species unique to this location included: zebraperch, ocean whitefish, Mexican scad, rock wrasse, California sheephead (critical species), C-O turbot, curlfin turbot, olive rockfish and black croaker. Most of these frequent kelp bed rocky-reef areas. The other stations sampled (A-50, C-25 and G-25) were located in sandy bottom areas.

In terms of depth comparison, greater total numbers of fish were collected at 25-foot stations (3164 fish) than at 50-foot sites (1900 fish). Species composition also differed somewhat between depths. Hierarchical analysis indicated a greater similarity between stations of the same depth than between those of different depths (Appendix Figure 16.3-18). Forty of the sixty-nine offshore fish species collected were taken at both depths (Appendix Table 16.3-34). Sixteen fish species were taken only at 25-foot stations, and thirteen only at 50-foot stations.

Of the 23 critically treated species captured offshore (excluding surf zone), 17 were present at both 25 and 50-foot stations (Table 6.5-6). Deepbody anchovy, staghorn sculpin, spotfin croaker, barred surfperch and giant kelpfish were only found at 25-foot depth areas. The California sheephead was the only critically treated species unique to the deeper water stations. Only three individuals were taken, all from the rocky-reef area at station F-50. This species is common in kelp bed and reef areas.

TABLE 6.5-6
DEPTH DISTRIBUTION OF CRITICALLY TREATED
NEKTON SPECIES TAKEN OFFSHORE
ENCINA POWER PLANT - AUGUST 1, 1980

SPECIES	Present at 25-foot Stations	Present at 50-foot Stations	Station Depth of Major Abundance (Feet)
Urolophus halleri (Round stingray)	X	X	
Engraulis mordax (Northern anchovy)	X	X	25
Anchoa compressa (Deepbody anchovy)	X		25
Atherinops affinis (Topsmelt)	X	X	25
Scorpaena guttata (Sculpin)	X	X	
Leptocottus armatus (Staghorn sculpin)	X		25
Paralabrax clathratus (Kelp bass)	X	X	
Paralabrax nebulifer (Barred sand bass)	X	X	
Seriphus politus (Queenfish)	X	X	
Cynoscion nobilis (White seabass)	X	X	
Menticirrhus undulatus (Corbina)	X	X	25
Genyonemus lineatus (White croaker)	X	X	
Roncador stearnsi (Spotfin croaker)	X		25
Amphistichus argenteus (Barred surfperch)	X		25
Hyperprosopon argenteum (Walleye surfperch)	X	X	
Cymatogaster aggregata (Shiner surfperch)	X	X	

TABLE 6.5-6 (Concluded)

SPECIES	Present at 25-foot Stations	Present at 50-foot Stations	Station Depth of Major Abundance (Feet)
Pimelometopon pulchrum (California sheephead)		X	50
Heterostichus rostratus (Giant kelpfish)	X		25
Paralichthys californicus (California halibut)	X	X	25
Citharichthys sordidus (Pacific sanddab)	X	X	25
Citharichthys stigmaeus (Speckled sanddab)	X	X	
Pleuronichthys verticalis (Hornyhead turbot)	X	X	
Hypsopsetta guttulata (Diamond turbot)	X	X	25

A total of 25 fish species (36,069 individuals) were collected in the surf zone at stations B, C, E and N (Appendix Table 6.3-35). Six species (Pacific herring, slough anchovy, California needlefish, California grunion, dwarf surfperch and striped mullet) were captured within the surf zone that were not taken farther offshore. Of these, only Pacific herring, California needlefish and dwarf surfperch were unique to the surf seine catches. The other three species were also found to be abundant within the lagoon system. In all, 16 critically treated species were collected from the surf zone. None of these were considered unique to the surf zone environment. Only California grunion, topsmelt, queenfish, California corbina, barred surfperch and walleye surfperch were taken in major abundance. California grunion landings in the surf zone, however, completely dominated the total nekton catch in 1979. This species comprised the most numerous fish captured in the surf (30,509 individuals) as well as in the entire nekton investigation (31,293 individuals).

Hierarchical analysis (Appendix Figures 16.3-17 and 16.3-18 and Appendix Table 16.3-34) indicates differences in nekton catches at the four different sample locations in the surf zone (stations B, C, E and N). These differences, however, appear to be an artifact of sampling rather than actual population differences. Station B, indicated to be the most unique, could only be sampled a single time during the entire program (Section 16.2.2, Appendix B). Station N, likewise, could not be sampled during five of the regular monthly collections. However, this station's total catch did not differ greatly from total catches at stations C and E. Collections during the months in which sampling was not conducted at N, yielded relatively small catches at the other stations (C, E). Thus, from the data obtained, differences in nekton populations at the different surf zone stations are not readily discernable. Differences observed at B and N are probably due to reduced sampling at these stations.

A total of 54 fish species (21,396 individuals) were collected from Agua Hedionda Lagoon nekton stations during the 1979 program. Of the total nekton catch, 15 fish species were unique to the lagoon landings (Table 6.5-7). Only one of these, the spotted sand bass, was a designated "critical species". With the exception of the gray smoothhound, cabezon, reef finspot and striped kelpfish, all can be considered to be characteristic lagoon species. Three of the fish, threadfin shad, California killifish and longjaw mudsucker, are typically freshwater species. These were only taken in the more inshore areas of the lagoon system in nekton collections and were not found to be present in the outer lagoon waters. A few were taken in impingement samples in the outer lagoon (Section 7.0).

To facilitate the comparison of species composition in the fish populations of the three lagoon areas, an index of similarity (S) was used (6-477, 6-478). The index was calculated according to the following equation:

TABLE 6.5-7
NEKTON SPECIES UNIQUE TO AGUA HEDIONDA LAGOON
ENCINA POWER PLANT - AUGUST 1, 1980

Species	Lagoon Area of Capture: Outer	Middle	Upper
Mustelus californicus (Gray smoothhound)			X
Dorosoma petenense (Threadfin shad)			X
Fundulus parvipinnis (California killifish)		X	X
Scorpaenichthys marmoratus (Cabezon)		X	
Paralabrax maculatofasciatus (Spotted sand bass)	X	X	X
Girella nigricans (Opaleye)	X	X	X
Hypsoblennius gentilis (Bay blenny)		X	
H. gilberti (Rockpool blenny)		X	
H. jenkinsi (Mussel blenny)		X	
Paraclinus integripinnis (Reef finspot)	X		
Gibbonsia metzi (Striped kelpfish)		X	
Gobionellus longicaudus (Longtail goby)	X		
Gillichthys mirabilis (Longjaw mudsucker)			X
Ilypnus gilberti (Cheekspot goby)	X	X	X
Quietula y-cauda (Shadow goby)		X	X

$$S = \frac{2C}{A + B} \quad \text{where } A = \text{number of species in sample A} \quad (1)$$

B = number of species in sample B

C = number of species common to both samples

When determined in this manner, S values may range from 0 (indicating no similarity in species composition) to 1 (indicating complete similarity). Similarity indices were calculated to compare the total annual species compositions of fish in the outer, middle and upper sections of Agua Hedionda Lagoon. Values have been presented in a matrix, showing the different pairs of comparisons examined (Table 6.5-8). All possible combinations were determined.

From these data, it appears that the three sections of Agua Hedionda Lagoon had very similar total species compositions. This is to be expected considering the high degree of similarity in the environments present in the three sections of the lagoon. In all, 28 fish species were common to the three lagoon areas (Table 6.5-9).

These "common" species contributed approximately 79 percent of the total lagoon nekton landings. In terms of the 24 critically treated species captured in Agua Hedionda Lagoon, 19 were taken from all three lagoon areas. Sculpin, speckled sanddab and hornyhead turbot were only noted in the outer section of the lagoon. This is not surprising since these are primarily offshore, rather than lagoon fish species. Slough anchovies, on the other hand, were common in both the upper and middle lagoon areas, but not taken from collections in the outer lagoon. This

TABLE 6.5-8
SIMILARITY INDICES COMPARING TOTAL NEKTON SPECIES COMPOSITION
WITHIN SECTIONS OF AGUA HEDIONDA LAGOON
ENCINA POWER PLANT - AUGUST 1, 1980

	Outer Lagoon	Middle Lagoon	Upper Lagoon
Outer Lagoon		0.73	0.76
Middle Lagoon	0.73		0.80
Upper Lagoon	0.76	0.80	

TABLE 6.5-9
FISH SPECIES COMMON TO ALL THREE SECTIONS OF AGUA HEDIONDA LAGOON, ENCINA POWER PLANT - AUGUST 1, 1980

Scientific Name	Common Name
Myliobatis californica	Bat ray
Urolophus halleri†	Round stingray
Anchoa compressa†	Deepbody anchovy
Leuresthes tenuis†	California grunion
Atherinops affinis†	Topsmelt
Syngnathus leptorhynchus	Bay pipefish
Leptocottus armatus†	Staghorn sculpin
Paralabrax clathratus†	Kelp bass
P. maculatofasciatus†	Spotted sand bass
P. nebulifer†	Barred sand bass
Xenistius californiensis	Salema
Anisotremus davidsonii	Sargo
Seriphus politus†	Queenfish
Cynoscion nobilis†	White seabass
Menticirrhus undulatus†	California corbina
Genyonemus lineatus†	White croaker
Roncador stearnsi†	Spotfin croaker
Girella nigricans	Opaleye
Embiotoca jacksoni	Black surfperch
Hyperprosopon argenteum†	Walleye surfperch
Cymatogaster aggregata†	Shiner surfperch
Phanerodon furcatus	White surfperch
Mugil cephalus†	Striped mullet
Sphyraena argentea	California barracuda
Heterostichus rostratus†	Giant kelpfish
Ilypnus gilberti	Cheekspot goby
Paralichthys californicus†	California halibut
Hypsopsetta guttulata†	Diamond turbot

† Denotes critically treated species.

000353

species appears to be primarily an inshore species, which favors the upper reaches of bays and lagoons. Northern anchovy were not found within the middle lagoon waters, but were taken in both the outer and upper sections.

Some additional information concerning fish species occurring in the lagoon is presented in Section 7.0 (Impingement Study).

To facilitate comparisons of relative critical species abundance in the three lagoon areas, total catch information for each has been consolidated into a discrete total population. Catch data has been adjusted to a total catch per unit effort for each gear type (Tables 6.5-10, 6.5-11 and 6.5-12). Critically treated nekton species distribution data has been summarized in Table 6.5-13.

Figure 6.5-15 shows the general relationships which exist between total nekton landings at different sampling stations. Data reflects the similarity of total populations and is based upon hierarchical analysis of species composition and abundance (Section 16.2.7 and Appendix Figure 16.3-18). Fish populations at each station have been represented by an encircled letter. All stations having nekton populations designated by the same letter are more similar than those designated by different letters. Among populations represented by different letters, degree of similarity is reflected by alphabetical order. Lagoon station fish populations (all designated by the encircled letter "A") were more similar to each other than to either offshore or surf zone populations. However, lagoon populations were more closely-related to offshore populations (designated by the encircled letter "B") than to surf zone populations (designated by the encircled letter "C"). Thus, three distinctly different nekton

TABLE 6.5-10
TOTAL ADJUSTED TRAWL LANDINGS (PER UNIT AREA) FOR CRITICALLY TREATED NEKTON SPECIES TAKEN FROM AGUA HEDIONDA LAGOON
ENCINA POWER PLANT - AUGUST 1, 1980

Species	Average Number Captured/Hectare By Lagoon Section		
	Outer Lagoon	Middle Lagoon	Upper Lagoon
Urolophus halleri	3.5	13.1	5.4
Engraulis mordax			
Anchoa compressa	1.3	2.5	86.2
A. delicatissima		2.2	19.3
Leuresthes tenuis			
Atherinops affinis			
Scorpaena guttata	0.2		
Leptocottus armatus			0.3
Paralabrax clathratus	9.5	6.9	3.1
P. maculatofasciatus	6.0	10.6	5.3
P. nebulifer	2.6	2.8	2.2
Seriphus politus	1.6	0.6	19.7
Cynoscion nobilis			
Menticirrhus undulatus			
Genyonemus lineatus	9.0	0.3	9.7
Roncador stearnsi	0.5		0.3
Amphistichus argenteus			
Hyperprosopon argenteum	0.6		
Cymatogaster aggregata	1.1	26.6	18.8
Mugil cephalus			
Pimelometopon pulchrum			
Heterostichus rostratus	5.5	12.2	1.9
Paralichthys californicus	17.2	12.8	42.8
Citharichthys sordidus			
C. stigmaeus	0.3		
Pleuronichthys verticalis	0.6		
Hypsopsetta guttulata	2.3	1.9	5.7

TABLE 6.5-11
TOTAL ADJUSTED SEINE LANDINGS (PER UNIT EFFORT) FOR CRITICALLY TREATED NEKTON TAKEN FROM AGUA HEDIONDA LAGOON
ENCINA POWER PLANT - AUGUST 1, 1980

Species	Average Number Captured/Seine By Lagoon Section		
	Outer Lagoon	Middle Lagoon	Upper Lagoon
Urolophus halleri		0.3	0.2
Engraulis mordax	0.2		17.7
Anchoa compressa		16.7	272.4
A. delicatissima		0.7	309.0
Leuresthes tenuis	23.1	40.2	2.0
Atherinops affinis	87.1	219.9	84.8
Scorpaena guttata			
Leptocottus armatus	0.2	2.8	1.2
Paralabrax clathratus	1.1	8.8	
P. maculatofasciatus	0.4	2.0	0.3
P. nebulifer		1.0	
Seriphus politus		0.1	2.4
Cynoscion nobilis			
Menticirrhus undulatus			0.3
Genyonemus lineatus			
Roncador stearnsi			0.2
Amphistichus argenteus			
Hyperprosopon argenteum			
Cymatogaster aggregata		30.6	1.0
Mugil cephalus			4.7
Pimelometopon pulchrum			
Heterostichus rostratus	1.0	3.7	
Paralichthys californicus	0.6	0.3	2.7
Citharichthys sordidus			
C. stigmaeus			
Pleuronichthys verticalis			
Hypsopsetta guttulata	0.2	0.2	1.9

000357

TABLE 6.5-12
TOTAL ADJUSTED GILL NET LANDINGS (PER UNIT EFFORT) FOR CRITICALLY TREATED NEKTON SPECIES TAKEN FROM AGUA HEDIONDA LAGOON
ENCINA POWER PLANT - AUGUST 1, 1980

	Average Number Captured/Net Set By Lagoon Section		
Species	Outer Lagoon	Middle Lagoon	Upper Lagoon
Urolophus halleri	0.2	0.5	
Engraulis mordax	0.1		0.1
Anchoa compressa		0.7	18.2
A. delicatissima			
Leuresthes tenuis		0.1	
Atherinops affinis	32.3	183.7	80.9
Scorpaena guttata			
Leptocottus armatus			
Paralabrax clathratus	0.2	0.5	1.2
P. maculatofasciatus	0.2	1.0	0.7
P. nebulifer		0.1	0.2
Seriphus politus	0.4	0.3	0.4
Cynoscion nobilis	0.2	0.2	0.1
Menticirrhus undulatus	0.5	0.2	0.5
Genyonemus lineatus			0.2
Roncador stearnsi	4.7	0.5	2.8
Amphistichus argenteus			
Hyperprosopon argenteum	9.2	0.3	0.5
Cymatogaster aggregata	0.6	13.1	4.7
Mugil cephalus	1.8	7.6	3.6
Pimelometopon pulchrum			
Heterostichus rostratus	0.2	0.2	0.2
Paralichthys californicus			0.2
Citharichthys sordidus			
C. stigmaeus			
Pleuronichthys verticalis			
Hypsopsetta guttulata	0.1	0.2	

000358

TABLE 6.5-13
AGUA HEDIONDA LAGOON CRITICALLY TREATED NEKTON SPECIES DISTRIBUTION†, ENCINA POWER PLANT - AUGUST 1, 1980

Species	Outer Lagoon	Middle Lagoon	Upper Lagoon
Urolophus halleri	X	X	X
Engraulis mordax	X		X
Anchoa compressa	X	X	X
A. delicatissima		X	X
Leuresthes tenuis	X	X	X
Atherinops affinis	X	X	X
Scorpaena guttata	X		
Leptocottus armatus	X	X	X
Paralabrax clathratus	X	X	X
P. maculatofasciatus	X	X	X
P. nebulifer	X	X	X
Seriphus politus	X	X	X
Cynoscion nobilis	X	X	X
Menticirrhus undulatus	X	X	X
Genyonemus lineatus	X	X	X
Roncador stearnsi	X	X	X
Amphistichus argenteus			
Hyperprosopon argenteum	X	X	X
Cymatogaster aggregata	X	X	X
Mugil cephalus	X	X	X
Pimelometopon pulchrum			
Heterostichus rostratus	X	X	X
Paralichthys californicus	X	X	X
Citharichthys sordidus			
C. stigmaeus	X		
Pleuronichthys verticalis	X		
Hypsopsetta guttulata	X	X	X

† "X" denotes presence of a given species within a sampling area.

populations are seen from the data; lagoon, offshore and surf zone populations.

Differences in species composition in these three areas partly account for this observation. Similarity indices (Equation [1]) were calculated to compare total annual nekton species compositions for the different sampling areas (Table 6.5-14). In addition, each lagoon section was also considered separately in the analysis. Greatest differences in similarity were indicated in comparisons of the offshore and lagoon populations to those of the surf zone (S = 0.40 and 0.48, respectively). These data reflect the uniqueness of surf habitat, in which only a relatively few species are found. Offshore and lagoon populations were more similar in species composition, although an "S" value of 0.59 indicates significant differences exist between these areas. In reference to different parts of Agua Hedionda Lagoon, it does appear that the outer section is the most similar to the offshore areas.

Because of differences in the size of the area sampled in the lagoon and offshore areas, total catch data were adjusted on a catch per unit of effort basis in order to compare the areas with respect to population size. Estimates of fish populations were made on the basis of the benthic fish catches within each area (trawl data) and along the shorelines (seine data). Gill net data were not included in the analysis, since they are not easily transformed to a quantitative approach. Population sizes,

TABLE 6.5-14
SIMILARITY INDICES COMPARING TOTAL ANNUAL FISH
SPECIES COMPOSITIONS BY AREA SAMPLED
ENCINA POWER PLANT - AUGUST 1, 1980

	Offshore	Lagoons	Outer Lagoon	Middle Lagoon	Upper Lagoon	Surf Zone
Offshore		0.59	0.59	0.50	0.53	0.40
Lagoons			0.84	0.85	0.85	0.48
Outer Lagoon				0.73	0.76	0.56
Middle Lagoon					0.80	0.46
Upper Lagoon						0.52

were probably underestimated since they did not take into account all pelagic fish species.

Benthic population estimates based on otter trawl data were made using the assumptions presented in Table 6.5-15. Total population densities were shown to be greatest in the upper section of Agua Hedionda Lagoon, and least in the outer section (Table 6.5-16). Offshore densities were greater than those calculated for the outer and middle lagoon areas. Using this information, estimated total benthic fish population sizes were determined for each sampling area (Table 6.5-17). Critically treated species population sizes were also estimated (Table 6.5-18).

In a similar manner, beach seine landings were used to estimate the sizes of shoreline fish populations for each sampling area. Assumptions used for this approach are presented in Table 6.5-19. In short, estimates were obtained by extrapolating seine landings per length of shoreline sampled to the total length of shoreline available within each sample area. Total estimated shoreline fish populations are presented in Table 6.5-20. Critically treated species populations were also determined (Table 6.5-21).

Total estimated minimum benthic population sizes were obtained by combining both estimates from the trawl and seine data (Table 6.5-22). As can be seen, the total lagoon population appears to be comparable to that of the offshore sampling area. In reality, the offshore population is probably much greater than the lagoon population. This is partly due to the fact that a

TABLE 6.5-15
ASSUMPTIONS MADE IN CALCULATING BENTHIC FISH POPULATION SIZE ESTIMATES BASED UPON TRAWL DATA
ENCINA POWER PLANT - AUGUST 1, 1980

---

1. Assume that the effective sample opening of a 4.9 meter otter trawl was 4 meters (4-479).

2. Assume that the effective sample opening of a 7.9 meter otter trawl was 6 meters (4-480).

3. Assume a constant towing speed and a constant sampling distance for each area sampled throughout the year.

4. Assume the following estimates (based upon distances towed at each station) reflect total bottom areas sampled during the 1979 study:

Offshore study area	-	35.7 hectares
Outer lagoon area	-	6.2 hectares
Middle lagoon area	-	3.2 hectares
Upper lagoon area	-	7.2 hectares

5. Assume an average catch efficiency of 30 percent for the otter trawl (6-481).

6. Assume an average total bottom area for each sampling zone as follows:

Offshore area	-	490.0 hectares
Outer lagoon	-	23.9 hectares
Middle lagoon	-	9.9 hectares
Upper lagoon	-	105.0 hectares

For these estimates, the offshore study area is considered to include all bottom areas between the 12 and 60 foot isobaths shown in Figure 6.5-16.

TABLE 6.5-16
ESTIMATED BENTHIC FISH POPULATION DENSITIES
BASED UPON TOTAL MONTHLY TRAWL LANDINGS
ENCINA POWER PLANT - AUGUST 1, 1980

Area	Average Density (Fish/Hectare)	Density Range (Fish/Hectare)
Offshore	416.7	22.3 - 1304.3
Outer Lagoon	226.3	25.7 - 613.0
Middle Lagoon	328.0	37.3 - 887.7
Upper Lagoon	756.3	111.0 - 1877.7

TABLE 6.5-17
ESTIMATED AVERAGE BENTHIC FISH POPULATIONS WITHIN EACH
SAMPLING AREA BASED UPON TOTAL TRAWL LANDINGS
ENCINA POWER PLANT - AUGUST 1, 1980

Area	Estimated Average Number of Individuals	Range in Estimated Number of Individuals
Offshore	204,167	10,943 - 639,123
Outer Lagoon	5,409	613 - 14,651
Middle Lagoon	3,247	370 - 8,788
Upper Lagoon	79,415	11,655 - 197,155
Total Lagoon	88,071	12,638 - 220,594

TABLE 6.5-18
ESTIMATED AVERAGE CRITICALLY TREATED SPECIES POPULATIONS WITHIN EACH SAMPLING AREA BASED UPON AVERAGE MONTHLY TRAWL LANDINGS
ENCINA POWER PLANT - AUGUST 1, 1980

Species	Offshore	Lagoons	Outer Lagoon	Middle Lagoon	Upper Lagoon
Urolophus halleri	640	2612	283	433	1896
Engraulis mordax	55451				
Anchoa compressa	229	30373	103	82	30188
A. delicatissima		6829		72	6757
Leuresthes tenuis					
Atherinops affinis					
Scorpaena guttata	1098	13	13		
Leptocottus armatus	275	97			97
Paralabrax clathratus		2054	758	227	1069
P. maculatofasciatus		2673	475	351	1847
P. nebulifer	641	1077	206	93	778
Seriphus politus	24386	7052	128	21	6903
Cynoscion nobilis					
Menticirrhus undulatus	92				
Genyonemus lineatus	12078	4133	720	10	3403
Roncador stearnsi		136	39		97
Amphistichus argenteus	549				
Hyperprosopon argenteum	6222	51	51		
Cymatogaster aggregata	2516	7529	90	877	6562
Mugil cephalus					
Pimelometopon pulchrum	92				
Heterostichus rostratus	183	1520	437	402	681
Paralichthys californicus	10706	16770	1375	423	14972
Citharichthys sordidus	595				
C. stigmaeus	48222	26	26		
Pleuronichthys verticalis	7686	51	51		
Hypsopsetta guttulata	961	2235	180	62	1993

TABLE 6.5-19
ASSUMPTIONS MADE IN CALCULATING SHORELINE
FISH POPULATION SIZES BASED UPON SEINE DATA
ENCINA POWER PLANT - AUGUST 1, 1980

1. Assume that the effective sampling width for a 50 meter seine is 25 meters, and for an 18 meter seine, 9 meters.

2. Assume that the seine catch reflects a population extending along the shoreline for a distance equal to the effective sampling width.

3. Assume that the total shoreline population is constant for the entire shoreline of each sampling area.

4. Assume the following average shoreline distances for each sampling area:

Upper lagoon	-	4828 m
Middle lagoon	-	1345 m
Outer lagoon	-	2578 m
Offshore (surf zone)	-	5851 m

For these estimates the offshore (surf zone) coastline is considered to include the entire shoreline shown in Figure 6.5-16.

TABLE 6.5-20
ESTIMATES OF AVERAGE SHORELINE FISH POPULATIONS
BASED ON AVERAGE MONTHLY SEINE CATCHES
ENCINA POWER PLANT - AUGUST 1, 1980

Area	Monthly Average Number of Individuals	Range in Estimated Number of Individuals
Offshore (Surf zone)	263,800	3,394 - 1,035,783
Outer Lagoon	67,410	2,578 - 221,135
Middle Lagoon	54,659	9,415 - 135,845
Upper Lagoon	380,071	13,948 - 1,142,090
Total Lagoon	502,140	25,941 - 1,499,070

TABLE 6.5-21
ESTIMATED AVERAGE SHORELINE POPULATION SIZES OF CRITICALLY TREATED FISH SPECIES WITHIN EACH SAMPLING AREA - BASED UPON AVERAGE MONTHLY SEINE LANDINGS
ENCINA POWER PLANT - AUGUST 1, 1980

Species	Offshore (Surf zone)	Lagoons	Outer Lagoon	Middle Lagoon	Upper Lagoon
Urolophus halleri	15	184		50	134
Engraulis mordax	2465	9620	143		9477
Anchoa compressa	395	148627		2491	146136
A. delicatissima	322	165861		100	165761
Leuresthes tenuis	223135	20300	13224	6003	1073
Atherinops affinis	16010	128218	49889	32865	45464
Scorpaena guttata					
Leptocottus armatus		1144	95	423	626
Paralabrax clathratus		1929	621	1308	
P. maculatofasciatus		717	239	299	179
P. nebulifer		149		149	
Seriphus politus	3737	1308		12	1296
Cynoscion nobilis	7				
Menticirrhus undulatus	3642	179			179
Genyonemus lineatus	29				
Roncador stearnsi	59	89			89
Amphistichus argenteus	3043				
Hyperprosopon argenteum	7372				
Cymatogaster aggregata	37	5107		4571	536
Mugil cephalus	146	2503			2503
Pimelometopon pulchrum					
Heterostichus rostratus	7	1121	573	548	
Paralichthys californicus		1815	334	50	1431
Citharichthys sordidus					
C. stigmaeus					
Pleuronichthys verticalis					
Hypsopsetta guttulata		1160	95	37	1028

TABLE 6.5-22
ESTIMATED AVERAGE FISH POPULATIONS WITHIN EACH SAMPLING AREA
BASED ON TRAWL AND SEINE POPULATION ESTIMATES
ENCINA POWER PLANT - AUGUST 1, 1980

Area	Estimated Average Number of Individuals	Range in Estimated Number of Individuals
Offshore	467,967	14,337 - 1,674,906
Outer Lagoon	72,819	3,191 - 235,786
Middle Lagoon	57,906	9,785 - 144,633
Upper Lagoon	459,486	25,603 - 1,339,245
Total Lagoon	590,211	38,579 - 1,719,664

000370

much greater volume of water available to pelagic species is present in the offshore area. Thus, a greater number of fish were probably not sampled in the offshore waters. The fact that the extensive offshore kelp beds, which attract large concentrations of fish, could not be sampled also contributes to a greater underestimate.

It is also important to note that the majority of fish (78 percent) within the lagoon system appear to be concentrated within the upper section of the lagoon. Only 12 percent of the total estimated lagoon population was contributed by the outer lagoon.

Total critically treated species population estimates for each sampling area are presented in Table 6.5-23.

6.5.8 Seasonal Patterns

Figure 6.5-17 summarizes total monthly nekton abundance trends for the 1979 program. Peak abundances occurred during September (12,561 individuals) and November (16,841 individuals). These two collections comprised approximately 46 percent of the total nekton landings and were primarily due to extremely large catches of California grunion from the surf zone. In terms of season, nekton were most abundant during the fall and least abundant during the spring. Winter abundances were somewhat greater than during spring but much less than those observed in summer and fall. Minimum and maximum species diversities occurred during the winter and fall, respectively (Figure 6.5-18).

TABLE 6.5-23
ESTIMATED AVERAGE POPULATION SIZES OF CRITICALLY TREATED FISH SPECIES WITHIN EACH SAMPLING AREA - BASED UPON AVERAGE TRAWL AND SEINE POPULATION ESTIMATES
ENCINA POWER PLANT - AUGUST 1, 1980

Species	Offshore	Lagoons	Outer Lagoon	Middle Lagoon	Upper Lagoon
Urolophus halleri	655	2796	283	483	2030
Engraulis mordax	57916	9620	143		9477
Anchoa compressa	624	179000	103	2573	176324
A. delicatissima	322	172690		172	172518
Leuresthes tenuis	223135	20300	13224	6003	1073
Atherinops affinis	16010	128218	49889	32865	45464
Scorpaena guttata	1098	13	13		
Leptocottus armatus	275	1241	95	423	723
Paralabrax clathratus		3983	1379	1535	1069
P. maculatofasciatus		3390	714	650	2026
P. nebulifer	641	1226	206	242	778
Seriphus politus	28123	8360	128	33	8199
Cynoscion nobilis	7				
Menticirrhus undulatus	3734	179			179
Genyonemus lineatus	12107	4133	720	10	3403
Roncador stearnsi	59	225	39		186
Amphistichus argenteus	3592				
Hyperprosopon argenteum	13594	51	51		
Cymatogaster aggregata	2553	12636	90	5448	7098
Mugil cephalus	146	2503			2503
Pimelometopon pulchrum	92				
Heterostichus rostratus	190	2641	1010	950	681
Paralichthys californicus	10706	18585	1709	473	16403
Citharichthys sordidus	595				
C. stigmaeus	48222	26	26		
Pleuronichthys verticalis	7686	51	51		
Hypsopsetta guttulata	961	3395	275	99	3021

Seasonal fluctuations in populations of the critically treated species have previously been discussed individually in Section 6.5.4. Nineteen of the entire twenty seven critically treated species were taken during every monthly collection. Deepbody anchovy, California grunion, kelp bass and barred sand bass were taken during all but one of the monthly collections. Each is considered a common and abundant fish species in the area studied. Slough anchovy, the fourth most abundant fish, was taken every month except January and April. The remaining three critical species, white seabass, California sheephead and Pacific sanddab, were relatively uncommon in monthly catches. Numbers taken were too small to adequately examine temporal patterns. The majority of critically treated species considered in the present study program, then, represent primarily year-round residents of the study area under consideration.

With respect to non-critical species, 25 were present in collections during all seasons (Table 6.5-24). Five species were unique to spring collections; 4 to summer, 6 to fall and 7 to winter (Table 6.5-25).

The basic data for nekton collections by month and for the lagoon and offshore areas is compiled in Appendix Tables 16.3-35 through 16.3-54.

6.5.9 Sportfishing and Commercial Fishing Activity

Sportfishing is a major industry in southern California. Over one and one-half million marine fish were landed by over

TABLE 6.5-24
NON-CRITICAL NEKTON SPECIES TAKEN DURING EVERY SEASON
ENCINA POWER PLANT - AUGUST 1, 1980

Scientific Name	Common Name
Platyrhinoidis triseriata	Thornback
Rhinobatos productus	Shovelnose guitarfish
Myliobatis californica	Bat ray
Synodus lucioceps	California lizardfish
Porichthys myriaster	Specklefin midshipman
Atherinopsis californiensis	Jacksmelt
Syngnathus leptorhynchus	Bay pipefish
Xenistius californiensis	Salema
Anisotremus davidsonii	Sargo
Umbrina roncador	Yellowfin croaker
Cheilotrema saturnum	Black croaker
Girella nigricans	Opaleye
Hermosilla azurea	Zebraperch
Embiotoca jacksoni	Black surfperch
Damalichthys vacca	Pile surfperch
Phanerodon furcatus	White surfperch
Chromis punctipinnis	Blacksmith
Hypsoblennius gentilis	Bay blenny
Ilypnus gilberti	Cheekspot goby
Scomber japonicus	Pacific mackerel
Peprilus simillimus	Pacific butterfish
Symphurus atricauda	California tonguefish
Xystreurys liolepis	Fantail sole
Hippoglossina stomata	Bigmouth sole
Citharichthys xanthostigma	Longfin sanddab

TABLE 6.5-25
NON-CRITICAL NEKTON SPECIES ONLY
CAPTURED DURING A SINGLE SEASON
ENCINA POWER PLANT - AUGUST 1, 1980

Season	Scientific Name	Common Name
Spring	*Heterodontus francisci*	Horn shark
	Alopias vulpinus	Common Thresher
	Dorosoma petenense	Threadfin shad
	Clupea harengus	Pacific herring
	Hypsoblennius gilberti	Rockpool blenny
Summer	*Mustelus californicus*	Gray smoothhound
	Strongylura exilis	California needlefish
	Trachurus symmetricus	Jack mackerel
	Gillichthys mirabilis	Longjaw mudsucker
Fall	*Raja inornata*	California skate
	Sardinops sagax caeruleus	Pacific sardine
	Sebastes serranoides	Olive rockfish
	Decapterus hypodus	Mexican scad
	Paraclinus integripinnis	Reef finspot
	Pleuronichthys coenosus	C-O turbot
Winter	*Squalus acanthias*	Spiny dogfish
	Scorpaenichthys marmoratus	Cabezon
	Rhacochilus toxotes	Rubberlip surfperch
	Hyperprosopon ellipticum	Silver surfperch
	Micrometrus minimus	Dwarf surfperch
	Gibbonsia metzi	Striped kelpfish
	Gobionellus longicaudus	Longtain goby

200,000 anglers in 1979 from partyboats between Imperial Beach and Dana Harbor (Figure 6.5-19). This does not account for shore fishing and private boats. The catch consisted of kelp bass, barred sandbass, mackerel, barracuda, rockfish, bonito, halibut, sheephead, sculpin, whitefish, croakers, white seabass, and flatfish.

In sportfishing surveys conducted near the Encina Power Plant in outer Agua Hedionda Lagoon and the ocean beach near the Power Plant, as many as 40 fishermen utilized the outer lagoon at one time and up to 14 were fishing in the vicinity of the discharge on the beach (Table 6.5-26). Fishermen were common every day of the week with peak numbers usually occurring on the weekends during summer months (at times, weekdays were popular). Fishing took place throughout the year (Table 6.5-26). Twenty-five different species of fish were caught by anglers in the vicinity of the Power Plant (Table 6.5-27).

Commercial fishermen in California landed 728 million pounds of fish worth 227 million dollars in 1979 (6-482). Landings in San Diego were 156 million pounds in 1979 (6-483). Many of the tuna landed were caught in foreign waters (approximately 73 percent of the catch in 1976).

000376

TABLE 6.5-26
RESULTS OF SPORTFISHING SURVEY IN
THE VICINITY OF THE ENCINA POWER PLANT, 1979

Month	Mean Number of Fishermen/Day ± S.D.†	Mean Number of Hrs. Fished/Day Per Fisherman ± S.D.†	Catch/Unit (hr) of Effort ± S.D.†
OUTER AGUA HEDIONDA LAGOON			
JAN	10.4 ± 4.9	2.8 ± 0.7	0.5 ± 1.2
FEB	No Data	-	-
MAR	18.6 ± 6.5	3.0 ± 0.8	0.1 ± 0.0
APRIL	22.0 ± 7.8	3.9 ± 1.4	0.2 ± 0.1
MAY	17.6 ±17.5	2.8 ± 1.8	0.1 ± 0.1
JUNE	25.2 ± 9.5	2.6 ± 0.5	0.3 ± 0.2
JULY	25.0 ±15.4	3.4 ± 0.9	0.4 ± 0.4
AUG	22.0 ± 5.8	3.3 ± 0.9	0.2 ± 0.3
SEPT	15.7 ± 5.6	3.0 ± 0.9	0.1 ± 0.1
OCT	12.0 ± 1.0	3.5 ± 1.1	0.0 ± 0.0
NOV	8.2 ± 6.0	4.1 ± 1.9	0.0 ± 0.0
DEC	5.4 ± 2.7	2.9 ± 0.3	0.2 ± 0.2
SURF ZONE - OCEAN BEACH			
MAR	7.3 ± 5.0	3.4 ± 0.9	0.4 ± 0.4
APRIL	4.7 ± 3.4	3.2 ± 0.5	0.7 ± 0.4
MAY	4.0 ± 2.1	2.9 ± 0.9	0.2 ± 0.0
JUNE	7.3 ± 0.9	2.1 ± 0.8	0.2 ± 0.1
JULY	7.8 ± 4.6	3.9 ± 2.1	1.1 ± 1.1
AUG	7.0 ± 5.0	3.6 ± 0.6	0.4 ± 0.5
SEPT	2.5 ± 0.7	3.1 ± 0.2	0.0 ± 0.0
OCT	2.5 ± 1.7	3.7 ± 2.0	0.3 ± 0.4
NOV	3.0 ± 0.0	2.3 ± 0.0	4.0 ± 0.0
DISCHARGE JETTY - OCEAN			
MAR	3.0 ± 1.4	2.1 ± 1.5	0.1 ± 0.1
APRIL	3.3 ± 1.5	2.5 ± 0.5	0.3 ± 0.4
MAY	3.6 ± 0.5	2.4 ± 0.3	0.3 ± 0.0
JUNE	-	-	-
JULY	5.0 ± 0.0	2.6 ± 0.0	1.0 ± 0.0
AUG	-	-	-
SEPT	4.0 ± 0.0	2.2 ± 0.0	0.2 ± 0.0
OCT	8.0 ± 0.0	3.4 ± 0.0	0.1 ± 0.0
NOV	3.3 ± 1.1	3.0 ± 0.5	0.4 ± 0.4
DEC	3.7 ± 1.0	3.0 ± 0.4	0.5 ± 0.7

†Standard Deviation

000377

TABLE 6.5-27
FISH SPECIES CAUGHT BY ANGLERS IN THE VICINITY OF
THE ENCINA POWER PLANT DURING 1979

Scientific Name	Common Name	Location of Capture: Lagoon	Location of Capture: Lagoon Entrance	Location of Capture: Ocean Beach	Location of Capture: Discharge Zone
Myliobatis californica	Bat ray	X	X		
Urolophus halleri	Round stingray	X		X	
Rhinobatos productus	Shovelnose guitarfish			X	X
Mustelus californicus	Gray smoothound			X	
Strongylura exilis	California needlefish		X	X	X
Atherinops affinis	Topsmelt	X		X	
Atherinopsis californiensis	Jacksmelt				X
Paralabrax clathratus	Kelp bass	X			
Paralabrax nebulifer	Barred sand bass	X		X	
Paralabrax maculatofasciatus	Spotted sand bass	X	X		X
Anisotremus davidsonii	Sargo		X	X	X
Cynoscion nobilis	White seabass	X	X	X	
Umbrina roncador	Yellowfin croaker	X	X	X	X
Menticirrhus undulatus	California corbina	X		X	X
Genyonemus lineatus	White croaker	X			
Roncador stearnsii	Spotfin croaker	X		X	X
Girella nigricans	Opaleye	X	X		X
Amphistichus argenteus	Barred surfperch			X	X
Hyperprosopon argenteum	Walleye surfperch	X	X	X	X
Damalichthys vacca	Pile surfperch	X			
Phaenerodon furcatus	White surfperch	X			
Scomber japonicus	Pacific mackerel	X			
Mugil cephalus	Striped mullet		X	X	X
Paralichthys californicus	California halibut	X	X		
Hypsopsetta guttulata	Diamond turbot	X			

6.6 DISCUSSION

The 254 fishes expected to occur (Table 6.2-1) in the vicinity of the Encina Power Plant were taken from Miller and Lea (6-484). Of the 254 species expected, 125 were captured during the study (Table 6.5-4). This is a significant number in light of the fact that many of the 254 species expected to occur are:

- Deeper water pelagic forms (such as tuna, swordfish, etc.) that primarily occur outside of the study area.
- Reside in habitats that could not be sampled in the study (i.e., rocky crevices, kelp beds),
- Are migratory species which are only present during part of the year.

In other studies in southern California, Lane and Hill (6-485) report the collection of 46 fish species in studies from Anaheim Bay, and Connell et al. (6-486) report the collection of 42 fish species in studies of a coastal power plant. In an extensive cooperative trawling study over a three-year period in the southern California bight, 121 species of fish were captured (6-487). The collection of 125 species at the Encina Power Plant during the one-year study would indicate a diverse fish fauna in the region which is representative of the variety of fish present in the inshore, coastal zone in southern California.

The selection of critical species for detailed study during the program was based on the criteria presented in Section 6.3.

Past impingement records were evaluated to select species which had a high potential for impingement. These records were compiled from 8 hr impingement samples taken several times a month since 1972. Critical species selections were re-evaluated during the course of the study in light of the species captured and their sbundances with regard to the criteria used in designating a critical status to a given species. Selected species were treated as critical when they satisfied several of the criteria and were common and/or abundant in the study area. Several of the original critically treated species (sheephead, Pacific sanddab) were scarce in collections. In the case of the sheephead, this is probably due to its attraction to kelp bed habitats. These areas (kelp beds) could not be sampled adequately with nets. Although sheephead were not collected in large numbers, numerous individuals were observed by SCUBA divers in the kelp beds in the study area. The Pacific sanddab prefers deeper water (up to 554 m [1800 ft]) which probably explains its scarcity in samples, as the deepest stations sampled were 15 meters (50 ft). The remainder of the critical species were all fairly common and comprised the majority of the catch.

Plankton studies were conducted offshore and in the lagoon. The long recognized problem of plankton patchiness with respect to obtaining a representative sample of a plankton population has been discussed by many workers (6-488, 6-489, 6-490, 6-491, 6-492, and 6-493). The spatial patchiness may occur in all three dimensions and can be random or non-random. It can be as a result of schooling, feeding, convergence or divergence zone spawning habits or other behavior. These factors help to explain some of the variation in plankton catches.

Many larval fish can exhibit a diel vertical distribution (6-494). Diel sampling was used in this study to examine any differences in day and night distribution. In certain cases, significant differences were found between day and night sampling with night collections capturing more organisms (Section 6.4.5). However, in others, no significant differences were found between day and night sampling. Avoidance can be one aspect of sampling which enters into diel differences in numbers sampled. Avoidance can be greater in the daytime when nets are more visible; however, work has shown that the bulk of the avoidance can be performed just as well at night as in the daytime (6-495). Disturbances projected ahead of the net due to bridles, towing apparatus or the net itself give advance warning of the approach of the net. Leithiser et al. (6-496) found that pumped samples at a power plant intake more accurately sampled fish larvae than did nets. Both nets and pumps were used in this study to sample plankton. In view of the various problems associated with plankton sampling, these results must be viewed as a best estimate of the population. Studies at the San Onofre (SONGS) power plant (6-497) also reported some difficulties in accurately sampling the plankton populations. Standing crop estimates of plankton at SONGS indicated 73.9×10^9 organisms passing Unit 1 between shore and 1.75 km in a 24-hr period (6-498). The volume of this water mass is not given by the authors so it cannot be compared directly to standing crop estimates in our study. In 316(b) studies published for the Potrero power plant in San Francisco (the only 316(b) study published to date for the west coast), no estimate was made of plankton standing crop (6-499), so a comparison cannot be made with that power plant.

Copepods comprise a major portion of marine zooplankton (6-500). Acartia tonsa has been reported to comprise over 50 percent of the total copepod biomass at some times of the year (6-501). In this study, they were frequently the bulk of plankton collections. Their wide-spread distribution in the study area (near-field and far-field) and short reproduction time provide capabilities for rapid regeneration or replacement of removed individuals.

Ichthyoplankton abundances in the California Current region have been studied for many years under the CalCOFI program (6-502). The majority of stations are offshore. Infrequent sampling is conducted in the coastal zone. However, Ahlstrom and Moser (6-503) do report larvae of the California halibut confined to coastal zone areas with abundances up to 100 under 10 m^2 of sea surface; Citharichthys sp with abundances up to 1000 under 10 m^2 of sea surface; and Pleuronichthys sp with abundances up to 100 under 10 m^2 of sea surface. Findings in the Encina study are consistent with CalCOFI reports as all three genera were common and Citharichthys sp was very abundant. These species are widespread offshore, occurring from central or southern Baja

000382

California to north of Point Conception (6-504). The widespread distribution of most of the major ichthyoplankton species (see Section 6.5.4) would appear to provide adequate recruitment to the study area.

A number of workers have dealt with the problems involved in attempting quantitative population estimates for nekton (6-505, 6-506, 6-507, 6-508, and 6-509). Factors which can affect the accuracy of these estimates have previously been discussed in Section 6.5.6. These include: 1) the ability of fish to avoid gear, 2) the selective nature of gear in relation to both the size and species of fish, and 3) the accessibility of fish to the gear.

The estimates used represent only the benthic fish populations. They do not take into account the populations of pelagic fish species. As a result, the population sizes are underestimated. This is especially true in the estimates made for the deeper offshore areas, where the populations in a greater portion of the water column remain unaccounted for.

The area density estimation method used consisted of randomly sampling a known area. The average number of fish per unit area was calculated and multiplied by the total area to obtain an estimate of the entire population. In this manner, population estimates for two types of gear (otter trawl and beach seine) were calculated. Total population estimates for a given area were obtained by combining trawl and seine estimates. The trawl data provided an estimate of the benthic population for all areas except along the shoreline. Beach seining provided the only adequate means of sampling and estimating the fish population in the surf zone and shoreline areas. Assumptions made for the population estimates by each gear type were presented in Tables 6.5-15 and 6.5-19.

By assuming a 30 percent catch efficiency for the trawling gear, a reasonable estimate of benthic fish populations can be obtained (6-510 and 6-511). In the seine estimate, however, a 100 percent catch efficiency was assumed. The actual efficiency probably varied from 30 to 70 percent (6-512). Thus, values estimated for the shoreline populations were conservative estimates.

The approach used assumed a more or less even distribution of benthic fish throughout each area; however, the highly random distribution characteristics of fishes in their environment generally results in estimates of low precision, unless sampling effort is sufficiently large (6-513). In the present study, a sufficiently large number of trawl samples was obtained to take this into account. Seine estimates, however, are subject to this limitation, since only single samples were obtained in each monthly lagoon collection.

Despite its apparent shortcomings, the approach used does provide an acceptable and economical means of estimating fish populations in assessing the effects of power plant induced mortality.

Non-critically treated species comprised a minor portion of the catch. Often they were species where only a few individuals were captured, or they were uncommon.

References

6-1 Miller, D. J. and R. N. Lea, "Guide to the Coastal Marine Fishes of California." Calif. Dept. of Fish and Game, Fish Bull. No. 157. 249 pp. (1972).

6-2 Bradshaw, J., B. Browning, K. Smith and J. Speth, The Natural Resources of Agua Hedionda Lagoon, U.S. Fish and Wildlife Service Coastal Wetland Series #16 (1976).

6-3 Miller and Lea (6-1).

6-4 Bradshaw et al. (6-2).

6-5 Bradshaw et al. (6-2).

6-6 Miller, J. N., The Present and Past Molluscan Faunas and Environment of Four Southern California Coastal Lagoons, Master's Thesis, Univ. of Calif., San Diego, 272 pp. (1966).

6-7 SCCWRP (Southern California Coastal Water Research Project), The Ecology of the Southern California Bight. Implications for Water Quality Management. SCCWRP Report #TR104, (1973).

6-8 SCCWRP (6-7).

6-9 Baxter, J. L., "Summary of Biological Information on the Northern Anchovy Engraulis mordax Girard." Calif. Coop. Oceanic Fish. Invest. Rep. (11):110-116. (1967).

6-10 Brewer, G. D., "Reproduction and Spawning of the Northern Anchovy, Engraulis mordax, in San Pedro Bay, California". Calif. Fish and Game 64(3):175-184 (1978).

6-11 Limbaugh, C., Fish Life in the Kelp Beds and the Effects of Kelp Harvesting, Univ. Calif. Inst. Mar. Resources IMR Reference 55-9, (Sept. 9, 1955).

6-12 Ford, R. F., Distribution, Population Dynamics and Behavior of Bothid Flatfish, Citharichthys stigmaeus, Ph.D. Thesis, University of California, San Diego. (1965).

6-13 Quast, J. C., "Observations of the Food and Biology of the Kelp Bass, Paralabrax clathratus, with Notes on its Sportsfishery at San Diego, California, In W. J. North and G. L. Hubbs (eds.) Utilization of Kelp-bed Resources in Southern California", Calif. Dept. of Fish and Game, Fish Bull. 139:81-108 (1968).

6-14 Skogsberg, T., "The Fishes of the Family Sciaenidae (Croakers) of California", Cal. Fish and Game, Fish Bull. No. 54:1-62 (1939).

6-15 Maxwell, W. D., "The Croakers of California", Calif. Dept. of Fish and Game, Resources Agency Leaflet No. 8 (1975).

6-16 Clark, G. H., "California Halibut", Calif. Fish and Game 16(4):315-317 (1930).

6-17 Bane, G. and M. Robinson, "Studies on the Shiner Perch, *Cymatogaster aggregata*, Gibbons, in Upper Newport Bay California", The Wassman Jour. of Biology 28(2):259-268 (1970).

6-18 Babel, J. S., "Reproduction, Life History, and Ecology of the Round Stingray *Urolophus halleri* Cooper". Calif. Dept. of Fish and Game, Fish Bull. 137 (1967).

6-19 McHugh, J. L., Estuarine Nekton In: Haugh, G. H. (ed.) Estuaries, Amer. Assoc. Adv. Science, Pub. 83, Washington D. C. 757 pp.

6-20 Horn, M. L., and L. G. Allen, "Numbers of Species and Faunal Resemblance of Marine Fishes in California Bays and Estuaries", Bull. of So. Calif. Acad. of Sci. 75(2): 159-170 (1976).

6-21 Weinstein, M. P., "Shallow Marsh Habitat as Primary Nurseries for Fishes and Shellfish, Cape Lear River, North Carolina", Fishery Bull. 77(2):339-358 (1979).

6-22 Horn and Allen (6-20).

6-23 Horn and Allen (6-20).

6-24 Bradshaw et al. (6-2).

6-25 Horn and Allen (6-20).

6-26 Bradshaw et al. (6-2).

6-27 Bradshaw et al. (6-2).

6-28 Bradshaw et al. (6-2).

6-29 Jacobs, J., "Animal Behavior and Water Movement as Co-determinants of Plankton Distribution in a Tidal System". Sarsia (34):355-370 (1968).

6-30 Thomson, J. M., "Synopsis of Biological Data on the Grey Mullet Mugil cephalus Linnaeus, 1758", CSIRO Fisheries and Oceanography (Australia) Fisheries Synopsis No. 1, 57 pp. (1963).

000389

6-31 Thomson, J. M., "The Grey Mullets", Oceangr. Mar. Biol. Ann. Rev., 4:301-335 (1966).

6-32 Odum, W. E., Utilization of the Direct Grazing and Plant Detritus Food Chains by the Striped Mullet Mugil cephalus, In J. H. Steele (ed.) 1970 Marine Food Chains, Oliver and Boyd, p. 222-240.

6-33 Fitch, J. E., and R. J. Lavenberg, Marine Food and Game Fishes of California, University of Calif. Press, Berkeley. 121 pp. (1971).

6-34 DeSilva, S. S. and M. J. S. Wijeyaratne, "Studies on The Biology of the Young Grey Mullet, Mugil cephalus L." II. Food and Feeding, Aquaculture, 12:157-167 (1977).

6-35 Limbaugh (6-11).

6-36 Feder, H. M., C. H. Turner, and C. Limbaugh, "Observations on Fishes Associated with Kelp Beds in Southern California." Calif. Dept. of Fish and Game, Fish Bull. No. 160 (1974).

6-37 Jones, A. C., "The Biology of the Euryhaline Fish, Leptocottus armatus armatus, Girard." Univ. Calif. Pubs. Zool. 67:321-368 (1962).

6-38 Miller and Lea (6-1).

6-39 Moyle, P. B., Inland Fishes of California, Univ. of Calif. Press., Berkeley, 405 pp. (1976).

6-40 Collyer, R. D. and P. H. Young, "Progress Report on a Study of the Kelp Bass, *Paralabrax clathratus*", Calif. Fish and Game 39(2):191-208 (1953).

6-41 Bane, G. W., "Fishes of the Upper Newport Bay". Museum of Systematics Biology: Univ. Calif. Irvine, Research Studies 3:1-115 (1968).

6-42 Fitch, J. E. and R. J. Lavenberg, "Tidepool and Nearshore Fishes of California", Univ. of Calif. Press, Calif. Natural History Guides (38):46-48 (1973).

6-43 Limbaugh (6-11).

6-44 Bane (6-41).

6-45 Feder et al. (6-36).

6-46 Bradshaw et al. (6-2).

6-47 Ebert, E. E., and C. H. Turner, "The Nesting Behavior, Eggs and Larvae of the Bluespot Goby", Calif. Fish and Game 48(4):249-252 (1962).

6-48 Feder et al. (6-36).

6-49 Goldberg, S. R., "Reproductive Cycle of the White Sea Perch", Copeia (2):334-336 (1978).

6-50 Babel (6-18).

6-51 Baxter, J. L., Inshore Fishes of California, Calif. Dept. of Fish and Game; Resources Agency, Sacramento, 78 pp. (1974).

6-52 Sumida, B. Y., E. H. Ahlstrom, H. G. Moser, Early Development of Seven Flatfishes of the Eastern North Pacific with Heavily Pigmented Larvae, Fishery Bull. 77(1):105-145 (1978).

6-53 Allen, L. G. and M. H. Horn, "Abundance, Diversity and Seasonality of Fishes in Colorado Lagoon, Alamitos Bay, California", Estuarine and Coastal Marine Sci. 3:371-380 (1975).

6-54 Bane (6-41).

6-55 Fitch and Lavenberg (6-42).

6-56 Allen and Horn (6-53).

6-57 Roedel, P. M., "Common Ocean Fishes of the California Coast", Calif. Dept. of Fish and Game, Fish Bull. No. 91, 184 pp. (1953).

6-58 Frey, H. W., California's Living Marine Resources and Their Utilization, Calif. Dept. of Fish and Game, Sacramento 148 pp. (1971).

6-59 Lane, E. D. and C. W. Hill, "The Marine Resources of Anaheim Bay", Calif Dept. of Fish and Game, Fish Bull. No. 165, 195 pp. (1975).

6-60 Bane and Robinson (6-17).

6-61 Skogsberg (6-14).

6-62 Feder et al. (6-36).

6-63 Skogsberg (6-14).

6-64 Limbaugh (6-11).

6-65 Feder et al. (6-36).

6-66 Feder et al. (6-36).

6-67 Maxwell (6-15).

6-68 Skogsberg (6-14).

6-69 Baxter (6-51).

6-70 Pinkas, L., M. S. Oliphant, C. W. Haugen, "Southern California Marine Sportfishing Survey: Private Boats, 1964; Shoreline 1965-66", Calif. Fish and Game, Fish Bull. No. 143, 42 pp. (1968).

6-71 Baxter (6-51).

6-72 Goldberg, S. R., "Seasonal Spawning Cycles of the Sciaenid Fishes Genyonemus lineatus and Seriphus politus", Fishery Bull. 74(4):983-984 (1977).

6-73 Limbaugh (6-11).

6-74 Quast (6-13).

6-75 Collyer and Young (6-40).

6-76 Limbaugh (6-11).

6-77 Thomas, J. C., "Management of the White Seabass (Cynocsion nobilis) in California Waters", Calif. Dept. of Fish and Game, Fish Bull. No. 142, 34 pp. (1968).

6-78 Fitch and Lavenberg (6-33).

6-79 Arora, H. L., "An Investigation of the California Sanddab (Citharichthys sordidus)", Calif. Fish and Game 37(1):3-42 (1951).

6-80 Fitch, J. E., Offshore Fishes of California, Calif. Dept. of Fish and Game, Sacramento (1958).

6-81 Pearcy, W. G., "Distribution and Abundance of Small Flatfishes and Other Demersal Fishes in a Region of Diverse Sediments and Bathymetry off Oregon", Fishery Bull. 76(3):629-640.

6-82 Ford (6-12).

6-83 Fitch and Lavenberg (6-42).

6-84 Weinstein (6-21).

6-85 Weinstein (6-21).

6-86 Baxter (6-9).

6-87 Hedgepeth, J. W., Ecological Aspects of the Laguna Madre, A Hypersaline Estuary. In: G. H. Lauff (ed.) Estuaries, Amer. Assoc. Advancement Science, Pub. 83: 408-419 (1967).

6-88 Conover, R. J., "Oceanography of Long Island Sound 1952-54. VI. Biology of Acartia clausi and A. tonsa" Bull. Bringham Oceanog. Coll. 15:156-233 (1956).

6-89 Woodmansee, R. A., "The Seasonal Distribution of the Zooplankton off Chicken Key in Biscayne Bay, Florida", Ecology 39:247-262 (1958).

6-90 Conover (6-88).

6-91 Deevey, G. B., "The Zooplankton of Tisbury Great Pond", Bull. Bringham Oceanog. Coll. 12:1-44 (1948).

6-92 Johnson, J. K., The Dynamics of an Isolated Population of Acartia tonsa Dana (copepoda) in Yaquina Bay, Oregon. Master's Thesis. Oregon State Univ., Corvallis, Ore. 97 pp. (1974).

6-93 Woodmansee (6-89).

6-94 Uye, S. and A. Flemiger, "Effects of Various Environment Factors on Egg Development of Several Species of Acartia in Southern California", Mar. Biol. 38:253-262 (1976).

6-95 Heinle, D. R., "Production of a Calanoid Copepod, Acartia tonsa, in the Patuxent River Estuary", Chesapeake Sci. 7:59-74 (1966).

6-96 Johnson, M. E. and H. J. Snook, Seashore Animals of the Pacific Coast, Dover Publication Inc., New York. 255 pp. (1967).

6-97 Esterly, C. O., "Pelagic Copepoda of the San Diego Region", Univ. Calif. Pub. Zool., Vol. 2 (1905).

6-98 Esterly, C. O., "The Free Swimming Copepoda from San Francisco Bay", University Calif. Publ. Zool. 26:81-129 (1924).

6-99 Jacobs (6-29).

6-100 Baxter (6-51).

6-101 Limbaugh (6-11).

6-102 Babel (6-18).

6-103 Baxter (6-51).

6-104 Babel (6-18).

6-105 Herald, E. S., Living Fishes of the World, Doubleday, Garden City, N.J. (1961).

6-106 Baxter (6-51).

6-107 Baxter (6-51).

6-108 Babel (6-18).

6-109 Miller and Lea (6-1).

6-110 Limbaugh (6-11).

6-111 Feder et al. (6-36).

6-112 Pinkas et al. (6-70).

6-113 Baxter (6-9).

6-114 Oliphant, M. S., "California Marine Fish Landings for 1976", Calif. Dept. of Fish and Game, Fish Bull. No. 170 56 pp. (1979).

6-115 Baxter (6-9)

6-116 Oliphant (6-114).

6-117 Baxter (6-9).

6-118 Lasker, R. and P. E. Smith, "Estimation of the Effects of Environmental Variations on Eggs and Larvae of the Northern Anchovy", Calif. Coop. Oceanic Fish. Invest., Rept. 19:128-137 (1977).

6-119 Brewer (6-10).

6-120 Baxter (6-9).

6-121 Hunter, J. R., "Behavior and Survival of Northern Anchovy, Engraulis mordax, Larvae", Calif. Coop. Oceanic Fish. Invest., Rept. 19:138-146 (1976).

6-122 Baxter (6-9).

6-123 Sunada, J. S., "Age and Length Composition of Northern Anchovies, _Engraulis mordax_, in the 1972-1973 Season California Anchovy Reduction Fishery", _Calif. Fish and Game_ 61(3):133-143 (1975).

6-124 Spratt, J. D., "Growth Rate of the Northern Anchovy, _Engraulis mordax_, in Southern California Waters, Calculated from Otoliths", _Calif. Fish and Game_ 61(3):116-126 (1975).

6-125 Pacific Fishery Management Council and U.S. Department of Commerce, National Marine Fisheries Service. _Northern Anchovy Fishery_ - Final Environmental Impact Statement and Fishery Management Plan. Washington D.C. 119 pp. (1978).

6-126 Baxter (6-9).

6-127 Bane (6-41).

6-128 Fitch and Lavenberg (6-42).

6-129 Fitch and Lavenberg (6-42).

6-130 Allen and Horn (6-53).

6-131 BMF (Bureau of Marine Fisheries), "The Commerical Fish Catch of California for the Year 1947 with an Historical Review 1916-1947", _Calif. Dept. of Fish and Game_, _Fish Bull_. No. 74, 267 pp. (1949).

6-132 Starks, E. C. and E. L. Morris, "The Marine Fishes of Southern California", University of Calif. Publ.: Zoology 3(11):177. (1907).

6-133 Allen and Horn (6-53).

6-134 Miller and Lea (6-1).

6-135 Walker, B. W., "A Guide to the Grunion", Calif. Fish and Game 38(3):409-420 (1952).

6-136 Baxter (6-51).

6-137 Walker (6-135).

6-138 David, L. R., "Embryonic and Early Larval Stages of the Grunion, Leuresthes tenuis, and of the Sculpin, Scorpaena guttata", Copeia 2:75-81 July 12, 1939).

6-139 Clark, F. N., "Grunion in Southern California", California Fish and Game 24:49-54 (1938).

6-140 David (6-138).

6-141 Fitch and Lavenberg (6-33).

6-142 Walker (6-135).

6-143 Reynolds, W. W., D. A. Thompson and M. E. Casterlin, "Responses of Young California Grunion, Leuresthes tenuis, to Gradients of Temperature and Light", Copeia (1):144-149 (1977).

6-144 Fitch and Lavenberg (6-33).

6-145 Fitch and Lavenberg (6-33).

6-146 Oliphant (6-114).

6-147 Feder et al. (6-36).

6-148 Roedel (6-57).

6-149 Fitch and Lavenberg (6-33).

6-150 Feder et al. (6-36).

6-151 Limbaugh (6-11).

6-152 Feder et al. (6-36).

6-153 Feder et al. (6-36).

6-154 Fitch and Lavenberg (6-33).

6-155 Feder et al. (6-36).

6-156 Fitch and Lavenberg (6-33).

6-157 Fitch and Lavenberg (6-33).

6-158 Feder et al. (6-36).

6-159 Duodorff, P., "The Resistance and Acclimitization of Marine Fishes to Temperature Changes. II Experiments with Fundulus and Atherinops", Biol. Bull: 88:194-206 (1945).

6-160 Roedel (6-57).

6-161 BMF (6-131).

6-162 Roedel (6-57).

6-163 Pinkas et al. (6-70).

6-164 Calif. Dept. of Fish and Game, Preliminary Report of the California Partyboat Fleet 1978, Calif. Dept. of Fish and Game, Sacramento (1979).

6-165 Fitch (6-80).

6-166 Oliphant (6-114).

6-167 Taylor, P. B., The Venom and Ecology of the California Scorpionfish Scorpaena guttata Girard, Univ. of Calif. SIO Dissertation, San Diego (1963).

6-168 David (6-138).

6-169 Taylor (6-167).

6-170 David (6-138).

6-171 Fitch (6-80).

6-172 Fitch (6-80).

6-173 Miller and Lea (6-1).

6-174 Feder et al. (6-36).

6-175 Limbaugh (6-11).

6-176 Pinkas et al. (6-70).

6-177 Jones (6-37).

6-178 Jones (6-37).

6-179 Fitch and Lavenberg (6-42).

6-180 Jones (6-37).

6-181 Jones (6-37).

6-182 Fitch and Lavenberg (6-42).

6-183 Pinkas et al. (6-70).

6-184 Quast (6-13).

6-185 Collyer and Young (6-40).

6-186 Calif. Dept. Fish and Game (6-164).

6-187 Collyer and Young (6-40).

6-188 Quast (6-13).

6-189 Quast (6-13).

6-190 Limbaugh (6-11).

6-191 Hulbrock, R., Lengths, Weights and Ages of Thirteen Southern California Marine Gamefish, (Revised 1976) Calif. Dept. of Fish and Game; Resources Agency, Sacramento 33 pp. (1974).

6-192 Collyer and Young (6-40).

6-193 Quast (6-13).

6-194 Quast (6-13).

6-195 Quast (6-13).

6-196 Fitch and Lavenberg (6-42).

6-197 Fitch and Lavenberg (6-42).

6-198 Bane (6-41).

6-199 Fitch and Lavenberg (6-42).

6-200 Fitch and Lavenberg (6-42).

6-201 Limbaugh (6-11).

6-202 Miller, D. J., D. Gotshall and R. Hitsos, A Field Guide to Some Common Ocean Sport Fishes of California Part II, Calif. Dept. of Fish and Game, Sacramento 41 pp. (1961).

6-203 Bane (6-41).

6-204 Fitch and Lavenberg (6-42).

6-205 Pinkas et al. (6-70).

6-206 Collyer and Young (6-40).

6-207 Calif. Dept. Fish and Game (6-164).

6-208 Limbaugh (6-11).

6-209 Collyer and Young (6-40).

6-210 Limbaugh (6-11).

6-211 Quast, J. C., "Observations on the Food of the Kelp-Bed Fishes", Calif. Dept. of Fish and Game, Fish Bull. No. 139:109-142 (1968).

6-212 Collyer and Young (6-40).

6-213 Limbaugh (6-11).

6-214 Miller et al. (6-202).

6-215 Bane (6-41).

6-216 Limbaugh (6-11).

6-217 Skogsberg (6-14).

6-218 Oliphant (6-114).

6-219 Skogsberg (6-14).

6-220 Feder et al. (6-36).

6-221 Skogsberg (6-14).

6-222 Skogsberg (6-14).

6-223 Limbaugh (6-11).

6-224 Goldberg (6-72).

6-225 Goldberg (6-72).

6-226 Feder at al. (6-36).

6-227 Skogsberg (6-14).

6-228 Skogsberg (6-14).

6-229 Feder et al. (6-36).

6-230 Thomas (6-77).

6-231 Fitch and Lavenberg (6-33).

6-232 Oliphant (6-114).

6-233 Thomas (6-77).

6-234 Calif. Dept. Fish and Game (6-164).

6-235 Thomas (6-77).

6-236 Fitch and Lavenberg (6-33).

6-237 Feder et al. (6-36).

6-238 Fitch (6-80).

6-239 Thomas (6-77).

6-240 Fitch and Lavenberg (6-33).

6-241 Fitch (6-80).

6-242 Fitch and Lavenberg (6-33).

6-243 Feder et al. (6-36).

6-244 Skogsberg (6-14).

6-245 Baxter (6-51).

6-246 Baxter (6-51).

6-247 Baxter (6-51).

6-248 Fitch and Lavenberg (6-33).

6-249 Pinkas et al. (6-70).

6-250 Fitch and Lavenberg (6-33).

6-251 Baxter (6-51).

6-252 Fitch and Lavenberg (6-33).

6-253 Limbaugh (6-11).

6-254 Fitch and Lavenberg (6-33).

6-255 Feder et al. (6-36).

6-256 Joseph, D. E., "Growth Characteristics of Two Southern California Surffishes, the California Corbina and the Spotfin Croaker, Family Sciaenidae", Calif. Dept. of Fish and Game, Fish Bull. No. 119; 54 pp. (1962).

6-257 Limbaugh (6-11).

6-258 Joseph (6-256).

6-259 Fitch and Lavenberg (6-33).

6-260 Starks, E. C., "The Fishes of the Croaker Family (Sciaenidae) of California", Calif. Fish and Game 5(1):13-20 (1919).

6-261 Feder et al. (6-36).

6-262 Feder et al. (6-36).

6-263 Limbaugh (6-11).

6-264 Starks (6-260).

6-265 Baxter (6-51).

6-266 Oliphant (6-114).

6-267 Pinkas et al. (6-70).

6-268 Calif. Dept. Fish and Game (6-164).

6-269 Starks (6-260).

6-270 Maxwell (6-15).

6-271 Goldberg (6-72).

6-262 Baxter (6-51).

6-273 Hulbrock (6-191).

6-274 Bane (6-41).

6-275 Baxter (6-51).

6-276 Goldberg (6-72).

6-277 Starks (6-260).

000409

6-278 Baxter (6-51).

6-279 Skogsberg (6-14).

6-280 Limbaugh (6-11).

6-281 Pinkas et al. (6-70).

6-282 Skogsberg (6-14).

6-283 Skogsberg (6-14).

6-284 Limbaugh (6-11).

6-285 Feder et al. (6-36).

6-286 Limbaugh (6-11).

6-287 Feder et al. (6-36).

6-288 Skogsberg (6-14).

6-289 Skogsberg (6-14).

6-290 Joseph (6-256).

6-291 Joseph (6-256).

6-292 Starks (6-260).

6-293 Barnhart P. S., Marine Fishes of Southern California, University of Calif. Press, Berkeley 209 pp. (1936).

6-294 Feder et al. (6-36).

6-295 Skogsberg (6-14).

6-296 Feder et al. (6-36).

6-297 Fitch and Lavenberg (6-33).

6-298 Pinkas et al. (6-70).

6-299 Carlisle, J. G. Jr., J. W. Schott and N. J. Abramson, "The Barred Surfperch (Amphisticus argenteus) in Southern California", Calif. Dept. of Fish and Game Fish Bull. No. 109, 79 pp. (1960).

6-300 Triplett, E. L., "Notes on the History of the Barred Surfperch (Amphisticus argenteus) and a Technique for Culturing Embiotocid Embryos", Calif. Fish and Game 46(4):433-439 (1960).

6-301 Carlisle et al. (6-299).

6-302 Carlisle et al. (6-299).

6-303 Triplett (6-300).

6-304 Carlisle et al. (6-299).

6-305 Fitch and Lavenberg (6-33).

000411

6-306 Clemens, W. A. and G. V. Wilby, "Fishes of the Pacific Coast of Canada", Fisheries Research Board of Canada, Bull. 68, 368 pp. (1946).

6-307 Miller, D.J., "A Field Guide to Some Common Ocean Sport Fishes of California Part I", Calif. Dept. of Fish and Game 41 pp. (1959).

6-308 Pinkas et al. (6-70).

6-309 Hart, J.L., "Pacific Fishes of Canada", Fisheries Research Board of Canada, Bull. 180, 740 pp (1973).

6-310 Feder et al. (6-36).

6-311 Baxter(6-51).

6-312 Oliphant (6-114).

6-313 Baxter (6-51).

6-314 Rechnityer, B. and C. Limbaugh, "Breeding Habits of Hyperprosopon argenteum, a Viviparous Fish of California", Copeia (1):41-42 (1952).

6-315 Hart (6-309).

6-316 Feder et al. (6-36).

6-317 Anderson, R. D., C. F. Bryan, "Age and Growth of three Surfperches (Embiotocidae) from Humboldt Bay, California", Trans. Amer. Fish Soc. 99(3):475-482 (1970).

6-318 Anderson and Bryan (6-317).

6-319 Hobson, E. S., James R. Chess, "Trophic Interactions Among Fishes and Zooplankters Near Shore at Santa Catalina", Fishery Bull. 74(3):567-598 (1976).

6-320 Miller and Lea (6-1).

6-321 Hart (6-309).

6-322 Feder et al. (6-36).

6-323 Tarp, F. H., "A Revision of the Family Embiotocidae (Surfperches)" Calif. Dept. of Fish and Game, Fish Bull. No. 88:51-53 (1952).

6-324 Wiebe, J. P., "The Reproductive Cycle of the Viviparous Seapeach, Cymatogaster aggregata, Gibbons", Canadian Jour. of Zoology (46):1221-1234 (1968).

6-325 Bane and Robinson (6-17).

6-326 Bane and Robinson (6-17).

6-327 Wiebe (6-324).

6-328 Bane and Robinson (6-17).

6-329 Fitch and Lavenberg (6-33).

6-330 Bane and Robinson (6-17).

6-331 Bane and Robinson (6-17).

6-332 Roedel, P. M., "Common Marine Fishes of California", Calif. Dept. of Fish and Game, Fish Bull. No. 68, 150 pp. (1948).

6-333 Oliphant (6-114).

6-334 Thomson (6-31).

6-335 Odum (6-32).

6-336 Thomson (6-30).

6-337 Fitch and Lavenberg (6-33).

6-338 Thomson (6-30).

6-339 Moyle (6-39).

6-340 Martin, F., E. Drewry, Development of Fishes of the Mid-Atlantic Bight, An Atlas of Egg, Larval and Juvenile Stages, Vol. 6 Stromateidae Through Ogcocephalidae, U.S. Dept. of Interior, Fish and Wildlife Service FWS/OBS - 78/12 Washington D.C. 416 pp. (1978).

6-341 Odum (6-32).

6-342 Thomson (6-30).

6-343 Moyle (6-39).

6-344 Miller and Lea (6-1).

6-345 Martin and Drewry (6-340).

6-346 Fitch (6-80).

6-347 Oliphant (6-114).

6-348 Fitch and Lavenberg (6-33).

6-349 C F G (6-164).

6-350 Limbaugh (6-11).

6-351 Fitch (6-80).

6-352 Warner, R., "The Reproductive Biology of the Protogynous Hermaphrodite Pimelometopon pulchrum", Fishery Bull. 73(2):262-283 (1975).

6-353 Warner (6-352).

6-354 Limbaugh (6-11).

6-355 Fitch and Lavenberg (6-33).

6-356 Limbaugh (6-11).

6-357 Feder et al. (6-36).

000415

6-358 Feder et al. (6-36).

6-359 Limbaugh (6-11).

6-360 Miller and Lea (6-1).

6-361 Warner (6-352).

6-362 Warner (6-352).

6-363 Bane (6-41).

6-364 Limbaugh (6-11).

6-365 Limbaugh (6-11).

6-366 Barnhart (6-293).

6-367 Limbaugh (6-11).

6-368 Feder et al. (6-36).

6-369 Bane (6-41).

6-370 Fitch and Lavenberg (6-33).

6-371 Oliphant (6-114).

6-372 Fitch and Lavenberg (6-33).

6-373 Pinkas et al. (6-70).

6-374 Calif. Dept. Fish and Game (6-164).

6-375 Clark (6-16).

6-376 Fitch and Lavenberg (6-33).

6-377 Frey (6-58).

6-378 Hildebrand, S. F., and L. E. Cable, "Development and Life History of Fourteen Teleostean Fishes at Beaufort, N. C." U.S. Bur. Fish., Bull. 46: 382-488 (1930).

6-379 Frey (6-58).

6-380 Fitch and Lavenberg (6-33).

6-381 Hulbrock (6-191).

6-382 Fitch and Lavenberg (6-33).

6-383 Frey (6-58).

6-384 Arora (6-79).

6-385 Roedel (6-332).

6-386 Arora (6-79).

6-387 Fitch and Lavenberg (6-33).

6-388 Kravitz, M. J., W. G. Pearcy, M. P. Guinn, "Food of Five Species of Co-occurring Flatfishes on Oregon's Continental Shelf", Fishery Bull. 74(4):984-990 (1976).

6-389 McAllister, R., "California Marine Landings for 1974", _Calif. Dept. of Fish and Game_, _Fish Bull_. No. 166, 53 pp. (1976).

6-390 Oliphant (6-114).

6-391 Pinkas, L., "California Marine Fish Landings for 1975" _Calif. Dept. of Fish and Game_, _Fish Bull_. No. 168, 55 pp (1977).

6-392 Pearcy (6-81).

6-393 Arora (6-79).

6-394 Fitch (6-80).

6-395 Arora (6-79).

6-396 Arora (6-79).

6-397 Fitch (6-80).

6-398 Kravitz et al. (6-388).

6-399 Pearcy, W. G., D. Hancock, "Feeding Habits of the Dover Sole, _Microstomus pacificus_; Rex Sole, _Glyptocephalus zachirus_; Slender Sole, _Lyopsetta exilis_ and Pacific Sanddab, _Citharichthys sordidus_, in a Region of Diverse Sediments and Bathymetry off Oregon", _Fishery Bull_. 76(3):641-651 (1978).

6-400 Arora (6-79).

6-401 Fitch and Lavenberg (6-33).

6-402 Fitch and Lavenbern (6-42).

6-403 Ford (6-12).

6-404 Fitch and Lavenberg (6-42).

6-405 Ford (6-12).

6-406 Fitch and Lavenberg (6-42).

6-407 Ford (6-12).

6-408 Best, E. A., "Status of the Animal Food Fishery in Northern California, 1956 and 1957", Calif. Fish and Game 45(1):5-18 (1959)

6-409 Fitch, J. E., "A Review of the Fisnes of the Genus Pleuronichthys" , Los Angeles Co. Museum Contri. Sci., No. 76, 33 pp. (1963).

6-410 Oliphant (6-114).

6-411 Budd, P. L., "Development of the Eggs and Early Larvae of Six California Fishes", Calif. Dept. of Fish and Game, Fish Bull. No. 56, 53 pp. (1940).

6-412 Budd (6-411).

6-413 Fitch (6-409).

6-414 Miller and Lea (6-1).

6-415 Miller and Lea (6-1).

6-416 McAllister, R., "California Marine Fish Landings for 1973", California Dept. of Fish and Game, Fish Bull. No. 163, 53 pp. (1975).

6-417 McAllister (6-389).

6-418 Pinkas (6-391).

6-419 Oliphant (6-114).

6-420 Baxter (6-51).

6-421 Sumida et al. (6-52).

6-422 Baxter (6-51).

6-423 Baxter (6-51).

6-424 Lane, E. D., M. C. S. Kingsley, D. E. Thorton, "Daily Feeding and Food Conversion Efficiency of the Diamond Turbot: An Analysis Based on Field Data", Trans. Amer. Fish. Soc. 108(6):530-535. (1979).

6-425 Bane (6-41).

6-426 Miller and Lea (6-1).

6-427 Baxter (6-51).

6-428 Zar, J. H., <u>Biostatistical Analysis</u>, Prentice-Hall, Inc. Englewood Cliffs, N.J., 620 pp. (1974).

6-429 Quast (6-13).

6-430 Limbaugh (6-11).

6-431 Fitch and Lavenberg (6-42).

6-432 Bane (6-41).

6-433 Limbaugh (6-11).

6-434 Hart (6-309).

6-435 Hart (6-309).

6-436 Frey (6-58).

6-437 Arora (6-79).

6-438 Fitch (6-80).

6-439 Frey (6-58)

6-440 Fitch and Lavenberg (6-42).

6-441 Ford (6-12).

6-442 Frey (6-58).

6-443 Fitch and Lavenberg (6-42).

6-444 Baxter (6-51).

6-445 Lasker and Smith (6-118).

6-446 Brewer (6-10).

6-447 Fitch and Lavenberg (6-42).

6-448 Clark (6-139).

6-449 Walker (6-135).

6-450 Fitch and Lavenberg (6-33).

6-451 Feder et al. (6-36).

6-452 David (6-138).

6-453 Fitch and Lavenberg (6-42).

6-454 Collyer and Young (6-40).

6-455 Fitch and Lavenberg (6-42).

6-456 Collyer and Young (6-40).

6-457 Limbaugh (6-11).

6-458 Goldberg (6-72).

6-459 Thomas (6-77).

6-460 Fitch and Lavenberg (6-33).

6-461 Feder et al. (6-36).

6-462 Maxwell (6-15).

6-463 Goldberg (6-72).

6-464 Skogsberg (6-14).

6-465 Triplett (6-300).

6-466 Hart (6-309).

6-467 Feder et al. (6-36).

6-468 Wiebe (6-324).

6-469 Bane and Robinson (6-17).

6-470 Limbaugh (6-11).

6-471 Bane (6-41).

6-472 Frey (6-58).

6-473 Fitch and Lavenberg (6-42).

6-474 Budd (6-411).

6-475 Sumida et al. (6-52).

6-476 Allen, G., A. Delacy and D. Gotshall, Quantitive Sampling of Marine Fishes - A Problem in Fish Behavior and Fishing Gear, College of Fisheries Contribution No. 70, University of Washington, Seattle (1960).

6-477 Odum, E. P., "Principles and Concepts Pertaining to Organization at the Community Level", In: Fundamentals of Ecology, 3rd edition, W. B. Saunders Co., Philadelphia, 575 pp. (1971).

6-478 Pankhurst, R. J., Biological Identification with Computers, Academic Press, New York, pp 83-87, (1975).

6-479 Kjelson, M., and G. Johnson, "Catch Efficiencies of a 6.1-meter Otter Trawl for Estuarine Fish Populations", Trans. Am. Fish. Soc. 107(2):246-254 (1978).

6-480 Kjelson and Johnson (6-479).

6-481 Mearns, A. J., and M. J. Allen, Use of Small Otter Trawls in Coastal Biological Surveys, Southern California Coastal Water Research Project, Contribution No. 66, Long Beach (1978).

6-482 N. M. F. S., Fisheries of the United States 1979, Current Fishery Statistics No. 8000, U.S. Dept. Commerce, 131 pp. (1980).

6-483 N M F S (6-482).

6-484 Miller and Lea (6-1).

6-485 Lane and Hill (6-59).

6-486 Connell, J. H., B. J. Mechalas and J.A. Mihursky, Annual Report to the California Coastal Commission Aug. 1976 - Aug. 1977, Appendix I Estimated Effects of Songs Unit I on Marine Organisms: Technical Analysis and Results. Marine Review Committee, MRC Doc. 77-09 No. 2 (1977).

6-487 SCCWRP (6-7).

6-488 Smith, P. E. and S. L. Richardson, Standard Techniques for Pelagic Fish Egg and Larva Surveys, FAO Fish. Tech. Paper No. 175 Rome, 100 pp. (1977).

6-489 Bowles, R. R., J. V. Merriner, G. C. Grant, Factors Associated with Accuracy in Sampling Fish Eggs and Larvae, U.S. Fish and Wildlife Service. Office of Biol. Services FWS/OBS - 78/83, 67 pp. (1978).

6-490 Colton, J. B., K. A. Honey, R. F. Temple, "The Effectiveness of Sampling Methods Used to Study the Distribution of Larval Herring in the Gulf of Maine", J. Cons. Perm. Int. Explor. Mer. 26:180-190 (1961).

6-491 Cassie, R. M., "Microdistribution of Plankton", Oceanogr. Mar. Biol. Annual Rev. 1:223-252. (1963).

6-492 Wiebe, P. H. "Small-scale Spatial Distribution in Oceanic Zooplankton", Limnol. Oceanogr. 15(2):205-217 (1970).

6-493 Wood, R. J., "Some Observations on the Vertical Distribution of Herring Larvae", Rapp. Proc. - Verb. Reun. Cons. Perm. Int. Explor. Mer. 160:60-64 (1971).

6-494 Bowles et al. (6-489).

6-495 Smith and Richardson (6-488).

6-496 Leithiser, R. M., K. F. Ehrlich, and A. B. Thum. "Comparison of a High Volume Pump and Conventional Plankton Nets for Collecting Fish Larvae Entrained in Power Plant Cooling Systems", Jour. Fish Res. Board Can. 36:81-84 (1979).

6-497 Connell et al. (6-486).

6-498 Connell et al. (6-486).

6-499 Ecological Analysts, Inc., Potrero Power Plant cooling water intake structures 316(b) demonstration. Prepared for Pacific Gas and Electric, San Francisco, Calif. (1980).

6-500 Alden, R. W. III, "Effects of a Thermal Discharge on the Mortality of Copepods in a Subtropical Estuary", Environmental Pollution:3-19 (1979).

6-501 Reeve, M. R. and E. Cosper, "The Acute Effects of Heated Effluents on the Copepod (Acartia tonsa) From a Sub-tropical Bay and Some Problems of Assessment," FAO Tech. Conf. on Mar. Poll. and Its Effects on Living Resources and Fishing. FIR:MP/70/E-59. Rome, Italy, 4 pp. (1970).

6-502 Ahlstrom, E. H. and H. G. Moser, Distributional Atlas of Fish Larvae in the California Current Region: Flatfishes, 1955 through 1960. CALCOFI Atlas No. 23 Marine Research Committee, State of Calif., La Jolla, Calif. 207 pp. (June 1975).

6-503 Ahlstrom and Moser (6-502).

6-504 Ahlstrom and Moser (6-502).

6-505 Allen et al. (6-476).

6-506 McFadden, J. T., Environmental Impact Assessment for Fish Populations, In: R. K. Sharma, J. D. Buffington, and J. T. McGladden (eds.) Proc. Workshop Biol. Significance Environ. Impacts, NR-CONF-002. Nuclear Regulatory Commission, Washington, D.C. pp 89-137 (1975).

6-507 Kjelson, M. A., Estimating the Size of Juvenile Fish Populations in Southeastern Coastal-Plain Estuaries, In: W. Van Winkle (ed) Proceedings of the conference on assessing the effects of power plant induced mortality on fish populations. Gatlinburg, Tennessee (May 3-6, 1977) pp 71-89.

6-508 Kjelson and Johnson (6-479).

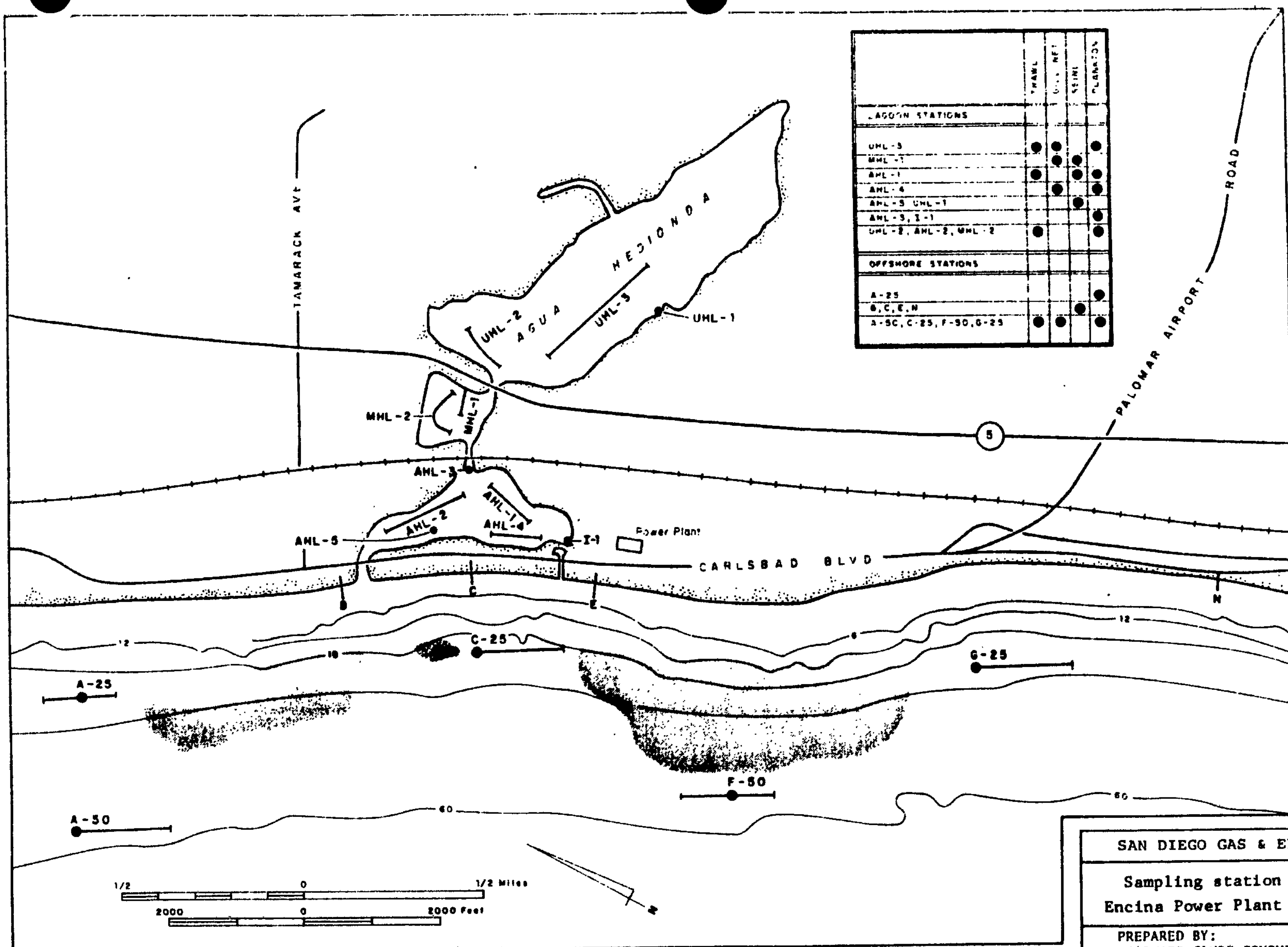
6-509 Mearns and Allen (6-481).

6-510 Kjelson and Johnson (6-479).

6-511 Mearns and Allen (6-481).

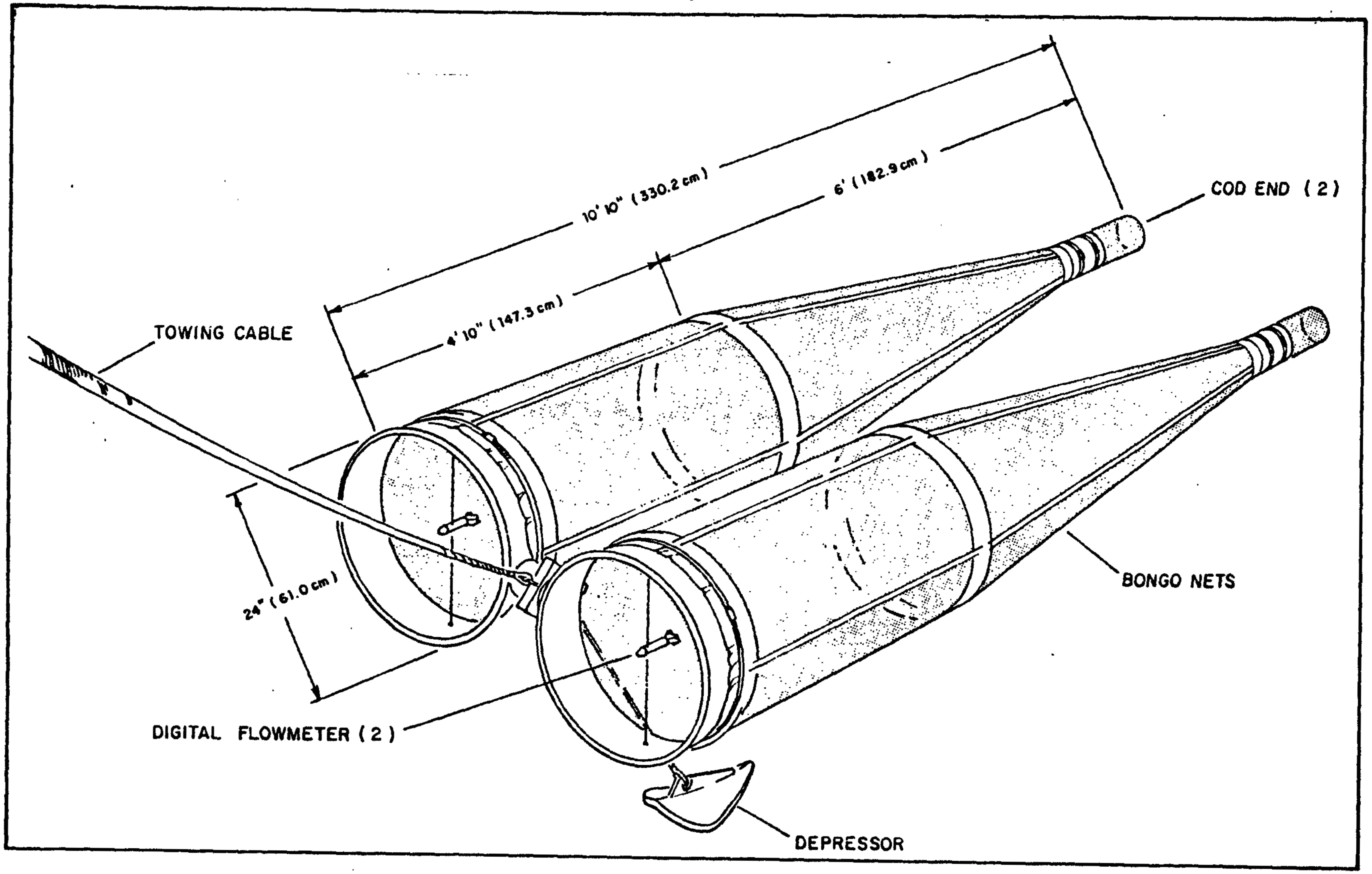
6-512 Kjelson (6-507).

6-513 Kjelson (6-507).

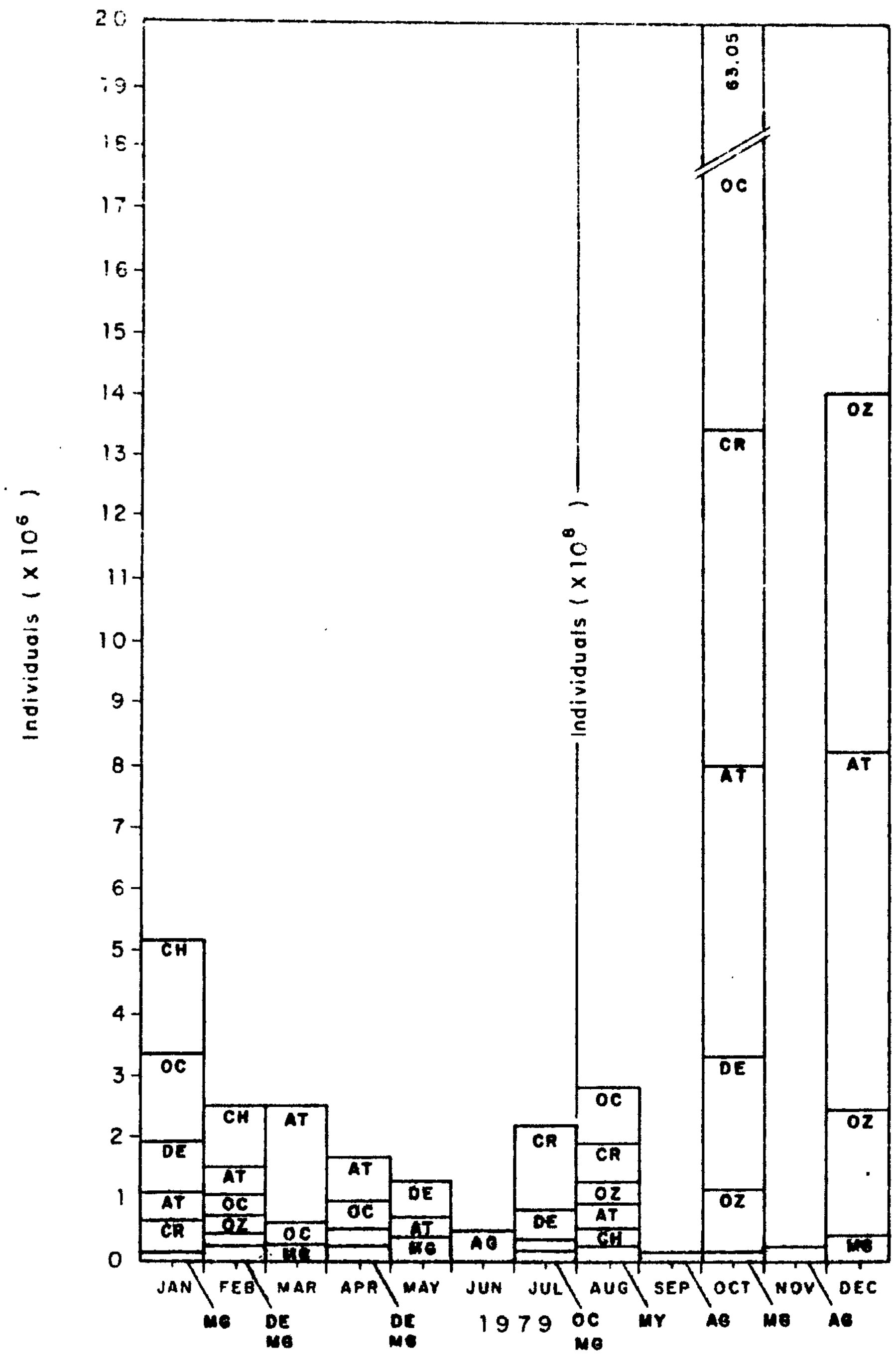


	TRAWL	GILL NET	SEINE	PLANKTON
LAGOON STATIONS				
UHL-3	●	●		●
MHL-1		●	●	
AHL-1	●		●	●
AHL-4		●		●
AHL-5 UHL-1			●	
AHL-3, I-1				●
UHL-2, AHL-2, MHL-2	●			●
OFFSHORE STATIONS				
A-25				●
B,C,E,N			●	
A-50, C-25, F-50, G-25	●	●		●

SAN DIEGO GAS & ELECTRIC COMPANY	
Sampling station locations Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.4-1



SAN DIEGO GAS & ELECTRIC COMPANY
Bongo net system for sampling plankton
Encina Power Plant - August 1, 1980
PREPARED BY: WOODWARD-CLYDE CONSULTANTS — FIGURE NO. 6.4-2



AT	*Acartia tonsa*
OC	Other Copepods
DE	Decapods
MY	Mysidacea
CR	Other Crustacea
CH	Chaetognaths
AG	All Groups
OZ	Other Zooplankton
MG	Miscellaneous Groups

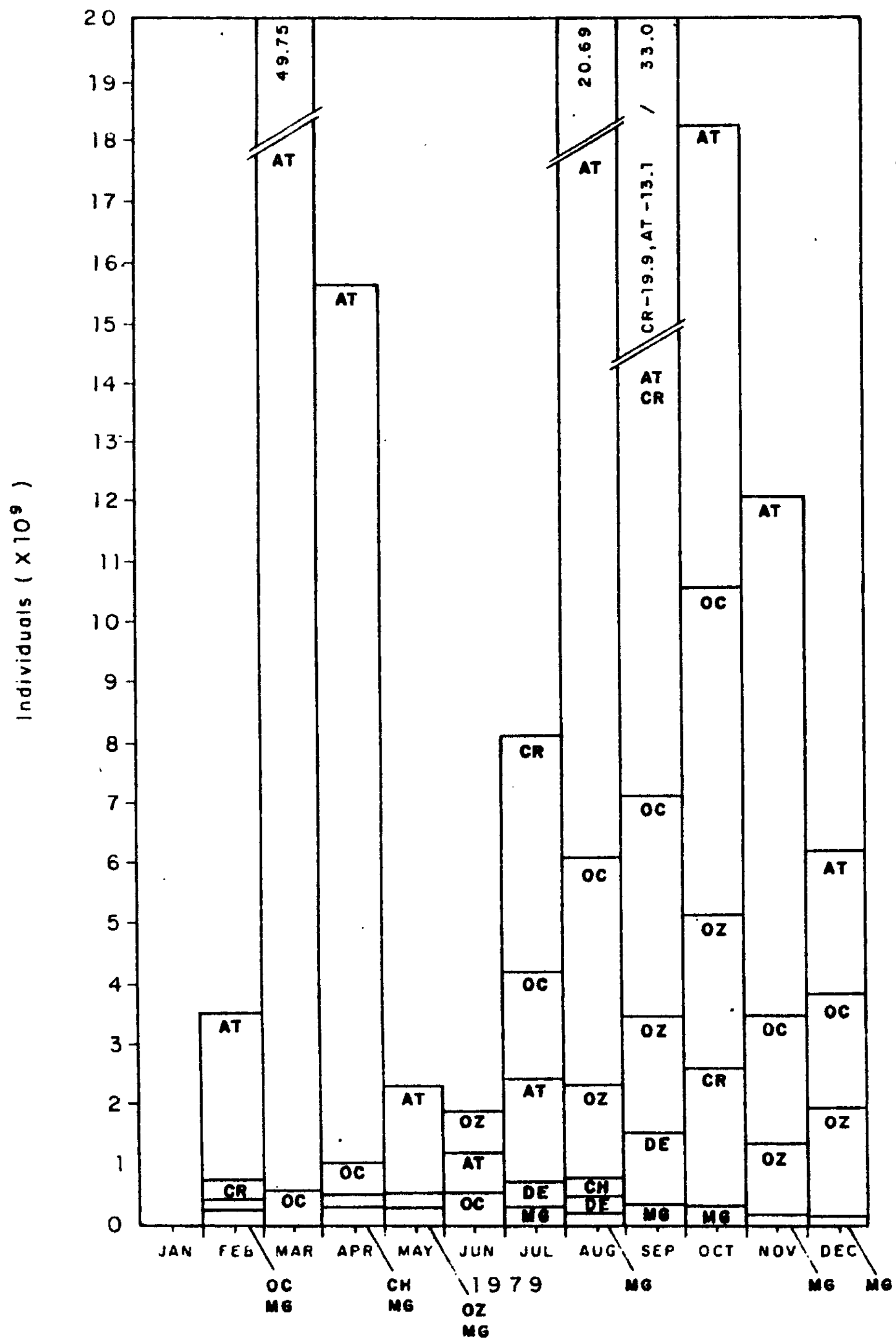
SAN DIEGO GAS & ELECTRIC COMPANY

Offshore zooplankton abundance - 505μ data

Encina Power Plant - August 1, 1980.

PREPARED BY: WOODWARD-CLYDE CONSULTANTS

FIGURE NO. 6.4-3



AT	*Acartia tonsa*
OC	Other Copepods
DE	Decapods
MY	Mysidacea
CR	Other Crustacea
CH	Chaetognaths
AG	All Groups
OZ	Other Zooplankton
MG	Miscellaneous Groups

SAN DIEGO GAS & ELECTRIC COMPANY

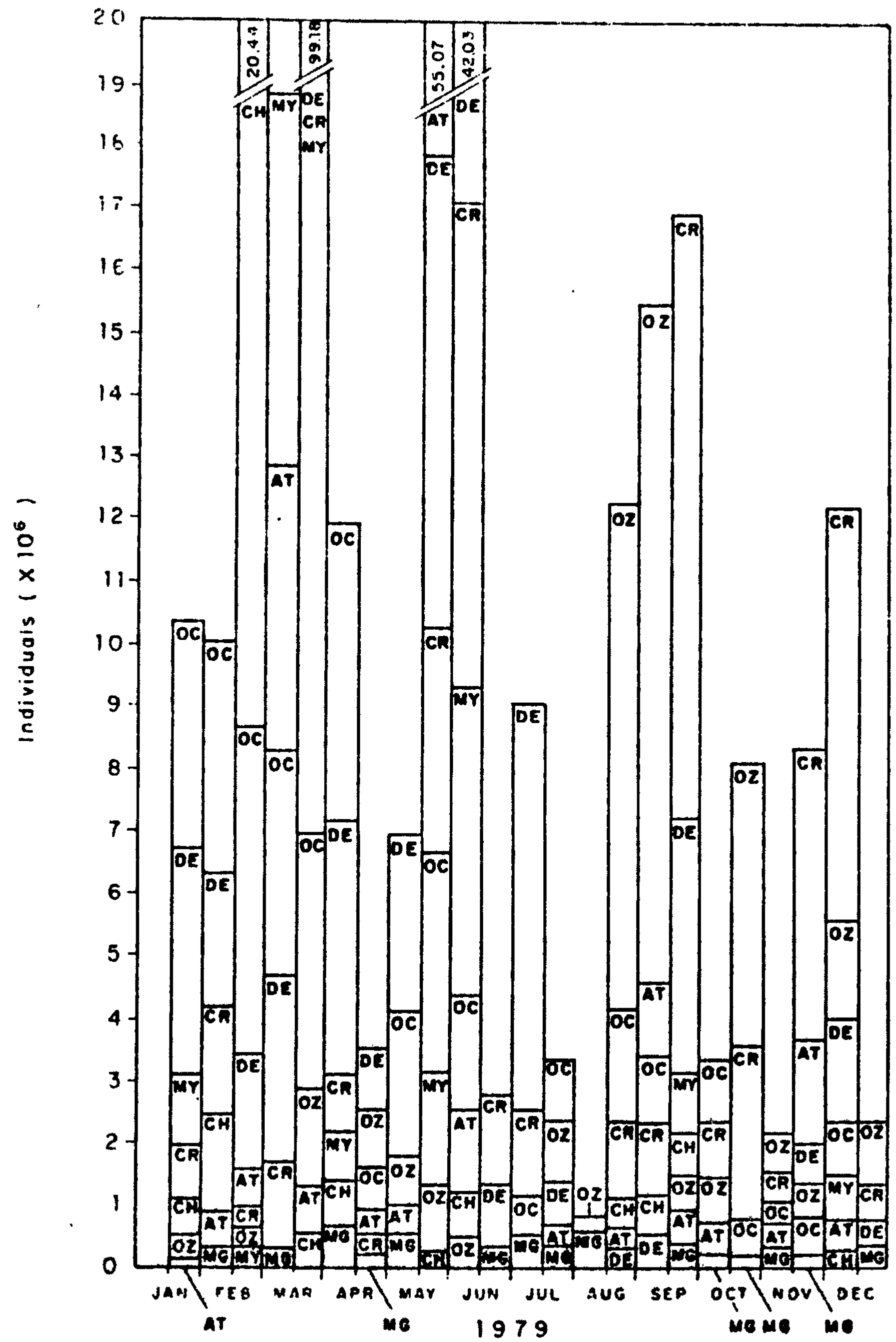
Offshore zooplankton abundance - 335μ data

Encina Power Plant - August 1, 1980

PREPARED BY: WOODWARD-CLYDE CONSULTANTS

FIGURE NO. 6.4-4

000432



AT	*Acartia tonsa*
OC	Other Copepods
DE	Decapods
MY	Mysidacea
CR	Other Crustacea
CH	Chaetognaths
AG	All Groups
OZ	Other Zooplankton
MG	Miscellaneous Groups

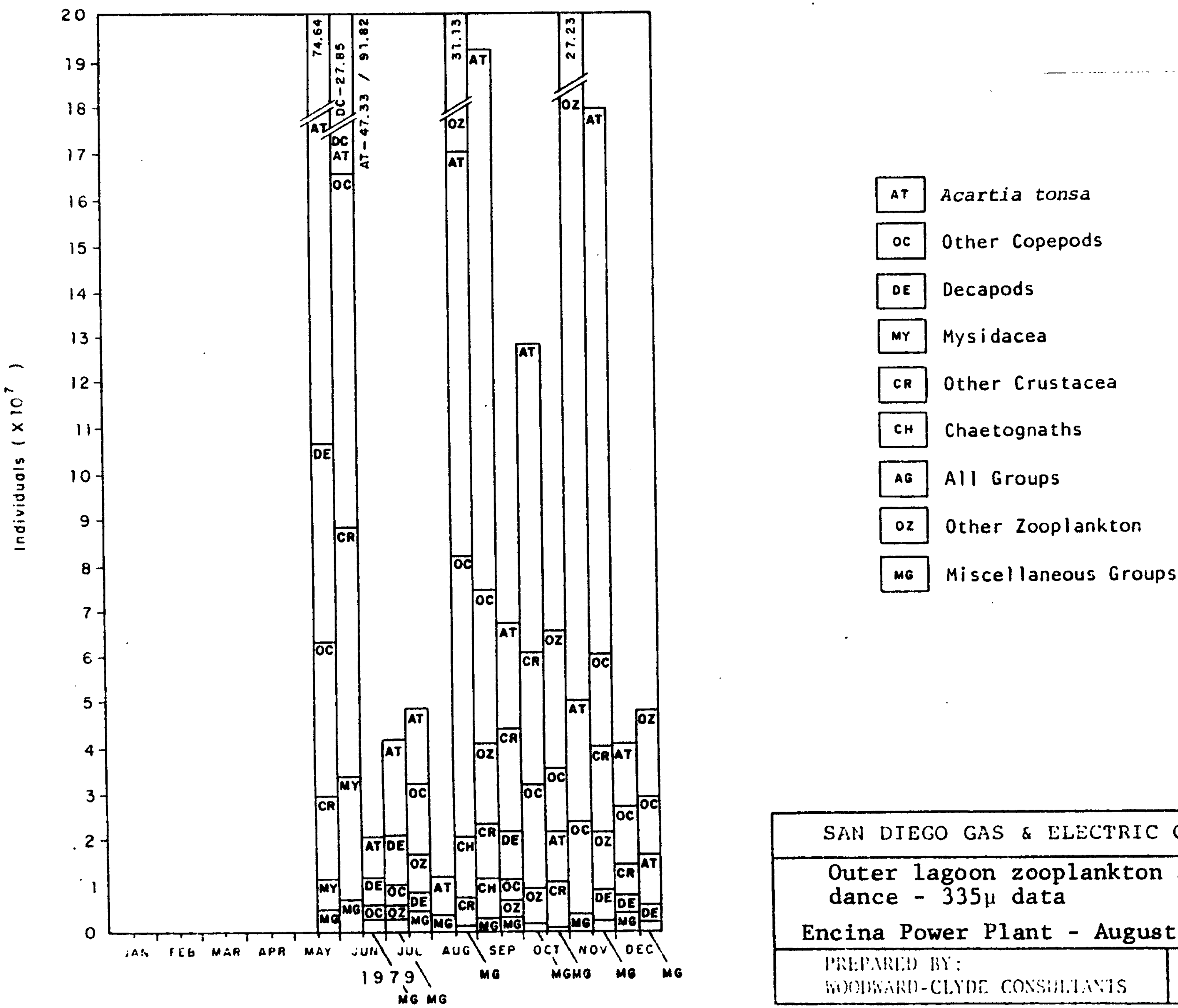
SAN DIEGO GAS & ELECTRIC COMPANY

Outer lagoon zooplankton abundance - 505μ data

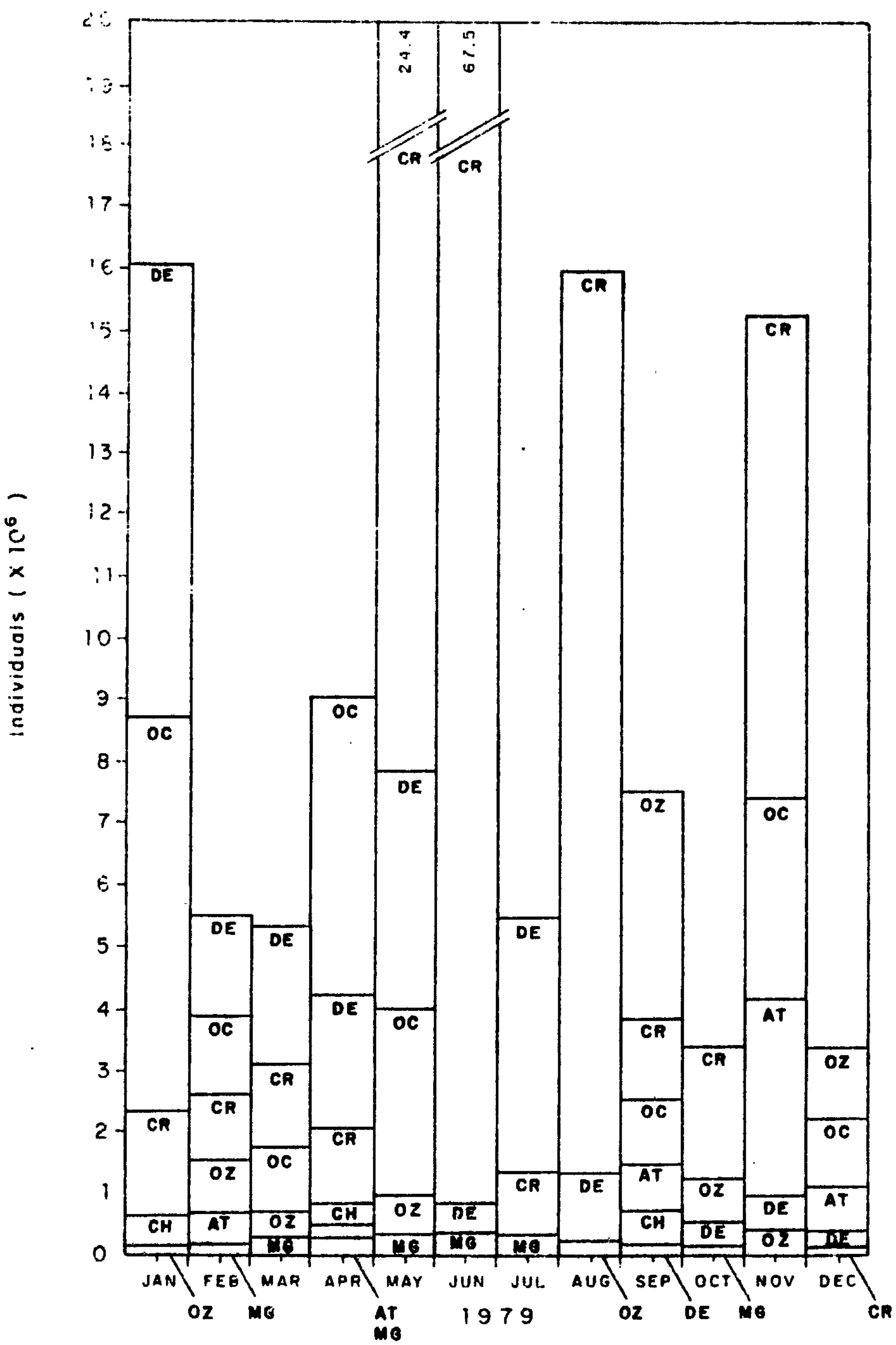
Encina Power Plant - August 1, 1980

PREPARED BY: WOODWARD-CLYDE CONSULTANTS

FIGURE NO. 6.4-5

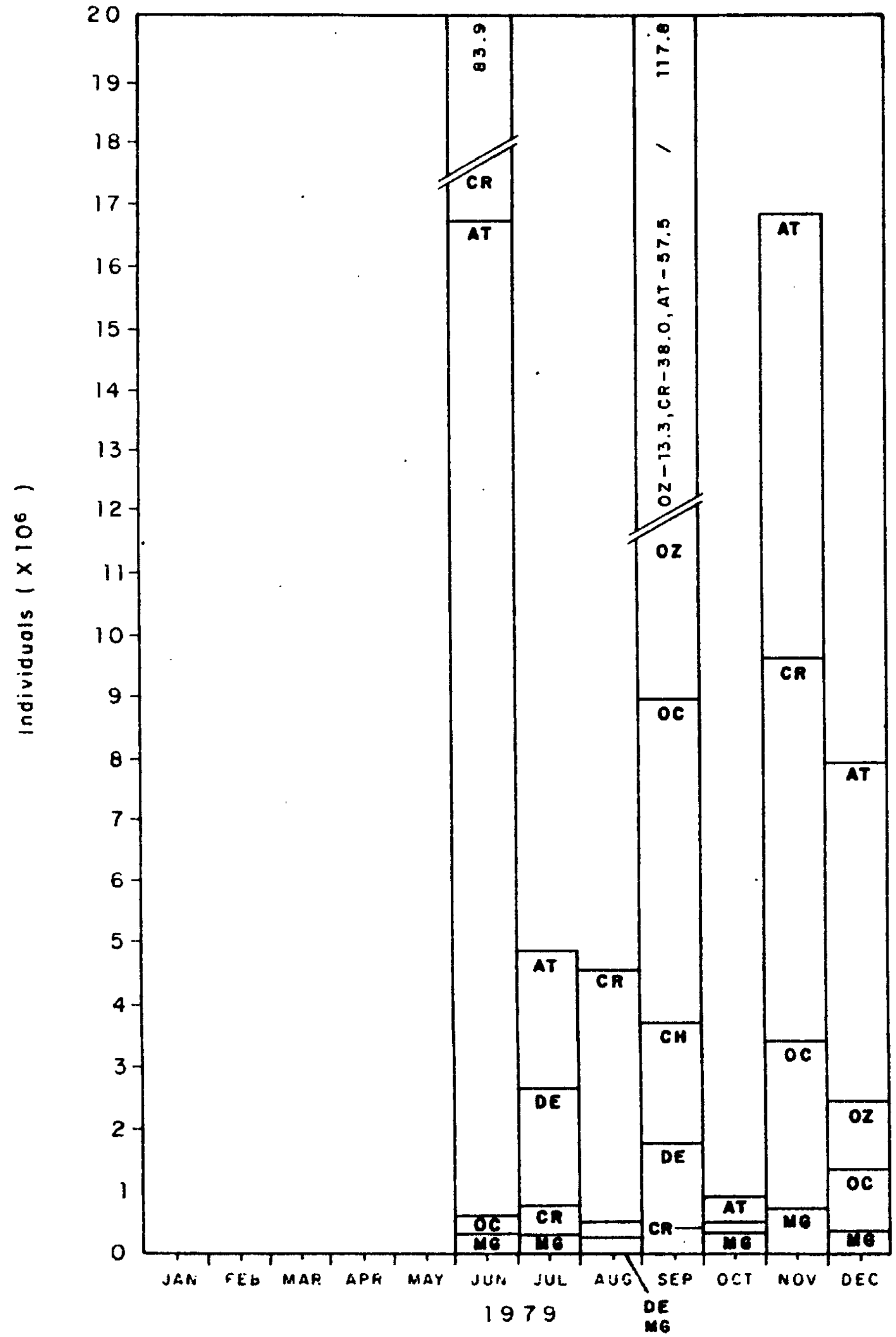


SAN DIEGO GAS & ELECTRIC COMPANY	
Outer lagoon zooplankton abundance - 335μ data Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.4-6



AT Acartia tonsa
OC Other Copepods
DE Decapods
MY Mysidacea
CR Other Crustacea
CH Chaetognaths
AG All Groups
OZ Other Zooplankton
MG Miscellaneous Groups

SAN DIEGO GAS & ELECTRIC COMPANY	
Middle lagoon zooplankton abundance - 505μ data	
Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.4-7



AT	*Acartia tonsa*
OC	Other Copepods
DE	Decapods
MY	Mysidacea
CR	Other Crustacea
CH	Chaetognaths
AG	All Groups
OZ	Other Zooplankton
MG	Miscellaneous Groups

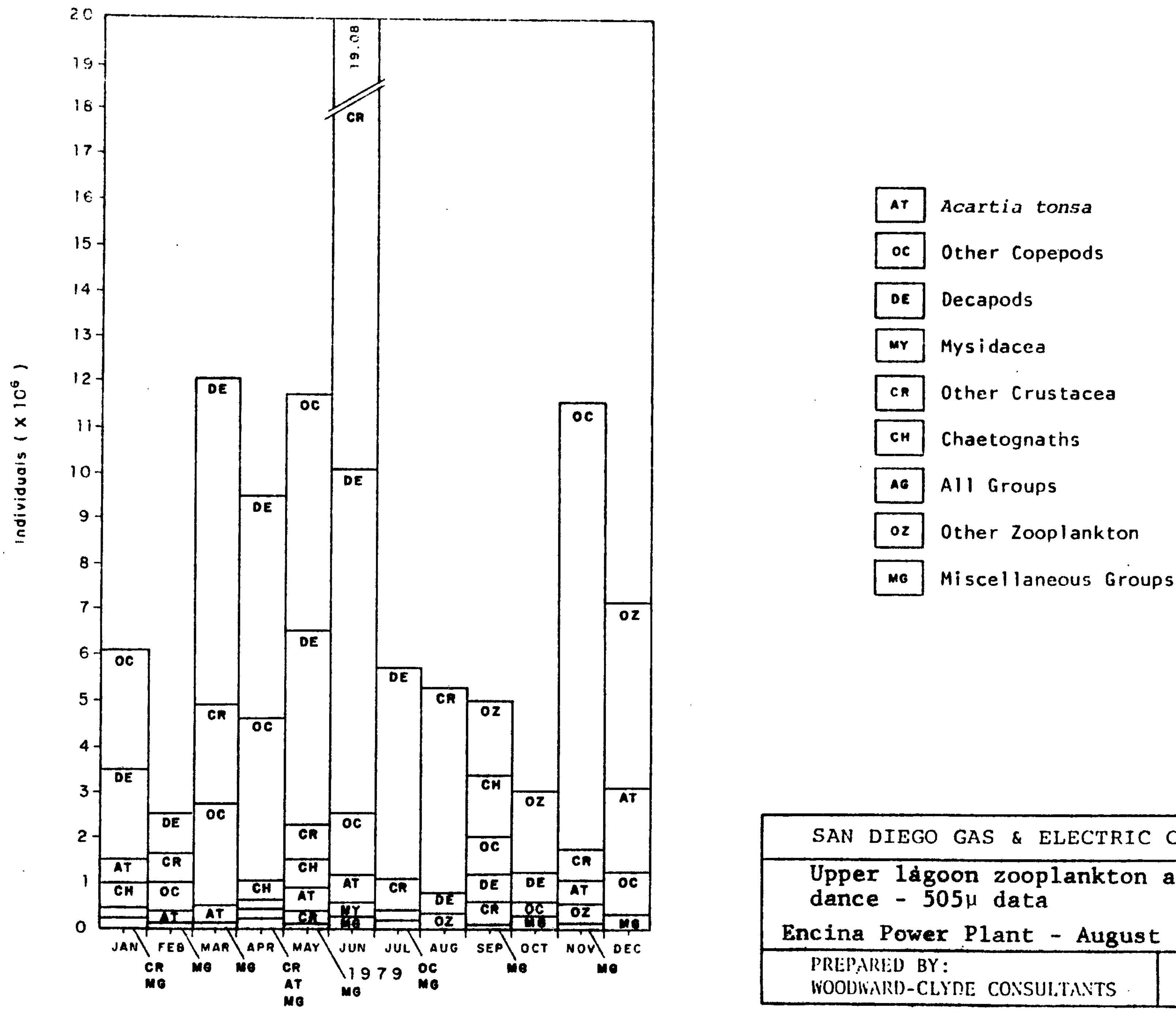
SAN DIEGO GAS & ELECTRIC COMPANY

Middle lagoon zooplankton abundance - 335µ data

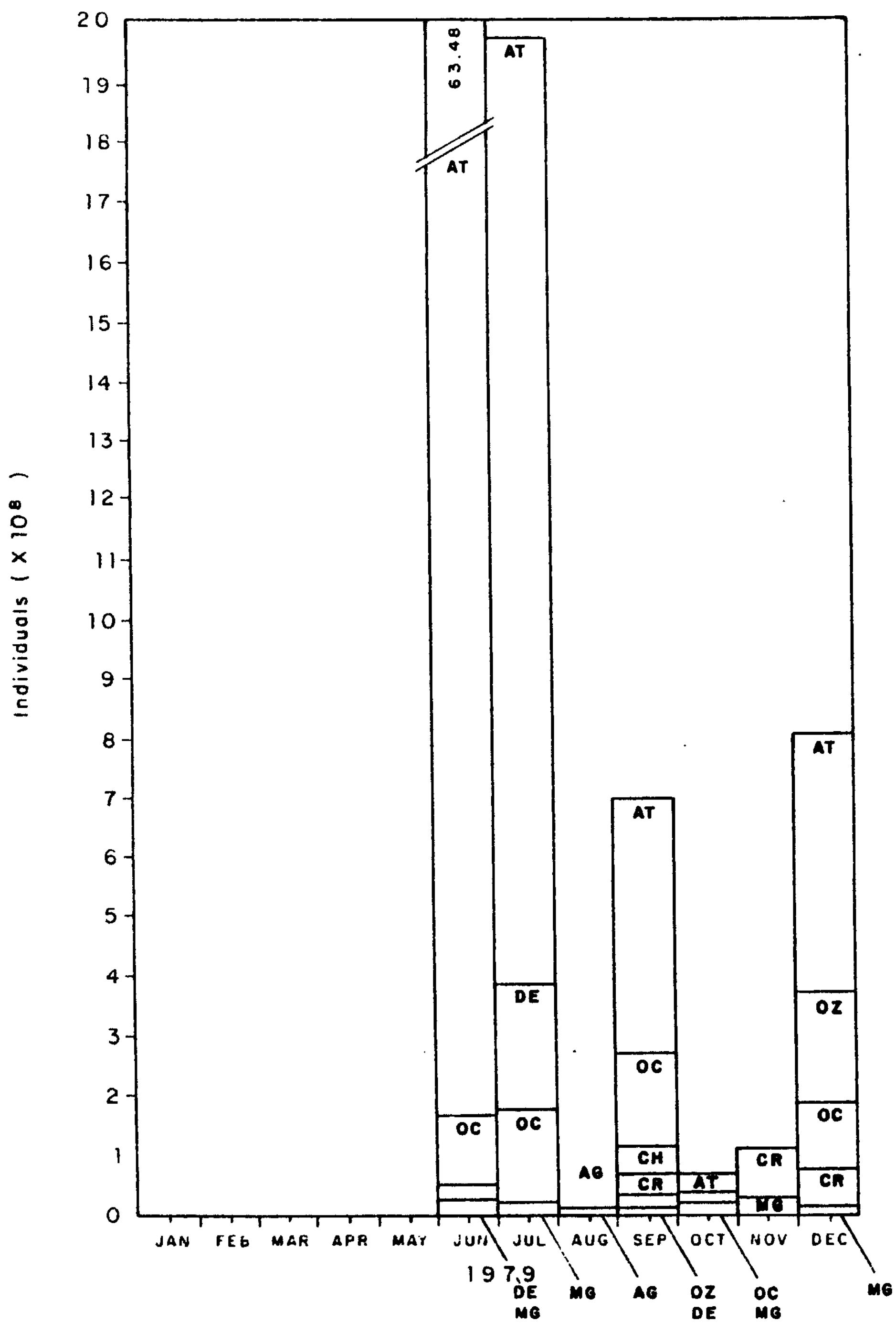
Encina Power Plant - August 1, 1980

PREPARED BY:
WOODWARD-CLYDE CONSULTANTS

FIGURE NO.
6.4-8



SAN DIEGO GAS & ELECTRIC COMPANY	
Upper lagoon zooplankton abundance - 505μ data	
Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.4-9



AT Acartia tonsa
OC Other Copepods
DE Decapods
MY Mysidacea
CR Other Crustacea
CH Chaetognaths
AG All Groups
OZ Other Zooplankton
MG Miscellaneous Groups

000438

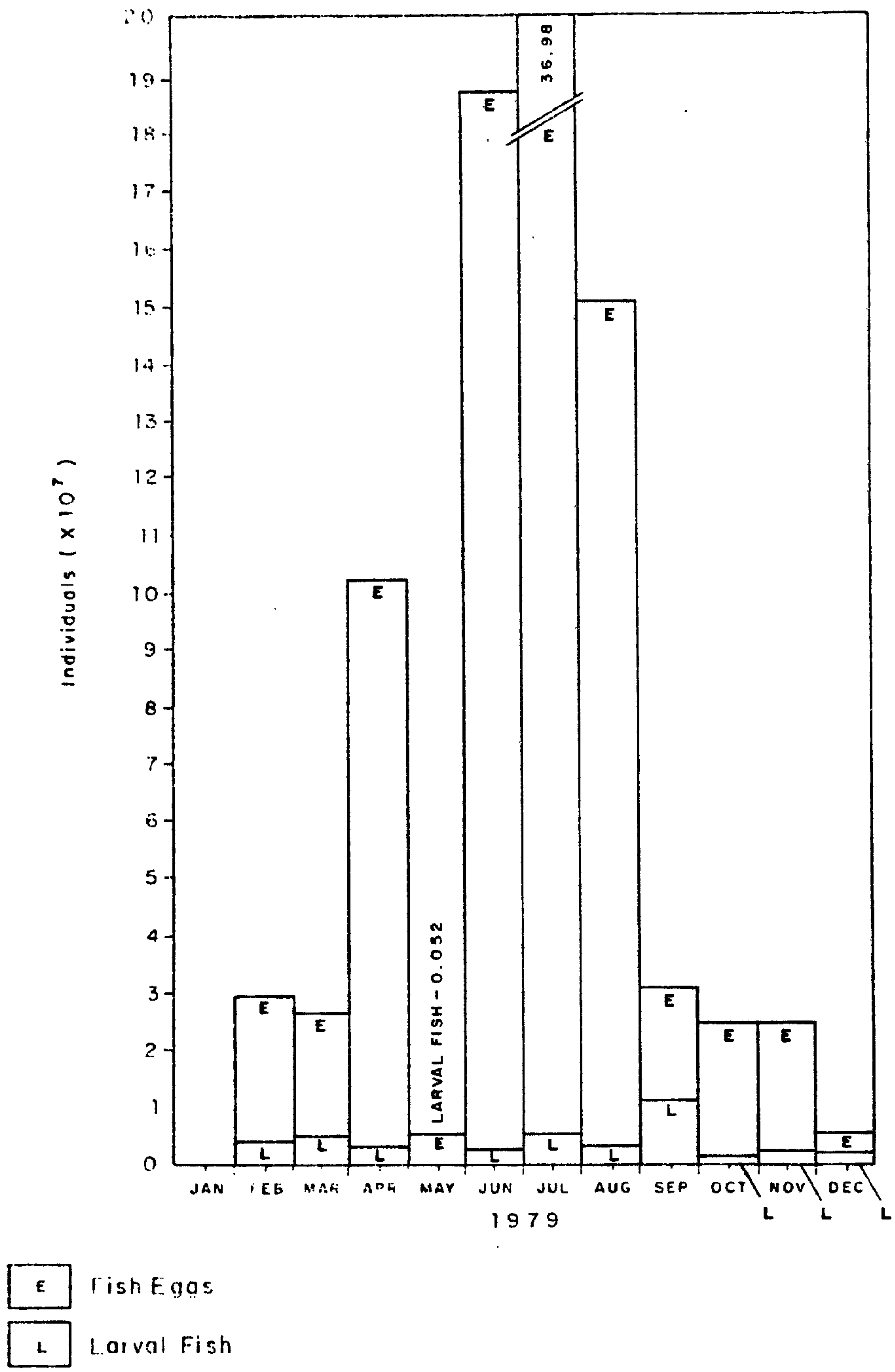
SAN DIEGO GAS & ELECTRIC COMPANY

Upper lagoon zooplankton abundance - 335μ data

Encina Power Plant - August 1, 1980

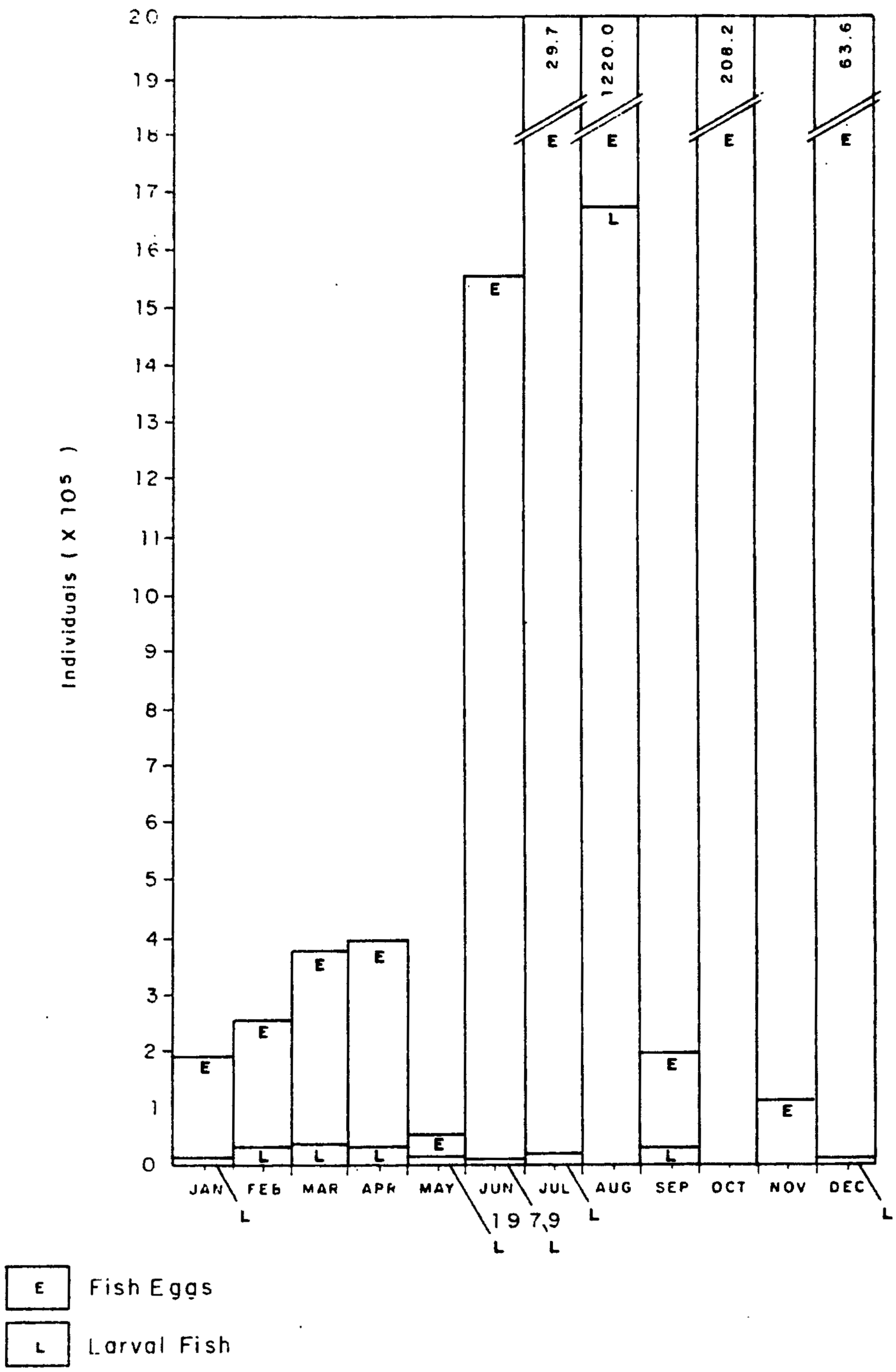
PREPARED BY:
WOODWARD-CLYDE CONSULTANTS

FIGURE NO.
6.4-10



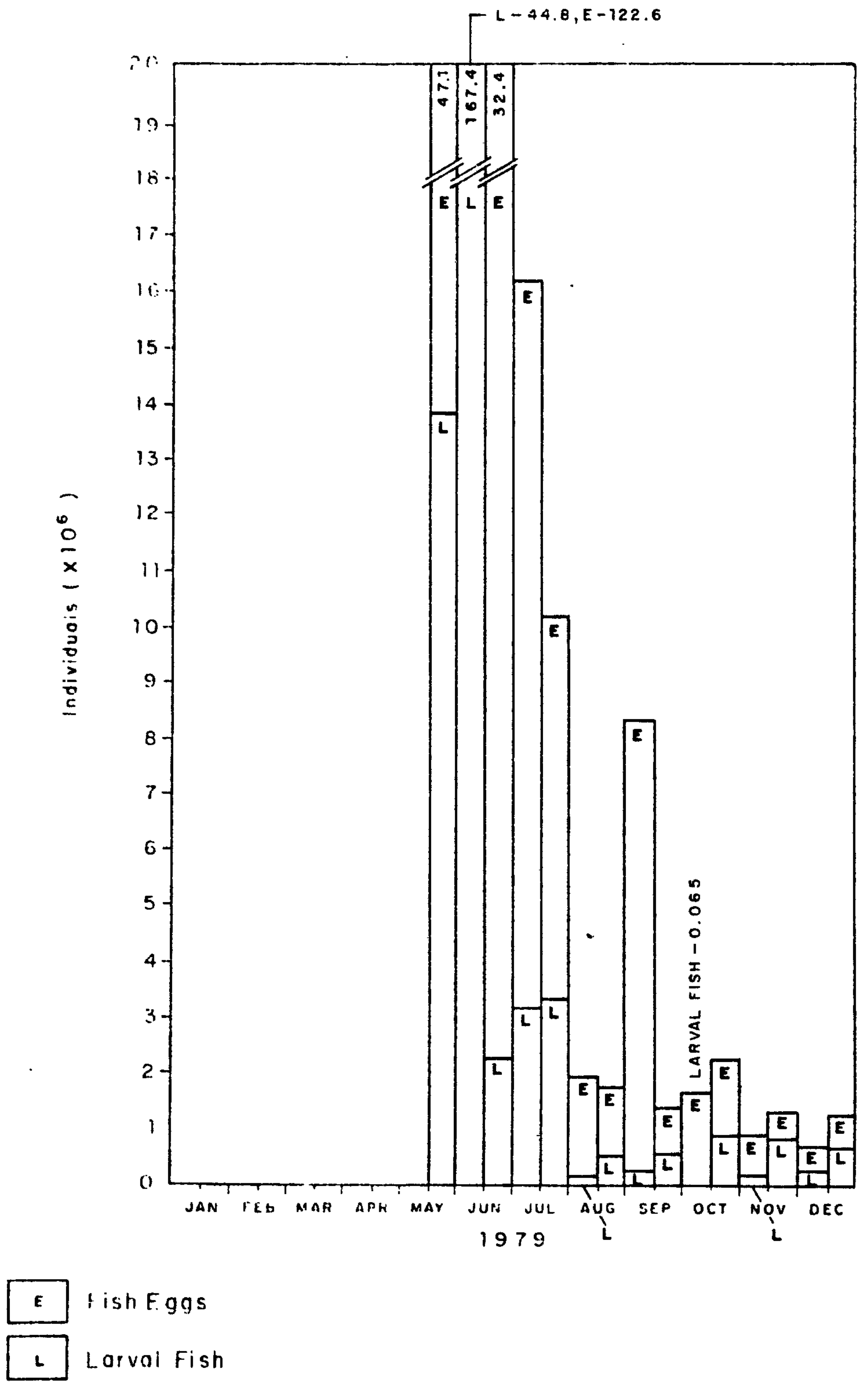
SAN DIEGO GAS & ELECTRIC COMPANY	
Offshore ichthyoplankton abundance - 335μ data Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.4-11

000439



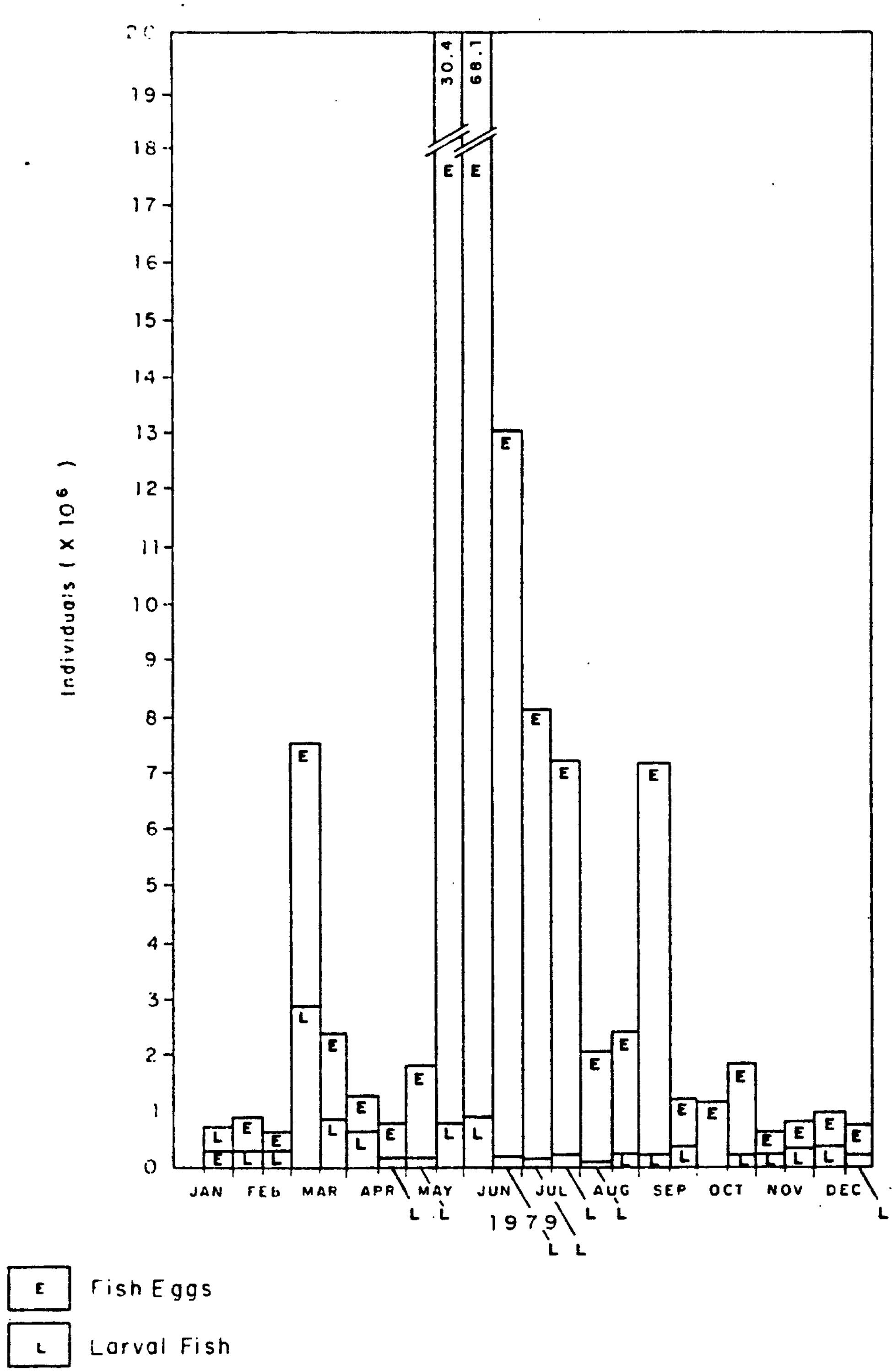
SAN DIEGO GAS & ELECTRIC COMPANY	
Offshore ichthyoplankton abundance - 505μ data Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.4-12

000440



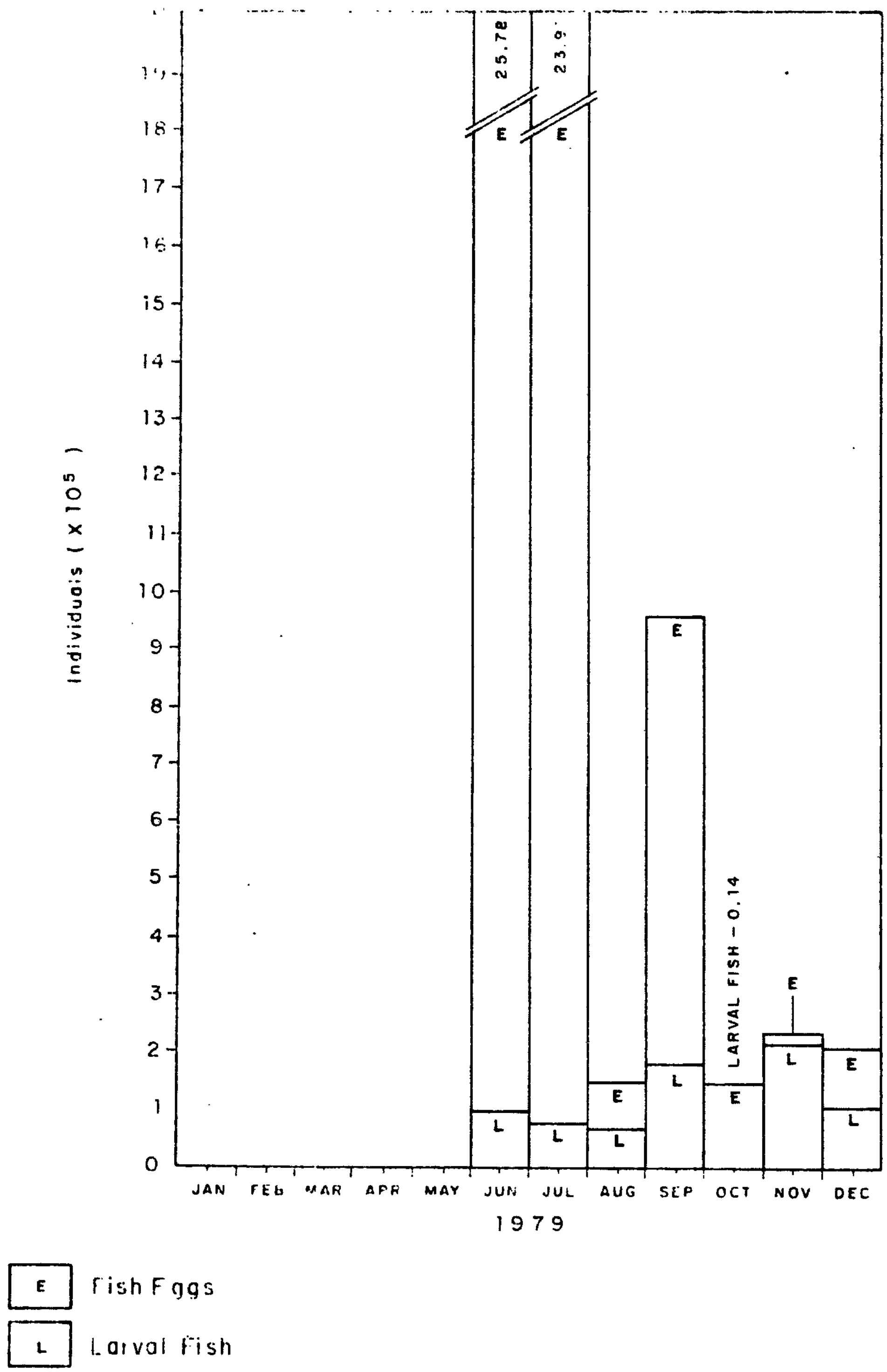
SAN DIEGO GAS & ELECTRIC COMPANY	
Outer lagoon ichthyoplankton abundance - 335μ data Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.4-13

000441



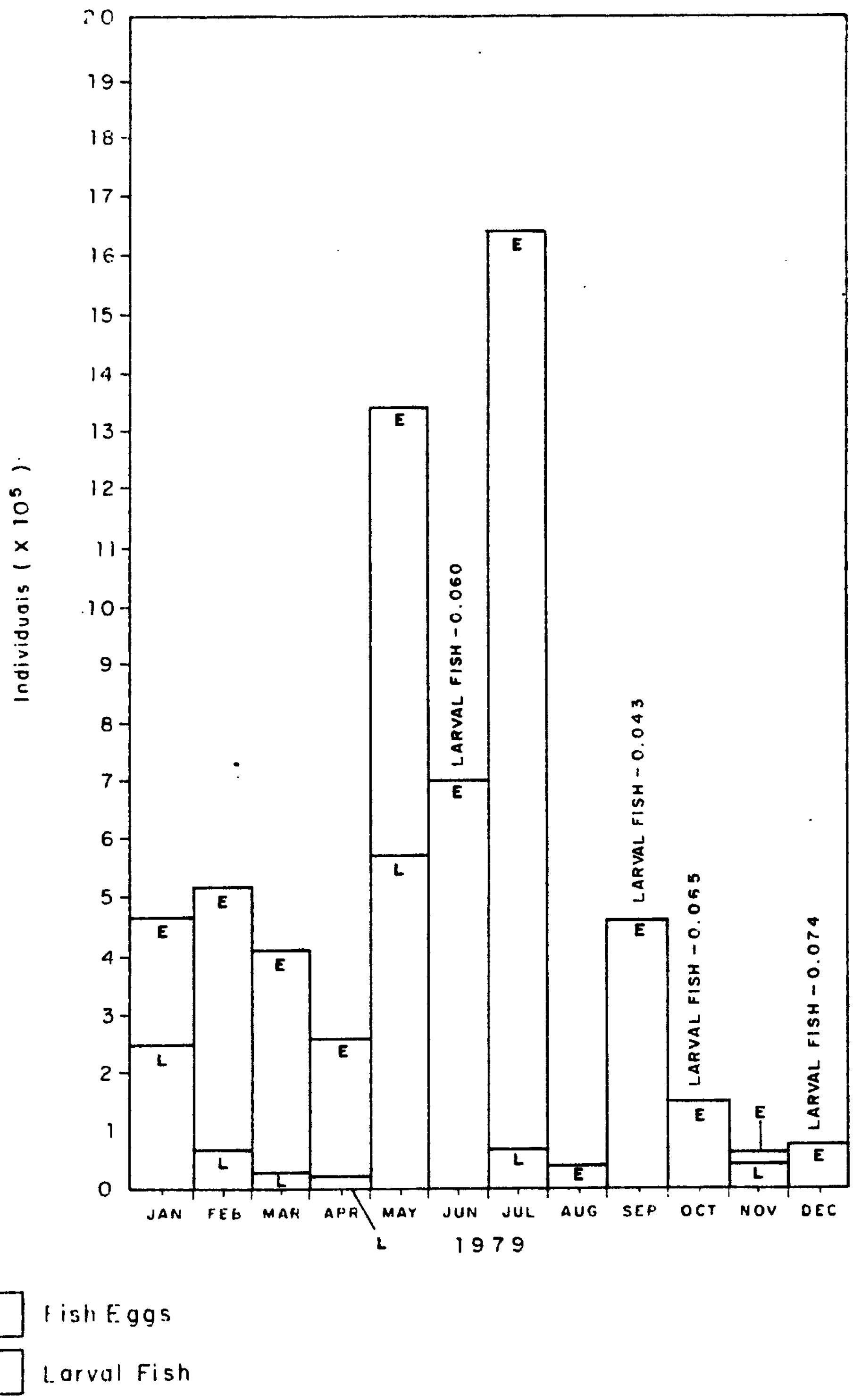
SAN DIEGO GAS & ELECTRIC COMPANY	
Outer lagoon ichthyoplankton abundance - 505μ data Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.4-14

000442



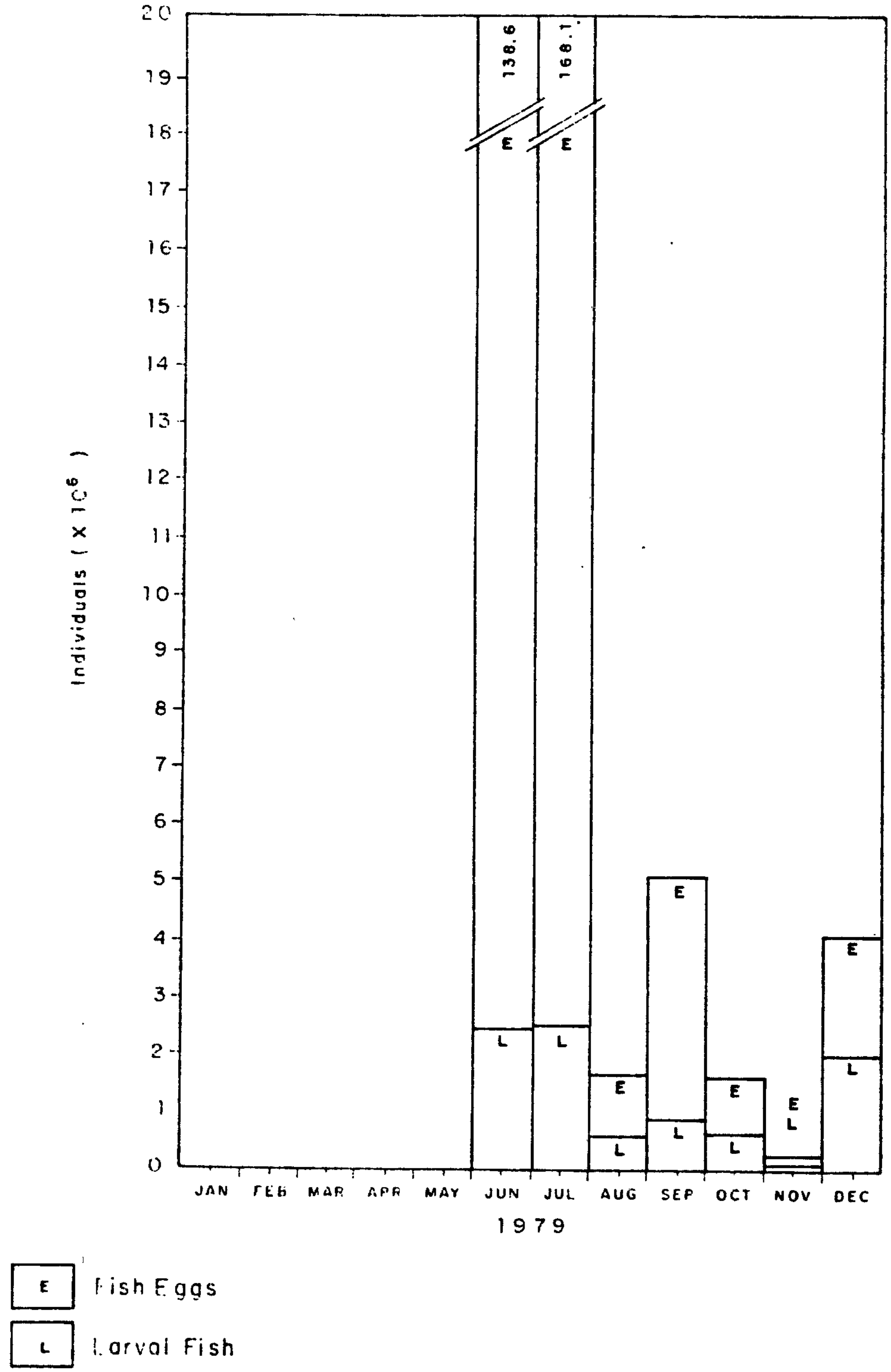
SAN DIEGO GAS & ELECTRIC COMPANY	
Middle lagoon ichthyoplankton abundance - 335μ data Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.4-15

000443



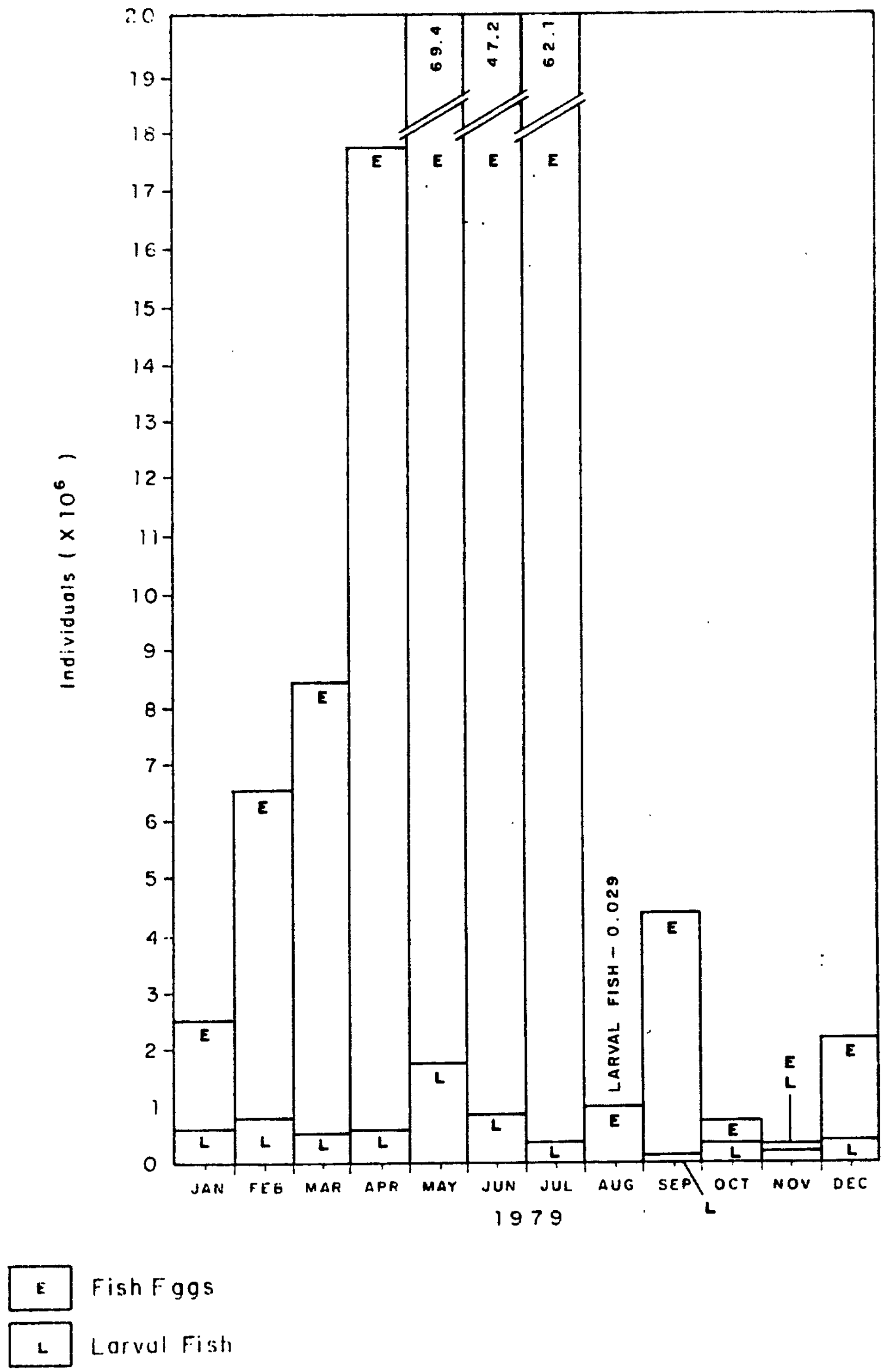
SAN DIEGO GAS & ELECTRIC COMPANY	
Middle lagoon ichthyoplankton abundance - 505μ data Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.4-16

000444



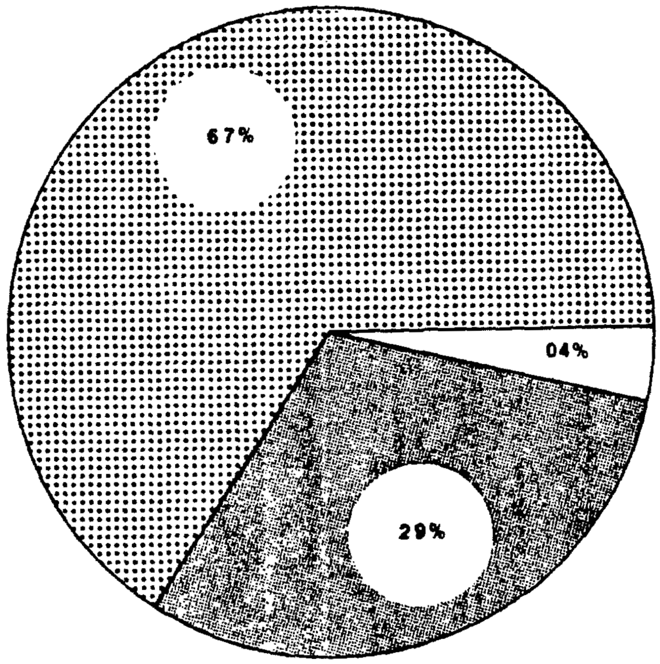
SAN DIEGO GAS & ELECTRIC COMPANY	
Upper lagoon ichthyoplankton abundance - 335 data Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.4-17

000445



SAN DIEGO GAS & ELECTRIC COMPANY	
Upper lagoon ichthyoplankton abundance - 505 data Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.4-18

000446



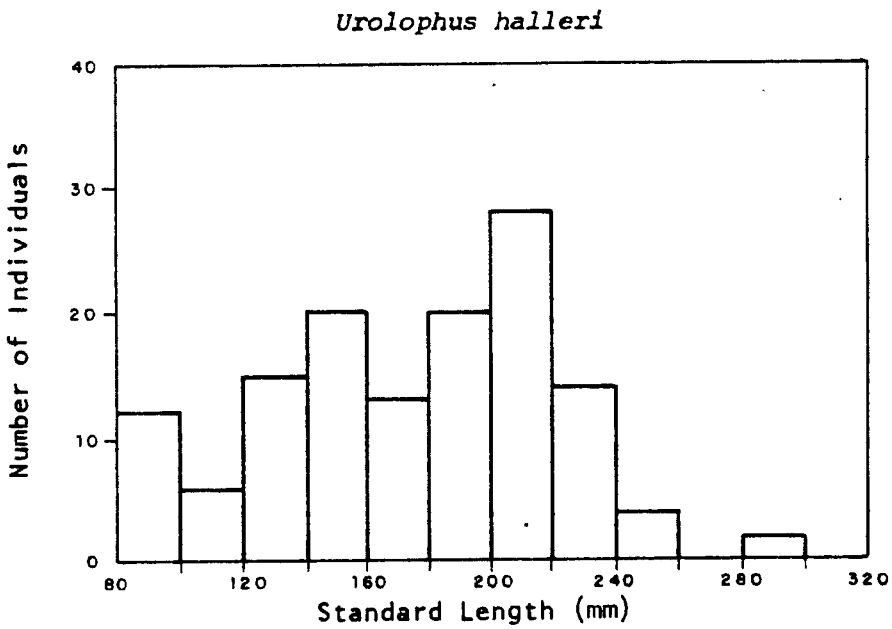
Additionally Treated As Critical Species (67 %)

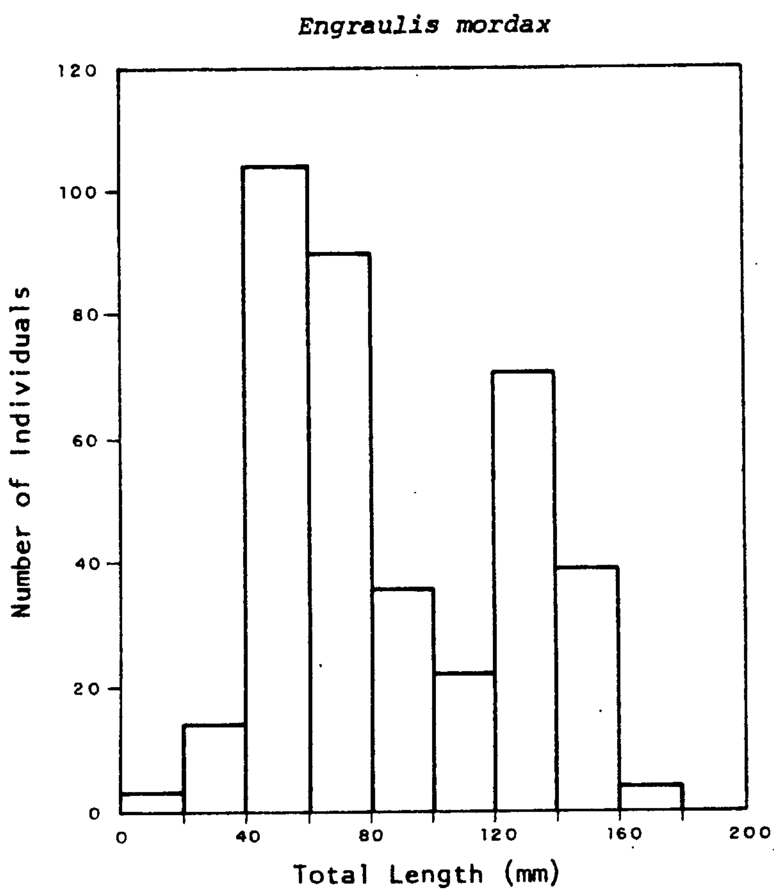
Original Critical Species (29 %)

Non-Critical Species (04 %)

000447

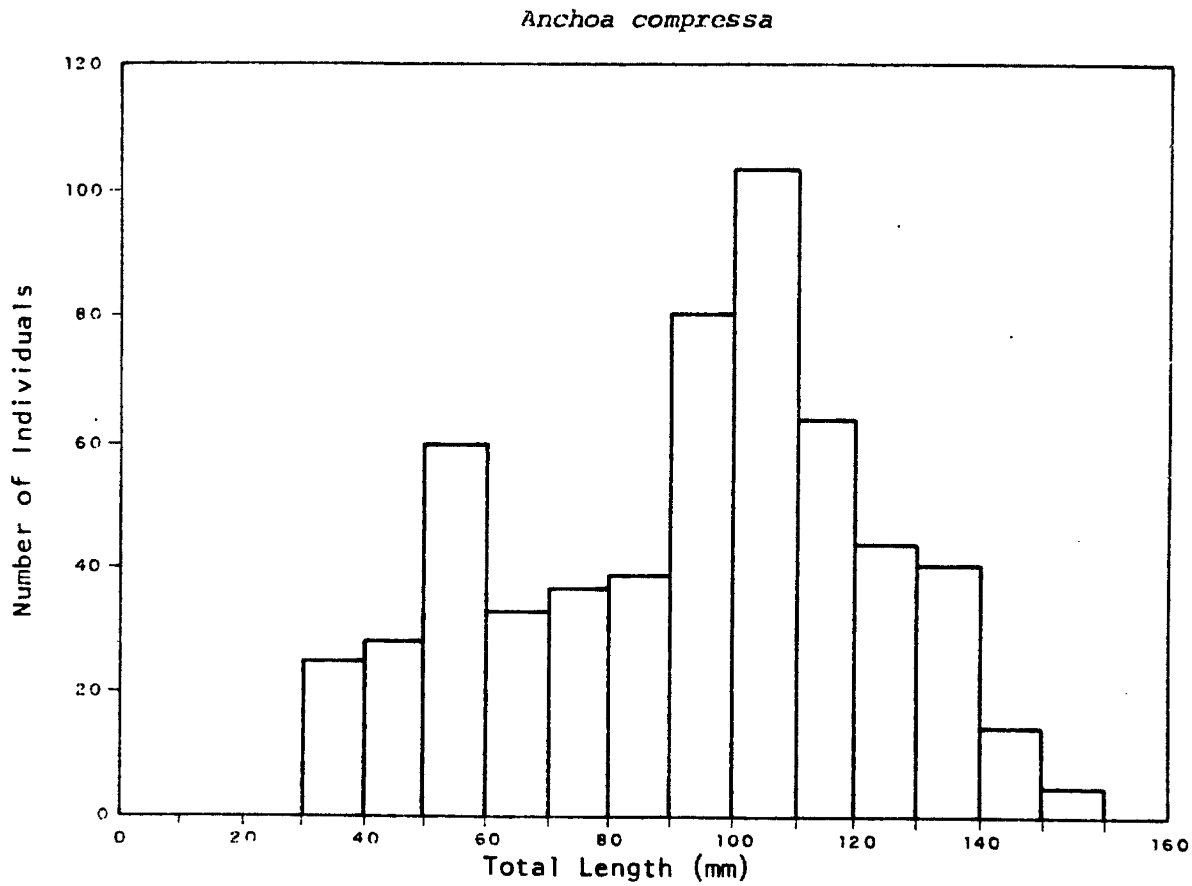
SAN DIEGO GAS & ELECTRIC COMPANY	
Percentages of total nekton abundance contributed by designated species categories Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.5-1

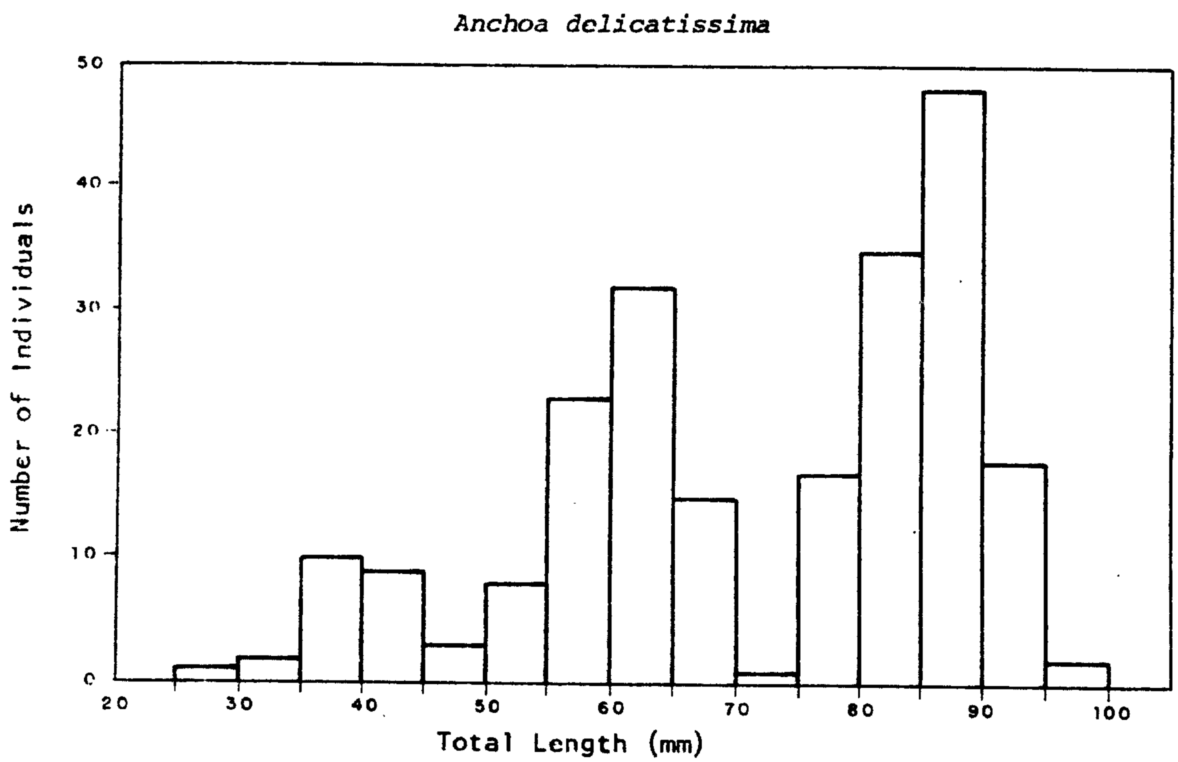




SAN DIEGO GAS & ELECTRIC COMPANY	
Length-frequencies for <u>Urolophus halleri</u> and <u>Engraulis mordax</u> Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.5-2

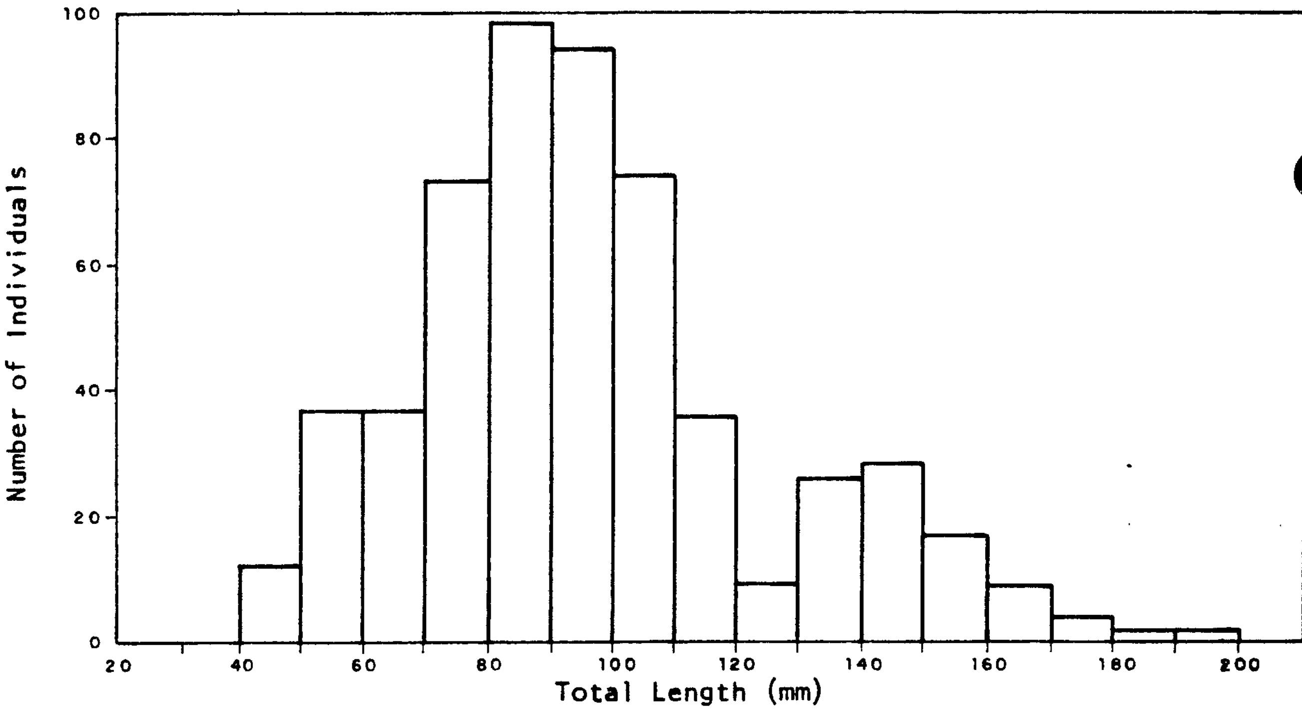
000448

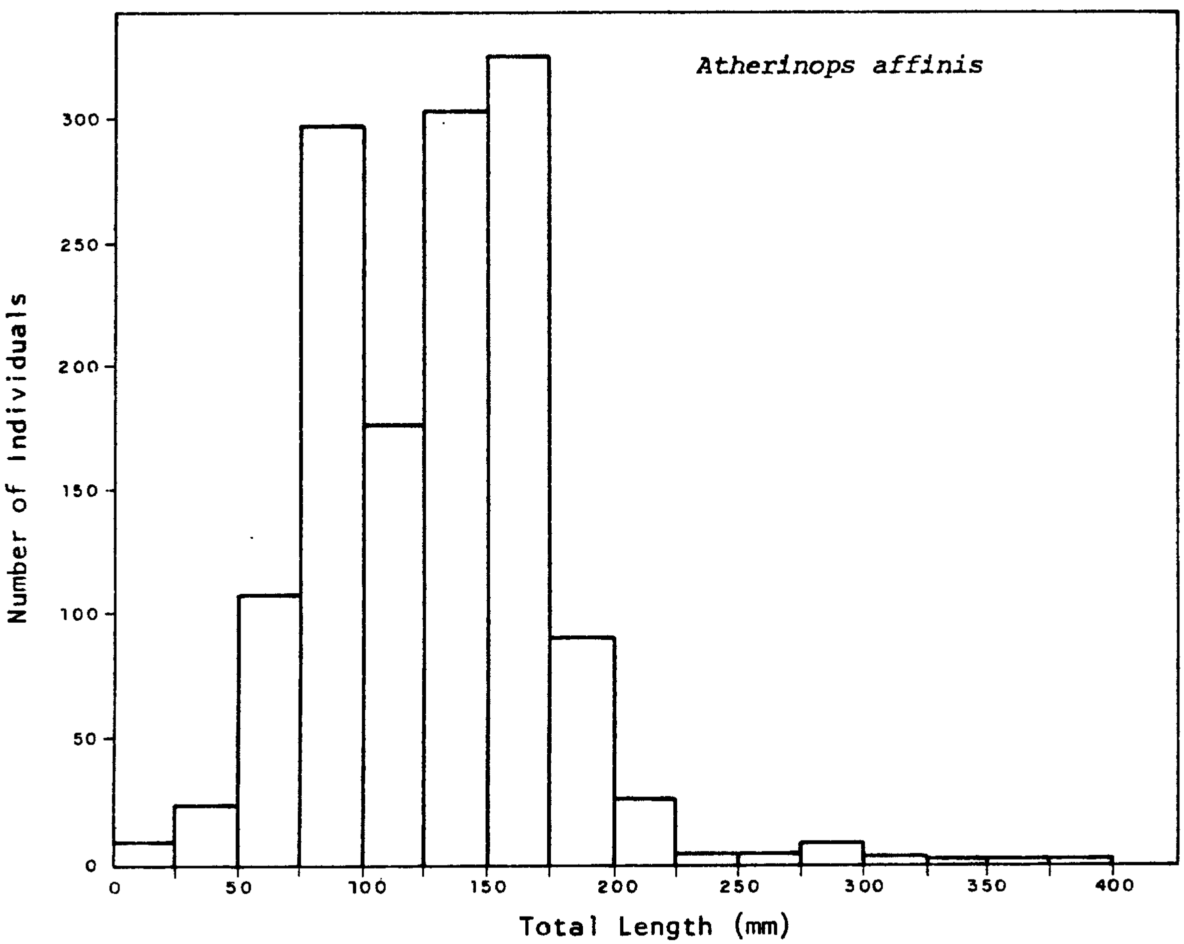




SAN DIEGO GAS & ELECTRIC COMPANY	
Length-frequencies for Anchoa compressa and Anchoa delicatissima Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.5-3

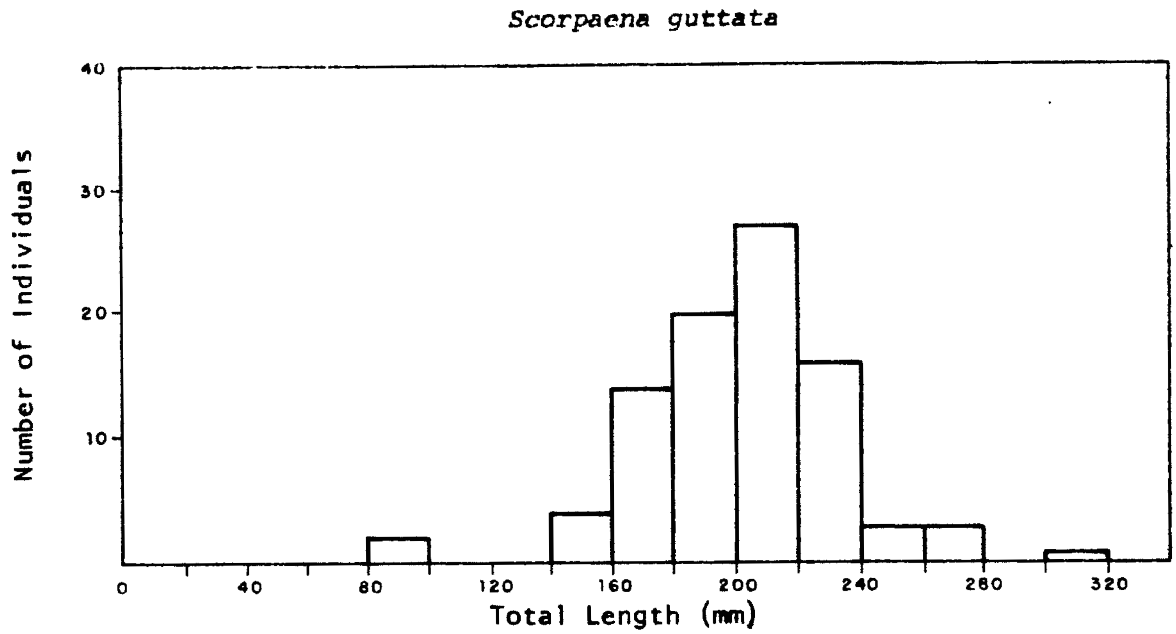
000449

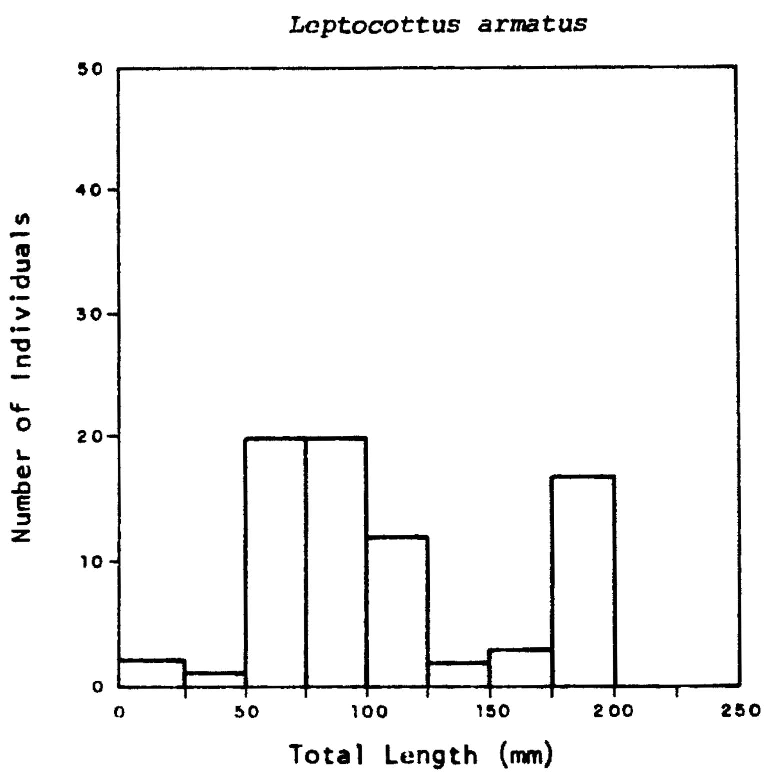




SAN DIEGO GAS & ELECTRIC COMPANY	
Length-frequencies for <u>Leuresthes tenuis</u> and <u>Atherinops affinis</u> Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.5-4

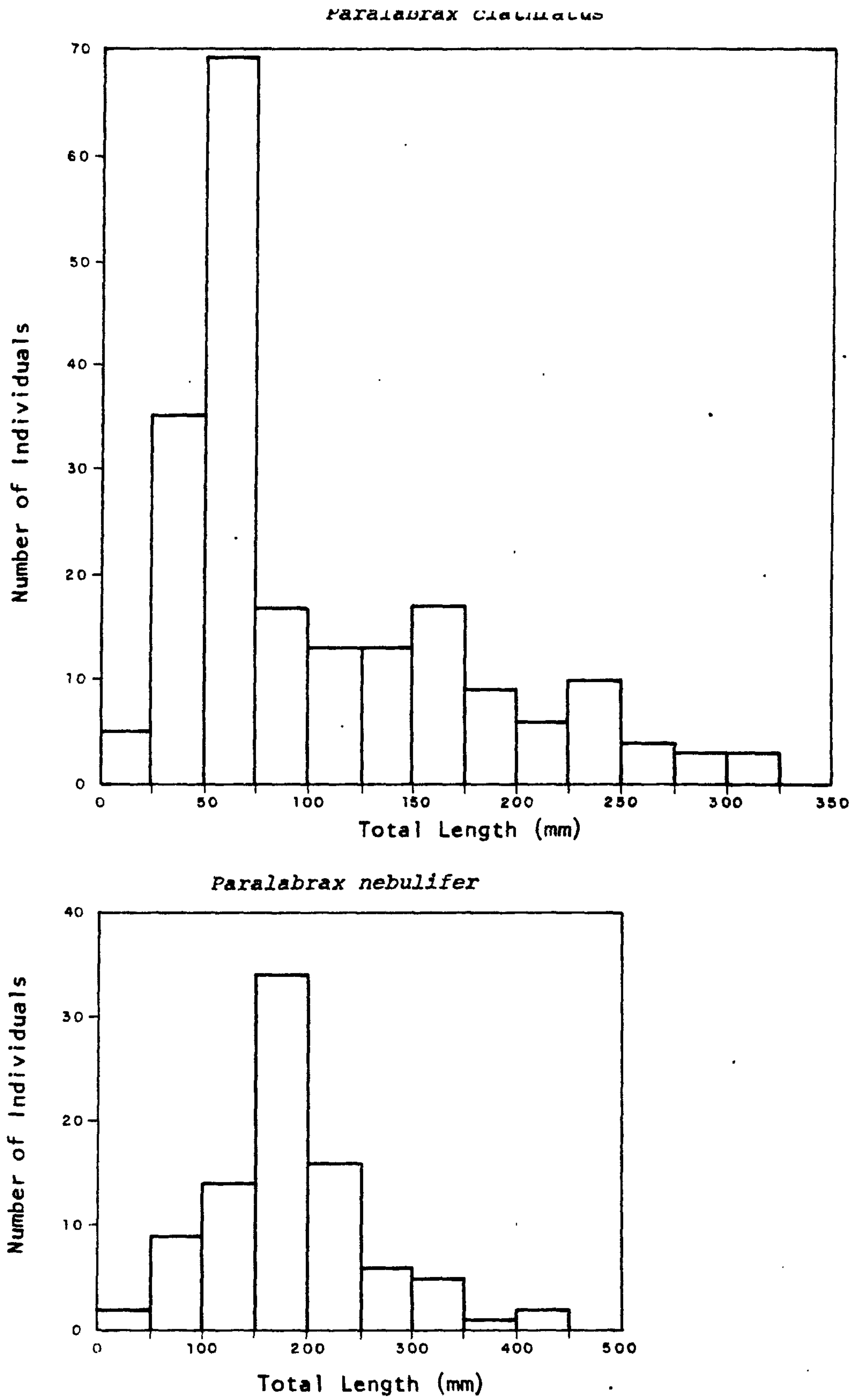
000450





SAN DIEGO GAS & ELECTRIC COMPANY	
Length-frequencies for Scorpaena guttata and Leptocottus armatus Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.5-5

000451



SAN DIEGO GAS & ELECTRIC COMPANY

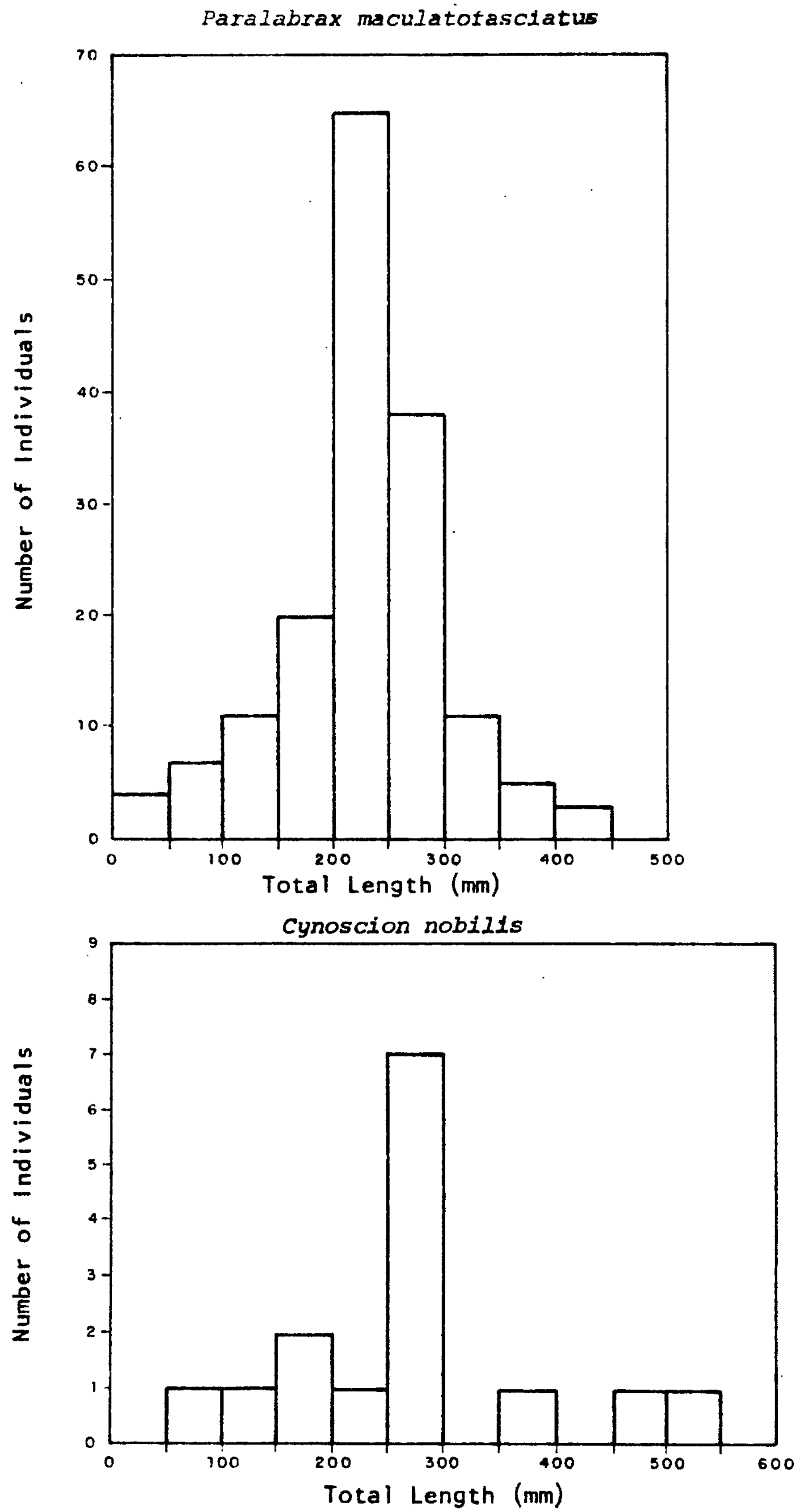
Length-frequencies for Paralabrax clathratus and Paralabrax nebulifer

Encina Power Plant - August 1, 1980

PREPARED BY: WOODWARD-CLYDE CONSULTANTS

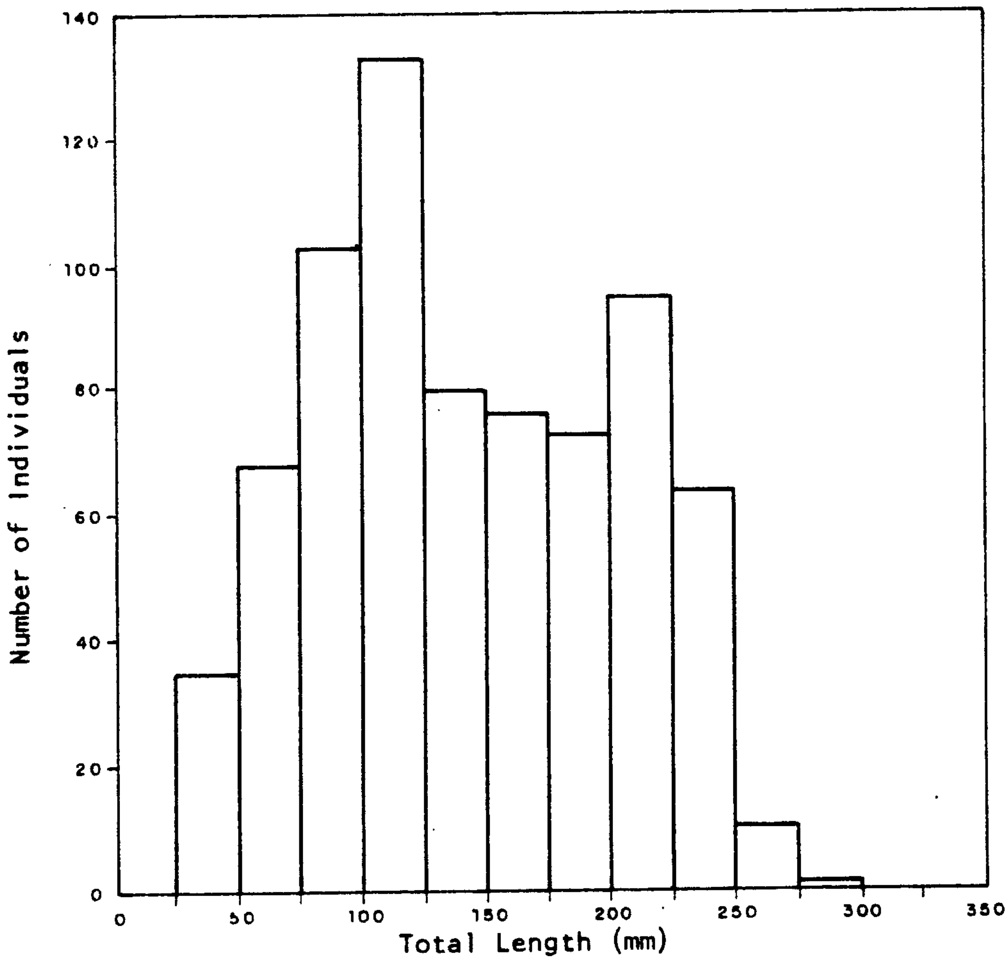
FIGURE NO. 6.5-6

000452

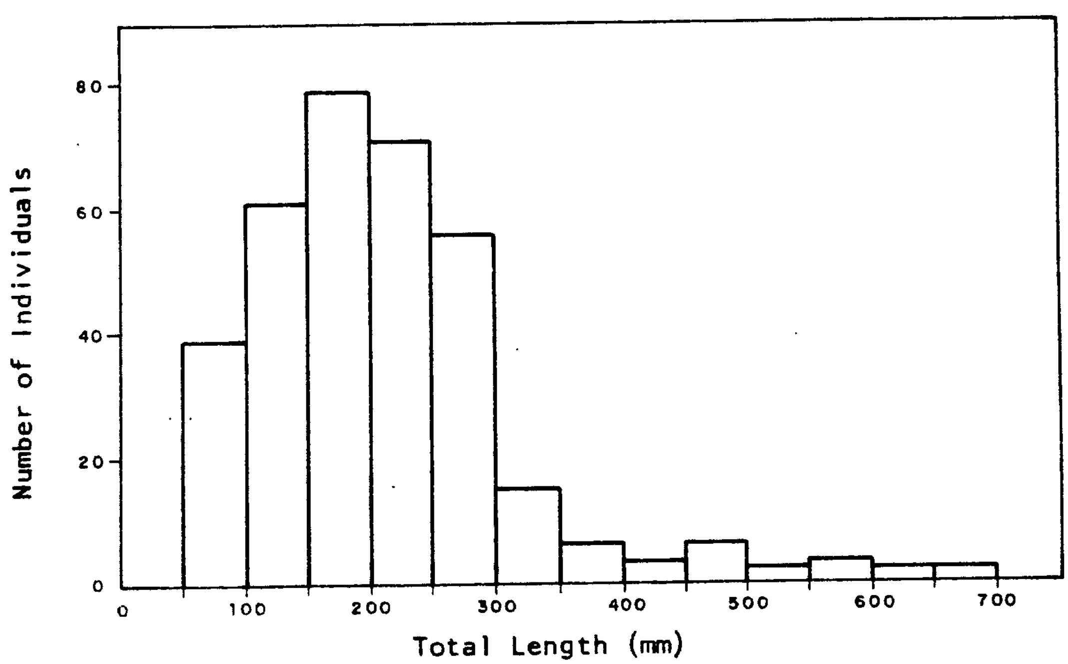


SAN DIEGO GAS & ELECTRIC COMPANY	
Length-frequencies for <u>Paralabrax maculatofasciatus</u> and <u>Cynoscion nobilis</u> Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.5-7

000453

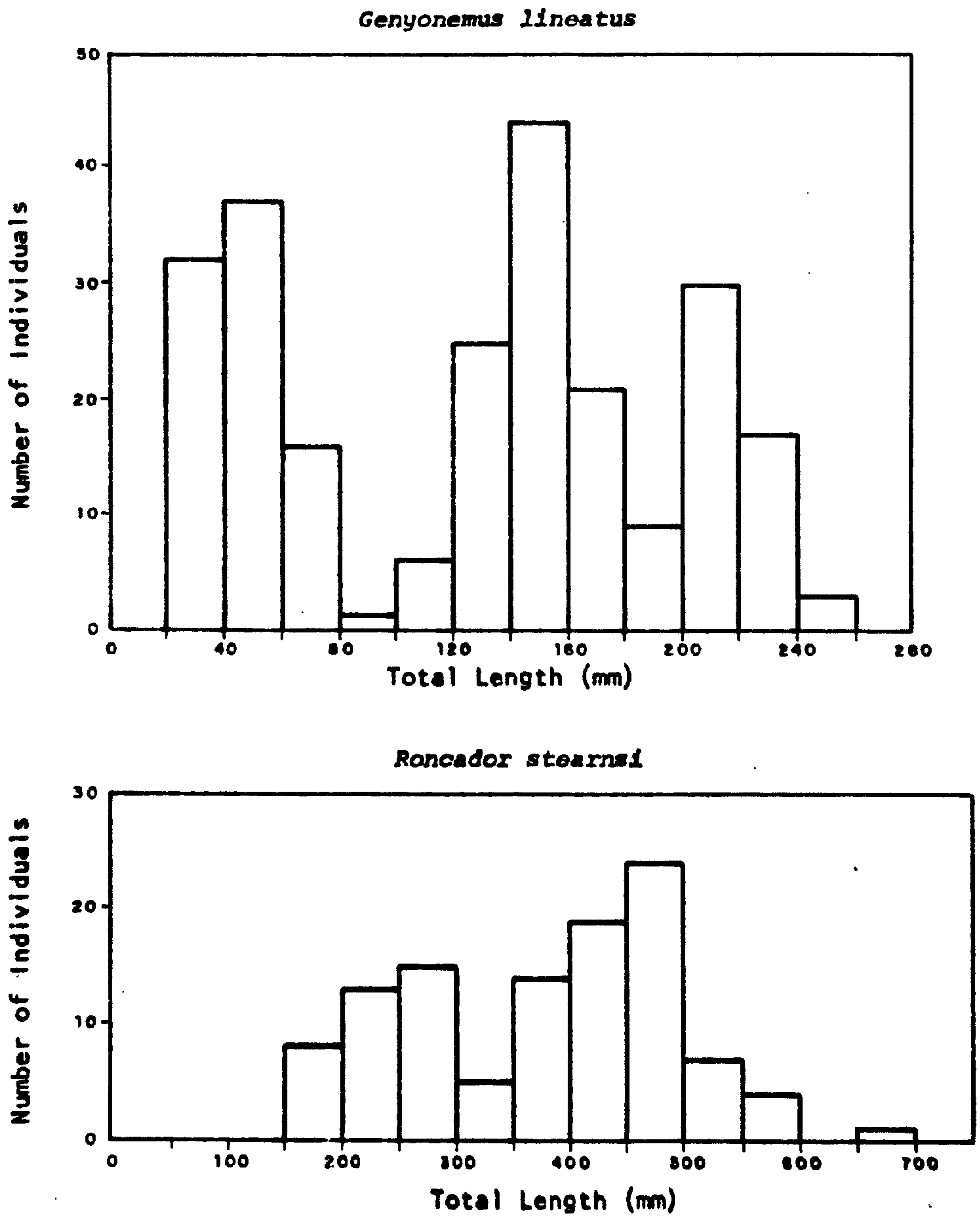


Menticirrhus undulatus

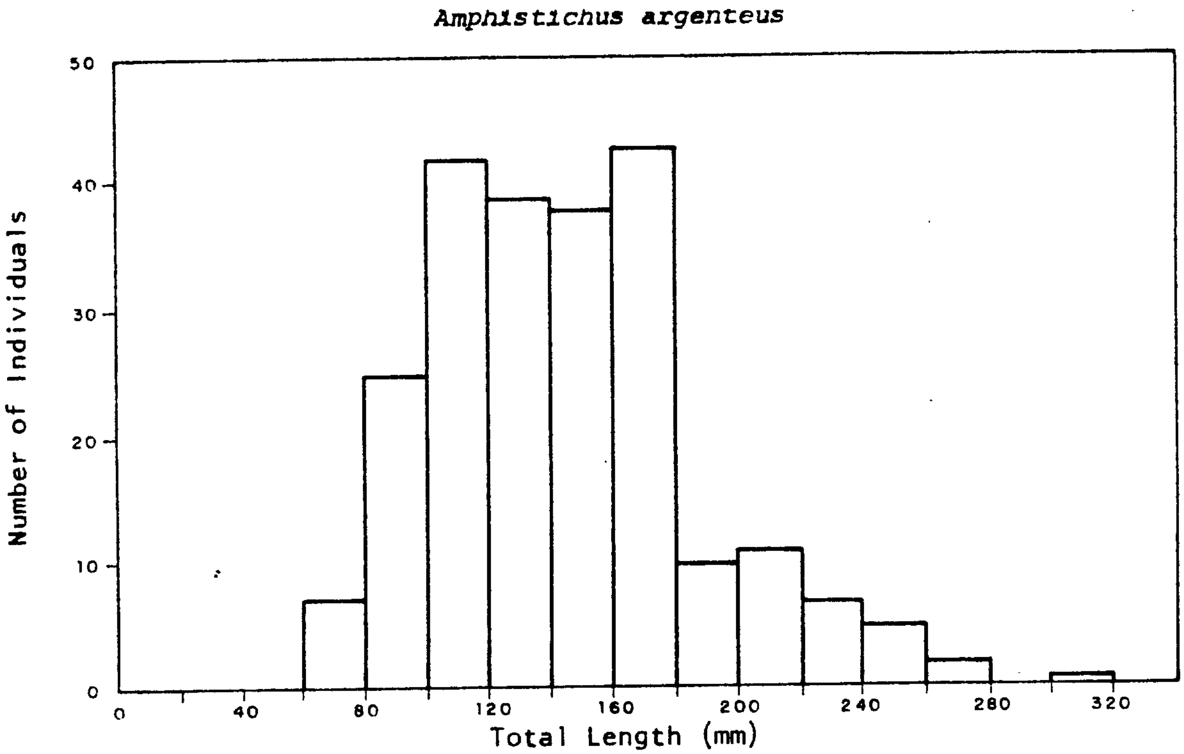


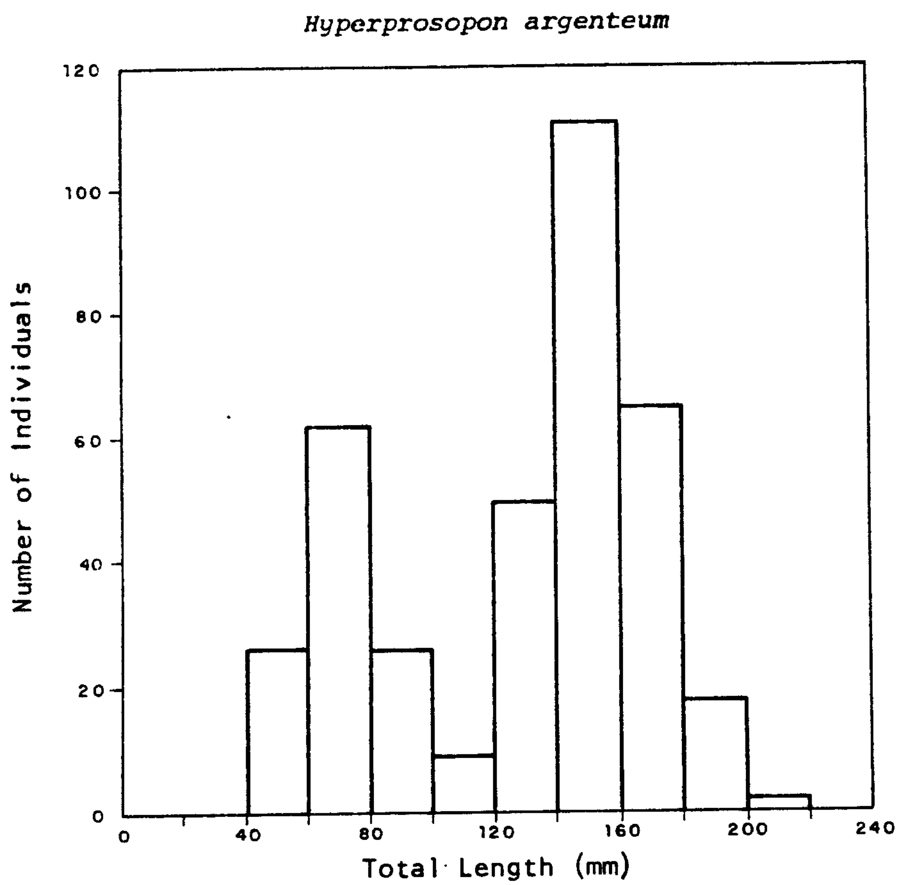
SAN DIEGO GAS & ELECTRIC COMPANY	
Length-frequencies for Seriphus p itus and Menticirrhus undulatus Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.5-8

000454



SAN DIEGO GAS & ELECTRIC COMPANY	
Length-frequencies for <u>Genyonemus lineatus</u> and <u>Roncador stearnsi</u> Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.5-9





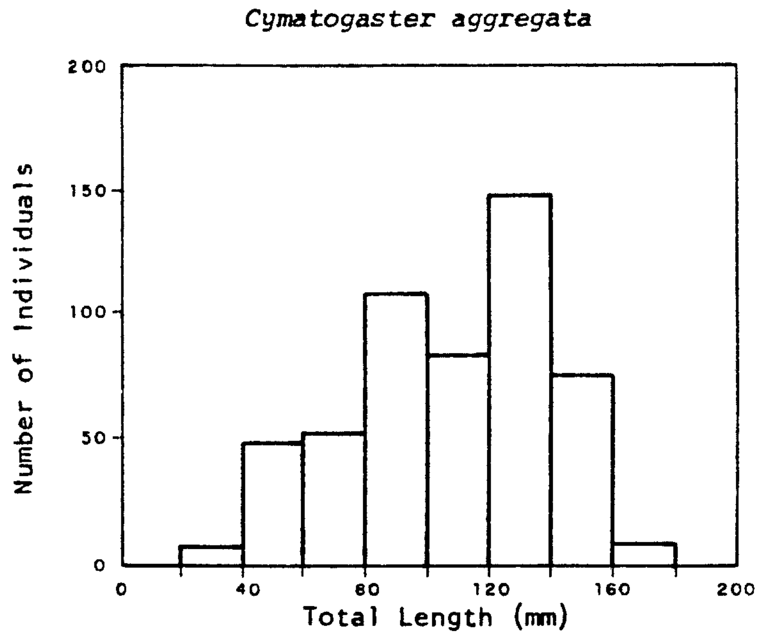
SAN DIEGO GAS & ELECTRIC COMPANY

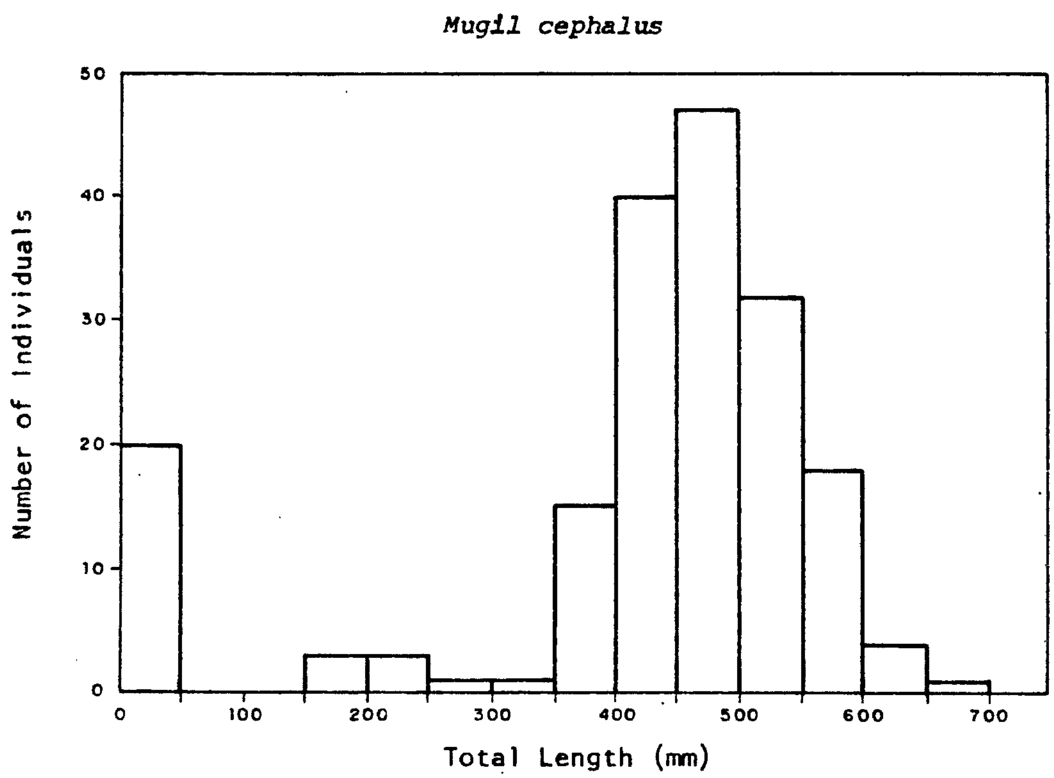
Length-frequencies for Amphistichu[illegible] argenteus and Hyperprosopon argent[illegible]

Encina Power Plant - August 1, 1980

PREPARED BY:
WOODWARD-CLYDE CONSULTANTS

FIGURE NO.
6.5-10





SAN DIEGO GAS & ELECTRIC COMPANY

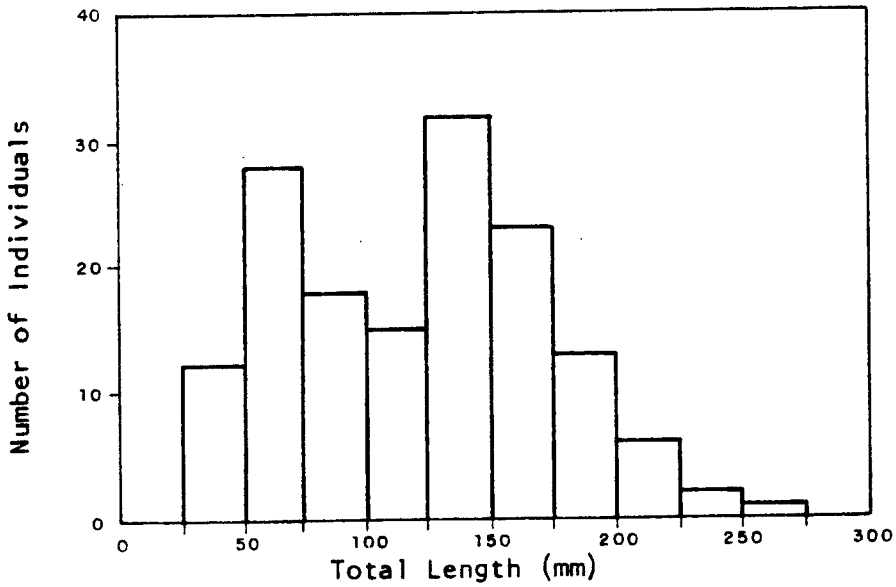
Length-frequencies for Cymatogaster aggregata and Mugil cephalus

Encina Power Plant - August 1, 1980

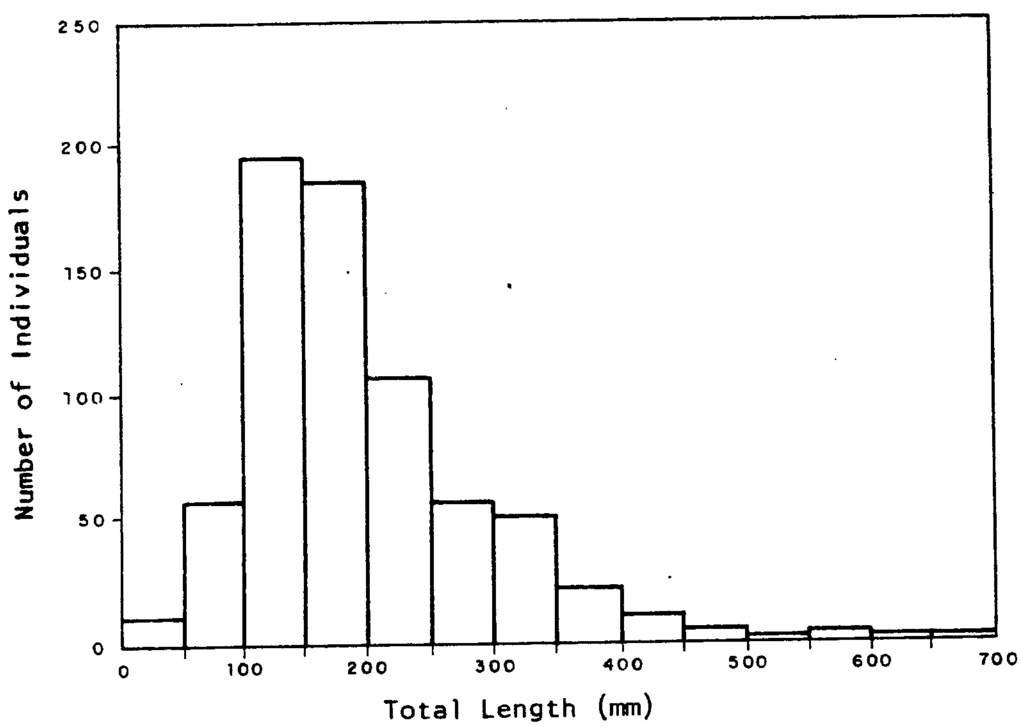
PREPARED BY: WOODWARD-CLYDE CONSULTANTS

FIGURE NO. 6.5-11

Heterostichus rostratus

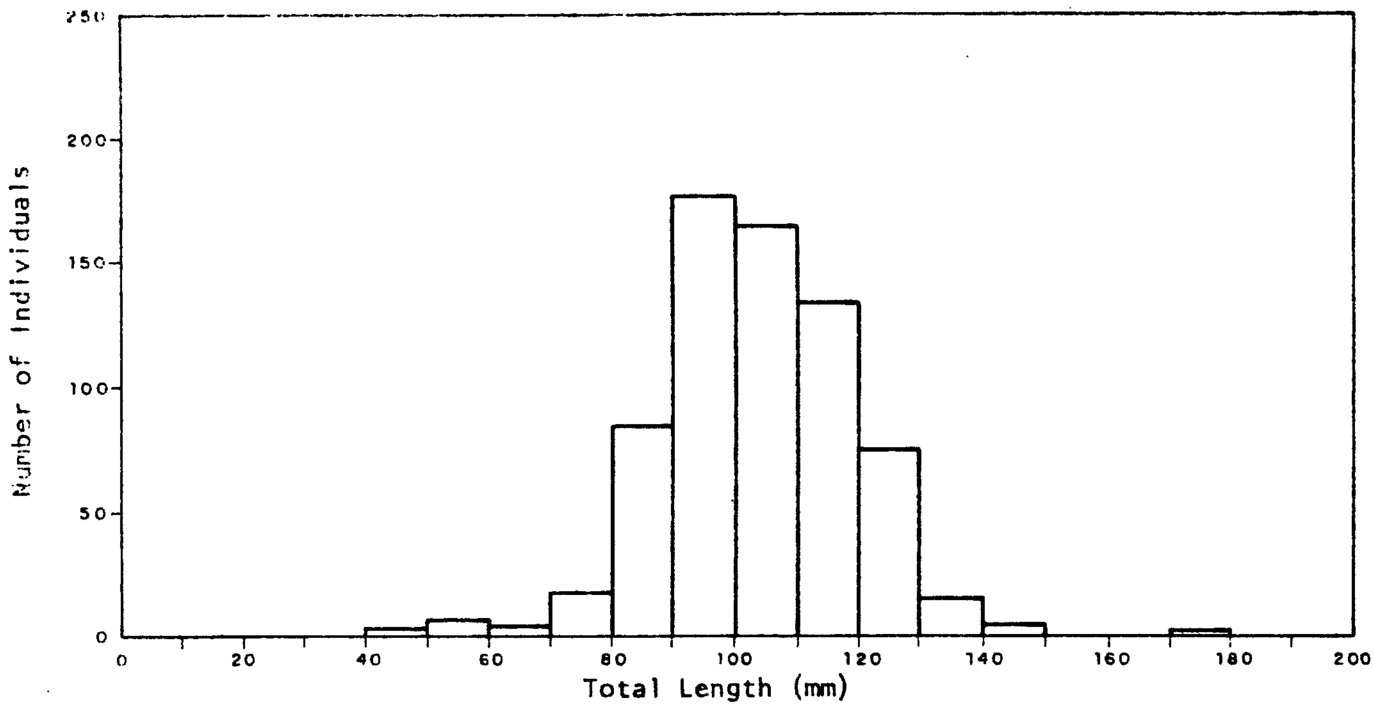


Paralichthys californicus

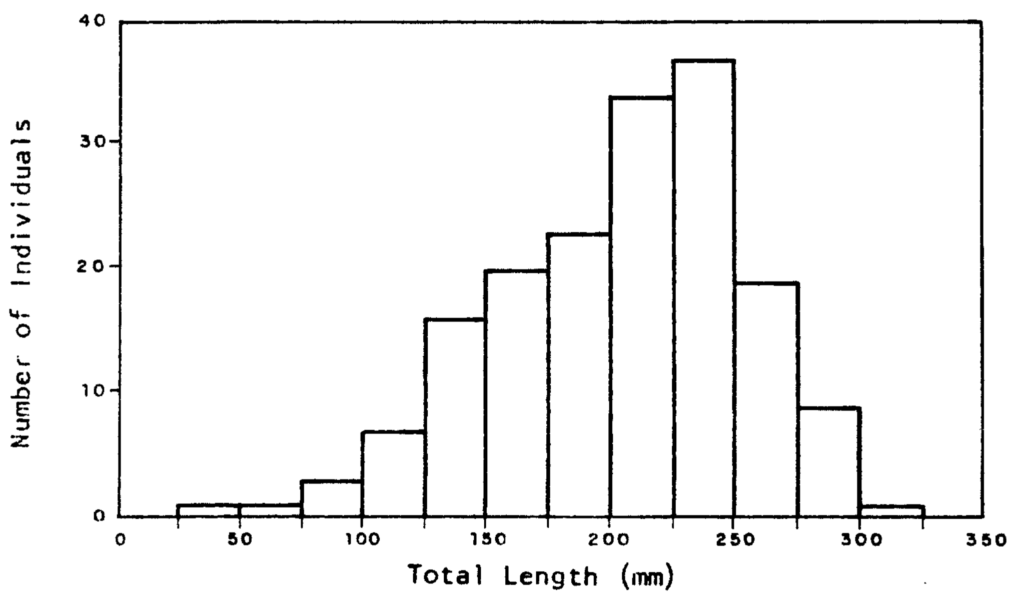


SAN DIEGO GAS & ELECTRIC COMPANY	
Length-frequencies for Heterostich[illegible] rostratus and Paralichthys califor[illegible]nicus Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.5-12

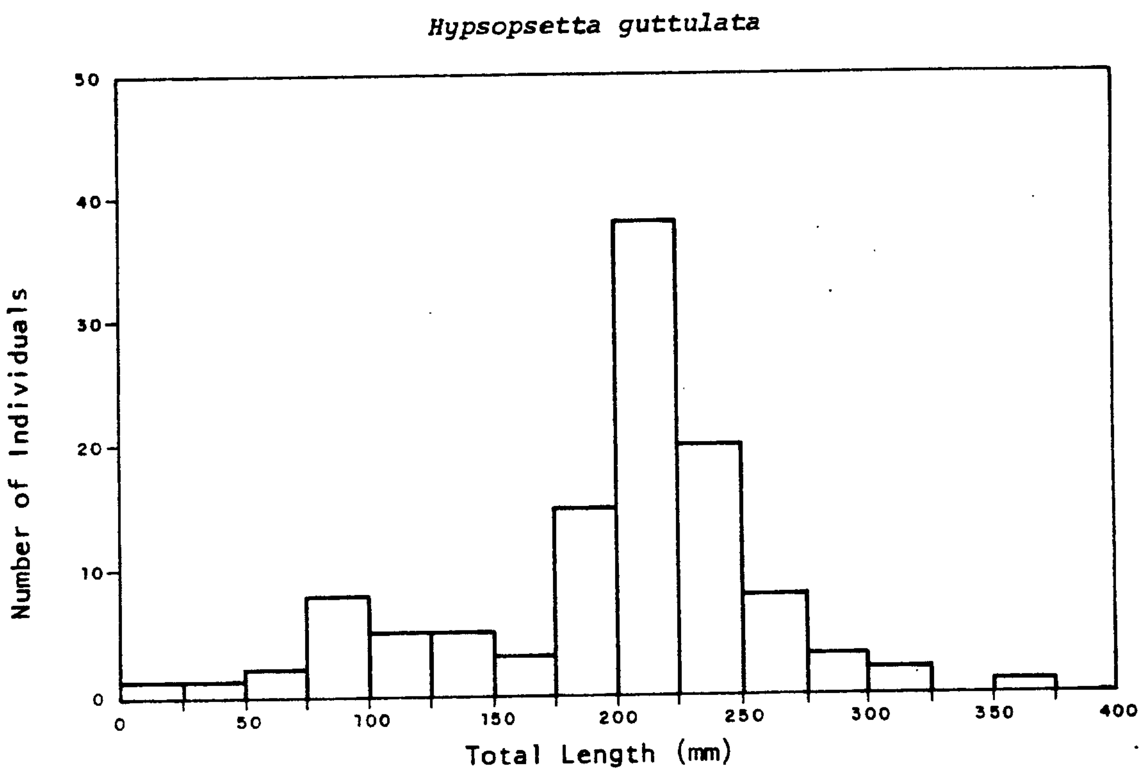
Citharichthys stigmaeus



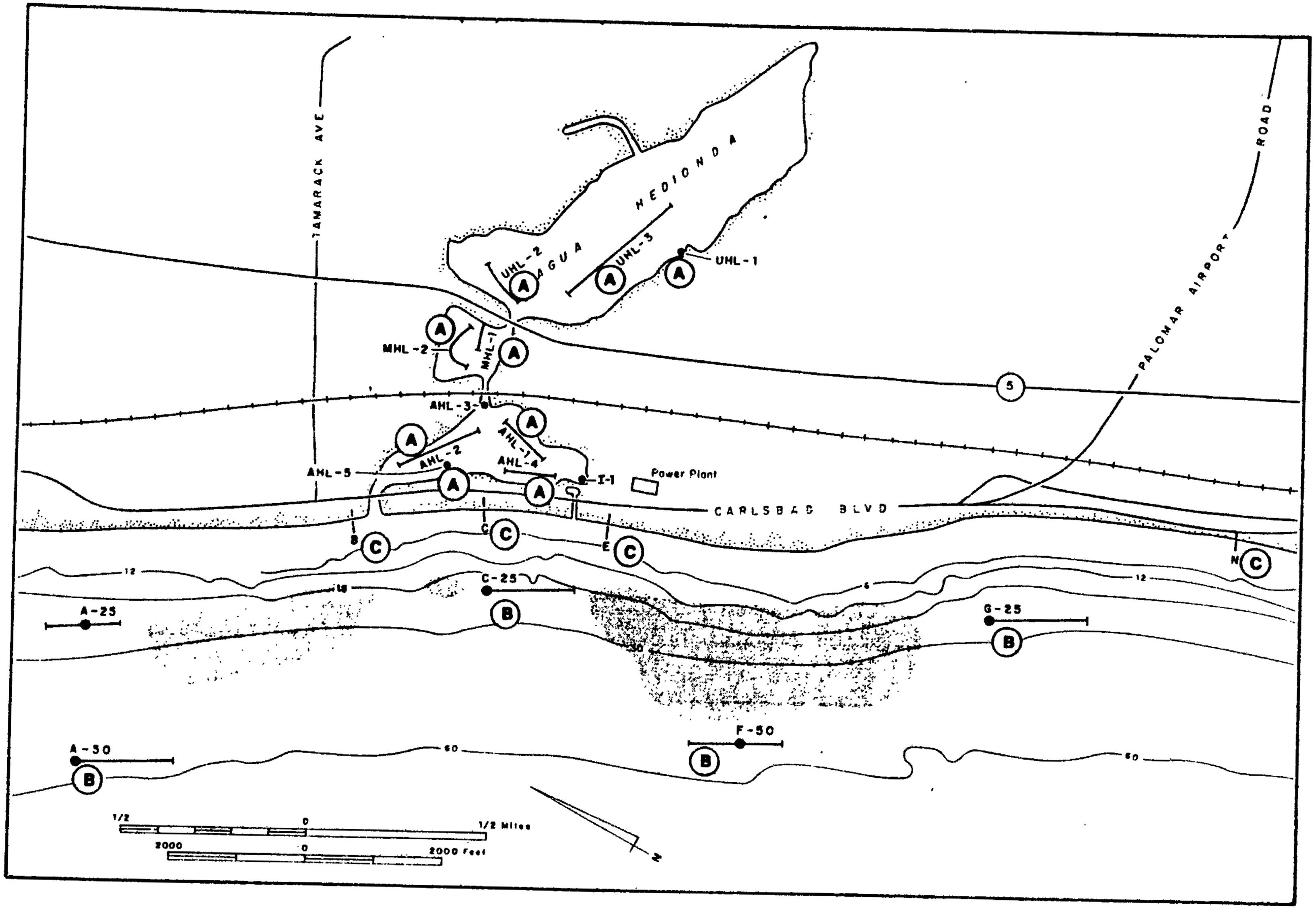
Pleuronichthys verticalis



SAN DIEGO GAS & ELECTRIC COMPANY	
Length-frequencies for *Citharichthys stigmaeus* and *Pleuronichthys verticalis* Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.5-13



SAN DIEGO GAS & ELECTRIC COMPANY	
Length-frequencies for Hypsopsetta guttulata Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.5-14



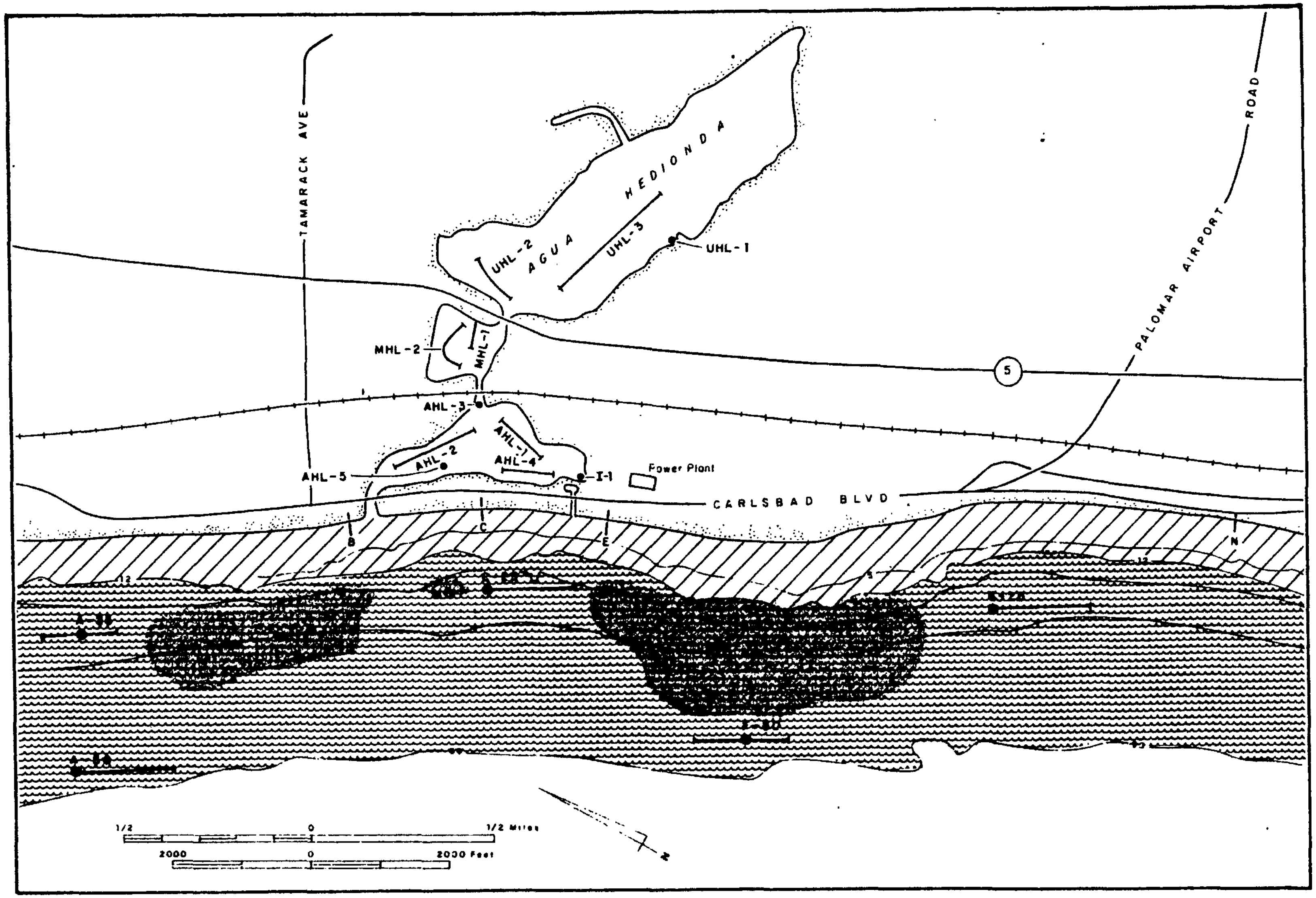
SAN DIEGO GAS & ELECTRIC COMPANY

Distribution of fish population types indicated by nekton landings

Encina Power Plant - August 1, 1980

PREPARED BY:
WOODWARD-CLYDE CONSULTANTS

FIGURE NO.
6.5-15

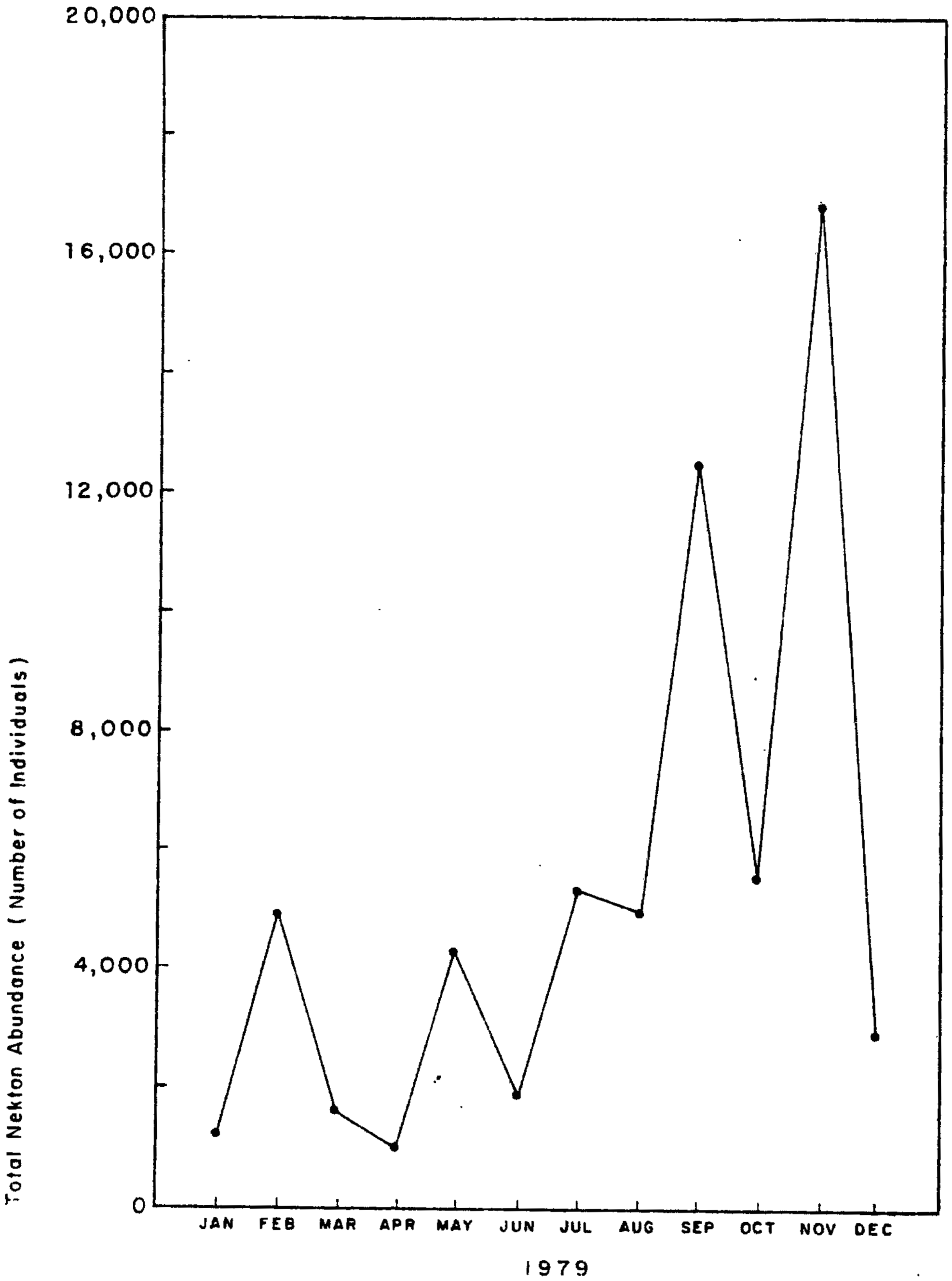


Surf Zone

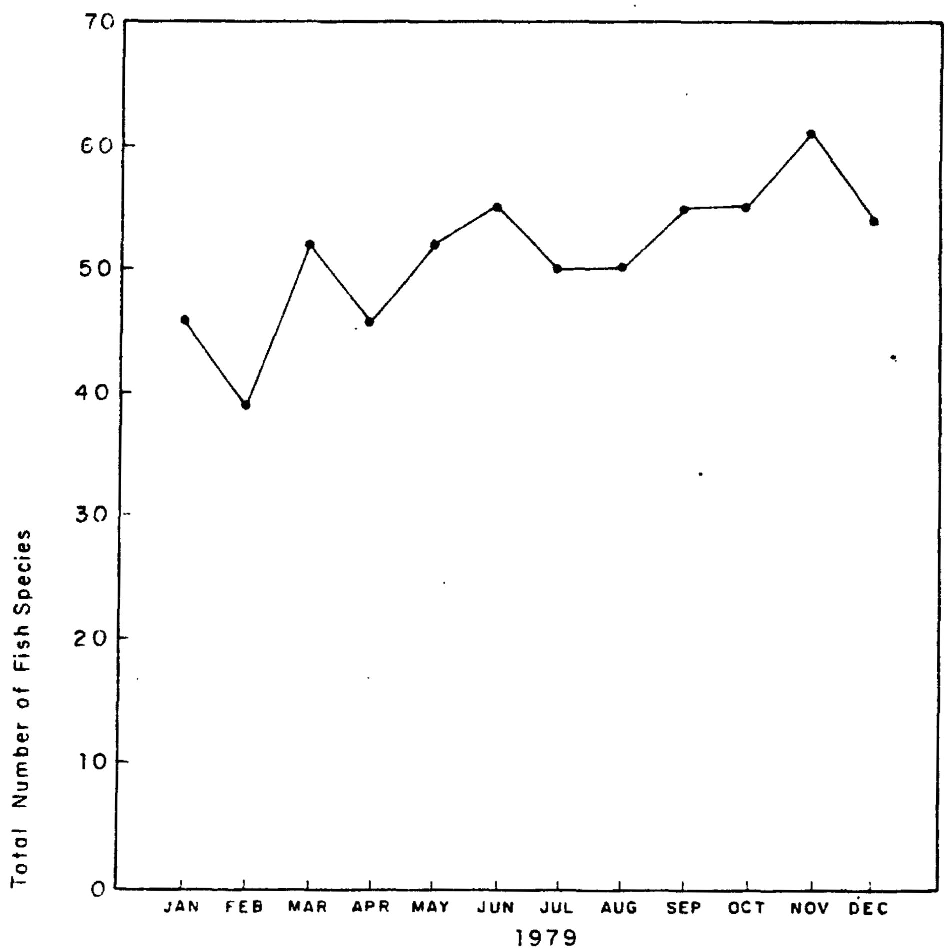
Offshore Area (excluding surf zone)

SAN DIEGO GAS & ELECTRIC COMPANY	
Area boundaries defined for offshore fish population estimates Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.5-16

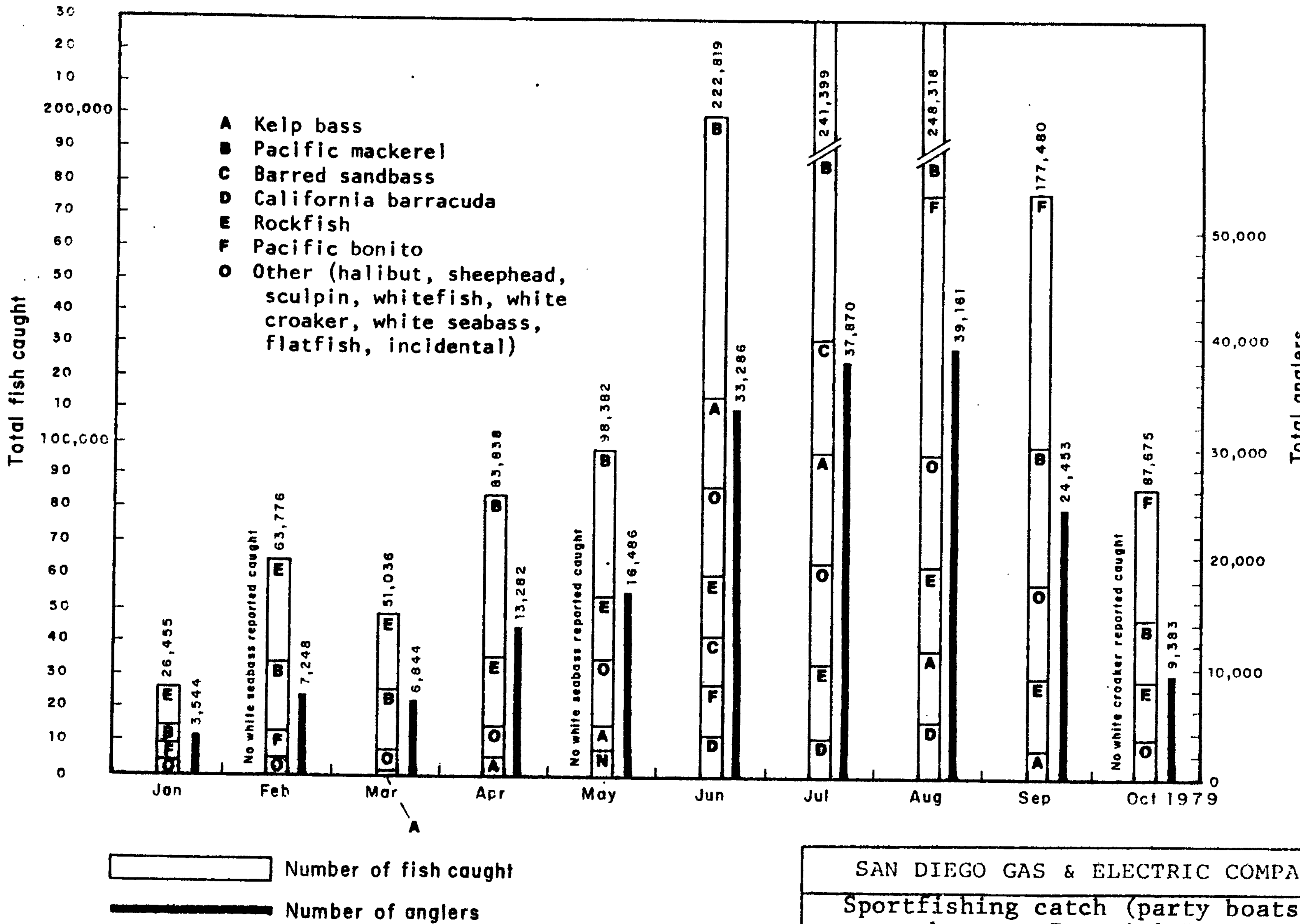
000462



SAN DIEGO GAS & ELECTRIC COMPANY	
Monthly total nekton abundance Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.5-17



SAN DIEGO GAS & ELECTRIC COMPANY	
Monthly total number of fish species captured in nekton collections Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 6.5-18



SAN DIEGO GAS & ELECTRIC COMPANY

Sportfishing catch (party boats) for ports between Imperial Beach and Dana Harbor, 1979

Encina Power Plant - August 1, 1980

PREPARED BY:
WOODWARD-CLYDE CONSULTANTS

FIGURE NO.
6.5-19

7.0

FISH REMOVAL BY INTAKE SCREENS (IMPINGEMENT STUDIES)

7.1 ABSTRACT AND SUMMARY

A 336 consecutive day study was conducted to describe and evaluate impingement of marine fishes, large invertebrates, and marine plants at the traveling screens and bar rack system of the Encina Power Plant cooling water intake. Detailed quantitative sampling and analysis to obtain biological and physical data were conducted twice daily during this period. The primary method of biological sampling was to obtain quantitative 12-hour accumulation samples during each day and night period, using nets placed in the trash collector baskets of all (three) traveling screen systems.

Results of the study included the following:

- Seventy-six species of fishes, 45 species of large invertebrates and seven species of marine grasses and algae were impinged.

- Marine plants were the largest component of material in the samples.

- The total amount of animal material impinged at the traveling screens during the 336 consecutive day period was 85,943 individuals weighing 1548 kg (3414 lb).

- 79,662 of the total individuals were fishes weighing a total of 1395 kg (3076 lb).
- During thermal treatments (seven for the year) 108,102 fish weighing 2422 kg (5341 lb) were removed.

Levels of impingement were lower at the Encina Power Plant compared to those reported for other coastal generating stations in southern California. Numbers impinged at Encina and other plants during a one year period, including thermal treatments, were:

- 187,764 fish weighing 3817 kg (8417 lb) at Encina Power Plant Units 1-5 with a maximum flow rate of 828 MGD.
- 260,917 fish weighing 19,553 kg (43,063 lb) at Redondo Beach Generating Station Units 7 and 8 with a maximum flow rate of approximately 673 MGD (7-1).
- 365,641 fish weighing 16,974 kg (37,423 lb) at San Onofre Nuclear Generating Station Unit 1 with a maximum flow rate of approximately 500 MGD (7-2).

The six highest ranking fish species by numbers impinged (83 percent of all fishes) are active, open water forms that occur in schools. In decreasing order of abundance, they are the queenfish, deepbody anchovy, topsmelt, California grunion, northern anchovy, and shiner surfperch.

Impingement of many fish species was relatively consistent throughout the year. Levels of impingement, however, showed considerable short- and long-term variation. There were no significant correlations between water temperature, salinity, cloud cover and ocean wave height and levels of impingement when these parameters were analyzed alone. It appears that impingement is influenced by a combination of factors. Primary causal factors involved appear to be high wind speeds, strong wave action and turbulence, rainfall and lowered salinity, and increased turbidity. For example, four of five storm periods (characterized by wind speeds $\geq$ 12 mph, rainfall, salinity $\leq$ 29.9 ppt, and wave heights >4 ft) had evident effects, the levels of impingement being significantly higher after onset of the storm than before it. Dredging operations throughout outer Agua Hedionda Lagoon also caused significantly higher impingement.

There was clear evidence that levels of impingement for fishes were significantly higher during darkness than during daylight. There also were significant correlations between levels of impingement and the flow rates of cooling water in the conveyance channels, impingement increasing fairly directly with increasing flow rates, assuming equal numbers of fish were present during the various flows. The peak impingement occurred in early spring during dredging operations. There were also seasonal peaks in summer and fall.

In general, there was little decomposition or physical damage for most fishes impinged, and a majority of these entered the screen well collector baskets alive. There appeared to be direct relationships between the degree of damage and both the fragility and size of fishes impinged. Delicate forms (e.g., anchovy species) experienced greatest damage during impingement.

Sex ratios of many critical species in the samples indicated that larger proportions of females than males were impinged during the 336 day period. In one case (the specklefin midshipmen) all of the females were in an advanced reproductive state. For most species considered, adult females in all stages of reproductive development occurred in the impingement samples.

Eelgrass and the giant kelp were the dominant marine plant species impinged at both the bar rack and traveling screen systems. Large rays and sharks were a small component of the bar rack samples. In general, highest levels of impingement for plants at the bar rack system occurred during and following storms. However, impingement of plants at the traveling screens generally was greater during the summer and fall.

Seven thermal treatments were sampled during the year. Seventy-three fish species and 34 invertebrates were collected at traveling screens during thermal treatments. Fourteen species were collected that were not taken during daily impingement samples. Over 90 percent of fish collected consisted of nine major species (deepbody anchovy, topsmelt, northern anchovy, shiner surfperch, California grunion, walleye surfperch, queenfish, round stingray, and giant kelpfish).

During thermal treatments for the year, 108,102 fish which weighed 2422 kg (5341 lb) were collected in addition to daily impingement samples. The greatest collections occurred in February and the least in December. Sampling indicates that certain larger fish live in the tunnels and are only impinged when killed during thermal treatments. The numbers of fish resident in the tunnels appears to be greatest in winter and lowest in summer. This could be due to fish seeking refuge in the lagoon during winter periods.

The results of this study were evaluated in relation to information from other research on behavior of fishes and factors affecting impingement. The primary factors involved appear to be water temperature, velocity of flow and other flow characteristics in the cooling water system, turbulence and salinity changes associated with storms, level of illumination, and the water depth and structural characteristics of the intake system.

7.2 HISTORICAL INFORMATION

Species lists and ecological information for fishes known or expected to occur in Agua Hedionda Lagoon and the inshore ocean area adjacent to the Encina Power Plant are given in Sections 6.2 and 6.3 of this report. Detailed information about fishes taken in these areas during monthly sampling by Woodward-Clyde Consultants is given in Section 6.5. Extensive data concerning benthic invertebrates and plants inhabiting Agua Hedionda Lagoon have been reported by Miller (1966), Bradshaw and Estberg (1973), and Bradshaw et al. (1976) (7-3, 7-4 and 7-5). These sources provide useful background information for the impingement study. They also provide a good indication of the fish, invertebrate, and plant species likely to be impinged in the cooling water system of the power plant.

The impingement study described in this report is the first detailed one conducted at the Encina Power Plant. Previously, regular monthly sampling was carried out at the plant by the San Diego Gas & Electric Company (SDG&E) during the five year period November, 1972 - February, 1978 to record the impingement of fishes and large crustaceans. These records provide useful historical information against which the results of the detailed study may be compared. They also were used in planning the methods used in this study.

Sampling was conducted by personnel of SDG&E at representative times on 1 to 4 days per month. As described in Section 16.2.3, material washed from the traveling screens passed through concrete troughs and a spout into large metal trash collecting baskets. Impingement samples for SDG&E monitoring study were obtained by placing a metal screen collecting device in place of the spout at the end of the trough. The collector was left in place for a known length of time (normally 8 hours) and the contents were then removed and examined.

A standard data form was used to record the information. These monitoring records are maintained by SDG&E. A sample of the data form is shown in Figure 7.2-1. Estimated number of individuals, estimated total weight, and estimated size range were recorded by month for each of 21 families of fishes and for lobsters and shrimp, as indicated in Figure 7.2-1. The estimated total weight of fish collected also was recorded.

The size of the sampling device employed by SDG&E was much smaller than that used in the detailed study and the methods of processing the samples were different. Despite these differences, the results from both approaches are generally comparable.

7.3 METHODOLOGY

Quantitative sampling and analysis of impinged fishes, large invertebrates and marine plants was conducted twice daily at the Encina Power Plant during the period February 4, 1979 through January 4, 1980. Preliminary sampling also was conducted during the period January 19 through February 3, 1979 to refine the methods used. Detailed descriptions for all methods of sampling and analysis employed in the impingement study are given in Appendix B, Section 16.2.3 of this report. Brief descriptions of these methods are provided here.

A morning sample at 0700 hr and an evening sample at 1900 hr were taken from large nylon nets suspended in the metal trash collector baskets associated with each of the three separate traveling screen systems of the Power Plant. The locations of these three traveling screen systems, designed as impingement stations 1, 4, and 5, are shown in Figure 7.3-1. Station 1 was located at the traveling screens of generating Units 1-3, station 4 at the screens of generating Unit 4, and station 5 at the screens of generating Unit 5. By sampling in this way, 12-hr accumulation samples were obtained continuously from each of three screenwell locations. The samples taken at 0700 hr represented impingement that occurred primarily during darkness, while those taken at 1900 hr represented impingement that occurred during daylight.

The entire contents of the net collector at each screenwell station location constituted the 12-hr accumulation sample.

Appropriate methods of subsampling were employed when the amounts of material and the numbers of individuals of a given animal species were large. These standard subsampling methods are described in Appendix Section 16.2.3. All data were recorded on standard forms, using a computer coding format.

In the laboratory, all fishes, large invertebrates, and marine plants were sorted from the whole sample or subsample prior to making identifications, counts and measurements. These organisms were identified to species or to the lowest possible taxonomic category, using keys and reference collections.

The aggregate weight of all animal and plant material combined and the aggregate weight of all marine plants were determined to the nearest 100 g. The rank order of abundance of each plant species by estimated volume and the numbers of individuals of each fish and motile invertebrate species were determined and recorded. The total body length of individual fishes was determined and recorded to the nearest 1 mm. The wet body weight of individual fishes was determined to the nearest 1 g after shaking loose water from the body. Total weight of all individuals combined was determined in the same manner. The qualitative body condition of individual fishes was determined, using standard codes for decomposition and physical damage as described in Appendix Section 16.2.3.

Once per month, fishes taken in one or more impingement samples at each station also were examined to determine their sex and reproductive condition. During periods when the amount of material impinged was small, samples from two to eight consecutive days were used to determine reproductive characteristics.

Individuals from the entire sample or series of samples were used in determining reproductive characteristics. All individuals were examined to determine the numbers of males and and females of each species present. All females were then examined by visual inspection of the ovary to determine reproductive condition. The characteristics and data codes used to indicate the sex of each individual and the reproductive condition of females are described in Appendix Section 16.2.3.

Fishes and marine plants that had accumulated in the trash collector trailers associated with the bar rack screening system also were examined at 0700 hr each day. The location of the bar rack system, designated as impingement station 9, is shown in Figure 7.3-1.

The contents of the trash collector trailers were examined qualitatively by searching through the material. The accumulated material consisted primarily of larger marine plants. The rank order of abundance of each marine plant species by estimated volume was recorded. Large fishes and other vertebrate animals were removed for identification and measurements of length and weight, using the same methods described for the traveling screen samples.

Pertinent physical and meteorological data were obtained from measurements and observations made during each sampling period or from records provided by SDG&E. Detailed descriptions of these data and the methods used to obtain them are given in Appendix B, Section 16.2.3.

Meteorological and other physical data were taken near the bar rack system four times during each 24-hr period. These were wind speed (nearest 1 mph), weather conditions, cloud cover, wave height, air and water temperatures (nearest 0.5 C), and salinity (nearest 0.1 ppt).

Data concerning tidal height and stage at the time samples were taken and the highest and lowest tide levels during the preceeding 12-hr period were obtained from a sine curve tide chart. Continuous information concerning the number of circulating water pumps operating for each generating unit of the Power Plant and the flow rates of these pumps was obtained from records maintained by SDG&E at the Encina Power Plant. Total flow rates of seawater through each of the three traveling screen impingement stations at a given time were then determined from the number of circulating pumps in operation and the known flow rates of these pumps.

000476

7.4 SPECIES COMPOSITION AND OCCURRENCE OF IMPINGED FISHES AND INVERTEBRATES

The scientific and common names of all fishes and large invertebrate animals taken in impingement samples at stations 1, 4, 5, and 9 during the period February 4, 1979 - January 4, 1980 are given in Tables 7.4-1 and 7.4-2, respectively. Marine grasses and algae taken in these samples are considered separately in Section 7.11.

As shown in Table 7.4-1, the total number of fish species impinged during the 336-day period of sampling was 76. All of these species are known to occur either in Agua Hedionda Lagoon or in the coastal ocean area adjacent to the Encina Power Plant, as indicated by information considered in Sections 6.2 and 6.5 of this report.

Only one species, the longfin sanddab (Citharichthys xanthostigma), was unexpected in the impingement samples, because it occurs in relatively deep water (> 30 m). However, it was represented in the samples by only five individuals. Somewhat unexpected was the occurrence of the California flying fish (Cypselurus californicus), of which 31 individuals were taken during the 336-day sampling period. This pelagic species normally occurs in coastal ocean areas, but its presence in the impingement samples indicates clearly that it sometimes enters Agua Hedionda Lagoon.

As indicated in Table 7.4-2, the total number of large invertebrate species taken in the impingement samples was 45. Most

TABLE 7.4-1
SPECIES OF FISHES TAKEN IN IMPINGEMENT SAMPLES AT THE ENCINA POWER PLANT DURING THE PERIOD JANUARY 1979 - JANUARY 1980

Scientific Name	Common Name
Alloclinus holderi	Island kelpfish
Amphistichus argenteus	Barred surfperch
Anchoa compressa	Deepbody anchovy
Anchoa delicatissima	Slough anchovy
Anisotremus davidsonii	Sargo
Atherinops affinis	Topsmelt
Atherinopsis californiensis	Jacksmelt
Brachyistius frenatus	Kelp surfperch
Chromis punctipinnis	Blacksmith
Citharichthys stigmaeus	Speckled sanddab
Citharichthys xanthostigma	Longfin sanddab
Clupea harengus	Pacific herring
Cymatogaster aggregata	Shiner surfperch
Cymatogaster gracilis	Island surfperch
Cynoscion nobilis	White seabass
Cypselurus californicus	California flying fish
Damalichthys vacca	Pile surfperch
Decapterus hypodus	Mexican scad
Dorosoma petenense	Threadfin shad
Embiotoca jacksoni	Black surfperch
Engraulis mordax	Northern anchovy
Fundulus parvipinnis	California killifish
Genyonemus lineatus	White croaker
Gibbonsia metzi	Striped kelpfish
Girella nigricans	Opaleye
Gymnothorax mordax	Moray eel
Gymnura marmorata	California butterfly ray
Hermosilla azurea	Zebra perch
Heterodontus francisci	Horn shark

TABLE 7.4-1 (Continued)

Scientific Name	Common Name
Heterostichus rostratus	Giant kelpfish
Hyperprosopon argenteum	Walleye surfperch
Hypsoblennius gilberti	Rockpool blenny
Hypsoblennius jenkinsi	Mussel blenny
Hypsopsetta guttulata	Diamond turbot
Hypsypops rubicundus	Garibaldi
Leptocottus armatus	Staghorn sculpin
Leuresthes tenuis	California grunion
Medialuna californiensis	Halfmoon
Menticirrhus undulatus	California corbina
Micrometrus minimus	Dwarf surfperch
Mugil cephalus	Striped mullet
Mustelus californicus	Gray smoothhound
Myliobatis californica	Bat ray
Oligocottus rubellio	Rosy sculpin
Ophichthus zophochir	Yellow snake eel
Paralabrax clathratus	Kelp bass
Paralabrax maculatotasciatus	Spotted sand bass
Paralabrax nebulifer	Barred sand bass
Paralichthys californicus	California halibut
Peprilus simillimus	Pacific butterfish
Phanerodon furcatus	White surfperch
Platyrhinoidis triseriata	Thornback ray
Pleuronichthys ritteri	Spotted turbot
Porichthys notatus	Plainfin midshipman
Porichthys myriaster	Specklefin midshipman
Rhacochilus toxotes	Rubberlip surfperch
Rhinobatos productus	Shovelnose guitarfish
Roncador stearnsii	Spotfin croaker

TABLE 7.4-1 (Concluded)

Scientific Name	Common Name
Sarda chiliensis	Pacific bonito
Scomberomorus concolor	Monterey Spanish mackerel
Scorpaena guttata	Sculpin/spotted scorpionfish
Seriphus politus	Queenfish
Sphyraena argentea	California barracuda
Squatina californica	Pacific angel shark
Strongylura exilis	California needlefish
Symphurus atricauda	California tonguefish
Syngnathus californiensis	Kelp pipefish
Syngnathus leptorhynchus	Bay pipefish
Torpedo californica	Pacific electric ray
Trachurus symmetricus	Jack mackerel
Triakis semifasciata	Leopard shark
Umbrina roncador	Yellowfin croaker
Urolophus halleri	Round stingray
Xenistius californiensis	Salema
Xystreurys liolepis	Fantail sole

TABLE 7.4-2
SPECIES OF LARGE MARINE INVERTEBRATE ANIMALS TAKEN IN IMPINGEMENT SAMPLES AT THE ENCINA POWER PLANT DURING THE PERIOD JANUARY 1979 - JANUARY 1980

Scientific Name	Common Name
Aeolidia papillosa	Nudibranch
Aequipecten aequisulcatus	Speckled scallop
Aglaophenia sp.	Hydroid
Alpheus dentipes	Pistol shrimp
Anthopleura elegantissima	Aggregate sea anemone
Aplysia californica	California sea hare
Balanus tintinnabulum	Red and white barnacle
Callianassa californiensis	Ghost shrimp
Cancer antennarius	Common rock crab
Cancer anthonyi	Anthony's rock crab
Cancer jordani	Jordan's rock crab
Cancer productus	Red rock crab
Chlamys hastatus	Pacific spear scallop
Crangon nigromaculata	Black spotted shrimp
Diaulula sandiegenesis	San Diego sea slug
Hemigrapsus nudus	Purple shore crab
Hermissenda crassicornis	Nudibranch
Hinnites multirugosus	Rock scallop
Loligo opalescens	Squid
Lovenia cordiformis	Sea porcupine
Loxorhynchus crispatus	Masking crab
Lysmata californica	Striped shrimp
Lytechinus pictus	Painted urchin
Megathura crenulata	Giant keyhole limpet
Molpadia arenicola	Sweet potato cucumber
Mytilus edulis	Bay mussel
Navanax inermis	Striped sea slug
Octopus bimaculatus	Two-spotted octopus

TABLE 7.4-2 (Concluded)

Scientific Name	Common Name
Octopus bimaculoides	Mud flat octopus
Pachygrapsus crassipes	Striped shore crab
Panulirus interruptus	California spiny lobster
Pelagia panopyra	Purple-striped jellyfish
Pelia tumida	Dwarf crab
Penaeus californiensis	California brown shrimp
Pentidotea rescata	Kelp isopod
Pilumnus spinohirsutus	Hairy crab
Pisaster ochraceus	Ochre starfish
Podochela hemphilli	Spider crab
Pollicipes polymerus	Pacific goose barnacle
Polyorchis penicillatus	Hydromedusa
Portunus xantusi	Swimming crab
Pugettia producta	Kelp crab
Pyromaia tuberculata	Spider crab
Strongylocentrotus purpuratus	Purple sea urchin
Taliepus nuttalli	Southern kelp crab

smaller forms, particularly those living attached to impinged marine plants, were not identified or considered in processing the samples because of time limitations. All of the species listed in Table 7.4-2 are relatively common in the area near the Power Plant and might be expected to be carried into the cooling water system.

Most are benthic species that inhabit unconsolidated sediment or rocky habitats either in Agua Hedionda Lagoon or in the adjacent nearshore ocean area. Only two large pelagic invertebrate species occurred in the samples. They are the squid (Loligo opalescens) and the purple-striped jellyfish (Pelagia panopyra), both common forms in coastal areas of southern California.

The numerical ranking of each animal species taken in samples at traveling screen stations 1, 4, and 5 is given in Table 7.4-3. Total numbers of individuals of each species and all species combined taken during the 336-day sampling period also are shown for each traveling screen station, and for the three stations combined.

As indicated in Table 7.4-3, 85,957 animals were taken in the impingement samples at stations 1, 4, and 5 during the 336-day period, of which 79,662 (92.7 percent) were fishes and only 6,281 (7.3 percent) were invertebrates. The largest total number of fishes was impinged at station 4 (39,509; 49.6 percent of total), the next largest at station 5 (25,037; 31.4 percent), and the smallest number at station 1 (15,116; 19.0 percent). Among

TABLE 7.4-3
NUMERICAL RANKING OF ALL ANIMAL SPECIES IMPINGED AT ENCINA POWER PLANT TRAVELING SCREEN STATIONS DURING THE PERIOD FEBRUARY 4, 1979 - JANUARY 4, 1980

RANK	COMMON NAME	SPECIES NAME	TOTAL NUMBERS IMPINGED STATION 1	STATION 4	STATION 5	TOTAL
1	QUEENFISH	SERIPHUS POLITUS	3733	9685	5263	18681
2	DEEPBODY ANCHOVY	ANCHOA COMPRESSA	2400	5148	5751	13299
3	TOPSMELT	ATHERINOPS AFFINIS	996	6443	3476	10915
4	CALIFORNIA GRUNION	LEURESTHES TENUIS	2044	5284	1255	8583
5	NORTHERN ANCHOVY	ENGRAULIS MORDAX	972	4874	1588	7434
6	SHINER SURFPERCH	CYMATOGASTER AGGREGATA	1248	2724	2573	6545
7	ANTHONY'S ROCK CRAB	CANCER ANTHONYI	1766	287	487	2540
8	WALLEYE SURFPERCH	HYPERPROSOPON ARGENTEUM	687	537	653	1877
9	SLOUGH ANCHOVY	ANCHOA DELICATISSIMA	463	1020	275	1758
10	WHITE SURFPERCH	PHANERODON FURCATUS	939	423	389	1751
11	ROUND STINGRAY	UROLOPHUS HALLERI	357	562	707	1626
12	CALIFORNIA HALIBUT	PARALICHTHYS CALIFORNICUS	179	406	630	1215
13	GIANT KELPFISH	HETEROSTICHUS ROSTRATUS	254	639	153	1046
14	SWIMMING CRAB	PORTUNUS XANTUSI	315	137	432	884
15	STRIPED SHORE CRAB	PACHYGRAPSUS CRASSIPES	240	182	444	866
16	SALEMA	XENISTIUS CALIFORNIENSIS	87	394	57	538
17	SQUID	LOLIGO OPALESCENS	146	293	83	522
18	DIAMOND TURBOT	HYPSOPSETTA GUTTULATA	31	91	338	460
19	CALIFORNIA BARRACUDA	SPHYRAENA ARGENTEA	116	273	44	433
20	PACIFIC GOOSE BARNACLE	POLLICIPES POLYMERUS	206	55	143	404
21	SPECKLEFIN MIDSHIPMAN	PORICHTHYS MYRIASTER	49	94	219	362
22	PACIFIC BUTTERFISH	PEPRILUS SIMILLIMUS	7	32	244	283
23	STAGHORN SCULPIN	LEPTOCOTTUS ARMATUS	61	67	117	245
24	BAT RAY	MYLIOBATUS CALIFORNICA	29	41	159	229
25	CALIFORNIA BUTTERFLY RAY	GYMNURA MARMORATA	42	39	139	220
26	PENAEID SHRIMP	PENAEUS CALIFORNIENSIS	22	13	170	205
27	BARRED SAND BASS	PARALABRAX NEBULIFER	37	78	74	189
28	THORNBACK RAY	PLATYRHINOIDIS TRISERIATA	34	42	99	175
29	SARGO	ANISOTREMUS DAVIDSONII	30	84	58	172
30	RED AND WHITE BARNACLE	BALANUS TINTINNABULUM	88	28	46	162
31	WHITE CROAKER	GENYONEMUS LINEATUS	42	34	77	153
32	CALIFORNIA TONGUEFISH	SYMPHURUS ATRICAUDA	34	54	52	140
33	CALIFORNIA CORBINA	MENTICIRRHUS UNDULATUS	26	41	50	117
34	KELP CRAB	PUGETTIA PRODUCTA	39	24	46	109
35	BAY PIPEFISH	SYNGNATHUS LEPTORHYNCHUS	23	65	19	107
36	BARRED SURFPERCH	AMPHISTICHUS ARGENTEUS	24	29	30	83
37	SPOTTED SAND BASS	PARALABRAX MACULATOFASCIATUS	5	28	40	73
37	PILE SURFPERCH	DAMALICHTHYS VACCA	19	24	30	73
37	STRIPED MULLET	MUGIL CEPHALUS	4	13	56	73
38	TWO-SPOTTED OCTOPUS	OCTOPUS BIMACULATUS	20	16	35	71
39	BAY MUSSEL	MYTILUS EDULIS	39	13	14	66
40	OPALEYE	GIRELLA NIGRICANS	7	6	51	64
41	ANCHOVY	ANCHOA SP.	5	9	47	60
42	YELLOWFIN CROAKER	UMBRINA RONCADOR	4	20	31	55
42	PAINTED URCHIN	LYTECHINUS PICTUS	34	13	8	55
43	STRIPED SEA SLUG	NAVANAX INERMIS	15	5	29	49
43	GHOST SHRIMP	CALLIANASSA CALIFORNIENSIS	24	25	0	49
44	PURPLE SHORE CRAB	HEMIGRAPSUS NUDUS	17	8	19	44
45	CALIFORNIA NEEDLEFISH	STRONGYLURA EXILIS	7	15	19	41
45	BLACK SURFPERCH	EMBIOTOCA JACKSONI	20	4	17	41

TABLE 7.4-3 (Continued)

RANK	COMMON NAME	SPECIES NAME	TOTAL NUMBERS IMPINGED STATION 1	STATION 4	STATION 5	TOTAL
46	JACKSMELT	ATHERINOPSIS CALIFORNIENSIS	0	23	17	40
47	SWEET POTATO CUCUMBER	MOLPADIA ARENICOLA	9	2	25	36
48	COMMON ROCK CRAB	CANCER ANTENNARIUS	14	8	13	35
49	KELP BASS	PARALABRAX CLATHRATUS	9	15	10	34
50	SPOTFIN CROAKER	RONCADOR STEARNSII	1	8	24	33
51	KELP PIPEFISH	SYNGNATHUS CALIFORNIENSIS	8	8	16	32
52	CALIFORNIA FLYING FISH	CYPSELURUS CALIFORNICUS	7	13	11	31
52	HYDROMEDUSA	POLYORCHIS PENICILLATUS	20	5	6	31
53	SPOTTED TURBOT	PLEURONICHTHYS RITTERI	6	5	19	30
54	THREADFIN SHAD	DOROSOMA PETENENSE	0	4	24	28
55	BLACK SPOTTED SHRIMP	CRANGON NIGROMACULATA	18	3	6	27
56	WHITE SEABASS	CYNOSCION NOBILIS	6	10	9	25
56	MUSSEL BLENNY	HYPSOBLENNIUS JENKINSI	10	9	6	25
57	GRAY SMOOTHHOUND	MUSTELUS CALIFORNICUS	1	5	16	22
58	PACIFIC ELECTRIC RAY	TORPEDO CALIFORNICA	4	6	11	21
59	BLACKSMITH	CHROMIS PUNCTIPINNIS	1	6	13	20
60	CALIFORNIA SEA HARE	APLYSIA CALIFORNICA	9	0	9	18
61	ROCKPOOL BLENNY	HYPSOBLENNIUS GILBERTI	5	6	6	17
62	SPECKLED SCALLOP	AEQUIPECTEN AEQUISULCATUS	8	6	2	16
62	HYDROID	AGLAOPHENIA (COLONY OF HYDROIDEA	4	2	10	16
62	PURPLE SEA URCHIN	STRONGYLOCENTROTUS PURPURATUS	12	1	3	16
63	NUDIBRANCH	HERMISSENDA CRASSICORNIS	15	0	0	15
64	CALIFORNIA KILLIFISH	FUNDULUS PARVIPINNIS	3	10	1	14
65	BASS	PARALABRAX SP.	0	9	4	13
66	HALFMOON	MEDIALUNA CALIFORNIENSIS	0	10	2	12
66	ISLAND SURFPERCH	CYMATOGASTER GRACILIS	2	9	1	12
67	SOUTHERN KELP CRAB	TALIEPUS NUTTALLI	4	2	5	11
68	PLAINFIN MIDSHIPMAN	PORICHTHYS NOTATUS	9	0	1	10
68	ISLAND KELPFISH	ALLOCLINUS HOLDERI	4	4	2	10
68	MONTEREY SPANISH MACKERAL	SCOMBEROMORUS CONCOLOR	0	0	10	10
68		BIRDS*	0	5	5	10
69	PACIFIC BONITO	SARDA CHILIENSIS	7	0	2	9
70	MORAY EEL	GYMNOTHORAX MORDAX	4	3	1	8
70	RUBBERLIP SURFPERCH	RHACOCHILUS TOXOTES	1	0	7	8
71	SHOVELNOSE GUITARFISH	RHINOBATOS PRODUCTUS	2	0	5	7
71	KELP SURFPERCH	BRACHYISTIUS FRENATUS	1	0	6	7
71	BAY BLENNY	HYPSOBLENNIUS GENTILIS	1	4	2	7
71		LARVAL FISH	2	0	5	7
72	FANTAIL SOLE	XYSTREURYS LIOLEPIS	0	5	1	6
73	LONGFIN SANDDAB	CITHARICHTHYS XANTHUSTIGMA	0	5	0	5
73	PACIFIC SPEAR SCALLOP	CHLAMYS HASTATUS	3	0	2	5
73	HAIRY CRAB	PILUMNUS SPINOHIRSUTUS	3	1	1	5
73	PURPLE-STRIPED JELLYFISH	PELAGIA PANOPYRA	2	0	3	5
74	LEOPARD SHARK	TRIAKIS SEMIFASCIATA	0	0	4	4
74	PACIFIC HERRING	CLUPEA HARENGUS	0	0	4	4
74	SCULPIN/SPOTTED SCORPIONFISH	SCORPAENA GUTTATA	0	3	1	4
74	DWARF SURFPERCH	MICROMETUS MINIMUS	1	0	3	4
74	SPECKLED SANDDAB	CITHARICHTHYS STIGMAEUS	3	0	1	4
75	HORN SHARK	HETERODONTUS FRANCISCI	0	0	3	3

TABLE 7.4-3 (Concluded)

RANK	COMMON NAME	SPECIES NAME	TOTAL NUMBERS IMPINGED STATION 1	STATION 4	STATION 5	TOTAL
75	YELLOW SNAKE EEL	OPHICHTHUS ZOPHOCHIR	0	0	3	3
75	JACK MACKERAL	TRACHURUS SYMMETRICUS	0	0	3	3
75	STRIPED KELPFISH	GIBBONSIA METZI	0	3	0	3
75	SPIDER CRAB	PYROMAIA TUBERCULATA	0	0	3	3
75	AGGREGATE SEA ANENOME	ANTHOPLEURA ELEGANTISSIMA	3	0	0	3
76	PACIFIC ANGEL SHARK	SQUATINA CALIFORNICA	0	1	1	2
76	MEXICAN SCAD	DECAPTERUS HYPODUS	0	2	0	2
76	ZEBRAPERCH	HERMOSILLA AZUREA	0	2	0	2
76	GARIBALDI	HYPSYPOPS RUBICUNDUS	0	0	2	2
76		SQUIRRELS*	0	0	2	2
76	GIANT KEYHOLE LIMPET	MEGATHURA CRENULATA	2	0	0	2
76	CALIFORNIA SPINY LOBSTER	PANULIRUS INTERRUPTUS	2	0	0	2
76	MASKING CRAB	LOXORHYNCHUS CRISPATUS	2	0	0	2
77	ROSY SCULPIN	OLIGOCOTTUS RUBELLIO	1	0	0	1
77		MICE*	1	0	0	1
77		RATS*	0	0	1	1
77	SAN DIEGO SEA SLUG	DIAULULA SANDIEGENESIS	1	0	0	1
77	NUDIBRANCH	AEOLIDIA PAPILLOSA	0	0	1	1
77	STRIPED SHRIMP	LYSMATA CALIFORNICA	1	0	0	1
77	PISTOL SHRIMP	ALPHEUS DENTIPES	0	0	1	1
77	SPIDER CRAB	PODOCHELA HEMPHILLI	1	0	0	1
77	RED ROCK CRAB	CANCER PRODUCTUS	1	0	0	1
77	OCHRE STARFISH	PISASTER OCHRACEUS	0	0	1	1
77	SEA PORCUPINE	LOVENIA CORDIFORMIS	0	0	1	1
77	BRITTLE STARS	OPHIUROIDEA	1	0	0	1
		TOTAL FISHES	15,116	39,509	25,037	79,662
		TOTAL INVERTEBRATES	3,104	1,129	2,048	6,281
		TOTAL TERRESTRIAL ANIMALS	1	5	8	14
		TOTAL ANIMALS	18,221	40,643	27,093	85,957

*Dead terrestrial animals impinged.

invertebrates, the largest total number was impinged at station 1 (3,104; 49.4 percent), the next largest at station 5 (2,048; 32.6 percent), and the smallest number at station 4 (1,129; 18.0 percent).

Based on the numerical rankings and numbers of individuals shown in Table 7.4-3, and on considerations described in Section 6.3, 22 species of fishes were treated as critical species for the impingement study. These include all of the 15 forms designated as critical species in Section 6.3 (Table 6.3-1). They are, in decreasing order of abundance in the samples:

Common Name	Species Name
Queenfish	*Seriphus politus*
Topsmelt	*Atherinops affinis*
Northern anchovy	*Engraulis mordax*
Walleye surfperch	*Hyperprosopon argenteum*
California halibut	*Paralichthys californicus*
Giant kelpfish	*Heterostichus rostratus*
Barred sand bass	*Paralabrax nebulifer*
California corbina	*Menticirrhus undulatus*
Barred surfperch	*Amphisticus argenteus*
Spotted sand bass	*Paralabrax maculatofasciatus*
Striped mullet	*Mugil cephalus*
Kelp bass	*Paralabrax clathratus*
White sea bass	*Cynoscion nobilis*

California sheephead	Pimelometopon pulchrum
Pacific sanddab	Citharichthys sordidus
Hornyhead turbot	Pleuronichthys verticalis

Seven other fish species represented in the impingement samples by a total of more than 500 individuals during the 336-day sampling period (Table 7.4-3) were treated as additional critical species for purposes of the impingement study. They are, in decreasing order of abundance:

Common Name	Species Name
Deepbody anchovy	Anchoa compressa*
California grunion	Leuresthes tenuis*
Shiner surfperch	Cymatogaster aggregata*
Slough anchovy	Anchoa delicatissima*
White surfperch	Phanerodon furcatus
Round stingray	Urolophus halleri*
Salema	Xenistius californiensis

Five of these seven, indicated by asterisks, also were treated as critical species for the nekton studies, as described in Section 6.3 of this report.

Data for these 22 critically treated species of fishes have been considered in greater detail than those for the remaining 57 species. In some cases, however, as described in the following subsections concerning impingement, there were insufficient data to allow detailed treatment.

Shown in Table 7.4-4 are the numerical rankings and percentages of occurrence for each of these 22 critical species. The values shown separately for each impingement station and for all stations combined are based on the total number of individuals of each species taken during the 336-day sampling period (Table 7.4-3), expressed as percentages of the total number of all fishes taken in that set of samples.

The data shown in Tables 7.4-3 and 7.4-4 indicate that the queenfish (Seriphus politus) had by far the highest level of impingement at the traveling screen stations (18,681 individuals; 23.4 percent of all fishes). The deepbody anchovy (Anchoa compressa) experienced the second highest level of impingement (13,299 individuals; 16.7 percent), the topsmelt (Atherinops affinis) the third highest level, and the California grunion (Leuresthes tenuis) the fourth highest level (8,583 individuals; 10.8 percent). Two species, the northern anchovy (Engraulis mordax) and the shiner surfperch (Cymatogaster aggregata) experienced the next highest levels of impingement that were essentially the same (9.3 and 9.2 percent, respectively).

All six of these highest ranking species are very abundant in the area near the Encina Power Plant, as described in Sections 6.2 and 6.5 of this report. Because of this, their relatively high levels of impingement are not surprising. Examination of impingement monitoring records obtained by SDG&E during the period 1972-1978 (see Section 7.3) indicated that, in general,

TABLE 7.4-4
NUMERICAL RANKING AND PERCENTAGES OF OCCURRENCE IN IMPINGEMENT SAMPLES AT STATIONS 1, 4 AND 5 FOR CRITICALLY TREATED FISH SPECIES
ENCINA POWER PLANT - AUGUST 1, 1980

Rank	Common Name	Species Name	PERCENT OCCURRENCE Station 1	Station 4	Station 5	All Stations
1	Queenfish	*Seriphus politus* (C)	24.7	24.5	21.0	23.4
2	Deepbody anchovy	*Anchoa compressa* (AC)	15.9	13.0	23.0	16.7
3	Topsmelt	*Atherinops affinis* (C)	5.6	16.3	13.9	13.7
4	California grunion	*Leuresthes tenuis* (AC)	13.5	13.4	5.0	10.8
5	Northern anchovy	*Engraulis mordax* (C)	5.4	12.3	5.3	9.3
6	Shiner surfperch	*Cymatogaster aggregata* (AC)	9.3	5.9	10.3	9.2
8	Walleye surfperch	*Hyperprosopon argenteum* (C)	4.5	1.4	2.6	2.4
9	Slough anchovy	*Anchoa delicatissima* (AC)	3.1	2.6	1.1	2.2
10	White surfperch	*Phanerodon furcatus* (AC)	5.2	1.1	1.5	2.2
11	Round stingray	*Urolophus halleri* (AC)	2.4	1.5	2.8	2.0
12	California halibut	*Paralichthys californicus* (C)	1.2	1.0	2.5	1.5
13	Giant kelpfish	*Heterostichus rostratus* (C)	1.7	1.6	0.5	1.3
16	Salema	*Xenistius californiensis* (AC)	0.6	1.0	0.2	0.7
27	Barred sand bass	*Paralabrax nebulifer* (C)	0.2	0.2	0.3	0.2
33	California corbina	*Menticirrhus undulatus* (C)	0.2	0.1	0.2	0.2
35	Barred surfperch	*Amphistichus argenteus* (C)	0.2	0.1	0.1	0.1
36	Spotted sand bass	*Paralabrax maculatofasciatus* (C)	0.03	0.1	0.2	0.1
37	Striped mullet	*Mugil cephalus* (C)	0.03	0.03	0.2	0.1
49	Kelp bass	*Paralabrax clathratus* (C)	0.1	0.04	0.04	0.04
56	White seabass	*Cynoscion nobilis* (C)	0.04	0.03	0.04	0.03
	California sheephead	*Pimelometopon pulchrum* (C)	0	0	0	0
	Pacific sanddab	*Citharichthys sordidus* (C)	0	0	0	0
	Hornyhead turbot	*Pleuronichthys verticalis* (C)	0	0	0	0

these same groups of fishes also had the highest levels of impingement during the previous six-year period.

The six species ranking next highest in impingement had considerably lower, similar levels ranging from 1,877 individuals (2.4 percent of all fishes) for the walleye surfperch (Hyperprosopon argenteum) to 1,046 individuals (1.3 percent) for the giant kelpfish (Heterostichus rostratus). All of the remaining species had levels of impingement that represented less than 1.0 percent of the total number of all fishes impinged during the 336-day sampling period.

Among the 12 species exhibiting levels of impingement greater than 1.0 percent, only three are bottom fishes (Tables 7.4-3 and 7.4-4). They are the round stingray (Urolophus halleri), the California halibut (Paralichthys californicus), and the giant kelpfish (Heterostichus rostratus). The other nine species are all relatively active, open water forms. They are also the nine highest ranking species in terms of levels of impingement (Table 7.4-3).

Seven of the critical species had levels of impingement less than 0.2 percent ($\leq$ 189 individuals), as shown in Tables 7.4-3 and 7.4-4. These species are:

Common Name	Species Name
Barred sand bass	Paralabrax nebulifer
California corbina	Menticirrhus undulatus
Barred surfperch	Amphistichus argenteus
Spotted sand bass	Paralabrax maculatofasciatus

Striped mullet	*Mugil cephalus*
Kelp bass	*Paralabrax clathratus*
White sea bass	*Cynoscion nobilis*

No individuals of the three remaining critical species were taken in any of the impingement samples during the 336-day period of the study (Table 7.4-4). These species are:

Common Name	Species Name
California sheephead	*Pimelometopon pulchrum*
Pacific sanddab	*Citharichthys sordidus*
Hornyhead turbot	*Pleuronichthys verticalis*

Their absence from the impingement samples is not surprising, because they are unlikely to occur in the immediate vicinity of the Power Plant. Pacific sanddab normally occurs at depths greater than 30 m in the ocean. Because they were absent from all impingement samples, these three species were not considered in the following subsections concerning impingement.

As shown in Table 7.4-4, there was some variation in the percentage of individuals of a given species impinged by the three different traveling screen systems (stations 1, 4, and 5). However, in general, the levels were fairly consistent between the three stations. There appears to be no pattern to these variations shown in Table 7.4-4 and they are presumed to be the result of random processes.

As indicated in Table 7.4-3, four large invertebrate species ranked relatively high in levels of impingement, with more than

500 individuals of each occurring in all samples during the 336-day period of the study. Anthony's rock crab (Cancer anthonyi) had by far the highest level of impingement (1,877 individuals, 40.4 percent of all large invertebrates impinged). However, in relation to all invertebrate and fish species taken in the impingement samples, Anthony's rock crab ranked seventh at 2.2 percent. Most of the individuals impinged were juveniles or small adults. Anthony's rock crab is of very slight commercial importance in the San Diego area. Two smaller crabs, Portunus xantusi and Pachygrapsus crassipes, had approximately equal levels of impingement (14.1 and 13.8 percent, respectively). These two species, which have no commercial or sportfishing value, are very common in Agua Hedionda Lagoon. A fourth species, the squid Loligo opalescens, represented 9.3 percent of the invertebrates impinged, but only 0.5 percent of all invertebrates and fishes combined (numerical rank 17). This species supports a commercial fishery elsewhere in California.

Three other invertebrate species of value to man as food ranked much lower in their levels of impingement (Table 7.4-3). The California brown shrimp (Penaeus californiensis) ranked twenty-sixth, representing only 3.2 percent of all large invertebrates impinged. The common rock crab (Cancer antennarius) ranked forty-eighth, representing only 0.6 percent of all large invertebrates. The California spiny lobster (Panulirus interruptus) ranked seventy-sixth, with only two individuals (0.03 percent) impinged during the 336-day period of the study.

In general, these results suggest that invertebrates formed a very small part of the animal material impinged at the Encina Power Plant. Because of this, they were not included in the more detailed evaluation described in the following subsections concerning impingement.

The numerical ranking, total number, and size data for each fish species taken at the bar rack screening system (station 9) during the period February 4, 1979 - January 4, 1980 are shown in Table 7.4-5. No large invertebrates were observed in these samples.

Only 22 individuals of 6 fish species were observed in the bar rack samples (Table 7.4-5). Of these, the Pacific electric ray (Torpedo californica) was the only common form (16 individuals; 72.7 percent of the total). The next most common species observed was the bat ray (Myliobatis californica), of which two individuals were observed (9.1 percent). With the exception of one large spotfin croaker (Roncador stearnsi), all of the species observed were rays or sharks (elasmobranch fishes).

All individuals were quite large, with a size range of 380-1200 mm in total length and individual body weights up to 34.7 kg. Because of the wide spacing of the vertical bars in the bar rack screening system, impingement of fishes was, as expected, limited to very few individuals of large size.

Shown in Table 7.4-6 is the ranking by weight of each fish and invertebrate species taken in samples at traveling screen stations 1, 4, and 5. Total weights (g) for all individuals

000495

TABLE 7.4-5
NUMERICAL RANKING OF LARGE FISH SPECIES IMPINGED AT THE BAR RACK SCREENING SYSTEM OF THE ENCINA POWER PLANT DURING THE PERIOD FEBRUARY 4, 1979 - JANUARY 4, 1980

Rank	Common Name	Scientific Name	Number Observed	Total Length (mm) $\bar{x}$	Total Length (mm) Range	Weight (g) $\bar{x}$	Weight (g) Range
1	Pacific electric ray	*Torpedo californica*	16	1015	650-1200	10584	6600-34700
2	Bat ray	*Myliobatis californica*	2	812	805-820	2250	2000-2500
3	California butterfly ray	*Gymnura marmorata*	1	380		1754	
3	Thornback ray	*Platyrhinoidis triseriata*	1	510		735	
3	Spotfin croaker	*Roncador stearnsi*	1	708		3630	
3	Pacific angel shark	*Squatina californica*	1	1130		14500	
		TOTAL -	22				

TABLE 7.4-6
RANKING BY WEIGHT OF ALL FISH AND INVERTEBRATE SPECIES IMPINGED AT ENCINA POWER PLANT TRAVELING SCREEN STATIONS DURING THE PERIOD FEBRUARY 4, 1979 - JANUARY 4, 1980

RANK	COMMON NAME	SCIENTIFIC NAME	TOTAL WEIGHT STATION 1	STATION 4	STATION 5	TOTAL
1	ROUND STINGRAY	UROLOPHUS HALLERI	40178	48384	97334	185896
2	PACIFIC ELECTRIC RAY	TORPEDO CALIFORNICA	15316	23470	87114	125900
3	TOPSMELT	ATHERINOPS AFFINIS	8587	44158	59595	112340
4	QUEENFISH	SERIPHUS POLITUS	13615	28646	49053	91314
5	SPECKLEFIN MIDSHIPMAN	PORICHTHYS MYRIASTER	7484	19694	51554	78732
6	CALIFORNIA BUTTERFLY RAY	GYMNURA MARMORATA	6164	9512	50448	66124
7	DEEPBODY ANCHOVY	ANCHOA COMPRESSA	14002	20506	29815	64323
8	CALIFORNIA HALIBUT	PARALICHTHYS CALIFORNICUS	5924	13694	37510	57128
9	DIAMOND TURBOT	HYPSOPSETTA GUTTULATA	3998	9812	42736	56546
10	BAT RAY	MYLIOBATUS CALIFORNICA	7352	9034	40042	56428
11	SHINER SURFPERCH	CYMATOGASTER AGGREGATA	9583	19516	24159	53258
12	WALLEYE SURFPERCH	HYPERPROSOPON ARGENTEUM	9860	14212	26333	50405
13	THORNBACK RAY	PLATYRHINOIDIS TRISERIATA	5284	8980	33886	48150
14	STRIPED MULLET	MUGIL CEPHALUS	2172	10904	31654	44730
15	TWO-SPOTTED OCTOPUS	OCTOPUS BIMACULATUS	10332	11298	19554	41184
16	ANTHONY'S ROCK CRAB	CANCER ANTHONYI	23542	4609	7057	35208
17	CALIFORNIA GRUNION	LEURESTHES TENUIS	7162	15922	10686	33770
18	CALIFORNIA SEA HARE	APLYSIA CALIFORNICA	10320	0	10460	20780
19	MORAY EEL	GYMNOTHORAX MORDAX	6400	170	13620	20190
20	OPALEYE	GIRELLA NIGRICANS	390	98	17522	18010
21	WHITE SURFPERCH	PHANERODON FURCATUS	6516	4525	5950	16991
22	SPOTFIN CROAKER	RONCADOR STEARNSII	2518	2516	11520	16554
23	BARRED SAND BASS	PARALABRAX NEBULIFER	3088	3314	8907	15309
24	GIANT KELPFISH	HETEROSTICHUS ROSTRATUS	2719	7376	4817	14912
25	NORTHERN ANCHOVY	ENGRAULIS MORDAX	2290	7280	5003	14573
26	PENAEID SHRIMP	PENAEUS CALIFORNIENSIS	1928	968	11376	14272
27	GRAY SMOOTHHOUND	MUSTELUS CALIFORNICUS	652	922	11710	13284
28	SQUID	LOLIGO OPALESCENS	3180	6791	2795	12766
29	SWIMMING CRAB	PORTUNUS XANTUSI	3576	1470	5982	11028
30	SPOTTED SAND BASS	PARALABRAX MACULATOFASCIATUS	1240	2496	7121	10857
31	CALIFORNIA CORBINA	MENTICIRRHUS UNDULATUS	136	1013	8114	9263
32	CALIFORNIA FLYING FISH	CYPSELURUS CALIFORNICUS	1444	2540	4034	8018
33	PACIFIC BUTTERFISH	PEPRILUS SIMILLIMUS	302	1305	6401	8008
34	CALIFORNIA NEEDLEFISH	STRONGYLURA EXILIS	1062	2164	4594	7820
35	JACKSMELT	ATHERINOPSIS CALIFORNIENSIS	0	3190	3786	6976
36	STRIPED SHORE CRAB	PACHYGRAPSUS CRASSIPES	2318	2170	1905	6393
37	WHITE CROAKER	GENYONEMUS LINEATUS	266	950	4845	6061
38	PILE SURFPERCH	DAMALICHTHYS VACCA	21	374	5504	5899
39	SARGO	ANISOTREMUS DAVIDSONII	188	2692	2276	5156
40	STAGHORN SCULPIN	LEPTOCOTTUS ARMATUS	1478	1562	2113	5153
41	CALIFORNIA BARRACUDA	SPHYRAENA ARGENTEA	1367	2178	690	4235
42	SLOUGH ANCHOVY	ANCHOA DELICATISSIMA	1548	1662	896	4106
43	BLACK SURFPERCH	EMBIOTOCA JACKSONI	792	820	1954	3566
44	YELLOW SNAKE EEL	OPHICHTHUS ZOPHOCHIR	0	0	2944	2944
45	SHOVELNOSE GUITARFISH	RHINOBATOS PRODUCTUS	1610	0	974	2584
46	PACIFIC BONITO	SARDA CHILIENSIS	1490	0	886	2376
47	SPOTTED TURBOT	PLEURONICHTHYS RITTERI	480	394	1432	2306
48	BLACKSMITH	CHROMIS PUNCTIPINNIS	48	248	1958	2254
49	SALEMA	XENISTIUS CALIFORNIENSIS	575	1047	622	2244
50	PLAINFIN MIDSHIPMAN	PORICHTHYS NOTATUS	2144	0	[illegible]	[illegible]

000496

TABLE 7.4-6 (Continued)

RANK	COMMON NAME	SCIENTIFIC NAME	TOTAL WEIGHT STATION 1	STATION 4	STATION 5	TOTAL
51	CALIFORNIA TONGUEFISH	SYMPHURUS ATRICAUDA	460	784	888	2132
52	RUBBERLIP SURFPERCH	RHACOCHILUS TOXOTES	10	0	1952	1962
53	SWEET POTATO CUCUMBER	MOLPADIA ARENICOLA	880	236	739	1855
54	BARRED SURFPERCH	AMPHISTICHUS ARGENTEUS	183	572	1098	1853
55	KELP CRAB	PUGETTIA PRODUCTA	600	360	838	1798
56	STRIPED SEA SLUG	NAVANAX INERMIS	734	92	884	1710
57	YELLOWFIN CROAKER	UMBRINA RONCADOR	24	264	1316	1604
58	PURPLE-STRIPED JELLYFISH	PELAGIA PANOPYRA	1288	0	96	1384
59	PAINTED URCHIN	LYTECHINUS PICTUS	905	230	190	1325
60	ZEBRAPERCH	HERMOSILLA AZUREA	0	1200	0	1200
61	BASS	PARALABRAX SP.	0	156	928	1084
62	LEOPARD SHARK	TRIAKIS SEMIFASCIATA	0	0	996	996
63	FANTAIL SOLE	XYSTREURYS LIOLEPIS	0	388	264	652
64	PURPLE SHORE CRAB	HEMIGRAPSUS NUDUS	222	92	294	608
65	COMMON ROCK CRAB	CANCER ANTENNARIUS	271	160	176	607
66	BAY PIPEFISH	SYNGNATHUS LEPTORHYNCHUS	302	194	108	604
67	MEXICAN SCAD	DECAPTERUS HYPODUS	0	556	0	556
68	CALIFORNIA SPINY LOBSTER	PANULIRUS INTERRUPTUS	506	0	0	506
69	KELP BASS	PARALABRAX CLATHRATUS	118	222	162	502
70	KELP PIPEFISH	SYNGNATHUS CALIFORNIENSIS	68	56	318	442
71	MONTEREY SPANISH MACKERAL	SCOMBEROMORUS CONCOLOR	0	0	416	416
72	CALIFORNIA KILLIFISH	FUNDULUS PARVIPINNIS	18	381	12	411
73	GARIBALDI	HYPSYPOPS RUBICUNDUS	0	0	400	400
74	THREADFIN SHAD	DOROSOMA PETENENSE	0	86	300	386
75	HYDROID	AGLAOPHENIA (COLONY OF HYDROIDEA)	64	38	272	374
76	ISLAND SURFPERCH	CYMATOGASTER GRACILIS	26	206	126	358
77	SOUTHERN KELP CRAB	TALIEPUS NUTTALLI	166	14	160	340
78	PACIFIC ANGEL SHARK	SQUATINA CALIFORNICA	0	130	164	294
79	SCULPIN/SPOTTED SCORPIONFISH	SCORPAENA GUTTATA	0	286	0	286
80	HYDROMEDUSA	POLYORCHIS PENICILLATUS	131	129	17	277
81	PURPLE SEA URCHIN	STRONGYLOCENTROTUS PURPURATUS	120	0	150	270
82	JACK MACKERAL	TRACHURUS SYMMETRICUS	0	0	244	244
83	MUSSEL BLENNY	HYPSOBLENNIUS JENKINSI	24	74	130	228
84	WHITE SEABASS	CYNOSCION NOBILIS	48	88	90	226
85	ISLAND KELPFISH	ALLOCLINUS HOLDERI	52	74	76	202
86	PACIFIC HERRING	CLUPEA HARENGUS	0	0	164	164
87	ROCKPOOL BLENNY	HYPSOBLENNIUS GILBERTI	72	44	34	150
88	ANCHOVY	ANCHOA SP.	24	6	96	126
89	GHOST SHRIMP	CALLIANASSA CALIFORNIENSIS	51	72	0	123
90	GIANT KEYHOLE LIMPET	MEGATHURA CRENULATA	122	0	0	122
91	DWARF SURFPERCH	MICROMETUS MINIMUS	12	0	108	120
92	KELP SURFPERCH	BRACHYISTIUS FRENATUS	6	0	112	118
93	BLACK SPOTTED SHRIMP	CRANGON NIGROMACULATA	76	10	30	116
94	STRIPED KELPFISH	GIBBONSIA METZI	0	104	0	104
95	SEA PORCUPINE	LOVENIA CORDIFORMIS	0	0	88	88
96	HAIRY CRAB	PILUMNUS SPINOHIRSUTUS	68	18	0	86
97	LONGFIN SANDDAB	CITHARICHTHYS XANTHOSTIGMA	0	82	0	82
97	HORN SHARK	HETERODONTUS FRANCISCI	0	0	74	74
98	SPECKLED SANDDAB	CITHARICHTHYS STIGMAEUS	48	0	26	74
99	HALFMOON	MEDIALUNA CALIFORNIENSIS	0	42	10	52

000497

TABLE 7.4-6 (Concluded)

RANK	COMMON NAME	SCIENTIFIC NAME	TOTAL WEIGHT STATION 1	STATION 4	STATION 5	TOTAL
100	RAY BLENNY	HYPSOBLENNIUS GENTILIS	24	10	6	40
101	SPIDER CRAB	PYROMAIA TUBERCULATA	0	0	32	32
102	ROSY SCULPIN	OLIGOCOTTUS RUBELLIO	26	0	0	26
103	RED ROCK CRAB	CANCER PRODUCTUS	18	0	0	18
104	AGGREGATE SEA ANEMONE	ANTHOPLEURA ELEGANTISSIMA	12	0	0	12
105	NUDIBRANCH	HERMISSENDA CRASSICORNIS	10	0	0	10
105	PISTOL SHRIMP	ALPHEUS DENTIPES	0	0	10	10
106	PACIFIC SPEAR SCALLOP	CHLAMYS HASTATUS	0	0	8	8
107	MASKING CRAB	LOXORHYNCHUS CRISPATUS	6	0	0	6
108	NUDIBRANCH	AEOLIDIA PAPILLOSA	0	0	4	4
108	OCHRE STARFISH	PISASTER OCHRACEUS	0	0	4	4
108	SAN DIEGO SEA SLUG	DIAULULA SANDIEGENSIS	4	0	0	4
108	SPECKLED SCALLOP	AEQUIPECTEN AEQUISULCATUS	2	2	0	4
108	SPIDER CRAB	PODOCHELA HEMPHILLI	4	0	0	4
108	STRIPED SHRIMP	LYSMATA CALIFORNICA	4	0	0	4
109	BRITTLE STARS	OPHIUROIDEA	2	0	0	2
		TOTAL WEIGHT OF FISHES (kg)	199.1	353.3	842.8	1395.2
		TOTAL WEIGHT OF INVERTEBRATES (kg)	61.4	28.7	63.1	153.2
		TOTAL WEIGHT OF ANIMALS (kg)	260.5	382.0	905.9	1548.4

of each species taken during the 336-day sampling period are shown for each traveling screen station and for the three stations combined. Also shown are total weights, rounded to the nearest 0.1 kg, for all fish species, all invertebrate species, and all animal material combined.

As indicated in Table 7.4-6, many of these rankings by weight differed considerably from those based on numbers of individuals impinged (Tables 7.4-3 and 7.4-4). The round stingray (Urolophus halleri) and the Pacific electric ray (Torpedo californica) ranked first and second based on total weights of animal material impinged. The total weight of round stingray impinged was 185.9 kg (410 lb) or 13.3 percent of all fishes by weight. The total weight of Pacific electric ray impinged was 125.9 kg (227.6 lb) or 9.0 percent of all fishes by weight. In contrast, they ranked only eleventh and fifty-eighth, respectively, based on numbers impinged. These and other large, heavy-bodied rays were prominent in the higher rankings based on weight, with the California butterfly ray (Myliobatis californica) among the first ten.

The topsmelt (Atherinops affinis) ranked third both in number and weight of individuals impinged (Tables 7.4-3 and 7.4-6). Its total weight of 112.3 kg (247.6 lb) represented 8.0 percent of all fishes by weight. The queenfish (Seriphus politus), which ranked first in numbers of individuals impinged, also has a high rank of fourth in terms of weight. Its total weight of 91.3 kg (201.3 lb) represented 6.5 percent of all fishes by weight. Among the other species ranked within the first ten on the basis of numbers impinged, only the deepbody anchovy (Anchoa compressa) also was ranked within that range on the basis of weight. It was ranked second by number impinged and seventh by weight. However, several of the other species ranked within the first ten by number impinged (Table 7.4-3) did fall within the first 20 ranks by weight (Table 7.4-6). They are the shiner surfperch (Cymatogaster aggregata) ranked eleventh by weight, the walleye surfperch (Hyperprosopon argenteum) ranked twelfth by weight, and the California grunion (Leuresthes tenuis) ranked seventeenth by weight.

The specklefin midshipman (Porichthys myriaster) also was a major component by weight (rank 5). Yet this species was ranked only twenty-first on the basis of numbers impinged. Two large invertebrate species ranked relatively high in terms of weight. They are the two-spotted octopus (Octopus bimaculatus) ranked fifteenth, and Anthony's rock crab (Cancer anthonyi) ranked sixteenth. In contrast, Anthony's rock crab was ranked seventh by number impinged and two-spotted octopus was ranked only thirty-eighth. Both species were periodically quite common in the study area, and their occurrence as major invertebrate components of the impingement samples is not surprising.

As indicated in Table 7.4-6, the total weight of all animal material impinged at the three traveling screen stations during sampling over the 336-day period was 1548.4 kg (3414 lb). Of this material, 1395.2 kg (3076 lb) consisted of fishes and 153.2

kg (338 lb) of large invertebrates. Thus, fishes accounted for 90.1 percent of this material and invertebrates only 9.9 percent. The highest weight of animals was impinged at traveling screen station 5 (842.8 kg or 18,158 lb of fishes; 63.1 kg or 139 lb of invertebrates). The second highest weight of animals was impinged at station 4 (353.3 kg or 779 lb of fishes; 28.7 kg or 63 lb of invertebrates), and the lowest weight of animals was impinged at station 1 (199.1 kg or 439 lb of fishes; 61.4 kg or 135 lb of invertebrates).

These weights are somewhat lower than the true amounts impinged during the period February 4, 1979 - January 4, 1980, because sampling could not be completed on all days and because some badly damaged animals were not weighed. These data also exclude the weights of fishes removed during tunnel recirculation. However, they represent reasonably accurate estimates for total weights of material impinged.

7.5 VARIATIONS IN NUMBER AND BIOMASS OF FISHES IMPINGED IN RELATION TO ENVIRONMENTAL FACTORS

Short- and long-term fluctuations in numbers and biomass of fishes impinged during the 48-week study period are considered in this section, with emphasis on the critical species identified in Section 7.4. The possible influences of major environmental factors on impingement also are considered. These factors are water temperature, salinity, wave conditions, wind speed, storms and rainfall, cloud cover, and dredging operations in outer Agua Hedionda Lagoon. Possible effects on impingement of day vs. night conditions, tidal conditions, and flow rates in the cooling water system are considered separately in Sections 7.6, 7.7, and 7.8, respectively.

Plots of mean total number and mean total weight of all fishes impinged at traveling screen station 1 per 24-hr interval over the period February 4, 1979-January 4, 1980 are shown in Figures 7.5-1 and 7.5-2, respectively. These mean values are based on data taken during each 7-day sampling interval. Also shown on these same figures for comparison is a plot of mean water temperatures for each of the same 7-day periods. Plots of these impingement data for traveling screen station 4 are given in Figures 7.5-3 and 7.5-4 and for station 5 in Figures 7.5-5 and 7.5-6. Plots of the combined impingement data for all three stations are shown in Figures 7.5-7 and 7.5-8.

The mean impingement values for each weekly interval on which these plots were based are given in Table 7.5-1. Also

TABLE 7.5-1
MEAN TOTAL NUMBER AND WEIGHT (g) OF ALL FISHES IMPINGED AT ENCINA POWER PLANT TRAVELING SCREEN STATIONS PER 24-HOUR INTERVAL OVER THE PERIOD FEBRUARY 4, 1979 - JANUARY 4, 1980

		STATION 1		STATION 4		STATION 5		ALL STATIONS	
TIME PERIOD	WEEK	Total Number	Total Weight	Total Number	Total Weight	Total Number	Total Weight	Total Number	Total Weight
Feb 4-10	1	46	522.0	293	2688.0	116	1786.0	455	4996.0
11-17	2	31	242.0	170	1107.0	90	1148.0	291	2497.0
18-24	3	72	788.0	519	5447.0	783	5759.0	1374	11994.0
Feb 25-Mar 3	4	91	914.0	160	2392.0	115	1603.0	366	4909.0
Mar 4-10	5	6	50.0	0	0.0	41	1123.0	47	1173.0
11-17	6	13	73.0	0	0.0	35	1157.0	48	1230.0
18-24	7	13	105.0	0	0.0	30	4583.0	43	4688.0
25-31	8	7	29.0	0	0.0	24	2232.0	31	2261.0
Apr 1- 7	9	5	174.0	0	0.0	271	9573.0	276	9747.0
8-14	10	3	91.0	0	0.0	21	1135.0	24	1226.0
15-21	11	2	47.0	0	0.0	18	1470.0	20	1517.0
22-28	12	8	110.0	0	0.0	50	1944.0	58	2054.0
Apr 29-May 5	13	14	185.0	0	0.0	11	2882.0	25	3067.0
May 6-12	14	97	521.0	0	0.0	0	0.0	97	521.0
13-19	15	33	219.0	0	0.0	0	0.0	33	219.0
20-26	16	67	820.0	0	0.0	0	0.0	67	820.0
May 27-Jun 2	17	52	478.0	0	0.0	0	0.0	52	478.0
Jun 3- 9	18	57	288.0	12	92.0	49	952.0	118	1332.0
10-16	19	91	798.0	42	224.0	61	948.0	194	1970.0
17-23	20	107	487.0	236	1943.0	148	3585.0	491	6015.0
24-30	21	51	274.0	320	927.0	145	2105.0	516	3306.0
Jul 1- 7	22	31	187.0	235	549.0	102	593.0	368	1329.0
8-14	23	30	59.0	323	716.0	258	1642.0	611	2417.0
15-21	24	31	274.0	77	426.0	58	752.0	166	1452.0
22-28	25	87	237.0	112	278.0	106	1052.0	305	1567.0
Jul 29-Aug 4	26	95	972.0	195	476.0	72	3193.0	362	4641.0
Aug 5-11	27	17	145.0	58	183.0	32	563.0	107	891.0
12-18	28	46	192.0	105	422.0	41	945.0	192	1559.0
19-25	29	108	425.0	380	1012.0	103	1040.0	591	2477.0
Aug 26-Sep 1	30	55	194.0	153	1381.0	53	267.0	261	1842.0
Sep 2- 8	31	54	113.0	216	703.0	73	739.0	343	1555.0
9-15	32	15	106.0	67	109.0	21	234.0	103	449.0
16-22	33	39	168.0	31	312.0	20	530.0	90	1010.0
23-29	34	57	463.0	42	365.0	90	932.0	189	1760.0
Sep 30-Oct 6	35	41	283.0	100	515.0	53	980.0	194	1778.0
Oct 7-13	36	33	2033.0	75	414.0	22	722.0	130	3169.0
14-20	37	34	110.0	94	257.0	28	501.0	156	868.0
21-27	38	79	471.0	223	909.0	68	760.0	370	2140.0
Oct 28-Nov 3	39	187	494.0	168	375.0	62	1114.0	417	1983.0
Nov 4-10	40	88	539.0	100	430.0	59	1164.0	247	2133.0
11-17	41	53	520.0	196	675.0	58	640.0	307	1835.0
18-24	42	210	711.0	394	1094.0	189	1353.0	793	3158.0
Nov 25-Dec 1	43	60	537.0	513	207.0	11	343.0	584	1087.0
Dec 2- 8	44	37	235.0	143	1032.0	49	1379.0	229	2646.0
9-15	45	13	152.0	60	544.0	24	866.0	97	1562.0
16-22	46	9	187.0	123	844.0	64	1146.0	196	2177.0
23-29	47	34	391.0	91	773.0	21	357.0	146	1521.0
Dec 30-Jan 4	48	8	112.0	33	1523.0	7	1204.0	48	2839.0
	48-WK MEAN	50.4	365.1	126.2	653.0	78.2	1437.0	254.8	2455.5

shown in Table 7.5-1 are the overall mean numbers and weights of all fishes impinged over the 48-week period of the study.

Plots of weekly mean temperature and salinity values for seawater entering the cooling water system of the Encina Power Plant during the 48-week period are shown in Figure 7.5-9. As indicated in Appendix Section 16.2.3, these measurements were made at the point where seawater enters the bar rack screening system. Weekly mean flow rates, temperature, and salinity values are given in Table 7.5-2.

Plots of weekly mean values for wave height of the ocean just offshore from the Encina Power Plant and of cloud cover are shown in Figure 7.5-10. Observations of wave height for the ocean were made at a point near where seawater enters Agua Hedionda Lagoon, the source of cooling water for the Power Plant. The presumption was that high waves at that point associated with storm conditions may cause some fishes to move into the lagoon seeking shelter and thus become more susceptible to impingement. Observations also were made of wave heights in Agua Hedionda Lagoon adjacent to the bar rack screening system. However, these wave heights were always less than one foot and for that reason were not considered to be a significant factor affecting impingement.

Shown in Table 7.5-3 are detailed data for total number and total weight of all fishes impinged at traveling screen stations 1, 4, and 5 during each 12-hr sampling interval over the period February 4, 1979-January 4, 1980. Also shown in this table are

TABLE 7.5-2
WEEKLY MEAN TEMPERATURES (°C), SALINITIES (‰) AND FLOW RATES (1000 gpm) OF SEAWATER ENTERING THE COOLING WATER SYSTEM OF THE ENCINA POWER PLANT DURING THE PERIOD FEBRUARY 4, 1979 - JANUARY 4, 1980

TIME PERIOD	WEEK	TEMPERATURE (°C)	SALINITY (°/oo)	UNITS 1-3 Flow Rate (1000 gpm)	UNIT 4 Flow Rate (1000 gpm)	UNIT 5 Flow Rate (1000 gpm)	TOTAL PLANT Flow Rate (1000 gpm)
Feb 4-10	1	13.5	32.5	121	180	220	521
11-17	2	14.5	32.5	134	180	220	534
18-24	3	14.0	31.3	134	153	220	507
Feb 25-Mar 3	4	14.0	32.1	134	153	220	507
Mar 4-10	5	14.5	32.5	134	0	220	354
11-17	6	15.5	31.5	134	0	220	354
18-24	7	15.0	30.6	134	0	220	354
25-31	8	16.5	30.9	134	0	220	354
Apr 1- 7	9	17.0	31.8	134	0	220	354
8-14	10	17.0	31.7	129	0	220	349
15-21	11	17.0	31.9	121	0	220	341
22-28	12	16.0	32.7	127	0	188	315
Apr 29-May 5	13	17.0	32.4	108	0	220	328
May 6-12	14	16.0	31.1	134	0	0	134
13-19	15	16.5	32.2	134	0	0	134
20-26	16	18.0	32.0	134	13	0	147
May 27-Jun 2	17	19.0	32.3	134	0	0	134
Jun 3- 9	18	18.5	32.6	128	27	220	375
10-16	19	20.5	33.0	134	27	215	376
17-23	20	20.0	32.5	97	27	220	344
24-30	21	21.5	32.8	88	0	220	308
Jul 1- 7	22	20.5	32.6	76	0	220	296
8-14	23	21.0	32.7	82	27	220	329
15-21	24	19.5	32.4	134	153	220	507
22-28	25	21.0	32.4	114	180	220	514
Jul 29-Aug 4	26	20.0	32.3	134	180	220	534
Aug 5-11	27	22.5	32.5	134	180	220	534
12-18	28	22.0	32.5	127	180	220	527
19-25	29	20.5	32.4	133	180	188	501
Aug 26-Sep 1	30	21.0	32.2	134	180	188	502
Sep 2- 8	31	21.0	32.7	134	180	220	534
9-15	32	20.5	32.6	134	129	220	483
16-22	33	21.0	32.6	134	153	210	497
23-29	34	19.5	32.6	134	153	220	507
Sep 30-Oct 6	35	16.5	32.8	134	153	220	507
Oct 7-13	36	17.5	32.7	134	180	220	534
14-20	37	18.0	32.7	134	180	220	534
21-27	38	17.5	32.7	134	180	220	534
Oct 28-Nov 3	39	14.5	32.8	134	180	220	534
Nov 4-10	40	16.0	32.7	134	180	220	534
11-17	41	15.0	32.7	134	180	220	534
18-24	42	11.5	32.8	134	180	220	534
Nov 25-Dec 1	43	14.0	32.8	127	180	220	527
Dec 2- 8	44	14.0	32.8	134	180	220	534
9-15	45	14.5	33.0	134	171	220	525
16-22	46	15.0	32.8	134	180	220	534
23-29	47	14.0	32.6	134	13	220	367
Dec 30-Jan 4	48	12.5	32.7	134	171	220	525

TABLE 7.5-3
TOTAL NUMBERS AND WEIGHTS (g) OF ALL FISHES IMPINGED AT ENCINA POWER PLANT TRAVELING SCREEN STATIONS DURING EACH 12-HOUR SAMPLING INTERVAL OVER THE PERIOD
FEBRUARY 4, 1979 - JANUARY 4, 1980

		STATION 1		4		5	
DATE	TIME OF DAY	TOTAL NUMBER	TOTAL WEIGHT	TOTAL NUMBER	TOTAL WEIGHT	TOTAL NUMBER	TOTAL WEIGHT
790204	DAY	21	653	514	6426	14	221
	NIGHT	0	0	13	79	20	642
790205	DAY	5	53	35	1187	13	450
	NIGHT	36	1267	47	2303	317	3337
790206	DAY	0	0	130	1094	26	491
	NIGHT	0	0	73	768	29	697
790207	DAY	80	116	115	220	72	594
	NIGHT	52	558	0	0	9	130
790208	DAY	4	15	115	1142	42	692
	NIGHT	3	121	360	660	60	345
790209	DAY	5	2	210	3017	80	3526
	NIGHT	96	690	292	1109	60	370
790210	DAY	18	180	84	630	35	243
	NIGHT	0	0	63	181	36	764
790211	DAY	16	25	10	77	45	228
	NIGHT	8	446	235	636	20	734
790212	DAY	0	0	0	0	27	343
	NIGHT	30	227	285	405	36	690
790213	DAY	5	7	70	959	4	42
	NIGHT	8	54	224	1230	32	517
790214	DAY	15	11	16	64	8	61
	NIGHT	0	0	50	349	88	504
790215	DAY	5	149	1	12	12	640
	NIGHT	36	221	0	0	101	1185
790216	DAY	1	0	67	894	70	1799
	NIGHT	26	161	101	1945	50	247
790217	DAY	6	7	21	423	27	503
	NIGHT	60	383	108	754	42	570
790218	DAY	0	0	8	77	10	640
	NIGHT	24	211	180	672	21	374
790219	DAY	5	57	0	0	17	1123
	NIGHT Start of	54	1034	324	1619	36	641
790220	DAY ← Dredging	3	34	27	379	26	530
	NIGHT ▲	41	373	321	1467	56	823
790221	DAY	10	77	191	2673	90	3310
	NIGHT ●	47	235	178	680	22	307
790222	DAY ◊ ×	27	99	402	3254	1184	8005
	NIGHT ●	150	610	1269	10259	1716	8694
790223	DAY ×	16	581	157	7741	370	2878
	NIGHT	44	1133	291	6644	692	5486
790224	DAY	27	233	3	25	888	5804
	NIGHT TR ×	54	838	282	2637	355	1698
790225	DAY	6	14	152	562	0	0
790226	DAY ●	46	840	100	736	84	4198
	NIGHT	54	259	76	605	96	4068
790227	DAY	24	193	63	2286	52	839

000506

TABLE 7.5-3 (Continued)

DATE	TIME OF DAY	STATION 1 TOTAL NUMBER	1 TOTAL WEIGHT	4 TOTAL NUMBER	4 TOTAL WEIGHT	5 TOTAL NUMBER	5 TOTAL WEIGHT
790228	DAY	51	882	72	2393	28	518
	NIGHT	57	566	162	1682	78	695
790301	DAY ▲	27	418	49	841	50	1068
	NIGHT ◇	51	665	59	509	0	0
790302	DAY ◇	40	667	63	1159	52	2067
	NIGHT	120	663	276	5019	78	1444
790303	DAY	15	53	0	0	252	3796
	NIGHT	78	1177	48	951	32	1636
790304	NIGHT	18	78	0	0	57	1674
790305	DAY	7	87	0	0	56	1299
790306	DAY	0	0	0	0	28	1043
	NIGHT	1	8	0	0	11	735
790307	DAY	1	3	0	0	28	376
	NIGHT	4	6	0	0	13	316
790308	DAY	1	9	0	0	14	632
	NIGHT	4	17	0	0	15	136
790309	DAY	1	3	0	0	16	600
	NIGHT	1	3	0	0	12	517
790310	DAY	0	0	0	0	24	216
	NIGHT	7	136	0	0	15	314
790311	DAY ◇	3	12	0	0	9	234
	NIGHT	9	31	0	0	9	210
790312	DAY ◇	2	8	0	0	7	122
	NIGHT ▲	2	6	0	0	8	83
790313	DAY	1	3	0	0	10	739
	NIGHT	12	100	0	0	30	624
790314	DAY	4	18	0	0	20	1367
	NIGHT	17	140	0	0	31	602
790315	DAY	5	17	0	0	14	178
	NIGHT ●	18	74	0	0	32	890
790316	DAY	5	21	0	0	10	614
	NIGHT ●	9	55	0	0	32	1242
790317	DAY × ▲	0	0	0	0	23	941
	NIGHT ×	6	25	0	0	9	251
790318	DAY	2	4	0	0	10	728
	NIGHT ●	14	85	0	0	20	600
790319	DAY	0	0	0	0	1	56
	NIGHT × ▲	5	23	0	0	12	9060
790320	DAY × ▲	7	28	0	0	12	1103
	NIGHT ×	10	78	0	0	6	489
790321	DAY ◇	4	16	0	0	23	1503
	NIGHT ● ×	9	31	0	0	27	1166
790322	DAY	15	196	0	0	11	276
	NIGHT	1	0	0	0	15	896
790323	DAY	2	27	0	0	21	9133
	NIGHT	7	24	0	0	27	2052
790324	DAY	3	181	0	0	7	446
	NIGHT	9	41	0	0	18	576
790325	DAY	1	4	0	0	10	470
	NIGHT	7	24	0	0	16	481
790326	DAY	0	0	0	0	5	843
	NIGHT	8	50	0	0	9	262
790327	DAY ● ●	1	4	0	0	8	781
	NIGHT ● ◇ ▲	7	23	0	0	19	851
790328	DAY × ▲	4	28	0	0	11	5529
	NIGHT ×	7	20	0	0	24	2536
790329	DAY	4	17	0	0	7	465
	NIGHT ●	4	11	0	0	19	452
790330	DAY ×	0	0	0	0	12	645
	NIGHT	3	11	0	0	15	570
790331	DAY ×	0	0	0	0	8	1594
	NIGHT TR	4	14	0	0	7	147

TABLE 7.5-3 (Continued)

DATE	TIME OF DAY	STATION 1 TOTAL NUMBER	TOTAL WEIGHT	4 TOTAL NUMBER	TOTAL WEIGHT	5 TOTAL NUMBER	TOTAL WEIGHT
790401	DAY	22	89	0	0	220	7171
	NIGHT	0	0	0	0	1403	34888
790402	DAY	1	208	0	0	84	2692
	NIGHT	4	702	0	0	72	1475
790403	DAY	0	0	0	0	24	4454
	NIGHT	0	0	0	0	20	1034
790404	DAY	2	9	0	0	20	4970
	NIGHT	1	158	0	0	10	1535
790405	DAY	2	39	0	0	8	299
	NIGHT	1	4	0	0	10	881
790406	DAY	0	0	0	0	4	56
	NIGHT	0	0	0	0	6	193
790407	DAY	0	0	0	0	11	341
	NIGHT	2	9	0	0	3	19
790408	DAY	0	0	0	0	2	54
	NIGHT	0	0	0	0	16	506
790409	DAY	1	3	0	0	7	1455
	NIGHT ●	3	86	0	0	6	582
790410	DAY ● ◇	1	7	0	0	3	131
	NIGHT	0	0	0	0	6	218
790411	DAY ◇	2	12	0	0	12	677
	NIGHT	0	0	0	0	22	1880
790412	DAY	1	373	0	0	11	673
	NIGHT	2	10	0	0	13	370
790413	DAY	3	6	0	0	14	217
	NIGHT	3	53	0	0	14	662
790414	DAY	0	0	0	0	10	337
	NIGHT	2	19	0	0	11	186
790415	DAY ×	0	0	0	0	8	227
	NIGHT	1	3	0	0	7	85
790416	DAY	3	16	0	0	9	333
	NIGHT	6	65	0	0	17	791
790417	DAY	1	5	0	0	6	448
	NIGHT	1	14	0	0	8	367
790418	DAY ●	1	35	0	0	9	576
	NIGHT ●	1	3	0	0	8	434
790419	DAY	1	29	0	0	10	887
	NIGHT	0	0	0	0	8	350
790420	DAY	0	0	0	0	11	847
	NIGHT	1	0	0	0	5	649
790421	DAY	0	0	0	0	12	321
	NIGHT	1	162	0	0	11	3972
790422	DAY	0	0	0	0	20	875
	NIGHT	0	0	0	0	12	656
790423	DAY	2	9	0	0	23	321
	NIGHT ●	2	11	0	0	14	833
790424	DAY	1	90	0	0	23	705
	NIGHT ←Dredging	7	126	0	0	53	2307
790425	NIGHT Completed	7	57	0	0	41	1170
790426	DAY	13	207	0	0	65	1871
790427	DAY	0	0	0	0	8	510
	NIGHT ●	7	23	0	0	26	418
790428	DAY	3	13	0	0	0	0
	NIGHT	6	125	0	0	18	2002
790429	DAY	3	278	0	0	5	509
	NIGHT	13	119	0	0	0	0
790430	DAY	0	0	0	0	11	7854
	NIGHT	1	5	0	0	9	447
790501	DAY	0	0	0	0	8	332
	NIGHT ●	1	2	0	0	8	8903
790502	DAY	0	0	0	0	9	1144
	NIGHT	2	4	0	0	7	347

TABLE 7.5-3 (Continued)

DATE	TIME OF DAY	STATION 1 TOTAL NUMBER	TOTAL WEIGHT	4 TOTAL NUMBER	TOTAL WEIGHT	5 TOTAL NUMBER	TOTAL WEIGHT
790503	DAY	1	28	0	0	4	106
	NIGHT	4	9	0	0	7	187
790504	DAY	7	162	0	0	0	0
	NIGHT	19	100	0	0	10	346
790505	DAY	6	219	0	0	0	0
	NIGHT	41	369	0	0	0	0
790506	DAY	7	60	0	0	0	0
	NIGHT	33	615	0	0	0	0
790507	DAY	17	294	0	0	0	0
	NIGHT	53	284	0	0	0	0
790508	DAY	8	132	0	0	0	0
	NIGHT	86	467	0	0	0	0
790509	DAY	41	164	0	0	0	0
	NIGHT	205	660	0	0	0	0
790510	DAY	14	138	0	0	0	0
	NIGHT	111	367	0	0	0	0
790511	DAY	13	114	0	0	0	0
	NIGHT	51	356	0	0	0	0
790512	DAY	7	181	0	0	0	0
	NIGHT	31	513	0	0	0	0
790513	DAY	8	115	0	0	0	0
	NIGHT	36	152	0	0	0	0
790514	DAY	5	103	0	0	0	0
	NIGHT	41	132	0	0	0	0
790515	DAY	3	358	0	0	0	0
	NIGHT	27	168	0	0	0	0
790516	DAY	1	2	0	0	0	0
	NIGHT	44	261	0	0	0	0
790517	DAY	4	10	0	0	0	0
	NIGHT	33	87	0	0	0	0
790518	DAY	1	2	0	0	0	0
	NIGHT	8	92	0	0	0	0
790519	DAY	1	3	0	0	0	0
	NIGHT	16	47	0	0	0	0
790521	DAY	8	347	0	0	0	0
	NIGHT	40	173	0	0	0	0
790522	DAY	13	50	0	0	0	0
	NIGHT	43	299	0	0	0	0
790523	DAY	22	1060	0	0	0	0
790524	DAY	49	345	0	0	0	0
	NIGHT	49	473	0	0	0	0
790525	DAY	25	560	0	0	0	0
	NIGHT	96	730	0	0	0	0
790526	DAY	1	7	0	0	0	0
	NIGHT	24	458	0	0	0	0
790527	DAY	5	49	0	0	0	0
	NIGHT	23	140	0	0	0	0
790528	DAY	8	17	0	0	0	0
	NIGHT	20	125	0	0	0	0
790529	DAY	6	242	0	0	0	0
	NIGHT	20	181	0	0	0	0
790530	DAY	10	23	0	0	0	0
	NIGHT	28	163	0	0	0	0
790531	DAY	36	494	0	0	0	0
	NIGHT	77	353	0	0	0	0
790601	DAY	17	62	0	0	0	0
	NIGHT	50	837	0	0	0	0
790602	DAY	5	154	0	0	0	0
	NIGHT	56	504	0	0	0	0
790603	DAY	2	0	0	0	0	0
	NIGHT	39	59	0	0	0	0
790604	DAY	3	16	0	0	5	149
	NIGHT	20	21	0	0	0	0
790605	DAY	4	11	4	14	6	122
	NIGHT	22	70	9	84	3	0

TABLE 7.5-3 (Continued)

DATE	TIME OF DAY	STATION 1 TOTAL NUMBER	STATION 1 TOTAL WEIGHT	4 TOTAL NUMBER	4 TOTAL WEIGHT	5 TOTAL NUMBER	5 TOTAL WEIGHT
790606	DAY	9	22	0	0	17	538
	NIGHT	27	114	2	13	24	128
790607	NIGHT	53	203	1	2	51	761
790608	DAY	0	0	1	3	25	663
	NIGHT	35	266	1	4	38	893
790609	DAY	40	63	24	42	72	178
	NIGHT	117	1025	33	434	80	2759
790610	DAY	12	12	10	15	36	164
	NIGHT	10	49	120	235	5	40
790611	DAY	95	406	1	0	31	441
	NIGHT	52	892	8	47	81	624
790612	DAY	44	98	7	28	52	407
790613	DAY	39	267	11	82	33	469
790614	DAY	8	33	2	7	41	620
	NIGHT	35	585	13	253	25	1757
790615	DAY	46	126	18	126	32	245
	NIGHT	0	0	22	374	0	0
790616	DAY	29	108	15	57	15	739
	NIGHT TR	176	2212	25	117	17	182
790617	DAY	0	0	34	446	62	2635
	NIGHT	0	0	43	455	142	1779
790618	DAY	0	0	69	565	19	2060
	NIGHT	0	0	35	636	35	1138
790619	DAY	0	0	3	53	0	0
	NIGHT	0	0	7	109	62	2426
790620	DAY	0	0	29	134	0	0
	NIGHT	33	222	102	387	104	1541
790621	DAY	8	24	11	525	53	1590
	NIGHT	626	2330	614	5078	78	766
790622	DAY	1	2	55	373	56	1873
	NIGHT	34	237	325	3113	158	3019
790623	DAY	6	51	53	547	111	2549
	NIGHT	44	540	271	1178	155	3720
790624	DAY	1	6	54	348	52	1063
	NIGHT	1	2	0	0	68	2612
790625	DAY	1	5	46	151	74	606
	NIGHT	44	273	372	725	91	1925
790626	DAY	14	1121	90	523	79	1735
	NIGHT	20	66	232	1399	60	525
790627	DAY	16	76	74	884	84	589
	NIGHT	4	5	100	385	65	1711
790628	DAY	6	8	108	165	84	538
	NIGHT	9	111	228	572	98	1671
790629	DAY	0	0	202	436	80	874
	NIGHT	4	6	336	483	0	0
790630	DAY	128	140	0	0	33	187
	NIGHT	108	71	316	419	144	596
790701	DAY	2	7	94	231	16	92
	NIGHT	0	0	87	378	0	0
790702	DAY	54	49	60	73	16	56
	NIGHT	11	102	66	107	20	325
790703	DAY	5	4	95	167	48	178
	NIGHT	8	10	228	396	102	499
790704	DAY	4	163	48	40	48	469
	NIGHT	18	26	140	789	70	204
790705	DAY	8	6	48	81	36	583
	NIGHT	40	393	672	1199	45	201
790706	DAY	0	0	54	80	60	843
	NIGHT	8	18	52	290	62	385
790707	DAY	2	124	0	0	188	286
	NIGHT	54	410	3	11	5	27
790708	DAY	7	24	36	391	49	1329
	NIGHT	6	14	126	291	0	0

TABLE 7.5-3 (Continued)

DATE	TIME OF DAY	STATION 1 TOTAL NUMBER	1 TOTAL WEIGHT	4 TOTAL NUMBER	4 TOTAL WEIGHT	5 TOTAL NUMBER	5 TOTAL WEIGHT
790709	DAY	64	112	291	391	248	2184
	NIGHT	54	86	564	1209	828	1681
790710	DAY	8	11	60	132	64	2246
	NIGHT	0	0	328	628	112	434
790711	DAY	10	18	6	8	48	247
	NIGHT	12	10	575	1039	175	445
790712	DAY	0	0	12	18	8	45
	NIGHT	24	46	104	148	114	823
790713	DAY	0	0	32	70	12	19
	NIGHT	12	14	90	206	39	823
790714	DAY	2	4	14	54	32	429
	NIGHT	11	77	24	427	75	788
790715	DAY	15	14	21	511	27	68
	NIGHT	84	711	17	89	2	0
790716	DAY	0	0	49	62	16	129
	NIGHT	28	26	128	154	66	175
790717	DAY	0	0	6	5	18	22
	NIGHT	76	336	42	60	45	111
790718	DAY	2	15	15	17	13	1000
	NIGHT	7	568	162	614	45	605
790719	DAY	0	0	12	1208	20	665
790720	DAY	0	0	10	19	48	430
	NIGHT	1	0	74	243	6	358
790721	DAY	0	0	0	0	72	953
	NIGHT	2	245	0	0	100	748
790722	DAY	0	0	0	0	12	209
	NIGHT	1	5	0	0	29	595
790723	DAY	7	8	12	118	30	900
	NIGHT	30	35	25	25	70	582
790724	DAY	0	0	24	78	21	178
	NIGHT	16	18	95	203	78	1892
790725	DAY	54	156	0	0	24	428
	NIGHT	138	358	0	0	88	1043
790726	DAY	160	150	128	240	16	23
790727	DAY	8	361	30	224	30	38
	NIGHT	115	354	159	101	128	79
790728	DAY	15	34	248	127	192	55
	NIGHT TR	20	63	138	692	104	814
790729	DAY	7	31	8	26	0	0
	NIGHT	78	164	66	513	142	8210
790730	DAY	0	0	66	43	21	7
	NIGHT	159	3108	39	180	37	2720
790731	DAY	0	0	7	42	28	2264
	NIGHT	0	0	59	472	39	4629
790801	NIGHT	0	0	126	548	7	26
790802	DAY	3	2	173	223	66	337
790803	DAY	2	3	12	93	11	224
	NIGHT	95	699	30	62	16	537
790804	DAY	6	10	34	119	2	1
	NIGHT	220	1812	550	533	60	203
790805	DAY	0	0	2	1	0	0
	NIGHT	12	606	0	0	6	933
790806	DAY	0	0	6	6	20	211
	NIGHT	24	42	78	293	38	218
790807	DAY	0	0	11	29	22	330
	NIGHT	0	0	0	0	45	912
790808	DAY	0	0	42	62	5	412
	NIGHT	0	0	56	77	8	43
790809	DAY	2	10	13	279	7	163
	NIGHT	51	190	8	100	18	127
790810	DAY	0	0	0	0	6	181
	NIGHT	4	32	6	4	8	12

TABLE 7.5-3 (Continued)

DATE	TIME OF DAY	STATION 1 TOTAL NUMBER	TOTAL WEIGHT	4 TOTAL NUMBER	TOTAL WEIGHT	5 TOTAL NUMBER	TOTAL WEIGHT
790811	DAY	4	9	20	149	3	65
	NIGHT	22	126	165	283	40	336
790812	DAY	4	6	8	18	4	7
	NIGHT	6	14	12	248	20	557
790813	DAY	0	0	6	1	3	0
	NIGHT	9	12	22	83	15	196
790814	DAY	1	3	13	20	11	346
	NIGHT	40	119	78	1042	38	53
790815	DAY	2	6	35	71	10	225
	NIGHT	12	13	51	185	4	3
790816	DAY	2	4	36	29	12	251
	NIGHT	24	759	0	0	36	1952
790817	DAY	3	5	39	43	30	164
	NIGHT	105	249	390	562	42	1509
790818	DAY	2	5	42	193	14	609
	NIGHT	111	149	396	462	45	42
790819	NIGHT	12	14	116	1041	27	191
790821	DAY	33	59	65	426	26	374
	NIGHT	0	0	0	0	4	9
790822	DAY	28	594	0	0	76	349
	NIGHT	294	730	386	465	152	1008
790823	DAY	0	0	150	198	28	2381
	NIGHT	112	275	105	600	118	875
790824	DAY	4	27	38	65	17	249
	NIGHT	60	391	260	456	64	910
790825	DAY	4	24	800	1185	0	0
	NIGHT	48	226	168	1131	54	475
790826	DAY	2	13	42	905	0	0
	NIGHT	9	105	284	2121	0	0
790827	DAY	2	13	46	443	0	0
	NIGHT	31	78	10	2176	2	19
790828	DAY	0	0	0	0	1	11
	NIGHT	23	82	82	2159	15	71
790829	DAY	6	212	100	483	2	29
	NIGHT	28	58	114	230	11	116
790830	DAY	4	3	60	79	12	144
	NIGHT	151	351	0	0	46	404
790831	DAY	2	4	32	120	30	186
	NIGHT	28	24	54	273	99	638
790901	DAY	0	0	42	180	18	72
	NIGHT TR*	100	412	204	498	132	182
790902	DAY	14	16	36	110	52	502
	NIGHT	86	122	186	1208	303	830
790903	DAY	2	1	34	70	16	1832
	NIGHT	162	543	549	1688	0	0
790904	DAY	0	0	21	14	0	0
790905	DAY	2	2	5	3	10	235
	NIGHT	0	0	288	350	0	0
790906	DAY	0	0	8	15	12	140
	NIGHT	0	0	42	244	0	0
790907	DAY	5	2	10	53	4	0
	NIGHT	68	156	202	734	36	454
790908	DAY	0	0	5	13	0	0
	NIGHT TR	12	24	16	65	42	810
790909	DAY	14	135	0	0	3	21
790910	DAY	0	0	3	3	2	55
	NIGHT	32	26	138	117	24	54
790911	DAY	0	0	0	0	1	2
	NIGHT	0	0	14	50	8	38
790912	DAY	0	0	6	13	3	91
	NIGHT	0	0	86	137	29	148
790913	NIGHT	0	0	0	0	38	392

*Incomplete tunnel recirculation limited to 2 hrs.

000512

TABLE 7.5-3 (Continued)

		STATION 1		4		5	
DATE	TIME OF DAY	TOTAL NUMBER	TOTAL WEIGHT	TOTAL NUMBER	TOTAL WEIGHT	TOTAL NUMBER	TOTAL WEIGHT
790914	DAY	0	0	4	14	8	572
	NIGHT	15	256	76	301	7	18
790915	DAY	0	0	6	23	2	10
	NIGHT	30	217	70	115	0	0
790916	DAY	0	0	6	36	4	18
	NIGHT	11	57	0	0	3	303
790917	DAY	12	31	2	15	3	19
	NIGHT	0	0	11	48	0	0
790918	DAY	6	2	6	8	3	41
	NIGHT	0	0	37	613	18	797
790919	DAY	5	29	8	67	4	142
	NIGHT	0	0	58	201	30	190
790920	DAY	0	0	10	68	3	31
	NIGHT	228	730	22	491	18	85
790921	DAY	0	0	12	86	3	39
	NIGHT	1	0	37	500	30	1124
790922	DAY	1	292	2	7	17	717
	NIGHT	6	35	8	46	7	201
790923	DAY	1	2	48	257	32	418
	NIGHT	30	111	46	204	114	1958
790924	DAY	2	27	1	14	24	171
	NIGHT	52	72	12	669	33	212
790925	DAY	0	0	5	20	1	10
	NIGHT	0	0	24	35	120	266
790926	DAY	1	11	0	0	7	424
	NIGHT	85	1250	50	755	88	637
790927	DAY	1	13	4	16	20	507
	NIGHT	110	866	0	0	35	341
790928	DAY	2	9	5	13	12	619
	NIGHT	146	592	93	552	41	424
790929	DAY	5	64	0	0	6	129
	NIGHT	36	221	3	18	30	407
790930	DAY	0	0	0	0	8	212
	NIGHT	32	277	0	0	75	130
791001	DAY	4	18	6	42	32	100
	NIGHT	42	400	5	86	33	896
791002	DAY	0	0	100	119	5	40
	NIGHT	26	126	54	799	44	1581
791003	DAY	4	29	76	873	11	332
	NIGHT	36	290	69	378	27	64
791004	DAY	7	86	18	174	1	9
	NIGHT	60	418	231	497	54	734
791005	DAY	0	0	0	0	9	1185
	NIGHT	20	210	72	145	69	673
791006	DAY	0	0	0	0	25	30
	NIGHT	56	130	70	492	45	876
791007	DAY	4	35	36	255	25	423
	NIGHT	24	7553	0	0	24	354
791008	DAY	6	37	20	113	3	8
	NIGHT	16	40	81	641	21	291
791009	NIGHT	21	48	87	801	36	707
791010	DAY	2	10	5	41	1	20
	NIGHT	0	0	0	0	9	2169
791011	NIGHT	80	3361	40	409	0	0
791012	DAY	30	84	4	25	0	0
791013	DAY	1	13	18	109	0	0
	NIGHT TR	0	0	119	138	0	0
791014	DAY	9	29	15	126	12	35
791015	DAY	8	4	276	203	4	529
	NIGHT	0	0	0	0	24	28
791016	DAY	1	0	36	31	24	890
	NIGHT	75	119	0	0	34	764

TABLE 7.5-3 (Continued)

DATE	TIME OF DAY	STATION 1 TOTAL NUMBER	TOTAL WEIGHT	4 TOTAL NUMBER	TOTAL WEIGHT	5 TOTAL NUMBER	TOTAL WEIGHT
791017	DAY	3	13	10	116	5	68
	NIGHT	42	96	92	401	14	33
791018	DAY	2	36	11	271	14	143
	NIGHT	4	14	27	102	0	0
791019	DAY	2	34	10	72	21	41
	NIGHT	30	350	26	160	18	243
791020	DAY	0	0	45	44	4	40
	NIGHT	5	21	64	145	11	442
791021	DAY	1	0	45	81	28	69
	NIGHT	180	201	20	205	24	43
791022	DAY	4	18	90	136	36	29
	NIGHT	0	0	117	400	20	66
791023	DAY	26	1485	29	2054	3	585
	NIGHT	144	416	56	496	0	0
791024	DAY	0	0	48	155	48	1216
791026	DAY	0	0	455	312	65	1128
791027	NIGHT	0	0	144	250	82	287
791028	DAY	78	424	187	604	35	2867
791029	DAY	0	0	15	18	0	0
	NIGHT	60	70	200	329	22	693
791031	DAY	0	0	120	105	0	0
791101	DAY	0	0	0	0	36	174
	NIGHT	192	390	49	284	0	0
791102	DAY	0	0	0	0	9	96
	NIGHT	164	359	105	348	80	220
791103	NIGHT	348	901	0	0	95	961
791105	DAY	40	70	75	261	60	375
791106	DAY	5	305	32	91	114	301
	NIGHT	55	341	30	207	0	0
791107	DAY	7	631	18	114	18	474
	NIGHT	31	182	74	487	36	4226
791108	DAY	40	284	0	0	32	154
791108	NIGHT	25	312	83	530	0	0
791109	DAY	31	205	44	92	6	113
	NIGHT	48	135	0	0	30	154
791110	DAY	0	0	36	54	8	116
	NIGHT	202	501	156	530	21	487
791111	DAY	8	37	792	1693	32	464
	NIGHT	82	1017	0	0	0	0
791112	DAY	1	25	36	106	6	49
	NIGHT	0	0	234	408	93	753
791113	DAY	12	10	12	15	18	887
	NIGHT	99	1301	182	1146	20	61
791114	DAY	0	0	0	0	8	175
	NIGHT	63	138	0	0	29	245
791115	DAY	0	0	0	0	10	25
	NIGHT	0	0	0	0	21	235
791116	DAY	26	182	18	395	72	749
	NIGHT	0	0	0	0	28	60
791117	DAY	1	89	25	67	25	109
	NIGHT	76	844	74	892	44	666
791118	DAY	5	11	80	380	75	327
	NIGHT	24	311	72	942	46	722
791119	DAY	0	0	30	222	28	196
	NIGHT	28	61	12	346	70	95
791120	DAY	0	0	0	0	18	153
	NIGHT	120	218	24	91	268	1430
791121	DAY	460	1972	52	231	24	213
	NIGHT	0	0	205	552	62	877
791122	NIGHT	626	1695	1533	2827	266	921
791123	DAY	0	0	246	854	170	1785
791124	DAY	0	0	112	117	16	434
	NIGHT TR	0	0	0	0	94	[illegible]

000514

TABLE 7.5-3 (Continued)

DATE	TIME OF DAY	STATION 1 TOTAL NUMBER	TOTAL WEIGHT	4 TOTAL NUMBER	TOTAL WEIGHT	5 TOTAL NUMBER	TOTAL WEIGHT
791125	DAY	40	204	64	394	0	0
791126	DAY	207	1103	74	384	0	0
	NIGHT	0	0	1743	2989	0	0
791127	DAY	0	0	8	13	7	135
	NIGHT	50	592	413	3153	0	0
791128	DAY	15	65	18	104	0	0
	NIGHT	0	0	763	4105	0	0
791129	DAY	6	27	22	169	15	21
	NIGHT	31	723	51	311	0	0
791130	DAY	0	0	30	548	26	1320
	NIGHT	40	777	38	253	6	152
791201	DAY	0	0	40	155	5	343
	NIGHT	0	0	68	901	12	259
791202	DAY	0	0	51	393	3	197
	NIGHT	0	0	48	222	18	1003
791203	DAY	45	478	87	1020	13	498
	NIGHT	0	0	32	576	10	5807
791204	DAY	0	0	40	206	8	489
	NIGHT	0	0	25	508	46	391
791205	DAY	1	34	9	26	28	105
	NIGHT	6	17	18	89	0	0
791206	DAY	39	247	174	433	14	191
	NIGHT	0	0	88	1049	23	282
791207	DAY	30	161	186	1079	14	93
	NIGHT	48	202	56	1128	32	221
791208	DAY	16	40	18	65	11	138
	NIGHT	77	469	172	731	24	235
791209	DAY	0	0	10	54	17	302
	NIGHT	0	0	39	352	30	1033
791210	DAY	5	99	30	100	10	111
	NIGHT	0	0	0	0	26	316
791211	DAY	0	0	5	48	6	152
	NIGHT	22	148	32	1087	0	0
791212	DAY	4	29	32	232	6	414
	NIGHT	4	11	0	0	7	107
791213	DAY	11	173	90	311	15	498
	NIGHT	21	272	0	0	0	0
791214	DAY	13	206	22	131	18	543
	NIGHT	0	0	60	758	13	811
791215	DAY	1	3	14	44	6	126
	NIGHT	9	126	77	692	15	1652
791216	DAY	2	3	10	29	6	170
	NIGHT	4	15	57	1215	12	382
791217	DAY	8	242	20	116	10	57
	NIGHT	0	0	54	319	17	243
791218	DAY	21	127	219	596	18	813
	NIGHT	0	0	180	426	94	1850
791219	DAY	11	266	0	0	29	1403
	NIGHT	0	0	0	0	20	90
791220	NIGHT	10	470	79	1331	94	994
791221	DAY	0	0	32	731	0	0
	NIGHT	0	0	90	303	40	279
791222	NIGHT	0	0	0	0	42	593
791224	DAY	4	69	30	83	7	128
791225	DAY	0	0	20	167	22	404
791226	DAY	24	258	90	804	24	200
	NIGHT	0	0	66	1109	0	0
791227	NIGHT	52	394	66	317	0	0
791228	DAY	2	28	8	189	5	171
	NIGHT	26	282	54	297	0	0
791229	DAY	4	185	11	77	8	224
	NIGHT TR	40	542	66	437	30	481
791230	DAY	0	0	16	26	0	0

TABLE 7.5-3 (Concluded)

		STATION 1		4		5	
DATE	TIME OF DAY	TOTAL NUMBER	TOTAL WEIGHT	TOTAL NUMBER	TOTAL WEIGHT	TOTAL NUMBER	TOTAL WEIGHT
791231	DAY	0	0	6	28	0	0
	NIGHT	11	39	0	0	0	0
800101	NIGHT	0	0	0	0	12	359
800102	DAY	6	12	30	454	0	0
	NIGHT	0	0	37	396	0	0
800103	NIGHT	8	63	0	0	0	0
800104	DAY	1	199	19	5607	8	4641
	NIGHT	10	193	40	343	10	419

LEGEND

TR - denotes times of tunnel recirculation

● - denotes wind speeds ≥ 12 mph

◇ - denotes ocean wave heights for ≥ 4 ft

x - denotes salinities ≤ 29.9 ‰

▲ - denotes light-heavy rain

the specific times of occurrence for physical conditions possibly related to impingement of fishes. These conditions are: wind speeds $\geq$12 mph (19 kph), ocean wave heights $\geq$4 ft (1.2 m), salinity values $\leq$29.9 ppt, associated conditions of light to heavy rainfall, and times of dredging operations in outer Agua Hedionda Lagoon. These physical data were obtained as described in Appendix B, Section 16.2.3. The specific times of tunnel recirculation or heat treatment of the cooling water system also are shown. Effects of tunnel recirculation are considered separately in Section 7.12. The format described above for biological and physical data in Table 7.5-3 allows their direct intercomparison, as described in the analyses of data that follow.

As indicated in Figures 7.5-1 through 7.5-8 and Tables 7.5-1 and 7.5-3, total numbers and biomass of fishes impinged varied considerably throughout the year and from week to week. For all traveling screen stations combined (Figures 7.5-7 and 7.5-8), the greatest number and weight of fishes impinged was in late February, 1979 during a period of winter storms, rainfall, and low salinity (Table 7.5-3 and Figure 7.5-9). This peak is most evident in the data for stations 4 and 5 (Figures 7.5-3 through 7.5-6). The highest peak in weight of fishes impinged occurred at station 5 in early April. As indicated in Table 7.5-2, generating Unit 4 was not in operation from early March through the end of May and generating Unit 5 also was out of service in May. This accounts in part for the lower levels of impingement during that period (Figures 7.5-1 through 7.5-8), as considered separately in Section 7.8. Peak levels of impingement at station 1 occurred in October and November (Figures 7.5-1 and 7.5-2) and for station 4 in November and early December (Figures 7.5-3 and 7.5-4). Levels of impingement were somewhat lower and variable during the summer and early fall months (Figures 7.5-7 and 7.5-8).

Parametric correlation analysis was used in an attempt to determine possible statistical relationships between four physical variables and the total number and weight of all fishes impinged at all stations combined during corresponding periods of time. Weekly mean values for the entire 336-day period of the study (Tables 7.5-1 and 7.5-2 and Figures 7.5-9 and 7.5-10) were used for these analyses. The possible correlations considered and the correlation coefficient determined for each were:

	Mean Total Number of Fishes Impinged	Mean total Weight of Fishes Impinged
Mean Temperature	-0.097	-0.227
Mean Salinity	-0.002	-0.190
Mean Ocean Wave Height	0.136	0.141
Mean Cloud Cover	0.097	-0.085

None of these correlations was significant (p values >0.05), as reflected also by the very low correlation coefficient values. Comparison of the impingement plots (Figures 7.5-1 through 7.5-8) with those for the physical data (Figures 7.5-9 and 7.5-10) tends to confirm that there were no evident relationships between these four physical variables and the mean number or weight of fishes impinged.

These results are not surprising, because the impingement data are quite variable and it also is very likely that impingement is influenced by a combination of factors, rather than one or two in isolation. For example, it might be argued that impingement was highest in the late fall, winter and early spring, when water temperatures were lowest (Figures 7.5-1 through 7.5-8). Yet this also was the period of increased cloud cover, storm conditions, intermittently reduced salinity, and dredging in Agua Hedionda Lagoon.

As a means of evaluating the effects of storm conditions on impingement, Mann-Whitney U tests were applied to data for total number and total weight of impinged fishes, shown in Table 7.5-3. Five distinct intervals of storm conditions during the period February 20-May 12, 1979 were selected, using the physical data noted in Table 7.5-3 as a guide. These five periods were characterized by wind speeds $\geq$12 mph (16 kph), rainfall, salinities $\leq$29.9 ppt in the lagoon, and, in four of the five cases, by ocean wave heights greater than 4 ft (1.2 m).

All data for a period of 4 to 7 days before the storm began were compared with all data from the same number of days after the onset of the storm. For example, in evaluating effects of the storm that began on February 20, 1979, data for the four days preceding that date were compared with those for the four-day period starting February 20. Values from each 12-hr sampling interval for total number and total weight of all fishes impinged were analyzed separately by station.

The Mann-Whitney U tests evaluated the null hypothesis that there was no difference in levels of impingement between the two consecutive time periods, against the one-way alternative hypothesis that the level of impingement during storm conditions was significantly greater than that just preceding the storm. The results of these Mann-Whitney U test comparisons were as follows (SIG indicates a significant difference at the level of significance shown; NS indicates difference not significant):

	Station 1		Station 4		Station 5	
Inclusive Dates	Number	Weight	Number	Weight	Number	Weight
2/16 - 2/24	SIG ($p < .10$)	SIG ($p < .05$)	SIG ($p < .05$)	SIG ($p < .05$)	SIG ($p < .05$)	SIG ($p < .05$)
3/8 - 3/22	SIG ($p < .10$)	NS	Unit Off		NS	SIG ($p < .05$)
3/23 - 3/30	NS	NS	Unit Off		NS	NS
4/5 - 4/13	SIG ($p < .05$)	SIG ($p < .05$)	Unit Off		SIG ($p < .05$)	NS
5/3 - 5/12	SIG ($p < .05$)	SIG ($p < .10$)	Unit Off		Unit Off	

The results show that in 13 of the 20 comparisons, the total number or weight of fishes impinged was significantly greater following the onset of storm conditions and reduced salinity than during the period just preceding the storm. In some of the remaining seven cases that did not show a statistically significant difference, there also was a tendency for the numbers and weights of fishes impinged to be higher following the onset of a storm than just before it (Table 7.5-3). This evidence indicates that the combination of conditions associated with storms during the winter and spring months often causes a significant increase in the number and biomass of fishes impinged at the traveling screens of the Encina Power Plant.

During the period February 20-April 25, 1979, maintenance dredging was done by SDG&E to remove accumulated sediment from the outer portion of Agua Hedionda Lagoon. The dredge was operated six days per week (Monday through Saturday) during this entire period. There was considerable disturbance of the sediment and turbidity levels were relatively high in the outer lagoon.

As indicated in Table 7.5-1 and Figures 7.5-1 through 7.5-8, the highest total numbers and weights of fishes for the 336-day period of the study were impinged at stations 4 and 5 during the week of February 18-24, and primarily after February 20 (Table 7.5-3). There also was a less pronounced but evident increase in the level of impingement at station 1 after dredging commenced.

This apparent effect of dredging was evaluated further by using a Mann-Whitney U test to compare weekly mean values for total number and weight of fishes impinged (Table 7.5-1) for the period February 18-April 28 with those for the succeeding period of April 29-June 23. The data for all traveling screen stations combined were used. The Mann-Whitney U test evaluated the null hypothesis that there was no difference in mean weekly levels of impingement during and following the dredging operations, against the one-way alternative hypothesis that mean weekly levels of impingement were significantly greater during the dredging operations than following them. The results of these statistical comparisons indicate that there was no significant difference ($p>0.05$) in mean number of fishes impinged during and after the dredging operations, while the mean weight of fishes was significantly greater ($p<0.05$) during dredging than following it.

In combination, the evidence described above indicates that dredging operations did have a significant effect in increasing the impingement of fishes. The same was true for motile invertebrate species inhabiting the unconsolidated sediment bottom of outer Agua Hedionda Lagoon. During the period of dredging several of these species, including particularly the crabs Portunus xantusi and Cancer spp. and the black spotted shrimp Crangon nigromaculata, were very abundant in the impingement samples.

Unfortunately, the period of dredging overlapped that of storm conditions during the winter and early spring. Because of this, it is difficult to separate the effects of these two confounding variables in evaluating the data.

Shown in Table 7.5-4 are the mean numbers of individuals of each critical species impinged per 24-hr sampling interval within each week during the period February 4, 1979-January 4, 1980. Corresponding mean weight data for these species are summarized in Table 7.5-5. The overall mean numbers and weights of each critical species impinged per 24-hr interval for the 336-day sampling period as a whole, based on that data in Tables 7.5-4 and 7.5-5, are given in Table 7.5-6. All of these values are

TABLE 7.5-4

WEEKLY MEAN NUMBERS OF CRITICALLY-TREATED FISH SPECIES IMPINGED AT THE ENCINA POWER PLANT PER 24-HR INTERVAL DURING THE PERIOD FEBRUARY 4, 1979 - JANUARY 4, 1980

SPECIES NAME	WEEK 1 (Feb 4)	2 (Feb 11)	3 (Feb 18)	4 (Feb 25)	5 (Mar 4)	6 (Mar 11)	7 (Mar 18)	8 (Mar 25)
UROLOPHUS HALLERI	13.5	6.2	3.5	1.3	.9	.7	.9	.9
ENGRAULIS MORDAX	.2	.4	.9	1.0	.1	.1	.5	.2
ANCHOA COMPRESSA	15.6	24.4	160.7	38.3	1.7	7.8	6.6	3.8
ANCHOA DELICATISSIMA	2.0	6.4	12.9	2.8	3.3	4.6	4.1	2.2
LEURESTHES TENUIS	.8	.7	.0	.2	.0	.4	.4	.4
ATHERINOPS AFFINIS	100.5	44.0	136.4	46.6	3.8	3.5	1.6	2.1
PARALABRAX CLATHRATUS	.0	.0	.0	.0	.0	.0	.1	.0
PARALABRAX MACULATOFASCIATUS	.0	.0	.2	.3	.0	.0	.0	.0
PARALABRAX NEBULIFER	.0	.0	.8	.4	.1	.1	.1	.0
XENISTIUS CALIFORNIENSIS	5.4	.4	.0	.0	.1	.1	.1	.1
SERIPHUS POLITUS	8.0	2.9	31.0	11.6	5.8	2.4	2.0	1.3
MENTICIRRHUS UNDULATUS	.0	.0	.2	.0	.0	.0	.0	.0
AMPHISTICHUS ARGENTEUS	.0	.1	.0	.0	.1	.1	.0	.0
HYPERPROSOPON ARGENTEUM	.5	.6	15.2	2.9	.2	.3	.4	1.0
CYMATOGASTER AGGREGATA	3.0	1.0	63.0	7.8	1.4	.6	.7	.6
PHANERODON FURCATUS	.0	.0	1.7	.0	.1	.0	.1	.1
MUGIL CEPHALUS	.3	.0	.2	.3	.0	.1	.1	.1
PARALICHTHYS CALIFORNICUS	1.6	2.1	11.3	3.0	.8	.9	1.1	.3

SPECIES NAME	WEEK 9 (Apr 1)	10 (Apr 8)	11 (Apr 15)	12 (Apr 22)	13 (Apr 29)	14 (May 6)	15 (May 13)	16 (May 20)
UROLOPHUS HALLERI	2.2	1.0	.9	1.4	.6	.9	.4	1.1
ENGRAULIS MORDAX	.2	.1	.2	1.1	.0	.0	.1	.0
ANCHOA COMPRESSA	46.5	.6	.1	.4	.0	.1	.0	.0
ANCHOA DELICATISSIMA	.0	.1	.0	.1	.0	.0	.0	.0
LEURESTHES TENUIS	.6	.2	.4	2.2	.1	.1	.4	.3
ATHERINOPS AFFINIS	74.2	1.7	1.4	3.7	1.8	2.1	.9	1.6
PARALABRAX MACULATOFASCIATUS	.1	.0	.0	.0	.0	.1	.0	.1
PARALABRAX NEBULIFER	.4	.0	.1	.0	.0	.0	.0	.0
XENISTIUS CALIFORNIENSIS	.1	.1	.0	.1	.0	.0	.0	.0
SERIPHUS POLITUS	3.6	1.7	1.1	3.7	.5	1.6	1.3	1.0
MENTICIRRHUS UNDULATUS	.0	.1	.0	.4	.0	.0	.0	.0
AMPHISTICHUS ARGENTEUS	.0	.4	.0	.1	.0	2.9	.0	.1
HYPERPROSOPON ARGENTEUM	4.8	1.1	1.1	3.7	5.8	48.0	15.0	5.0
CYMATOGASTER AGGREGATA	.9	1.9	2.7	2.7	1.7	1.6	.9	2.0
PHANERODON FURCATUS	.1	.0	.0	.4	1.5	34.1	9.4	33.4
MUGIL CEPHALUS	.2	.1	.0	.1	.0	.0	.0	.1
PARALICHTHYS CALIFORNICUS	.1	.4	.0	.2	.1	.0	.0	.3

TABLE 7.5-4 (Continued)

SPECIES NAME	WEEK 17 (May 27)	18 (Jun 3)	19 (Jun 10)	20 (Jun 17)	21 (Jun 24)	22 (July 1)	23 (July 8)	24 (July 15)
UROLOPHUS HALLERI	1.0	.8	1.5	2.5	.9	.6	1.5	.3
ENGRAULIS MORDAX	.0	.2	.7	10.3	8.3	3.3	61.7	4.0
ANCHOA COMPRESSA	.4	7.9	11.9	43.5	44.0	24.6	30.5	13.1
ANCHOA DELICATISSIMA	.3	.2	.6	4.0	1.6	.6	.2	.0
LEURESTHES TENUIS	.1	.1	.2	2.8	7.3	1.5	4.0	.8
ATHERINOPS AFFINIS	1.3	4.1	4.4	7.1	9.9	4.8	11.5	4.5
PARALABRAX CLATHRATUS	.0	.0	.0	.1	.0	.0	.0	.0
PARALABRAX MACULATOFASCIATUS	.0	.0	.1	.2	.0	.0	.0	.0
PARALABRAX NEBULIFER	.0	.0	.1	.6	.4	.2	.2	.0
XENISTIUS CALIFORNIENSIS	.0	.0	.1	.2	.3	.0	.0	.0
SERIPHUS POLITUS	1.9	5.3	5.6	60.4	27.4	53.1	32.1	21.0
CYNOSCION NOBILIS	.0	.0	.0	.4	.0	.0	.0	.0
MENTICIRRHUS UNDULATUS	.0	.0	.0	.1	.0	.0	.0	.3
AMPHISTICHUS ARGENTEUS	.0	.1	.0	.0	.2	.0	.4	.0
HYPERPROSOPON ARGENTEUM	5.0	1.4	1.0	6.9	2.4	1.4	3.0	1.5
CYMATOGASTER AGGREGATA	3.6	8.8	16.9	26.8	51.4	21.5	39.7	6.4
PHANERODON FURCATUS	27.7	7.0	4.8	8.5	7.7	5.4	5.2	1.5
MUGIL CEPHALUS	.0	.9	.0	.1	.0	.0	.0	.0
PARALICHTHYS CALIFORNICUS	.0	.2	.5	3.0	1.4	1.7	3.8	1.9

SPECIES NAME	WEEK 25 (July 22)	26 (July 29)	27 (Aug 5)	28 (Aug 12)	29 (Aug 19)	30 (Aug 26)	31 (Sept 2)	32 (Sept 9)
UROLOPHUS HALLERI	.2	4.2	.4	.1	.4	.4	.4	.2
ENGRAULIS MORDAX	46.3	26.6	5.0	6.6	126.2	25.0	25.0	2.4
ANCHOA COMPRESSA	10.1	26.4	1.6	10.1	5.2	7.1	12.4	2.5
ANCHOA DELICATISSIMA	.0	3.3	.4	5.1	4.1	2.7	1.1	2.1
LEURESTHES TENUIS	.0	.3	.8	.4	6.0	2.4	13.7	1.7
ATHERINOPS AFFINIS	5.9	3.7	1.8	3.2	8.1	7.3	2.4	.2
PARALABRAX CLATHRATUS	.0	.0	.0	.0	.2	.0	.1	.0
PARALABRAX MACULATOFASCIATUS	.0	1.3	.0	.0	.2	.0	.0	.0
PARALABRAX NEBULIFER	.8	1.5	.4	.0	.0	.6	.6	.0
XENISTIUS CALIFORNIENSIS	.0	.2	.0	.0	.1	.1	.0	.0
SERIPHUS POLITUS	22.6	33.8	15.0	48.0	19.9	40.4	51.5	20.8
CYNOSCION NOBILIS	.0	.0	.0	.0	.0	.0	.0	.4
MENTICIRRHUS UNDULATUS	.0	.0	.0	.1	.0	.0	.0	.0
HYPERPROSOPON ARGENTEUM	.2	.2	.0	.6	.5	.2	.9	.0
CYMATOGASTER AGGREGATA	19.0	3.4	7.8	.4	.8	.5	1.7	.7
PHANERODON FURCATUS	1.6	1.8	.9	.4	.2	.0	.9	.0
MUGIL CEPHALUS	.0	.0	.0	.1	.0	.0	.2	.0
PARALICHTHYS CALIFORNICUS	3.1	1.2	1.0	2.7	2.9	.5	2.8	.4

TABLE 7.5-4 (Concluded)

SPECIES NAME	WEEK 33 (Sept 16)	34 (Sept 23)	35 (Sept 30)	36 (Oct 7)	37 (Oct 14)	38 (Oct 21)	39 (Oct 28)	40 (Nov 4)
UROLOPHUS HALLERI	.6	.7	1.1	.8	.4	.9	.3	.4
ENGRAULIS MORDAX	1.5	7.3	1.0	1.5	.8	3.3	8.1	1.4
ANCHOA COMPRESSA	.7	7.3	5.9	4.8	5.3	11.8	11.4	10.1
ANCHOA DELICATISSIMA	.7	2.9	1.5	1.1	1.0	13.3	.3	.9
LEURESTHES TENUIS	9.4	20.5	10.0	6.4	10.4	26.1	47.1	16.4
ATHERINOPS AFFINIS	.8	1.5	5.0	3.3	.5	4.1	4.8	2.9
PARALABRAX CLATHRATUS	.0	.0	.0	.0	.0	.0	.0	.2
PARALABRAX MACULATOFASCIATUS	.0	.0	.0	.0	.5	.0	.4	.0
PARALABRAX NEBULIFER	.0	.1	.2	.1	.3	.0	.3	.0
XENISTIUS CALIFORNIENSIS	.0	.0	.0	.0	.0	.0	.0	.8
SERIPHUS POLITUS	12.2	18.1	34.0	14.6	22.9	39.7	35.4	33.0
CYNOSCION NOBILIS	.0	.1	.1	.1	.0	.0	.0	.1
MENTICIRRHUS UNDULATUS	.1	.0	.6	.2	.1	1.3	.3	.1
AMPHISTICHUS ARGENTEUS	.0	.0	.1	.0	.0	.0	.3	.0
HYPERPROSOPON ARGENTEUM	.0	.2	.7	.2	.3	1.0	1.3	2.3
CYMATOGASTER AGGREGATA	.1	.5	.5	.6	.1	.3	.3	1.3
PHANERODON FURCATUS	.0	.0	.1	.0	.1	.0	.8	.2
MUGIL CEPHALUS	.0	.1	.0	.0	.0	.3	.3	.2
PARALICHTHYS CALIFORNICUS	1.8	.1	1.4	.0	.0	.9	1.1	.6

SPECIES NAME	WEEK 41 (Nov 11)	42 (Nov 18)	43 (Nov 25)	44 (Dec 2)	45 (Dec 9)	46 (Dec 16)	47 (Dec 23)	48 (Dec 30)
UROLOPHUS HALLERI	1.8	1.8	7.4	8.2	1.3	6.3	5.2	1.9
ENGRAULIS MORDAX	2.1	1.7	2.4	1.6	.6	.2	.6	1.7
ANCHOA COMPRESSA	21.5	8.9	31.1	2.5	3.4	3.4	3.5	2.6
ANCHOA DELICATISSIMA	2.2	1.4	2.6	.2	.1	2.9	.6	.4
LEURESTHES TENUIS	17.3	134.7	96.6	12.1	5.5	2.4	1.5	.9
ATHERINOPS AFFINIS	2.7	7.4	10.3	17.0	1.4	4.6	3.1	4.2
PARALABRAX CLATHRATUS	.1	.2	.4	.3	.0	.0	.2	.2
PARALABRAX MACULATOFASCIATUS	.3	.3	.0	.0	.0	.0	.0	.0
PARALABRAX NEBULIFER	.0	.4	.8	.5	.0	.0	.0	.0
XENISTIUS CALIFORNIENSIS	.6	4.1	8.5	2.1	1.7	.6	1.7	2.4
SERIPHUS POLITUS	57.0	69.7	33.2	24.5	11.7	35.4	5.3	3.2
CYNOSCION NOBILIS	.0	.0	.0	.1	.0	.0	.0	.0
MENTICIRRHUS UNDULATUS	.2	.7	.3	.2	.3	.8	.0	.0
AMPHISTICHUS ARGENTEUS	.0	.8	.3	.3	.0	.0	.0	.0
HYPERPROSOPON ARGENTEUM	3.2	3.9	1.8	.9	.1	.8	1.1	.3
CYMATOGASTER AGGREGATA	.1	1.3	5.1	4.7	3.6	.6	14.8	.9
PHANERODON FURCATUS	.6	.0	.4	.1	.0	.3	.0	.0
MUGIL CEPHALUS	.0	.2	.0	.1	.0	.1	.0	.0
PARALICHTHYS CALIFORNICUS	.0	.9	1.7	.8	1.1	1.5	.6	.5

000525

TABLE 7.5-5

WEEKLY MEAN WEIGHT (g) OF EACH CRITICALLY-TREATED SPECIES IMPINGED AT ENCINA POWER PLANT PER 24-HR SAMPLING INTERVAL DURING THE PERIOD FEBRUARY 4, 1979 - JANUARY 4, 1980

SPECIES NAME	WEEK 1 (Feb 4)	2 (Feb 11)	3 (Feb 18)	4 (Feb 25)	5 (Mar 4)	6 (Mar 11)	7 (Mar 18)	8 (Mar 25)
UROLOPHUS HALLERI	1079.6	540.1	399.6	123.6	82.3	94.4	157.2	107.4
ENGRAULIS MORDAX	.9	1.0	5.5	9.4	.7	.4	2.2	1.0
ANCHOA COMPRESSA	197.0	198.8	1744.6	292.3	11.2	52.6	35.9	22.2
ANCHOA DELICATISSIMA	4.4	20.9	40.1	10.5	8.6	13.1	12.4	6.6
LEURESTHES TENUIS	4.1	2.8	.0	1.4	.0	2.3	2.7	3.9
ATHERINOPS AFFINIS	651.5	348.0	2123.8	688.4	85.3	80.4	39.6	54.7
PARALABRAX CLATHRATUS	.0	.0	.0	.0	.0	.0	.4	.0
PARALABRAX MACULATOFASCIATUS	.0	.0	.6	22.8	.0	.0	.0	.0
PARALABRAX NEBULIFER	.2	.0	5.1	16.3	.6	.3	1.8	.0
XENISTIUS CALIFORNIENSIS	14.4	1.0	.0	.0	2.1	.2	.4	.2
SERIPHUS POLITUS	128.4	38.2	1101.3	370.5	105.7	37.9	127.4	22.6
MENTICIRRHUS UNDULATUS	.0	.0	18.7	.0	.0	.0	.0	.0
AMPHISTICHUS ARGENTEUS	.0	11.6	5.5	.0	3.6	3.0	.0	.0
HYPERPROSOPON ARGENTEUM	21.3	28.5	777.9	176.3	4.0	14.6	12.9	62.4
CYMATOGASTER AGGREGATA	54.5	31.7	1691.3	244.0	46.9	19.3	31.4	13.4
PHANERODON FURCATUS	.0	.0	148.2	7.9	13.1	.0	29.8	13.1
MUGIL CEPHALUS	720.3	.0	117.1	193.3	.0	41.4	104.9	98.2
PARALICHTHYS CALIFORNICUS	96.2	151.8	971.2	853.9	31.4	45.9	40.5	7.9

SPECIES NAME	WEEK 9 (Apr 1)	10 (Apr 8)	11 (Apr 15)	12 (Apr 22)	13 (Apr 29)	14 (May 6)	15 (May 13)	16 (May 20)
UROLOPHUS HALLERI	721.8	109.0	66.7	92.0	49.1	82.7	66.6	58.7
ENGRAULIS MORDAX	1.6	1.3	1.8	10.1	.0	.0	.1	.0
ANCHOA COMPRESSA	410.6	6.1	1.8	2.4	.0	1.3	.0	.0
ANCHOA DELICATISSIMA	.0	.2	.0	.3	.0	.0	.0	.0
LEURESTHES TENUIS	7.4	2.1	5.4	27.6	.8	1.1	4.4	5.6
ATHERINOPS AFFINIS	1311.0	47.0	25.0	71.6	41.3	32.0	5.4	19.1
PARALABRAX MACULATOFASCIATUS	12.5	.0	.0	.0	.0	20.7	.0	64.6
PARALABRAX NEBULIFER	153.3	.0	11.6	.0	.0	.0	.0	.0
XENISTIUS CALIFORNIENSIS	.2	.2	.0	.2	.0	.0	.0	.0
SERIPHUS POLITUS	162.3	8.1	9.4	19.9	3.8	10.9	3.4	4.1
MENTICIRRHUS UNDULATUS	.0	.6	.0	59.6	.0	.0	.0	.0
AMPHISTICHUS ARGENTEUS	.0	6.0	.0	1.1	.0	8.3	.0	.4
HYPERPROSOPON ARGENTEUM	187.0	50.5	65.9	106.0	159.6	244.1	80.6	23.6
CYMATOGASTER AGGREGATA	24.8	[illegible]	95.9	63.2	28.3	25.4	9.3	12.9
PHANERODON FURCATUS	17.2	.0	.0	1.3	15.5	96.9	26.4	133.6
MUGIL CEPHALUS	86.5	42.2	.0	30.7	.0	.0	.0	136.0
PARALICHTHYS CALIFORNICUS	[illegible]	17.9	.0	58.4	[illegible]	.0	.0	1.4

TABLE 7.5-5 (Continued)

SPECIES NAME	WEEK 17 (May 27)	18 (Jun 3)	19 (Jun 10)	20 (Jun 17)	21 (Jun 24)	22 (July 1)	23 (July 8)	24 (July 15)
UROLOPHUS HALLERI	46.5	106.3	199.1	327.6	74.8	48.4	199.7	33.5
ENGRAULIS MORDAX	.0	1.5	3.6	68.2	18.9	11.8	237.1	13.8
ANCHOA COMPRESSA	11.9	41.1	71.1	258.8	261.4	175.0	206.0	102.0
ANCHOA DELICATISSIMA	1.0	.5	1.3	9.0	5.1	1.9	.7	.0
LEURESTHES TENUIS	1.7	1.5	4.5	35.9	73.7	20.1	36.6	8.3
ATHERINOPS AFFINIS	17.7	89.2	70.8	106.8	165.0	94.9	158.8	52.9
PARALABRAX CLATHRATUS	.0	.0	.0	.0	.0	.0	.0	.0
PARALABRAX MACULATOFASCIATUS	.0	.0	.6	13.6	.0	.0	.0	.0
PARALABRAX NEBULIFER	.0	.0	.7	14.8	137.6	31.7	1.4	.0
XENISTIUS CALIFORNIENSIS	.0	.0	.5	1.6	12.3	.0	.0	.0
SERIPHUS POLITUS	3.6	21.1	27.9	328.2	193.6	234.4	202.8	93.4
CYNOSCION NOBILIS	.0	.0	.0	1.9	.0	.0	.0	.0
MENTICIRRHUS UNDULATUS	.0	.0	.0	1.9	.0	.0	.0	151.4
AMPHISTICHUS ARGENTEUS	.0	.3	.0	.0	1.2	.0	8.9	.0
HYPERPROSOPON ARGENTEUM	53.3	14.3	39.7	36.6	38.2	24.0	44.0	26.3
CYMATOGASTER AGGREGATA	18.4	34.2	65.7	117.9	261.5	91.8	219.2	37.1
PHANERODON FURCATUS	117.4	32.1	22.7	64.5	56.0	48.7	190.0	32.3
MUGIL CEPHALUS	.0	4.3	.0	27.6	.0	.0	.0	.0
PARALICHTHYS CALIFORNICUS	.0	7.8	12.8	121.6	46.3	50.7	90.7	68.4

SPECIES NAME	WEEK 25 (July 22)	26 (July 29)	27 (Aug 5)	28 (Aug 12)	29 (Aug 19)	30 (Aug 26)	31 (Sept 2)	32 (Sept 9)
UROLOPHUS HALLERI	10.9	727.6	91.9	17.1	38.5	59.0	65.3	27.8
ENGRAULIS MORDAX	90.0	46.8	8.4	9.6	343.1	59.9	60.9	7.3
ANCHOA COMPRESSA	74.1	156.1	8.4	40.0	33.8	37.8	65.5	12.7
ANCHOA DELICATISSIMA	.0	10.8	.9	10.9	11.3	5.1	2.4	2.8
LEURESTHES TENUIS	.0	.8	8.3	2.9	49.4	17.8	115.6	17.3
ATHERINOPS AFFINIS	53.1	50.9	15.3	37.4	102.6	97.1	26.9	1.7
PARALABRAX CLATHRATUS	.0	.0	.0	.0	6.0	.0	4.0	.0
PARALABRAX MACULATOFASCIATUS	.0	246.3	.0	.0	212.4	.0	.0	.0
PARALABRAX NEBULIFER	5.5	258.1	64.8	.0	.0	64.0	93.3	.0
XENISTIUS CALIFORNIENSIS	.0	2.2	.0	4.3	9.4	4.0	.0	.0
SERIPHUS POLITUS	161.7	275.6	92.2	169.5	94.7	128.9	381.3	78.5
CYNOSCION NOBILIS	.0	.0	.0	.0	.0	.3	.0	2.2
MENTICIRRHUS UNDULATUS	.0	.0	.0	201.3	.0	.0	.0	.0
HYPERPROSOPON ARGENTEUM	1.4	6.2	.0	5.9	4.1	8.4	26.1	.0
CYMATOGASTER AGGREGATA	154.4	25.7	76.6	6.6	9.2	6.8	41.1	7.1
PHANERODON FURCATUS	19.7	26.8	12.3	1.1	2.5	.8	14.4	.0
MUGIL CEPHALUS	.0	.0	.0	37.2	.0	.0	.0	.0
PARALICHTHYS CALIFORNICUS	102.5	11.2	11.8	79.9	76.2	16.4	97.7	13.2

TABLE 7.5-5 (Concluded)

SPECIES NAME	WEEK 33 (Sept 16)	34 (Sept 23)	35 (Sept 30)	36 (Oct 7)	37 (Oct 14)	38 (Oct 21)	39 (Oct 28)	40 (Nov 4)
UROLOPHUS HALLERI	123.3	132.9	141.3	36.9	99.9	147.1	52.0	102.4
ENGRAULIS MORDAX	6.6	29.4	3.3	3.6	1.8	8.5	69.9	11.3
ANCHOA COMPRESSA	4.6	60.8	54.5	42.3	30.0	57.4	55.1	58.8
ANCHOA DELICATISSIMA	6.9	5.0	3.5	2.4	1.8	28.7	.6	2.3
LEURESTHES TENUIS	104.0	293.7	114.7	59.6	81.7	234.2	400.8	131.8
ATHERINOPS AFFINIS	10.7	16.0	29.0	29.5	11.4	35.3	47.9	52.3
PARALABRAX CLATHRATUS	.0	.0	.0	.0	.0	.0	.0	1.2
PARALABRAX MACULATOFASCIATUS	.0	.0	.0	.0	32.4	.0	4.1	.0
PARALABRAX NEBULIFER	.0	.3	.8	.3	12.3	.0	3.1	.0
XENISTIUS CALIFORNIENSIS	.0	.2	.1	.0	.0	.0	.0	2.6
SERIPHUS POLITUS	49.5	88.2	144.8	93.6	91.2	201.1	172.4	174.0
CYNOSCION NOBILIS	.0	1.0	3.1	1.2	.0	.0	.0	1.3
MENTICIRRHUS UNDULATUS	.7	.0	2.0	1.3	.2	2.6	.8	.3
AMPHISTICHUS ARGENTEUS	.0	.0	9.3	.0	.0	.0	4.7	.0
HYPERPROSOPON ARGENTEUM	.0	2.5	6.1	2.0	15.4	15.3	38.3	45.2
CYMATOGASTER AGGREGATA	1.6	6.3	9.2	7.4	1.0	4.5	2.8	18.3
PHANERODON FURCATUS	.0	.0	1.2	.0	5.8	.0	52.3	4.4
MUGIL CEPHALUS	25.5	12.6	.0	.0	.0	264.9	191.9	166.5
PARALICHTHYS CALIFORNICUS	35.3	6.7	49.8	.0	.8	22.5	94.4	37.6

SPECIES NAME	WEEK 41 (Nov 11)	42 (Nov 18)	43 (Nov 25)	44 (Dec 2)	45 (Dec 9)	46 (Dec 16)	47 (Dec 23)	48 (Dec 30)
UROLOPHUS HALLERI	332.5	353.2	606.7	601.8	88.4	533.7	299.4	73.5
ENGRAULIS MORDAX	12.2	7.1	17.6	10.8	3.7	1.9	3.3	7.6
ANCHOA COMPRESSA	66.6	57.7	94.6	12.8	14.9	21.0	27.3	17.6
ANCHOA DELICATISSIMA	4.6	2.9	3.6	.5	.1	6.7	.9	.7
LEURESTHES TENUIS	93.6	710.9	353.7	63.7	26.8	13.8	7.0	11.4
ATHERINOPS AFFINIS	33.3	114.8	59.1	118.4	14.3	41.8	36.1	31.4
PARALABRAX CLATHRATUS	.4	2.3	6.2	3.3	.0	.0	1.9	2.3
PARALABRAX MACULATOFASCIATUS	1.4	.5	.6	.0	.0	.0	.0	.0
PARALABRAX NEBULIFER	.0	2.5	25.3	3.0	.0	.0	.0	.0
XENISTIUS CALIFORNIENSIS	1.7	12.1	22.8	6.1	5.1	1.2	5.4	9.3
SERIPHUS POLITUS	277.9	302.2	114.6	179.7	63.3	180.4	28.4	25.1
CYNOSCION NOBILIS	.0	.0	.0	.6	.0	.0	.0	.0
MENTICIRRHUS UNDULATUS	2.1	5.2	1.3	1.7	62.1	5.3	.0	.0
AMPHISTICHUS ARGENTEUS	.0	14.0	5.9	5.2	.9	.0	.0	.0
HYPERPROSOPON ARGENTEUM	192.0	174.6	37.6	18.3	2.2	26.7	22.5	4.9
CYMATOGASTER AGGREGATA	1.4	17.4	92.2	87.9	63.8	12.7	280.8	8.0
PHANERODON FURCATUS	18.4	.0	7.4	.8	.0	6.8	.0	.0
MUGIL CEPHALUS	.0	222.5	.0	93.1	.0	178.4	.0	.0
PARALICHTHYS CALIFORNICUS	25.7	46.7	75.9	36.5	114.3	47.0	31.6	12.9

TABLE 7.5-6

OVERALL MEAN NUMBER AND WEIGHT OF CRITICALLY-TREATED SPECIES† IMPINGED AT ENCINA POWER PLANT PER 24-HR INTERVAL DURING THE PERIOD FEBRUARY 4, 1979 - JANUARY 4, 1980

Rank	Common Name	Species Name	Mean Number	Mean Weight (g)
1	Queenfish	*Seriphus politus* (C)	20.5	142.2
2	Deepbody anchovy	*Anchoa compressa* (AC)	12.8	106.6
3	Topsmelt	*Atherinops affinis* (C)	12.0	155.3
4	California grunion	*Leuresthes tenuis* (AC)	10.2	65.9
5	Northern anchovy	*Engraulis mordax* (C)	8.2	25.3
6	Shiner surfperch	*Cymatogaster aggregata* (AC)	7.0	88.3
8	Walleye surfperch	*Hyperprosopon argenteum* (C)	3.1	61.5
9	Slough anchovy	*Anchoa delicatissima* (AC)	1.2	5.2
10	White surfperch	*Phanerodon furcatus* (AC)	3.3	25.8
11	Round stingray	*Urolophus halleri* (AC)	1.9	200.6
12	California halibut	*Paralichthys californicus* (C)	1.3	77.2
13	Giant kelpfish	*Heterostichus rostratus* (C)	0.8	6.8
16	Salema	*Xenistius californiensis* (AC)	0.6	2.5
27	Barred sand bass	*Paralabrax nebulifer* (C)	0.2	19.3
33	California corbina	*Menticirrhus undulatus* (C)	0.1	10.8
36	Barred surfperch	*Amphistichus argenteus* (C)	0.1	1.9
36	Spotted sand bass	*Paralabrax maculatofasciatus* (C)	0.1	13.2
37	Striped mullet	*Mugil cephalus* (C)	0.4	58.6
49	Kelp bass	*Paralabrax clathratus* (C)	0.04	0.6
56	White seabass	*Cynoscion nobilis* (C)	0.03	0.2
	California sheephead	*Pimelometopon pulchrum* (C)	0.0	0.0
	Pacific sanddab	*Citharicthys sordidus* (C)	0.0	0.0
	Hornyhead turbot	*Pleuronichthys verticalis* (C)	0.0	0.0

† Symbols (C) and (AC) are used to indicate critical and additionally-treated critical species.

averages based on data from the three traveling screen stations, not totals for all stations combined.

As indicated in Table 7.5-6, the queenfish (Seriphus politus) had the highest overall mean number of individuals impinged (20.5 per 24 hr). It had the third highest mean level of impingement by weight (142.2 g or 0.31 lb per 24 hr). The round stingray (Urolophus halleri) had the highest mean level of impingement by weight (200.6 g or 0.44 lb per 24 hr). The deep-body anchovy (Anchoa compressa) and the topsmelt (Atherinops affinis) were second and third in number of individuals impinged with 12.8 and 12.0 per 24 hr, respectively. Topsmelt had the second highest mean level of impingement by weight (155.3 g or 0.34 lb per 24 hr), while deepbody anchovy was fourth with 106.6 g (0.24 lb) per 24 hr. The California grunion (Leuresthes tenuis) was fourth in mean number of individuals impinged per 24-hr interval (10.2) and sixth in mean weight (65.9 g or 0.15 lb).

The weekly means for number and weight of individuals impinged shown in Tables 7.5-4 and 7.5-5, respectively, provide detailed information about short-term and seasonal variations in impingement of the critical species. Impingement of queenfish was continuous throughout the year. Highest mean numbers of individuals were impinged during the period mid-June through early September, when ambient water temperatures were highest (Figure 7.5-9), and again in November. Lowest mean numbers of queenfish were impinged during the period March-May, during a period of relatively low water temperatures. However, the largest mean weight of individuals impinged was during the week of February 18 (1101.3 g or 2.4 lb per 24 hr). Impingement of round stingray also was continuous and variable throughout the year (Tables 7.5-4 and 7.5-5). The largest mean number (13.5) and weight (1076.9 g or 2.4 lb) of individuals were impinged during the week of February 4, when water temperatures were low. The lowest mean numbers (0.1 to 0.4 individuals per 24 hr) were impinged during the period July-September, when ambient water temperatures were highest.

The highest mean numbers of deepbody anchovy (100.5 to 160.7 per 24 hr) were impinged in February, and the lowest mean numbers (0.4 per 24 hr) from mid-April through May (Table 7.5-4). The largest mean weight of individuals (1744.6 g or 3.9 lb per 24 hr) also was impinged in February (Table 7.5-5). Topsmelt also showed very definite peaks in mean number impinged (100.5 to 136.4 per 24 hr) during February, generally lower numbers throughout most of the rest of the year, and lowest mean numbers impinged during April and May. Mean weights of topsmelt showed a similar pattern.

Impingement of California grunion was relatively continuous throughout the year, with increasing numbers during September and October and a peak in mean number impinged during November (134.7 per 24 hr). Lowest mean numbers were impinged during the period February through June (Table 7.5-4). In general, mean weights of this species showed a similar pattern (Table 7.5-5). The northern anchovy (Engraulis mordax) also occurred in the impingement samples almost continuously throughout the year, with lowest mean numbers during the period September through early June. This was followed by variable but increasing mean numbers during June and July, with a peak of 126.2 per 24 hr in August. Mean weights of northern anchovy impinged showed a similar pattern.

Shiner surfperch had relatively high levels of impingement from late May through late July, with lower, variable levels throughout the rest of the year. However, the largest mean weight of shiner surfperch was impinged in February (1101.3 g or 2.4 lb per 24 hr). Both the walleye surfperch (Hyperprosopon argenteum) and the white surfperch (Phanerodon furcatus) had the largest mean numbers of individuals impinged in May, relatively large mean numbers during the early summer months, and much lower numbers during the remainder of the year (Table 7.5-4).

The California halibut (Paralichthys californicus) had the highest levels of impingement, in terms of both mean number and weight, during February (11.3 individuals per 24 hr; 971.2 g or 2.1 lb per 24 hr). Its levels of impingement were lower throughout the remainder of the year. Most of these individuals were small to large juveniles and small adults.

The short-term and seasonal patterns of impingement for most of the remaining critical species are much less clear (Tables 7.5-4 and 7.5-5). This is due in part to the fact that relatively few individuals were taken in the impingement samples.

None of these remaining species showed distinct short-term or seasonal patterns of impingement.

7.6 DAY VS NIGHT VARIATION

It is evident from examining the detailed data in Table 7.5-3 that, in general, total numbers and weights of fishes impinged seemed to be higher during the predominantly night time sampling period (1900 to 0700 hr) than during the preceding daytime period (0700 to 1900 hr). This was tested by applying a series of Wilcoxon paired-sample tests to the data for all three traveling screen stations combined. These data for numbers of individuals are shown in Table 7.6-1.

Separate tests were used to evaluate data for each week of sampling and for total number and total weight of all fishes impinged. The data for the 12-hr day and night periods of each date (Tables 7.5-3 and 7.6-1) were treated as pairs. The Wilcoxon paired-sample tests evaluated the null hypothesis that there was no difference in levels of impingement between the 12-hr day and night periods, against the one-way alternative hypothesis that levels of impingement were significantly higher at night than during the day.

The results of these tests for total number of fishes indicated that during 47 of the 48 weeks considered, impingement was significantly greater ($p<0.05$) at night than during the day. Similarly, the results for total weight of fishes indicated that during 44 of the 48 weeks considered, impingement also was significantly greater ($p<0.05$) at night than during the day.

The relationships described above are very strikingly evident in the comparative plots for numbers of individuals

TABLE 7.6-1
WEEKLY MEAN TOTAL NUMBER OF FISH IMPINGED PER 12-HR DAY AND NIGHT SAMPLING INTERVAL AT ENCINA POWER PLANT DURING THE PERIOD FEBRUARY 4, 1979 - JANUARY 4, 1980

WEEK	DAY	NIGHT
1	80.9	92.1
2	22.4	77.0
3	182.2	293.2
4	64.5	84.3
5	14.7	13.2
6	8.1	16.0
7	8.4	12.9
8	5.1	10.6
9	78.4	109.4
10	4.8	7.0
11	5.1	5.4
12	14.4	16.1
13	4.9	10.2
14	15.3	81.4
15	3.3	29.3
16	16.9	50.4
17	12.4	39.1
18	14.1	32.9
19	28.4	45.3
20	35.6	159.9
21	64.7	125.3
22	44.3	89.0
23	47.8	163.6
24	20.2	52.1
25	56.2	77.1
26	29.7	107.7
27	8.6	34.6
28	13.2	72.8
29	105.8	123.8
30	21.1	74.9
31	13.9	153.2
32	3.5	43.6
33	5.3	32.8
34	9.3	60.4
35	18.0	52.5
36	11.9	46.5
37	25.6	33.3
38	67.5	87.4
39	53.3	139.5
40	35.4	65.9
41	64.8	80.4
42	101.2	230.0
43	33.9	292.3
44	41.4	45.2
45	16.6	25.9
46	29.7	56.6
47	18.5	50.0
48	12.3	18.3

shown in Figure 7.6-1. All of this evidence indicates clearly that the total number or weight of fishes impinged during the period 1900 to 0700 hr was usually greater than that impinged during the preceding daylight period of 0700 to 1900 hr. There are several possible explanations for this. Many fishes tend to be more quiescent during darkness. Visual cues used in swimming and avoidance behavior also would be reduced at that time. Because of this, some fishes may be more susceptible to being transported into the cooling water system during periods of darkness. Another possible explanation is that some fishes may move into the area near the Power Plant during the night to feed or to seek shelter. Some or all of these processes may be acting in combination to produce the effects observed.

7.7 VARIATION IN RELATION TO TIDAL CONDITIONS

Statistical evaluations were done to consider the possible effects of spring and neap tide conditions on levels of impingement for fishes. During minimum or neap tide periods, the oscillation of water above and below mean sea level is more compressed than during extreme or spring tidal periods, when high tide levels are lower and the low tide levels higher. The presumption was that these differences in tidal range might lead to differences in levels of impingement.

A series of Mann-Whitney U tests was applied to data for total number and weight of all fishes impinged (Tables 7.5-3 and 7.6-1) during the spring and neap tide periods of each monthly series of moon phases, using standard tide and moon phase tables as a basis for classification. Data from all three traveling screen stations combined were used in these tests.

The Mann-Whitney U tests evaluated the null hypothesis that there was no difference in levels of impingement between spring and neap tide conditions during a given series of moon phases, against the alternative hypothesis that there was a significant difference between them.

The results indicate that in only one of 46 test comparisons for number of fishes and in only two of 46 comparisons for weight of fishes were the differences significantly different between spring and neap tide periods ($p<0.05$). All of the remaining comparisons show no significant differences ($p<0.05$) in levels of impingement.

This evidence suggests that tidal conditions, as considered in this evaluation, had no evident effects on the total number or weight of fishes impinged. No attempt was made to evaluate effects of incoming and outgoing tidal flow on levels of impingement. This more detailed evaluation was not possible because both conditions of tidal flow occurred within a given 12-hr sampling interval.

000538

7.8 RELATIONSHIP OF IMPINGEMENT TO FLOW RATES IN THE COOLING WATER SYSTEM

As described in Section 3.0 and Appendix Section 16.2.3 of this report, flow rates of seawater into the cooling water system of the Encina Power Plant and within different parts of the system vary, depending on the number of circulating pumps and generating units in operation. An attempt was made to evaluate the relationship between levels of impingement for fishes and different conditions of flow rate that occurred during the 48-week period of the study. This was done by analyzing data for each traveling screen station separately and for all stations combined.

The basic biological data on which these evaluations were based, total number and weight of all fishes impinged, are given in Tables 7.5-1 and 7.5-3. Mean flow rates of water moving past the three traveling screen stations associated with generating Units 1-3, 4, and 5 and mean total flow rates of water for all generating units combined are shown in Table 7.5-2 for each weekly interval during the period February 4, 1979 to January 4, 1980. The methods of determining flow rates are described in Appendix Section 16.2.3.

Plots of these weekly mean flow rate data are shown together in Figure 7.8-1 for comparison. The long period during March - July when Unit 4 was out of service or operating at a low level of flow, and the period during May when Unit 5 was out of service, are reflected in the plots. Variations in flow at each traveling screen station and for the cooling water system as a whole also are evident.

Weekly mean data for total numbers of fishes impinged at stations 1, 4, and 5 are shown in Figures 7.8-2, 7.8-3, and 7.8-4, respectively. Also shown in these figures are the corresponding plots of weekly mean flow rates. Plots of mean total numbers of all fishes impinged at the three stations combined and the combined flow rate for all generating units are shown in Figure 7.8-5.

Parametric correlation analysis was used in an attempt to determine possible statistical relationships between flow rates of the cooling water and the total number and weight of all fishes impinged during corresponding periods of time. Weekly mean values for the entire 48-week period of the study (Figures 7.8-2 through 7.8-5) were employed in these analyses.

The possible correlations considered and the correlation coefficient determined for each were as follows (SIG indicates significant correlation at the level shown):

	Station 1		Station 4		Station 5		All Stations Combined	
Flow Rate For:	Number of Fishes	Weight of Fishes	Number of Fishes	Weight of Fishes	Number of Fishes	Weight of Fishes	Number of Fishes	Weight of Fishes
All Units Combined	0.181	0.138	0.392 SIG ($p<.05$)	0.332 SIG ($p<.05$)	0.140	-0.012	0.315 SIG ($p<.05$)	0.156
Units 1-3	0.047	0.168						
Unit 4			0.428 SIG ($p<.05$)	0.349 SIG ($p<.05$)				
Unit 5					0.204	0.276 SIG ($p<.05$)		

000540

These results indicate that there were statistically significant positive correlations between total flow rate for all units combined and both total number and weight of all fishes impinged at station 4. There also were significant positive correlations between the flow rate of water passing to generating Unit 4 and the total number and weight of fishes impinged at station 4. The flow rate for all units combined showed a significant positive correlation with total number of fishes impinged at all traveling screen stations combined, but not with total weight of these fishes. The flow rate of water to generating Unit 5 showed a significant positive correlation with total weight of fishes impinged at station 5, but not with the total number of fishes.

These correlation analyses suggest that, in general, levels of impingement increased in relation to increasing flow rates of the cooling water. Effects of other factors and random variability probably tended to mask or alter this relationship in some cases. This appears to be the case for levels of impingement at station 1, as shown in Figure 7.8-2. Despite the fact that the flow rate of water past the traveling screens at this station was relatively constant, levels of impingement varied widely.

It is interesting to note that during March, April, and early May, when generating Unit 4 was not operating and total flow rates into the cooling water system of the Power Plant were reduced from approximately 500,000 gpm to 350,000 gpm (Figure 7.8-1, Table 7.5-2), impingement at stations 1 and 5 declined and generally tended to remain at low levels (Figures 7.8-2 and 7.8-4, Table 7.5-1). While by no means conclusive, this evidence suggests that such a reduction in flow rate of water entering the Power Plant from the lagoon tended to reduce impingement at stations 1 and 5, despite the fact that flow rates at the traveling screens for generating Units 1-3 and 5 remained relatively constant during the entire period (Figure 7.8-1, Table 7.5-2).

7.9 BODY CONDITION AND SIZE DISTRIBUTIONS OF FISHES IMPINGED

The degree of decomposition and the degree of physical damage found during examination of all of the impinged fishes were characterized on grading scales of 1 to 4, as shown in Table 7.9-1. The mean values of these two estimates of body condition are shown in Table 7.9-2 for the 19 critically treated species. Separate mean values are shown for each traveling screen station and for all stations combined. These means are based on all data obtained during the 48-week period of the study.

In general, there was little decomposition of the fishes impinged at the three traveling screen stations. Almost all of the critical species were assigned decomposition codes of 1 or 2. Also, in most cases there was relatively little physical damage to the fish. Together, these data indicate that most of the fishes impinged probably were alive at the time they reached the traveling screens and passed into the collector baskets. Direct observation of the fishes in the sampling nets confirmed this fact. A majority of those that had entered sampling nets and trash collectors recently appeared to be alive and in relatively good condition. Much of the observed decomposition probably occurred while the fish were held in the sampling nets over periods of several hours. On many occasions when the traveling screens had been operated shortly before the sampling net was removed, most of the fish were still alive in the net at the time the samples were collected. Routinely, these live fishes were placed in holding tanks at the Encina laboratory and were

TABLE 7.9-1
CODES USED FOR EVALUATING BODY CONDITION OF IMPINGED FISHES AT ENCINA POWER PLANT DURING 1979

DECOMPOSITION CODE

Characteristics/ Appearance	Code 1	Code 2	Code 3	Code 4
Skin	Normal luster, color clear and bright	Color dull, no apparent slime	Normal color and luster gone, some muscle structure visible	Gross discoloration, skin in abnormal stage of discoloration
Odor	Fresh: typical of freshly caught fish	Flat to slightly fishy odor	Slightly stale or rancid odor, but not sour, putrid	Sour, putrid (stinkers) or definite off odor
Degree of firmness	Firm, elastic	Firm, no elasticity	Soft	Very soft and mushy

PHYSICAL DAMAGE CODE

Characteristics/ Appearance	Code 1	Code 2	Code 3	Code 4
Eyes	Clear, bright and protruding	Sunken, cloudy-white or reddish	Sunken, dull-white, smashed, red	Missing
Physical damage	No mutilation or deformity	Slight deformities or mutilation, no splitting	Some splitting of body or shell, slightly broken or smashed	Badly split, smashed or mutilated, or with >20% of flesh exposed

TABLE 7.9-2
MEAN DECOMPOSITION AND DAMAGE CODES FOR ALL INDIVIDUALS OF CRITICALLY-TREATED SPECIES EXAMINED AT ENCINA POWER PLANT DURING 1979

SPECIES NAME	STATION 1 DECOMP	DAMAGE	4 DECOMP	DAMAGE	5 DECOMP	DAMAGE
UROLOPHUS HALLERI	1.57	1.29	1.16	1.36	1.76	1.70
ENGRAULIS MORDAX	1.43	2.32	1.61	2.16	1.92	2.66
ANCHOA COMPRESSA	1.31	1.80	1.35	1.76	1.71	2.37
ANCHOA DELICATISSIMA	1.25	1.83	1.28	1.81	1.33	2.03
LEURESTHES TENUIS	1.07	1.26	1.17	1.36	1.42	2.06
ATHERINOPS AFFINIS	1.45	1.54	1.30	1.39	1.73	1.96
PARALABRAX CLATHRATUS	1.00	1.00	1.00	1.00	1.50	1.50
PARALABRAX MACULATOFASCIATUS	1.75	1.60	2.00	1.75	3.85	3.39
PARALABRAX NEBULIFER	1.13	1.25	1.41	1.40	2.35	2.42
XENISTIUS CALIFORNIENSIS	1.24	1.23	1.07	1.18	1.31	1.36
SERIPHUS POLITUS	1.19	1.38	1.21	1.37	1.34	1.64
CYNOSCION NOBILIS	1.33	1.00	1.00	1.40	1.00	1.25
MENTICIRRHUS UNDULATUS	1.00	1.00	1.19	1.25	1.21	1.42
AMPHISTICHUS ARGENTEUS	1.00	1.08	1.09	1.27	1.21	1.58
HYPERPROSOPON ARGENTEUM	1.08	1.29	1.23	1.26	1.69	1.90
CYMATOGASTER AGGREGATA	1.40	1.48	1.26	1.28	1.54	1.62
PHANERODON FURCATUS	1.05	1.18	1.14	1.24	1.14	1.28
MUGIL CEPHALUS	1.33	1.67	1.00	1.50	1.15	1.53
PARALICHTHYS CALIFORNICUS	1.06	1.14	1.10	1.18	1.26	1.33

000545

released after being processed as part of the sample. These individuals appeared to be in good condition when released.

There was at least one exception to the generalization described above. For periods of up to several days after tunnel recirculation (heat treatment), the impinged fishes were noticeably more decomposed than at other times during the year. One critical species, the spotted sand bass (Paralabrax maculatofasciatus), was impinged in significant numbers only after periods of tunnel recirculation, and thus the mean values given in Table 7.9-2 for decomposition of this species are much higher than for other species. To some extent this also appeared to be true for the barred sand bass (Paralabrax nebulifer), at least at screenwell station 5.

The overall average decomposition and damage codes for the 19 critical species at the three stations were:

Station	Mean Decomposition Code	Mean Physical Damage Code
1	1.25	1.39
4	1.24	1.42
5	1.60	1.84

From these overall values it is apparent that screenwell stations 1 and 4 were approximately equal in the amount of physical damage experienced by impinged fishes. Damage at station 5 appeared to be slightly more severe.

Some differences in degree of physical damage also were observed among species. There appeared to be a fairly direct relationship between the amount of damage and the fragility or delicate morphological characteristics of the species. For example, all three of the anchovy species shown in Table 7.9-2 (Anchoa compressa, A. delicatissima and Engraulis mordax) were subject to much more damage than the two relatively more "firm-fleshed" atherinid species (Atherinops affinis and Leuresthes tenuis). Similar correlations can be seen for the sciaenids and other groups.

The data also were examined for possible relationships in size of fishes and physical damage that occurred during impingement. Size data for the critical species are summarized in Table 7.9-3. Disregarding the fragile anchovy species, a general trend appears to be evident in which the larger species of fishes seem to be slightly more damaged during impingement than smaller species. However, more extensive analyses of the data would be required to verify this relationship.

From Table 7.9-3 it is evident that a considerable size range of each species was impinged. For example, individuals of the strong swimming striped mullet (Mugil cephalus) varying from 67 to 630 mm in total length were impinged (mean = 303 mm). This may indicate that the impingement was not necessarily a function of swimming speed, strength or stamina. Once again, however, more detailed analysis of the data would be required to verify this observation. The mean lengths of several of the impinged species were represented in the samples primarily by smaller juvenile sizes. However, this could be attributed to the natural

TABLE 7.9-3
MEAN, STANDARD DEVIATION, AND RANGE OF TOTAL LENGTHS (mm) FOR EACH CRITICALLY-TREATED SPECIES MEASURED AT ENCINA POWER PLANT DURING 1979

SPECIES NAME	N	MEAN	STANDARD DEVIATION	MINIMUM LENGTH	MAXIMUM LENGTH
UROLOPHUS HALLERI	929	199.7	54.0	44	403
ENGRAULIS MORDAX	2056	86.0	25.4	16	170
ANCHOA COMPRESSA	4494	101.8	18.4	12	186
ANCHOA DELICATISSIMA	821	76.0	10.6	46	132
LEURESTHES TENUIS	2016	115.7	30.0	47	202
ATHERINOPS AFFINIS	3257	127.2	34.5	27	313
PARALABRAX CLATHRATUS	20	108.6	30.2	61	213
PARALABRAX MACULATOFASCIATUS	42	202.3	93.7	55	430
PARALABRAX NEBULIFER	82	150.3	86.9	45	422
XENISTIUS CALIFORNIENSIS	293	68.3	16.8	46	220
SERIPHUS POLITUS	6743	81.7	30.4	40	420
CYNOSCION NOBILIS	12	96.1	21.4	64	138
MENTICIRRHUS UNDULATUS	50	127.8	116.5	50	540
AMPHISTICHUS ARGENTEUS	54	92.8	37.9	25	196
HYPERPROSOPON ARGENTEUM	1085	98.1	45.5	40	240
CYMATOGASTER AGGREGATA	2399	88.6	28.0	7	260
PHANERODON FURCATUS	1063	79.2	26.0	53	357
MUGIL CEPHALUS	42	302.9	190.0	67	630
HETEROSTICHUS ROSTRATUS	525	118.7	40.7	17	310
PARALICHTHYS CALIFORNICUS	549	154.8	60.3	17	631

attraction of smaller fishes to bays and estuaries such as Agua Hedionda Lagoon, rather than a selectivity in the size of fishes impinged in the cooling water system of the Encina Power Plant.

7.10 SEX RATIOS AND REPRODUCTIVE CONDITION OF CRITICAL SPECIES

Using the methods described in Appendix B, Section 16.2.3, monthly samples of fishes were analyzed in detail in an attempt to determine the sex ratios and female reproductive condition for the 19 critically treated species. The dates for which regular 12-hr impingement samples were employed in these analyses were:

February 4, 1979
March 6-8 and 11-14
April 9-12 and 15-17
May 7-10 and 13-15
June 13-16
July 29-31
August 27-30
September 26-27
November 6-8 and 27-29
December 31
January 2-3, 1980

Data obtained for each traveling screen station and for all the dates indicated within a given month were pooled. The results of these analyses are described in this subsection.

The monthly analyses provided data for only 11 of the 19 critically treated species. They are:

Common Name	Species Name
Queenfish	*Seriphus politus*
Topsmelt	*Atherinops affinis*

Northern anchovy	_Engraulis mordax_
Walleye surfperch	_Hyperprosopon argenteum_
California halibut	_Paralichthys californicus_
Deepbody anchovy	_Anchoa compressa_
California grunion	_Leuresthes tenuis_
Shiner surfperch	_Cymatogaster aggregata_
Slough anchovy	_Anchoa delicatissima_
Round stingray	_Urolophus halleri_
Salema	_Xenistius californiensis_

Adults of the other eight critical species did not occur in the samples used. One additional species, the specklefin midshipman (_Porichthys myriaster_), also was included because the individuals impinged had unusual reproductive characteristics.

Table 7.10-1 gives the number of males and females of each species and the resulting sex ratio (M/F). These data are shown separately by month. Values also are given for all months combined. Not shown in Table 7.10-1 are the numbers of immature individuals for which the sex could not be determined. In general, approximately 70 to 80 percent of the individuals examined in these samples were immature. As indicated in Table 7.10-1, the numbers of adult males and females of a species present in samples for a given month generally were small. Because of this, the sex ratio estimates for some species varied considerably from month to month. The data for round stingray and deepbody anchovy illustrate the problem. Sex ratios estimated for round stingray varied from 0.18 to 1.67 and those for deepbody

TABLE 7.10-1
MONTHLY NUMBERS OF MALES AND FEMALES AND SEX RATIOS OF CRITICALLY-TREATED SPECIES EXAMINED AT ENCINA POWER PLANT DURING 1979

SPECIES NAME	01 JANUARY 1980 NO. OF MALES	NO. OF FEMALES	RATIO (M/F)	02 FEBRUARY 1979 NO. OF MALES	NO. OF FEMALES	RATIO (M/F)	03 MARCH 1979 NO. OF MALES	NO. OF FEMALES	RATIO (M/F)
UROLOPHUS HALLERI	0	0	.00	14	20	.70	3	2	1.50
ENGRAULIS MORDAX	0	0	.00	0	0	.00	0	0	.00
ANCHOA COMPRESSA	2	2	1.00	0	0	.00	2	16	.13
ANCHOA DELICATISSIMA	0	0	.00	0	0	.00	5	17	.29
PORICHTHYS MYRIASTER	0	0	.00	0	0	.00	0	0	.00
LEUPESTHES TENUIS	0	0	.00	2	0	.00	0	0	.00
ATHERINOPS AFFINIS	2	4	.50	3	13	.23	2	13	.15
XENISTIUS CALIFORNIENSIS	0	0	.00	0	0	.00	0	0	.00
SERIPHUS POLITUS	0	0	.00	0	0	.00	0	0	.00
HYPERPROSOPON ARGENTEUM	0	0	.00	0	0	.00	0	0	.00
CYMATOGASTER AGGREGATA	0	0	.00	0	0	.00	0	0	.00
PARALICHTHYS CALIFORNICUS	0	0	.00	0	0	.00	3	1	3.00

SPECIES NAME	04 APRIL 1979 NO. OF MALES	NO. OF FEMALES	RATIO (M/F)	05 MAY 1979 NO. OF MALES	NO. OF FEMALES	RATIO (M/F)	06 JUNE 1979 NO. OF MALES	NO. OF FEMALES	RATIO (M/F)
UROLOPHUS HALLERI	4	4	1.00	1	4	.25	3	6	.50
ENGRAULIS MORDAX	0	0	.00	0	0	.00	0	0	.00
ANCHOA COMPRESSA	2	1	2.00	0	0	.00	13	23	.57
ANCHOA DELICATISSIMA	0	0	.00	0	0	.00	0	0	.00
PORICHTHYS MYRIASTER	0	0	.00	0	0	.00	1	5	.20
LEURESTHES TENUIS	1	3	.33	2	1	2.00	0	0	.00
ATHERINOPS AFFINIS	2	4	.50	2	0	.00	0	0	.00
XENISTIUS CALIFORNIENSIS	0	0	.00	0	0	.00	0	0	.00
SERIPHUS POLITUS	0	0	.00	0	0	.00	0	0	.00
HYPERPROSOPON ARGENTEUM	0	0	.00	0	0	.00	0	0	.00
CYMATOGASTER AGGREGATA	0	0	.00	0	0	.00	0	0	.00
PARALICHTHYS CALIFORNICUS	0	0	.00	0	0	.00	0	0	.00

000553

TABLE 7.10-1 (Concluded)

SPECIES NAME	07 JULY 1979 NO. OF MALES	NO. OF FEMALES	RATIO (M/F)	08 AUGUST 1979 NO. OF MALES	NO. OF FEMALES	RATIO (M/F)	09 SEPTEMBER 1979 NO. OF MALES	NO. OF FEMALES	RATIO (M/F)
UROLOPHUS HALLERI	3	17	.18	0	0	.00	1	3	.33
ENGRAULIS MORDAX	0	0	.00	0	0	.00	0	0	.00
ANCHOA COMPRESSA	1	4	.25	4	20	.20	2	1	2.00
ANCHOA DELICATISSIMA	2	2	1.00	0	0	.00	0	0	.00
PORICHTHYS MYRIASTER	0	0	.00	2	5	.40	0	0	.00
LEURESTHES TENUIS	0	0	.00	0	0	.00	2	17	.12
ATHERINOPS AFFINIS	2	1	2.00	0	0	.00	0	0	.00
XENISTIUS CALIFORNIENSIS	0	0	.00	1	0	.00	0	0	.00
SERIPHUS POLITUS	0	0	.00	0	0	.00	0	0	.00
HYPERPROSOPON ARGENTEUM	0	0	.00	0	0	.00	0	0	.00
CYMATOGASTER AGGREGATA	0	0	.00	0	0	.00	0	0	.00
PARALICHTHYS CALIFORNICUS	0	0	.00	0	0	.00	0	0	.00

SPECIES NAME	11 NOVEMBER 1979 NO. OF MALES	NO. OF FEMALES	RATIO (M/F)	12 DECEMBER 1979 NO. OF MALES	NO. OF FEMALES	RATIO (M/F)	ALL MONTHS NO. OF MALES	NO. OF FEMALES	RATIO (M/F)
UROLOPHUS HALLERI	24	23	1.04	5	3	1.67	58	82	0.71
ENGRAULIS MORDAX	3	4	.75	0	0	.00	3	4	0.75
ANCHOA COMPRESSA	9	1	9.00	0	0	.00	35	68	0.51
ANCHOA DELICATISSIMA	1	1	1.00	0	0	.00	8	20	0.40
PORICHTHYS MYRIASTER	0	0	.00	0	0	.00	3	10	0.30
LEURESTHES TENUIS	1	5	.20	0	0	.00	6	26	0.23
ATHERINOPS AFFINIS	1	3	.33	0	0	.00	14	38	0.37
XENISTIUS CALIFORNIENSIS	0	0	.00	0	0	.00	1	0	0.00
SERIPHUS POLITUS	1	1	1.00	0	0	.00	1	1	1.00
HYPERPROSOPON ARGENTEUM	1	0	.00	0	0	.00	1	0	0.00
CYMATOGASTER AGGREGATA	2	0	.00	0	0	.00	2	0	0.00
PARALICHTHYS CALIFORNICUS	0	0	.00	0	0	.00	3	1	3.00

anchovy from 0.13 to 9.00 (Table 7.10-1). It appears very unlikely that these reflect true variations in sex ratio of the impinged individuals from month to month. Instead, it is more likely that the variations were due primarily to the small total numbers of adult males and females taken in the samples.

The data for all months combined show that deepbody anchovy and round stingray had sex ratios of 0.51 and 0.71, respectively. This indicates that, overall, the proportion of females impinged was greater than that of males. The same was true for slough anchovy, with an overall sex ratio of 0.40.

Some species showed more consistency in their sex ratios. The specklefin midshipman occurred in samples only during June, July, and August. In both instances, however, the numbers of females were much greater than the numbers of males, with sex ratios of 0.20 and 0.40 (Table 7.10-1). The sex ratio for both months combined was 0.30. With one exception in each case, the same was true for California grunion (sex ratios of 0.12 to 0.33) and topsmelt (sex ratios of 0.15 to 0.50). Sex ratios of these two species for all months combined were 0.23 and 0.37, respectively. California halibut were taken only in the samples for March. As indicated in Table 7.10-1, there were more males than females, giving a sex ratio of 3.00. Data for the remaining species were too limited to allow generalizations about their sex ratios (Table 7.10-1). Among the eight species for which adequate data were available, seven had overall sex ratios well below 1.00, indicating that the number of adult females impinged was greater than the number of males.

Table 7.10-2 summarizes data concerning the reproductive condition of females for 11 critical species of fishes. No adult females of the remaining eight critical species occurred in the reproductive samples. Data also are included for specklefin midshipman. The reproductive condition codes shown in Table 7.10-2 are the following:

Female Reproductive Condition Code		Criteria
1	Immature	Ovary small and completely undeveloped
2	Developing	Ovary small but with eggs visible
3	Ripe	Ovary large with eggs visible; eggs can be expelled by pressure on body wall
4	Spent	Ovary ragged in appearance

Additional reproductive condition codes used for embiotocid and elasmobranch fishes only:

5 Carrying young fishes - early stages of development

6 Carrying young fishes - late stages of development

These codes were assigned to individual females by dissecting and examining the ovaries and by determining the presence of young in embiotocids (surfperches) and elasmobranchs (rays). A detailed description of these methods is provided in Appendix Section 16.2.3. The values in Table 7.10-2 are the percentages

TABLE 7.10-2
PERCENTAGES OF FEMALES IN DIFFERENT STAGES OF REPRODUCTIVE CONDITION SHOWN BY MONTH FOR THE PERIOD FEBRUARY 1979 - JANUARY 1980
ENCINA POWER PLANT

MONTHLY REPRODUCTIVE CONDITION FOR SERIPHUS POLITUS

MONTH	N	REPRODUCTIVE CONDITION CODE 1 %	2 %	3 %	4 %	5 %	6 %
02	1	.00	1.00	.00	.00	.00	.00
03	1	1.00	.00	.00	.00	.00	.00
04	1	1.00	.00	.00	.00	.00	.00
06	1	.00	1.00	.00	.00	.00	.00
07	4	.25	.50	.25	.00	.00	.00
09	1	.00	.00	.00	1.00	.00	.00
11	1	1.00	.00	.00	.00	.00	.00

MONTHLY REPRODUCTIVE CONDITION FOR ANCHOA COMPRESSA

MONTH	N	REPRODUCTIVE CONDITION CODE 1 %	2 %	3 %	4 %	5 %	6 %
01	2	.50	.50	.00	.00	.00	.00
03	16	.25	.75	.00	.00	.00	.00
04	1	.00	1.00	.00	.00	.00	.00
06	24	.00	.54	.42	.04	.00	.00
07	4	.50	.50	.00	.00	.00	.00
08	20	.95	.05	.00	.00	.00	.00
09	1	1.00	.00	.00	.00	.00	.00
11	1	1.00	.00	.00	.00	.00	.00

MONTHLY REPRODUCTIVE CONDITION FOR ATHERINOPS AFFINIS

MONTH	N	REPRODUCTIVE CONDITION CODE 1 %	2 %	3 %	4 %	5 %	6 %
01	4	.00	1.00	.00	.00	.00	.00
02	13	.00	.85	.15	.00	.00	.00
03	13	.08	.46	.46	.00	.00	.00
04	4	.00	.50	.50	.00	.00	.00
07	1	.00	1.00	.00	.00	.00	.00
08	1	1.00	.00	.00	.00	.00	.00
11	3	1.00	.00	.00	.00	.00	.00

TABLE 7.10-2 (Continued)

MONTHLY REPRODUCTIVE CONDITION FOR LEURESTHES TENUIS

		REPRODUCTIVE CONDITION CODE					
		1	2	3	4	5	6
MONTH	N	%	%	%	%	%	%
04	3	.00	.67	.33	.00	.00	.00
05	1	.00	.00	1.00	.00	.00	.00
06	2	.00	.00	1.00	.00	.00	.00
08	6	1.00	.00	.00	.00	.00	.00
09	17	.41	.29	.00	.29	.00	.00
11	5	.80	.20	.00	.00	.00	.00

MONTHLY REPRODUCTIVE CONDITION FOR ENGRAULIS MORDAX

		REPRODUCTIVE CONDITION CODE					
		1	2	3	4	5	6
MONTH	N	%	%	%	%	%	%
03	1	.00	1.00	.00	.00	.00	.00
04	1	.00	1.00	.00	.00	.00	.00
07	1	1.00	.00	.00	.00	.00	.00
08	1	1.00	.00	.00	.00	.00	.00
11	4	.75	.25	.00	.00	.00	.00

MONTHLY REPRODUCTIVE CONDITION FOR CYMATOGASTER AGGREGATA

		REPRODUCTIVE CONDITION CODE					
		1	2	3	4	5	6
MONTH	N	%	%	%	%	%	%
03	5	.00	.00	.00	.00	1.00	.00
04	15	.07	.20	.07	.13	.13	.40
05	1	.00	1.00	.00	.00	.00	.00
06	1	.00	.00	1.00	.00	.00	.00
08	1	1.00	.00	.00	.00	.00	.00

000557

TABLE 7.10-2 (Continued)

MONTHLY REPRODUCTIVE CONDITION FOR HYPERPROSOPON ARGENTEUM

MONTH	N	REPRODUCTIVE CONDITION CODE 1 %	2 %	3 %	4 %	5 %	6 %
03	1	.00	.00	.00	.00	.00	1.00
04	5	.00	.40	.00	.40	.00	.20
05	5	.00	.80	.00	.00	.00	.20
06	2	.50	.00	.00	.50	.00	.00

MONTHLY REPRODUCTIVE CONDITION FOR ANCHOA DELICATISSIMA

MONTH	N	REPRODUCTIVE CONDITION CODE 1 %	2 %	3 %	4 %	5 %	6 %
03	17	.06	.94	.00	.00	.00	.00
07	2	.00	1.00	.00	.00	.00	.00
11	1	.00	1.00	.00	.00	.00	.00

MONTHLY REPRODUCTIVE CONDITION FOR UROLOPHUS HALLERI

MONTH	N	REPRODUCTIVE CONDITION CODE 1 %	2 %	3 %	4 %	5 %	6 %
01	1	1.00	.00	.00	.00	.00	.00
02	1	1.00	.00	.00	.00	.00	.00
03	2	1.00	.00	.00	.00	.00	.00
04	4	1.00	.00	.00	.00	.00	.00
05	4	1.00	.00	.00	.00	.00	.00
06	6	1.00	.00	.00	.00	.00	.00
07	10	1.00	.00	.00	.00	.00	.00
08	1	1.00	.00	.00	.00	.00	.00
09	3	.67	.00	.00	.00	.00	.33
11	22	1.00	.00	.00	.00	.00	.00
12	3	1.00	.00	.00	.00	.00	.00

TABLE 7.10-2 (Concluded)

MONTHLY REPRODUCTIVE CONDITION FOR PARALICHTHYS CALIFORNICUS

		REPRODUCTIVE CONDITION CODE					
		1	2	3	4	5	6
MONTH	N	%	%	%	%	%	%
03	1	1.00	.00	.00	.00	.00	.00

MONTHLY REPRODUCTIVE CONDITION FOR HETEROSTICHUS ROSTRATUS

		REPRODUCTIVE CONDITION CODE					
		1	2	3	4	5	6
MONTH	N	%	%	%	%	%	%
11	2	.00	.50	.50	.00	.00	.00

MONTHLY REPRODUCTIVE CONDITION FOR PORICHTHYS MYRIASTER

		REPRODUCTIVE CONDITION CODE					
		1	2	3	4	5	6
MONTH	N	%	%	%	%	%	%
06	5	.00	.40	.60	.00	.00	.00
07	2	.00	.00	1.00	.00	.00	.00
08	5	.00	.00	1.00	.00	.00	.00

of females in each of these different stages of reproductive condition, shown by month for the period February 1979 to January 1980.

The data for queenfish show a clear pattern of reproductive development, despite the fact that the number of females examined was relatively small. Only females with immature ovaries or those with developing eggs in the ovaries were encountered in the samples during the period from January to June. Females with developing and ripe ovaries occurred in the July samples, and a spent female was present in August.

For deepbody anchovy, both ripe and spent females were taken only during the June collections (Table 7.10-2). Females with immature ovaries were present during January, March, July through September, and November. Those with developing ovaries were noted during January, March, April, and June through August.

For topsmelt only females with immature ovaries were encountered in the August and November samples (Table 7.10-2). Only females with developing eggs occurred in January, and both developing and ripe females were encountered in the samples for February, March and April. For California grunion, only females with immature and developing ovaries occurred in samples during the period from August to November. Developing and ripe females were taken in April, and only ripe females were encountered in May and June.

Only females with immature or developing ovaries were taken in the monthly samples for both northern anchovy and slough anchovy. However, the numbers of individuals examined were very small (Table 7.10-2).

The two species of surfperches, shiner surfperch and walleye surfperch, showed fairly distinct patterns of reproductive activity. For shiner surfperch, only females with immature and developing ovaries were encountered in May and August. A ripe female occurred in June. Females carrying young were encountered in March and April. Both spent females and those carrying young in advanced stages of development occurred in the April samples. Female walleye surfperch carrying young in advanced stages of development were encountered in March, April and May. Spent females also occurred in April and June. Females of the round stingray had only immature ovaries in all samples except those for September. The latter contained one female carrying young in an advanced stage of development.

Only one immature female of California halibut was taken in the reproductive samples. Female giant kelpfish occurred only in the November samples. Females with both developing and ripe ovaries were present in this sample. Female specklefin midshipman occurred in impingement samples during June, July, and August. As indicated in Table 7.10-2, almost all of them (10 of 12) had ripe ovaries.

While these data are limited, they do indicate that for most of the 12 species considered, adult females in all stages of reproductive development are impinged. Possible exceptions are northern anchovy, slough anchovy, round stingray, and California halibut. However, too few individuals of all these species except round stingray were taken in the samples to evaluate this question adequately.

Relatively large numbers of female round stingray were taken (57). Yet the ovaries of all but one of these were immature. In the case of specklefin midshipman, on the other hand, 10 of the 12 adult females encountered were in ripe condition.

7.11 IMPINGEMENT OF MARINE PLANTS

In terms of volume, the largest component of biological material normally encountered in impingement samples at the Encina Power Plant consisted of marine algae and grasses. Most of this was large or small fragments of detrital plant material that had broken free from the bottom and entered the cooling water system in floating or drifting masses.

The species of vascular plants (marine grasses) and marine algae encountered in impingement samples at stations 1, 4, 5, and 9 during the study are listed in Table 7.11-1. Seven species were represented in these samples. Fragments of other species may have been present in very small amounts, but were not identified.

Very large accumulations of marine plant material were impinged and removed at the bar rack screening system (station 9), shown in Figure 7.3-1. All seven species listed in Table 7.11-1 were taken in the bar rack samples. The rankings for these, based on frequency of occurrence and estimated relative volume, are shown in Table 7.11-2. The two highest ranked species, eel grass (Zostera marina) and giant kelp (Macrocystis pyrifera), had essentially the same frequency of occurrence at station 9, but the volume of eel grass was generally greater in most samples. Eel grass is a very common species in Agua Hedionda Lagoon, forming extensive beds in shallow water as described in Section 6.0 of this report. Similarly, giant kelp is the dominant large marine alga in shallow ocean areas near the Power

TABLE 7.11-1
SPECIES OF MARINE GRASSES AND ALGAE TAKEN IN IMPINGEMENT SAMPLES AT THE ENCINA POWER PLANT DURING THE PERIOD JANUARY 1979 - JANUARY 1980

Scientific Name	Common Name
Vascular plants (marine grasses):	
Phyllospadix torreyi	Torrey's surf grass
Zostera marina	Eel grass
Algae:	
Codium fragile	Codium
Cystoseira setchelli	Bladder chain
Egregia menziesii	Feather boa
Macrocystis pyrifera	Giant kelp
Sargassum agardhianum	Sargassum

000564

TABLE 7.11-2
RANKING OF MARINE GRASS AND ALGAL SPECIES (BASED ON VOLUME) IMPINGED AT THE BAR RACK SCREENING SYSTEM OF ENCINA POWER PLANT DURING THE PERIOD FEBRUARY 4, 1979 - JANUARY 4, 1980

			Frequency of Daily Occurrence at Each Rank					
Rank	Common Name	Scientific Name	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5-6	Total
1	Eel grass	*Zostera marina*	163	28	4	0	0	195
2	Giant kelp	*Macrocystis pyrifera*	34	155	5	0	0	194
3	Feather boa	*Egregia menziesii*	1	12	138	8	1	160
4	Sargassum	*Sargassum agardhianum*	0	0	13	99	6	118
5	Torrey's surf grass	*Phyllospadix torreyi*	0	0	13	13	59	85
6	Codium	*Codium fragile*	0	0	1	5	0	6
7	Bladder chain	*Cystoseira setchelli*	0	0	0	0	2	2

Plant. Because of this, their large volumes in the impingement samples are not surprising. The feather boa (Egregia menziesii) and sargassum (Sargassum agardhianum) also were relatively common in samples at station 9. Most of the plant material impinged on the bar rack screening system consisted of relatively large masses or fragments.

A plot showing variation in mean total volume of material impinged at station 9 per 24-hr interval for each month of the study appears in Figure 7.11-1. Almost all of this material consisted of marine plants. Levels of impingement were highest in February and lowest in May and June. In general, the highest levels of impingement occurred following storms. The reason for this presumably is that storm waves and surge dislodge and transport large amounts of plant material. In late October, the log boom at the ocean entrance to Agua Hedionda Lagoon broke. After this time, much larger volumes of plant material were impinged at the bar rack system and at the traveling screens. This increase in volume at station 9 is evident in Figure 7.11-1.

All seven plant species listed in Table 7.11-1 also occurred in the samples at traveling screen stations 1, 4, and 5. The rankings for these species, based on frequency of occurrence and estimated relative volume in all traveling screen samples combined, are shown in Table 7.11-3.

As in the bar rack samples, eel grass and giant kelp had essentially the same total frequency of occurrence, but the volume of first-ranked eel grass was greater in a majority of the

TABLE 7.11-3
RANKING OF MARINE GRASS AND ALGAL SPECIES IMPINGED AT ENCINA POWER PLANT TRAVELING SCREEN STATIONS DURING THE PERIOD FEBRUARY 4, 1979 - JANUARY 4, 1980

Rank	Common Name	Scientific Name	Frequency of Occurrence						
			Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	>Rank 5	Total
1	Eel grass	*Zostera marina*	1039	322	35	11	0	1	1408
2	Giant kelp	*Macrocystis pyrifera*	363	999	40	2	0	0	1404
3	Sargassum	*Sargassum agardhianum*	1	27	464	268	20	1	781
4	Feather boa	*Egregia menziesii*	5	41	368	171	13	1	599
5	Torrey's surf grass	*Phyllospadix torreyi*	4	15	222	144	148	23	556
6	Codium	*Codium fragile*	0	7	119	139	86	25	376
7	Bladder chain	*Cystoseira setchelli*	0	0	7	17	29	6	59

samples (Table 7.11-3). Sargassum ranked third, feather boa was fourth, Torrey's surf grass was fifth and codium was sixth in order of estimated volume. The seventh-ranked brown alga, bladder chain, occurred much less frequently in traveling screen samples and was generally represented by much smaller volumes of material than for the other species.

A plot showing mean total weight of all plant material impinged per 24-hr period for each week of the study is given in Figure 7.11-2. The weekly mean values on which this plot is based also are shown in Table 7.11-4. These weekly mean values were determined from the data obtained during each day of sampling at the three traveling screen stations. They represent the average value for the three stations, rather than the total for all stations combined.

As indicated in Table 7.11-4, the overall mean value for the 48-week period was 51.45 kg (113 lb) per day. Weekly mean values ranged from 20.57 kg (45 lb) per day in mid-May to 103.53 kg (228 lb) per day in early November (Figure 7.11-2; Table 7.11-4). A second peak of 93.83 kg (212 lb) per day occurred in late June.

TABLE 7.11-4
WEEKLY MEAN TOTAL WEIGHT OF ALL MARINE PLANT MATERIAL IMPINGED AT ENCINA POWER PLANT TRAVELING SCREEN STATIONS PER 24-HR INTERVAL DURING THE PERIOD FEBRUARY 4, 1979 - JANUARY 4, 1980

DATE	WEEK	MEAN WEIGHT (g) PER 24 HRS
Feb. 4	1	44571.4
Feb. 11	2	49314.3
Feb. 18	3	56628.6
Feb. 25	4	45714.3
Mar. 4	5	44342.9
Mar. 11	6	46028.6
Mar. 18	7	30685.7
Mar. 25	8	40371.4
Apr. 1	9	32202.9
Apr. 8	10	41571.4
Apr. 15	11	34171.4
Apr. 22	12	56285.7
Apr. 29	13	34314.3
May 6	14	23200.0
May 13	15	20571.4
May 20	16	20914.3
May 27	17	26657.1
Jun. 3	18	68914.3
Jun. 10	19	93828.6
Jun. 17	20	69771.4
Jun. 24	21	91828.6
Jul. 1	22	60342.9
Jul. 8	23	63200.0
Jul. 15	24	52314.3
Jul. 22	25	60542.9
Jul. 29	26	59228.6
Aug. 5	27	62000.0
Aug. 12	28	58085.7
Aug. 19	29	52066.7
Aug. 26	30	78514.3
Sept. 2	31	54114.3
Sept. 9	32	41657.1
Sept. 16	33	50571.4
Sept. 23	34	54857.1
Sept. 30	35	53950.0
Oct. 7	36	41028.6
Oct. 14	37	60085.7
Oct. 21	38	41166.7
Oct. 28	39	43800.0
Nov. 4	40	103533.3
Nov. 11	41	58171.4
Nov. 18	42	46714.3
Nov. 25	43	40457.1
Dec. 2	44	60514.3
Dec. 9	45	59171.4
Dec. 16	46	51971.4
Dec. 23	47	45966.7
Dec. 30	48	43500.0
48-WEEK MEAN		51446.0

7.12 TUNNEL RECIRCULATION

Tunnel recirculations (thermal treatments) were performed at approximately six-week intervals during the year to prevent fouling (see Section 3.1.5.10 for a description of procedures). Treatments were generally run on Saturday evenings during periods of lower power demand and during a high tide. Temperatures in the channels were raised to about 41 C (105 F) and held for approximately 2.5 hours. Depending upon ambient temperature, the time required to bring the temperature up to 41 C can take up to two hours. Cool down time to return to ambient can also take a similar time span, so that the complete operation can take up to six hours. Generally the treatment is completed by about 0500 or 0600 hr on Sunday morning. During this operation, organisms in residence in the intake channels between the trash rack and traveling screens (Figure 7.3-1) are killed.

Seven thermal treatments were conducted during 1979 (February, April, June, July, September, October, and December). All organisms impinged during thermal treatments were collected and a rank order listing of all species was compiled (Table 7.12-1). A total of 73 fish and 34 invertebrate species were obtained. Fourteen species occurred in the thermal treatment sampling that were not captured during daily impingement sampling (Table 7.12-2). Impingement samples coupled with thermal treatment and regular lagoon net collections resulted in a total of 96 different fish species from Agua Hedionda Lagoon (Table 7.12-3) during the year long study.

TABLE 7.12-1
RANK ORDER OF THERMAL TREATMENT SPECIES CAPTURED FROM JANUARY THROUGH DECEMBER, 1979 AT ENCINA POWER PLANT

SPECIES NAME	COMMON NAME	NUMBER CAUGHT	TOTAL WEIGHT	RANK
ANCHOA COMPRESSA	DEEPBODY ANCHOVY	23142	182179	1
ATHERINOPS AFFINIS	TOPSMELT	21788	166058	2
ENGRAULIS MORDAX	NORTHERN ANCHOVY	19567	93981	3
CYMATOGASTER AGGREGATA	SHINER SURFPERCH	12326	275549	4
LEURESTHES TENUIS	CALIFORNIA GRUNION	9671	81708	5
HYPERPROSOPON ARGENTEUM	WALLEYE SURFPERCH	8305	522797	6
SERIPHUS POLITUS	QUEENFISH	3485	96320	7
UROLOPHUS HALLERI	ROUND STINGRAY	1685	404237	8
HETEROSTICHUS ROSTRATUS	GIANT KELPFISH	1421	36212	9
ORDER DECAPODA		811	28577	10
GIRELLA NIGRICANS	OPALEYE	617	64921	11
PARALABRAX MACULATOFASCIATUS	SPOTTED SAND BASS	616	87360	12
PHANERODON FURCATUS	WHITE SURFPERCH	604	8609	13
PARALABRAX CLATHRATUS	KELP BASS	568	38505	14
PARALABRAX NEBULIFER	BARRED SAND BASS	518	26724	15
ANCHOA DELICATISSIMA	SLOUGH ANCHOVY	464	1405	16
BRACHYURANS	CRABS	376	3178	17
PORICHTHYS MYRIASTER	SPECKLEFIN MIDSHIPMAN	345	62191	18
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT	329	52995	19
PACHYGRAPSUS CRASSIPES	SHORE CRAB	323	2555	20
UMBRINA RONCADOR	YELLOWFIN CROAKER	306	7423	21
FAMILY ATHERINIDAE		288	34225	22
HYPSOBLENNIUS JENKINSI	MUSSEL BLENNY	277	2100	23
HYPSOBLENNIUS GILBERTI	ROCKPOOL BLENNY	259	923	24
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT	185	35897	25
AMPHISTICHUS ARGENTEUS	BARRED SURFPERCH	166	15946	26
XENISTIUS CALIFORNIENSIS	SALEMA	161	1389	27
CANCER ANTENNARIUS	COMMON ROCK CRAB	144	396	28
GENYONEMUS LINEATUS	WHITE CROAKER	125	6084	29
LOLIGO OPALESENS	SQUID	99	7446	30
EMBIOTOCA JACKSONI	BLACK SURFPERCH	89	8411	31
LEPTOCOTTUS ARMATUS	STAGHORN SCULPIN	82	2762	32
ANISOTREMUS DAVIDSONII	SARGO	79	5778	33
OCTOPUS		76	5038	34
SPHYRAENA ARGENTEA	CALIFORNIA BARRACUDA	75	1268	35
SQUID (TEUTHOIDEA)	SQUID	68	609	36
DOROSOMA PETENENSE	THREADFIN SHAD	59	245	37
HYPSOBLENNIUS SP.		58	535	38
MYLIOBATIS CALIFORNICA	BAT RAY	49	15806	39
CHEILOTREMA SATURNUM	BLACK CROAKER	46	881	40
CHROMIS PUNCTIPINNIS	BLACKSMITH	36	2227	41
DAMALICHTHYS VACCA	PILE SURFPERCH	32	5529	42
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA	29	4634	43
CANCERIDAE	ROCK CRABS	28	22	44
GYMNURA MARMORATA	CALIFORNIA BUTTERFLY RAY	24	9998	45
SYNGNATHUS LEPTORHYNCHUS	BAY PIPEFISH	24	82	45
ATHERINOPSIS CALIFORNIENSIS	JACKSMELT	21	4279	46
FUNDULUS PARVIPINNIS	CALIFORNIA KILLIFISH	21	95	46

000571

TABLE 7.12-1 (Concluded)

SPECIES NAME	COMMON NAME	NUMBER CAUGHT	TOTAL WEIGHT	RANK
HERMOSILLA AZUREA	ZEBRAPERCH	21	778	46
PORTUNUS SP.	SWIMMING CRAB	18	0	47
PORTUNUS XANTUSII	SWIMMING CRAB	18	10	47
FAMILY PORTUNIDAE	SWIMMING CRAB	17	97	48
FAMILY PENAEIDAE	PENAEID SHRIMP	15	38	49
PEPRILUS SIMILLIMUS	PACIFIC BUTTERFISH	15	775	49
CYNOSCION NOBILIS	WHITE SEABASS	13	833	50
MAJIDAE	KELP CRAB	13	65	50
MEDIALUNA CALIFORNIENSIS	HALFMOON	10	150	51
MUGIL CEPHALUS	STRIPED MULLET	10	5593	51
RONCADOR STEARNSII	SPOTFIN CROAKER	10	11884	51
MICROMETRUS MINIMUS	DWARF SURFPERCH	8	80	52
PACHYGRAPSUS SP.	SHORE CRAB	8	0	52
PLATYRHINOIDIS TRISERIATA	THORNBACK	8	3896	52
BRACHYISTIUS FRENATUS	KELP SURFPERCH	7	362	53
CALLIANASSA	GHOST SHRIMP	7	0	53
HYPSOBLENNIUS GENTILIS	BAY BLENNY	7	22	53
MUSTELUS CALIFORNICUS	GRAY SMOOTHHOUND	7	2498	53
PENAEUS CALIFORNIENSIS	PENAEID SHRIMP	7	179	53
PANULIRUS INTERRUPTUS	SPINY LOBSTER	6	1061	54
SCOMBER JAPONICUS	PACIFIC MACKEREL	6	808	54
HYPSYPOPS RUBICUNDUS	GARIBALDI	5	1911	55
PUGETTIA PRODUCTUS	NORTHERN KELP CRAB	5	0	55
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT	3	492	56
SARDA CHILIENSIS	PACIFIC BONITO	3	1284	56
SQUALUS ACANTHIAS	SPINY DOGFISH	3	4050	56
STRONGYLURA EXILIS	CALIFORNIA NEEDLEFISH	3	510	56
CANCER ANTHONYI	ANTHONYS ROCK CRAB	2	0	57
GIBBONSIA ELEGANS	SPOTTED KELPFISH	2	18	57
GYMNOTHORAX MORDAX	CALIFORNIA MORAY	2	11050	57
MUSTELUS HENLEI	BROWN SMOOTHHOUND	2	1300	57
NEMERTEAN	RIBBON WORMS	2	0	57
OXYLEBIUS PICTUS	PAINTED GREENLING	2	20	57
PUGETTIA SP.	KELP CRAB	2	0	57
TALIPUS	KELP CRAB	2	0	57
APLYSIA SP.	SEA HARE	1	0	58
CANCER PRODUCTUS	COMMON ROCK CRAB	1	1	58
CANCER SP.		1	3705	58
CLINOCOTTUS ANALIS	WOOLY SCULPIN	1	20	58
EPIALTUS NUTALLII	KELP CRAB	1	70	58
GIBBONSIA METZI	STRIPED KELPFISH	1	5	58
GRAPSIDAE	SHORE CRABS	1	2	58
HALICHOERES SEMICINCTUS	ROCK WRASSE	1	90	58
HIPPOLYTE CALIFORNIENSIS	SHRIMP	1	0	58
ICTALURUS MELAS	BLACK BULLHEAD	1	68	58
IDOTEA RESECATA	KELP ISOPOD	1	1	58
NAVANAX INERMIS	STRIPED SEA SLUG	1	12	58
OPHICHTHUS ZOPHOCHIR	YELLOW SNAKE EEL	1	257	58
OXYJULIS CALIFORNICA	SENORITA	1	20	58
PARAXANTHIAS TAYLORI	LUMPY CRAB	1	0	58
SCOMBEROMORUS CONCOLOR	MONTEREY SPANISH MACKEREL	1	25	58
SCORPAENA GUTTATA	SCULPIN OR SPOTTED SCORPIONFISH	1	120	58
SEBASTES PAUCISPINIS	BOCACCIO	1	211	58
SEBASTES RASTRELLIGER	GRASS ROCKFISH	1	670	58
STRONGYLOCENTROTUS PURPURATUS	PURPLE URCHIN	1	0	58
SYMPHURUS ATRICAUDA	CALIFORNIA TONGUEFISH	1	25	58
TORPEDO CALIFORNICA	PACIFIC ELECTRIC RAY	1	4280	58
TRACHURUS SYMMETRICUS	JACK MACKEREL	1	0	58
TRIBE CARIDES	CARID SHRIMP	1	0	58
CIRRIPEDIA	BARNACLES	0	5120	59
KELP		0	137814	59
MYTILIDAE	ASSORTED MUSSELS	0	24031	59
TOTAL		110160	2642373	

TABLE 7.12-2
FISH SPECIES COLLECTED DURING THERMAL TREATMENT
THAT WERE NOT COLLECTED DURING DAILY IMPINGEMENT SAMPLES
IN 1979 AT THE ENCINA POWER PLANT

SCIENTIFIC NAME	COMMON NAME
Cheilotrema saturnum	Black croaker
Hypsoblennius gentilis	Bay blenny
Scomber japonicus	Pacific mackerel
Pleuronichthys verticalis	Horneyhead turbot
Squalus acanthias	Spiny dogfish
Biggonsia elegans	Spotted kelpfish
Mustelus henlei	Brown smoothhound
Oxylebius pictus	Painted greenling
Clinocottus analis	Wooly sculpin
Halichoeres semicinctus	Rock wrasse
Ictalurus melas	Black bullhead
Oxyjulis californica	Señorita
Sebastes paucispinis	Bocaccio
Sebastes rastrelliger	Grass rockfish

TABLE 7.12-3
FISH SPECIES CAPTURED IN AGUA HEDIONDA LAGOON (TRAWLS, GILL NETS, SEINE, TRAVELING SCREENS, THERMAL TREATMENT) SAMPLES AT THE ENCINA POWER PLANT DURING 1979

SCIENTIFIC NAME	COMMON NAME
Alloclinus holderi	Island kelpfish
Amphistichus argenteus	Barred surfperch
Anchoa compressa	Deepbody anchovy
Anchoa delicatissima	Slough anchovy
Anisotremus davidsonii	Sargo
Atherinops affinis	Topsmelt
Atherinopsis californiensis	Jacksmelt
Brachyistius frenatus	Kelp surfperch
Cheilotrema saturnum	Black croaker
Chromis punctipinnis	Blacksmith
Citharichthys stigmaeus	Speckled sanddab
Citharichthys xanthostigma	Longfin sanddab
Clinocottus analis	Wooly sculpin
Clupea harengus	Pacific herring
Cymatogaster aggregata	Shiner surfperch
Cymatogaster gracilis	Island surfperch
Cynoscion nobilis	White seabass
Cypselurus californicus	California flying fish
Damalichthys vacca	Pile surfperch
Decapterus hypodus	Mexican shad
Dorosoma petenense	Threadfin shad
Embiotoca jacksoni	Black surfperch
Engraulis mordax	Northern anchovy
Fundulus parvipinnis	California killifish
Genyonemus lineatus	White croaker
Gibbonsia elegans	Spotted kelpfish
Gibbonsia metzi	Striped kelpfish
Gillichthys mirabilis	Longjaw mudsucker
Girella nigricans	Opaleye
Gobionellus longicaudus	Longtain goby
Gymnothorax mordax	Moray eel
Gymnura marmorata	California butterfly ray

TABLE 7.12-3 (Continued)

SCIENTIFIC NAME	COMMON NAME
Halichoreres semicinctus	Rock wrasse
Hermosilla azurea	Zebra perch
Heterodontus francisci	Horn shark
Heterostichus rostratus	Giant kelpfish
Hyperprosopon argenteum	Walleye surfperch
Hypsoblennius gentilis	Bay blenny
Hypsoblennius gilberti	Rockpool blenny
Hypsoblennius jenkinsi	Mussel blenny
Hypsopsetta guttulata	Diamon turbot
Hypsypops rubicundus	Garibaldi
Ictalurus melas	Black bullhead
Ilypnus gilberti	Cheekspot goby
Leptocottus armatus	Staghorn sculpin
Leuresthes tenuis	California grunion
Medialuna californiensis	Halfmoon
Menticirrhus undulatus	California corbina
Micrometrus minimus	Dwarf surfperch
Mugil cephalus	Striped mullet
Mustelus californicus	Gray smoothhound
Mustelus henlei	Brown smoothhound
Myliobatis californica	Bat ray
Oligocottus rubellio	Rosy sculpin
Ophichthus zophochir	Yellow snake eel
Oxyjulis californica	Señorita
Oxylebius pictus	Painted greenling
Paraclihus rostratus	Reef finspot
Paralabrax clathratus	Kelp bass
Paralabrax maculatofasciatus	Spotted bass
Paralabrax nebulifer	Barred sand bass
Paralichthys californicus	California halibut
Peprilus simillimus	Pacific butterfish
Phanerodon furcatus	White surfperch
Platyrhinoidis triseriata	Thornback ray
Pleuronichthys ritteri	Spotted turbot
Pleronichthys vertecalis	Horneyhead turbot
Porichthys notatus	Plainfin midshipman
Porichthys myriaster	Specklefin midshipman

000575

TABLE 7.12-3 (Concluded)

SCIENTIFIC NAME	COMMON NAME
Quietula y-cauda	Shadow goby
Rhacochilus toxotes	Rubberlip surfperch
Rhinobatos productus	Shovelnose guitarfish
Roncador stearnsi	Spotfin croaker
Sarda chiliensis	Pacific bonito
Scomber japonicus	Pacific mackerel
Scomberomorus concolor	Monterey Spanish mackerel
Scorpaena guttata	Sculpin/spotted scropionfish
Scorpaenichthys marmoratus	Cabezon
Sebastes paucispinis	Bocaccio
Sebastes rastrelliger	Grass rockfish
Seriphus politus	Queenfish
Sphyraena argentea	California barracuda
Squalus acanthias	Spiny dogfish
Squatina californica	Pacific angel shark
Strongylura exilis	California needlefish
Symphurus atricauda	California tonguefish
Syngnathus californiensis	Kelp pipefish
Syngnathus leptorhynchus	Bay pipefish
Torpedo californica	Pacific electric ray
Trachurus symmetricus	Jack mackerel
Triakis semifasciata	Leopard shark
Umbrina roncador	Yellowfin croaker
Urolophus halleri	Round stingray
Xenistius californiensis	Salema
Xystreurys liolepis	Fantail sole

Generally, those species that ranked high in abundance during thermal treatment were the same species that ranked high in daily impingement samples. Over 90 percent of the fish collected during all thermal treatments were comprised of 9 major species (Table 7.12-1) which also comprised 88 percent of the total daily impingement catch. A total of 108,102 fish were killed during thermal treatments for the year. This, compared with 79,662 fish removed by daily impingement sampling for the year, indicates that significant numbers of fish reside in the intake tunnels without being impinged.

Several species (opaleye, spotted sand bass, kelp bass, barred sand bass, mussel blenny, and rockpool blenny) were taken in much higher numbers during thermal treatments than during daily impingement samples. The data suggest that these species are able to survive within the tunnels, with a low probability of being impinged. In the case of the two blennies, this may be due to their preference for a sedentary habit among encrusting growths and fouling organisms. Such a lifestyle would lead to a scarcity of encounters with the traveling screens.

As for the three species of bass, their demersal habits and swimming strength may account for the low daily impingement removals. Opaleye also hide in holes and crevices at times and are strong swimmers.

The total weight of fish collected during thermal treatments was 2,422.4 kg (5,341 lb) (63 percent of the total removed by both thermal treatment and daily impingement during 1979). The average weight (per fish) for all fish collected during thermal treatments was 22.4 g, which was 32 percent greater than the average weight of fish obtained from daily impingement samples (17 g).

Fish impingement during thermal treatments varied seasonally. Greatest abundances were taken during February and the least, during December (Tables 7.12-4 through 7.12-10). The greatest weight of organisms removed occurred in February and the smallest weight, in July. Average weight per organism varied during the year from 10.3 to 36.0 g. Smallest organisms were abundant in summer treatments (July - September) and the largest were more abundant in winter and spring.

Different traveling screens removed different amounts of organisms during periods of tunnel recirculation. Generally speaking, screen 5 (Unit 5) caught the most organisms (54 percent of total removal by thermal treatment). Screens 1 (Units 1, 2, and 3) and 4 (Unit 4) accounted for 30 and 16 percent, respectively, of the total number of organisms killed during thermal treatment. However, based on weight of organisms, screen 5 again ranked first (79 percent), screen 4 ranked second (12 percent), and screen 1 ranked last (9 percent). The data show that the greatest numbers and largest organisms were impinged in the longest intake tunnel (leading to screen 5), while a significant number of smaller species were impinged at screen 1, and a smaller number of larger organisms were impinged in the intermediate length tunnel of screen 4 (Table 7.12-11). No

TABLE 7.12-4
INVENTORY OF SPECIES REMOVED BY THERMAL TREATMENT
AT ENCINA POWER PLANT DURING FEBRUARY, 1979

SCIENTIFIC NAME	COMMON NAME	SCREEN TS1 NUMBER CAUGHT	WEIGHT	TS4 NUMBER CAUGHT	WEIGHT	TS5 NUMBER CAUGHT	WEIGHT	TOTAL CAUGHT	TOTAL WEIGHT
SQUALUS ACANTHIAS	SPINY DOGFISH					1	1500	1	1500
MUSTELUS CALIFORNICUS	GRAY SMOOTHHOUND					4	1694	4	1694
TORPEDO CALIFORNICA	PACIFIC ELECTRIC RAY	1	4280					1	4280
PLATYRHINOIDIS TRISERIATA	THORNBACK					1	252	1	252
UROLOPHUS HALLERI	ROUND STINGRAY	1	144			511	155444	512	155588
GYMNURA MARMORATA	CALIFORNIA BUTTERFLY RAY					3	1635	3	1635
GYMNOTHORAX MORDAX	CALIFORNIA MORAY					1	6100	1	6100
DOROSOMA PETENENSE	THREADFIN SHAD					47		47	0
ENGRAULIS MORDAX	NORTHERN ANCHOVY	9	52			1	20	10	72
ANCHOA COMPRESSA	DEEPBODY ANCHOVY	396	2030	266	1906	4528	32226	5190	36162
ANCHOA DELICATISSIMA	SLOUGH ANCHOVY	29	141			4	13	33	154
PORICHTHYS MYRIASTER	SPECKLEFIN MIDSHIPMAN	1	3					1	3
LEURESTHES TENUIS	CALIFORNIA GRUNION	8	24					8	24
ATHERINOPS AFFINIS	TOPSMELT	8401	41989	1299	15366	3098	38098	12798	95453
SYNGNATHUS LEPTORHYNCHUS	BAY PIPEFISH	3	11					3	11
SCORPAENA GUTTATA	SCULPIN OR SPOTTED SCORPIONFISH					1	120	1	120
SEBASTES RASTRELLIGER	GRASS ROCKFISH					1	670	1	670
SEBASTES PAUCISPINIS	BOCACCIO					1	211	1	211
LEPTOCOTTUS ARMATUS	STAGHORN SCULPIN					3	204	3	204
PARALABRAX CLATHRATUS	KELP BASS	2	7	1	38	208	12951	211	12996
PARALABRAX MACULATOFASCIATUS	SPOTTED SAND BASS			21	95	302	36240	323	36335
PARALABRAX NEBULIFER	BARRED SAND BASS	27	139	2	6			29	145
XENISTIUS CALIFORNIENSIS	SALEMA			20	120			20	120
ANISOTREMUS DAVIDSONII	SARGO			1	1500	1	180	2	1680
SERIPHUS POLITUS	QUEENFISH	18	77	21	929	351	3260	390	4266
UMBRINA RONCADOR	YELLOWFIN CROAKER					32	3159	32	3159
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA					3	1558	3	1558
RONCADOR STEARNSII	SPOTFIN CROAKER					5	4552	5	4552
GIRELLA NIGRICANS	OPALEYE	4	20			66	26268	70	26288
HERMOSILLA AZUREA	ZEBRAPERCH					1	700	1	700
MEDIALUNA CALIFORNIENSIS	HALFMOON			9				9	0
EMBIOTOCA JACKSONI	BLACK SURFPERCH					4	897	4	897
AMPHISTICHUS ARGENTEUS	BARRED SURFPERCH					79	11050	79	11050
HYPERPROSOPON ARGENTEUM	WALLEYE SURFPERCH			31	2346	4308	344540	4339	346886
CYMATOGASTER AGGREGATA	SHINER SURFPERCH	2	45	3	29	3690	142794	3695	142868
BRACHYISTIUS FRENATUS	KELP SURFPERCH					3	162	3	162
DAMALICHTHYS VACCA	PILE SURFPERCH	19	76			6	2726	25	2802
PHANERODON FURCATUS	WHITE SURFPERCH					5	377	5	377
HYPSYPOPS RUBICUNDUS	GARIBALDI					2	961	2	961
SPHYRAENA ARGENTEA	CALIFORNIA BARRACUDA	1	21			1	62	2	83
OXYJULIS CALIFORNICA	SENORITA					1	20	1	20
HALICHOERES SEMICINCTUS	ROCK WRASSE					1	90	1	90
HYPSOBLENNIUS GILBERTI	ROCKPOOL BLENNY			142		6	137	148	137
HYPSOBLENNIUS JENKINSI	MUSSEL BLENNY	221	1989					221	1989

TABLE 7.12-4 (Concluded)

SCIENTIFIC NAME	COMMON NAME	SCREEN TS1 NUMBER CAUGHT	WEIGHT	TS4 NUMBER CAUGHT	WEIGHT	TS5 NUMBER CAUGHT	WEIGHT	TOTAL CAUGHT	TOTAL WEIGHT
HETEROSTICHUS ROSTRATUS	GIANT KELPFISH			1	26	68	6976	69	7002
SCOMBER JAPONICUS	PACIFIC MACKEREL					5	766	5	766
SCOMBEROMORUS CONCOLOR	MONTEREY SPANISH MACKEREL	1	25					1	25
PEPRILUS SIMILLIMUS	PACIFIC BUTTERFISH					9	645	9	645
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT	1	24	3	141	93	28243	97	28408
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT	1	4			96	19685	97	19689
OCTOPUS		2		1	180	4	1315	7	1495
CIRRIPEDIA	BARNACLES						130	0	130
FAMILY PENAEIDAE	PENAEID SHRIMP					3	38	3	38
TRIBE CARIDES	CARID SHRIMP	1						1	0
CALLIANASSA	GHOST SHRIMP	7						7	0
MAJIDAE	KELP CRAB			1		7	38	8	38
TALIPUS	KELP CRAB	2						2	0
PUGETTIA SP.	KELP CRAB	2						2	0
PUGETTIA PRODUCTUS	NORTHERN KELP CRAB	4						4	0
CANCER SP.		1						1	0
CANCER ANTENNARIUS	COMMON ROCK CRAB	9		3				12	0
CANCER ANTHONYI	ANTHONYS ROCK CRAB	2						2	0
FAMILY PORTUNIDAE	SWIMMING CRAB	2				15	97	17	97
PORTUNUS SP.	SWIMMING CRAB	9						9	0
PORTUNUS XANTUSII	SWIMMING CRAB	9		4				13	0
PARAXANTHIAS TAYLORI	LUMPY CRAB			1				1	0
PACHYGRAPSUS SP.	SHORE CRAB	8						8	0
NEMERTEAN	RIBBON WORMS	2						2	0
*TOTAL FEBRUARY		9206	51101	1830	226820	17580	888804	28616	962587

000580

TABLE 7.12-5
INVENTORY OF SPECIES REMOVED BY THERMAL TREATMENT
AT ENCINA POWER PLANT DURING APRIL, 1979

SCIENTIFIC NAME	COMMON NAME	SCREEN TS1 NUMBER CAUGHT	WEIGHT	TS4 NUMBER CAUGHT	WEIGHT	TS5 NUMBER CAUGHT	WEIGHT	TOTAL CAUGHT	TOTAL WEIGHT
SQUALUS ACANTHIAS	SPINY DOGFISH					2	2550	2	2550
MUSTELUS CALIFORNICUS	GRAY SMOOTHHOUND					1	364	1	364
MYLIOBATIS CALIFORNICA	BAT RAY					6	2225	6	2225
UROLOPHUS HALLERI	ROUND STINGRAY	1	652			242	88400	243	89052
GYMNURA MARMORATA	CALIFORNIA BUTTERFLY RAY					4	2350	4	2350
DOROSOMA PETENENSE	THREADFIN SHAD	1	76			11	169	12	245
ENGRAULIS MORDAX	NORTHERN ANCHOVY	1	4			11	104	12	108
ANCHOA COMPRESSA	DEEPBODY ANCHOVY	2005	7903			2523	24634	4528	32537
ANCHOA DELICATISSIMA	SLOUGH ANCHOVY					2	6	2	6
PORICHTHYS MYRIASTER	SPECKLEFIN MIDSHIPMAN					2	2050	2	2050
ICTALURUS MELAS	BLACK BULLHEAD	1	68					1	68
STRONGYLURA EXILIS	CALIFORNIA NEEDLEFISH					1	250	1	250
FUNDULUS PARVIPINNIS	CALIFORNIA KILLIFISH					2		2	0
LEURESTHES TENUIS	CALIFORNIA GRUNION					5	28	5	28
ATHERINOPSIS CALIFORNIENSIS	JACKSMELT					15	3009	15	3009
ATHERINOPS AFFINIS	TOPSMELT	3234	14529			2140	22432	5374	36961
SYNGNATHUS LEPTORHYNCHUS	BAY PIPEFISH	3	6					3	6
PARALABRAX CLATHRATUS	KELP BASS	1	69			27	902	28	971
PARALABRAX MACULATOFASCIATUS	SPOTTED SAND BASS	1	110			51	5950	52	6060
PARALABRAX NEBULIFER	BARRED SAND BASS	23	118			90	2800	113	2918
XENISTIUS CALIFORNIENSIS	SALEMA					1	4	1	4
ANISOTREMUS DAVIDSONII	SARGO					5	40	5	40
SERIPHUS POLITUS	QUEENFISH	3	19			38	2692	41	2711
UMBRINA RONCADOR	YELLOWFIN CROAKER					2	4	2	4
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA					2	634	2	634
RONCADOR STEARNSII	SPOTFIN CROAKER	1	4082					1	4082
GIRELLA NIGRICANS	OPALEYE					27	8000	27	8000
AMPHISTICHUS ARGENTEUS	BARRED SURFPERCH					5	313	5	313
HYPERPROSOPON ARGENTEUM	WALLEYE SURFPERCH	4	260			851	67146	855	67406
CYMATOGASTER AGGREGATA	SHINER SURFPERCH					744	25597	744	25597
BRACHYISTIUS FRENATUS	KELP SURFPERCH					4	200	4	200
MICROMETRUS MINIMUS	DWARF SURFPERCH					8	80	8	80
DAMALICHTHYS VACCA	PILE SURFPERCH					1	440	1	440
PHANERODON FURCATUS	WHITE SURFPERCH	1	34			7	809	8	843
MUGIL CEPHALUS	STRIPED MULLET					2	767	2	767
HYPSOBLENNIUS GILBERTI	ROCKPOOL BLENNY	53	278					53	278
HETEROSTICHUS ROSTRATUS	GIANT KELPFISH	1	4			27	1696	28	1700
SCOMBER JAPONICUS	PACIFIC MACKEREL					1	42	1	42
PEPRILUS SIMILLIMUS	PACIFIC BUTTERFISH					6	130	6	130
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT					20	1850	20	1850
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT					1	192	1	192
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT					41	7400	41	7400
NAVANAX INERMIS	STRIPED SEA SLUG	1	12					1	12
APLYSIA SP.	SEA HARE					1		1	0

000581

TABLE 7.12-5 (Concluded)

SCIENTIFIC NAME	COMMON NAME	SCREEN TS1 NUMBER CAUGHT	WEIGHT	TS4 NUMBER CAUGHT	WEIGHT	TS5 NUMBER CAUGHT	WEIGHT	TOTAL CAUGHT	TOTAL WEIGHT
OCTOPUS		6	42			4		10	42
CIRRIPEDIA	BARNACLES		4990					0	4990
IDOTEA RESECATA	KELP ISOPOD	1	1					1	1
PENAEUS CALIFORNIENSIS	PENAEID SHRIMP					2		2	0
HIPPOLYTE CALIFORNIENSIS	SHRIMP					1		1	0
BRACHYURANS	CRABS		1988					0	1988
MAJIDAE	KELP CRAB	4	27			1		5	27
PUGETTIA PRODUCTUS	NORTHERN KELP CRAB					1		1	0
CANCRIDAE	ROCK CRABS	5	22			23		28	22
CANCER PRODUCTUS	COMMON ROCK CRAB	1	1					1	1
PORTUNUS SP.	SWIMMING CRAB					9		9	0
PORTUNUS XANTUSII	SWIMMING CRAB	3	10			2		5	10
GRAPSIDAE	SHORE CRABS	1	2					1	2
PACHYGRAPSUS CRASSIPES	SHORE CRAB	1	5			2		3	5
KELP			30845				9100	0	39945
*TOTAL APRIL		5357	66157			6974	285359	12331	351516

TABLE 7.12-6
INVENTORY OF SPECIES REMOVED BY THERMAL TREATMENT AT ENCINA POWER PLANT DURING JUNE, 1979

SCIENTIFIC NAME	COMMON NAME	SCREEN TS1 NUMBER CAUGHT	WEIGHT	TS4 NUMBER CAUGHT	WEIGHT	TS5 NUMBER CAUGHT	WEIGHT	TOTAL CAUGHT	TOTAL WEIGHT
MYLIOBATIS CALIFORNICA	BAT RAY			1	400			1	400
UROLOPHUS HALLERI	ROUND STINGRAY	14	2942			292	51200	306	54142
GYMNURA MARMORATA	CALIFORNIA BUTTERFLY RAY					3	1400	3	1400
ENGRAULIS MORDAX	NORTHERN ANCHOVY	2	8	2				4	8
ANCHOA COMPRESSA	DEEPBODY ANCHOVY	572	4219	1128	8187	249	1743	1949	14149
ANCHOA DELICATISSIMA	SLOUGH ANCHOVY	30	106					30	106
PORICHTHYS MYRIASTER	SPECKLEFIN MIDSHIPMAN	7	2813			252	37425	259	40238
FAMILY ATHERINIDAE						289	34225	288	34225
LEURESTHES TENUIS	CALIFORNIA GRUNION	16	23					16	23
ATHERINOPSIS CALIFORNIENSIS	JACKSMELT			1	150	2	350	3	500
ATHERINOPS AFFINIS	TOPSMELT	164	598	921	10867	425	6840	1510	18305
OXYLEBIUS PICTUS	PAINTED GREENLING	2	20					2	20
LEPTOCOTTUS ARMATUS	STAGHORN SCULPIN			5	25	22	400	27	425
PARALABRAX CLATHRATUS	KELP BASS	9	1742	17	4250	12	1314	38	7306
PARALABRAX MACULATOFASCIATUS	SPOTTED SAND BASS	33	1179	1	350	38	7900	72	9429
PARALABRAX NEBULIFER	BARRED SAND BASS	14	1008	3		73	1754	90	2762
XENISTIUS CALIFORNIENSIS	SALEMA			11				11	0
ANISOTREMUS DAVIDSONII	SARGO	2	20	2	400	1	1250	5	1670
SERIPHUS POLITUS	QUEENFISH	9	35	120	3875	246	10840	375	14750
UMBRINA RONCADOR	YELLOWFIN CROAKER			9				9	0
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA					1	175	1	175
GENYONEMUS LINEATUS	WHITE CROAKER			45	3517	70	2120	115	5637
RONCADOR STEARNSII	SPOTFIN CROAKER					1	1000	1	1000
GIRELLA NIGRICANS	OPALEYE	10	546	4	850	71	7525	85	8921
EMBIOTOCA JACKSONI	BLACK SURFPERCH					12	634	12	634
AMPHISTICHUS ARGENTEUS	BARRED SURFPERCH					2	450	2	450
HYPERPROSOPON ARGENTEUM	WALLEYE SURFPERCH	26	2756	182	11612	586	36173	794	50538
CYMATOGASTER AGGREGATA	SHINER SURFPERCH	66	516	1613	9026	713	11525	2392	21067
DAMALICHTHYS VACCA	PILE SURFPERCH					1	675	1	675
PHANERODON FURCATUS	WHITE SURFPERCH			165	1576	80	2081	245	3657
HYPSYPOPS RUBICUNDUS	GARIBALDI					1	300	1	300
CHROMIS PUNCTIPINNIS	BLACKSMITH	2	117	1	200	5	400	8	717
MUGIL CEPHALUS	STRIPED MULLET					5	2630	5	2630
HYPSOBLENNIUS SP.						58	535	58	535
HYPSOBLENNIUS GILBERTI	ROCKPOOL BLENNY	52	457					52	457
HYPSOBLENNIUS JENKINSI	MUSSEL BLENNY			12				12	0
HETEROSTICHUS ROSTRATUS	GIANT KELPFISH	117	750	417	3130	134	2734	668	6614
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT			1	100	43	2986	44	3086
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT			2	300			2	300
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT					18	3424	18	3424
MYTILIDAE	ASSORTED MUSSELS		24031					0	24031
OCTOPUS		1		1				2	0
ORDER DECAPODA			21938	490	6066			490	28004
FAMILY PENAEIDAE	PENAEID SHRIMP	12						12	0

000583

TABLE 7.12-6 (Concluded)

SCIENTIFIC NAME	COMMON NAME	SCREEN TS1 NUMBER CAUGHT	WEIGHT	TS4 NUMBER CAUGHT	WEIGHT	TS5 NUMBER CAUGHT	WEIGHT	TOTAL CAUGHT	TOTAL WEIGHT
PENAEUS CALIFORNIENSIS	PENAEID SHRIMP					5	179	5	179
PANULIRUS INTERRUPTUS	SPINY LOBSTER	1	150			1	142	2	292
CANCER SP.							3705	0	3705
STRONGYLOCENTROTUS PURPURATUS	PURPLE URCHIN	1						1	0
KELP					8044			0	8044
*TOTAL JUNE		1162	65974	5154	72745	3710	236031	10026	374930

TABLE 7.12-7
INVENTORY OF SPECIES REMOVED BY THERMAL TREATMENT AT ENCINA POWER PLANT DURING JULY, 1979

SCIENTIFIC NAME	COMMON NAME	SCREEN TS1 NUMBER CAUGHT	SCREEN TS1 WEIGHT	TS4 NUMBER CAUGHT	TS4 WEIGHT	TS5 NUMBER CAUGHT	TS5 WEIGHT	TOTAL CAUGHT	TOTAL WEIGHT
MUSTELUS HENLEI	BROWN SMOOTHHOUND					2	1300	2	1300
PLATYRHINOIDIS TRISERIA A	THORNBACK					1	1000	1	1000
MYLIOBATIS CALIFORNICA	BAT RAY					20	6590	20	6590
UROLOPHUS HALLERI	ROUND STINGRAY					150	22500	150	22500
GYMNURA MARMORATA	CALIFORNIA BUTTERFLY RAY					2	770	2	770
ENGRAULIS MORDAX	NORTHERN ANCHOVY	6164	10950	389	1042	15	50	6568	12042
ANCHOA COMPRESSA	DEEPBODY ANCHOVY	912	4871	859	5199	996	10215	2767	20285
ANCHOA DELICATISSIMA	SLOUGH ANCHOVY					18	142	18	142
PORICHTHYS MYRIASTER	SPECKLEFIN MIDSHIPMAN	1	200			36	7560	37	7760
LEURESTHES TENUIS	CALIFORNIA GRUNION	20	100	378	699	33	344	431	1143
ATHERINOPSIS CALIFORNIENSIS	JACKSMELT					1	300	1	300
ATHERINOPS AFFINIS	TOPSMELT	363	826	69	653	200	3843	632	5322
PARALABRAX CLATHRATUS	KELP BASS					29	2730	29	2730
PARALABRAX MACULATOFASCIATUS	SPOTTED SAND BASS					40	11206	40	11206
PARALABRAX NEBULIFER	BARRED SAND BASS			3	71	10	800	13	871
XENISTIUS CALIFORNIENSIS	SALEMA					11	432	11	432
SERIPHUS POLITUS	QUEENFISH	69	450	1	4	45	5617	115	6071
UMBRINA RONCADOR	YELLOWFIN CROAKER					45	1800	45	1800
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA					3	440	3	440
GENYONEMUS LINEATUS	WHITE CROAKER			5	210			6	210
RONCAD STEARNSII	SPOTFIN CROAKER					1	160	1	160
GIRELLA NIGRICANS	OPALEYE	39	15[illegible]	17	40	1	345	57	542
EMBIOTOCA JACKSONI	BLACK SURFPERCH					13	950	13	950
HYPERPROSOPON ARGENTEUM	WALLEYE SURFPERCH			2	171	50	3610	52	3781
CYMATOGASTER AGGREGATA	SHINER SURFPERCH			15	78	131	1961	146	2039
DAMALICHTHYS VACCA	PILE SURFPERCH					3	1000	3	1000
CHROMIS PUNCTIPINNIS	BLACKSMITH					3	512	3	512
HYPSOBLENNIUS JENKINSI	MUSSEL BLENNY			40	97			40	97
HETEROSTICHUS ROSTRATUS	GIANT KELPFISH	177	1301	3	18	15	1357	195	2676
GIBBONSIA METZI	STRIPED KELPFISH	1	5					1	5
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT					25	5482	25	5482
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT					9	1396	9	1396
OCTOPUS						1	520	1	520
ORDER DECAPODA				321	573			321	573
PANULIRUS INTERRUPTUS	SPINY LOBSTER					1	200	1	200
CANCER ANTENNARIUS	COMMON ROCK CRAB	132	396					132	396
PACHYGRAPSUS CRASSIPES	SHORE CRAB	99	330					99	330
KELP							3800	0	3800
*TOTAL JULY		7977	19586	2103	8855	1910	98932	11990	127373

000585

TABLE 7.12-8
INVENTORY OF SPECIES REMOVED BY THERMAL TREATMENT AT ENCINA POWER PLANT DURING SEPTEMBER, 1979

SCIENTIFIC NAME	COMMON NAME	SCREEN TS1 NUMBER CAUGHT	WEIGHT	TS4 NUMBER CAUGHT	WEIGHT	TS5 NUMBER CAUGHT	WEIGHT	TOTAL CAUGHT	TOTAL WEIGHT
MUSTELUS CALIFORNICUS	GRAY SMOOTHHOUND					2	440	2	440
MYLIOBATIS CALIFORNICA	BAT RAY			5	1500	15	4600	20	6100
UROLOPHUS HALLERI	ROUND STINGRAY			3	1080	131	25900	134	26980
GYMNURA MARMORATA	CALIFORNIA BUTTERFLY RAY					5	875	5	875
GYMNOTHORAX MORDAX	CALIFORNIA MORAY					1	4950	1	4950
ENGRAULIS MORDAX	NORTHERN ANCHOVY	3421	9688	2645	7260	6380	62480	12446	79428
ANCHOA COMPRESSA	DEEPBODY ANCHOVY	387	1713	464	5035	4070	39930	4921	46678
ANCHOA DELICATISSIMA	SLOUGH ANCHOVY	89	279	137	371			226	650
PORICHTHYS MYRIASTER	SPECKLEFIN MIDSHIPMAN			1	220	43	11050	44	11270
STRONGYLURA EXILIS	CALIFORNIA NEEDLEFISH					1	80	1	80
LEURESTHES TENUIS	CALIFORNIA GRUNION	732	3857	1060	23977	1650	16170	3442	44004
ATHERINOPS AFFINIS	TOPSMELT	41	193	136	650			177	843
PARALABRAX CLATHRATUS	KELP BASS	2	115	8	708	30	3450	40	4273
PARALABRAX MACULATOFASCIATUS	SPOTTED SAND BASS			27	4903	59	14550	86	19453
PARALABRAX NEBULIFER	BARRED SAND BASS			78	4618	24	2350	102	6968
XENISTIUS CALIFORNIENSIS	SALEMA			1	20			1	20
ANISOTREMUS DAVIDSONII	SARGO			1	30			1	30
SERIPHUS POLITUS	QUEENFISH	117	528	363	8149	1444	45180	1924	53857
CYNOSCION NOBILIS	WHITE SEABASS			2	70			2	70
UMBRINA RONCADOR	YELLOWFIN CROAKER	14	83			4	310	18	393
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA					1	160	1	160
GENYONEMUS LINEATUS	WHITE CROAKER			4	237			4	237
RONCADOR STEARNSII	SPOTFIN CROAKER			1	790			1	790
GIRELLA NIGRICANS	OPALEYE	2	208	16	2141	250	6700	268	9049
MEDIALUNA CALIFORNIENSIS	HALFMOON					1	150	1	150
EMBIOTOCA JACKSONI	BLACK SURFPERCH			1	60	1	70	2	130
HYPERPROSOPON ARGENTEUM	WALLEYE SURFPERCH			119	4569	945	11930	1064	16499
CYMATOGASTER AGGREGATA	SHINER SURFPERCH	14	124	103	2811	2090	20460	2207	23395
DAMALICHTHYS VACCA	PILE SURFPERCH			1	22			1	22
PHANERODON FURCATUS	WHITE SURFPERCH			1	12	332	3320	333	3332
HYPSYPOPS RUBICUNDUS	GARIBALDI					2	650	2	650
SPHYRAENA ARGENTEA	CALIFORNIA BARRACUDA	14	110					14	110
HYPSOBLENNIUS GENTILIS	BAY BLENNY	3	12					3	12
HYPSOBLENNIUS GILBERTI	ROCKPOOL BLENNY	2	11					2	11
HYPSOBLENNIUS JENKINSI	MUSSEL BLENNY	1	4					1	4
HETEROSTICHUS ROSTRATUS	GIANT KELPFISH	2	26	25	568	26	1250	53	1844
GIBBONSIA ELEGANS	SPOTTED KELPFISH	1	8					1	8
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT	1	36	9	372	46	3500	56	3908
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT	1	148			4	550	5	698
OCTOPUS		41	221	1	80	5	1000	47	1301
PANULIRUS INTERRUPTUS	SPINY LOBSTER					2	400	2	400
BRACHYURANS	CRABS	307	690					307	690
EPIALTUS NUTTALLII	KELP CRAB					1	70	1	70
PACHYGRAPSUS CRASSIPES	SHORE CRAB					221	2220	221	2220
KELP							26400	0	26400
*TOTAL SEPTMBER		5192	18054	5212	70253	17786	311145	28190	399432

TABLE 7.12-9
INVENTORY OF SPECIES REMOVED BY THERMAL TREATMENT
AT ENCINA POWER PLANT DURING OCTOBER, 1979

SCIENTIFIC NAME	COMMON NAME	SCREEN TS1 NUMBER CAUGHT	WEIGHT	TS4 NUMBER CAUGHT	WEIGHT	TS5 NUMBER CAUGHT	WEIGHT	TOTAL CAUGHT	TOTAL WEIGHT
PLATYRHINOIDIS TRISERIATA	THORNBACK					4	2420	4	2420
MYLIOBATIS CALIFORNICA	BAT RAY					2	491	2	491
UROLOPHUS HALLERI	ROUND STINGRAY					115	25864	115	25864
GYMNURA MARMORATA	CALIFORNIA BUTTERFLY RAY			1	225	6	2743	7	2968
OPHICHTHUS ZOPHOCHIR	YELLOW SNAKE EEL	1	257					1	257
ENGRAULIS MORDAX	NORTHERN ANCHOVY	3	7			54	567	57	574
ANCHOA COMPRESSA	DEEPBODY ANCHOVY	462	1911	402	934	2681	27250	3545	30095
ANCHOA DELICATISSIMA	SLOUGH ANCHOVY	152	342					152	342
PORICHTHYS MYRIASTER	SPECKLEFIN MIDSHIPMAN					2	870	2	870
FUNDULUS PARVIPINNIS	CALIFORNIA KILLIFISH	19	95					19	95
LEURESTHES TENUIS	CALIFORNIA GRUNION	1919	14098	839	6988	2627	36242	5385	57328
ATHERINOPS AFFINIS	TOPSMELT	92	540			131	1545	223	2085
CLINOCOTTUS ANALIS	WOOLY SCULPIN			1	20			1	20
PARALABRAX CLATHRATUS	KELP BASS			9	474	83	5686	92	6160
PARALABRAX MACULATOFASCIATUS	SPOTTED SAND BASS			1	159	38	3818	39	3977
PARALABRAX NEBULIFER	BARRED SAND BASS			10	572	89	6144	99	6716
XENISTIUS CALIFORNIENSIS	SALEMA			2	17	11	327	13	344
ANISOTREMUS DAVIDSONII	SARGO			1	15	47	1922	48	1937
SERIPHUS POLITUS	QUEENFISH	23	149	135	2207	267	7441	425	9797
CYNOSCION NOBILIS	WHITE SEABASS					11	763	11	763
UMBRINA RONCADOR	YELLOWFIN CROAKER			1	50	33	186	34	236
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA			1	404	3	726	4	1130
RONCADOR STEARNSII	SPOTFIN CROAKER					1	1300	1	1300
CHEILOTREMA SATURNUM	BLACK CROAKER			11	45	22	436	33	481
GIRELLA NIGRICANS	OPALEYE			11	1397	85	8304	96	9701
HERMOSILLA AZURRA	ZEBRAPERCH	19	76					19	76
EMBIOTOCA JACKSONI	BLACK SURFPERCH			1	60	5	490	6	550
HYPERPROSOPON ARGENTEUM	WALLEYE SURFPERCH			84	2360	107	3885	191	6245
CYMATOGASTER AGGREGATA	SHINER SURFPERCH			51	760	126	1712	177	2472
DAMALICHTHYS VACCA	PILE SURFPERCH					1	590	1	590
CHROMIS PUNCTIPINNIS	BLACKSMITH			1	51	22	752	23	803
MUGIL CEPHALUS	STRIPED MULLET					3	2196	3	2196
SPHYRAENA ARGENTEA	CALIFORNIA BARRACUDA			3	58	22	109	25	167
HYPSOBLENNIUS GENTILIS	BAY BLENNY			1				1	0
HYPSOBLENNIUS GILBERTI	ROCKPOOL BLENNY			1				1	0
HYPSOBLENNIUS JENKINSI	MUSSEL BLENNY			1				1	0
HETEROSTICHUS ROSTRATUS	GIANT KELPFISH			3	110	100	3621	103	3731
SARDA CHILIENSIS	PACIFIC BONITO					3	1284	3	1284
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT			6	481	63	7900	69	8381
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT					8	2175	8	2175
SQUID (TEUTHOIDEA)	SQUID					68	609	68	609
OCTOPUS						3	825	3	825
PANULIRUS INTERRUPTUS	SPINY LOBSTER			1	169			1	169
KELP			13300				46325	0	59625
*TOTAL OCTOBER		2690	30775	1578	17556	6843	207518	11111	197513

000587

TABLE 7.12-10
INVENTORY OF SPECIES REMOVED BY THERMAL TREATMENT
AT ENCINA POWER PLANT DURING DECEMBER, 1979

SCIENTIFIC NAME	COMMON NAME	SCREEN TS1 NUMBER CAUGHT	WEIGHT	TS4 NUMBER CAUGHT	WEIGHT	TS5 NUMBER CAUGHT	WEIGHT	TOTAL CAUGHT	TOTAL WEIGHT
PLATYRHINOIDIS TRISERIATA	THORNBACK	1	224	1				2	224
UROLOPHUS HALLERI	ROUND STINGRAY	11	757	10	554	204	28800	225	30111
ENGRAULIS MORDAX	NORTHERN ANCHOVY	67	232	177	584	226	933	470	1749
ANCHOA COMPRESSA	DEEPBODY ANCHOVY	23	102	19	38	200	2133	242	2273
ANCHOA DELICATISSIMA	SLOUGH ANCHOVY			3	5			3	5
STRONGYLURA EXILIS	CALIFORNIA NEEDLEFISH					1	180	1	180
LEURESTHES TENUIS	CALIFORNIA GRUNION	28	112	143	715	213	800	384	1627
ATHERINOPSIS CALIFORNIENSIS	JACKSMELT					2	470	2	470
ATHERINOPS AFFINIS	TOPSMELT	299	1540	482	3149	293	2400	1074	7089
SYNGNATHUS LEPTORHYNCHUS	BAY PIPEFISH	2	1	16	64			18	65
LEPTOCOTTUS ARMATUS	STAGHORN SCULPIN			1		51	2133	52	2133
PARALABRAX CLATHRATUS	KELP BASS	7	27	60	692	63	3350	130	4069
PARALABRAX MACULATOFASCIATUS	SPOTTED SAND BASS					4	900	4	900
PARALABRAX NEBULIFER	BARRED SAND BASS	1	58	11	916	60	5370	72	6344
TRACHURUS SYMMETRICUS	JACK MACKEREL			1				1	0
XENISTIUS CALIFORNIENSIS	SALEMA	27	100	61	282	16	87	104	469
ANISOTREMUS DAVIDSONII	SARGO	1	4	2	300	15	117	18	421
SERIPHUS POLITUS	QUEENFISH	8	41	7	161	200	4666	215	4868
UMBRINA RONCADOR	YELLOWFIN CROAKER	3	13	3	85	160	1733	166	1831
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA					15	537	15	537
CHEILOTREMA SATURNUM	BLACK CROAKER					13	400	13	400
GIRELLA NIGRICANS	OPALEYE					14	2420	14	2420
HERMOSILLA AZUREA	ZEBRAPERCH	1	2					1	2
EMBIOTOCA JACKSONI	BLACK SURFPERCH					52	5250	52	5250
AMPHISTICHUS ARGENTEUS	BARRED SURFPERCH					80	4133	80	4133
HYPERPROSOPON ARGENTEUM	WALLEYE SURFPERCH			77	2780	933	28662	1010	31442
CYMATOGASTER AGGREGATA	SHINER SURFPERCH	18	371	707	13080	2240	44660	2965	58111
PHANERODON FURCATUS	WHITE SURFPERCH					13	400	13	400
CHROMIS PUNCTIPINNIS	BLACKSMITH					2	195	2	195
SPHYRAENA ARGENTEA	CALIFORNIA BARRACUDA	1	10	8	195	25	703	34	908
HYPSOBLENNIUS GENTILIS	BAY BLENNY			3	10			3	10
HYPSOBLENNIUS GILBERTI	ROCKPOOL BLENNY	3	40					3	40
HYPSOBLENNIUS JENKINSI	MUSSEL BLENNY			2	10			2	10
HETEROSTICHUS ROSTRATUS	GIANT KELPFISH			12	381	293	12264	305	12645
GIBBONSIA ELEGANS	SPOTTED KELPFISH	1	10					1	10
SYMPHURUS ATRICAUDA	CALIFORNIA TONGUEFISH					1	25	1	25
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT			3	270	15	1610	18	1880
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT			1		6	1115	7	1115
LOLIGO OPALESCENS	SQUID	1	30	6	250	92	7166	99	7446
OCTOPUS		3	80			3	775	6	855
BRACHYURANS	CRABS	69	500					69	500
*TOTAL DECEMBER		575	4254	1816	24521	5505	164387	7896	193162
TOTAL		32156	255601	17693	319409	58382	2125569	108231	2700579

TABLE 7.12-11
FISH, INVERTEBRATE, AND ALGAE COLLECTIONS AT TRAVELING SCREENS
FOR ENCINA POWER PLANT, JANUARY - DECEMBER, 1979

	Screen 1 (Units 1-3)			Screen 4 (Unit 4)			Screen 5 (Unit 5)			
	Daily Impinged	Thermal Treatment	Yearly Total	Daily Impinged	Thermal Treatment	Yearly Total	Daily Impinged	Thermal Treatment	Yearly Total	All Screens Yearly Total
Fish										
Numbers	15,116	31,411	46,527	39,509	16,863	56,372	25,037	59,831	84,868	187,767
Weight (Kg)	199.1	156.3	355.4	353.3	201.4	554.7	842.8	2,088.5	2,931.3	3,841.4
Invertebrates										
Numbers	3,104	750	3,854	1,129	830	1,959	2,048	477	2,525	8,338
Weight (Kg)	61.4	55.5	116.9	28.7	7.3	36.0	63.1	18.0	81.1	244.0
Weight of Kelp, Algae (Kg)		44.1			8.0			85.6		137.8
TOTAL NUMBER (fish & invert.)			50,381			58,331			87,393	196,105
TOTAL WEIGHT (Kg) (fish & invert.)			472.3			590.7			3,012.5	4,075.4

traveling screen was consistently number one in terms of number of organisms captured during each thermal treatment. All three screens ranked number 1, 2, and 3 during various thermal treatments; however, screen 5 ranked number one more frequently than the others, screen 4 ranked second most frequently, and screen 1 ranked third most frequently. With regard to weight of organisms captured, screen 5 consistently ranked first.

The study shows that certain numbers of fish species inhabit the intake tunnel systems without being impinged. Some relatively large individuals apparently live in the tunnels and their numbers appear to be greatest in winter and lowest during summer. However, all these organisms are killed during thermal treatments. Following each treatment repopulation of the tunnels begins, as organisms move into the intake from Agua Hedionda Lagoon. A number of lagoon species do not appear to move into the Plant and thus are not subject to impingement or thermal treatment (Table 7.12-12).

The specific times when tunnel recirculation was conducted were given in Table 7.5-3. Examination of data in this table for total number and weight of fishes impinged indicates that sometimes there were residual effects of tunnel recirculation lasting for one or more days following the operation. During those periods, larger than usual numbers and total weights of fishes occurred in the samples, despite the fact that all material impinged during the 6-hr period of the tunnel recirculation itself was removed by sampling at that time.

000590

TABLE 7.12-12
FISH SPECIES COLLECTED IN AGUA HEDIONDA LAGOON THAT WERE NOT COLLECTED AT THE TRAVELING SCREENS AT ENCINA POWER PLANT DURING 1979

SCIENTIFIC NAME	COMMON NAME
Scorpaenichthys marmoratus	Cabezon
Paraclinus rostratus	Reef finspot
Gobionellus longicaudus	Longtail goby
Gillichthys mirabilis	Longjaw mudsucker
Ilypnus gilberti	Cheekspot goby
Quietula y-cauda	Shadow goby

This effect was evaluated statistically by comparing the levels of impingement for 48-hr periods just before and just after tunnel recirculation. The 12-hr period 1900-0700 hr, within which tunnel recirculation occurred, was omitted from consideration. The comparisons were made with a series of Mann-Whitney U tests on total number and weight of all fishes impinged for the three traveling screen stations combined. These tests evaluated the null hypothesis that there was no significant difference in levels of impingement before and after tunnel recirculation, against the one-way alternative hypothesis that the level of impingement was significantly greater after tunnel recirculation than before.

A comparison was not made for the tunnel recirculation of February 24-25, 1979, because of possible confounding effects associated with a storm and the start of dredging operations at that time (Table 7.5-3). The incomplete tunnel recirculation on September 1-2, 1979 also was not considered, because it lasted only two hours.

The results of the Mann-Whitney U tests were as follows (SIG indicates a significant difference at the level of significance shown; NS indicates difference not significant):

Dates of Tunnel Recirculation	Total Number of Fishes	Total Weight of Fishes
3/31-4/1	SIG ($p<.05$)	SIG ($p<.05$)
6/16-6/17	SIG ($p<.10$)	SIG ($p<.05$)

Dates of Tunnel Recirculation	Total Number of Fishes	Total Weight of Fishes
7/28-7/29	NS	NS
9/8-9/9	NS	NS
10/13-10/14	SIG ($p<.05$)	NS
11/24-11/25	NS	NS
12/29-12/30	NS	NS

For only three of the seven tunnel recirculations considered were levels of impingement significantly greater following recirculation than just before. It is clear from the statistical results and from examination of Table 7.5-3 that residual effects of impingement sometimes did occur following tunnel recirculation, but not in all cases.

7.13 DISCUSSION

The nature and extent of entrapment and impingement of fishes and invertebrates in cooling water systems of power plants is influenced by a number of physical and biological factors (7-6, 7-7, 7-8, 7-9, 7-10, 7-11, 7-12, 7-13, and 7-14). The primary physical factors involved appear to be water temperature, velocity of flow and other flow characteristics in the cooling water system, waves, surge, turbulence and salinity changes associated with storms, level of illumination, and the water depth and structural characteristics of the intake system. All of these factors contribute to impingement through their interactions with the species-specific and size-specific behavior and condition of fishes and invertebrates inhabiting the area adjacent to the intake, including the attraction of many species to man-made structures (7-15, 7-16, and 7-17). The detailed, two-year study of environmental factors affecting impingement of fishes at the Redondo Beach Generating Station in Redondo Beach, California (7-18), is particularly useful as a basis for comparing the results of this study at the Encina Power Plant.

Specific interpretations of results from this impingement study are considered in preceding subsections of the report. A more general interpretation of the important results is provided here.

The detailed, daily sampling programs conducted during the period February 4, 1979 - January 4, 1980 provided a very comprehensive set of data concerning impingement of fishes, large invertebrates, and marine plants in the cooling water system of the Encina Power Plant. The methods used were effective in obtaining accurate quantitative and qualitative data.

During the 336-day period of the study, 76 species of fishes, 45 species of large invertebrates, and 7 species of marine grasses and algae were impinged at the traveling screens and the bar rack screening system. All were species common in Agua Hedionda Lagoon or in adjacent ocean areas.

Johnson et al. (1976) (7-19) reported that 112 species of fishes were impinged in the cooling water system of generating Units 7 and 8 at the Redondo Beach Generating Station during the two-year period September 1974 - August 1976. In common with the Encina Power Plant, these units use cooling water drawn from an area inhabited by both bay and ocean species. However, the intake structure at the Redondo Generating Station is located near the head of the Redondo Submarine Canyon. As a result, the fish fauna and the marine biota in general are particularly rich in species composition (7-20 and 7-21). These characteristics probably explain in part the difference in number of species impinged at the two power plants.

The total amount of fish and invertebrate material impinged at the traveling screens of the Encina Power Plant during the 336-day period was 85,943 individuals, with a combined weight of approximately 1548.4 kg (3414 lb). Of these, 79,662 individuals were fishes weighing a total of 1395.2 kg (3076 lb). In contrast to this, Johnson et al. (1976) (7-22) reported that an estimated

260,917 fishes weighing 19,553.4 kg (43,063 lb) were impinged at the traveling screens for Units 7 and 8 of the Redondo Beach Generating Station during the 52-week (364-day) period September 1, 1974 - August 31, 1975. These figures included fishes impinged during tunnel recirculation.

Several differences between the two power plants probably account for the very different total levels of impingement observed. The cooling water systems supplying Units 7 and 8 of the Redondo Generating Station had a maximum flow rate of 468,000 gpm, in contrast to a maximum flow rate of 534,300 gpm for all Units of the Encina Power Plant (41,900-220,000 gpm per Unit). The cooling water passes through a relatively long conduit from 366 m (1200 ft) to the Redondo Beach Generating Station, while the cooling water conveyance channels of the Encina Power Plant (Figure 7.3-1) are shorter. The structures through which water enters the cooling water system are different at the two power plants and the velocity of flow into the intake structure is relatively high at the Redondo Beach Generating Station ($\bar{x}$ = 73.2 cm/sec or 2.4 ft/sec). In addition, the richer fish fauna in King Harbor and at the head of the Redondo Submarine Canyon probably contributed to the higher levels of impingement reported at Redondo Beach. In any case, the results obtained in this study indicate that the levels of impingement for fishes and invertebrates are relatively low at the Encina Power Plant compared to those for the Redondo Beach Generating Station and other large coastal power plants in southern California.

The queenfish (Seriphus politus) had by far the highest level of impingement at the Encina Power Plant in terms of number of individuals (18,681 individuals, 23.4 percent of all fishes). It also ranked fourth in weight (6.5 percent of all fishes). The deepbody anchovy (Anchoa compressa) had the second highest level of impingement (13,299 individuals; 16.7 percent of all fishes) and ranked seventh in weight. Next in order by number of individuals impinged were the topsmelt (Atherinops affinis), the California grunion (Leuresthes tenuis), the northern anchovy (Engraulis mordax), and the shiner surfperch (Cymatogaster aggregata), represented by from 9.2 to 13.7 percent of all fishes impinged. All six of these highest ranking species were common in the area near the Encina Power Plant during the study. All also are relatively active, open water forms. Because of these characteristics, it is not surprising that they form the large majority (83.1 percent) of all individuals impinged.

Generally similar results were reported for the Redondo Generating Station (7-23). In 1974-75, the highest ranking fishes in number impinged were northern anchovy (38 percent of all fishes), shiner surfperch (16 percent), and queenfish (16 percent).

The six species ranking next highest in impingement at the Encina Power Plant had considerably lower, similar levels ranging from 1877 individuals (2.4 percent of all fishes) for the walleye surfperch (Hyperprosopon argenteum) to 1046 individuals (1.3 percent) for the giant kelpfish (Heterostichus rostratus). All of the remaining species had levels of impingement that represented less than 1.0 percent of the total number of all fishes impinged. Two of these six, walleye surfperch and the white surfperch also were important components of impingement samples at Redondo Beach (7-24).

Among the 12 species exhibiting levels of impingement greater than 1.0 percent at the Encina Power Plant, only three are bottom fishes. They are the round stingray (*Urolophus halleri*), the California halibut (*Paralichthys californicus*) and the giant kelpfish (*Heterostichus rostratus*). In general, bottom fishes are less susceptible to impingement because they are heavy-bodied forms influenced very little by water flow more than 1 to 2 m above the bottom. The giant kelpfish normally remains close to the fronds and blades of the giant kelp (*Macrocystis pyrifera*). It probably is carried into the cooling water system with the large masses of giant kelp that have broken off from the kelp canopy.

Many of the rankings by weight differed considerably from those by number of individuals impinged. The round stingray (*Urolophus halleri*) and the Pacific electric ray (*Torpedo californica*) ranked first and second on the basis of weight (13.3 percent and 9.0 percent of all fishes), respectively. Other heavy-bodied rays within the first ten species on the basis of weight were the sixth ranked California butterfly ray (*Gymnura marmorata*) and the tenth ranked bat ray (*Myliobatis californica*). Johnson et al. (1976) (7-25) noted a similar large component of elasmobranch fishes in the biomass of impingement samples at the Redondo Beach Generating Station. They found that 33 percent of the impinged fishes by weight consisted of sharks and rays, and that during 1974-75 Pacific electric ray accounted for 9 percent of all fishes by weight.

The topsmelt (Atherinops affinis) ranked third in the impingement samples at the Encina Power Plant, both in number and weight of individuals, representing 8 percent of all fishes by weight. The queenfish (Seriphus politus) ranked fourth in weight. Thus, all three of these open water species ranked high in both numbers and weight of individuals impinged.

The rankings of fishes on the basis of weight are a useful component of the impingement study. Yet they are less important ecologically than the rankings based on number of individuals impinged. This is because most population processes of the species involved are more directly affected by the numbers of individuals in the population and variation in these numbers than they are by the total biomass of individuals. For this reason, selection of additional critical species was based on the numerical rankings and total numbers of individuals impinged, as described in subsection 7.4.

Both the numbers and weights of fishes and invertebrates varied considerably throughout the year and from day to day and week to week. Results of correlation analyses indicated that there were no significant correlations between weekly mean values of temperature, salinity, ocean wave height, or cloud cover on either the weekly mean total numbers or weights of fishes impinged. The lack of significant correlations may be a reflection of the fact that impingement is influenced by a combination of factors, rather than by one or two acting in isolation.

The seasonal pattern of changes in impingement for some critical species of fishes appeared to be related either directly or indirectly to water temperature. For example, the queenfish (Seriphus politus) had the highest levels of impingement during the period mid-June through early September, when ambient water temperatures were highest. Lowest mean numbers were impinged during the period March-May, when water temperatures were relatively low. In contrast, the largest numbers of round stingrays (Urolophus halleri) were impinged in February, when water temperatures were low, and the smallest numbers were impinged from July to September, the period of highest water temperatures. While this evidence does not show conclusively that water temperature is related to levels of impingement, it suggests that temperature probably is involved in the process for some species. This had been shown to be the case in other studies of impingement (7-26, 7-27, 7-28, 7-29, and 7-30).

Effects of five distinct storm periods on numbers and weights of fishes were evaluated statistically by comparing data for periods of 4 to 7 days before and after onset of storms. The storm periods were characterized by wind speeds $\geq$ 12 mph (16 kph), rainfall, salinities $\leq$ 29.9 ppt in the lagoon, and ocean wave heights $\geq$ 4 ft ((1.2 m). Four of the five storm periods had significant effects, with larger numbers or weights of fishes impinged during the storm conditions than just before.

The results do not allow specific assessment of the individual physical conditions involved, but only their combined effects. However, it is very likely that all of these physical conditions, and possibly the associated increase in turbidity as well, act in combination to cause increased impingement. Turbulent water conditions in the ocean adjacent to the entrance to Agua Hedionda Lagoon may affect impingement by causing fishes to seek shelter in the lagoon. Johnson et al. (1976) (7-31) and others (7-32, 7-33, 7-34, and 7-35) have observed similar effects in other studies.

Johnson et al. (1976) (7-36) reported that storms accompanied by high wind speeds caused turbulent water conditions around the intake structure of the Redondo Beach Generating Station. During six storms over the two-year period September 1974 - August 1976, in which wind speeds averaged greater than 17.3 mph (27.7 kph) for 24-hr periods, 208,052 fishes were impinged in 19 days. This represented 24 percent of all fishes impinged during the two-year period of their study. Two major storms alone accounted for 21 percent of all fishes impinged. They also found that the mean number of fishes impinged per day during storm periods ($\bar{x}$ = 8223) was significantly greater than during normal periods ($\bar{x}$ = 817).

The effects of storm conditions on the area around the intake structure of the Redondo Beach Generating Station undoubtedly are much greater than for the Encina Power Plant. At Redondo Beach the intake structure for Units 7 and 8 is located in an area directly exposed to wind, ocean swells, and turbulence, while at the Encina Power Plant water enters the system from the relatively sheltered outer part of Agua Hedionda Lagoon. Evidence of this is the fact that during storms, when ocean wave heights exceeded 4 ft (1.2 m), wave heights in outer Agua Hedionda Lagoon remained less than 1 ft (0.3 m). This difference presumably is one major reason why storm conditions had much less pronounced effects on levels of impingement at the Encina Power Plant.

Dredging operations to remove accumulated sediment from outer Agua Hedionda Lagoon during the period from February 20 to April 25, 1979, also caused increased impingement of fishes and invertebrates. This was true particularly for species living in the lagoon. Evidence from statistical comparisons between levels of impingement during and following the dredging operations support this conclusion. Unfortunately, the period of dredging overlapped that of storm conditions during the winter and early spring, so that it was difficult to separate the effects of these two confounding variables.

Most of the effects of dredging operations in increasing impingement are relatively obvious ones. Disturbance and removal of bottom sediment would cause displacement of benthic fishes and invertebrates into the water column, making them more vulnerable to impingement. High levels of turbidity in the lagoon caused by dredging would reduce light levels and visibility markedly, with a resulting increase in impingement of fishes. In addition, both benthic and open water fishes probably were attracted into the areas affected by dredging to feed on organisms displaced by disturbance of the sediment. The resulting higher densities of some species in the outer part of Agua Hedionda Lagoon probably contributed to the higher levels of impingement observed.

Evaluation of more detailed information about short-term and seasonal variations in impingement of fishes considered as critical species suggests that for most of them impingement was relatively continuous throughout the year. However, the numbers and weights of individuals for each species varied greatly from day to day, week to week, and seasonally. In some cases these variations appeared to be related directly or indirectly to effects of water temperature, storm conditions, dredging operations in outer Agua Hedionda Lagoon, and other environmental factors.

There is a very clear evidence that the numbers and weights of fishes impinged during the night and early morning period primarily of darkness (1900 to 0700 hr) were significantly greater in almost all cases than those during the day (0700 to 1900 hr). Diurnal effects of this kind on impingement have been reported for several freshwater cooling systems (7-37, 7-38, 7-39, and 7-40).

There are a number of probable reasons for this evident day-night difference in levels of impingement at the Encina Power Plant. Many fishes tend to be relatively quiescent and reduce their swimming activities during darkness. The visual cues used by most species of fishes in swimming and avoidance behavior also would be reduced at low levels of illumination. Because of these effects, some species would be more susceptible to being transported into the cooling water system and impinged during periods of darkness. Another possible effect is that some species may move into the area of Agua Hedionda Lagoon adjacent to the Encina Power Plant during darkness to feed or seek shelter. Higher densities of these individuals might then contribute to increased levels of impingement. Several of the species with high levels of impingement at the Encina Power Plant are active at night. These include the queenfish (Seriphus politus), the northern anchovy (Engraulis mordax), and the Pacific electric ray (Torpedo californica).

As in the case of evaluating effects of storm conditions, it is very difficult to consider each of these possible causal factors in isolation. Specific field and laboratory experiments would be required to do so.

Results of correlation analyses and evaluation of variations in impingement indicate that, in general, there was a direct relationship between increasing flow rates of cooling water and the impingement levels of fishes. Johnson et al. (1976) (7-41) reported a similar relationship for Units 7 and 8 of the Redondo Generating Station. They found that an average of twice as many fishes were impinged during periods when all four circulator pumps supplying these units were in operation (468,000 gpm; maximum intake velocity of 97.5 cm/sec or 3.2 ft/sec) than when only two pumps were operating. The numbers of fishes impinged were significantly different at these two levels of flow.

Swimming capabilities of fishes and their reactions to flow velocities at the point where cooling water enters the Power Plant are known to influence impingement. Schuler and Larsen (1975) (7-42) showed in laboratory tests using simulated intake structures that entrapment of fishes increases with increasing approach velocities of water at the intake. Johnson et al. (1976) (7-43) also reported the results of field and laboratory studies to evaluate the swimming capabilities and impingement of four species, the queenfish (Seriphus politus), the northern anchovy (Engraulis mordax), the shiner surfperch (Cymatogaster aggregata), and the white croaker (Genyonemus lineatus). Of these, only the northern anchovy showed significantly higher levels of entrapment and impingement with four, as opposed to two, circulator pumps of Units 7 and 8 in operation at the Redondo Generating Station. Results of their laboratory studies also showed that shiner surfperch and white croaker both have swimming capabilities greater than those required to escape from flow with approach velocities up to 97.5 cm/sec (3.2 ft/sec) at the point where cooling water enters the intake structure. Such velocities exceed those measured in the cooling water system of the Encina Power Plant. However, the specific swimming capabilities of most fish species impinged at the Encina Power Plant are not known.

Generating Unit 4 at the Encina Power Plant was out of service during March, April, and May and the total flow rates of cooling water into the plant were reduced from approximately 500,000 gpm to 350,000 gpm. During this time impingement at the traveling screens for the two units remaining in operation declined and generally remained at relatively low levels. While not conclusive, this evidence suggests that such a reduction in total flow rate of water entering the Power Plant from Agua Hedionda Lagoon tended to reduce impingement at the traveling screens of both units still in operation, despite the fact that the flow rates within the conveyance channels for these two units remained approximately the same. This possible effect could be evaluated further through comparisons of impingement levels at different total flow rates. The information obtained would be of practical value in determining the optimal flow characteristics of the cooling water system to maintain low levels of impingement.

In general, there was little decomposition or physical damage evident among most species of fishes in the impingement samples. However, following tunnel recirculation (heat treatment) the numbers of decomposed individuals increased, reflecting the fact that substantial numbers of dead fishes from the tunnel recirculation remained in the conveyance channels for periods of several days before they were impinged.

Observations during sampling indicated that when first washed into the sampling nets and trash collector units, most fishes were alive and in relatively good condition. Death and decomposition of most individuals appeared to be the result of exposure out of water in the trash collector baskets, rather than to impingement on the traveling screens. Live fishes removed from the sampling nets and held in tanks supplied with seawater recovered and appeared to be normal. These individuals were routinely released.

There appeared to be a fairly direct relationship between the amount of physical damage and the fragility or delicate morphological characteristics of a given species. For example, all three of the anchovy species were subject to much more damage than the two relatively more "firm-fleshed" atherinid species and other fishes. Aside from the anchovies, there also appeared to be a tendency for species with larger body size to sustain slightly more physical damage than those of smaller size.

The sex ratios of the round stingray (Urolophus halleri), the deepbody anchovy (Anchoa compressa), the slough anchovy (A. delicatissima), the topsmelt (Atherinops affinis), the California grunion (Leuresthes tenuis), and the specklefin midshipman (Porichthys myriaster) all reflected the fact that frequently larger numbers of adult females than males were impinged. The causes of this are not clear. However, in the case of the specklefin midshipman all of the females impinged were in advanced stages of reproductive development. Johnson et al. (1976) (7-44) reported similar observations on midshipman species, shiner surfperch, and other species that when impingement of females was greater than that for males, the females usually were in an advanced reproductive stage. This evidence suggests that reproductive condition of females in some species, including specklefin midshipman and shiner surfperch, influences their susceptibility to impingement. Blaxter (1969) (7-45), in a review concerning swimming performance of fishes, noted that reproductive condition can influence swimming capabilities. As Johnson et al. (1976) (7-46) have indicated, the orientation behavior of female fishes also may change when they are in an advanced reproductive state. It is difficult to assess the impact such differential impingement of females in reproductive condition would have on the natural populations. While the data obtained concerning reproductive condition are limited, they do indicate that for most of the 12 species considered, adult females in all stages of reproductive development occurred in the impingement samples.

The largest component of marine organisms in almost all impingement samples from the bar rack and traveling screen stations consisted of marine grasses and algae. Large rays and sharks accounted for a relatively small part of the material impinged at the bar rack screening system. Eel grass (*Zostera marina*) and the giant kelp (*Macrocystis pyrifera*) were the dominant species in terms of volume. In general, the highest levels of impingement at the bar rack system occurred during and following storms. The reason for this appears to be that surge and wave action associated with storm conditions dislodge and transport large amounts of plant material. However, impingement of plants at the traveling screens generally was greater during the summer and fall.

References

7-1 Johnson, R. L., P. Dorn, K. Muench, and M. Hood, An Evaluation of Fish Entrapment Associated with the Offshore Cooling Water Intake System at the Redondo Beach Steam Generating Station, Phase II, Southern California Edison Company - 77-RD-12, 1976.

7-2 Marine Review Committee (MRC), Annual Report to the California Coastal Commission, August 1976-August 1977, Appendix I, Estimated Effects of SONGS Unit I on Marine Organisms: Technical Analysis and Results, MRC DOC. 77-09, No. 2, 1977.

7-3 Miller, J. N., The Present and Past Molluscan Faunas and Environments of Four Southern California Coastal Lagoons, Master's Thesis, University of California, San Diego, 1966.

7-4 Bradshaw, J. S. and G. N. Estberg, An Ecological Study of the Subtidal Marine Life in Agua Hedionda Lagoon, University of San Diego Environmental Studies Laboratory Technical Report, Prepared for San Diego Gas & Electric Company, San Diego, California, 1973.

7-5 Bradshaw, J., B. Browning, K. Smith, and J. Speth, The Natural Resources of Agua Hedionda Lagoon, U. S. Fish and Wildlife Service, Coastal Wetland Series No. 16, 1976.

7-6 Kerr, J. E., Studies of Fish Preservation at the Contra Costa Steam Plant of the Pacific Gas & Electric Company, State of California, The Resources Agency, The Department of Fish and Game - Fish Bulletin 92, Sacramento, CA. 1953.

7-7 Herald, E. S. and D. A. Simpson, "Fluctuations in Abundance of Certain Fishes in South San Francisco Bay as Indicated by Sampling at a Trash Screen," Calif. Fish and Game, Vol. 39(2), pp. 271-278, (1955).

7-8 Bainbridge, J. C., "The Problem of Excluding Fish from Water Intakes," Ann. Appl. Biol., Vol. 53, pp. 505-508, (1964).

7-9 Prentice, E. F. and F. J. Ossiander, Fish Diversion Systems and Biological Investigations of Horizontal Traveling Screen Model III, Proceedings of the Second Entrainment and Intake Screening Workshop, Baltimore, MD, December 1974, pp. 205-214.

7-10 Schuler, V. J., Experimental Studies in Guiding Marine Fishes of Southern California with Screens and Louvers, Proceedings of the Second Entrainment and Intake Screening Workshop, Baltimore, MD, December 1974, pp. 305-315.

7-11 Johnson, Dorn, Muench, and Hood, (7-1).

7-12 Jensen, L. D., (ed.), Proceedings of the Second Entrainment and Intake Screening Workshop, Electric Power Research Institute, "EPRI Publication No. 74-049-00-5," Palo Alto, CA, 347 pp., (1974).

7-13 Jensen, L. D. (ed.), Third National Workshop on Entrainment and Impingement: Section 316(b) - Research and Compliance, Ecological Analysts, Inc., Melville, New York, 425 pp. (1977).

7-14 Jensen, L. D. (ed.), Fourth National Workshop on Entrainment and Impingement, Ecological Analysts, Inc., Melville, New York, 424 pp., (1978).

7-15 Turner, C. H., E. E. Ebert, and R. R. Given, Man-made reef ecology, State of California, The Resources Agency, Department of Fish and Game - Fish Bulletin 146, Sacramento, CA, 1969.

7-16 Klima, E. F., and D. A. Wickham, "Attraction of Coastal Pelagic Fishes with Artificial Structures," Trans. Am. Fish. Soc., Vol. 100(1), pp. 86-99, (1971).

7-17 Johnson, Dorn, Muench, and Hood, (7-1).

7-18 Johnson, Dorn, Muench, and Hood, (7-1).

7-19 Johnson, Dorn, Muench, and Hood, (7-1).

7-20 Ford, R. F., D. G. Foreman, C. D. Kroll, and D. G. Watts, Ecological Effects of Thermal Effluent from a Coastal Electric Generating Station on Benthic Marine Invertebrates, Phase III, Southern California Edison Company - 78-RD-56, (1978).

7-21 Stephens, J. S., Effects of Thermal Effluent of Southern California Edison's Redondo Beach Steam Generating Station on the Warm Temperate Fish Fauna of King Harbor Marina, Annual Report for Phase III, Southern California Edison Company - 78-RD-47, (1978).

7-22 Johnson, Dorn, Muench, and Hood, (7-1).

7-23 Johnson, Dorn, Muench, and Hood, (7-1).

7-24 Johnson, Dorn, Muench, and Hood, (7-1).

7-25 Johnson, Dorn, Muench, and Hood, (7-1).

7-26 Jensen, (7-12).

7-27 Jensen, (7-13).

7-28 Jensen, (7-14).

7-29 Johnson, Dorn, Muench, and Hood, (7-1).

7-30 Lifton, W. S. and J. F. Storr, The Effect of Environmental Variables on Fish Impingement, Fourth National Workshop on Entrainment and Impingement, Ecological Analysts, Inc., Melville, New York, 424 pp., (1978).

7-31 Johnson, Dorn, Muench, and Hood, (7-1).

7-32 Jensen, (7-12).

7-33 Jensen, (7-13).

7-34 Jensen, (7-14).

7-35 Lifton and Storr, (7-30).

7-36 Johnson, Dorn, Muench, and Hood, (7-1).

7-37 Voightlander, C., Assessment of Impingement Impacts on TVA Reservoirs, Third National Workshop on Entrainment and Impingement: Section 316(b) - Research and Compliance, Ecological Analysts, Inc., Melville, New York, 425 pp., (1977).

7-38 Lifton and Storr, (7-30).

7-39 Jensen, (7-13).

7-40 Jensen, (7-14).

7-41 Johnson, Dorn, Muench, and Hood, (7-1).

7-42 Schuler, V. J. and L. E. Larson, "Improved Fish Protection at Intake Systems," J. Envir. Engin. Div., Am. Soc., Civil Engineer, Proc. Paper 11756, Vol. 101, pp. 897-910, (1975).

7-43 Johnson, Dorn, Muench, and Hood, (7-1).

7-44 Johnson, Dorn, Muench, and Hood, (7-1).

7-45 Blaxter, J. H. S., "Swimming Speeds of Fish," Food Agr. Organiz., U. N. Fish Rep., Vol. 62, pp. 62-100, (1969).

7-46 Johnson, Dorn, Muench, and Hood, (7-1).

PLANT Encina

DATE 3-6-74

FISH OBSERVATIONS

NORMAL OPERATION 7 hours observed on each date shown below

Month of February 1974

Type of Fish	Estimated Number of Fish	Estimate of Total Weight	Size Range Inches
ATHERINIDAE (SILVERSIDE FAMILY) JACKSMELT, TOPSMELT-ATHERINOPS SPP.	10	2 lb	3-7
BATRACHOIDIDAE (TOADFISH FAMILY) SLIM MIDSHIPMAN-PORICHTHYS MYRIASTER			
BELONIDAE (NEEDLEFISH FAMILY) CALIFORNIA NEEDLEFISH-STRONGYLURA EXILIS			
BOTHIDAE (LEFTEYED FLOUNDER FAMILY) CALIFORNIA HALIBUT-PARALICHTYS CALIFORNICUS			
CARANGIDAE (JACK FAMILY)			
PACIFIC JACK MACKEREL-TRACHURUS SYMMETRICUS			
CALIFORNIA YELLOWTAIL-SERIOLA DORSALIS			
CLUPEIDAE (HERRING FAMILY) PACIFIC SARDINE-SARDINOPS CAERULEA	5	1 lb	3-6
CYBIIDAE (SPANISH MACKEREL FAMILY) CALIFORNIA BONITO-SARDA LINEOLATA			
EMBIOTOCIDAE (SURFPERCH FAMILY) ALL SPECIES COMBINED	1	2 lb	15
ENGRAULIDAE (ANCHOVY FAMILY) NORTHERN ANCHOVY-ENGRAULIS MORDAX	6	0.5 lb	3-6
GIRELLIDAE (NIBBLER FAMILY) OPALEYE-GIRELLA NIGRICANS	1	0.5 lb	8
MUGILIDAE (MULLET FAMILY) STRIPED MULLET-MUGIL CEPHALUS	6	0.5 lb	2-3
OSMERIDAE (SMELT FAMILY) SURF SMELT-HYPOMESUS PRETIOSUS			
PLEURONECTIDAE (RIGHTEYED FLOUNDER FAMILY) SOLE, FLOUNDER, TURBOT	1	0.5 lb	9
SCIAENIDAE (CROAKER FAMILY)			
QUEENFISH-SERIPHUS POLITUS			
WHITE SEABASS-CYNOSCION NOBILIS			
SPOTFIN CROAKER-RONCADOR STEARNSI			
YELLOWFIN CROAKER-UMBRINA RONCADOR			
OTHER			
SCOMBRIDAE (MACKEREL FAMILY) PACIFIC MACKEREL-PNEUMATOPHORUS DIEGO			
SCORPAENIDAE (ROCKFISH FAMILY) SCULPIN-SCORPAENA GUTTATA			
SERRANIDAE (BASS FAMILY)			
KELP BASS-PARALABRAX CLATHRATUS			
SAND BASS-P. NEBULIFER			
SPOTTED BASS-P. MACULATOFASCIATUS	~~6~~	~~2 lb~~	~~4-6~~
SPHYRAENIDAE CALIFORNIA BARRACUDA-SPHYRAENA ARGENTEA			
DASYATIDAE (STINGRAY FAMILY)	4	4 lb	8-12
RAJIDAE (SKATE FAMILY)			
SHARKS			
CALIFORNIA SPINY LOBSTER-PANULIRUS INTERRUPTUS			
MYSIDAE (SHRIMP FAMILY)			
OTHER SPECIES	1	0.3 lb	6

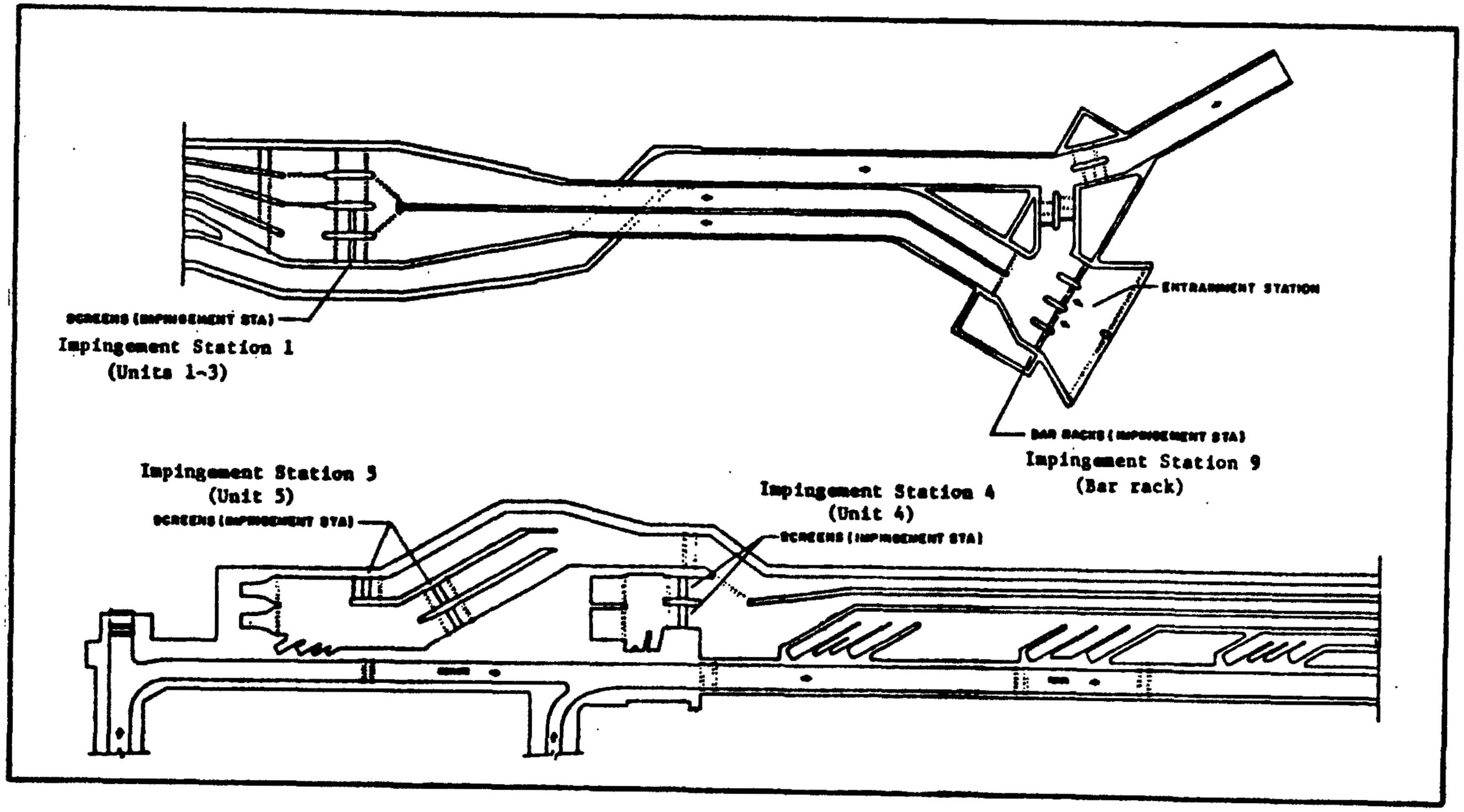
Estimated total pounds of fish during observation 13.3 lb

Remarks: (Include unusual events such as red tide, excessive rain, which has affected amount of fish observed

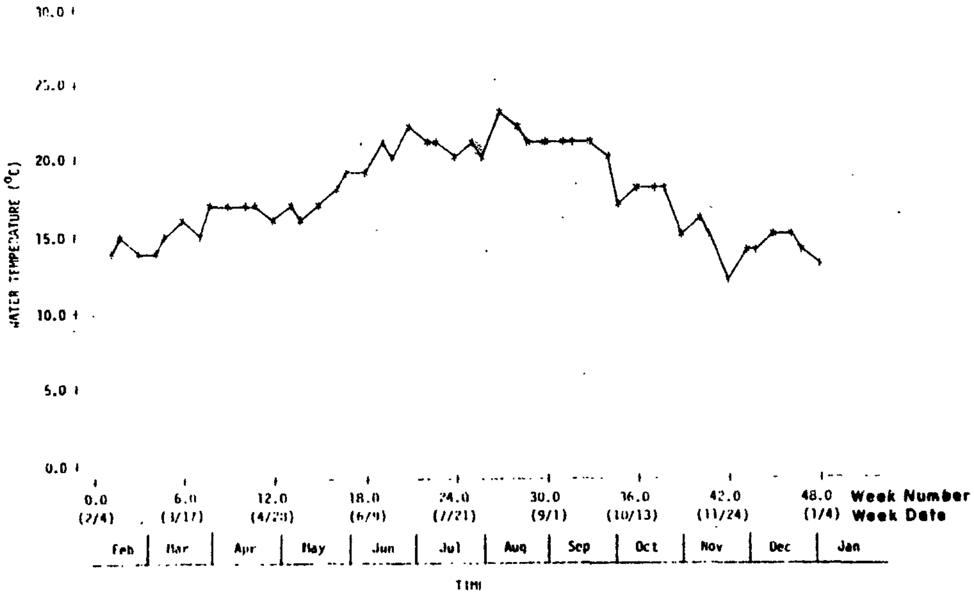
Circulating Water Tunnel Heat Treating Period, February 10, 1974

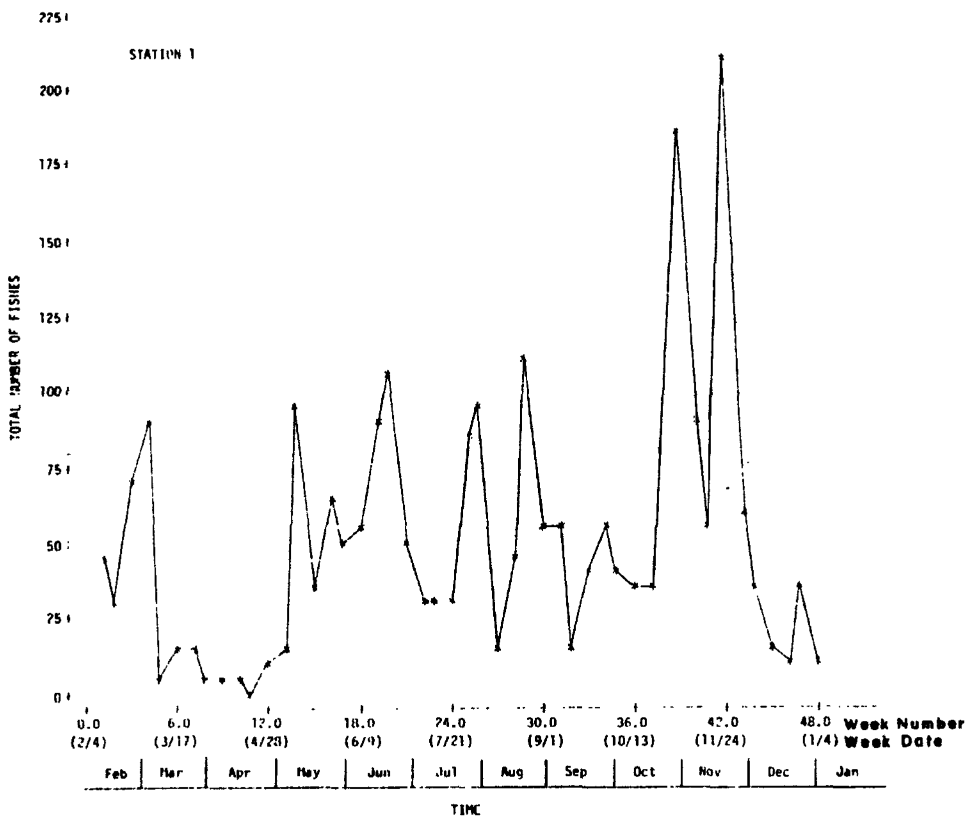
Company Representative

SAN DIEGO GAS & ELECTRIC COMPANY	
Standard form used by SDG&E in recording impingement data. Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.2-1

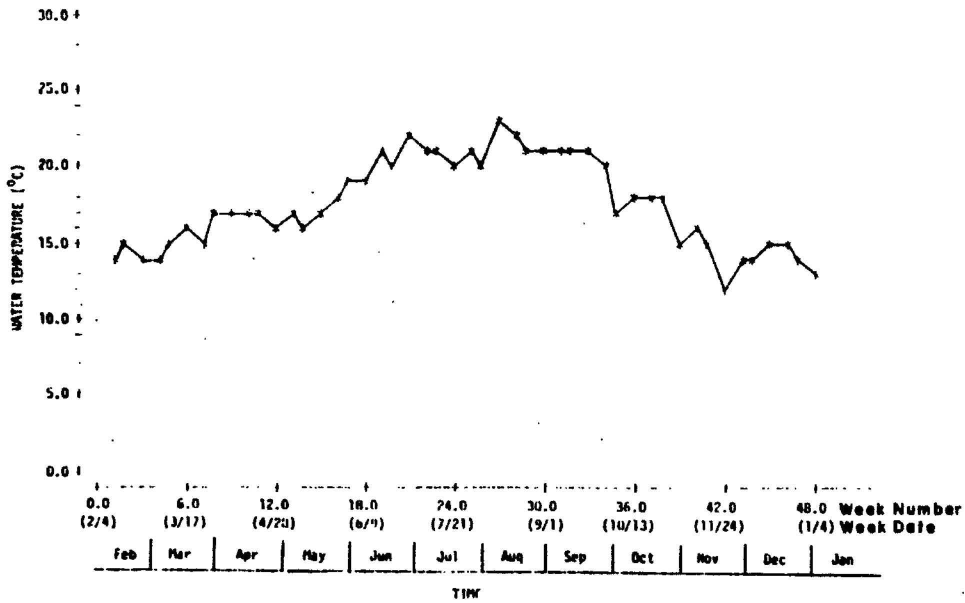


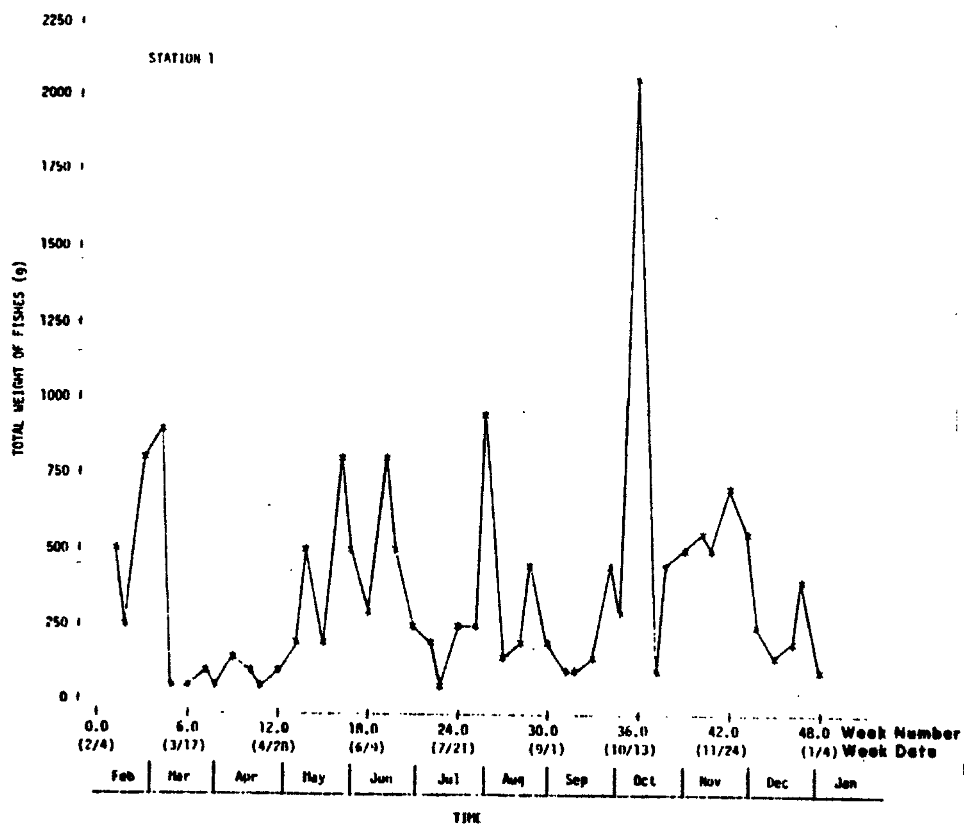
SAN DIEGO GAS & ELECTRIC COMPANY	
Cooling water system of the Encina Power Plant showing the location of the four impingement sampling stations August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.3-1



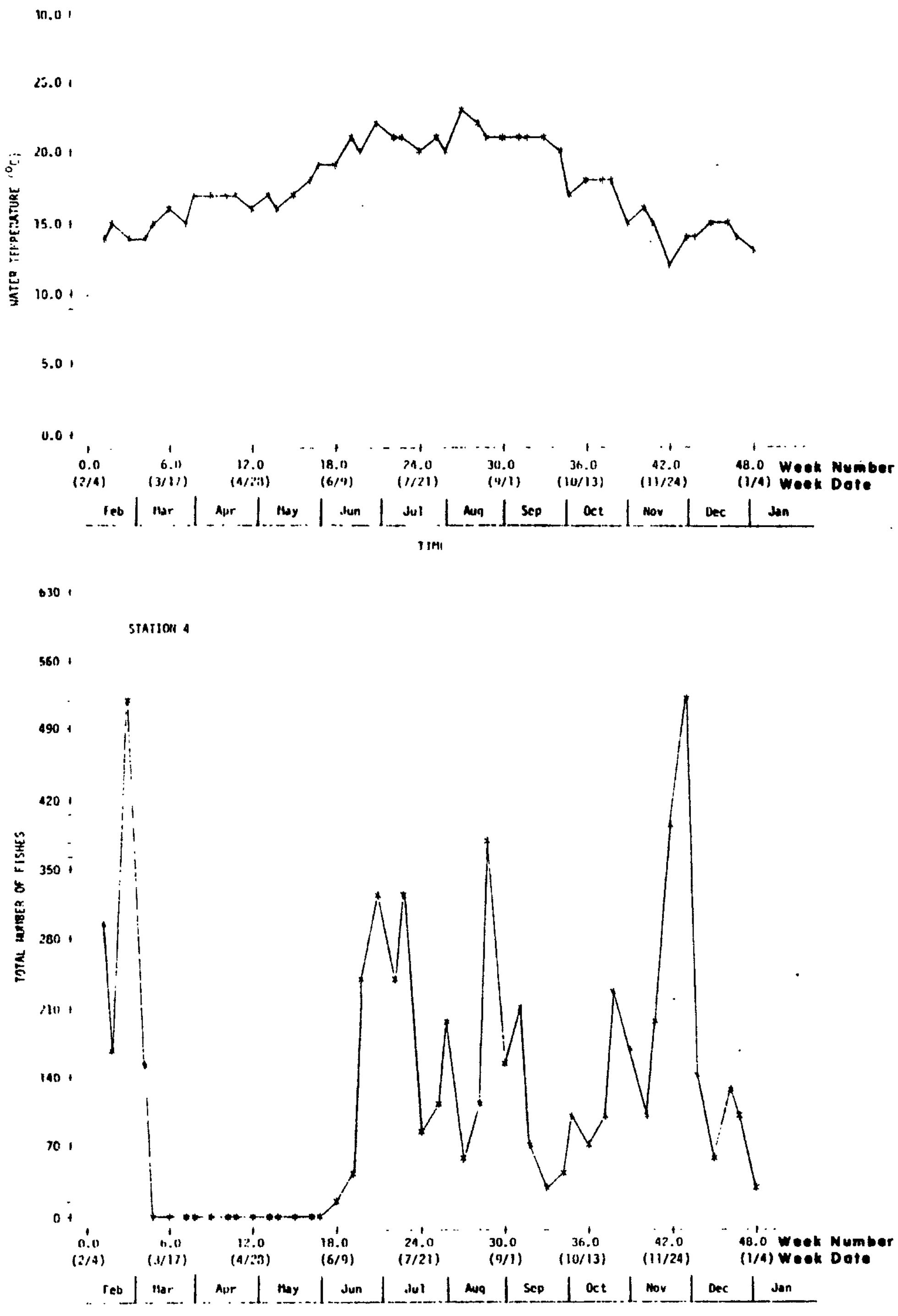


SAN DIEGO GAS & ELECTRIC COMPANY	
Weekly mean total number of fishes impinged at station 1 per 24-hour interval from 2-4-79 to 1-4-80 Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.5-1





SAN DIEGO GAS & ELECTRIC COMPANY	
Weekly mean total weight of fishes impinged at station 1 per 24-hour interval from 2-4-79 to 1-4-80 Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.5-2



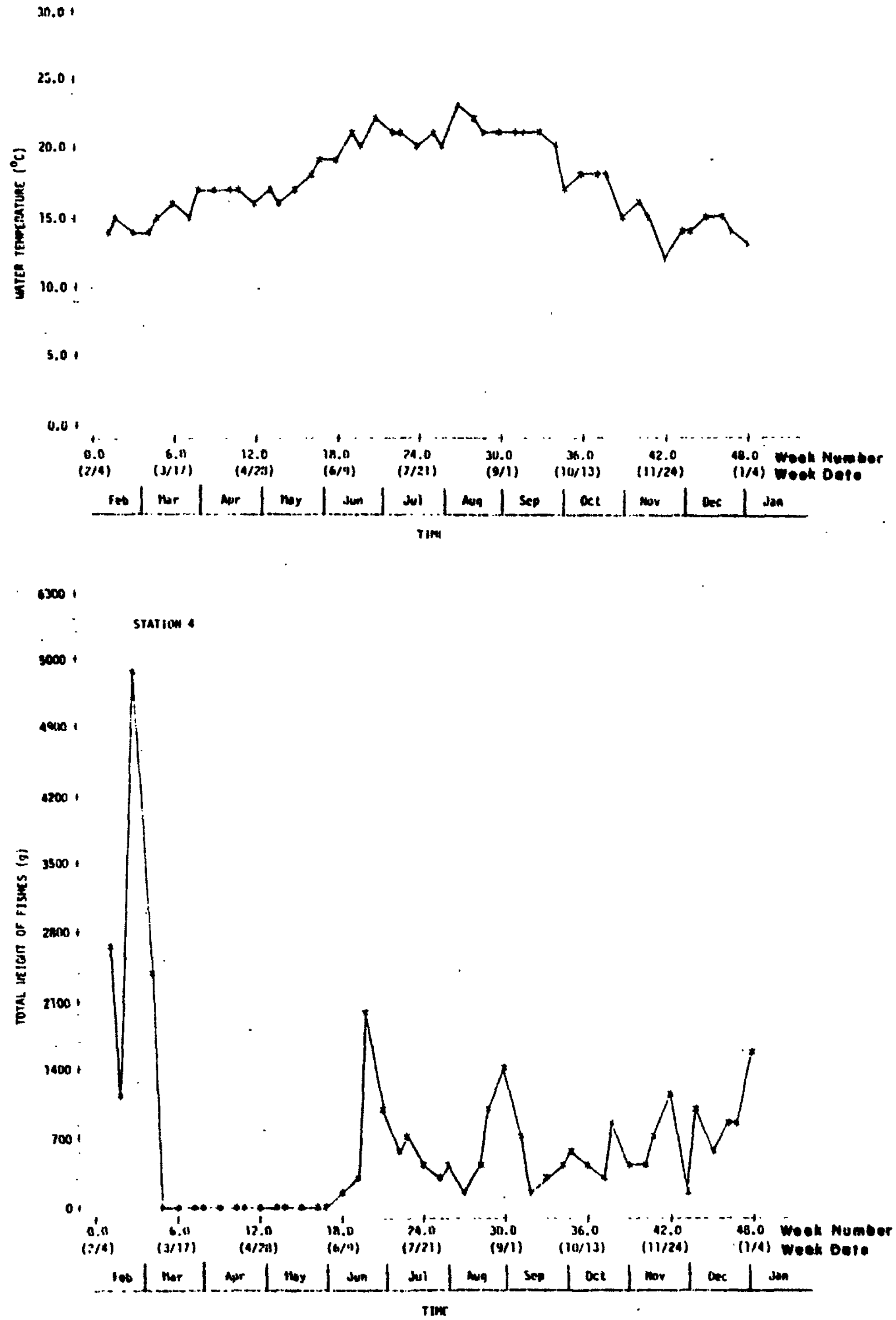
SAN DIEGO GAS & ELECTRIC COMPANY

Weekly mean total number of all fishe impinged at station 4 per 24-hour interval from 2-4-79 to 1-4-80

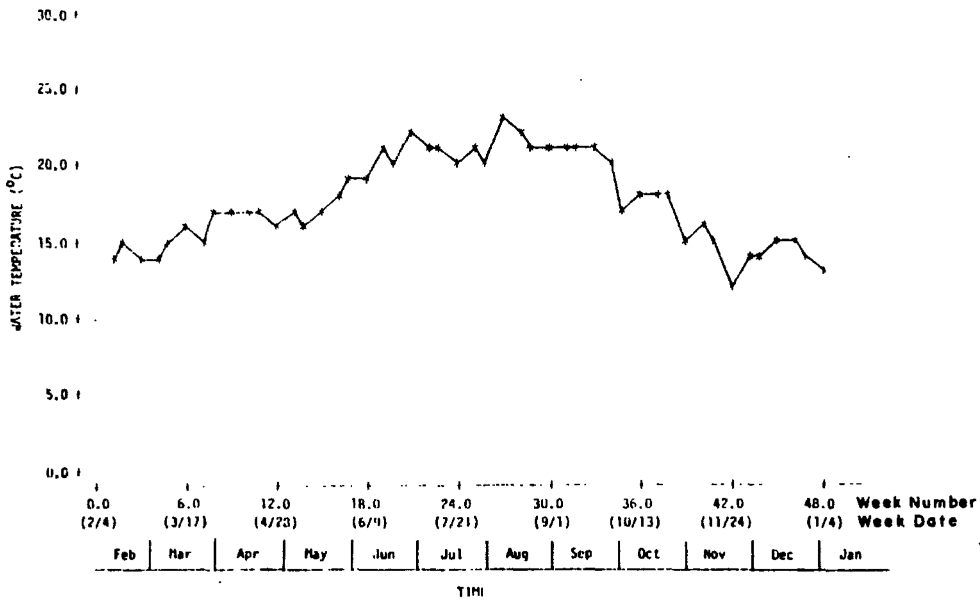
Encina Power Plant - August 1, 1980

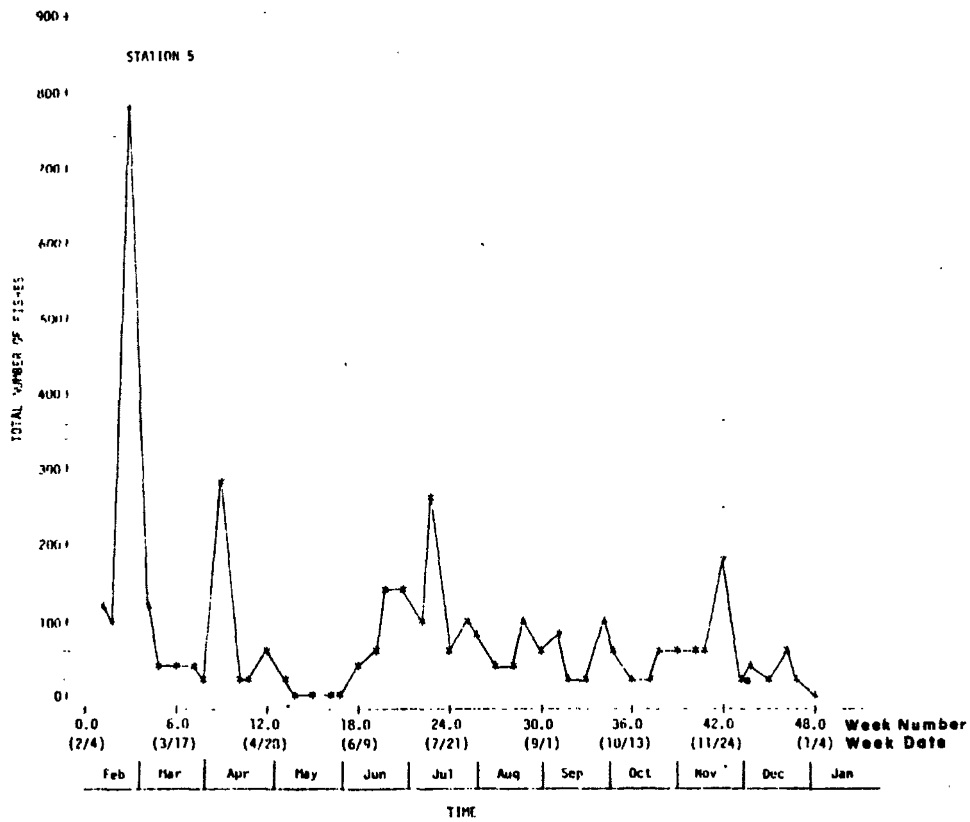
PREPARED BY:
WOODWARD-CLYDE CONSULTANTS

FIGURE NO.
7.5-3



SAN DIEGO GAS & ELECTRIC COMPANY	
Weekly mean total weight of fishes impinged at station 4 per 24-hour interval from 2-4-79 to 1-4-80 Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.5-4



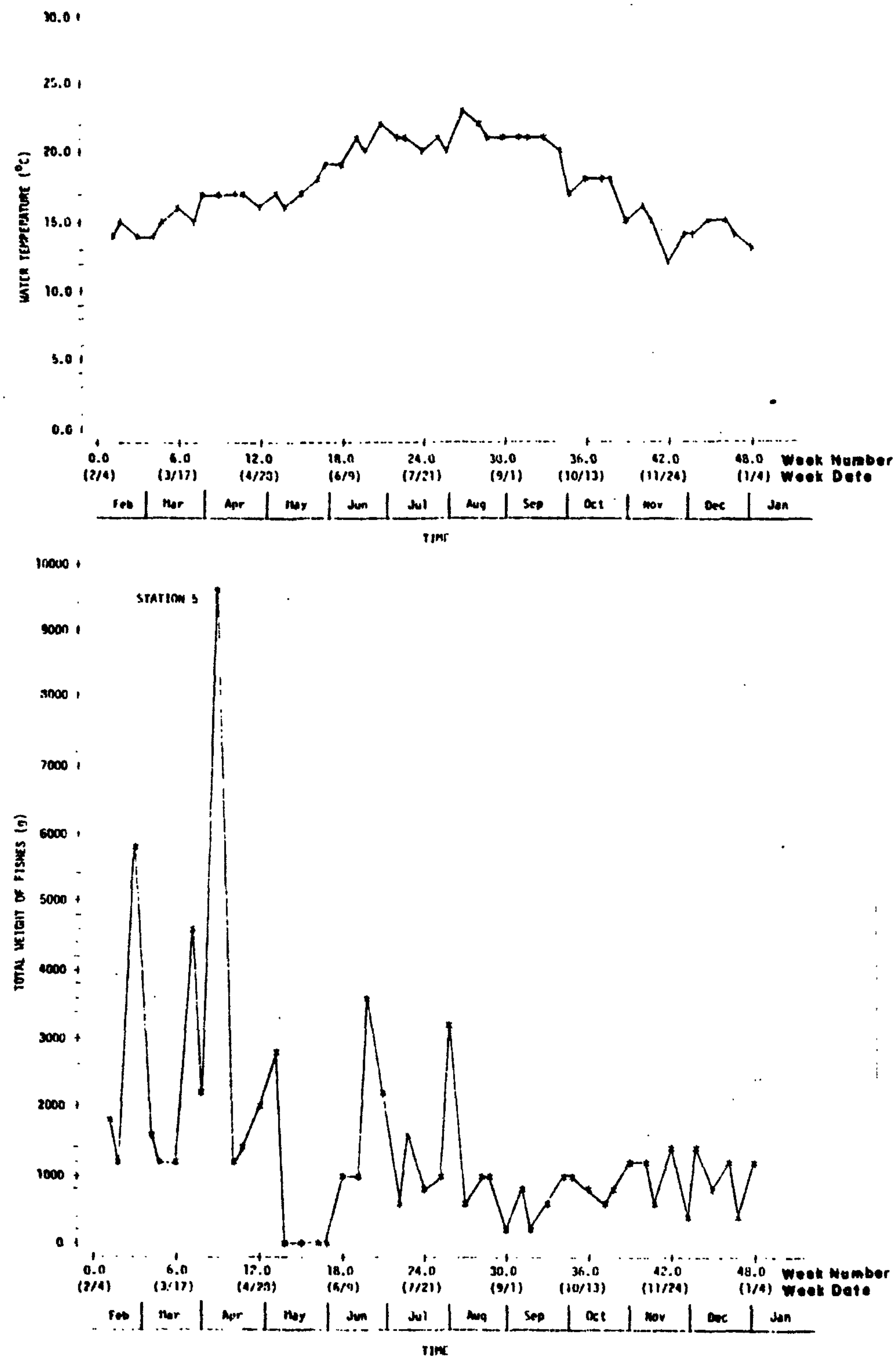


SAN DIEGO GAS & ELECTRIC COMPANY

Weekly mean total number of all fishes impinged at station 5 per 24-hour interval from 2-4-79 to 1-4-80
Encina Power Plant - August 1, 1980

PREPARED BY:
WOODWARD-CLYDE CONSULTANTS

FIGURE NO.
7.5-5

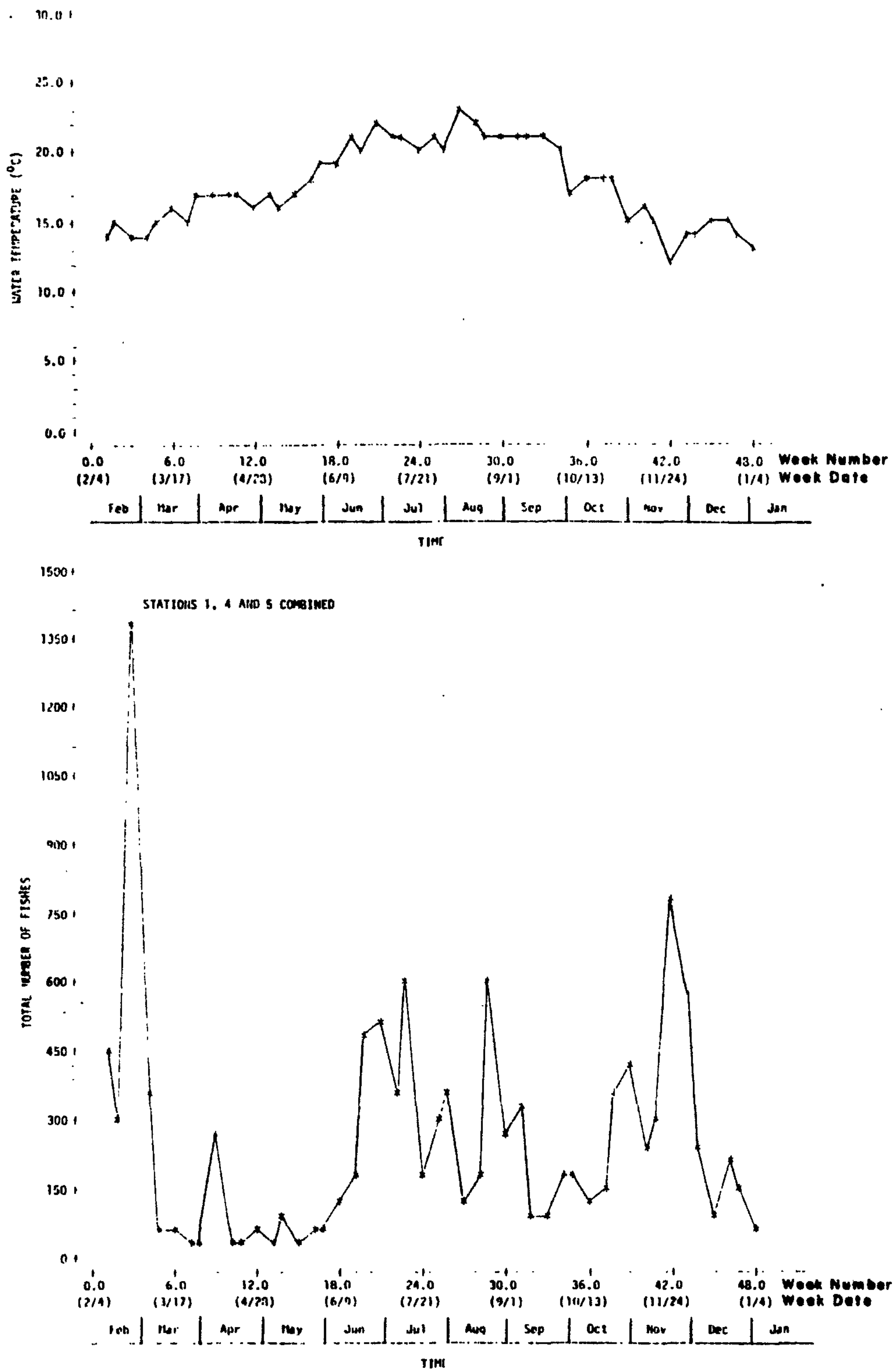


SAN DIEGO GAS & ELECTRIC COMPANY

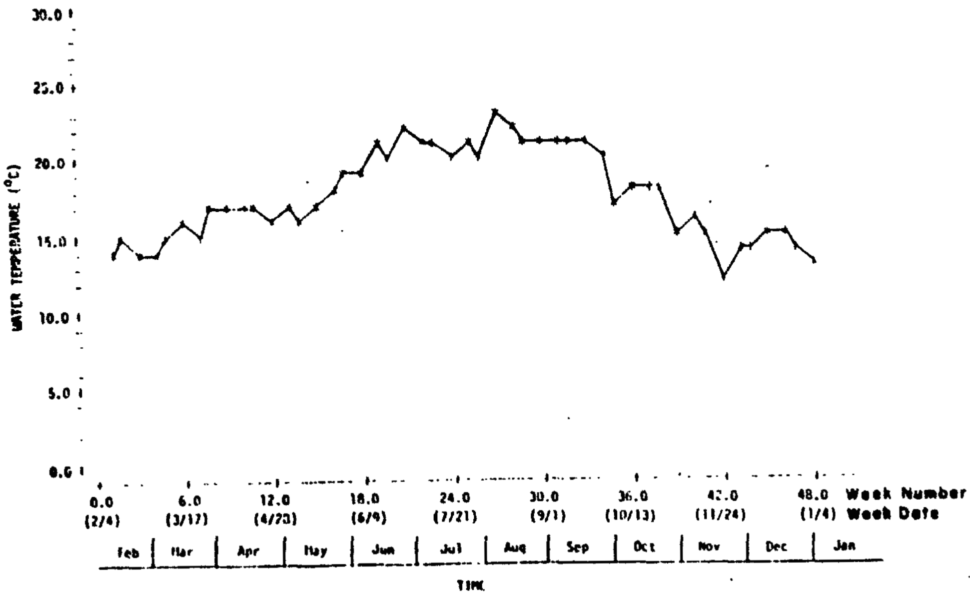
Weekly mean total weight of fishes impinged at station 5 per 24-hour interval from 2-4-79 to 1-4-80
Encina Power Plant - August 1, 1980

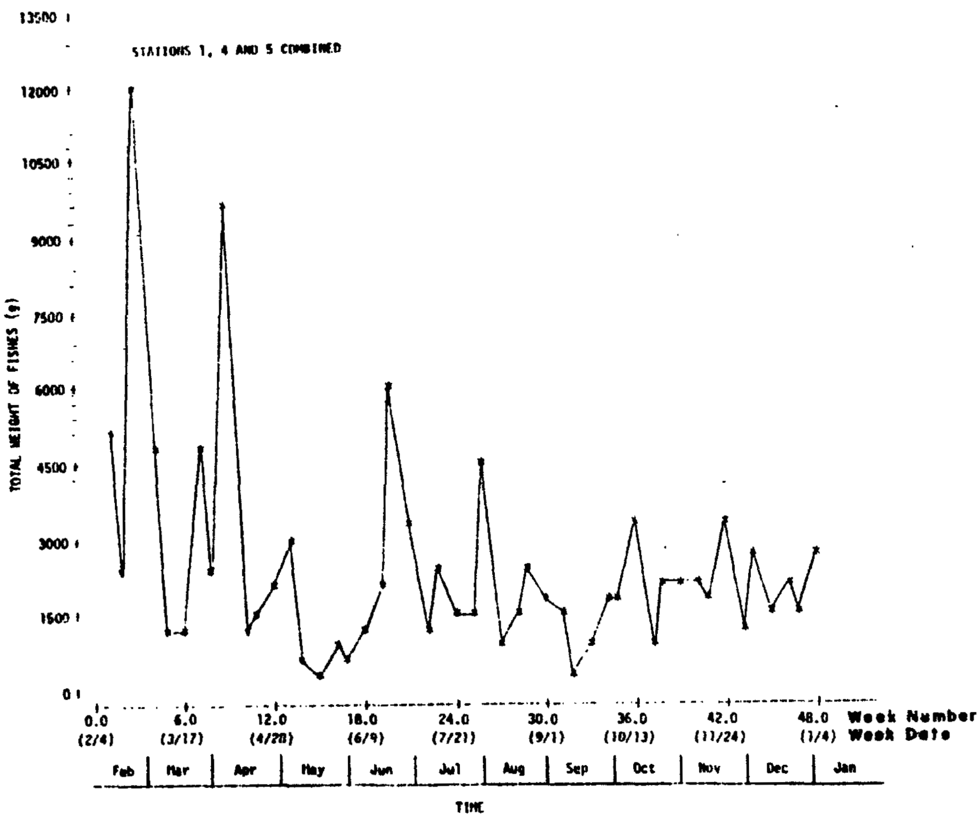
PREPARED BY:
WOODWARD-CLYDE CONSULTANTS

FIGURE NO.
7.5-6

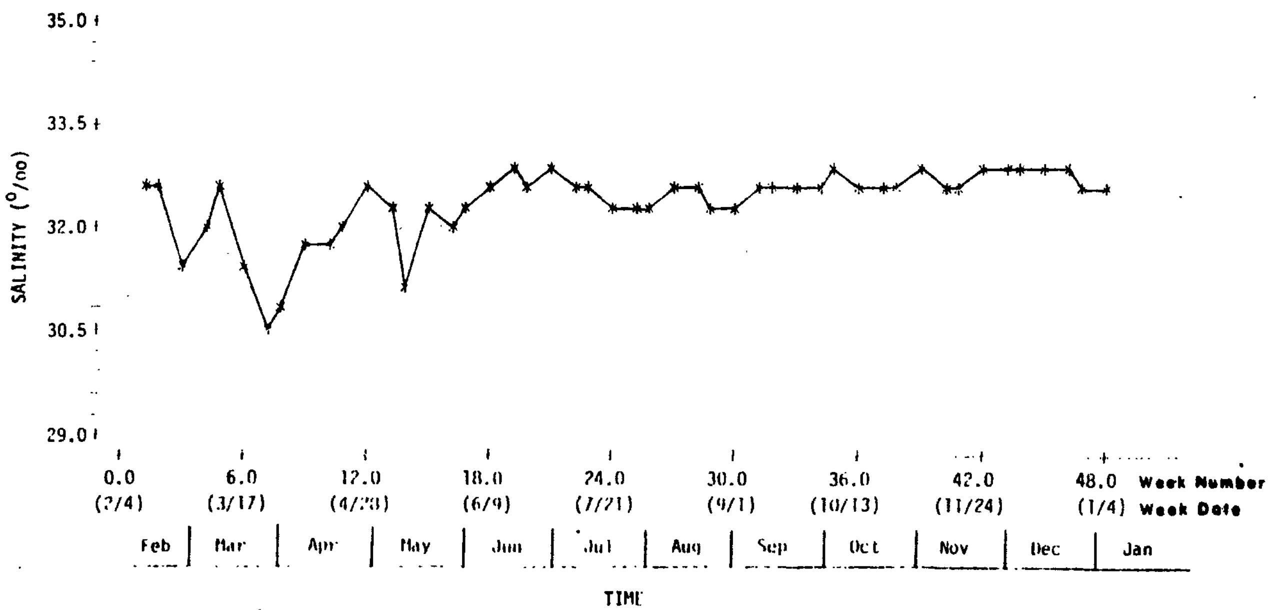


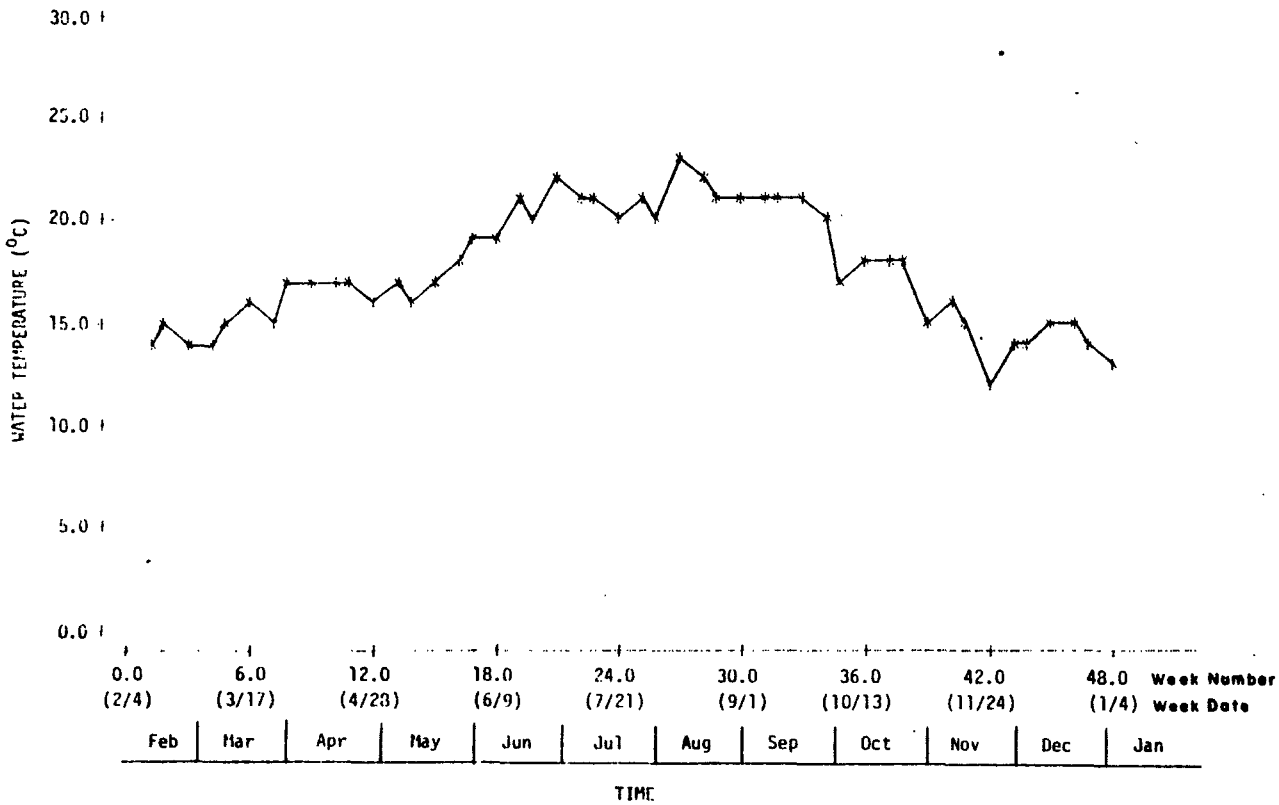
SAN DIEGO GAS & ELECTRIC COMPANY	
Weekly mean total number of all fishes impinged at all stations per 24-hour interval from 2-4-79 to 1-4-80 Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.5-7





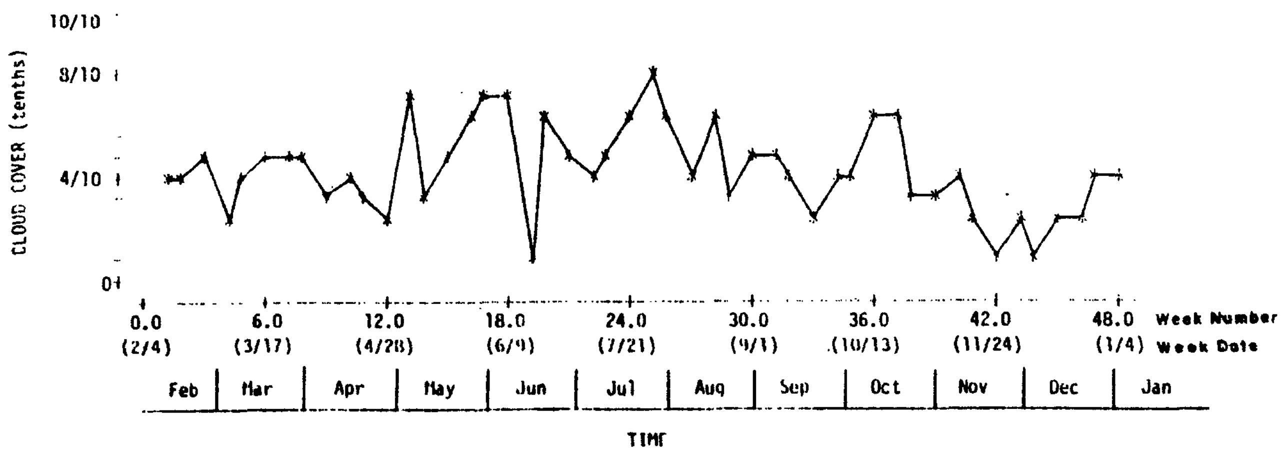
SAN DIEGO GAS & ELECTRIC COMPANY	
Weekly mean total weight of all fishes impinged at all stations per 24-hour interval from 2-4-79 to 1-4-80 Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.5-8

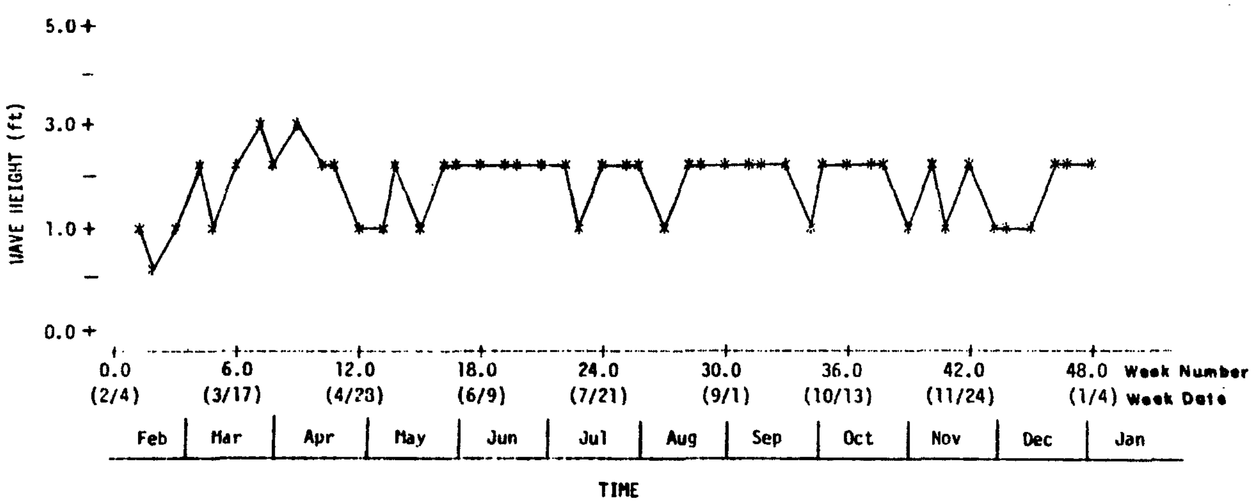




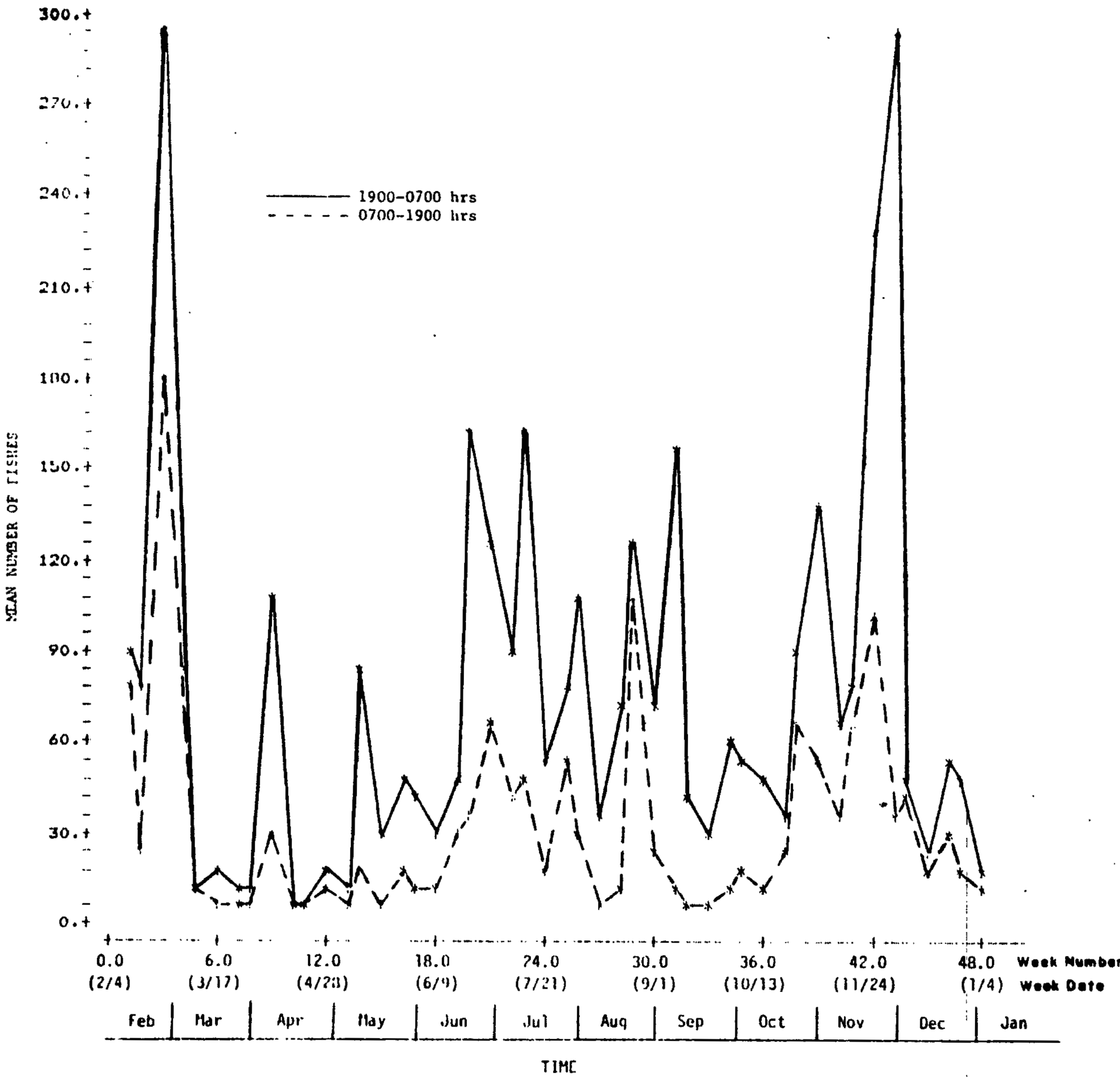
SAN DIEGO GAS & ELECTRIC COMPANY	
Weekly mean values of temperature and salinity for seawater entering the cooling water intake from 2-4-79 to 1-4-8[0] Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.5-9

000625



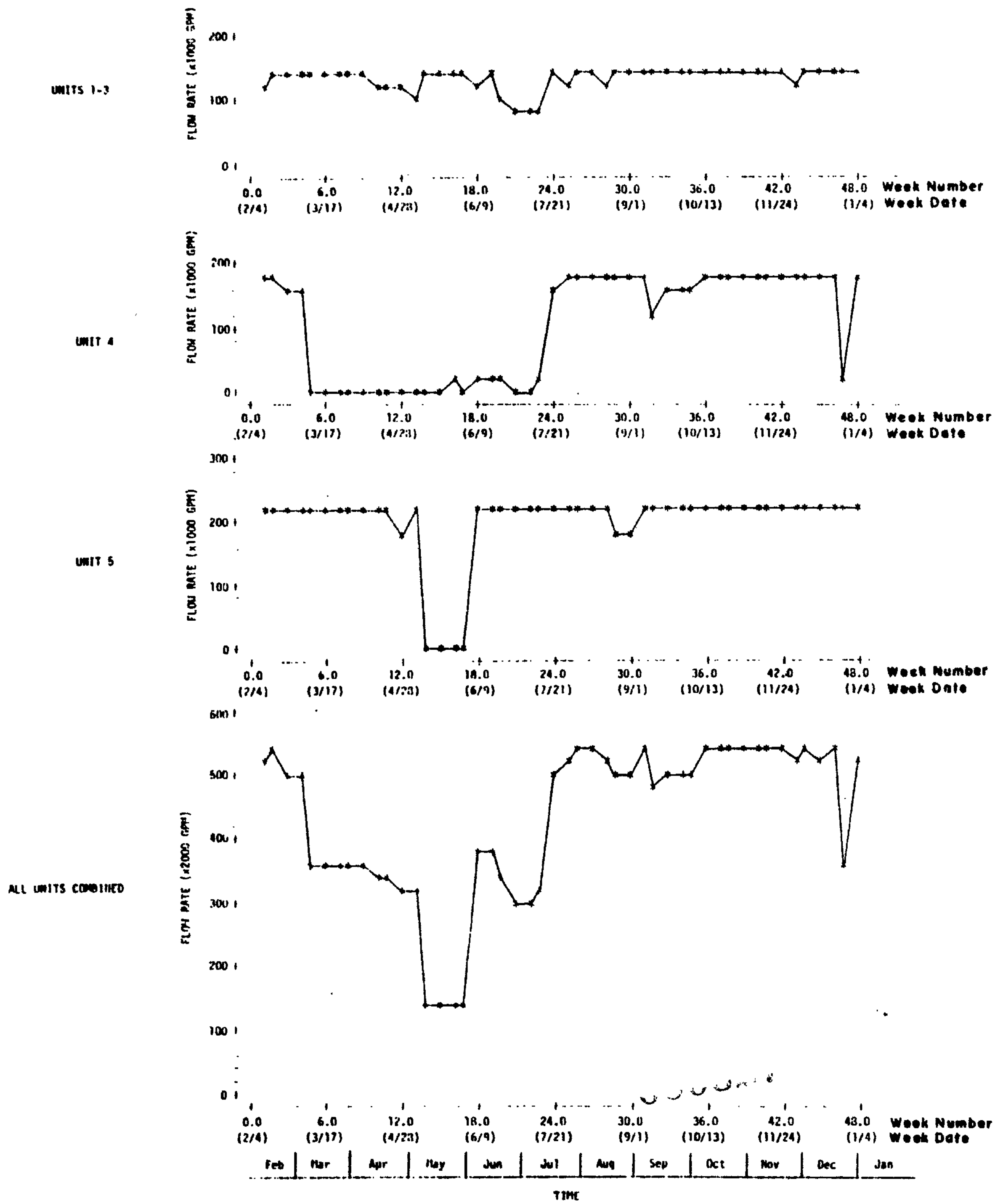


SAN DIEGO GAS & ELECTRIC COMPANY	
Weekly mean values for wave height (ft) and cloud cover (units of 1/10 cover) from 2-4-79 to 1-4-80 Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.5-10

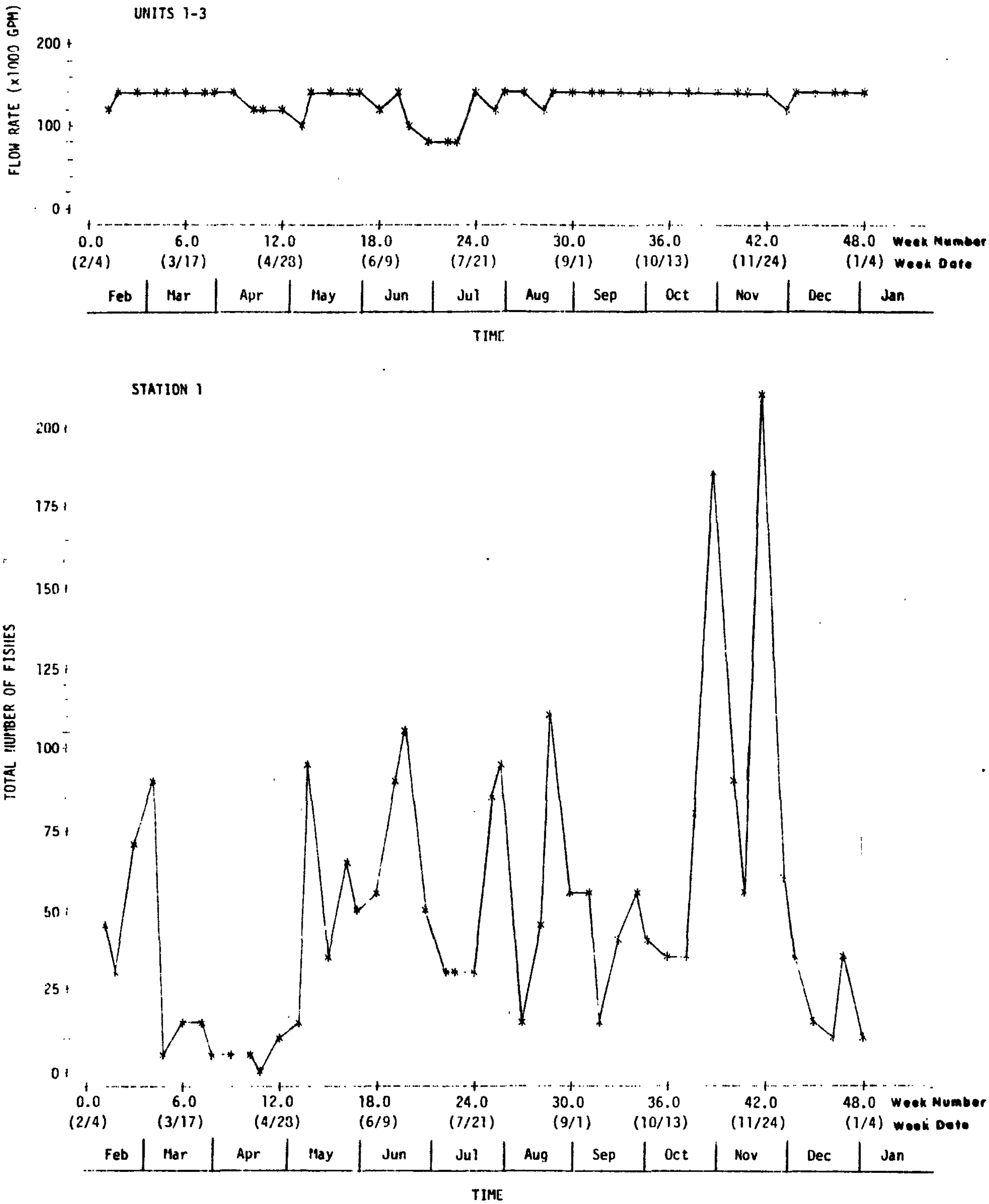


SAN DIEGO GAS & ELECTRIC COMPANY	
Comparisons of daytime and nighttime impingement for the period 2-4-79 to 1-4-80 Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.6-1

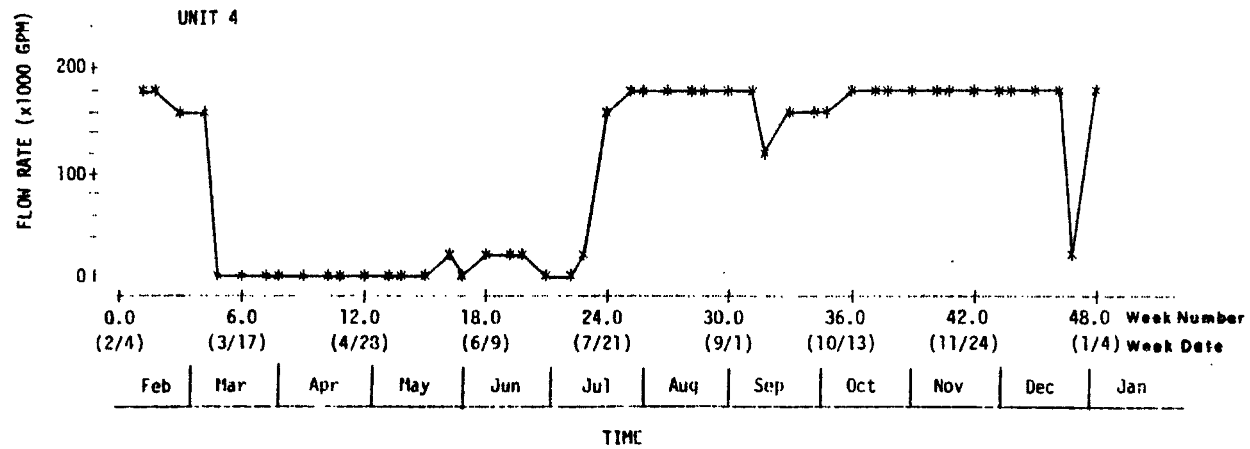
627

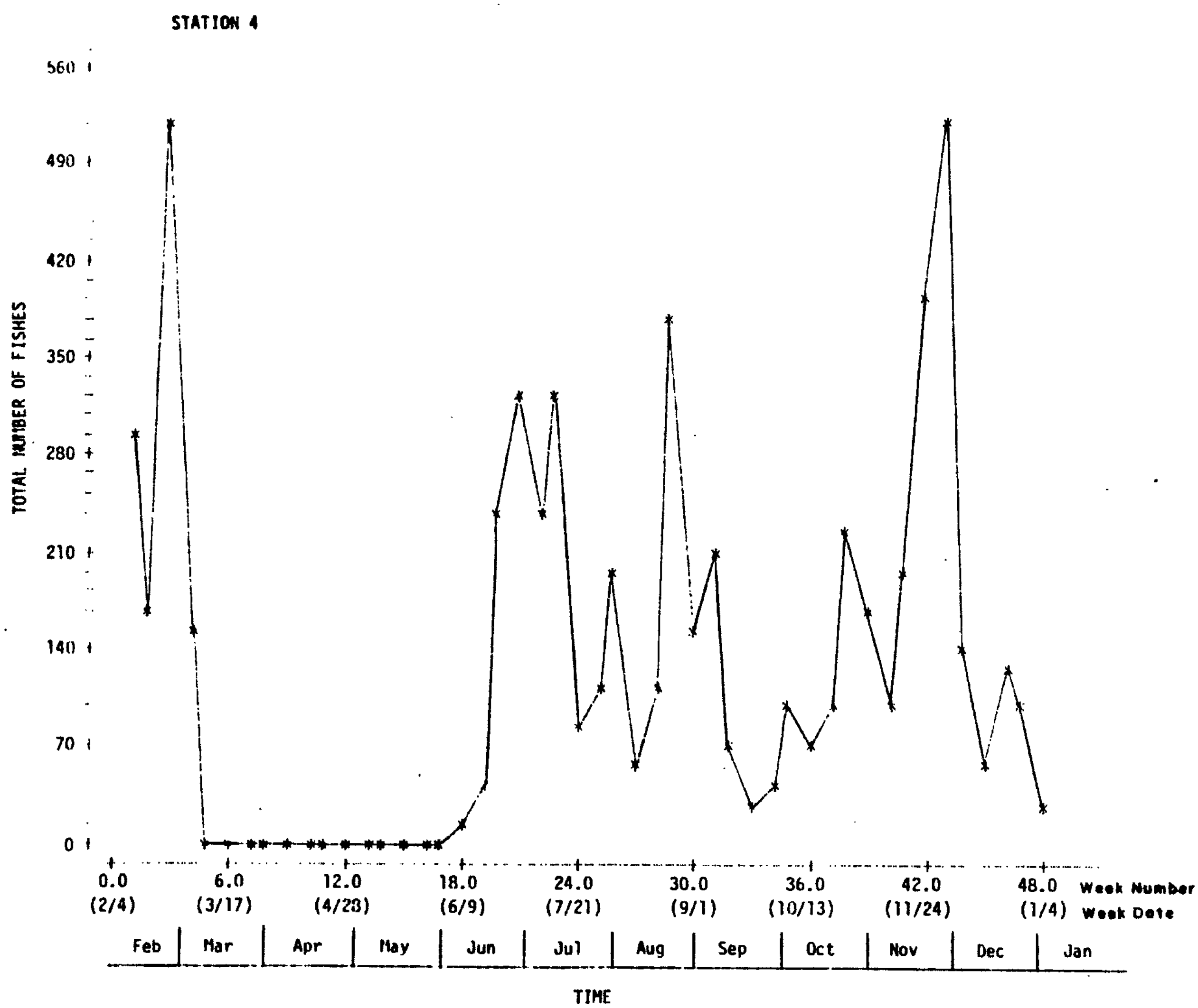


SAN DIEGO GAS & ELECTRIC COMPANY	
Weekly mean flow rates during the period 2-4-79 to 1-4-80 Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.8-1

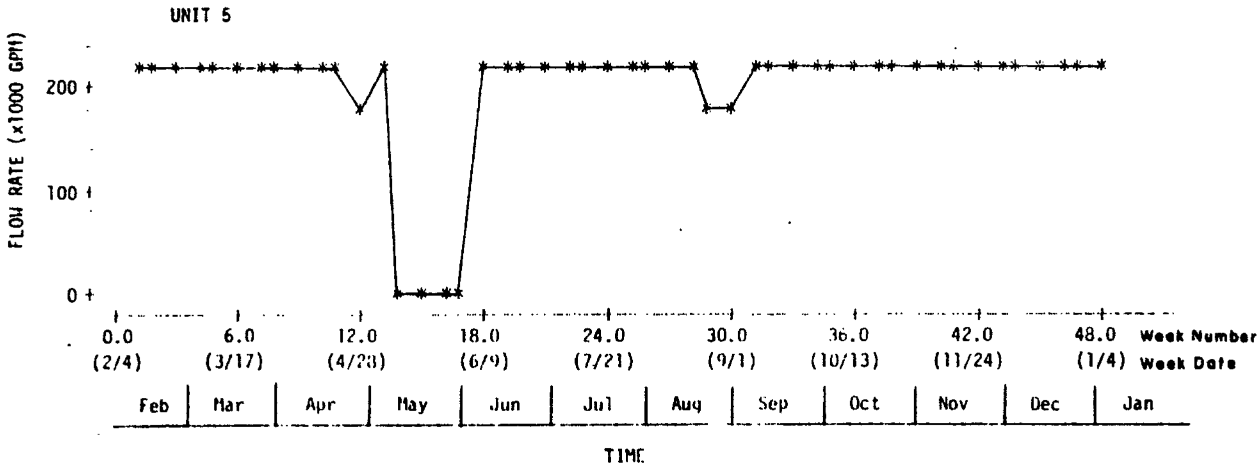


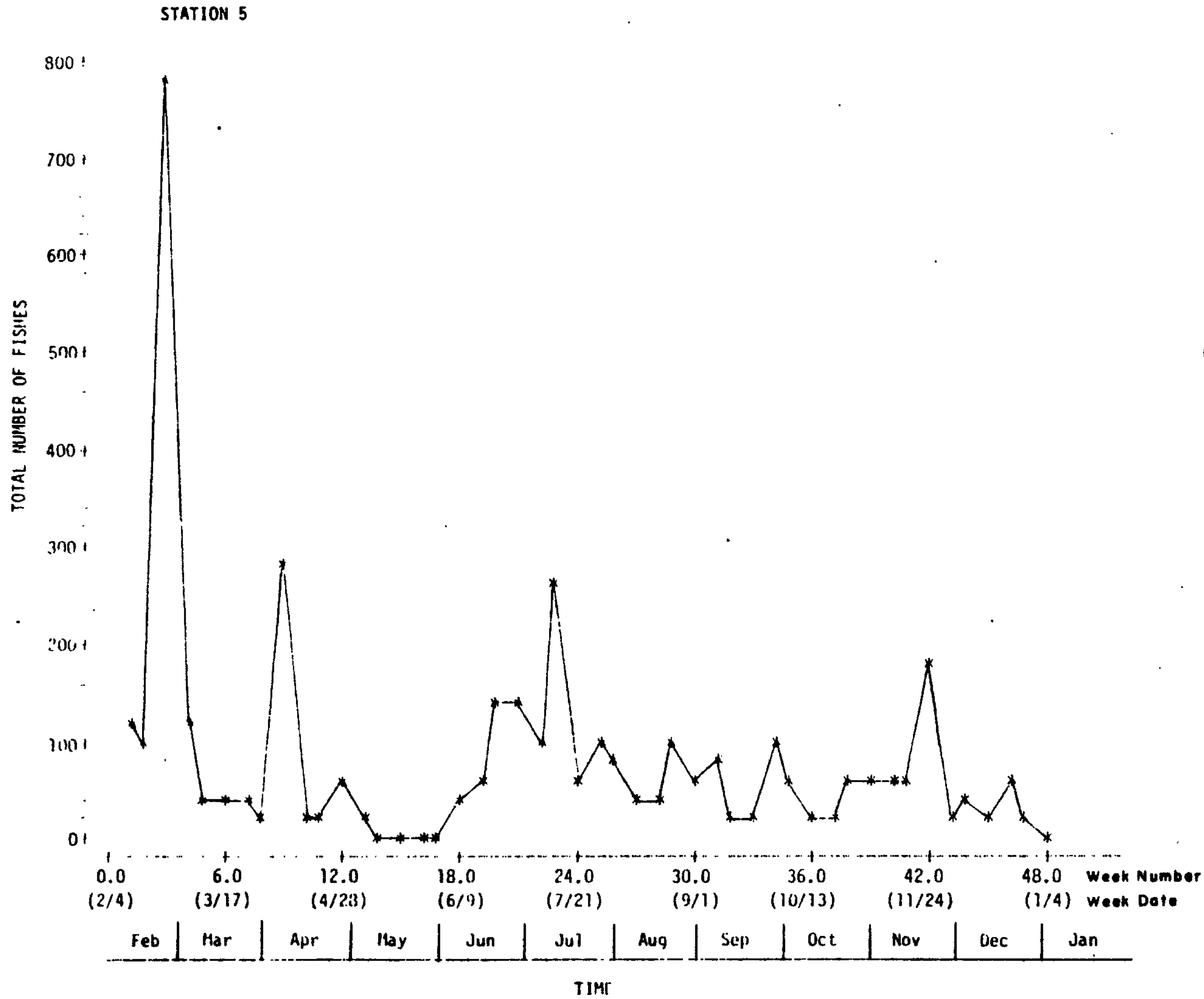
SAN DIEGO GAS & ELECTRIC COMPANY	
Comparisons of weekly mean flow rates and impingement at station 1 from 2-4-79 to 1-4-80 Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.8-2



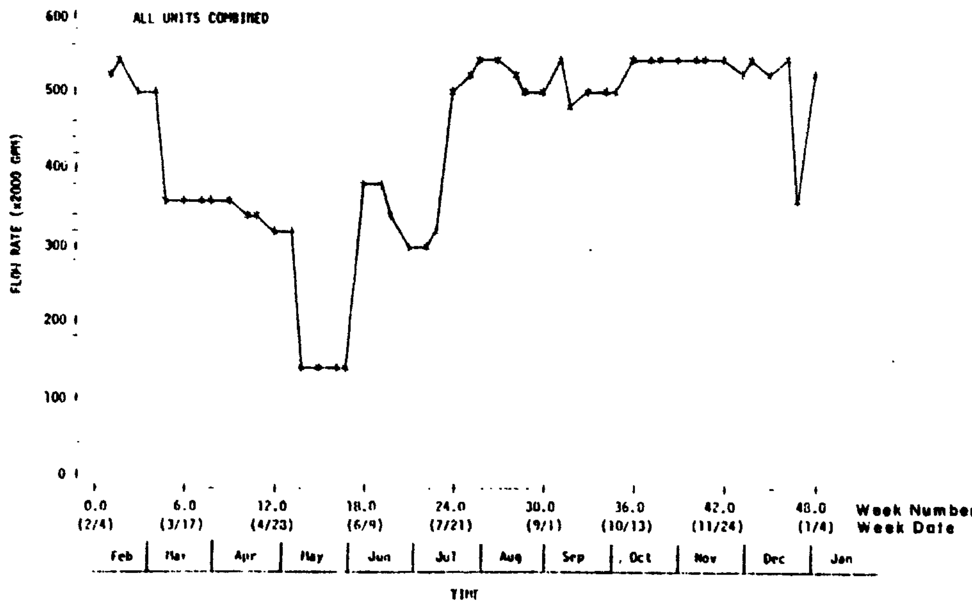


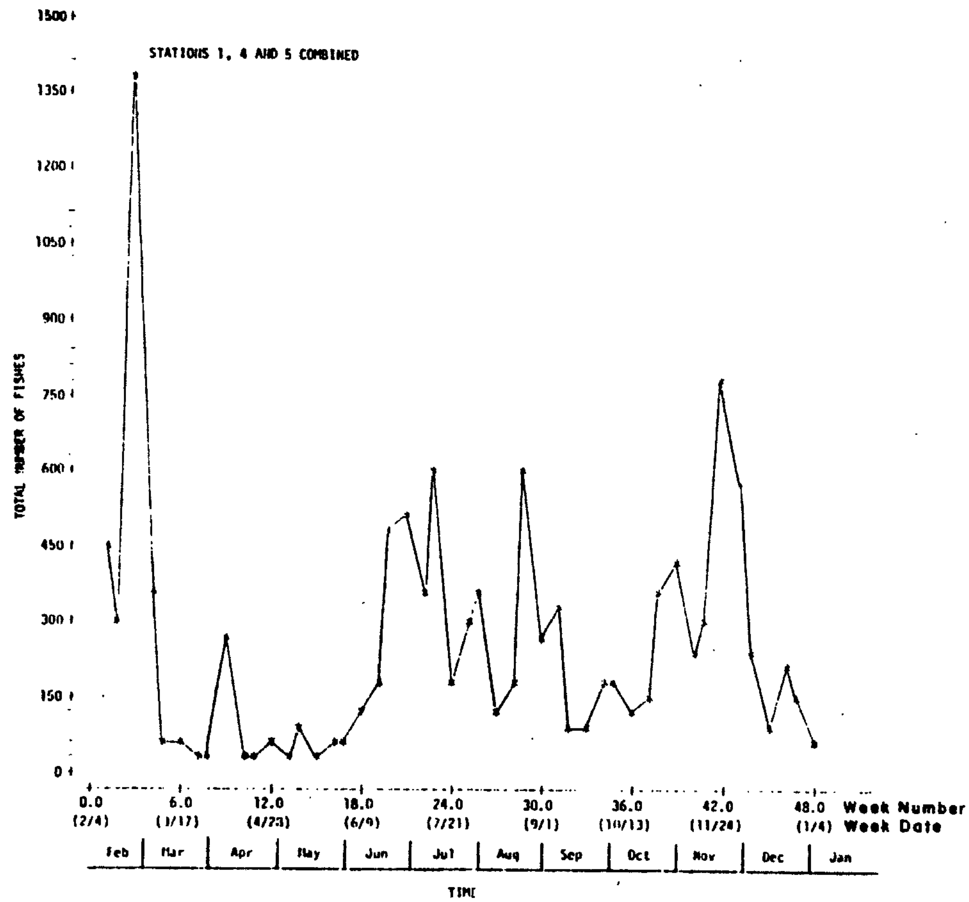
SAN DIEGO GAS & ELECTRIC COMPANY	
Comparisons of weekly mean flow rates and impingement at station 4 from 2-4-79 to 1-4-80 Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.8-3



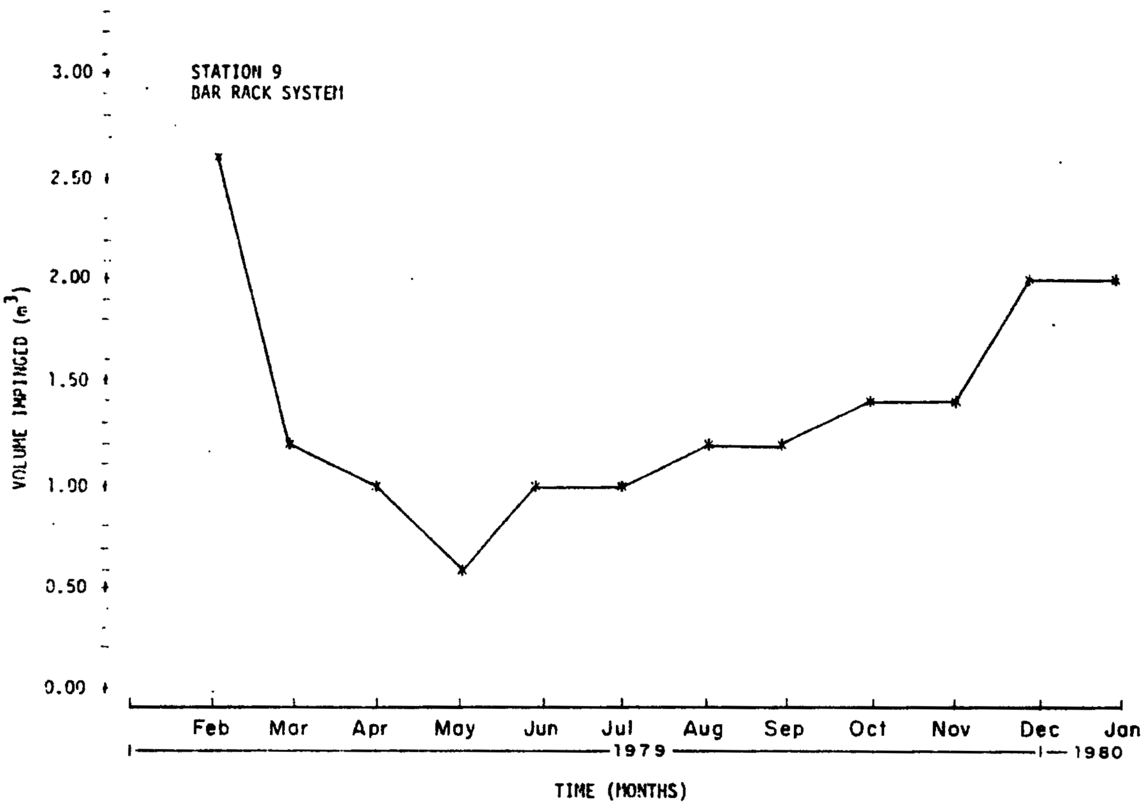


SAN DIEGO GAS & ELECTRIC COMPANY	
Comparisons of weekly mean flow rates and impingement at station 5 from 2-4-79 to 1-4-80 Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.8-4



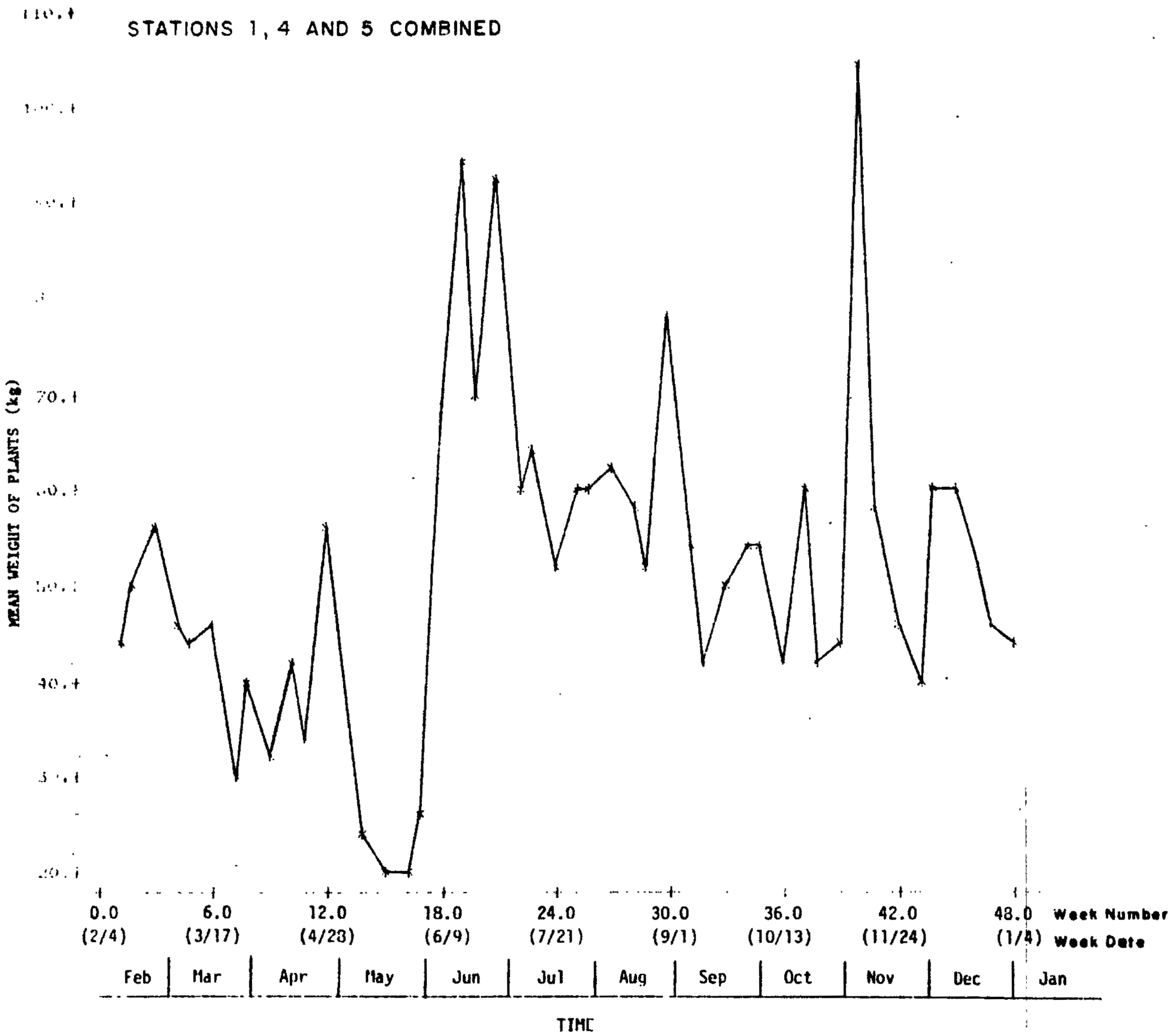


SAN DIEGO GAS & ELECTRIC COMPANY	
Comparisons of weekly mean flow rates and total impingement from 2-4-79 to 1-4-80 Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.8-5



SAN DIEGO GAS & ELECTRIC COMPANY	
Monthly mean volume of all material impinged at the bar rack per 24-hour interval from 2-4-79 to 1-4-80 Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.11-1

000633



SAN DIEGO GAS & ELECTRIC COMPANY	
Weekly mean total weight of plants impinged per 24-hour interval from 2-4-79 to 1-4-80 Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 7.11-2

8.0

COOLING WATER SYSTEM

(ENTRAINMENT STUDY)

8.1 ABSTRACT AND SUMMARY

A one-year study of entrainment was conducted at the Encina Power Plant during 1979. Samples were collected every two weeks at the plant's intake structure and in the adjacent waters of the outer segment of Agua Hedionda Lagoon. Plankton pumping systems and 0.5 m diameter plankton nets were used at intake and lagoon sites, respectively. Both 505μ and 335μ mesh nets were utilized with each type of gear. Justification of mesh sizes used has been previously discussed (Section ~~6.1~~ 6.4.1) and data for each mesh size is considered separately.

There were observed differences in plankton distribution between the intake and lagoon sites and between different plankton groups which are assumed to be a result of sampling variability (Table 8.3-1). This variability arises from differences in catch efficiencies and selectivities of the two types of sampling gear used (plankton pumps at the intake, plankton nets in the lagoon). The differences noted were as follows:

- Results of analysis of 505μ mesh data indicated nearly identical average total plankton densities for lagoon (2158 individuals/100 m^3) and intake (2165 individuals/100 m^3) sites; 335μ mesh data showed that average total densities at the intake (7350 individuals/100 m^3) were only 34 percent of

those observed in the lagoon (21,391 individuals/ 100 m^3).

- 505μ mesh data indicated greater ichthyoplankton densities at the intake and greater zooplankton densities in the lagoon; 335μ mesh data indicated both greater ichthyoplankton and zooplankton densities in the lagoon.

Additional findings of the entrainment studies were as follows:

- The ten most abundant plankton groups collected were similar for the different mesh sizes used at all the lagoon stations and the intake site.

- No significant vertical differences in the distribution of plankton were found at either lagoon or intake locations.

- Greater ichthyoplankton (1.3 to 2.2 times greater) and zooplankton (5.4 to 17.6 times greater) abundances were shown to occur at night than during the day.

- No marked relationship between tidal stage and plankton abundance was indicated from the data.

- Peak seasonal abundances in both ichthyoplankton and zooplankton were observed to occur during the spring.

8.2 METHODOLOGY

Entrainment sampling was conducted every two weeks at the Encina Power Plant. Three lagoon sites and one site at the Plant's intake structure were chosen for collections.

Outer lagoon plankton were sampled using two 0.5 m diameter plankton nets of different size mesh (335μ and 505μ). Intake samples were collected with paired plankton pumping systems, also utilizing different mesh sizes (335μ and 505μ). Justification of mesh sizes used previously has been discussed (Section 6.4.2) and data for each mesh size is considered separately.

Throughout the year-long program, entrainment sampling was conducted at various times during the day. Although the majority of collections were performed during the daylight hours, samples were occasionally taken instead during the evening or early morning. In this manner, the sampling regime included a variety of fluctuating environmental conditions (time of day, tidal stage, season, etc.) which occurred. The resulting data, then, provide a good cross-sectional representation of entrainment as it occurs during the year.

In addition to the regular program, diurnal fluctuations in entrainment were specifically examined during October 16, 1979 collections. Both day and evening samples were collected for comparison.

Vertical distribution of planktonic organisms was examined by comparative sampling at 5, 10, and 15 foot depths on several occasions (see Section 6.4.4.1.4.4).

Quantitative estimates of entrainment were calculated for both zooplankton and ichthyoplankton. Entrainment was estimated during each sampling period (every two weeks) by multiplying indicated average plankton densities (at the intake) by the volumes of cooling water taken into the plant during that period. Annual, monthly and daily rates were estimated by averaging entrainment estimates for all sampling periods and extrapolating the values to the appropriate time frame (Tables 8.4-2, 8.4-3 and 8.5-4). Key Findings of this analysis are:

- Annual estimates of total zooplankton entrainment yielded values of 7.4×10^9 (505μ data) and 30.9×10^9 (335μ data) individuals. Acartia tonsa was by far the most abundant invertebrate entrained.
- Estimates of total annual ichthyoplankton entrainment were 4.2×10^9 and 6.7×10^9 individuals for 505μ and 335μ data, respectively. The majority of ichthyoplankton entrainment was contributed by fish eggs.

Table 8.5-4 p 8-27

All specimens were preserved for subsequent laboratory analysis. Detailed methodologies for all entrainment studies are given in Appendix B, Section 16.2.4.

000639

8.3 GENERAL INFORMATION

Differences in plankton distribution between the intake and lagoon sites and between different plankton groups were observed during the present study. Data from 505μ mesh net collections indicated nearly identical average total plankton densities for lagoon (Stations AHL 1, AHL 2, and AHL 3) and intake (Station I 1) sites (Table 8.3-1). However, 335μ mesh net data indicated that overall average total plankton densities at the intake were only 34 percent of those observed in the lagoon (Table 8.3-1). The relative contributions of ichthyoplankton and zooplankton to these total densities varied, depending upon the mesh size used. Data from 505μ mesh nets revealed greater ichthyoplankton densities at the intake (74 percent greater than average lagoon densities), but greater zooplankton densities were observed in the lagoon (47 percent greater). In contrast, 335μ mesh data showed greater ichthyoplankton (32 percent greater) and zooplankton (229 percent greater) densities at lagoon sites. The observed differences in plankton distribution described above are assumed to be primarily a result of sampling variability. This variability arises from differences in catch efficiencies and selectivities of the two types of sampling gear used (plankton pumping systems at the intake, plankton nets in the lagoon). Although some naturally occurring variations would be expected due to the characteristically patchy distribution of plankton (see Section 6.6), they would be overshadowed by such gear-induced variability.

TABLE 8.3-1
SUMMARY OF ENTRAINMENT DATA FOR 1979 STUDY
AT THE ENCINA POWER PLANT

Mesh Size	Plankton Group	AVERAGE TOTAL DENSITY (Individuals captured/100m^3)	
		Lagoon	Intake
505μ	Ichthyoplankton	660	1,149
505μ	Zooplankton	1,498	1,016
335μ	Ichthyoplankton	1,856	1,408
335μ	Zooplankton	19,535	5,942

000641

TABLE 8.3-3
RANK ORDER OF ENTRAINMENT SPECIES CAPTURED IN 505μ
NETS AT INTAKE STATION I1 FROM JANUARY THROUGH
DECEMBER, 1979 AT ENCINA POWER PLANT

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
FAMILY SCIAENIDAE		999.277	46.15	1
ACARTIA TONSA		355.386	16.41	2
ORDER DECAPODA		234.392	10.82	3
OTHER CRUSTACEANS		148.968	6.88	4
SUBCLASS COPEPODA		103.891	4.80	5
ORDER MYSIDACEA		78.947	3.65	6
FAMILY ENGRAULIDAE		77.552	3.58	7
PHYLUM CHAETOGNATHA		69.527	3.21	8
UNID. FISH EGGS		36.823	1.70	9
OTHER ZOOPLANKTON		25.368	1.17	10
CITHARICHTHYS SP.		22.369	1.03	11
FAMILY GOBIIDAE		4.181	.19	12
FAMILY LABRIDAE		1.943	.09	13
PLEURONICHTHYS RITTERI	SPOTTED TURBOT	1.244	.06	14
FAMILY ATHERINIDAE		1.052	.05	15
HYPSOBLENNIUS SP.		1.038	.05	16
FAMILY CLINIDAE		.804	.04	17
PAROPHRYS VETULUS	ENGLISH SOLE	.527	.02	18
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT	.524	.02	19
PLEURONICHTHYS SP.		.422	.02	20
SYNGNATHUS SP.		.379	.02	21
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT	.230	.01	22
TRACHURUS SYMMETRICUS	JACK MACKEREL	.072	.00	23
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA	.066	.00	24
FAMILY SERRANIDAE		.054	.00	25
PIMELOMETOPON PULCHRUM	CALIFORNIA SHEEPHEAD	.043	.00	26
CORYPHOPTERUS NICHOLSII	BLACKEYE GOBY	.033	.00	27
COTTIDAE TYPE 1		.033	.00	27
FAMILY COTTIDAE		.033	.00	27
FAMILY GOBIESOCIDAE		.033	.00	27
GENYONEMUS LINEATUS	WHITE CROAKER	.033	.00.	27
GIBBONSIA MONTEREYENSIS	CREVICE KELPFISH	.033	.00	27
TYPHLOGOBIUS CALIFORNIENSIS	BLIND GOBY	.033	.00	27
SERIPHUS POLITUS	QUEENFISH	.020	.00	28
TOTAL		2165.325	100.00	

000642

Rank orders of abundance data for the different plankton groups have been presented in Tables 8.3-2 through 8.3-7. In general, the top ten most abundant groups were the same for both intake and lagoon sites, as well as for both 505μ and 335μ mesh net landings. However, actual group orders varied within the top ten rankings. Most of the top ten groups appeared to be more abundant in the lagoon than at the intake structure. Sampling variability would also account for these observations.

TABLE 8.3-2
RANK ORDER OF ENTRAINMENT SPECIES CAPTURED IN 505μ NETS AT LAGOON STATIONS AHL1-3 FROM JANUARY THROUGH DECEMBER, 1979 AT ENCINA POWER PLANT

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
ORDER DECAPODA		387.898	17.98	1
OTHER CRUSTACEANS		373.466	17.31	2
FAMILY SCIAENIDAE		273.828	12.69	3
FAMILY ENGRAULIDAE		269.761	12.50	4
ACARTIA TONSA		215.162	9.97	5
SUBCLASS COPEPODA		174.980	8.11	6
ORDER MYSIDACEA		162.520	7.53	7
OTHER ZOOPLANKTON		148.342	6.88	8
CITHARICHTHYS SP.		59.892	2.78	9
PHYLUM CHAETOGNATHA		35.724	1.66	10
UNID.FISH EGGS		18.178	.84	11
FAMILY GOBIIDAE		10.376	.48	12
FAMILY ATHERINIDAE		9.192	.43	13
ANCHOA SP.		5.031	.23	14
FAMILY LABRIDAE		2.968	.14	15
PLEURONICHTHYS RITTERI	SPOTTED TURBOT	2.042	.09	16
PAROPHRYS VETULUS	ENGLISH SOLE	1.727	.08	17
FAMILY CLINIDAE		1.705	.08	18
ENGRAULIS MORDAX	NORTHERN ANCHOVY	.938	.04	19
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT	.583	.03	20
HYPSOBLENNIUS SP.		.380	.02	21
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT	.366	.02	22
PARALICHTHYS SP.		.358	.02	23
FAMILY SERRANIDAE		.321	.01	24
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT	.251	.01	25
SYNGNATHUS SP.		.175	.01	26
GIRELLA NIGRICANS	OPALEYE	.167	.01	27
MUGIL CEPHALUS	STRIPED MULLET	.165	.01	28
GENYONEMUS LINEATUS	WHITE CROAKER	.123	.01	29
GOBIIDAE TYPE A		.121	.01	30
FAMILY EXOCOETIDAE		.114	.01	31
UMBRINA/CHEILOTREMA COMPLEX		.097	.00	32
PLEURONICHTHYS SP.		.096	.00	33
SERIPHUS POLITUS	QUEENFISH	.081	.00	34
FAMILY COTTIDAE		.077	.00	35
TRACHURUS SYMMETRICUS	JACK MACKEREL	.055	.00	36
FAMILY GOBIESOCIDAE		.053	.00	37
CHEILOTREMA SATURNUM	BLACK CROAKER	.050	.00	38
CORYPHOPTERUS NICHOLSII	BLACKEYE GOBY	.049	.00	39
TYPHLOGOBIUS CALIFORNIENSIS	BLIND GOBY	.041	.00	40
PLEURONICHTHYS COENOSUS	C-O TURBOT	.035	.00	41
ATHERINOPS AFFINIS	TOPSMELT	.026	.00	42
FAMILY BLENNIIDAE		.022	.00	43
ANCHOA DELICATISSIMA	SLOUGH ANCHOVY	.021	.00	44
HYPSOBLENNIUS GENTILIS	BAY BLENNY	.015	.00	45
ILYPNUS GILBERTI	CHEEKSPOT GOBY	.014	.00	46
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA	.010	.00	47
CHROMIS PUNCTIPINNIS	BLACKSMITH	.009	.00	48
GOBIESOX PAPILLIFER	BEARDED CLINGFISH	.009	.00	49
COTTIDAE TYPE 7		.007	.00	49
GRAPSIDAE	SHORE CRABS	.004	.00	50
LEPIDOGOBIUS LEPIDUS	BAY GOBY	.004	.00	51
TOTAL		2157.623	100.00	

TABLE 8.3-4
RANK ORDER OF ENTRAINMENT SPECIES CAPTURED IN 505μ NETS FROM JANUARY THROUGH DECEMBER, 1979 AT ENCINA POWER PLANT

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
FAMILY SCIAENIDAE		454.673	20.97	1
ORDER DECAPODA		351.138	16.19	2
OTHER CRUSTACEANS		329.445	15.19	3
ACARTIA TONSA		240.977	11.11	4
FAMILY ENGRAULIDAE		223.998	10.33	5
SUBCLASS COPEPODA		159.314	7.35	6
ORDER MYSIDACEA		147.767	6.81	7
OTHER ZOOPLANKTON		113.830	5.25	8
CITHARICHTHYS SP.		50.495	2.33	9
PHYLUM CHAETOGNATHA		42.660	1.97	10
UNID. FISH EGGS		21.531	.99	11
FAMILY GOBIIDAE		9.037	.42	12
FAMILY ATHERINIDAE		7.500	.35	13
ANCHOA SP.		4.312	.20	14
FAMILY LABRIDAE		2.720	.13	15
PLEURONICHTHYS RITTERI	SPOTTED TURBOT	1.850	.09	16
FAMILY CLINIDAE		1.481	.07	17
PAROPHRYS VETULUS	ENGLISH SOLE	1.427	.07	18
ENGRAULIS MORDAX	NORTHERN ANCHOVY	.804	.04	19
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT	.553	.03	20
HYPSOBLENNIUS SP.		.490	.02	21
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT	.329	.02	22
PARALICHTHYS SP.		.275	.01	23
FAMILY SERRANIDAE		.253	.01	24
SYNGNATHUS SP.		.227	.01	25
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT	.201	.01	26
PLEURONICHTHYS SP.		.144	.01	27
GIRELLA NIGRICANS	OPALEYE	.130	.01	28
MUGIL CEPHALUS	STRIPED MULLET	.124	.01	29
GENYONEMUS LINEATUS	WHITE CROAKER	.110	.01	30
GOBIIDAE TYPE A		.090	.00	31
FAMILY EXOCOETIDAE		.085	.00	32
UMBRINA/CHEILOTREMA COMPLEX		.072	.00	33
FAMILY COTTIDAE		.067	.00	34
SERIPHUS POLITUS	QUEENFISH	.065	.00	35
TRACHURUS SYMMETRICUS	JACK MACKEREL	.059	.00	36
CORYPHOPTERUS NICHOLSII	BLACKEYE GOBY	.046	.00	37
FAMILY GOBIESOCIDAE		.043	.00	38
TYPHLOGOBIUS CALIFORNIENSIS	BLIND GOBY	.037	.00	39
CHEILOTREMA SATURNUM	BLACK CROAKER	.032	.00	40
PLEURONICHTHYS COENOSUS	C-O TURBOT	.026	.00	41
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA	.022	.00	42
ATHERINOPS AFFINIS	TOPSMELT	.022	.00	43
ANCHOA DELICATISSIMA	SLOUGH ANCHOVY	.018	.00	44
FAMILY BLENNIIDAE		.016	.00	45
HYPSOBLENNIUS GENTILIS	BAY BLENNY	.011	.00	46
ILYPNUS GILBERTI	CHEEKSPOT GOBY	.011	.00	47
COTTIDAE TYPE 1		.008	.00	48
PIMELOMETOPON PULCHRUM	CALIFORNIA SHEEPHEAD	.008	.00	49
CHROMIS PUNCTIPINNIS	BLACKSMITH	.007	.00	50
GOBIESOX PAPILLIFER	BEARDED CLINGFISH	.007	.00	50
COTTIDAE TYPE 7		.007	.00	51
GIBBONSIA MONTEREYENSIS	CREVICE KELPFISH	.005	.00	52
LEPIDOGOBIUS LEPIDUS	BAY GOBY	.004	.00	53
GRAPSIDAE	SHORE CRABS	.003	.00	54
TOTAL		2168.561	100.00	

TABLE 8.3-5
RANK ORDER OF ENTRAINMENT SPECIES CAPTURED IN 335µ NETS AT LAGOON STATIONS AHL1-3 FROM JANUARY THROUGH DECEMBER, 1979 AT ENCINA POWER PLANT

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
ACARTIA TONSA		10377.953	48.52	1
OTHER ZOOPLANKTON		2993.506	13.99	2
ORDER DECAPODA		2364.301	11.05	3
SUBCLASS COPEPODA		2102.648	9.83	4
OTHER CRUSTACEANS		1222.313	5.71	5
FAMILY ENGRAULIDAE		1177.571	5.51	6
FAMILY SCIAENIDAE		437.572	2.05	7
ORDER MYSIDACEA		259.333	1.21	8
PHYLUM CHAETOGNATHA		214.868	1.00	9
CITHARICHTHYS SP.		114.088	.53	10
FAMILY GOBIIDAE		55.468	.26	11
UNID. FISH EGGS		20.626	.10	12
FAMILY ATHERINIDAE		18.537	.09	13
HYPSOBLENNIUS SP.		7.471	.03	14
FAMILY LABRIDAE		6.316	.03	15
SEBASTES SP.		4.571	.02	16
PAROPHRYS VETULUS	ENGLISH SOLE	3.307	.02	17
FAMILY CLINIDAE		2.127	.01	18
PARALICHTHYS SP.		2.086	.01	19
FAMILY SERRANIDAE		1.472	.01	20
PLEURONICHTHYS RITTERI	SPOTTED TURBOT	1.110	.01	21
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT	.490	.00	22
TYPHLOGOBIUS CALIFORNIENSIS	BLIND GOBY	.410	.00	23
FAMILY COTTIDAE		.395	.00	24
ANCHOA SP.		.290	.00	25
CORYPHOPTERUS NICHOLSII	BLACKEYE GOBY	.243	.00	26
SYNGNATHUS SP.		.239	.00	27
HETEROSTICHUS ROSTRATUS	GIANT KELPFISH	.169	.00	28
GOBIIDAE TYPE A		.142	.00	29
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT	.101	.00	30
TRACHURUS SYMMETRICUS	JACK MACKEREL	.095	.00	31
ORDER TETRAODONTIFORMES		.092	.00	32
MUGIL CEPHALUS	STRIPED MULLET	.085	.00	33
PLEURONICHTHYS SP.		.080	.00	34
ANISOTREMUS DAVIDSONII	SARGO	.079	.00	35
SYMPHURUS ATRICAUDA	CALIFORNIA TONGUEFISH	.073	.00	36
CHROMIS PUNCTIPINNIS	BLACKSMITH	.067	.00	37
PLEURONICHTHYS COENOSUS	C-O TURBOT	.062	.00	38
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT	.055	.00	39
COLOLABIS SAIRA	PACIFIC SAURY	.053	.00	40
FAMILY GOBIESOCIDAE		.046	.00	41
GENYONEMUS LINEATUS	WHITE CROAKER	.041	.00	42
SYNODUS LUCIOCEPS	CALIFORNIA LIZARDFISH	.040	.00	43
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA	.031	.00	44
RONCADOR STEARNSII	SPOTFIN CROAKER	.030	.00	45
HYPSYPOPS RUBICUNDUS	GARIBALDI	.027	.00	46
CYNOSCION NOBILIS	WHITE SEABASS	.020	.00	47
ENGRAULIS MORDAX	NORTHERN ANCHOVY	.016	.00	48
COTTIDAE TYPE 1		.015	.00	49
SYNGNATHUS LEPTORHYNCHUS	BAY PIPEFISH	.014	.00	50
ATHERINOPS AFFINIS	TOPSMELT	.013	.00	51
GIRELLA NIGRICANS	OPALEYE	.013	.00	51
FAMILY CLUPEIDAE		.010	.00	52
TOTAL		21390.680	100.00	

000646

Intake

TABLE 8.3-6
RANK ORDER OF ENTRAINMENT ~~SPECIES~~ CAPTURED IN 335μ NETS AT ~~LAGOON~~ STATION I1 FROM JANUARY THROUGH DECEMBER, 1979 AT ENCINA POWER PLANT

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
ACARTIA TONSA		3464.829	47.14	1
ORDER DECAPODA		1112.211	15.13	2
FAMILY ENGRAULIDAE		714.472	9.72	3
FAMILY SCIAENIDAE		569.731	7.75	4
OTHER CRUSTACEANS		492.038	6.69	5
SUBCLASS COPEPODA		458.038	6.23	6
OTHER ZOOPLANKTON		257.924	3.51	7
PHYLUM CHAETOGNATHA		101.159	1.38	8
CITHARICHTHYS SP.		61.011	.83	9
ORDER MYSIDACEA		56.216	.76	10
UNID.FISH EGGS		32.360	.44	11
FAMILY GOBIIDAE		19.846	.27	12
HYPSOBLENNIUS SP.		4.426	.06	13
FAMILY LABRIDAE		1.475	.02	14
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT	.957	.01	15
FAMILY ATHERINIDAE		.740	.01	16
FAMILY CLINIDAE		.664	.01	17
PLEURONICHTHYS RITTERI	SPOTTED TURBOT	.463	.01	18
FAMILY COTTIDAE		.291	.00	19
TYPHLOGOBIUS SP.		.282	.00	20
FAMILY SERRANIDAE		.272	.00	21
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT	.159	.00	22
PSETTICHTHYS SP.		.159	.00	22
SYNGNATHUS SP.		.120	.00	23
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT	.080	.00	24
PLEURONICHTHYS COENOSUS	C-O TURBOT	.080	.00	24
PARALICHTHYS SP.		.053	.00	25
COTTIDAE TYPE 7		.040	.00	26
FAMILY BLENNIIDAE		.040	.00	26
FAMILY GOBIESOCIDAE		.040	.00	26
PLEURONICHTHYS SP.		.040	.00	26
TYPHLOGOBIUS CALIFORNIENSIS	BLIND GOBY	.040	.00	26
TRACHURUS SYMMETRICUS	JACK MACKEREL	.024	.00	27
TOTAL		7350.020	100.00	

000647

TABLE 8.3-7
RANK ORDER OF ENTRAINMENT SPECIES CAPTURED IN 335μ NETS FROM JANUARY THROUGH DECEMBER, 1979 AT ENCINA POWER PLANT

SPECIES NAME	COMMON NAME	# PER 100 M3	PERCENT OF TOTAL	RANK
ACARTIA TONSA		7838.602	49.55	1
OTHER ZOOPLANKTON		1915.022	12.10	2
ORDER DECAPODA		1894.079	11.97	3
SUBCLASS COPEPODA		1491.366	9.43	4
OTHER CRUSTACEANS		869.234	5.49	5
FAMILY ENGRAULIDAE		855.224	5.41	6
FAMILY SCIAENIDAE		400.590	2.53	7
PHYLUM CHAETOGNATHA		204.088	1.29	8
ORDER MYSIDACEA		173.406	1.10	9
CITHARICHTHYS SP.		82.722	.52	10
FAMILY GOBIIDAE		42.979	.27	11
UNID.FISH EGGS		20.230	.13	12
FAMILY ATHERINIDAE		10.899	.07	13
HYPSOBLENNIUS SP.		5.737	.04	14
FAMILY LABRIDAE		4.036	.03	15
SEBASTES SP.		2.571	.02	16
PAROPHRYS VETULUS	ENGLISH SOLE	1.860	.01	17
FAMILY CLINIDAE		1.425	.01	18
PLEURONICHTHYS VERTICALIS	HORNYHEAD TURBOT	1.249	.01	19
PARALICHTHYS SP.		1.224	.01	20
PLEURONICHTHYS RITTERI	SPOTTED TURBOT	.962	.01	21
FAMILY SERRANIDAE		.915	.01	22
FAMILY COTTIDAE		.366	.00	23
TYPHLOGOBIUS SP.		.268	.00	24
TYPHLOGOBIUS CALIFORNIENSIS	BLIND GOBY	.240	.00	25
PARALICHTHYS CALIFORNICUS	CALIFORNIA HALIBUT	.189	.00	26
ANCHOA SP.		.163	.00	27
SYNGNATHUS SP.		.163	.00	28
CORYPHOPTERUS NICHOLSII	BLACKEYE GOBY	.145	.00	29
PLEURONICHTHYS COENOSUS	C-O TURBOT	.110	.00	30
HETEROSTICHUS ROSTRATUS	GIANT KELPFISH	.095	.00	31
PLEURONICHTHYS SP.		.093	.00	32
GOBIIDAE TYPE A		.078	.00	33
TRACHURUS SYMMETRICUS	JACK MACKEREL	.076	.00	34
HYPSOPSETTA GUTTULATA	DIAMOND TURBOT	.076	.00	35
ORDER TETRAODONTIFORMES		.052	.00	36
SYMPHURUS ATRICAUDA	CALIFORNIA TONGUEFISH	.051	.00	37
MUGIL CEPHALUS	STRIPED MULLET	.048	.00	38
ANISOTREMUS DAVIDSONII	SARGO	.044	.00	39
FAMILY GOBIESOCIDAE		.042	.00	40
COTTIDAE TYPE 7		.038	.00	41
PSETTICHTHYS SP.		.038	.00	42
CHROMIS PUNCTIPINNIS	BLACKSMITH	.038	.00	43
COLOLABIS SAIRA	PACIFIC SAURY	.030	.00	44
GENYONEMUS LINEATUS	WHITE CROAKER	.023	.00	45
RONCADOR STEARNSII	SPOTFIN CROAKER	.023	.00	46
SYNODUS LUCIOCEPS	CALIFORNIA LIZARDFISH	.022	.00	47
MENTICIRRHUS UNDULATUS	CALIFORNIA CORBINA	.017	.00	48
HYPSYPOPS RUBICUNDUS	GARIBALDI	.015	.00	49
CYNOSCION NOBILIS	WHITE SEABASS	.011	.00	50
FAMILY BLENNIIDAE		.009	.00	51
ENGRAULIS MORDAX	NORTHERN ANCHOVY	.009	.00	52
COTTIDAE TYPE 1		.009	.00	53
SYNGNATHUS LEPTORHYNCHUS	BAY PIPEFISH	.008	.00	54
ATHERINOPS AFFINIS	TOPSMELT	.007	.00	55
GIRELLA NIGRICANS	OPALEYE	.007	.00	55
FAMILY CLUPEIDAE		.005	.00	56
TOTAL		15820.918	100.00	

000648

8.4 INVERTEBRATE ZOOPLANKTON

8.4.1 Vertical Distribution

Vertical distribution within the lagoon and intake was difficult to examine due to shallow depths in many portions of the study area. The extent of vertical distribution was examined in the deeper areas of the outer lagoon and found to be insignificant, indicating no vertical stratification of species within the lagoon water column (see Section 6.4.4.1.4.4).

8.4.2 Temporal Distribution

8.4.2.1 Diel. Comparative daytime and evening sampling was conducted during the October 10, 1979 entrainment collections. Both the outer lagoon and intake data were tested for possible diurnal differences using the Mann-Whitney U-test (8-1). Results of the analysis indicated significant day-night differences in the plankton populations examined (Table 8.4-1). Total invertebrate zooplankton abundances were 5.4 times higher in night samples for 335μ mesh data. Analysis of the 505μ mesh data indicated zooplankton densities to be 17.6 times greater at night than during the day.

8.4.2.2 Tidal. Hierarchical analysis was used to examine possible tidal differences in the data obtained during the entrainment sampling program (Appendix Figures 16.3-20 and 16.3-22; Tables 16.3-55 and 16.3-56). No clear trends were indicated. The relationship of the zooplankton population to tidal stage

000649

TABLE 8.4-1
SUMMARY OF ANALYSIS OF DIURNAL PLANKTON ABUNDANCE
USING THE MANN-WHITNEY U-TEST (LEVEL OF SIGNIFICANCE = 0.05)
ENCINA POWER PLANT - AUGUST 1, 1980

Plankton Group	Results of Test (Day-Night Differences)	
	335μ Data	505μ Data
Fish eggs and larvae	Not significant	Significant
Acartia tonsa	Significant	Significant
Other copepods	Significant	Significant
Mysidacea	Significant	Significant
Decapoda	Significant	Significant
Other crustacea	Significant	Significant
Chaetognatha	Not significant	Significant
Other zooplankton	Not significant	Not significant

000650

does not appear to be marked. However, tidal effects may have been masked by the greater, seascnal changes in the population.

8.4.2.3 Seasonal. Hierarchical analysis of 505μ zooplankton data indicated two distinct seasonal groupings, a January-June and a June-December period (Appendix Figure 16.3-32 and Appendix Table 16.3-57). All major zooplankton divisions examined were present throughout the year. Seasonal differences in populations appeared to be due to increased zooplankton abundances during the January-June period. Overall peak abundances were observed during February, March, and May (Figures 8.4-1 and 8.4-2). At these times, peak abundances were exhibited by all major zooplankton groups examined (Acartia tonsa, other copepods, mysids, decapods, and chaetognaths).

Data from 335μ net collections was incomplete and did not present clear seasonal trends (Figures 8.4-3 and 8.4-4). Regular continuous sampling with 335μ mesh was not started until late May, missing most of the previously indicated peak abundance period.

8.4.3 Quantitative Estimates of Entrainment

Average total estimated entrainment rates were calculated for all major zooplankton groups. Estimates have been presented for average daily, monthly, and yearly rates using both 505μ and 335μ mesh net catch data. Entrainment values were determined for each sampling period (every two weeks) by multiplying indicated average plankton densities (at the intake) by the volumes of cooling water taken into the plant during that period. Daily, monthly, and yearly rates were estimated by averaging entrainment estimates for all sampling periods and extrapolating the values to the appropriate time frame.

8.4.3.1 Daily. Average daily estimates of total zooplankton entrainment were 2.03×10^7 and 8.45×10^7 individuals, for 505μ and 335μ net data, respectively. Estimated average daily rates for all major zooplankton groups have been presented in Tables 8.4-2 and 8.4-3. *Acartia tonsa* was by far the most abundant invertebrate entrained by the Power Plant.

8.4.3.2 Monthly. Average monthly entrainment estimates for zooplankton were 6.17×10^8 (505μ net estimate) and 2.57×10^9 (335μ net estimate) individuals. Entrainment estimates for all major zooplankton groups have been shown in Tables 8.4-2 and 8.4-3.

8.4.3.3 Yearly. Average annual estimates of entrainment have been determined for all major zooplankton groups (Tables 8.4-2 and 8.4-3). Estimated total annual entrainment rates were 7.41×10^9 (505μ net estimate) and 3.09×10^{10} (335μ net estimate) individuals.

TABLE 8.4-2
ESTIMATED INVERTEBRATE ENTRAINMENT RATES FOR THE ENCINA POWER PLANT USING 505 MICRON NET COLLECTION DATA OBTAINED DURING THE 1979 STUDIES

Plankton Group	Average Total Estimated Entrainment (Number of Individuals)		
	Daily	Monthly	Yearly
Acartia tonsa	7.63×10^6	2.32×10^8	2.79×10^9
Other copepoda	2.16×10^6	6.58×10^7	7.90×10^8
Mysidacea	1.34×10^6	4.07×10^7	4.89×10^8
Decapoda	4.44×10^6	1.35×10^8	1.62×10^9
Other crustacea	2.70×10^6	8.20×10^7	9.84×10^8
Chaetognatha	1.56×10^6	4.75×10^7	5.70×10^8
Other zooplankton	4.55×10^5	1.38×10^7	1.66×10^8
Total Invertebrates	2.03×10^7	6.17×10^8	7.41×10^9

TABLE 8.4-3
ESTIMATED INVERTEBRATE ENTRAINMENT RATES FOR THE ENCINA POWER PLANT USING 335 MICRON NET COLLECTION DATA OBTAINED DURING THE 1979 STUDIES

Plankton Group	Average Total Estimated Entrainment (Number of Individuals)		
	Daily	Monthly	Yearly
Acartia tonsa	4.77×10^{7}	1.45×10^{9}	1.74×10^{10}
Other copepods	8.47×10^{6}	2.57×10^{8}	3.09×10^{9}
Mysidacea	6.70×10^{5}	2.04×10^{7}	2.44×10^{8}
Decapoda	1.32×10^{7}	4.03×10^{8}	4.84×10^{9}
Other crustacea	6.95×10^{6}	2.11×10^{8}	2.54×10^{9}
Chaetognatha	1.83×10^{6}	5.57×10^{7}	6.68×10^{8}
Other zooplankton	5.68×10^{6}	1.73×10^{8}	2.07×10^{9}
Total Invertebrates	8.45×10^{7}	2.57×10^{9}	3.09×10^{10}

8.5 ICHTHYOPLANKTON

8.5.1 Vertical Distribution

Vertical distribution within the lagoon and intake was difficult to examine due to shallow depths in many portions of the study area. The extent of vertical distribution was examined in the deeper areas of the outer lagoon and found to be insignificant, indicating no vertical stratification of species within the lagoon water column (see Section 6.4.4.1.4.4).

8.5.2 Temporal Distribution

8.5.2.1 Diel. Comparisons of daytime and evening ichthyoplankton catches were performed as described in Section 8.4.2.1. Results of the Mann-Whitney test indicated significant diurnal differences in the 505μ ichthyoplankton data (see Table 8.4-1). The average number of ichthyoplankton in night samples was 1.3 times the average number in day samples according to 335μ mesh data, 2.2 times according to 505μ mesh data. Analysis of the 335μ data did not reveal any significant day-night differences at a 0.05 level of significance.

8.5.2.2 Tidal. Hierarchical analysis was used to examine possible tidal differences in the ichthyoplankton populations sampled during the entrainment program (Appendix Figures 16.3-23 through 16.3-30 and Appendix Tables 16.3-58 through 16.3-61). No clear relationships of ichthyoplankton abundance to tidal stage were indicated.

8.5.2.3 Seasonal. Ichthyoplankton data from 505μ net collections indicated peak abundances of fish larvae and eggs during the March-June period. Eggs were taken in greatest abundances during May and June at both lagoon and intake sites (Figures 8.5-1 and 8.5-2). Fish larvae were collected in greatest numbers during March and April, at the lagoon and intake sites, respectively.

Seasonal variations in ichthyoplankton composition and abundance were similar for lagoon and intake sites. Individual accounts for different groups and species have been previously discussed under plankton abundance and distribution studies (Section 6.4.5).

Peak ichthyoplankton abundances during the spring/early summer period are a result of two plankton groups. The first includes those fish eggs and larvae which were found to be present in the plankton throughout most of the year, but exhibited peak abundances during the March-June period (Table 8.5-1). Other species, however, were found almost exclusively during the spring/early summer period (Table 8.5-2). A number of additional contributors were taken primarily during other times of the year. These have been listed in Table 8.5-3.

As previously mentioned, 335μ mesh net collection data were somewhat incomplete, missing the peak abundance period (Figures 8.5-3 and 8.5-4).

TABLE 8.5-1
YEAR-ROUND CONTRIBUTORS TO THE ICHTHYOPLANKTON
POPULATION WHICH EXHIBIT PEAK ABUNDANCES
DURING SPRING AND EARLY SUMMER
ENCINA POWER PLANT - AUGUST 1, 1980

Atherinidae

Cottidae

Sciaenidae

Hypsoblennius sp.

Gobiidae

Pleuronichthys ritteri

Pleuronichthys verticalis

Citharichthys sp.

TABLE 8.5-2
ICHTHYOPLANKTON PRESENT PRIMARILY
DURING THE SPRING AND EARLY SUMMER
ENCINA POWER PLANT - AUGUST 1, 1980

Anchoa sp.

Anchoa delicatissima

Engraulis mordax

Gobiesox papillifer

Atherinops affinis

Serranidae

Trachurus symmetricus

Genyonemus lineatus

Girella nigricans

Chromis punctipinnis

Pimelometopon pulchrum

Blenniidae

Gibbonsia montereyensis

Coryphopterus nicholsii

Lepidogobius lepidus

Parophrys vetulus

TABLE 8.5-3
ICHTHYOPLANKTON WHICH ARE PRIMARILY
PRESENT DURING OTHER SEASONS
ENCINA POWER PLANT - AUGUST 1, 1980

Group	Primary Season of Contribution
Gobiesocidae	Summer through Winter
Seriphus politus	Summer and Winter
Menticirrhus undulatus	Summer/Fall
Cheilotrema saturnum	Summer
Mugil cephalus	Fall/Winter
Hypsoblennius gentilis	Summer/Fall
Typhlogobius californiensis	Winter/Spring
Paralichthys californicus	Winter
Pleuronichthys coenosus	Late Summer through Winter
Hypsopsetta guttulata	Winter/Spring

8.5.3 Quantitative Estimates of Entrainment

Average total estimated entrainment rates were calculated for fish eggs and larvae in the same manner described in Section 8.4.3. Estimates have been prepared for average daily, monthly, and yearly rates using both 505 and 335μ mesh net data. In all cases, fish eggs constituted the majority of individuals entrained.

8.5.3.1 Daily. Daily estimates of ichthyoplankton entrainment were 1.13×10^7 and 1.82×10^7 individuals, for 505 and 335μ net data, respectively (Table 8.5-4).

8.5.3.2 Monthly. Monthly estimates of ichthyoplankton entrainment were 3.45×10^8 (505μ net data) and 5.55×10^8 (335μ net data) individuals (Table 8.5-4).

8.5.3.3 Yearly. Annual ichthyoplankton entrainment estimates were 4.15×10^9 (505μ net data) and 6.66×10^9 (335μ net data) individuals (Table 8.5-4). For the 505μ net estimates, fish eggs comprised 98 percent of total annual ichthyoplankton entrainment, for the 335μ net estimates, only 86 percent.

000660

TABLE 8.5-4
ESTIMATED ICHTHYOPLANKTON ENTRAINMENT RATES
FOR ENCINA POWER PLANT DURING 1979

Plankton Group	Mesh Size	Average Totals (Number of Individuals)		
		Daily	Monthly	Yearly
Fish Eggs	505μ	$1.11x10^7$	$3.38x10^8$	$4.06x10^9$
Fish Larvae	505μ	$2.46x10^5$	$7.49x10^6$	$8.99x10^7$
Total		$1.13x10^7$	$3.45x10^8$	$4.15x10^9$
Fish Eggs	335μ	$1.57x10^7$	$4.78x10^8$	$5.74x10^9$
Fish Larvae	335μ	$2.52x10^6$	$7.66x10^7$	$9.19x10^8$
Total		$1.82x10^7$	$5.55x10^8$	$6.66x10^9$ p 8-3

000661

8.6 DISCUSSION

Table 8.6-1 summarizes the available daily entrainment estimates for the San Onofre Nuclear Generating Station (8-2), the Potrero Power Plant (8-3), and the Encina Power Plant. All three studies employed plankton pump systems; however, different mesh data are reported in each case. The San Onofre entrainment study used 202μ mesh nets, the Potrero study presents data from combined 335μ and 505μ mesh sampling, and the Encina study presents separate 335μ and 505μ mesh estimates. These differences limit the degree of power plant comparisons.

The entrainment data for San Onofre are consistently higher than comparable data for either Potrero or Encina. The small mesh size employed in the San Onofre study is most likely responsible. Mysidacea entrainment estimates for San Onofre were extremely large in comparison with the other power plants' data and this may be due to extensive deep water and nighttime sampling carried out in that study.

Potrero estimates generally fall between the 335μ and 505μ mesh estimates of the Encina study. At Potrero, 505μ mesh sampling was carried out during the first half of the study year, 335μ mesh sampling was performed in the second half, and the mesh data were combined for entrainment estimates. The roughly equivalent magnitude of Potrero and Encina daily entrainment estimates is noteworthy because Encina withdraws 2.25 times as much cooling water each day.

TABLE 8.6-1
DAILY ENTRAINMENT ESTIMATES FOR SELECTED PLANKTON GROUPS
AT SAN ONOFRE, POTRERO, AND ENCINA POWER PLANTS
ENCINA POWER PLANT - AUGUST 1, 1980

Category	Power Plant (year)			
	San Onofre (1976-77)	Potrero (1978-79)	Encina (1979)	
Generating capacity	450 MW	332 MW	931 MW	
Daily discharge	450 MGD	353 MGD	795 MGD	
Sampling gear	Pump	Pump	Pump	
Mesh size	202μ	335μ/505μ combined	335μ	505μ
Plankton Group				
Larval fish	†	1.06×10^{6}	2.52×10^{6}	2.46×10^{5}
Fish eggs	†	1.47×10^{6}	1.57×10^{7}	1.11×10^{7}
Acartia tonsa	9.10×10^{7}	†	4.77×10^{7}	7.63×10^{6}
Copepoda	4.67×10^{8}	†	8.47×10^{6}	2.16×10^{6}
Decapoda	†	3.38×10^{6}	1.32×10^{7}	4.44×10^{6}
Other crustacea	1.21×10^{9}	1.58×10^{7}	6.95×10^{6}	2.70×10^{6}
Mysidacea	1.30×10^{11}	9.07×10^{4}	6.70×10^{5}	1.34×10^{6}
Chaetognatha	6.00×10^{6}	2.58×10^{5}	1.83×10^{6}	1.56×10^{6}
Other zooplankton	1.00×10^{7}	†	5.68×10^{6}	4.55×10^{5}

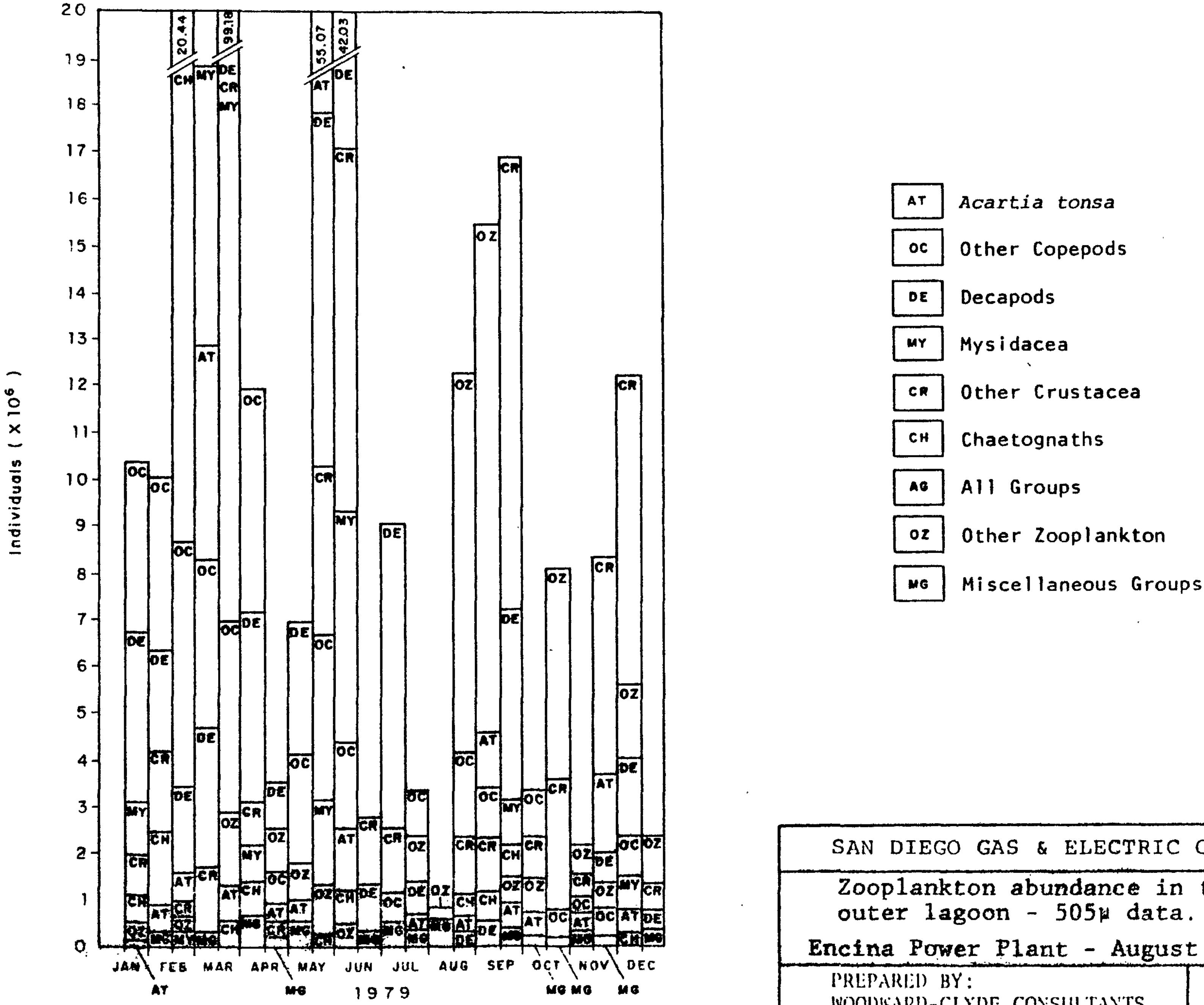
†: Data not available.

References

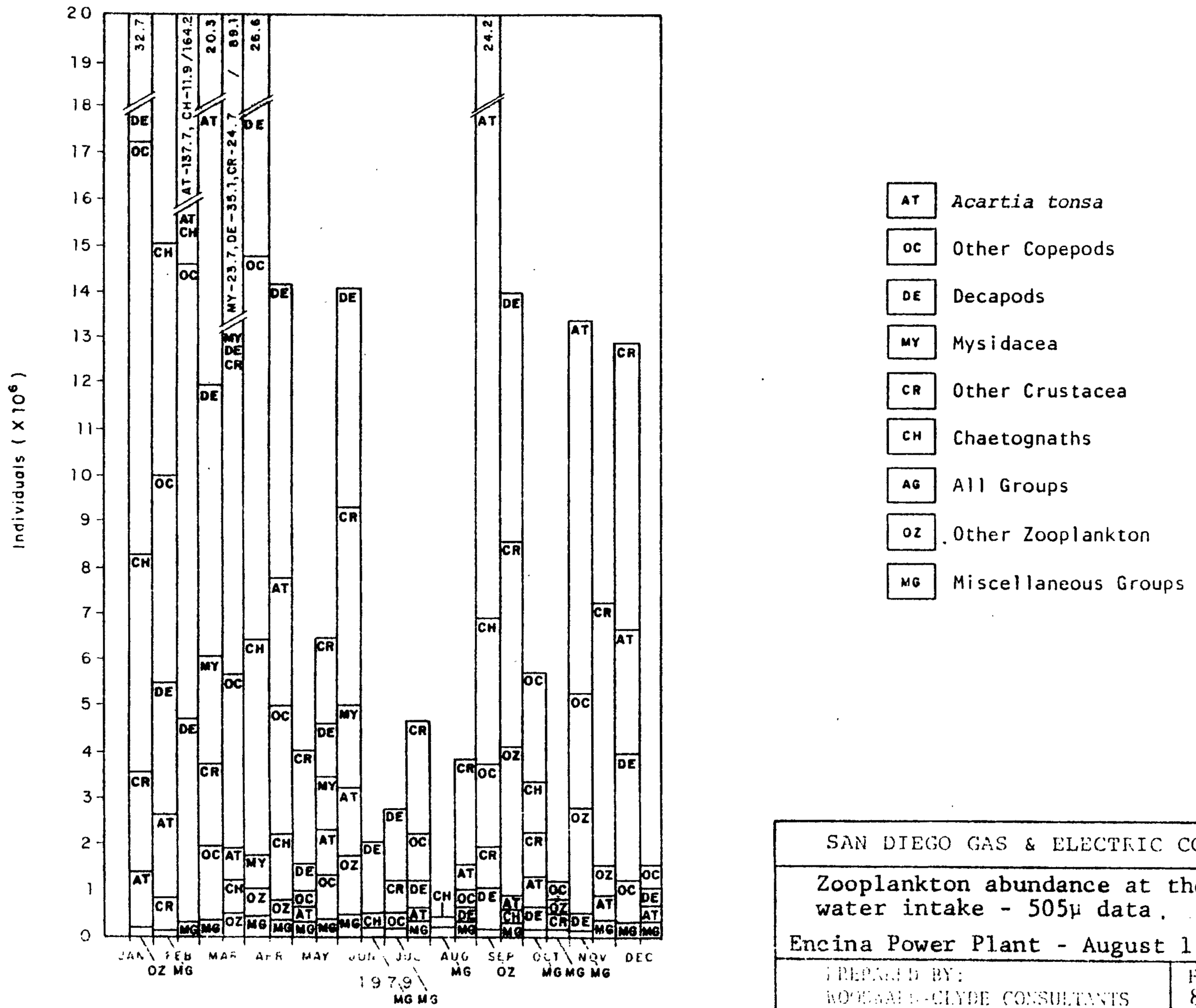
8-1 Sokal, R. R., and J. F. Rohlf, Biometry, W. H. Freeman and Company, San Francisco, Calif., pp. 392-393, (1969).

8-2 Marine Review Committee (MRC), Annual Report to the California Coastal Commission, August 1976-August 1977, Appendix I, Estimated Effects of SONGS Unit I on Marine Organisms: Technical Analysis and Results - MRC Doc. 77-09 No. 2, (1977).

8-3 Ecological Analysts, Inc., Potrero Power Plant Cooling Water Intake Structures 316(b) Demonstration (Prepared for Pacific Gas and Electric Company), (1980).



SAN DIEGO GAS & ELECTRIC COMPANY	
Zooplankton abundance in the outer lagoon - 505µ data.	
Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 8.4-1



SAN DIEGO GAS & ELECTRIC COMPANY

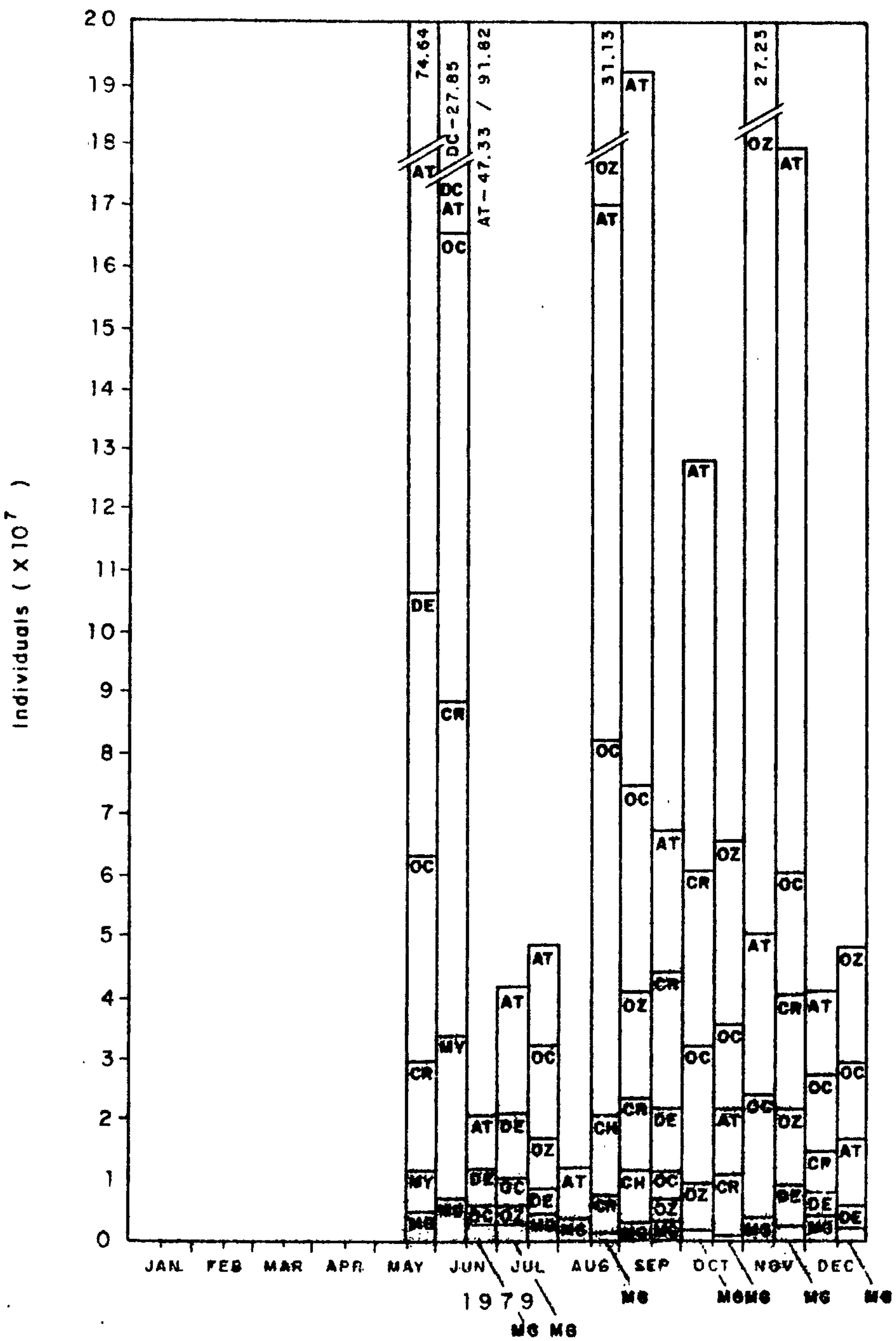
Zooplankton abundance at the cooling water intake - 505µ data.

Encina Power Plant - August 1, 1980

PREPARED BY: WOODWARD-CLYDE CONSULTANTS

FIGURE NO. 8.4-2

000666



AT	*Acartia tonsa*
OC	Other Copepods
DE	Decapods
MY	Mysidacea
CR	Other Crustacea
CH	Chaetognaths
AG	All Groups
OZ	Other Zooplankton
MG	Miscellaneous Groups

SAN DIEGO GAS & ELECTRIC COMPANY

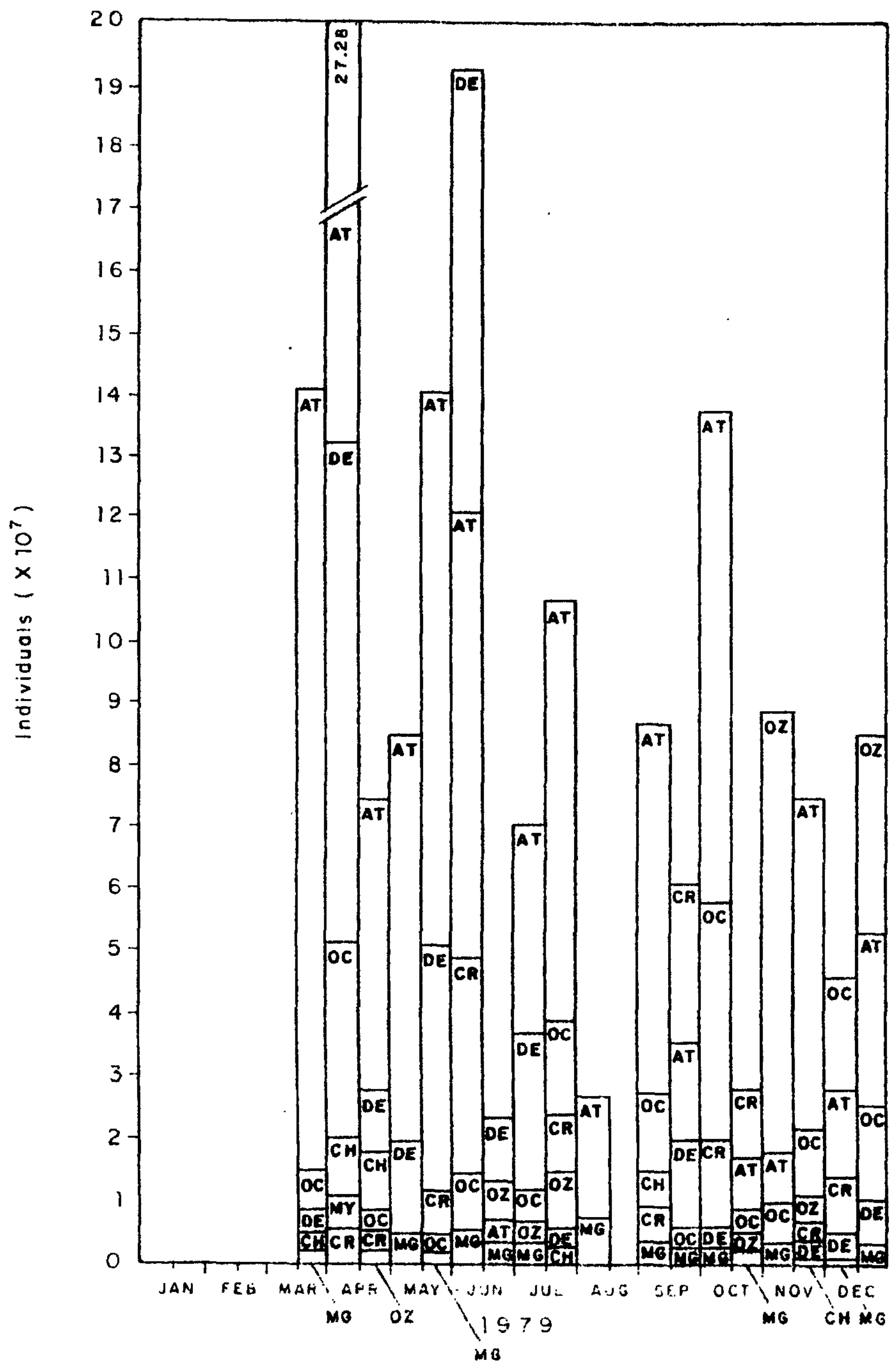
Zooplankton abundance in the outer lagoon - 335μ data.

Encina Power Plant - August 1, 1980

PREPARED BY:
WOODWARD-CLYDE CONSULTANTS

FIGURE NO. 8.4-3

000667



AT	*Acartia tonsa*
OC	Other Copepods
DE	Decapods
MY	Mysidacea
CR	Other Crustacea
CH	Chaetognaths
AG	All Groups
OZ	Other Zooplankton
MG	Miscellaneous Groups

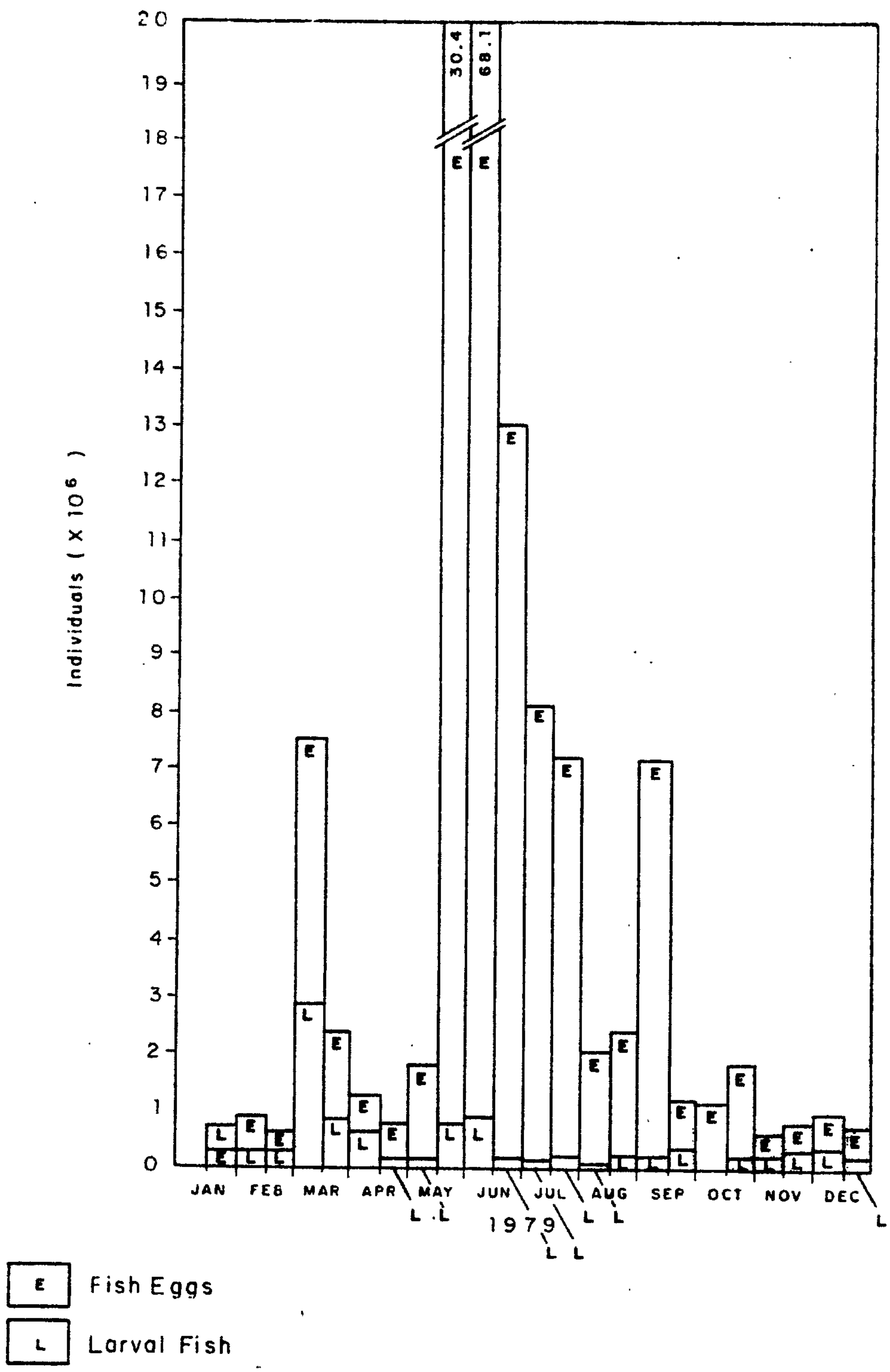
SAN DIEGO GAS & ELECTRIC COMPANY

Zooplankton abundance at the cooling water intake - 335μ data.

Encina Power Plant - August 1, 1980

PREPARED BY: WOODWARD-CLYDE CONSULTANTS

FIGURE NO. 8.4-4



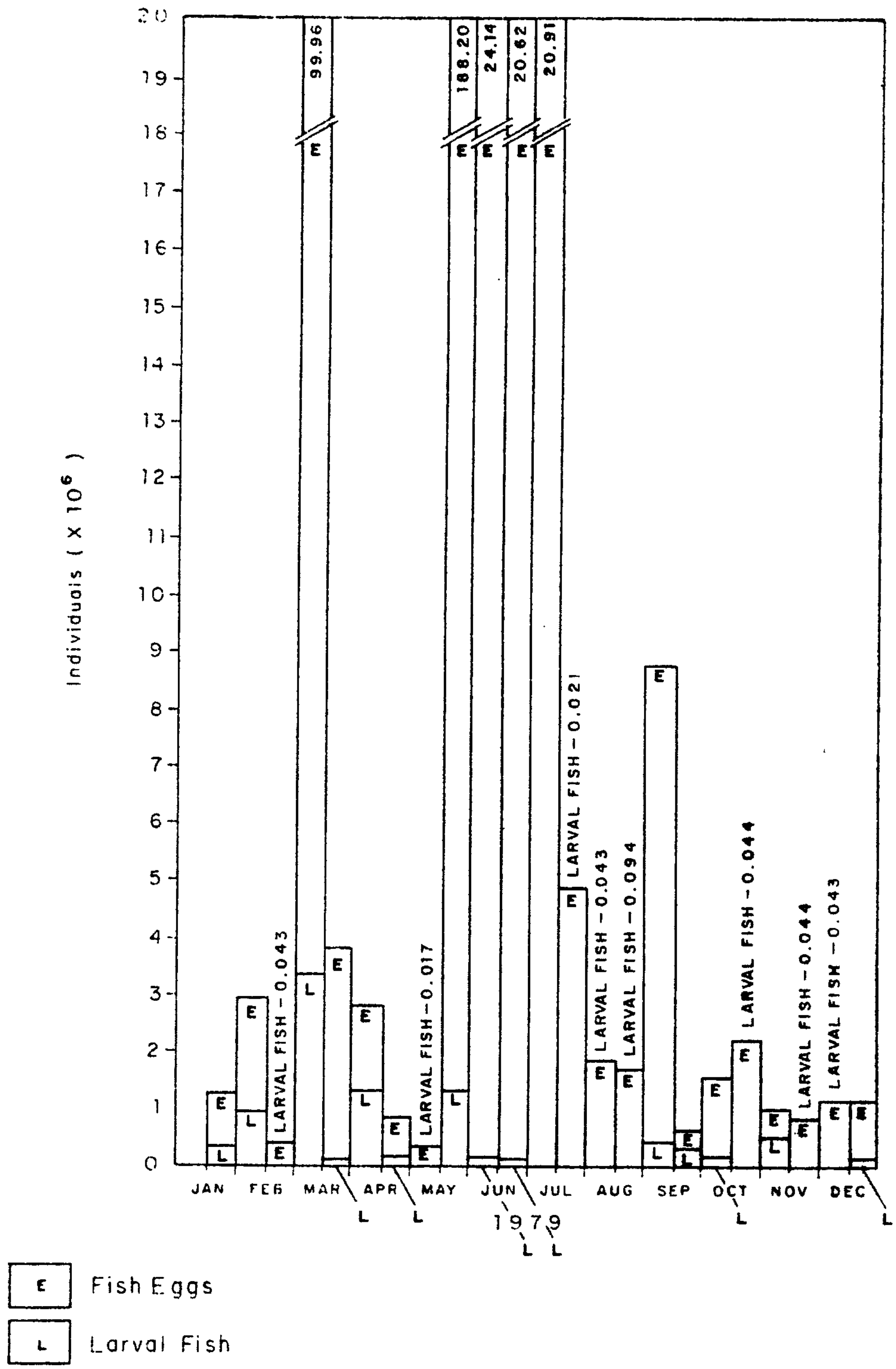
SAN DIEGO GAS & ELECTRIC COMPANY

Ichthyoplankton abundance in the outer lagoon - 505μ data.

Encina Power Plant - August 1, 1980

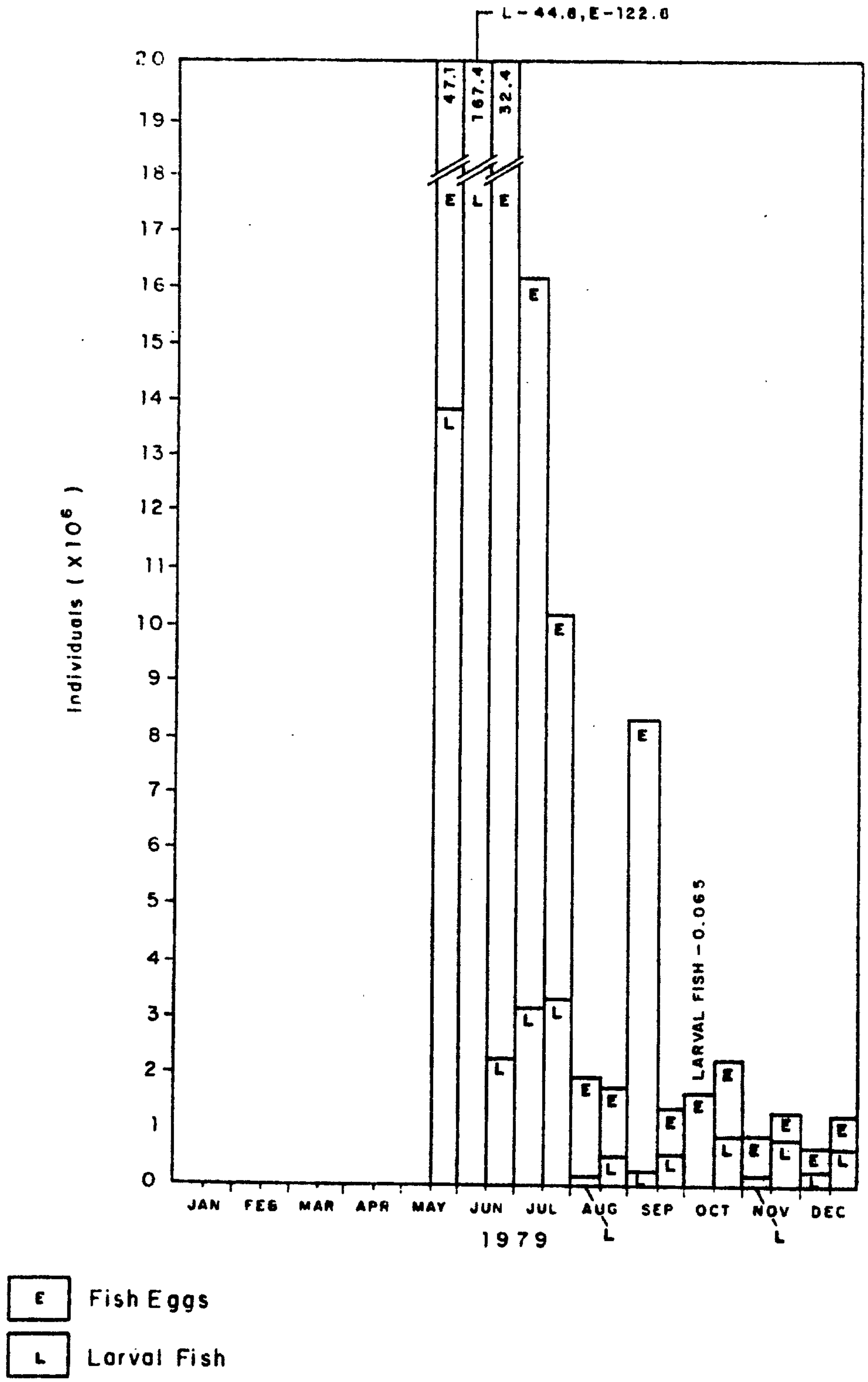
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 8.5-1

000669



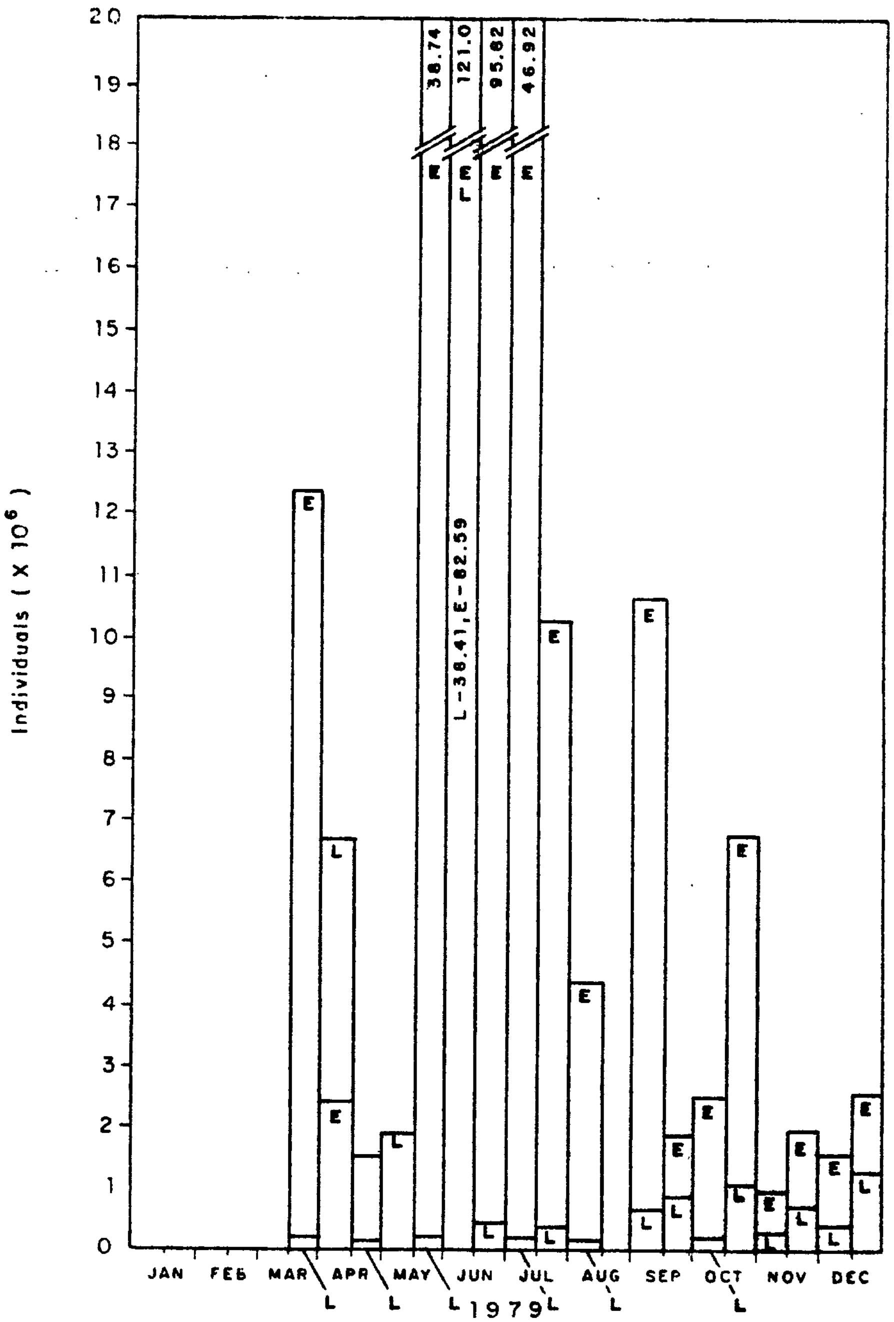
SAN DIEGO GAS & ELECTRIC COMPANY	
Ichthyoplankton abundance at the cooling water intake - 505µ data. **Encina Power Plant - August 1, 1980**	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 8.5-2

000670



SAN DIEGO GAS & ELECTRIC COMPANY	
Ichthyoplankton abundance in the outer lagoon - 335μ data. **Encina Power Plant - August 1, 1980**	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 8.5-3

000671



SAN DIEGO GAS & ELECTRIC COMPANY

Ichthyoplankton abundance at the cooling water intake - 335µ data.

Encina Power Plant - August 1, 1980

PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 8.5-4

000672

9.0

ENTRAINMENT MORTALITY

9.1 ABSTRACT AND SUMMARY

Entrainment mortality was evaluated twice during the year; once during warm summer ambient temperatures (September) and once during cold winter ambient temperatures (December). Phytoplankton samples were collected with water bottles. Ichthyoplankton and zooplankton samples were collected by plankton pump and larval tables. The mesh size used in sampling was 335μ in order to retain sufficient quantities of organisms for analysis. During each of the two sample periods experiments were run to examine:

(1) Thermal and mechanical effects, and
(2) Thermal, mechanical, and chemical (chlorination) effects of entrainment.

Subtracting results of (1) from (2) above gave the mortality effects due to chlorination. Samples were examined for primary productivity (light-dark bottle), pigment analysis, initial mortality and delayed mortality (96 hr).

These experiments permitted assessment of seasonal (summer, winter) and chemical (chlorination) influences on the magnitude of plankton mortality induced by entrainment through the power plant:

- The chemical and seasonal effects of entrainment on phytoplankton productivity and biomass were negligible in most experiments (Tables 9.4-1, 9.4-2).

In one of the four experiments, a 14 percent decrease in chlorophyll a was observed. This level of reduction is considered to have a negligible effect on the receiving water ecosystem (9-1).

- The effect of chlorination on entrainment mortality for zooplankton and ichthyoplankton was generally statistically insignificant in both summer and winter seasons.
- Summer entrainment mortality rates observed for zooplankton were consistently higher than the winter rates. The summer rate for Acartia tonsa was 66 percent; the winter rate was 33 percent. These results are in agreement with reported findings (9-2) of lethal thermal limits for Acartia tonsa which are approached in summer due to higher ambient temperatures coupled with temperature increases resulting from condenser passage.
- No viable ichthyoplankton larvae were recovered at the discharge in any of the experiments and therefore the mortality rate was 100 percent for larval fish in both summer and winter seasons. The results of fish egg experiments in the present study indicated mortality rates of 87 percent in summer and 62 percent in winter.
- Total mortality estimates were computed for 335 and 505μ mesh entrainment data. The total mortality

of organisms during entrainment over a 290 day period according to 335μ mesh net data were 5.3×10^9 _Acartia tonsa_, 4.0×10^9 individuals of other zooplankton species, and 4.4×10^9 ichthyoplankton larvae and eggs. The total mortality of organisms during entrainment over a 338 day period according to 505μ mesh net data were: 9.8×10^8 _Acartia tonsa_, 2.0×10^9 individuals of other zooplankton species and 3.3×10^9 ichthyoplankton larvae and eggs.

- Predation studies within the intake tunnels indicated predation within the intake system was negligible (Encina minimizes biofouling by routine thermal treatments) (Table 9.5-4).

- Total entrainment mortality estimates for various plankton groups were compared with the total numbers available in the outer lagoon. It was found that, in general, amounts equivalent to 12 to 30 percent of the outer lagoon standing populations were killed during entrainment on an annual basis. This does not take into account the replenishment of lagoon populations from offshore during tidal cycles and recruitment from populations within the lagoon, which if considered would make the percentages smaller.

9.2 HISTORICAL INFORMATION/INTRODUCTION

Entrainment mortality studies have been carred out for many power plants on the east coast and in midwestern United States; however, there are few published reports of mortality studies for west coast power plants.

The results of the first 316(b) demonstration performed for a west coast power plant has recently been published (9-3). The Potrero Power Plant, located on San Francisco Bay, is a three unit fossil fuel facility with a generating capacity of 335 MW and a cooling water capacity of 352.8 mgd. It was estimated that 25 percent of the entrained organisms were lost during transit through the plant. In a twelve month period from 1978 to 1979, 3.87×10^6 fish eggs and larvae and 2.173×10^9 invertebrates were estimated to die as a result of entrainment (9-4).

Two recent reports (9-5, 9-6) concern the San Onofre Nuclear Generating Station (SONGS) which is located on the southern California coast and employs an offshore intake and discharge cooling water system. This plant, at present, with one unit operating, has a generating capacity of 450 MW and a cooling water capacity of 450 mgd. Over a typical 24 hr period, it was estimated that 1.662×10^9 entrained invertebrates were lost (9-7). On an annual basis, 1.31×10^{11} entrained mysids were killed in 1976-77 (9-8) and 8.75×10^8 fish larvae were entrained in 1978 (9-9). At the present time, these are the only published mortality studies for west coast power plants.

The following paragraphs discuss the theoretical approach to entrainment mortality assessment and aspects of the sampling design.

It is important in entrainment mortality assessments to (1) identify the various sources of mortality that may occur and (2) recognize the limitations of the assessment approach.

Equations (1) and (2) below represent simplified models expressing major mortality components for ichthyoplankton and zooplankton studies:

$$MI_{exp} = MI_{natl} + MI_{samp} \text{ (1)} \qquad (1)$$

$$MD_{exp} = MI_{natl} + MD_{natl} + MD_{samp} + M_{pred} + M_{cond} \qquad (2)$$

Where:

MI_{exp} is the mortality found by experimentation at the intake station.

MI_{natl} is the mortality due to natural causes, pre-plant.

MI_{samp} is the mortality due to sampling at the intake station.

MD_{exp} is the mortality found by experimentation at the discharge station.

MD_{natl} is the mortality due to natural causes within the plant.

MD_{samp} is the mortality due to sampling at the discharge station.

000677

MD_{pred} is mortality due to predation within the plant

and

M_{cond} is the mortality due to thermal, mechanical and chemical effects of pump and condenser passage.

The common practice in estimating entrainment mortality is to treat MI_{exp} as a control value and subtract it from MD_{exp}. However, this method involves simplifying assumptions. If equation (1) is subtracted from equation (2), the resulting equation is:

$$M_{entrain} = M_{exp} - MI_{exp} = MD_{natl} + MD_{samp} - MI_{samp} + M_{pred} + M_{cond} \quad (3)$$

Where:

$M_{entrain}$ is the estimate of entrainment mortality.

Natural mortality occurring during plant passage (MD_{natl}) is generally considered insignificant because plant transit times are relatively short term. It is also assumed that MD_{samp} = MI_{samp}; however, this has not been proven. Mortality induced by sampling organisms presumably weakened by condenser passage will generally be higher than mortality induced by sampling pre-plant organisms (9-10). Estimating this difference in mortalities would require extrapolation from laboratory simulation experiments. It should also be recognized that, in this approach, it is not known how many discharge organisms presumed to be killed by sampling were actually killed by entrainment. In addition, the higher MI_{samp} is, the lower, by definition, the estimate of $M_{entrain}$ will be. Thus, this approach yields a minimum entrainment mortality estimate. Survival estimates based on this approach (e.g., Ecological Analysts 1980) are, therefore, maximum survival estimates and should be so designated.

As a consequence of the preceding considerations, initial mortality rate estimates in this study were calculated using the following equation:

$$\text{Initial Entrainment Mortality Rate} = 1 - \frac{\%\ \text{live at discharge}}{\%\ \text{live at intake}},$$

(4)(from 9-11)

This method is considered more robust than evaluating entrainment mortality by subtracting the discharge fraction of live organisms from the intake fraction (9-12, 9-13).

The term M_{pred} is rarely considered in entrainment studies and its influence on mortality has only recently been assessed (9-14). At the Encina Power Plant, travel distances to and from each unit vary (Table 9.2-1) and predation will presumably correlate with travel distance. Therefore, attempts will be made to estimate the magnitude of M_{pred} for each unit in the Encina plant.

The final term in equation (3), M_{cond}, may be expressed as:

$$M_{cond} = M_{therm} + M_{chem} + M_{mech} \qquad (5)$$

Where:

000679

TABLE 9.2-1
PARAMETERS INVOLVED IN DETERMINING RESIDENCE TIME WITHIN THE ENCINA POWER PLANT FOR ENTRAINED ORGANISMS IN 1979

UNIT	INTAKE TO UNIT DISTANCE (m)	ESTIMATED AVERAGE FLOW RATE (m/s)	INTAKE TRANSIT TIME (min)	UNIT TO DISCHARGE DISTANCE (m)	ESTIMATED AVERAGE FLOW RATE (m/s)	DISCHARGE TRANSIT TIME (min)	TOTAL TRANSIT TIME (min)	FLOW VOLUME WEIGHTING FACTOR	TOTAL TRANSIT TIME X WEIGHTING FACTOR (min)
1	203.0 (670 ft)	0.31	10.9	236.4 (780 ft)	0.58	6.8	17.7	0.11	1.9
2	233.3 (770 ft)	0.31	12.5	266.7 (880 ft)	0.58	7.7	20.2	0.11	2.2
3	272.7 (900 ft)	0.31	14.7	303.0 (1000 ft)	0.58	8.7	23.4	0.11	2.6
4	310.6 (1025 ft)	0.27	19.2	343.9 (1135 ft)	0.58	9.9	29.1	0.33	9.6
5	378.8 (1250 ft)	0.27	23.4	418.2 (1380 ft)	0.58	12.0	35.4	0.33	11.7

VOLUME
FLOW-WEIGHTED
AVERAGE RESIDENCE TIME: 28.0

M_{therm} is the mortality due to thermal effects of condenser passage.

M_{chem} is the mortality due to chemical effects of condenser passage (chlorine and anti-corrosive additives).

and

M_{mech} is the mortality due to mechanical effects of condenser passage (pressure changes, physical sheer forces, mechanical damage, etc.).

These components act synergistically on entrainment mortality; however, there are an increasing number of studies performed that attempt to assess one or more of these factors.

The approach used involves assessing entrainment mortality during full plant operation followed by a repeat assessment when either power generation is shut down, eliminating M_{therm}, or when the anti-fouling injection system is interrupted, eliminating M_{chem}. Results of such studies indicate that mechanical stress (M_{mech}) is generally the major source of mortality for plankton passing through a power plant unit (9-15).

The magnitude of M_{therm} usually varies seasonally: as ambient water temperature increases, M_{therm} becomes more important. The current explanation for seasonal changes in magnitude of entrainment mortality is as follows: Thermal research indicates that organisms will die if exposed to certain, species-specific, elevated temperatures (9-16). Upon entrainment, planktonic organisms are subjected to extreme, rapid increases in water temperature. If the increase does not surpass the organism's upper lethal temperature limit, entrainment mortality will be reduced. Therefore, during winter conditions of low ambient water temperatures, the probability that the temperature increase induced by condenser passage will surpass the upper lethal temperatures for most of the entrained organisms is low, and entrainment mortality is expected to be relatively low. On the other hand, in summer, high intake temperatures, coupled with temperature increases induced by condenser passage, increase the probability that a majority of the entrained organisms will be subjected to temperatures exceeding their upper lethal limit. During this season, entrainment mortality should be relatively high. Therefore, the maximum temperature that entrained organisms experience is considered the critical influence on the thermal component of entrainment mortality. Under conditions where critical high temperatures are not approached, the change in water temperature during entrainment will be a more important influence on mortality.

Chemical additives are also considered an important influence on mortality within the Plant (9-17), but in the receiving water ecosystem, chemical effects are considered to decrease rapidly due to dilution and chemical decay (9-18). In the present study, M_{chem} was estimated by performing assessments with and without the chlorination system operating.

The effect of entrainment on phytoplankton was assessed by comparing pigment concentrations and productivity data of pre- and post-entrainment phytoplankton samples.

Sampling Design

The accuracy of entrainment mortality estimation relies on sampling the same water mass before and after entrainment. In order to accomplish this, the residence time of the average water parcel within the plant must be estimated. Residence time is defined as the average amount of time necessary for a water parcel to pass completely through the power plant cooling system. The estimate was calculated by considering travel distance, current flow and water volume of each unit.

At the Encina Power Plant, travel distances to and from each unit vary (Table 9.2-1). Current flow measurements within the Plant at various tidal stages indicate that intake currents for the whole plant average 0.29 m/sec. The range in flow rates is from 0.27 m/sec (Units 4 and 5) to 0.31 m/sec (Units 1-3). No discharge flow rates could be directly measured; however, inspection of the blueprints for the Power Plant indicates that the discharge tunnel is approximately one-half as large as the intake tunnels. Therefore, discharge flow rate was assumed to be twice as large as the average intake flow rate (0.29 m/sec) or 0.58 m/sec.

The average values for total transit time for each unit are listed in Table 9.2-1. If all the units had equivalent flow

000683

volumes, the average residence time would be the mean value for all the units or 25.2 min. However, flow volumes for Units 4 and 5 are equivalent in magnitude and each of these units has a flow volume equal to Units 1-3 combined. Therefore, a weighting factor must be included which takes flow volume into consideration (9-19). Column 9 of Table 9.2-1 lists flow volume weighting factors for each unit. Total average transit time for each unit was multiplied by the appropriate factor. The resulting numbers were summed to produce a volume-weighted average residence time of 28 min. Consequently, discharge sampling was performed 28 min after intake sampling for all studies.

The magnitude of two influences on entrainment mortality were estimated at the Encina Power Plant--ambient water temperature and chlorination. It is generally though as ambient water temperature increases, the probability of entrainment mortality increases. The accepted explanation for this observation is that, as ambient water temperature increases, the probability increases that the thermal addition induced by condenser passage will subject entrained organisms to water temperatures exceeding lethal thermal limits (9-20). In an effort to estimate the range of magnitude of the seasonal influence on entrainment mortality, sampling was performed during periods of maximum and minimum ambient water temperatures (September and December, respectively).

Chlorination influences on entrainment mortality were estimated during maximum and minimum temperature periods by performing assessments with and without the chlorine injection system in operation.

000685

9.3 METHODOLOGY

Sampling for entrainment mortality studies was carried out in September and December, 1979, at intake and discharge stations. Assessments were made with and without chlorination. All sampling was performed at night because preliminary studies in Agua Hedionda Lagoon indicated that larval fish distributions were spread throughout the water column at night. Intake and discharge sampling were separated by the estimated 28 min residence time a water parcel spends in transit within the Plant.

Phytoplankton samples were randomly taken at intake and discharge stations. Each sample supplied aliquots for primary productivity incubations and pigment analyses. Primary productivity was estimated using the light/dark oxygen method. Concentrations of pigments (chlorophylls a, b and c, and phaeopigments) were estimated spectrophotometrically.

Zooplankton and ichthyoplankton samples were collected with plankton pumps which were coupled with specially designed samplers. Multiple pump and net samples were taken simultaneously at intake and discharge stations for mortality assessments. Live and dead organisms were counted. In delayed mortality assessments, live organisms were held for up to 96 hours.

Two assessments of the magnitude of predation occurring within the intake channels were performed. Replicate pump samples were simultaneously collected at the intake and at each of the main forebays leading into the various units. Plankton abundances were compared for indications of predation.

Detailed methodology for all mortality assessments is contained in Appendix B (Section 17.2-5).

000687

9.4 PHYTOPLANKTON

The results of entrainment studies on phytoplankton productivity and biomass are discussed in the following sections and compiled in Tables 9.4-1, and 9.4-2.

9.4.1 Thermal and Mechanical Effects

Two assessments were performed when the Plant chlorination system was not operating. In these studies, the thermal and mechanical effects of entrainment on phytoplankton were assessed.

Table 9.4-3 is a summary of the plant operational characteristics during phytoplankton sampling for the entrainment survival studies. Information was compiled from Encina daily basement logs, direct measurements at Station D (the sampling station on the discharge side of the Plant) and cooling water data supplied by SDG&E. Text descriptions of temperature data below are approximate, detailed data are contained in Table 9.4-3.

The average intake water temperature for all units during sampling for the 15 September 1979 no chlorination run was 23 C (74 F). Average cooling water temperature immediately after condenser passage was 32 C (90 F) and the average change in water temperature induced by condenser passage was 9 C (16 F). Unit 4 was off-line during this sampling period and the total water flow rate for the plant was 79.9 million liter/hr (21.1 mgh) (Table 9.4-3).

The average intake water temperature for all units during sampling for the 2 December 1979 no chlorination assessment was

TABLE 9.4-1
NET PRODUCTIVITY AND RESPIRATION VALUES DURING PRIMARY PRODUCTIVITY STUDIES AT THE ENCINA POWER PLANT IN 1979

DATE	NET PRODUCTIVITY (mg C fixed/m^3/hr)			
	INTAKE	DISCHARGE	Significant?†	$\Delta \frac{D}{I}$
15 Sept. 1979	5.4 ± 15.7	26.2 ± 18.6	YES	4.85
27 Sept. 1979	-2.5 ± 13.1	0.2 ± 6.8	NO	-
Significant?†	NO	YES		
2 Dec. 1979	8.4 ± 7.2	5.0 ± 4.1	NO	-
11 Dec. 1979	-1.9 ± 5.3	-0.9 ± 6.3	NO	-
Significant?†	YES	YES		
	RESPIRATION (ml.O_2/hr)			
15 Sept. 1979	0.004 ± 0.035	-0.038 ± 0.040		
27 Sept. 1979	0.020 ± 0.032	0.006 ± 0.015		
2 Dec. 1979	-0.012 ± 0.016	-0.005 ± 0.012		
11 Dec. 1979	0.028 ± 0.040	0.029 ± 0.027		

† Mann-Whitney U-Test

000689

TABLE 9.4-2
PIGMENT RESULTS OF PHYTOPLANKTON ENTRAINMENT
MORTALITY STUDIES AT THE ENCINA POWER PLANT IN 1979

PIGMENT	15 September 1979				27 September 1979			
	I	D	%Δ	Sig?†	I	D	%Δ	Sig?†
Chlorophyll a	2.18 ± 0.35	2.19 ± 0.42	0.5	NO	1.98 ± 0.32	1.77 ± 0.13	-11	NO
Chlorophyll a After Acid	1.16 ± 0.22	1.36 ± 0.87	17	NO	0.96 ± 0.28	0.83 ± 0.23	-13.5	NO
Phaeopigments	1.72 ± 0.36	1.47 ± 0.61	-15	NO	1.55 ± 0.36	1.09 ± 0.51	-30	YES
Chlorophyll b	0.28 ± 0.15	0.12 ± 0.12	-57	YES	0.65 ± 0.24	0.38 ± 0.16	-42	YES
Chlorophyll c	2.22 ± 0.63	1.57 ± 0.47	-29	YES	2.90 ± 0.86	1.97 ± 0.72	-32	YES

TABLE 9.4-2 (Concluded)

PIGMENT	2 December 1979				11 December 1979			
	I	D	%Δ	Sig?†	I	D	%Δ	Sig?†
Chlorophyll a	1.25 ± 0.13	1.08 ± 0.09	-14	YES	0.93 ± 0.09	0.90 ± 0.14	-3	NO
Chlorophyll a After Acid	0.91 ± 0.22	0.92 ± 0.19	+1	NO	0.96 ± 0.24	1.14 ± 0.33	+16	NO
Phaeopigments	0.59 ± 0.26	0.28 ± 0.20	-53	YES	NOT DETECTABLE	NOT DETECTABLE	-	-
Chlorophyll b	0.37 ± 0.09	0.20 ± 0.10	-46	YES	0.70 ± 0.15	0.67 ± 0.21	-4	NO
Chlorophyll c	1.66 ± 0.43	1.03 ± 0.44	-38	YES	2.91 ± 0.65	2.72 ± 0.77	-7	NO

† Mann-Whitney U-Test

TABLE 9.4-3
ENCINA POWER PLANT OPERATIONAL CHARACTERISTICS DURING PHYTOPLANKTON SAMPLING FOR ENTRAINMENT MORTALITY STUDIES IN 1979

DATE	CI?	ALL UNITS			COOLING WATER FLOW RATE
		IN	OUT	ΔT	
15 Sept. 1979	OFF	22.9 ± 0.6° (73.3 ± 1.0° F)	32.2 ± 1.5° (89.9 ± 2.7° F)	9.2° (16.6° F)	UNITS 1-3, 5 79.9 x 10^6 liters/hr (21.1 x 10^6 gal/hr)
27 Sept. 1979	ON	18.8 ± 0.6° (65.8 ± 1.1° F)	28.1 ± 2.8° (82.6 ± 5.0° F)	9.3° (16.7° F)	UNITS 1-5 125.3 x 10^6 liters/hr (33.1 x 10^6 gal/hr)
Differences Significant? -		YES	YES	NO	
2 Dec. 1979	OFF	14.9 ± 0.5° (58.8 ± 0.9° F)	22.6 ± 0.8° (72.6 ± 1.4° F)	7.7° (13.8° F)	UNITS 1, 3-5 114.5 x 10^6 liters/hr (30.25 x 10^6 gal/hr)
11 Dec. 1979	ON	16.7 ± 0.5° (62.0 ± 0.9° F)	24.9 ± 2.2° (76.8 ± 3.9° F)	8.2° (14.8° F)	UNITS 1-5 125.3 x 10^6 liters/hr (33.1 x 10^6 gal/hr)
Differences Significant? †		YES	NO	YES	

TABLE 9.4-3 (Continued)

DATE	CI?	UNIT 1 IN	UNIT 1 OUT	UNIT 1 ΔT	UNIT 2 IN	UNIT 2 OUT	UNIT 2 ΔT
15 Sept. 1979	OFF	22.8 ± 0.6° (73.0 ± 1.0°F)	30.7 ± 1.0° (87.2 ± 1.8°F)	7.9° (14.2°F)	22.9 ± 0.3° (73.3 ± 0.6°F)	34.1 ± 0.7° (93.3 ± 1.2°F)	11.1° (20.0°)
27 Sept. 1979	ON	19.4 ± 0.0° (67.0 ± 0.0°F)	28.3 ± 2.2° (82.9 ± 4.0°F)	8.9° (16.0°F)	19.4 ± 0.0° (67.0 ± 0.0°F)	30.0 ± 1.1° (86.0 ± 2.0°F)	10.6° (19.1°F)
Differences Significant? †		YES	NO	NO	YES	YES	YES
2 Dec. 1979	OFF	15.0 ± 0.0° (59.0 ± 0.0°F)	23.4 ± 0.7° (74.2 ± 1.2°F)	8.4° (15.2°F)	DOWN	DOWN	DOWN
11 Dec. 1979	ON	17.2 ± 0.0° (63.0 ± 0.0°F)	24.2 ± 0.3° (75.5 ± 0.5°F)	6.9° (12.5°F)	17.2 ± 0.0° (63.0 ± 0.0°F)	28.3 ± 0.6° (83.0 ± 1.1°F)	11.1° (20.0°F)
Differences Significant? †		YES	NO	YES			

TABLE 9.4-3 (Continued)

DATE	CI?	UNIT 3 IN	UNIT 3 OUT	UNIT 3 ΔT	UNIT 4 IN	UNIT 4 OUT	UNIT 4 ΔT
15 Sept. 1979	OFF	22.4 ± 0.3° (72.3 ± 0.6°F)	32.5 ± 0.4° (90.5 ± 0.8°F)	10.1° (18.2°F)	DOWN	DOWN	DOWN
27 Sept. 1979	ON	18.0 ± 0.3° (64.4 ± 0.5°F)	30.4 ± 2.0° (86.7 ± 3.6°F)	12.4° (22.3°F)	18.3 ± 0.0° (65.0 ± 0.8°F)	28.0 ± 2.2° (82.4 ± 4.0°F)	9.7° (17.5°F)
Differences Significant? –		YES	NO	YES			
2 Dec. 1979	OFF	14.4 ± 0.0° (58.0 ± 0.0°F)	22.3 ± 0.7° (72.2 ± 1.2°F)	7.9° (14.2°F)	14.4 ± 0.0° (58.0 ± 0.0°F)	21.9 ± 1.2° (71.5 ± 2.1°F)	7.5° (13.5°F)
11 Dec. 1979	ON	16.1 ± 0.0° (61.0 ± 0.0°F)	25.7 ± 0.3° (78.3 ± 0.6°F)	9.6° (17.3°F)	15.9 ± 0.3° (60.7 ± 0.6°F)	22.5 ± 1.5° (72.5 ± 2.7°F)	6.6° (11.8°F)
Differences Significant? †		YES	YES	YES	YES	NO	NO

TABLE 9.4-3 (Concluded)

DATE	CI?	UNIT 5 IN	OUT	ΔT
15 Sept. 1979	OFF	23.5 ± 0.3° (74.3 ± 0.6°F)	31.3 ± 0.7° (88.3 ± 1.2°F)	7.8° (14.0°F)
27 Sept. 1979	ON	18.7 ± 0.3° (65.7 ± 0.5°F)	23.9 ± 0.0° (75.0 ± 0.0°F)	5.2° (9.4°F)
Differences Significant? †		YES	YES	YES
2 Dec. 1979	OFF	15.7 ± 0.3° (60.3 ± 0.6° F)	22.9 ± 0.4° (73.2 ± 0.8°F)	7.2° (12.9°F)
11 Dec. 1979	ON	16.7 ± 0.0° (62.0 ± 0.0°F)	23.9 ± 0.0° (75.0 ± 0.0°F)	7.2° (13.0°F)
Differences Significant? †		YES	YES	NO

† Mann Whitney U-Test

15 C (59 F). Average cooling water temperature immediately after condenser passage was an average of 23 C (73 F). The average change in water temperature, induced by condenser passage was 8 C (14 F) which was the lowest average temperature change observed during experimentation. Unit 2 was off-line during this sampling period and total water flow rate during sampling was 114.5 million liters/hr (30.25 mgh) (Table 9.4-3).

9.4.1.1 Light/Dark Bottle Determination. Primary productivity values were estimated by the light/dark bottle oxygen technique (9-21). Forty samples taken 15 September 1979 were incubated at ambient water temperatures of 22.8-23.3 C (73-74 F) for 8 hours. Samples taken 2 December 1979 were incubated 12 hours at water temperatures of 15-15.2 C (59-59.4 F) (Figure 9.4-1). Insolation data during the September and December incubations are graphically presented in Figure 9.4-2.

9.4.1.1.1 Intake Collections. The average net primary productivity estimate for intake samples collected 15 September 1979 was 5.4 ± 15.7 mgC fixed/m^3/ hr. Samples collected 2 December 1979 gave an estimate of 8.4 ± 7.2 mgC fixed/m^3/hr (Figure 9.4-3).

9.4.1.1.2 Discharge Collections. Discharge samples collected 15 September 1979 exhibited an average net primary productivity of 26.2 ± 18.6 mgC fixed/m^3/hr. The 2 December 1979 samples yielded an estimate of 5 ± 4.1 mgC fixed/m^3/hr (Figure 9.4-3).

Intake and discharge values for the 15 September 1979 period were significantly different (Mann-Whitney U-test, $\alpha = 0.05$, (9-22). Average net productivity after entrainment was observed to be approximately five times higher than the control (intake) average. Intake and discharge values for the 2 December 1979 experiment were not significantly different (Table 9.4-1).

9.4.1.2 Pigment Analyses. Pigment concentrations were determined spectrophotometrically using acetone extraction (9-23). Data are compiled in Table 9.4-2.

9.4.1.2.1 Intake Collections. The average concentration of chlorophyll *a* in the 15 September 1979 intake samples was 2.18 ± 0.35 mg/m^3 (Figure 9.4-4). The average estimate of chlorophyll *a* after acidification was 1.16 ± 0.22 mg/m^3 (Figure 9.4-5). Phaeopigments averaged 1.72 ± 0.36 mg/m^3. The 2 December 1979 intake samples yield average values of 1.25 ± 0.13 mg chlorophyll *a*/m^3, 0.91 ± 0.22 mg chlorophyll *a*/m^3 after acification, and 0.59 ± 0.26 mg phaeopigments/m^3 (Figure 9.4-6).

9.4.1.2.2 Discharge Collections. The 15 September 1979 discharge samples yielded an average of 2.19 ± 0.42 mg chlorophyll *a*/m^3, 1.36 ± 0.87 mg chlorophyll *a*/m^3 after acidification, and 1.47 ± 0.61 mg phaeopigments/m^3 (Figures 9.4-4 through 9.4-6). The average pigment concentrations

000697

for 2 December 1979 discharge samples were: 1.08 ± 0.09 mg chlorophyll a/m^3, 0.92 ± 0.19 mg chlorophyll a/m^3 after acidification, and 0.28 ± 0.20 mg phaeopigments/m^3 (Figures 9.4-4 through 9.4-6).

Intake and discharge values for chlorophyll a (trichromatic method), chlorophyll a (acid technique) and phaeopigments from the 15 September 1979 assessment were not significantly different (Mann-Whitney U-test). In the 2 December 1979 experiment, trichromatic chlorophyll a was observed to significantly decrease by an average of 14 percent between intake and discharge samples. Acid-determined chlorophyll a values from intake and discharge samples were not significantly different, but phaeopigment values were observed to significantly decrease by an average of 53 percent between intake and discharge samples (Table 9.4-2).

9.4.2 Thermal, Mechanical, and Chemical Effects

Two assessments were performed when the plant chlorination system was operating. In these studies the thermal, mechanical and chemical effects of entrainment on phytoplankton were assessed.

The average intake water temperature for all units during sampling for the 27 September 1979 chlorination experiment was 19 C (66 F). Average water temperature immediately after condenser passage during this period was 28 C (83 F). The resulting average change in temperature induced by condenser passage was

9 C (17 F) (Table 9.4-3), which was the highest average temperature change observed during experimentation. All units were operational during the sampling period and the total water flow rate was 125.3 million liters/hr (33.1 mgh).

The average water temperature for all units during sampling for the 11 December 1979 chlorination run was an average 17 C (62 F). Average water temperature immediately after condenser passage was 25 C (77 F). The average change in water temperature induced by condenser passage was 8 C (15 F) (Table 9.4-3). All units were on-line during sampling and the total water flow rate was 125.3 million liters/hr (33.1 mgh).

9.4.2.1 Light/Dark Bottle Determination. Samples collected 27 September 1979 were incubated for eleven hours at ambient water temperatures of 18.3-19.4 C (65-67 F). The 11 December 1979 samples were incubated for 12 hours at water temperatures of 16.1-17.2 C (61-63 F) (Figure 9.4-1). Insolation data for those experiments are graphically presented in Figure 9.4-2).

9.4.2.1.1 Intake Collections. Intake samples collected 27 September 1979 yielded an average net productivity estimate of -2.5 ± 13.1 mgC fixed/m^3/hr. An average net productivity value of -1.9 ± 5.3 mgC fixed/m^3/hr was estimated for the 11 December 1979 intake samples (Figure 9.4-3, Table 9.4-1). Negative productivity values signify that respiration exceeded productivity during the incubation period (see Discussion).

9.4.2.1.2 Discharge Collections. Discharge samples collected 27 September 1979 gave an average net productivity estimate of 0.2 ± 6.8 mgC fixed/m^3 hr. The 11 December 1979 discharge samples yielded an average net productivity estimate of -0.9 ± 6.3 mgC fixed/m^3/hr (Figure 9.4-3, Table 9.4-1).

Intake and discharge values for the 27 September 1979 period were not significantly different (Mann-Whitney U-test). In the 11 December 1979 assessment, no significant difference was observed between intake and discharge samples (Table 9.4-1).

9.4.2.2 Pigment Analyses. Pigment data for the September and December chlorination runs are compiled in Table 9.4-2

9.4.2.2.1 Intake Collections. The average concentration of chlorophyll a in the 27 September 1979 intake samples was 1.98 ± 0.31 mg/m^3 (Figure 9.4-4). Chlorophyll a concentration after acidification averaged 0.98 ± 0.28 mg/m^3 (Figure 9.4-5). Phaeopigments averaged 1.55 ± 0.36 mg/m^3 (Figure 9.4-6). The 11 December 1979 intake samples yielded average values of 0.93 ± 0.09 mg chlorophyll a/m^3, 0.96 ± 0.24 mg chlorophyll a/m^3 after acidification, and phaeopigments were undetectable (Figures 9.4-4 through 9.4-6).

9.4.2.2.2 Discharge Collections. The 27 September 1979 discharge samples yielded averages of 1.77 ± 0.13 mg

000700

chlorophyll a/m^3, 0.83 ± 0.23 mg chlorophyll a after acidification, and 1.09 ± 0.51 mg phaeopigments/m^3 (Figures 9.4-4 through 9.4-6). The average pigment concentrations for 11 December 1979 discharge samples were: 0.90 ± 0.14 mg chlorophyll a/m^3, 1.14 ± 0.33 mg chlorophyll a after acidification, and phaeopigments were undetectable (Figures 9.4-4 through 9.4-6).

In the 27 September 1979 assessment, intake and discharge values for chlorophyll a determined by either method were not significantly different (Mann-Whitney U-test). Phaeopigments during this period were significantly reduced by an average of 30 percent from intake to discharge samples. In the 11 December 1979 experiment, intake and discharge values for chlorophyll a determined by either method were not significantly different, and phaeopigments were undetectable (Table 9.4-2).

9.5 INVERTEBRATE ZOOPLANKTON

Table 9.5-1 summarizes the results of immediate and latent mortality analyses for each plankton group studied. The copepod Acartia tonsa was designated as a critical species in this study and comprised the most abundant invertebrate group investigated. The remaining invertebrate groups studied were taxonomic conglomerates: other copepod species, decapods, other crustacea, mysids, chaetognaths, and other zooplankton species combined. Appendix Tables 16.3-62 and 16.3-63 summarize the species compositions of these groups collected for immediate and latent mortality assessments. All groups were not collected during every experiment. Immediate mortality and latent mortality (after incubation) were statistically analyzed using Cochran's test (9-24).

9.5.1 Thermal and Mechanical Effects

Two assessments (14-18 September 1979 and 1-5 December 1979) were performed while the plant chlorination system was not operating in order to assess thermal and mechanical effects on entrained invertebrate zooplankton.

The average intake water temperature for all units during sampling for the 14-18 September 1979 no chlorination run was 24 C (75 F). Cooling water temperature immediately after condenser passage averaged 34 C (93 F). Therefore, the average change in water temperature was 10 C (18 F). Discharge water temperature at Station D was 30.5 C (87 F) (Table 9.5-2, Figure

TABLE 9.5-1
COMPILATION OF ZOOPLANKTON ENTRAINMENT MORTALITY
STUDIES AT THE ENCINA POWER PLANT IN 1979

PLANKTON GROUP	ASSESSMENT	14-18 September 1979 % LIVE (n) I	14-18 September 1979 % LIVE (n) D	14-18 September 1979 Estimated Mortality Rate	14-18 September 1979 Sig?†	24-29 September 1979 % LIVE (n) I	24-29 September 1979 % LIVE (n) D	24-29 September 1979 Estimated Mortality Rate	24-29 September 1979 Sig?†
Other Zooplankton	IMMEDIATE MORTALITY	95.3 (256)	14.3 (28)	0.85	YES	79.5 (117)	54.5 (55)	0.31	YES
	LATENT MORTALITY	33.3 (15)	25.0 (8)	0.08	NO	8.8 (34)	10.3 (29)	-0.02	NO
Other Crustacea	IMMEDIATE MORTALITY	100.0 (33)	40.0 (25)	0.60	YES	85.7 (7)	33.3 (3)	0.62	NO
	LATENT MORTALITY	71.4 (14)	37.5 (8)	0.34	NO	43.0 (7)	34.4 (64)	0.09	NO
Copepoda	IMMEDIATE MORTALITY	81.1 (74)	17.0 (42)	0.79	YES	76.0 (96)	62.5 (64)	0.18	NO
	LATENT MORTALITY	0.0 (24)	18.7 (16)	-0.19	YES[1]	0.0 (31)	0.0 (22)	0.0	NO
Acartia tonsa	IMMEDIATE MORTALITY	95.4 (109)	7.0 (131)	0.93	YES	80.5 (41)	48.2 (274)	0.40	YES
	LATENT MORTALITY	0.0 (14)	4.7 (43)	-0.05	NO	0.0 (46)	0.0 (71)	0.0	NO
Mysidacea	IMMEDIATE MORTALITY	100.0 (1)	15.0 (20)	0.85	NO	-	44.4 (9)	-	-
	LATENT MORTALITY	-	-	-	-	-	-	-	-
Decapoda	IMMEDIATE MORTALITY	100.0 (15)	40.0 (25)	0.60	YES	100.0 (9)	50.0 (14)	0.50	YES
	LATENT MORTALITY	4.3 (23)	57.7 (78)	-0.53	YES[1]	0.0 (34)	18.6 (43)	-0.19	YES[1]
Chaetognatha	IMMEDIATE MORTALITY	86.0 (8)	0.0 (4)	1.00	YES	44.4 (9)	-	-	
	LATENT MORTALITY	-	-	-	-	-	-	-	

000703

TABLE 9.5-1 (Concluded)

PLANKTON GROUP	ASSESSMENT	1-5 December 1979 % LIVE (n) I	1-5 December 1979 % LIVE (n) D	1-5 December 1979 Estimated Mortality Rate	1-5 December 1979 Sig?†	10-14 December 1979 % LIVE (n) I	10-14 December 1979 % LIVE (n) D	10-14 December 1979 Estimated Mortality Rate	10-14 December 1979 Sig?†
Other Zooplankton	IMMEDIATE MORTALITY	94.5 (199)	76.0 (185)	0.20	YES	33.3 (37)	51.7 (58)	-0.55	NO
	LATENT MORTALITY	-	-	-	-	-	-	-	-
Other Crustacea	IMMEDIATE MORTALITY	100.0 (3)	90.9 (11)	0.09	NO	97.9 (48)	36.2 (29)	0.12	NO
	LATENT MORTALITY	-	-	-	-	-	-	-	-
Copepoda	IMMEDIATE MORTALITY	82.3 (158)	86.6 (95)	-0.05	NO	81.3 (91)	87.1 (85)	-0.07	NO
	LATENT MORTALITY	70.6 (17)	33.3 (15)	0.37	YES	33.3 (21)	45.5 (11)	-0.12	NO
Acartia tonsa	IMMEDIATE MORTALITY	59.9 (212)	73.1 (390)	-0.22	NO	72.2 (302)	66.0 (319)	0.09	NO
	LATENT MORTALITY	47.4 (95)	0.0 (76)	0.47	YES	46.4 (69)	41.6 (101)	0.05	NO
Mysidacea	IMMEDIATE MORTALITY	0.0 (1)	75.0 (16)	-	NO	71.4 (7)	34.0 (27)	0.52	NO
	LATENT MORTALITY	84.2 (95)	41.3 (75)	0.43	YES	83.1 (77)	75.6 (82)	0.08	NO
Decapoda	IMMEDIATE MORTALITY	83.3 (12)	83.3 (18)	0.0	NO	80.6 (31)	100.0 (7)	-0.24	NO
	LATENT MORTALITY	93.7 (79)[2]	42.5 (87)	0.51	YES	77.7 (103)	53.6 (69)	0.24	YES
Chaetognatha	IMMEDIATE MORTALITY	0.0 (1)	-	-	-	-	100.0 (1)	-	-
	LATENT MORTALITY	-	-	-	-	-	-	-	-

†Cochran's Test

[1]Significant Discharge Survival > Intake Survival

[2]Forty-eight Hour Incubation

TABLE 9.5-2
ENCINA POWER PLANT OPERATIONAL CHARACTERISTICS DURING ICHTHYOPLANKTON AND ZOOPLANKTON SAMPLING FOR ENTRAINMENT MORTALITY STUDIES IN 1979

DATE	CL?	ALL UNITS IN	ALL UNITS OUT	ΔT	STATION D	COOLING WATER FLOW RATE (PER HOUR)
14-15 Sept. 1979	OFF	23.5 ± 0.7° (74.3 ± 1.3°F)	33.9 ± 3.5° (93.1 ± 6.3°F)	10.4° (18.8°F)	30.5 ± 1.0° (87.0 ± 1.8°F)	UNITS 1-5 125.3 x 10^6 liters/hr (33.1 x 10^6 gal hr)
25 Sept. 1979	ON	21.3 ± 0.9° (70.4 ± 1.6°F)	30.2 ± 1.6° (86.4 ± 2.9°F)	8.9° (16.0°F)	29.1 ± 0.3° (84.3 ± 0.6°F)	UNITS 1-5 125.3 x 10^6 liters/hr (33.1 x 10^6 gal/hr)
Differences Significant?		YES†	YES††	YES ††		
1-2 Dec. 1979	OFF	15.2 ± 0.7° (59.3 ± 1.2°F)	24.8 ± 2.2° (76.6 ± 3.9°F)	9.6° (17.3°F)	23.0 ± 0.0° (74.0 ± 0.0°F)	UNITS 1, 3, 4, 5 114.7 x 10^6 liters/hr (30.3 x 10^6 gal/hr)
10-11 Dec. 1979	ON	16.2 ± 0.7° (61.2 ± 1.2°F)	27.2 ± 3.0° (80.9 ± 5.4°F)	10.9° (19.7°F)	25.6 ± 0.0° (78.0 ± 0.0°F)	UNITS 1-5 125.3 x 10^6 liters/hr (33.1 x 10^6 gal/hr)
Differences Significant?		YES†	NO††	YES ††		

000705

TABLE 9.5-2 (Continued)

DATE	CL?	UNIT 1 IN	UNIT 1 OUT	UNIT 1 ΔT	UNIT 2 IN	UNIT 2 OUT	UNIT 2 ΔT	UNIT 3 IN	UNIT 3 OUT	UNIT 3 ΔT
14-15 Sept. 1979	OFF	23.7 ± 0.3° (74.6 ± 0.5°F)	34.2 ± 1.1° (93.5 ± 1.9°F)	10.9° (18.9°F)	23.7 ± 0.3° (74.6 ± 0.5°F)	37.1 ± 0.9° (98.8 ± 1.6°F)	13.4° (24.2°F)	23.1 ± 0.3° (73.6 ± 0.5°F)	36.2 ± 1.2° (97.2 ± 2.2°F)	13.1° (23.6°F)
25 Sept. 1979	ON	21.7 ± 0.6° (71.1 ± 1.1°F)	28.7 ± 1.9° (83.7 ± 3.7°F)	7.0° (12.6°F)	21.7 ± 0.6° (71.1 ± 1.1°F)	30.9 ± 0.8° (87.7 ± 1.5°F)	9.2° (16.6°F)	20.9 ± 0.8° (69.6 ± 1.5°F)	31.6 ± 0.9° (88.9 ± 1.7°F)	10.7° (19.3°F)
Differences Significant?		YES†	YES†−	YES−†	YES †	YES ††	YES −−	YES −	YES ††	YES ††
1-2 Dec. 1979	OFF	15.8 ± 0.4° (60.5 ± 0.8°F)	25.9 ± 1.1° (78.6 ± 2.0°F)	10.1° (18.1°F)	DOWN	DOWN	DOWN	14.6 ± 0.2° (58.2 ± 0.4°F)	25.5 ± 1.1° (77.9 ± 2.0°F)	10.9° (19.7°F)
10-11 Dec. 1979	ON	16.7 ± 0.2° (62.1 ± 0.3°F)	27.1 ± 1.8° (80.8 ± 3.2°F)	10.4° (18.7°F)	16.7 ± 0.2° (62.1 ± 0.3°F)	30.7 ± 1.8° (87.2 ± 3.2°F)	13.9° (25.1°F)	15.7 ± 0.3° (60.2 ± 0.5°F)	28.8 ± 2.5° (83.9 ± 4.5°F)	13.2° (23.7°F)
Differences Significant?		YES†	NO−†	NO††	--	--	--	YES −	YES††	YES ††

000705

TABLE 9.5-2 (Concluded)

DATE	CL?	UNIT 4 IN	UNIT 4 OUT	UNIT 4 ΔT	UNIT 5 IN	UNIT 5 OUT	UNIT 5 ΔT
14-15 Sept. 1979	OFF	22.2 ± 0.0° (72.0 ± 0.0°F)	27.4 ± 3.3° (81.3 ± 6.0°F)	5.2° (9.3°F)	24.4 ± 0.4° (75.9 ± 0.8°F)	33.3 ± 0.5° (91.9 ± 0.9°F)	8.9° (16.0°F)
25 Sept. 1979	ON	20.5 ± 0.5° (68.9 ± 0.9°F)	30.2 ± 2.6° (86.3 ± 4.6°F)	9.7° (17.4°F)	21.8 ± 0.9° (71.3 ± 1.6°F)	29.3 ± 1.0° (84.7 ± 1.8°F)	7.4° (13.4°F)
Differences Significant?		YES †	NO ††	YES ††	YES †	YES §	YES †
1-2 Dec. 1979	OFF	14.6 ± 0.2° (58.2 ± 0.4°F)	24.1 ± 1.3° (75.4 ± 2.4°F)	9.6° (17.3°F)	15.7 ± 0.3° (60.3 ± 0.5°F)	23.5 ± 0.3° (74.3 ± 0.5°F)	7.8° (14.0°F)
10-11 Dec. 1979	ON	15.2 ± 0.3° (59.4 ± 0.6°F)	24.8 ± 1.9° (76.7 ± 3.5°F)	9.6° (17.3°F)	16.7 ± 0.2° (62.1 ± 0.3°F)	24.3 ± 0.3° (75.7 ± 0.6°F)	7.6° (13.6°F)
Differences Significant?		YES †	NO ††	NO ††	YES †	YES ††	YES ††

† = t-Test
†† = Square Root Transformed Data, then t-Test
§ = Mann-Whitney U-Test

9.5-1). Inspection of the basement log for Unit 4 revealed a constant decrease in water temperature from 32.2 C (90 F) to 20 C (68 F) on the discharge side of the condensers during the first 6 hr of sampling. The unit was off-line during the final 3 hr of sampling. The average change in water temperature for Unit 4 during this period, 5.2 C (9.3 F), was the lowest observed for any unit during the four experiments. The average change in water temperature for all units exclusive of Unit 4 was 11.5 C (20.7 F). The total water flow rate with all five units on-line was 125.3 million liters (33.1 mgh). After Unit 4 went off-line, flow rate decreased to 79.9 million liters/hr (31.1 mgh) (Table 9.5-2, Figure 9.5-1).

Intake water temperature for all units during sampling for the 1-5 December 1979 no chlorination run averaged 15 C (59 F). Water temperature immediately after condenser passage during this period averaged 25 C (77 F). The average change in temperature during sampling for this run was 10 C (18 F). Water temperature at Station D during this period was 23 C (74 F). Unit 2 was off-line the entire sampling period and therefore water flow rate was only 114.7 million liters/hr (30.3 mgh) (Table 9.5-2, Figure 9.5-1).

9.5.1.1 Initial Survival. Initial survival assessments without the chlorination system operating were performed 14 September 1979 and 1 December 1979. In each assessment, approximately 32 m^3 of water were sampled at intake and discharge stations.

9.5.1.1.1 Intake Collection. In the 14 September 1979 assessment, 95 percent of 109 *Acartia tonsa*, 81 percent of 74 individuals of other copepod species, 100 percent of 15 decapod larvae, 100 percent of 33 other crustacea, 100 percent of one mysid, seven (88 percent) of eight chaetognaths and 95 percent of 256 individuals of other zooplankton species were collected alive at the intake (Table 9.5-1, Figures 9.5-2 through 9.5-5).

In the 1 December 1979 experiment, 60 percent of 212 *Acartia tonsa*, 82 percent of 158 individuals of other copepod species, 10 (83 percent) of 12 decapod larvae, 100 percent of three other crustacea, 0 percent of 1 mysid, 0 percent of 1 chaetognath, and 95 percent of 199 individuals of other zooplankton species were recovered alive at the intake (Table 9.5-1, Figures 9.5-2 through 9.5-5).

9.5.1.1.2 Discharge Collection. In the 14 September 1979 assessment, 7 percent of 131 *Acartia tonsa*, 17 percent of 42 individuals of other copepod species, 40 percent of 25 decapod larvae, 40 percent of 25 other crustacea, 15 percent of 20 mysids, 0 percent of 4 chaetognaths, and 14 percent of 28 individuals of other zooplankton species were collected alive at the discharge (Table 9.5-1, Figures 9.5-2 through 9.5-5).

In the 1 December 1979 experiment, 73 percent of 390 *Acartia tonsa*, 87 percent of 95 individuals of other copepod species, 83 percent of 18 decapod larvae, 10 (91 percent) of 11 other crustacea, 12 (75 percent) of 16 mysids, and 76 percent of 185 individuals of other zooplankton species were recovered alive at the discharge (Table 9.5-1, Figures 9.5-2 through 9.5-5). Chaetognaths were not collected during discharge sampling.

In the 14 September 1979 assessment, the differences in percent initial survival of <u>Acartia tonsa</u> between intake and discharge samples was significant (Cochran's test) and the estimated mortality rate was 0.93 (Table 9.5-1). Calculated initial mortality rates for the remaining invertebrate zooplankton groups were - other copepod species: 0.79, statistically significant; decapod larvae: 0.60, significant; other crustacea: 0.60, significant; mysids: 0.85,not significant; chaetognaths: 1.00, significant; and other zooplankton species: 0.85, significant (Table 9.5-1).

In the 1 December 1979 experiment, the following initial mortality rates were calculated - <u>Acartia tonsa</u>: 0.22, not significant; other copepod species: 0.05, not significant; decapod larvae: 0.00, not significant; other crustacea: 0.09, not significant; mysids: 0.00, not significant; and other zooplankton species: 0.20, significant (Table 9.5-1).

000710

9.5.1.2 Delayed. Delayed effects on mortality induced by thermal and mechanical components of entrainment were assessed 14-18 September 1979 and 1-5 December 1979. Sampling was performed 14 September 1979 and 1 December 1979 when the chlorination system was not operational. The results of bioassays reported are values observed at the end of 96 hr of incubation, except where indicated.

The ambient water temperatures experienced by ichthyoplankton and zooplankton during incubations for latent survival analyses of thermal and mechanical effects of entrainment are graphically presented in Figures 9.5-6 and 9.5-7. Appendix Table 16.3-64 contains a summary of data for all experiments.

The incubation water temperature range during the 14-18 September 1979 no chlorination run was from 20.5 to 26 C (68.9 to 78.8 F). The average temperature fluctuation during incubation was 2.2 C (4.0 F) with a range from 0.5 to 4.0 C (0.9 to 7.2 F). A total of 17 fluctuations occurred during the course of incubation. The mean value of all temperature data was 24 C (75 F) during this experiment (Figure 9.5-6).

The incubation water temperature range during the 1-5 December 1979 no chlorination run was from 8 to 11.2 C (46.4 to 52.2 F). The average temperature fluctuation was 1.2 C (2.2 F) with a range from 0.5 to 2.0 C (0.9 to 3.6 F). There were a total of 16 fluctuations observed during incubation. The mean value of all temperature data during this incubation was 9.6 C (49.3 F) (Figure 9.5-7).

9.5.1.2.1 Intake Sample Bioassay. In the 14-18 September 1979 intake bioassays, the following results were observed: 0 percent of 14 *Acartia tonsa*, 0 percent of 24 individuals of other copepod species, 4 percent of 23 decapod larvae, 71 percent of 14 other crustacea, and 33 percent of 15 individuals of other zooplankton species were alive at the end of 96 hr incubations (Table 9.5-1, Figures 9.5-8 through 9.5-12). Mysids and chaetognaths were not collected in sufficient numbers for latent survival assessments. Approximately 154 m^3 of waterwere sampled to generate those numbers of organisms.

In the 1-5 December 1979 intake bioassay, 47 percent of 95 *Acartia tonsa*, 71 percent of 17 individuals of other copepod species, 94 percent of 79 decapod larvae (48-hr incubation), and 84 percent of 95 mysids were alive at the end of incubation (Table 9.5-1, Figures 9.5-8 through 9.5-10, 9.5-13). Other crustacea, chaetognaths, and other zooplankton species were not recovered in sufficient numbers for latent survival assessments. Approximately 193 m^3 of water were sampled in generating the above number of organisms.

9.5.1.2.2 Discharge Sample Bioassay. In the 14-18 September 1979 discharge bioassays: 5 percent of 43 *Acartia tonsa* 19 percent of 16 individuals of other copepod species, 58 percent of 78 decapod larvae, 38 percent of 8 other

000712

crustacea, and 25 percent of 8 individuals of other zooplankton species were alive after 96 hr incubations (Table 9.5-1, Figures 9.5-8 through 9.5-12). Low numbers of mysids and chaetognaths precluded delayed bioassay. Approximately 154 m^3 of water were sampled.

In the 1-5 December 1979 discharge bioassays, 0 percent of 76 Acartia tonsa, 33 percent of 15 individuals of other copepod species, 43 percent of 87 decapod larvae (48 hr incubation), and 41 percent of 75 mysids were alive at the end of incubations (Table 9.5-1, Figures 9.5-8 through 9.5-10, 9.5-13). Other crustacea, chaetognaths, and other zooplankton species were not collected in sufficient numbers for latent analyses. Approximately 400 m^3 of water were sampled in generating the above number of organisms.

9.5.1.2.3 Delayed Mortality. Differences in delayed mortality percentages for intake and discharge collections after incubation for all invertebrate zooplankton groups in each run were statistically analyzed using Cochran's test.

In the 14-18 September 1979 experiment, statistical analyses indicated that entrainment did not affect all the plankton groups in the same way during incubations. The differences in percent survival after incubation between intake and discharge collections gave estimates of the following mortality rates: -0.05 for Acartia tonsa, not significant; 0.19 for other copepod species, significant;

-0.53 for decapod larvae, significant; 0.34 for other crustacea, not significant; and 0.08 for other zooplankton species, not significant (Table 9.5-1).

In the 1-5 December 1979 experiment, all plankton groups tested exhibited significant reductions in latent survival after entrainment: 0.47 for Acartia tonsa, 0.37 for other copepod species, 0.51 for decapod larvae, and 0.43 for mysids (Table 9.5-1).

9.5.2 Thermal, Mechanical and Chemical Effects

Two assessments (24-29 September 1979 and 10-14 December 1979) were performed while the plant chlorination system was operational in order to assess thermal, mechanical, and chemical effects on entrained invertebrate zooplankton.

The average intake water temperature for all units during sampling for the 24-29 September 1979 chlorination run was 21 C (70 F). Immediately after condenser passage, the water temperature averaged 30 C (86 F). Thus, the change in water temperature during sampling was 9 C (16 F). Discharge water temperature at Station D was observed to be 29 C (84 F). All units were on-line throughout the sampling period and the water flow rate was 125.3 million liters/hr (33.1 mgh) (Table 9.5-2, Figure 9.5-1).

In the 10-14 December 1979 chlorination run, for all units, an average intake water temperature of 16 C (61 F) was observed during sampling. Water temperature immediately after condenser passage during this period averaged 27 C (81 F). The average change in water temperature was 11 C (20 F). That was the highest temperature change observed during experimentation. Discharge water temperature at Station D was 25.6 C (78 F). Total water flow rate was 125.3 million liters/hr (33.1 mgh) as all units were on-line (Table 9.5-1, Figure 9.5-1).

9.5.2.1 Initial Survival. Initial survival assessments during normal plant operations with chlorination were performed 24 September 1979 and 10 December 1979. In each assessment, approximately 32 m^3 of water were sampled at the intake and discharge stations.

9.5.2.1.1 Intake Collection. In the 24 September 1979 experiment, 81 percent of 41 *A. tonsa*, 76 percent of 96 individuals of other copepod species, 100 percent of 9 decapod larvae, 6 (86 percent) of 7 other crustacea, 5 (56 percent) of 9 chaetognaths, and 80 percent of 117 individuals of other zooplankton species were collected alive at the intake (Table 9.5-1, Figures 9.5-2 through 9.5-5). Mysids were not recovered at the intake during sampling.

In the 10 December 1979 assessment, 72 percent of 302 *A. tonsa*, 81 percent of 91 individuals of other copepod species, 81 percent of 31 decapod larvae, 98 percent of 48 other crustacea, 5 (71 percent) of 7 mysids and 33 percent of 37 individuals of other zooplankton species were collected alive at the intake (Table 9.5-1, Figures 9.5-2 through

9.5-5. Chaetognaths were not collected during intake sampling.

9.5.2.1.2 Discharge Collection. In the 24 September 1979 experiment, 48 percent of 274 *A. tonsa*, 63 percent of 64 individuals of other copepod species, 7 (50 percent) of 14 decapod larvae, 1 (33 percent) of 3 other crustacea, 5 (56 percent) of 9 mysids, and 55 percent of 55 individuals of other zooplankton species were collected alive at the discharge (Table 9.5-1, Figures 9.5-2 through 9.5-5). Chaetognaths were not collected during intake sampling.

In the 10 December 1979 assessment, 66 percent of 319 *A. tonsa*, 87 percent of 85 individuals of other copepod species, 100 percent of seven decapod larvae, 86 percent of 29 other crustacea, 34 percent of 27 mysids, 1 chaetognath, and 52 percent of 58 individuals of other zooplankton species were collected alive at the discharge (Table 9.5-1, Figures 9.5-2 through 9.5-5).

In the 24 September 1979 assessment, the calculated initial mortality rate of *A. tonsa* was 0.40 and significant (Table 9.5-1). Initial mortality rates for the remaining invertebrate zooplankton groups were - other copepod species: 0.18, not significant; decapod larvae: 0.50, significant; other crustacea: 0.62, not significant; and other zooplankton species: 0.31, significant (Table 9.5-1). Mysids and chaetognaths were not captured at both intake and discharge stations.

In the 10 December 1979 assessment, the following initial mortality rates were observed - A. tonsa: 0.09, not significant; other copepod species: -0.07, not significant; decapod larvae: -0.24, not significant; other crustacea: 0.12, not significant; mysids: 0.52, not significant; and other zooplankton species: -0.55, not significant (Table 9.5-1).

9.5.2.2 Delayed. Delayed effects induced by thermal, mechanical, and chemical components of entrainment were assessed 24-29 September 1979 and 10-14 December 1979. Sampling was performed 24 September 1979 and 10 December 1979 when the chlorination system was operational. The results of bioassays reported are values observed at the end of incubations.

The ambient water temperatures experienced by test organisms during incubations for latent survival analyses of the thermal, mechanical, and chemical effects of entrainment are graphically presented in Figures 9.5-14 and 9.5-15. Appendix Table 16.3-64 contains a compilation of data for all experiments.

In the 24-29 September 1979 chlorination run, incubation temperatures ranged from 14 to 21.8 C (57 to 71.2 F). A total of 13 fluctuations averaging 4.0 C (7.2 F) occurred during incubation with a range from 2 to 5.8 C (3.6 to 10.4 F). The mean value of all temperature data during this run was 17 C (62.6 F) (Figure 9.5-14).

In the 10-14 December 1979 chlorination run, incubation temperatures ranged from 6 to 12.5 C (42.8 to 54.5 F). A total of

10 fluctuations occurred during the experiment with an average of 1.9 C (3.4 F). The range in fluctuations was 0.3 to 5.3 C (0.5 to 9.5 F). The mean value of all temperature data during this incubation was 8.5 C (47.3 F) (Figure 9.5-15).

9.5.2.2.1 Intake Sample Bioassay. In the 24-29 September 1979 intake bioassays, the following results were observed: 0 percent of 46 *A. tonsa*; 0 percent of 31 individuals of other copepod species; 0 percent of 34 decapod larvae, 43 percent of 7 other crustacea, and 9 percent of 34 individuals of other zooplankton species were alive at the end of incubations (Table 9.5-1, Figures 9.5-11, 9.5-12, 9.5-16, 9.5-17, 9.5-18). Mysids and chaetognaths were not sufficiently abundant for latent assessments. Approximately 175 m^3 of water were sampled in generating the above number of organisms.

In the 10-14 December 1979 intake bioassay, 46 percent of 69 *A. tonsa*, 33 percent of 21 individuals of other copepod species, 78 percent of 103 decapod larvae, and 83 percent of 77 mysids were alive at the end of incubations (Table 9.5-1, Figures 9.5-13, 9.5-16, 9.5-17, 9.5-18). Other crustacea, chaetognaths, and other zooplankton species were not recovered in sufficient quantities for latent assessments. Approximately 212 m^3 of water were sampled in generating the above number of organisms.

9.5.2.2.2 Discharge Sample Bioassay. In the 24-29 September 1979 discharge bioassays, 0 percent of 71 *A. tonsa*, 0 percent of 22 individuals of other copepod species, 19 percent of 43 decapod larvae, 34 percent of 64 other crustacea, and 10 percent of 29 individuals of other zooplankton species were alive at the end of incubation (Table 9.5-1, Figures 9.5-11, 9.5-12, 9.5-16, 9.5-17, 9.5-18). Mysids and chaetognaths were not recovered in sufficient numbers for latent assessments. Approximately 175 m^3 of water were sampled to derive those numbers of organisms.

In the 10-14 December 1979 discharge bioassays, 41.6 percent of 101 *A. tonsa*, 5 (45 percent) of 11 individuals of other copepod species, 54 percent of 69 decapod larvae, and 76 percent of 82 mysids were alive at the end of incubations (Table 9.5-1, Figures 9.5-13, 9.5-16, 9.5-17, 9.5-18). Other crustacea, chaetognaths, and other zooplankton species were not collected in sufficient quantities for latent assessments. Approximately 193 m^3 of water were sampled in generating the above number of organisms.

9.5.2.2.3 Delayed Mortality. Differences in latent survival percentages for intake and discharge collections after incubations for all invertebrate zooplankton groups in each run were statistically analyzed using Cochran's test.

000719

In the 24-29 September 1979 assessment, the difference in percent survival after incubations between intake and discharge collections yield mortality rate estimates of 0.00 for A. tonsa, not significant; 0.00 for other copepod species, not significant; -0.19 for decapod larvae, significant; 0.09 for other crustacea, not significant; and -0.02 for other zooplankton species, not significant (Table 9.5-1).

In the 10-14 December 1979 experiment, the following differences in survival between intake and discharge collections yielded mortality rate estimates of: 0.05 for A. tonsa, not significant; -0.12 for other copepod species, not significant; 0.24 for decapod larvae, significant; and 0.08 for mysids, not significant (Table 9.5-1).

Total mortality rate estimates for zooplankton for summer and winter seasons are compiled in Table 9.5-3.

9.5.3 Predation

Two assessments were performed in an effort to estimate the magnitude of predation on invertebrate zooplankton by nekton populations maintaining themselves in the intake tunnels of the Plant. The procedures used for those assessments are contained in the Appendix methodology (Section 16.2). The first assessment, 19 July 1979, was performed 33 days after a tunnel recirculation (heat treatment) and employed 335μ and 505μ mesh size nets. The second assessment was performed on 22 August 1979,

TABLE 9.5-3
TOTAL MORTALITY RATE ESTIMATES FOR THE ENCINA POWER PLANT FOR SUMMER AND WINTER PERIODS IN 1979

Group	Summer			Winter		
	IM	DM	TM	IM	DM	TM
Other Zooplankton	0.58	0.04	0.61	0.10	n/d	0.10
Other Crustacea	0.61	0.22	0.69	0.11	n/d	0.11
Copepoda	0.40	0.00	0.40	0.00	0.37	0.37
A. tonsa	0.66	0.00	0.66	0.00	0.24	0.24
Mysidacea	0.85	n/d	0.85	0.52	0.25	0.64
Decapoda	0.55	0.00	0.55	0.00	0.38	0.38
Chaetognatha	1.00	n/d	1.00	1.00†	n/d	1.00
Fish Eggs	0.87	0.02	0.87	0.62	0.00	0.62
Fish	1.00	-	1.00	1.00	-	1.00

LEGEND

IM (% Dead) = $1 - \frac{\text{D \% Live}}{\text{I \% Live}}$

DM (% Dead) = I% Live - D% Live

TM = Total mortality

†Summer rate estimate

n/d = no data

000721

24 days after a tunnel recirculation, and only 505μ mesh nets were used.

The 19 July 1979, 335μ mesh data for all traveling screen stations (TS 1, TS 4, TS 5) were combined and compared with intake data using the Mann-Whitney U-test. The 19 July 1979, 505μ mesh data and the 22 August 1979, 505μ mesh data were subjected to the same analysis. In addition, the 505μ mesh data from the 19 July 1979 and 22 August 1979 sampling runs were combined in order to compare the intake with individual traveling screens using the Mann-Whitney U-test. In a final analysis, all of the 505μ mesh data for intake and traveling screen stations for both sampling dates were combined. Abundances at the intake and the traveling screens in combination were tested for significant differences using the Wilcoxon sign rank test (9-25).

Results of all predation sampling are presented in Table 9.5-4. In almost all cases, there was either no significant difference between numbers of organisms captured at the intake and numbers captured at traveling screens or where significant differences were observed, greater numbers were taken at traveling screens than at the intake (Table 9.5-4). Only two groups (fish eggs and chaetognaths) showed a decrease during one of the experiments which was significant (Table 9.5-4). Generally, there appeared to be no significant predation in intake tunnels.

TABLE 9.5-4
COMPILATION AND ANALYSES OF RESULTS OF PREDATION STUDIES AT THE ENCINA POWER PLANT IN 1979

DATE/COMPARISON (Statistical Test)	FISH			FISH EGGS			*Acartia tonsa*		
	I	TS	Sig?*	I	TS	Sig?*	I	TS	Sig?*
19 July 1979 335 μ I versus all TS n = 3/station (Mann-Whitney U)	12.9 ± 10.8	6.1 ± 3.5	NO	357.6 ± 75.7	168.2 ± 106.1	NO	2495.0 ± 2016.0	3139.7 ± 1962.7	NO
19 July 1979 505 μ I versus all TS n = 3/station (Mann-Whitney U)	0.7 ± 1.3	2.3 ± 0.0	NO	177.3 ± 31.8	76.5 ± 19.1	YES	10.6 ± 14.6	51.5 ± 42.0	NO
22 Aug. 1979 505 μ I versus all TS n = 6/station (Mann-Whitney U)	3.4 ± 1.9	7.6 ± 2.8	YES	59.1 ± 40.6	73.8 ± 75.3	NO	19.3 ± 20.7	53.4 ± 91.5	NO
19 July + 22 Aug. (Combined) 505 μ I versus TS1 n= 3/station (Mann-Whitney U)	2.3 ± 2.3	5.3 ± 3.5	NO	122.7 ± 76.5	134.1 ± 61.9	NO	28.8 ± 26.4	129.6 ± 95.5	NO
19 July + 22 Aug. (Combined) 505 μ I versus TS4 n = 3/station (Mann-Whitney U)	3.8 ± 2.6	7.6 ± 4.7	NO	115.9 ± 58.3	58.3 ± 6.6	NO	19.7 ± 7.0	18.2 ± 8.2	NO
19 July + 22 Aug. (Combined) 505 μ I versus TS5 n = 3/station (Mann-Whitney U)	1.5 ± 1.3	4.5 ± 2.3	NO	56.8 ± 77.0	31.8 ± 47.3	NO	0.8 ± 1.3	10.6 ± 14.4	NO
19 July + 22 Aug (Combined) 505 μ I versus all TS n = 9/station Wilcoxon Sign Rank	2.5 ± 2.1	5.8 ± 3.4	YES	98.5 ± 69.1	74.7 ± 60.3	NO	16.4 ± 18.4	52.8 ± 75.3	NO

000723

TABLE 9.5-4 (Continued)

DATE/COMPARISON (Statistical Test)	OTHER COPEPODS			CHAETOGNATHS			DECAPOD LARVAE		
	I	TS	Sig?*	I	TS	Sig?*	I	TS	Sig?*
19 July 1979 335 μ I versus all TS n = 3/station (Mann-Whitney U)	551.5 ± 279.5	457.6 ± 286.7	NO	75.0 ± 38.8	0.8 ± 1.3	YES	120.5 ± 56.5	233.3 ± 208.2	NO
19 July 1979 505 μ I versus all TS n = 3/station (Mann-Whitney U)	38.6 ± 39.4	199.2 ± 92.5	YES	3.0 ± 3.5	3.0 ± 2.6	NO	20.4 ± 19.4	38.6 ± 6.9	NO
22 Aug. 1979 505 μ I versus all TS n = 6/station (Mann-Whitney U)	14.0 ± 10.9	19.3 ± 24.4	NO	82.3 ± 109.2	240.9 ± 333.9	NO	12.9 ± 11.3	51.2 ± 82.4	NO
19 July + 22 Aug. (Combined) 505 μ I versus TS1 n= 3/station (Mann-Whitney U)	40.9 ± 36.1	119.7 ± 125.7	NO	16.7 ± 16.1	394.7 ± 440.7	NO	22.0 ± 10.2	100.0 ± 102.4	YES
19 July + 22 Aug. (Combined) 505 μ I versus TS4 n = 3/station (Mann-Whitney U)	23.5 ± 5.2	86.4 ± 133.8	NO	150.0 ± 124.9	87.1 ± 116.6	NO	22.0 ± 16.0	22.0 ± 8.6	NO
19 July + 22 Aug. (Combined) 505 μ I versus TS5 n = 3/station (Mann-Whitney U)	2.3 ± 2.3	31.8 ± 53.2	NO	0.8 ± 1.3	3.0 ± 3.5	NO	2.3 ± 2.3	18.9 ± 17.0	YES
19 July + 22 Aug (Combined) 505 μ I versus all TS n = 9/station Wilcoxon Sign Rank	22.2 ± 24.8	79.3 ± 103.0	NO	55.8 ± 94.9	160.9 ± 290.0	NO	15.4 ± 13.7	47.0 ± 65.6	YES

000724

TABLE 9.5-4 (Concluded)

DATE/COMPARISON (Statistical Test)	MYSIDACEA			OTHER CRUSTACEA			OTHER ZOOPLANKTON		
	I	TS	Sig?*	I	TS	Sig?*	I	TS	Sig?*
19 July 1979 335 μ I versus all TS n = 3/station (Mann-Whitney U)	0.0 ± 0.0	42.4 ± 37.8	NO	353.8 ± 51.9	400.0 ± 175.6	NO	325.7 ± 419.2	31.1 ± 10.8	NO
19 July 1979 505 μ I versus all TS n = 3/station (Mann-Whitney U)	0.8 ± 1.3	3.8 ± 4.7	NO	88.6 ± 104.3	105.3 ± 61.5	NO	8.3 ± 9.2	28.0 ± 22.1	NO
22 Aug. 1979 505 μ I versus all TS n = 6/station (Mann-Whitney U)	0.0 ± 0.0	3.4 ± 3.7	YES	6.1 ± 6.0	62.5 ± 77.1	YES	3.8 ± 9.3	30.3 ± 27.7	YES
19 July + 22 Aug. (Combined) 505 μ I versus TS1 n= 3/station (Mann-Whitney U)	0.0 ± 0.0	8.3 ± 1.3	YES	13.6 ± 11.4	137.9 ± 89.8	YES	2.3 ± 3.9	57.6 ± 17.7	YES
19 July + 22 Aug. (Combined) 505 μ I versus TS4 n = 3/station (Mann-Whitney U)	0.8 ± 1.3	2.3 ± 0.0	NO	17.4 ± 12.5	68.2 ± 49.5	YES	7.6 ± 13.1	11.4 ± 10.4	NO
19 July + 22 Aug. (Combined) 505 μ I versus TS5 n = 3/station (Mann-Whitney U)	0.0 ± 0.0	0.0 ± 0.0	NO	69.7 ± 120.7	24.3 ± 10.5	NO	6.7 ± 10.0	19.7 ± 12.9	NO
19 July + 22 Aug (Combined) 505 μ I versus all TS n = 9/station Wilcoxon Sign Rank	0.3 ± 0.8	3.5 ± 3.8	NO	33.6 ± 66.7	76.8 ± 71.5	NO	5.3 ± 8.9	29.6 ± 24.5	YES

000725

9.6 ICHTHYOPLANKTON

Table 9.6-1 summarizes the results of immediate and latent survival analyses for ichthyoplankton larvae and eggs. Data for all ichthyoplankton species collected for an assessment were combined in order to generate adequate numbers for statistical analyses. Differences in immediate and latent reductions in percent survival between control (intake) and entrained (discharge) organisms were tested for significance (0.05 level) using Cochran's test. Appendix Tables 16.3-65 and 16.3-66 summarize the species composition of those ichthyoplankton groups collected for immediate and latent survival assessments.

9.6.1 Thermal and Mechanical Effects

Two assessments were performed while the plant chlorination system was not operating in order to assess thermal and mechanical effects of entrainment on ichthyoplankton.

9.6.1.1 Initial Survival. Initial survival assessments without the chlorination system operating were performed 14 September 1979 and 1 December 1979. Plant operations during sampling were described earlier (Section 9.5-1). Assessments were made during peak ambient water temperatures in September and low ambient water temperatures in December.

9.6.1.1.1 Intake Collection. In the 14 September 1979 assessment, 10 of 12 larval fish collected at the intake were alive (Table 9.6-1, Figure 9.6-1). Of the ten live

TABLE 9.6-1
COMPILATION OF RESULTS OF ICHTHYOPLANKTON ENTRAINMENT MORTALITY STUDIES AT THE ENCINA POWER PLANT IN 1979

PLANKTON GROUP	ASSESSMENT	14-18 Sept. 1979 % LIVE (n) I	D	ESTIMATED MORTALITY RATE	Sig?*	24-29 Sept. 1979 % LIVE (n) I	D	ESTIMATED MORTALITY RATE	Sig?*
FISH EGGS	IMMEDIATE MORTALITY	100.0 (345)	9.6 (136)	0.90	YES	100.0 (40)	16.1 (87)	0.84	YES
	LATENT MORTALITY	3.7 (107)	0.0 (4)	0.04	NO	0.0 (5)	0.0 (28)	0.00	NO
FISH	IMMEDIATE MORTALITY	83.3 (12)	0.0 (33)	1.00	YES	19.2 (26)	0.0 (32)	1.00	YES
	LATENT MORTALITY	34.8 (23)	-	-	-	100.0 (4)	-	-	-

000727

TABLE 9.6-1 (Concluded)

PLANKTON GROUP	ASSESSMENT	1-4 Dec. 1979 % LIVE (n) I	D	ESTIMATED MORTALITY RATE	Sig?*	10-14 Dec. 1979 % LIVE (n) I	D	ESTIMATED MORTALITY RATE	Sig?*
FISH EGGS	IMMEDIATE MORTALITY	100.0 (2)	30.0 (10)	0.70	NO	95.0 (19)	44.0 (9)	0.54	YES
	LATENT MORTALITY	0.0 (3)	0.0 (27)	0.00	NO	-	0.0 (7)	-	-
FISH	IMMEDIATE MORTALITY	21.2 (52)	0.0 (12)	1.00	NO	46.5 (114)	0.0 (25)	1.00	YES
	LATENT MORTALITY	21.4 (35)	-	-	-	28.0 (50)	-	-	-

Legend:
- * = Significant at 95% level.
- I = Intake
- D = Discharge

fish, six were Hypsopsetta guttulata, three were family Clinidae and one was family Cottidae. The dead larval fish (n=2) were: one family Sciaenidae and one family Gobiidae (Appendix Table 16.3-65). For fish eggs, 100 percent of 345 eggs were collected alive at the intake (Table 9.6-1, Figure 9.6-1). Approximately 97 percent of the eggs (n=336) were from the family Sciaenidae, the remaining three percent (n=9) were unidentifiable (Appendix Table 16.3-65). Approximately 32 m^3 of water were sampled in generating the above numbers of organisms.

In the 1 December 1979 experiment, 11 of 52 larval fish were collected alive at the intake (Table 9.6-1, Figure 9.6-1). Ten of the eleven live larvae were from the family Gobiidae and one was Hypsopsetta guttulata. Of the dead larvae (n=41), 19 were from the family Gobiidae, 18 were from the family Engraulidae, 2 were Clinidae, 1 was Sciaenidae, and 1 was Pleuronichthys ritteri (Appendix Table 16.3-65). In the fish egg assessment, all three eggs collected at the intake were alive (Table 9.6-1, Figure 9.6-1), two were unidentifiable, and the other egg was identified as Pleuronichthys ritteri (Appendix Table 16.3-65). Approximately 130 m^3 of water were sampled in generating the above number of organisms.

9.6.1.1.2 Discharge Collection. In the 14 September 1979 assessment, 0 percent of 33 larval fish collected were alive at the discharge (Table 9.6-1, Figure 9.6-1). Twenty-eight of the dead larvae were from the family Gobiidae, two were *Hypsoblennius* sp, two were Gobiescocidae and one was Engraulidae (Appendix Table 16.3-65). In the egg assessment, 9.6 percent of 136 eggs were collected alive at the discharge (Table 9.6-1, Figure 9.6-1) and all of the eggs were from the family Sciaenidae (Appendix Table 16.3-65). Approximately 32 m^3 of water were sampled in generating the above number of organisms.

In the 1 December 1979 experiment, 0 percent of the 12 larval fish collected were alive at the discharge (Table 9.6-1): 8 of the dead larvae were from the Gobiidae family and 4 were Clinidae larvae. In the egg assessment, three of ten eggs were collected alive at the discharge (Table 9.6-1): of the live eggs, two were unidentifiable, one was *Pleuronichthys ritteri*; of the seven dead eggs: five were unidentifiable, one was *Pleuronichthys ritteri*, and one was *Citharichthys* spp (Appendix Table 16.3-65). Approximately 130 m^3 of water were sampled.

In the 14 September 1979 assessment, the following initial mortality rates for ichthyoplankton were observed - larvae: 1.00, significant; fish eggs: 0.90, significant (Table 9.6-1).

In the 1 December 1979 assessment, the following differences were observed - larvae: 1.00, not significant; eggs: 0.70, not significant (Table 9.6-1).

9.6.1.2 Delayed. Latent effects on survival induced by thermal and mechanical components of entrainment were assessed 14-18 September 1979 and 1-5 December 1979. Sampling was performed 14 September 1979 and 1 December 1979 when the chlorination system was not operational. Plant operations during sampling and ambient water temperatures during incubations were described earlier (Section 9.5-1). The results of bioassays reported are values observed at the end of 96 hr of incubation.

9.6.1.2.1 Intake Sample Bioassay. In the 14-18 September 1979 intake assessment, 8(35 percent) of 23 larvae and 3.7 percent of 107 fish eggs were alive at the end of incubation (Table 9.6-1, Figures 9.6-2 and 9.6-3). The species composition of larvae was: live(n=8): 4 were Gobiidae, 2 were Sciaenidae, 1 was *Syngnathus* sp, and 1 was *Hypsoblennius* sp; dead(n=15): 13 were Gobiidae, 1 was *Exocoetidae*, and 1 was *Hypsoblennius* sp. All of the eggs collected were of the family Sciaenidae (Appendix Table 16.3-66). Approximately 160 m^3 of water were sampled to derive those numbers of organisms.

In the 1-5 December 1979 intake assessment, 4(11 percent) of 35 larval fish and 0 percent of 3 eggs were alive at the end of incubations (Table 9.6-1, Figures 9.6-2 and 9.6-3). All larval fish collected were members of the Gobiidae family. The fish eggs were unidentifiable

(Appendix Table 16.3-66). Approximately 200 m^3 of water were sampled to generate those numbers of organisms.

9.6.1.2.2 Discharge Sample Bioassay. In the 14-18 September 1979 experiment, no viable fish larvae were recovered from the discharge station. Approximately 200 m^3 of water were sampled in an effort to collect viable larvae and over 150 larvae were inspected for signs of vitality. In the egg assessment, 0 percent of 4 unidentified fish eggs were alive after incubation (Table 9.6-1, Figure 9.6-3, Appendix Table 16.3-66).

In the 1-5 December 1979 assessment, no living fish larvae were recovered from the discharge station. Approximately 250 m^3 of water were sampled in an effort to collect viable larvae and over 175 larvae were inspected for signs of vitality. In the egg assessment, 0 percent of 27 eggs were viable at the end of incubation: 22 were unidentified, 4 were *Citharichthys* sp and 1 was *Pleuronichthys ritteri* (Table 9.6-1, Figure 9.6-3, Appendix Table 16.3-66).

9.6.1.2.3 Delayed Mortality. In the 14-18 September 1979 assessment, the lack of viable fish larvae at the discharge precluded delayed mortality analysis. The delayed mortality rate for fish eggs amounted to 0.04 and was not significant (Table 9.6-1).

In the 1-5 December 1979 assessment, latent effects analysis could not be performed for larval fish due to the lack of viable larvae at the discharge. There was a 0.00 mortality rate calculated for fish eggs, not significant (Table 9.6-1).

9.6.2 Thermal, Mechanical, and Chemical Effects. Two assessments were performed while the plant chlorination system was operational in order to assess thermal, mechanical, and chemical effects of entrainment cn ichthyoplankton.

9.6.2.1 Initial Survival. Initial survival assessments with the chlorination system operational were performed 24 September 1979 and 10 December 1979. Plant operations during sampling were described earlier (Section 9.5.1).

9.6.2.1.1 Intake Collection. In the 24 September 1979 assessment, 5(19 percent) of the 26 larval fish and 100 percent of 40 eggs were collected alive at the intake station (Table 9.6-1). The larval fish species composition was: live (n=5) - 3 were *Syngnathus* sp, 1 was Gobiidae, and 1 was *Hypsopsetta guttulata*; dead (n=21) - 10 were *Hypsoblennius* sp, 8 were Gobiidae, 2 were *Syngnathus* sp, and 1 was *Chilotrema saturnum*. The egg species composition was: 30 Sciaenidae, 5 unidentified, 3 *Citharichthys* sp, and 2 Labridae (Appendix Table 16.3-65). Approximately 32 m^3 of water were sampled in generating the above number of organisms.

In the 10 December 1979 experiment, 53 (46 percent) of 114 larval fish and 18 (95 percent) of 19 eggs were collected alive at the intake station (Table 9.6-1, Figure 9.6-1).

The larval fish species composition was: live (n=53) - 48 Gobiidae and 5 Clinidae; dead (n=61) - 52 Gobiidae, 7 Clinidae, 1 Atherinidae and 1 Cottidae Type 7. The egg species composition was: live (n=18) - 9 Citharichthys sp, 3 Sciaenidae, 3 Pleuronichthys ritteri and 3 unidentified; dead (n=1) - 1 unidentified egg (Appendix Table 16.3-65). Approximately 130 m^3 of water were sampled in generating the above number of organisms.

9.6.2.1.2 Discharge Collections. In the 24 September 1979 assessment, 0 percent of 32 larval fish and 16.1 percent of 87 fish eggs were collected alive at the discharge (Table 9.6-1, Figure 9.6-1). The larval fish species composition was: 13 Engraulis mordax, 8 Seriphus politus, 5 Engraulidae, 3 Gobiidae, 1 Syngnathus sp, 1 Clinidae, and 1 Hypsoblennius sp. The egg species composition was: live (n=14) - 12 Sciaenidae, and 2 unidentified eggs; dead (n=73) - 70 Sciaenidae and 3 unidentified eggs (Appendix Table 9.6-65 Approximately 32 m^3 of water were sampled in generating the above number of organisms.

In the 10 December 1979 experiment, 0 percent of 25 larval fish and 4 (44 percent) of 9 eggs were collected alive at the discharge (Table 9.6-1, Figure 9.6-1). The larval fish species composition was: 23 Gobiidae and 2 Clinidae.

000734

The egg species composition was: live (n=4) - 2 Citharichthys sp, and 2 unidentified eggs; dead (n=5) - 3 Pleuronichthys ritteri, 1 Citharichthys sp, and 1 unidenti- egg (Appendix Table 16.3-65). Approximately 130 m^3 of water were sampled in generating the above number of organ- isms.

In the 24 September 1979 assessment, the following ini- tial mortality rates for ichthyoplankton were calculated - fish larvae: 1.00, significant, fish eggs: 0.84, significant (Table 9.6-1).

In the 10 December 1979 experiment, the following ini- tial mortality rates were calculated - fish larvae: 1.00, significant, fish eggs: 0.54, significant (Table 9.6-1).

9.6.2.2 Delayed. Delayed effects on survival induced by thermal, mechanical and chemical components of entrainment were assessed 24-29 September 1979 and 10-14 December 1979. Sampling was performed 24 September 1979 and 10 December 1979 when the chlorination system was operational. Plant operations during sampling and ambient water water tempera- tures during incubations have been described earlier (Section 9.5.1). The results of bioassays reported are va- lues observed at the end of 96 hr of incubation.

9.6.2.2.1 Intake Sample Bioassay. In the 24-29 September 1979 intake bioassay, 100 percent of 4 larval fish and 0 per- cent of 5 fish eggs were viable at the end of incubation

000735

(Table 9.6-1, Figures 9.6-2 and 9.6-4). Three of the larvae were Syngnathus sp and one was Hypsopsetta guttulata; two of the eggs were Sciaenidae and three were unidentified (Appendix Table 16.3.6). Approximately 175 m^3 of water were sampled in generating the above number of organisms.

In the 10-14 December 1979 intake bioassay, 14 (28 percent) of the 50 larval fish were alive at the end of incubation (Table 9.6-1, Figures 9.6-2 and 9.6-4). No fish eggs were collected. The larval fish species composition was: live (n=14) - 12 Gobiidae, 1 Clinidae and 1 Cottidae; dead (n=36) - 34 Gobiidae, 1 Clinidae and 1 Cottidae (Appendix Table 16.3-66). Approximately 175 m^3 of water were sampled in generating the above number of organisms.

9.6.2.2.2 Discharge Sample Bioassay. In the 24-29 September 1979 discharge bioassay, no viable larval fish were collected. Approximately 200 m^3 of water were sampled in an effort to collect living larvae and over 150 larvae were inspected for signs of vitality. In the egg assessment, 0 percent of 28 fish eggs were alive after incubation (Table 9.6-1, Figure 9.6-4). The egg species composition was: 16 Sciaenidae, 9 unidentified, 2 Pleuronichthys verticalis and 1 Pleuronectes sp (Appendix Table 16.3-66).

In the 10-14 December 1979 discharge bioassay, no viable larval fish were collected. Approximately 200 m^3 of water were sampled in an effort to recover live larvae and over 175 larvae were inspected for signs of vitality. In the egg bioassay, 0 percent of 7 eggs were alive at the end of incubation (Table 9.6-1, Figure 9.6-4). The egg species composition was: five unidentified, and two Pleuronichthys ritteri (Appendix Table 16.3-66).

9.6.2.2.3 Delayed Mortality. In the 24-29 September 1979 assessment, the lack of viable fish larvae at the discharge precluded delayed mortality analysis. The delayed mortality estimate for fish eggs after incubation was 0.0, not significant (Table 9.6-1).

In the 10-14 December 1979 experiment, delayed mortality analysis could not be performed for larval fish due to the lack of viable larvae at the discharge station; and for fish eggs due to the absence of eggs from intake collections (Table 9.6-1). Total mortality rates for ichthyoplankton in summer and winter seasons are summarized in Table 9.5-3.

9.6.3 Predation

Two assessments were performed in an effort to estimate the magnitude of predation on ichthyoplankton by nekton populations maintaining themselves in the intake tunnels of the plant. The procedures used for those assessments are described in the Appendix Methodology (Section 16.2). The first assessment, 19 July 1979, was performed 33 days after a tunnel recirculation and employed 335μ and 505μ mesh size nets. The second assessment was performed on 22 August 1979, 24 days after a tunnel recirculation, and only 505μ mesh nets were used. Data are summarized in Table 9.5-4.

The 19 July 1979, 335μ mesh data for all traveling screen stations (TS 1, TS 4, TS 5) were combined and compared with intake data using the Mann-Whitney U-test. The 19 July 1979, 505μ mesh data and the 22 August 1979, 505μ mesh data were subjected to the same analysis. In addition, the 505μ mesh data from the 19 July 1979 and 22 August 1979 sampling runs were combined in order to compare the intake with individual traveling screens using the Mann-Whitney U-test. In a final analysis, all of the 505μ mesh data for intake and traveling screen stations for both sampling dates were combined. Abundances at the intake and the traveling screens in combination were tested for significant differences using the Wilcoxon sign rank test.

Results of all predation sampling are presented in Table 9.5-4. In almost all cases there was either no significant difference between numbers of organisms captured at the intake and numbers captured at traveling screens or where significant differences were observed, greater numbers were taken at traveling screens than at the intake (Table 9.5-4). Only one comparison (fish eggs, 19 July 1979, 505μ mesh) showed a significant dedrease at the traveling screens compared with the intake. Generally, there appeared to be no significant predation on ichthyoplankton in the intake tunnels.

000738

9.7 QUANTITATIVE ESTIMATES OF SURVIVAL

Summer and winter total entrainment mortality rate estimates for the plankton groups are summarized in Table 9.5-3. In order to complete the mortality assessment, summer and winter seasons at the Encina location must be identified.

The average intake water temperatures during sampling for entrainment mortality assessments were 22.4 C (72.3 F) in September and 15.7 C (60.4 F) in December. The average of those values is 19.1 C (66.4 F). When intake water temperatures are less than 18 C (64.4 F), winter mortality rates apply. When intake water temperatures exceed 18 C, summer mortality rates apply. Therefore, the seasonal delineation was considered to be 18 C.

Figure 9.6-5 is a plot of intake and discharge temperatures recorded at Encina in 1979. Application of the 18 C delineation to that plot suggests that the summer season begins about the third week in May and ends the last week of October. The rest of the year was considered the winter season. In late September, the temperature drop observed was ignored and summer rates were considered to apply. This would lead to a small overestimation of total mortality. It is felt that the seasons are representative of actual events.

Quantitative estimates of biotic abundances from entrainment data were calculated. Appendix Section 16.2.5 contains the detailed methodologies used in calculations.

9.7.1 Phytoplankton

Quantitative estimates of entrainment effects on phytoplankton were not calculated as phytoplankton were only examined four times during entrainment mortality studies. Results of those experiments indicate that entrainment effects on phytoplankton productivity and biomass are generally negligible. In studies of two New England marine power plants (9-26), it was concluded that entrainment effects on phytoplankton at the ecosystem level are generally insignificant because phytoplankton species exhibit recovery from entrainment and fast generation times. Arguments such as these have prompted some reviewers (9-27) to recommend that phytoplankton studies generally may not be necessary in site-specific situations where the volume of water entrained is a small portion of the available volume, e.g., marine sites.

9.7.2 Invertebrate Zooplankton

Table 9.7-1 summarizes the quantitative estimates of each plankton group from 335μ and 505μ mesh entrainment data.

335μ Data: Sampling Period 5/18/79 - 12/26/79

The total number of other zooplankton estimated to have been entrained during the 335μ mesh sampling period was 1.620×10^9 individuals. Entrainment mortality rate calculations indicate that 5.520×10^8 of the entrained individuals were killed during entrainment. The estimated total number of other zooplankton present in the outer Agua Hedionda Lagoon during that period was 1.741×10^{10}. Therefore, the estimated number killed by entrainment

000740

TABLE 9.7-1
TOTAL NUMBER OF INVERTEBRATE ZOOPLANKTON ENTRAINED, KILLED DURING ENTRAINMENT, AND AVAILABLE IN OUTER AGUA HEDIONDA LAGOON AT THE ENCINA POWER PLANT IN 1979

PLANKTON GROUP	335 μ (5/18 - 12/26)				505 μ (1/22 - 12/26)			
	OL_A	E	K_E	% of OL	OL_A	E	K_E	% of OL
Other Zooplankton	1.741×10^{10}	1.620×10^{9}	5.520×10^{8}	3.2	1.417×10^{9}	1.539×10^{8}	6.450×10^{7}	4.6
Other Crustacea	5.543×10^{9}	1.868×10^{9}	1.148×10^{9}	20.7	2.657×10^{9}	9.115×10^{8}	2.369×10^{8}	8.9
Copepoda	1.050×10^{10}	1.843×10^{9}	9.415×10^{8}	9.0	1.215×10^{9}	7.314×10^{8}	2.743×10^{8}	22.6
Acartia tonsa	3.421×10^{10}	8.789×10^{9}	6.404×10^{9}	18.7	8.324×10^{8}	2.579×10^{9}	7.353×10^{8}	94.3
Mysidacea	7.225×10^{9}	1.353×10^{8}	1.021×10^{8}	14.1	9.903×10^{8}	4.527×10^{8}	2.993×10^{8}	30.2
Decapoda	6.030×10^{9}	2.411×10^{9}	1.292×10^{9}	21.4	2.238×10^{9}	1.501×10^{9}	6.125×10^{8}	27.4
Chaetognaths	1.292×10^{9}	2.795×10^{8}	2.795×10^{8}	21.6	5.808×10^{8}	5.278×10^{8}	5.278×10^{8}	90.9
Totals	7.570×10^{10}	1.690×10^{10}	1.072×10^{10}	14.2	9.930×10^{9}	6.860×10^{9}	2.801×10^{9}	28.2

LEGEND:

E = Number Entrained

K_E = Number Killed By Entrainment

OL_A = Number Available for Entrainment in Outer Agua Hedionda Lagoon represented 3.2 percent of the total number available (Table 9.7-1).

The total number of other crustacea estimated to have been entrained during 335μ sampling was 1.868×10^9 individuals. Of those, 1.148×10^9 individuals were estimated to have died during entrainment. The total number of other crustacea estimated to be present in the outer lagoon during that period was 5.543×10^9. Therefore, 20.7 percent of the total number of other crustacea available for entrainment were estimated to be killed during entrainment (Table 9.7-1).

Copepoda 335μ data indicates that 1.843×10^9 individuals were entrained by the plant during 335μ sampling. Mortality calculations estimate that 9.415×10^8 of those copepods were killed during entrainment. The estimate of the total number of copepods present in the outer lagoon during that period was 1.050×10^{10}. Thus, 9.0 percent of the lagoon copepods were estimated to be killed during entrainment (Table 9.7-1).

The following 335μ estimates were made for <u>Acartia</u> <u>tonsa</u>: 8.789×10^9 individuals were entrained during sampling; 6.404×10^9 of those individuals were killed during entrainment; and 3.421×10^{10} individuals were present in the outer lagoon during that period. Therefore, 18.7 percent of the available <u>A</u>. <u>tonsa</u> individuals were estimated to be killed during entrainment (Table 9.7-1).

Mysidacea 335μ data gave estimates of: 1.353×10^8 individuals entrained during sampling; 1.021×10^8 individuals were killed during entrainment, and 7.225×10^8 individuals were present in the outer lagoon during that period. Thus, 14.1 percent of the available mysids were estimated to be killed during entrainment in the 335μ mesh sampling period (Table 9.7-1).

The total number of decapods estimated to have been entrained during 335μ sampling was 2.411×10^9 individuals. Of those, 1.292×10^9 individuals were killed during entrainment. The total number of decapods estimated to be present in the outer lagoon was 6.030×10^9 individuals. Therefore, it is estimated that 21.4 percent of the available decapods in the outer lagoon were killed during entrainment (Table 9.7-1).

Chaetognatha 335μ data yielded the following estimates: 2.795×10^8 chaetognaths were entrained during sampling; the mortality rate was 1.00, therefore, 2.795×10^8 chaetognaths were killed during entrainment. The total number of chaetognaths in the outer lagoon during that period was 1.292×10^9 individuals. Thus, 21.6 percent of the available chaetognaths were estimated to be killed during entrainment (Table 9.7-1).

The total number of zooplankton that were estimated by 335μ mesh data to be entrained during the period from 5/18/79 - 12/26/79 was 1.690×10^{10}. Of those, 1.072×10^{10} were estimated to be killed during entrainment. The total number of zooplankton in the outer AHL during that period was 7.570×10^{10}. Thus 14.2 percent of the available invertebrate zooplankton were estimated to be killed during entrainment (Table 9.7-1).

505μ Mesh Data: Sampling Period 1/22/79 - 12/26/79

The total number of other zooplankton estimated to be entrained during the 505μ mesh sampling period was 1.539×10^8 individuals. Of those, 6.450×10^7 individuals were estimated to be killed during entrainment. The total number of other zooplankton estimated to have been present in the lagoon was 1.417×10^9 individuals. Therefore, 4.6 percent of the available individuals of other zooplankton species were estimated to have been killed during entrainment (Table 9.7-1).

The total number of other crustacea estimated to be entrained during 505μ sampling was 9.115×10^8 individuals. Of those, 2.369×10^8 individuals were estimated to have been killed during entrainment. The total number of other crustacea in the outer lagoon was 2.657×10^9. Thus 8.9 percent of the available crustacea were estimated to be killed during entrainment in the period from 1/22/79 to 12/26/79 (Table 9.7-1).

Copepod data yielded the following 505μ mesh data estimates: 7.314×10^8 copepods were entrained; of those, 2.743×10^8 individuals were killed; and 1.215×10^9 copepods were present during the sampling period in the outer lagoon. Thus, from 505μ mesh data, 22.6 percent of the available copepods were estimated to be killed during entrainment (Table 9.7-1).

The total number of *Acartia tonsa* individuals estimated to be entrained during 505μ sampling was 2.579×10^9. Of those, 7.853×10^8 individuals were killed during entrainment. The total number of *A. tonsa* individuals available in the outer AHL for entrainment was 8.324×10^8. Therefore, 94.3 percent of the number of *A. tonsa* individuals present in the outer lagoon were estimated to be killed during entrainment (Table 9.7-1).

The 505μ mesh estimates for Mysidacea were: 4.527×10^8 individuals were entrained, 2.993×10^8 were killed during entrainment and 9.903×10^8 were present in the outer lagoon. Thus, 30.2 percent of the available mysids were estimated to be killed during entrainment (Table 9.7-1).

Decapod data yielded the following estimates: 1.501×10^9 individuals were entrained during 505μ sampling; of those, 6.125×10^8 were killed during entrainment; and 2.238×10^9 were present in the outer lagoon. Therefore, 27.4 percent of the available decapods were estimated to be killed during entrainment (Table 9.7-1).

The total number of chaetognaths entrained during 505μ sampling was estimated to be 5.278×10^8. All of those individuals were predicted to die during entrainment. The total number of chaetognaths present in the outer lagoon during sampling was estimated to be 5.808×10^8 individuals. Thus, 90.9 percent of the available chaetognaths were estimated to be killed during entrainment (Table 9.7-1).

The total number of invertebrate zooplankton that were estimated to be entrained during 505μ sampling was 6.860×10^9. Of those, 2.801×10^9 individuals were estimated to be killed during entrainment. The total number of zooplankton present in the outer lagoon was 9.930×10^9. Thus, 28.2 percent of the available invertebrate zooplankton were estimated to be killed during entrainment in the 505μ mesh sampling period (Table 9.7-1).

9.7.3 Ichthyoplankton

Table 9.7-2 summarizes the quantitative estimates for ichthyoplankton from 335μ and 505μ mesh entrainment data.

335μ Mesh Data: Sampling Period 5/18/79 - 12/26/79

The total number of fish eggs estimated to be entrained during the 335μ mesh sampling period was 4.292×10^9. Of those, 3.719×10^9 eggs were estimated to be killed during entrainment. The total number of fish eggs estimated to be present in the outer lagoon during that period was 4.328×10^9. Therefore, 85.9 percent of the available fish eggs were estimated to be killed during entrainment in the 335μ mesh sampling period (Table 9.7-2).

The total number of larval fish estimated to be entrained during 335μ sampling was 6.700×10^8. All of those were estimated to be killed during entrainment. The total number of larvae estimated to be present in the outer lagoon for entrainment during sampling was 1.213×10^9. Thus, 55.2 percent of the available fish larvae were estimated to be killed during entrainment in the 335μ sampling period (Table 9.7-2).

The total number of ichthyoplankton (eggs + larvae) estimated to be entrained in the 335μ mesh sampling period was 4.96×10^9. The dominant taxonomic groups of that total according to entrainment data were individuals of the family Engraulidae (50.8

TABLE 9.7-2
TOTAL NUMBER OF ICHTHYOPLANKTON ENTRAINED, KILLED DURING ENTRAINMENT AND AVAILABLE IN OUTER AGUA HEDIONDA LAGOON IN 1979 AT THE ENCINA POWER PLANT

PLANKTON GROUP	335 μ (5/18-12/26)				505 μ (1/22-12/26)			
	OL_A	E	K_E	% of OL_A	OL_A	E	K_E	% of OL_A
Fish Eggs	4.328×10^9	4.292×10^9	3.719×10^9	85.9	3.086×10^9	3.757×10^9	3.184×10^9	103.2
Larval Fish	1.213×10^9	6.700×10^8	6.700×10^8	55.2	2.344×10^8	8.323×10^7	8.323×10^7	35.5
Totals	5.541×10^9	4.962×10^9	4.389×10^9	79.2	3.320×10^9	3.840×10^9	3.267×10^9	98.4

<u>Legend</u>

E = Number Entrained

K_E = Number Killed by Entrainment

OL_A = Number Available for Entrainment in Outer Agua Hedionda Lagoon percent of the total) and the family Sciaenidae (40.5 percent). Citharichthys sp abundance was 4.2 percent of the total (Table 8.3-7). A total of 17 ichthyoplankton taxonomic groups comprise their remaining 4.4 percent. Of the entrainment total, $4.389x10^9$ ichthyoplankton were estimated to be killed during entrainment in the 335μ sampling period. The total number of ichthyoplankton estimated by 335μ mesh data to be present in the outer lagoon for entrainment was $5.541x10^9$. The dominant taxonomic groups of that total were individuals of the family Engraulidae (63.5 percent) and family Sciaenidae (23.58 percent). Citharichthys sp abundance was 6.2 percent of the total (Table 8.3-7). A total of 42 ichthyoplankton taxonomic groups comprised the remaining 6.9 percent. Thus, 79.2 percent of the total number of ichthyoplankton available for entrainment in the outer lagoon were estimated by the 335μ data to be killed during entrainment (Table 9.7-2).

505μ Mesh Data: Sampling Period 1/22/79 - 12/26/79

The total number of fish eggs estimated by 505μ sampling to be entrained was $3.757x10^9$. Of those, $3.184x10^9$ were estimated to be killed during entrainment. The total number of fish eggs estimated to be present in the outer lagoon for entrainment during the 505μ sampling period was $3.086x10^9$. Therefore, 103.2 percent of the available fish eggs were estimated to be killed during entrainment (Table 9.7-2). The Encina Power Plant in 1979, withdrew, on an average daily basis, a volume of water equivalent to 2.18 outer lagoons. The offshore region is the ultimate source of water for the outer lagoon and therefore, the excess percentage of fish eggs was derived from offshore.

The total number of larval fish estimated by 505μ sampling to be entrained was 8.323×10^7. All of those larvae were estimated to be killed during entrainment. The total number of larvae estimated to be present in the outer lagoon was 2.344×10^8. Thus, 35.5 percent of the available larvae were killed during entrainment in the 505μ sampling period (Table 9.7-2).

The total number of ichthyoplankton estimated to be entrained by 505μ sampling was 3.840×10^9. The dominant taxonomic group of that total was family Sciaenidae (87 percent). Family Engraulidae was 6.75 percent, unidentified fish eggs were 3.21 percent and Citharichthys sp was 1.95 percent of the total (Tabel 8.3-4). A total of 17 taxonomic categories comprise the remaining 1.11 percent. Of those entrained ichthyoplankton, 3.267×10^9 were estimated to die during entrainment. The total number of ichthyoplankton individuals estimated by 505μ sampling to be present in the outer lagoon was 3.320×10^9. The dominant taxonomic groups of the total were: family Sciaenidae (41.5 percent), family Engraulidae (40.9 percent) and Citharichthys sp (9.1 percent) (Table 8.3-4). A total of 41 taxonomic groups comprise the remaining 8.5 percent. In summary, 98.4 percent of the available ichthyoplankton in the outer lagoon were estimated by 505μ sampling to be killed during entrainment in the 1/22/79 - 12/26/79 sampling period (Table 9.7-2).

9.8 DISCUSSION

<u>Phytoplankton</u>

Net primary productivity estimates (Table 9.4-1) were consistently low in magnitude. In a recent report (9-28), the annual net productivity of phytoplankton in nearby Tijuana estuary was less than one gm dry wt C/m^2, and results presented in this study seems to agree. Efforts toward estimating gross productivity were confounded by anomalous (negative) respiration values. Similar problems with respiration data in previous productivity studies in Agua Hedionda Lagoon have been observed (9-29).

Statistical comparison of the productivity data reveals that the 15 September 1979 no chlorination experiment yielded significantly different intake and discharge values (Table 9.4-1, Figure 9.4-3). In this run, average net productivity after entrainment was 4.85 times higher than the control (intake) average (26.2 ± 18.6 mg C fixed/m^3/hr at discharge, 5.4 ± 15.7 mg C fixed/m^3/hr at intake). The estimated chlorophyll a concentrations, as determined by the trichromatic method, were 2.18 ± 0.35 mg/m^3 for intake samples and 2.19 ± 0.42 mg/m^3 for discharge samples, not significantly different (Table 9.4-2, Figure 9.4-4). Therefore, those data yield estimates of the ratio of net productivity/chlorophyll a of 3.09 ± 8.86 mg C fixed/mg Chl a/m^3/hr for intake samples and 11.82 ± 8.25 mg C fixed/mg Chl a/m^3/hr for discharge samples, significantly different (Table 9.8-1). The net productivity/chlorophyll a ratio is

TABLE 9.8-1
RATIOS OF NET PRODUCTIVITY/CHLOROPHYLL a
CONCENTRATION MEASURED AT THE ENCINA POWER PLANT IN 1979

Date	RATIO Intake	Discharge	Significant††
15 Sept. 1979	3.09 ± 8.86†	11.82 ± 8.25	Yes
27 Sept. 1979	-1.36 ± 7.30	0.31 ± 3.61	No
2 Dec. 1979	6.94 ± 5.88	4.53 ± 3.41	No
11 Dec. 1979	-1.69 ± 6.09	-1.34 ± 8.56	No

† mg C fixed/mg CHL a/m^3/hr

†† Mann-Whitney U-test

000751

considered an important parameter for comparing productivity results within and between power plant studies (9-30). The concentration of chlorophyll a as determined by the acidification technique was 1.16 ± 0.22 mg/m^3 at the intake and 1.36 ± 0.87 mg/m^3 at the discharge. Productivity/chlorophyll a ratios using the acid chlorophyll a values were 4.7 mg C fixed/mg Chl a/m^3/hr at the intake and 19.3 mg C fixed/mg Chl a/m^3/hr at the discharge. The acidification techniqueused in the present study is a standard method taken from the American Public Health Association (9-31). The recent literature contains many articles, each describing "improved" methodology for determining chlorophyll a after acidification (9-32 through 9-35). Each report warns that there are errors inherent in the traditional method. Until these methodologies are evaluated and the optimum technique selected, intercalibration of the techniques cannot be performed. Because of the uncertainty associated with the acidification technique, chlorophyll a values after acidification will be reported, but all subsequent net productivity/chlorophyll a ratios will employ the trichromatic estimates.

In the 27 September 1979 experiment, intake net productivity was -2.5 ± 13.1 mg C fixed/m^3/hr and discharge net productivity was 0.2 ± 6.8 mg C fixed/m^3/hr. These values were not significantly different (Table 9.4-1). Negative net productivity implies that plankton respiration exceeded plankton primary production during experimentation. This observation has been reported in the literature (9-36). Chlorophyll a values

(Table 9.4-2) were 1.98 ± 0.32 mg/m^3 at the intake and 1.77 ± 0.13 mg/m^3 at the discharge (not significantly different). Therefore, the net productivity/chlorophyll a ratio was -1.36 ± 7.30 mg C fixed/mg Chl a/m^3/hr for the intake and 0.31 ± 3.61 mg C fixed/mg Chl a/m^3/hr for the discharge (Table 9.8-1). Those values were not significantly different.

In the 2 December 1979 run net productivity at the intake was 8.4 ± 7.2 mg C fixed/m^3/hr and discharge net productivity was 5.0 ± 4.1 mg C fixed/m^3/hr. Those values were not significantly different (Table 9.4-1, Figure 9.4-3). The intake assessment yielded a higher net productivity mean than the 15 September 1979 intake assessment, but statistically, the difference was not significant. Chlorophyll a was 1.25 ± 0.13 mg/m^3 at the intake and 1.08 ± 0.09 mg/m^3 at the discharge (Table 9.4-2). These values were significantly different with discharge values reduced 14 percent relative to intake values. Net productivity/Chl a ratio estimates were 6.94 ± 5.88 mg C fixed/mg Chl a/m^3/hr at the intake and 4.53 ± 3.41 mg C fixed/mg Chl a/m^3/hr at the discharge (no significant difference, Table 9.8-1).

In the 11 December 1979 experiment, net productivity estimates were -1.9 ± 5.3 mg C fixed/m^3/hr at the intake and -0.9 ± 6.3 mg C fixed/m^3/hr at the discharge. Those values were not significantly different (Table 9.4-1, Figure 9.4-3). Negative net productivity values imply greater respiration than production during experimentation. Chlorophyll a at the intake averaged

0.93 ± 0.09 mg/m^3 and at the discharge, 0.90 ± 0.14 mg/m^3. Those values were not significantly different. The resulting net productivity/Chl a ratios were: -1.69 ± 6.09 mg C fixed/mg Chl a/ m^3/hr at the intake and -1.34 ± 8.56 mg C fixed/mg Chl a/m^3/hr at the discharge (not significantly different, Table 9.8-1). In this experiment, acid-determined phaeopigments were undetectable (Table 9.4-2, Figure 9.4-6). The relatively close equivalence in trichromatic chlorophyll a and acid-determined chlorophyll a estimates would indicate that very little phaeopigment was present in the samples.

In an overview of the phytoplankton assessments, the results indicate that the combined thermal, physical, and chemical effects of entrainment (experiments performed 27 September 1979 and 11 December 1979) have a generally negligible effect on phytoplankton productivity and pigment concentrations. The 15 September 1979 experiment suggests that the physical and mechanical effects of entrainment may actually stimulate productivity. However, lack of productivity stimulation in the 2 December 1979 experiment indicates that unknown biotic and abiotic factors may influence the amount of stimulation possible. The relatively high incubation temperatures during the 15 September 1979 assessment may have been a major influence on productivity results (Figure 9.4-1).

Pigment concentrations decreased with each successive assessment. Estimates in this study are in general agreement with values found in Baja California lagoons (9-37). The net productivity/chlorophyll a ratios for the intake and discharge samples were not significantly different in the final three experiments. This would indicate that the effect of entrainment on phytoplankton is generally negligible.

A review of the literature reveals that conflicting results of entrainment on phytoplankton have been observed. Researchers have observed significant inhibition (9-38, 9-39, 9-40, 9-41), stimulation during winter seasons (9-42, and 9-43), or no power-plant-induced effects (9-44). Lawler, Matusky and Skelly Engineers (9-45) suggest that entrainment effects on phytoplankton in an open, marine ecosystem are minimal regardless of estimated magnitudes of phytoplankton losses due to entrainment because phytoplankton communities exhibit resiliency. Therefore, the negligible effects of entrainment observed in this study would suggest a minimal impact of the Encina Power Plant on the phytoplankton communities of the source and receiving waters.

Zooplankton and Ichthyoplankton

Figure 9.5-1 contains plots of the temperature regimes experienced by entrained organisms during sampling for invertebrate zooplankton and ichthyoplankton assessments. Statistical comparisons revealed that intake water temperatures and plant operational characteristics in the two assessments in September were significantly different (Table 9.5-2). The difference in mean temperatures and standard deviations immediately after condenser passage between the 14 September 1979 and 24 September 1979 experiments is somewhat reduced because Unit 4 went off-line during the 14 September 1979 run. In the December assessments, intake water temperatures were significantly different but cooling water temperatures immediately after condenser passage were not. Those observed statistical differences limit interpretation of the chemical effects of chlorination on initial entrainment mortality.

Figures 9.5-6, 9.5-7, 9.5-14 and 9.5-15 are plots of the ambient water temperatures experienced by test organisms during delayed assessment incubations of the four experiments. Two of the four assessments were characterized by larger temperature fluctuations. The 24-29 September 1979 incubations experienced average temperature fluctuations of 4 C(7.2 F) throughout the 96 hr period (Figure 9.5-14). The 10-14 December 1979 incubations were subjected to constantly decreasing water temperatures during segments of the incubations (Figure 9.5-15). The magnitude of temperature variations was not expected.

In the 24-29 September 1979 experiment, particular oceanographic conditions resulted in the observed fluctuations (Section 5.4). In the days preceding sampling for that experiment, offshore ocean water temperatures had been fairly stable (Figure 9.6-5). As a result lagoon and offshore waters tended towards temperature equilibrium. At some point during the time period 22-25 September 1979, a meso-scale mass of cold oceanic water moved into the coastal region around the Power Plant. Tidal exchange resulted in the introduction of that cold water into the Agua Hedionda lagoon system. Water used for incubation was drawn continuously from a position near the intake of the Power

Plant, so those observed fluctuations in incubation temperatures were the first indication that tidal conditions influenced whether offshore water or lagoon water was entrained by the plant. The oceanographic interpretation of the temperature fluctuations observed during incubation is as follows: on lagoon ebb tide, water temperatures were observed to increase, as more warm lagoon water was drawn into the Plant; on lagoon flood tide, water temperatures decreased as the cold oceanic water became the major source of water drawn into the Plant. The mean water temperature decreased over the course of incubation and that indicates mixing of lagoon and oceanic waters occurred (Section 5.4).

In the 10-14 December 1979 delayed assessment, incubation water temperatures were 11-13 C (51.8-55.4 F) for the first 24 hr. In the final 72 hr, water temperatures were 6-9 C (42.8-48.2 F). In that situation, a similar cold water introduction into the lagoon system occurred (Figure 9.6-5); however, large temperature fluctuations were not observed. That may be related to low insolation (heating) effects on surface waters in the lagoon system in December (Figure 9.4-2).

The importance of incubation temperature is illustrated in Figure 9.8-1. The plots are of total observed mortality for all plankton organisms collected versus incubation time. In the 14-18 September 1979 assessment, total mortality increased gradually, with discharge organisms exhibiting less mortality than intake organisms. In the 24-29 September 1979 experiments, significant mortality (>60 percent) occurred within 12 hr of incubation initiations, and again discharge organism mortality was less than intake mortality. In the 1-5 December 1979 run, overall mortality gradually increased with intake mortality less than discharge mortality. In the 10-14 December 1979 incubation, the increase in total mortality observed was the lowest of any experiment. In that run, intake and discharge mortalities were essentially equal.

Mortality results for the 14-18 September 1979, 1-5 December 1979 and 10-14 December 1979 experiments are relatively characteristic of bioassays. The 25-29 September 1979 mortality results reveal that the major increase in mortality occurred during the first major incubation temperature fluctuation (Figure 9.5-14). Water temperatures increased from 16 C (60.8 F) to 21.8 C (71.2 F) in 8 hr, and rapidly decreased to 16 C within a span of 4 hr. The correlation of the temperature shift with the major mortality increase suggests an interaction. The significance of that interaction must be balanced by the observation that the total mortality observed in 10-14 December 1979 assessment was the lowest of the four bioassays. In that run, a 6.5 C (11.7 F) drop in incubation temperature occurred over a span of 40 hr: 12.5 C (54.5 F) at 16 hr, 6 C (42.8 F) at 56 hr (Figure 9.5-15). Therefore, the data suggest that rapidly increasing and decreasing incubation temperatures have a greater effect on increasing mortality than prolonged temperature reductions.

The preceding discussion illustrates that incubating test organisms at ambient water temperatures, the common delayed mortality approach, may not be ideal in marine situations. Marine test organisms held in a flow-through, ambient temperature, water bath incubation system will most certainly experience the thermal influence of different water masses over the course of 96 hr incubation. In the present study, fluctuations were observed in every assessment. That variability in incubation temperature may effect mortality results. If significant temperature fluctuations can occur, it is recommended that test organisms be maintained at the water temperature experienced by intake organisms during collection.

Zooplankton

Acartia tonsa

In the 14 September 1979 no chlorination experiment, the initial entrainment mortality rate estimate for Acartia tonsa was 0.93. The 24 September 1979 chlorination estimate was 0.40 (Table 9.5-1). The higher mortality estimate in the no chlorination run was unexpected; however, thermal effects may be responsible. Intake water temperatures for the 14 September 1979 assessment were an average 4.1 C (7.4 F) higher than the intake water temperatures for the 24 September 1979 run (Figure 9.5-1). In addition, immediately after condenser passage, average cooling water temperature for the 14 September 1979 assessment was 32.2 C (89.9 F), the average for the 24 September 1979 experiment was

28.1 C (82.6 F). Thus, while intake temperatures were different, the changes in water temperature induced by condenser passage were essentially equivalent in the two September runs.

As stated in the introduction, the maximum temperature that entrained organisms experience is considered the critical influence on the thermal component of entrainment mortality. In the September experiments, if the presence or absence of chlorination is not taken into consideration, _Acartia tonsa_ individuals experiencing a maximum water temperature of 28.1 C (82.6 F) exhibited a mortality rate of 0.40. Those experiencing maximum temperatures of 32.3 C (90.0 F) exhibited a rate of 0.93. Gonzalez (9-46) reports a critical thermal maximum of 34-37 C (93.2-98.6 F) for an east coast, 20 C (68 F) acclimated, _Acartia tonsa_ population. Therefore, the high mortality rate exhibited by _Acartia tonsa_ in the 14 September 1979 experiment appears to be related to the maximum temperature experienced during entrainment. The average 4.1 C (7.4 F) decrease in maximum temperature of entrainment between the 14 September 1979 and 27 September 1979 runs resulted in a greater than 50 percent reduction in observed initial mortality, even though chlorine was present in the latter experiment. This would indicate that chlorination at the Encina Power Plant may not be a major influence on entrainment mortality. Results of chlorine analyses performed on water samples taken from the discharge pond (Table 9.8-2) reveal low levels of chlorine in the water discharged into the ocean.

000760

TABLE 9.8-2
1979 MONTHLY CHLORINE LEVELS (PPM)
IN THE DISCHARGE POND OF THE ENCINA POWER PLANT

Month	Chlorine
January	0.02
February	n.d.†
March	0.01
April	0.02
May	0.02
June	0.04
July	n.d.†
August	n.d.†
September	0.02
October	0.01
November	0.02
December	0.16

†: not detectable

000761

In summary, for *A. tonsa*, it appears that environmental and plant operational characteristics of the September experiments were of enough difference, that the chemical effects of chlorination on initial entrainment mortality in the summer were not apparent.

In September delayed assessments (14-18 September and 24-29 September 1979), the chemical effects of chlorination on delayed entrainment mortality could not be estimated due to high intake and discharge mortalities observed in the early stages of the 24-29 September 1979 incubation. Large incubation temperature fluctuations were considered responsible. Greater than 90 percent of intake and discharge *Acartia tonsa* individuals died within 12 hr of incubation (Figure 9.5-12). This precludes comparison with the 14-18 September incubation results. In the 14-18 September 1979 no chlorination run, mortality results of intake and discharge *Acartia tonsa* were not significantly different (Table 9.5-1), although discharge individuals exhibited less mortality than intake test organisms. Icanberry and Warrick (9-47) report similar results for *Acartia clausi* in studies of the Diablo Canyon, California power plant. There is a growing realization that the approach to delayed effects bioassays may have to be re-evaluated, as live organisms captured after entrainment often exhibit greater tolerance of incubation conditions than control organisms. Such results were common in the present study for other plankton groups (see Decapoda discussion).

The total entrainment mortality estimate for Acartia tonsa during the summer season was arrived at in the following manner: rate estimates of initial entrainment mortality for the September runs were averaged to yield a rate of 0.66. Delayed entrainment mortality could not be detected in the experiments. Therefore, the rate of 0.66 was used in calculating summer mortality of A. tonsa due to entrainment (Table 9.5-3).

In the winter season, the December assessments yielded estimates of initial entrainment mortality much lower than those observed in the summer experiments. In the 1 December 1979 no chlorination run, the observed discharge mortality rate was less than the intake rate and, as a result, the calculated initial entrainment mortality rate was -0.22 (Table 9.5-1). The difference in the proportions (live/[live + dead]) for the intake and discharge collections was not significant, and, therefore, the initial mortality rate was considered to be 0.00. In the 10 December 1979 chlorination run, the calculated estimate of initial mortality was 0.09 but the difference in the proportions was again not significant (Table 9.5-1). Therefore, the 10 December 1979 rate estimate was also 0.00.

In the December assessments, water temperatures immediately after condenser passage for the two runs were not significantly different: 24.8 ± 2.2 C (76.6 ± 3.9 F) for the 1 December 1979 experiment and 27.2 ± 3.0 C (80.9 ± 5.4 F) for the 10 December 1979 run (Table 9.5-2, Figure 9.5-1). The fact that both December assessments yield an initial mortality rate of 0.00 when the thermal conditions were not significantly different, suggests that chlorination is not a major influence on entrainment mortality.

In the delayed effects assessments performed in December, significant delayed entrainment mortality of _A. tonsa_ was observed in the 1-5 December 1979 no chlorination bioassay, but no effect was observed in the 10-14 December 1979 chlorination run (Figures 9.5-8, 9.5-16, Table 9.5-1). The calculated delayed entrainment mortality rate for the 1-5 December 1979 experiment was 0.48. In that run, at the end of 96 hr, 0 percent of the discharge individuals and 47.7 percent of the intake individuals were alive. In the 10-14 December 1979 bioassay, 46.4 percent of the intake organisms and 41.6 percent of the discharge organisms were alive at the end of 96 hr. The difference in the latter percentages was statistically insignificant (Table 9.5-1), and the calculated delayed entrainment mortality rate was 0.00.

The average incubation temperature in the 1-5 December 1979 bioassay was 9.6 C (49.3 F) and temperatures were observed to increase from 8 C to 11 C over the course of incubation (Figure 9.5-7). In the 10-14 December 1979 experiment, the average incubation temperature was 8.5 C (47.3 F) and temperatures were observed to steadily decrease from 12 C to 6 C during the 96 hr period (Figure 9.5-15). The effect of those temperature trends on mortality results is unknown, but, in any event, the chemical effect of chlorination on delayed entrainment mortality is undetectable. The results also indicate that delayed effects on entrainment mortality may be appreciable in winter season. The reason delayed effects are observed to be larger in the winter than the summer is unknown.

The total entrainment mortality rate estimate for Acartia tonsa during the winter season was calculated in the following manner: the initial rate estimate in each December assessment was 0.00. The delayed rate estimates for the 1-5 December bioassay, 0.48, and the 10-14 December 1979 run, 0.00, were averaged to give an estimate of 0.24. Therefore, the total winter mortality rate used was 0.24 (Table 9.5-3).

Other Copepod Species

In the September assessments, the estimated initial entrainment mortality rate of other copepod species for the 14 September 1979 no chlorination experiment was 0.79 and significant. In the 24 September 1979 run, the estimate was 0.18, not significant, and, therefore, was considered to be 0.00 (Table 9.5-1). Interpretation of those results is identical to explanations put forth previously in the discussion of A. tonsa results. The high mortality estimate in the 14 September 1979 assessment is probably related to the high entrainment temperatures experienced by organisms during sampling. The differences in environmental and plant operational characteristics were large enough to preclude an assessment of the effects of chlorination on initial entrainment mortality in September.

In the September delayed effects bioassays, the 14-18 September 1979 no chlorination run yielded a delayed mortality rate estimate of -0.19, which was significant (Table 9.5-1, Figure 9.5-9). That estimate indicates that discharge copepods exhibited greater survival than intake copepods during incubation. That result was observed and discussed for _A. tonsa_. In the 24-29 September 1979 chlorination bioassay, approximately 90 percent of intake and discharge organisms were killed after 12 hours of incubation (Figure 9.5-17) and therefore delayed effects could not be estimated. Thus the chemical effects of chlorination on delayed entrainment mortality could not be estimated in September.

The total summer entrainment mortality rate estimate for other copepod species was calculated as follows: the initial mortality rates for the September experiments were averaged to yield an estimate of 0.40. Delayed effects were observed to be near zero, and therefore, the total summer mortality estimate was placed at 0.40 (Table 9.5-3).

In the December assessments, the initial entrainment mortality estimates were negative for both experiments (Table 9.5-1). The results are probably related to sampling variability (9-48). Those observations indicate that the initial entrainment mortality rate is near zero, with or without chlorination, for other copepods during the winter season.

In the December delayed effects assessments, a significant delayed entrainment mortality estimate of 0.37 was observed in the 1-5 December 1979 no chlorination run (Table 9.5-1, Figure 9.5-9). In the 10-14 December 1979 chlorination run, discharge copepods exhibited higher survival than intake copepods and the resulting mortality estimate was -0.12 (Table 9.5-1, Figure 9.5-17). Similar results for December were observed and discussed for *A. tonsa*.

The total winter entrainment mortality rate estimate was calculated as follows: initial mortality for other copepods was considered essentially zero in winter. The delayed value used was the estimate generated by the 1-5 December 1979 bioassay, 0.37. It is felt that using that delayed estimate will give a more conservative estimate of entrainment mortality in the winter. Therefore, the total entrainment mortality rate estimate for winter was 0.37 (Table 9.5-3).

Decapoda

In September, the estimated initial entrainment mortality rate for decapods was 0.60 in the 14 September 1979 no chlorination run and 0.50 in the 24 September 1979 chlorination experiment (Table 9.5-1). In both cases, the results were significant. The effect of chlorination on initial entrainment mortality could not be discerned in September because environmental and plant operational characteristics were different for each experiment.

In delayed assessments in September, significant negative delayed mortality was observed in both bioassays (Table 9.5-1, Figures 9.5-10 and 9.5-18). In those cases, discharge decapods had significantly lower mortality than intake decapods: -0.53 for the 14-18 September 1979 bioassay, -0.19 for the 24-29 September 1979 run. Those observations may be related to the following considerations. Decapods collected alive for incubation at the discharge have survived extremely stressful conditions (i.e., entrainment) and, therefore, may be considered generally hardy individuals. At the intake both hardy and weak individuals may be collected for incubation. Over the course of the bioassay, weak individuals in the intake collection may become less tolerant of incubation conditions than hardy individuals and therefore will exhibit a relatively higher mortality rate. That occurrence would increase the overall mortality rate of the intake collection. As the discharge collection contains predominantly hardy individuals, one may expect a relatively low overall mortality rate. Icanberry and Warrick (9-49) alluded to a similar mechanism. That explanation may be involved in the mortality rates exhibited by intake and discharge decapods. The higher overall mortality rates exhibited by intake and discharge decapods in the 24-29 September 1979 bioassay may be related to large incubation temperature fluctuations experienced by test organisms during the 96 hr period.

The total summer entrainment mortality rate estimate for decapods was calculated as follows: the initial mortality estimates for the September runs were averaged to yield an estimate of 0.55. Delayed effects were not apparent in the September bioassays and therefore were considered 0.00. Thus the total summer entrainment mortality rate estimate was calculated to be 0.55 (Table 9.5-3).

In December assessments, the initial entrainment mortality estimates for decapods were 0.00 for the 1 December 1979 no chlorination run, and -0.24 for the 10 December chlorination run (Table 9.5-1). Those results were not significantly different. The negative rate exhibited in the chlorination assessment probably reflects sampling variability (9-50). The presence or absence of chlorination did not appear to effect the initial entrainment mortality of decapods in December.

In delayed effects assessments for decapods in December, results of 48 hr incubations in the 1-5 December 1979 no chlorination experiment yield a delayed mortality estimate of 0.51, and the 96 hr chlorination incubations during 10-14 December 1979 yielded an estimate of 0.24 (Table 9.5-1, Figures 9.5-10 and 9.5-18). Results of the 1-5 December 1979 bioassay are reported after 48 hr of incubation because formalin was inadvertantly added to the intake decapods after the 48 hr incubation check. This would explain why the exhibited mortality of intake decapods greatly increased between 48 and 72 hr in this experiment (Table 9.5-10).

The total winter entrainment mortality rate estimate for decapods was calculated as follows: initial mortality was considered 0.00. Delayed estimates were averaged to yield a value of 0.38. Therefore, the total winter mortality rate estimate for decapods was calculated to be 0.38 (Table 9.5-3).

Other Crustacea

Initial entrainment mortality rates of other crustacea for the September experiments were estimated to be 0.60 for the 14 September 1979 no chlorination run and 0.62 for the 24 September 1979 chlorination assessment (Table 9.5-1). Only the former estimate was statistically significant because low numbers of other crustacea collected for the latter assessment limited statistical inference.

In September delayed effects bioassays, the delayed entrainment mortality rate estimates for other crustacea were 0.34 for the 14-18 September 1979 no chlorination run and 0.09 for the 24-49 September 1979 chlorination bioassay (Table 9.5-1, Figure 9.5-11). Neither estimate was statistically significant; the 14-18 September 1979 bioassay was limited by low numbers. Thus, the effect of chlorination on delayed entrainment mortality of other crustacea could not be calculated. In the 14-18 September 1979 bioassay, discharge mortality was observed to increase significantly compared with intake test organisms in the first 3 hr of incubation. From that point on, the slopes of intake and discharge mortality were not significantly different (Figure 9.5-11). The 24-29 September 1979 intake and discharge bioassays exhibited essentially equivalent delayed mortality characteristics.

The total summer entrainment mortality rate estimate for other crustacea was calculated as follows: the initial mortality rate estimates were averaged to yield a value of 0.61. Delayed mortality rate estimates were averaged to yield a value of 0.22. Thus, of the 39 percent of the other crustacea estimated to survive entrainment, 22 percent, or an additional 8 percent of the total number entering the Plant, were estimated to die as a result of delayed effects. Thus the total summer entrainment mortality rate estimate for other crustacea equals 0.61 + 0.08 or 0.69 (Table 9.5-3).

In December assessments, the initial entrainment mortality rate estimates of other crustacea were 0.09 in the 1 December 1979 no chlorination run and 0.12 in the 10 Decmeber chlorination run (Table 9.5-1). The values are not statistically significant.

Delayed assessments for other crustacea in December could not be performed because virtually no other crustacea were collected at the intake or discharge during the sampling (Table 9.5-1).

The total winter entrainment mortality rate estimate for other crustacea was calculated as follows: the two initial mortality estimates were averaged to yield a value of 0.11, while delayed estimates could not be determined. Although, initial mortality estimates were statistically insignificant, the values obtained were used because of the lack of delayed mortality estimates. Therefore, the total winter entrainment mortality rate estimates was considered to be 0.11 (Table 9.5-3).

Mysidacea

In September initial entrainment mortality assessments for mysids, low numbers of individuals limited mortality rate

000771

estimation. The 14 September 1979 no chlorination initial rate estimate was 0.85, but not significant. The reason is that only one live mysid was collected at the intake and this limited statistical inference (Table 9.5-1). In the 24-29 September 1979 chlorination run, mysids were only collected at the discharge and of those, 44.4 percent were alive. That observation suggests that entrainment may increase the susceptibility of mysids to collection (9-51). In any event, the chemical effects of chlorination on initial entrainment mortality were not apparent in September. No September delayed assessments could be performed because insufficient numbers of mysids were collected. Inspection of entrainment data reveals that mysids were virtually absent in September (Section 8.0).

The total summer entrainment mortality rate estimates was calculated as follows: As only one estimate of initial mortality rate and no estimates of delayed mortality rates were made, the one estimate of 0.85 was used as the total summer entrainment mortality rate estimate of mysids (Table 9.5-3).

In December assessments, the 10 December 1979 chlorination experiment yielded an initial entrainment mortality estimate of 0.52, which was not significant (Table 9.5-1). Low numbers of intake individuals limited statistical inference. In the 1 December 1979 no chlorination run, only one mysid, which was dead, was recovered from the intake, while 75 percent of the discharge mysids were collected alive. The initial mortality equation could not be used because it required division by zero percent live for the intake value; therefore no initial mortality estimate was made.

In December delayed mortality assessments, inspection of Figure 9.5-13 reveals that, overall, mysid mortality during incubation was relatively low. Differences in the mortality of intake and discharge collections in both bioassays became apparent after 48 hr of incubation. The 1-5 December 1979 no chlorination run yielded a delayed mortality rate estimate of 0.43 (significant) and the 10-14 December 1979 chlorination run rate estimate was 0.08 (not significant, Table 9.5-1). This result for December assessments was also observed for Acartia tonsa and may be related to the trends in incubation temperatures during the respective 96 hr of monitoring. Incubation temperatures constantly increased from 8 C to 11 C in the 1-5 December 1979 bioassay and decreased from 12 C to 6 C in the 10-14 December run. The effect of those temperature trends on mortality results is unknown, but, in any event, the chemical effect of chlorination on delayed entrainment mortality cannot be isolated in December.

The total winter entrainment mortality rate was calculated in the following manner: Only one initial mortality rate estimate could be made, 0.52, for the chlorination experiment, and this was used for the initial rate estimate. The estimates for the delayed assessments were averaged to yield a value of 0.26. Therefore, of 48 percent of the mysids surviving entrainment, an additional 26 percent, or 12 percent of the total number entrained, are also estimated to die from entrainment effects. Therefore, the total winter mortality rate estimate for mysids was calculated to be 0.64 (Table 9.5-3).

Chaetognaths

The entrainment mortality assessments for chaetognaths had the lowest numbers of individuals of any plankton group studied (Table 9.5-1). A total of 23 chaetognaths (12 alive, 11 dead) were collected for initial mortality estimations and 1 live chaetognath was collected at the discharge. Therefore, the initial mortality rate estimate of 1.00 for the summer season is equivalent to the total entrainment mortality rate at this time. The winter initial rate estimate could not be determined because chaetognaths were not collected at both stations in each run (Table 9.5-1). Chaetognaths are relatively fragile invertebrates and it was felt that chaetognath entrainment would probably result in 100 percent mortality, therefore, the summer mortality rate was used as an estimate of the winter rate. Total winter mortality was considered to be 1.00 (Table 9.5-3).

Other Zooplankton

In September assessments for other zooplankton species, the estimated initial entrainment mortality rates were 0.85 for the 14 September 1979 no chlorination run, and 0.31 for the 24 September 1979 chlorination run (Table 9.5-1). Those values were statistically significant. The higher mortality rate for the no chlorination run versus the rate for the chlorination run was also observed for *A. tonsa*. Possible reasons for those results were discussed for *A. tonsa* and would ostensibly apply for these planktonic organisms (see *A. tonsa* discussion).

The delayed mortality rate estimations were 0.08 for the 14-18 September 1979 no chlorination bioassay and -0.02 for the 24-29 September 1979 no chlorination bioassay (Table 9.5-1, Figure 9.5-12). The latter delayed mortality rate was considered to be zero. Results from the chlorination bioassay are influenced by the large incubation temperature fluctuations discussed earlier, and, therefore, the chemical effects of chlorination on entrainment mortality were not apparent.

The total summer entrainment mortality rate estimate was calculated as follows: The initial mortality estimates were averaged to yield a value of 0.58. The delayed mortality estimate used was, 0.04, which was the average of the 14-18 September 1979 bioassay and the 24-27 September 1979 bioassay. Therefore, of the 42 percent of the other zooplankton species surviving entrainment, 4 percent or an additional 2 percent of the total number entrained were estimated to be killed by delayed effects. Thus, the total summer entrainment mortality rate estimate was 0.61 (Table 9.5-3).

In December assessments, the initial mortality rate estimates were 0.20 for the 1 December 1979 no chlorination bioassay and -0.55 for the 10 December 1979 chlorination experiment (Table 9.5-1). The former estimate was significant but the latter was not and therefore the 10 December estimate was considered to be

0.00. The low total number of organisms involved in each case influenced statistical inference.

Delayed mortality rate estimates for other zooplankton species could not be made because virtually no individuals of these species were collected in December (Table 9.5-1).

The total winter entrainment mortality rate estimate was calculated as follows: The initial rate estimate of the 1 December 1979 run, 0.20, was averaged with the initial estimate (the estimate of the 10 December 1979 experiment was ignored). As delayed effects could not be estimated, total entrainment mortality was calculated to be 0.10 (Table 9.5-3).

Predation Effects on Invertebrate Zooplankton

Statistical analyses of the predation data indicate that, in general, the magnitude of predation within intake channels on invertebrate zooplankton induced by attached organisms and nekton maintaining themselves within the intake tunnels of the plant is negligible (Table 9.5-4). Significant reduction in abundance was observed for chaetognaths in the 19 July 1979 335μ mesh data. All other significant changes were increases in biotic abundances at the traveling screens relative to the intake. These results were unexpected and may be a reflection of sampling variability.

Quantitative estimates were calculated for periods when 335μ mesh (18 May 1979 to 26 December 1979) and 505μ mesh (22 January 1979 to 26 december 1979) sampling was performed.

The 335μ mesh estimates indicated that, in general, the number of invertebrate zooplankton killed during entrainment was a small portion of the available population in the outer lagoon. If the numbers of organisms present in the additional source waters (i.e., offshore region, middle lagoon and upper lagoon) were taken into account, the percentage of available organisms killed during entrainment would be even smaller. Calculations for all source waters were not performed because monthly estimates of plankton abundances do not provide reliable quantitative estimates. Therefore, it is felt that the percentages listed in Table 9.7-1 are conservative estimates.

The 505μ mesh estimates generally indicate that the number of invertebrate zooplankton killed during entrainment was a small portion of the available population in the outer lagoon. The total 505μ mesh invertebrate percentage was higher than the 335μ mesh percentage (14.2 percent for 335μ mesh versus 28.2 percent for 505μ mesh, Table 9.7-1).

Ichthyoplankton

Larval Fish

Since low numbers of larval fish were collected, mortality results are presented for larval fish as a taxonomic conglomerate.

In September assessments, no larval fish were recovered alive at the discharge station. Thus the initial entrainment mortality rate estimate is 1.00 in each case. Intake mortality for the 14 September 1979 no chlorination run was approximately

17 percent; for the 24 September 1979 chlorination experiment, it was approximately 81 percent (Table 9.6-1). The reason for the high intake mortality in the second run is unknown. Inspection of species composition for the intake collections indicates that Hypsoblennius sp and members of the Gobiidae family were significant influences on mortality observed in the 24 September 1979 assessment (Appendix Table 16.3-65). In any event, the chemical effects of chlorination on entrainment mortality were not discernable in September.

Delayed effects could not be estimated in September because viable larvae were not collected at the discharge (Table 9.6-1). Over 150 larvae collected at the discharge were examined for signs of life in each assessment. The absence of any viable larvae at the discharge increases confidence in the initial mortality rate estimate.

Intake collections were incubated and monitored for 96 hr (Table 9.6-1, Figure 9.6-2). In the 14-18 September 1979 run, 35 percent of the larvae were alive at the end of incubation. In the 24-29 September 1979 run, 100 percent of the larvae were alive after incubation. The major increase in larval mortality for the 14-18 September 1979 incubation occurred after 72 hr (Figure 9.6-2).

A review of the literature indicates that larval fish generally undergo irreversible damage if deprived of food for more than two or three days after yolk sac absorption (9-52, 9-53, 9-54, 9-55). The sudden increase in larval mortality observed after 72 hr of incubation in that assessment may be a result of starvation. Realization of this limitation has prompted some researchers to report delayed mortality results for larval fish after 12 hr of incubation (9-56). However, the validity of this approach is open to review.

The total survival of the 24-29 September 1979 intake larvae is unexpected considering the larvae experienced numerous large incubation temperature fluctuations during the bioassay period. The species composition of the four larvae incubated was: three Syngnathus sp (pipe fish), and one Hypsopsetta guttulata (diamond turbot), (Appendix Table 16.3-66).

These species are considered hardy and easily reared in the laboratory (9-57). Apparently those species were not only able to withstand starvation effects but also large fluctuations in incubation temperatures.

In December assessments, again, no viable larvae were collected at the discharge for initial mortality estimations (Table 9.6-1). Therefore, the calculated initial entrainment mortality rate estimate is 1.00 for both runs and the chemical effects of chlorination on mortality are not apparent (Table 9.6-1). In the 1 December 1979 no chlorination run, 21 percent of the intake larvae were collected alive. In the 10 December 1979 chlorination run 47 percent were alive. The differences in intake initial mortality exhibited by September and December assessments illustrates the variability involved in using the pump-larval sampler system. The observed variability may result from differences in the magnitude of natural mortality and in the sampling tolerances of individual larvae and species.

Delayed effects could not be assessed in December because no viable larvae were recovered at the discharge (Table 9.6-1). Over 175 discharge larvae were inspected for signs of variability. The lack of any viable larvae at the discharge increases confidence in the initial mortality estimate.

Intake larvae were incubated and monitored for 96 hr in both December assessments (Figure 9.6-2). In the 1-5 December 1979 no chlorination run, 21 percent of the larvae were alive at the end of incubation; in the 10-14 December 1979 chlorination run, 28 percent were alive (Table 9.6-1). As in the 14 September 1979 bioassay, major increases in mortality were observed after 72 hr of incubation in both December assessments (Figure 9.6-2). Inspection of species compositions for the three runs exhibiting mortality indicate that larvae of the family Gobiidae strongly influenced mortality results (Appendix Table 16.3-66).

This suggests that Gobiid larvae may be more susceptible to incubation and starvation effects than Syngnathus sp or Hypsopsetta guttulata.

In overview of larval fish assessments, the total entrainment mortality rate estimate was considered 1.00 for every assessment (Table 9.5-3). Low numbers of larvae limit the precision of those estimates; however, no larvae were ever recovered alive at the discharge. Ecological Analysts (9-58) report a mortality value for the Potrero Power Plant in San Francisco Bay of 25 percent. The estimate was calculated in the traditional manner by subtracting the percent dead at the intake from the percent dead at the discharge. The estimates calculated in the present study employed a more robust equation (9-59).

Fish Eggs

Mortality results are presented for fish eggs as a taxonomic conglomerate. In September assessments, the estimated initial mortality rate of fish eggs for the 14 September 1979 no chlorination experiment was 0.90 and significant; the 24 September 1979 chlorination run yielded a significant estimate of 0.84 (Table 9.6-1). In both runs, eggs of the Sciaenid family were predominant (Appendix Table 9.6-65). The chemical effects of chlorination on entrainment mortality were not apparent in the summer season. It is felt that differences in environmental and plant operational characteristics were large enough to preclude assessment of chlorination effects.

September delayed effects assessments were hampered by low numbers of incubated eggs (Table 9.6-1) and high mortality during incubations (Figures 9.6-3, 9.6-4). The difference in percent alive intake and discharge eggs of the 14-18 September 1979 no chlorination bioassay was 0.04 and not significant. The difference for the 24-29 September 1979 chlorination run was 0.00 (Table 9.6-1). In the no chlorination run, low mortality was observed up until 48 hr, and then a significant increase was recorded, where, by 72 hr, all the discharge eggs and 96 percent of the intake eggs had died (Figure 9.6-3). Three Sciaenid eggs hatched by 48 hr in the intake collection, and remained alive throughout the remaining incubation. In the chlorination bioassay, all intake eggs were dead by 12 hr and all discharge eggs were dead by 48 hr (Figure 9.6-4). Sciaenid eggs were again predominant (Appendix Table 16.3-66). The results of the 24-29 September 1979 bioassay may have been influenced by large temperature fluctuations during incubation.

The total summer entrainment mortality rate estimate was calculated in the following manner: The initial rate estimates for the two experiments were averaged to yield a value of 0.87. The delayed estimates were also averaged to yield a value of 0.02. That delayed estimate had an insignificant effect on the initial estimate; therefore, the total estimate was considered to be 0.87 (Table 9.5-3).

In winter assessments, the initial entrainment mortality rate estimates were: 0.70 in the 1 December 1979 no chlorination run and 0.54 in the 10 December 1979 chlorination run. The former value was statistically insignificant because sample sizes were small (Table 9.6-1). The eggs were 39 percent unidentified, 32 percent Citharichthys sp, 22 percent Pleuronichthys ritteri; and 3 percent Sciaenids (Appendix Table 16.3-65). The chemical effect of chlorination on entrainment mortality was not apparent.

In delayed assessments, a mortality estimate could not be made for the 10-14 December 1979 chlorination bioassay because intake eggs were not collected (Table 9.6-1). In the 1-5

December 1979 no chlorination experiment, all three intake eggs were dead by 9 hr and all discharge eggs were dead in 48 hr (Figure 9.6-3). Eggs in those assessments were predominantly unidentifiable (Appendix Table 16.3-66). Therefore, the estimated delayed mortality rate was calculated to be 0.00 (Table 9.6-1).

The total winter entrainment mortality rate estimate was calculated in the following manner: The initial mortality rate estimates were averaged to yield a value of 0.62. Delayed effects could not be adequately assessed in December; therefore, the total entrainment mortality rate estimate for fish eggs was considered to be 0.62 (Table 9.5-3).

In overview of fish egg assessments, September initial mortality estimates should be given maximum weight as sample sizes were sufficient. December initial estimates are weakened by small sample sizes. Delayed effects were hampered by low sample size and high incubation mortality. Constant agitation of incubation chambers through bubbling might improve fish egg delayed assessments. In any event, higher entrainment mortality was estimated for the summer season compared with the winter season.

Statistical analyses of the predation data for ichthyoplankton indicates that, in general, the magnitude of predation within intake channels is negligible (Table 9.5-4). A significant reduction in fish egg abundance of 57 percent was observed in the 19 July 1979, 505μ mesh data, but all other egg analyses indicated insignificant reductions. Larval fish abundance was observed to significantly increase in two analyses: a 2.2 fold average increase in the 22 August 1979 505μ data, and a 2.3 fold average increase in the combined 505μ data. The remaining analyses indicated insignificant changes in abundance. The observed increases were unexpected and may be a reflection of sampling variability.

Quantitative ichthyoplankton estimates were calculated for periods when 335μ mesh (18 May 1979 to 26 December 1979) and 505μ mesh (22 January 1979 to 26 December 1979) sampling was performed.

The 335μ estimates indicated that a major portion of the ichthyoplankton present in outer lagoon were killed during entrainment (Table 9.7-2). If the numbers of ichthyoplankton present in the additional source waters (i.e., offshore region, middle lagoon and upper lagoon) were taken into account the percentage would be smaller. Calculations of abundance estimates for those source waters were not performed because monthly estimates of plankton abundances do not provide reliable quantitative estimates. Therefore, it is felt that the percentages listed in Table 9.7-2 are conservative estimates.

The 505μ estimates indicate that a major portion of the ichthyoplankton present in the outer lagoon were killed during entrainment. The major influence on the ichthyoplankton results were fish eggs. More eggs were killed during entrainment than were present in the outer lagoon. The excess percentage was ultimately derived from offshore, as the Power Plant takes in 2.18 times the outer lagoon volume of water per day.

References

9-1 Lawler, Matusky, and Skelly Engineers, Ecosystem Effects of Phytoplankton and Zooplankton Entrainment, Electric Power Research Institute - EPRI-1038, Palo Alto, CA, April 1979.

9-2 Gonzalez, J. G., "Critical Thermal Maxima and Upper Lethal Temperatures for the Calanoid Copepods *Acartia tonsa* and *A. clausi*," Marine Biology, Vol. 27, pp. 219-223, (1974).

9-3 Ecological Analysts, Potrero Power Plant Cooling Water Intake Structures 316(b) Demonstration, Pacific Gas and Electric Company - EA-PGE61F1, Concord, CA (January 1980).

9-4 Ecological Analysts (9-3).

9-5 Marine Review Committee (MRC), Annual Report to the California Coastal Commission, August 1976-August 1977, Appendix I, Estimated Effects of SONGS Unit I on Marine Organisms: Technical Analysis and Results, Marine Reivew Committee - MRC Doc 77-09 No. 2 (September 1977).

9-6 Southern California Edison Co., 1979 Annual Operation Report for San Onofre Nuclear Generating Station, Vol. 5: Biological and Oceanographical Data Analysis, Special Study: Ichthyoplankton, Southern California Edison Company - 80-RD-100, Rosemead, CA (June 1980).

9-7 Marine Review Committee (9-5).

9-8 Marine Review Committee (9-5).

9-9 Southern California Edison Co. (9-6).

9-10 Lawler, Matusky and Skelly Engineers (9-1).

9-11 Lawler, J. P., Physical Measurements: Their Significance in the Prediction of Entrainment Effects, Third National Workshop on Entrainment and Impingement: Section 316(b) - Research and Compliance (L. D. Jensen, ed.), pp. 59-91. Ecological Analysts, Melville, NY, 425 pp (1976).

9-12 Christensen, S. W., "Quantitative Methodologies for Estimating the Probability of Mortality for Live Organisms Entrained by Power Plants," Bull, Ecol. Soc. Am. 58(2):39 (1977).

9-13 Boreman, J. and C. P. Goodyear, Biases in the Estimation of Entrainment Mortality, Paper presented before the Fifth National Workshop on Entrainment and Impingement, San Francisco, CA (May 1980).

9-14 Kauffman, T. A., J. A. Lindsay, and A. Carpener, Impact of the Intake Conduit Biofouling Community, Paper presented before the Fifth National Workshop on Entrainment and Impingement, San Francisco, CA (May 1980).

9-15 Lawler, Matusky, and Skelly Engineers (9-1).

9-16 Talmage, S. S. and C. C. Coutant, "Thermal Effects," Journal of the Water Pollution Control Federation, Vol. 51, pp. 1517-1554 (1979).

9-17 Lawler, Matusky, and Skelly Engineers (9-1).

9-18 Goldman, J. C. and H. L. Quinby, "Phytoplankton Recovery After Power Plant Entrainment," Journal of the Water Pollution Control Federation, Vol. 51(7), pp. 1816-1823 (1979)

9-19 Holloway, J. L., "Smoothing and Filtering of Time Series and Space Fields," Advances in Geophysics, Vol. 4, pp. 351-389 (1958).

9-20 Lawler, Matusky, and Skelly Engineers (9-1).

9-21 American Public Health Association, Standard Methods for the Examination of Water and Wastewater, 14th edition, American Public Health Association, Washington, D.C. (1976).

9-22 Sokal, R. R. and J. F. Rohlf, Biometry, W. H. Freeman and Co., San Francisco, CA, pp. 392-393 (1969).

9-23 American Public Health Assocation (9-21).

9-24 Fleiss, J. L., Statistical Methods for Rates and Proportions, John Wiley and Sons, New York, NY (1973).

9-25 Snedecor, G. W. and W. G. Cochran, Statistical Methods, 6th edition, Iowa State University Press, Ames, Iowa (1972).

9-26 Goldman and Quinby (9-18).

9-27 Lawler, Matusky, and Skelly Engineers (9-1).

9-28 Zedler, J., T. Winfield and D. Mauriello, "Primary Production in a Southern California Estuary," Coastal Zone '78, Vol. 2, pp. 649-662 (1978).

9-29 Bradshaw, J. S., Personal Communication, University of San Diego, San Diego, CA (February 1980).

9-30 Lawler, Matusky, and Skelly Engineers (9-1).

9-31 American Public Health Association (9-21).

9-32 Holm-Hansen, O. and B. Riemann, "Chlorophyll a Determination: Improvements in Methodology," OIKOS, Vol. 30, pp. 438-447 (1978).

9-33 Riemann, B., "Carotenoid Interference in the Spectrophotometric Determination of Chlorophyll Degradation Products from Natural Populations of Phytoplankton," Limnology and Oceanography, Vol. 23, pp. 1059-1066 (1978).

9-34 Whitney, D. E. and W. M. Darley, "A Method for the Determination of Chlorophyll a in Samples Containing Degradation Products," Limnology and Oceanography, Vol. 24, pp. 183-186 (1979).

9-35 Stauffer, R. E., G. F. Lee and D. E. Armstrong, "Estimating Chlorophyll Extraction Biases," Journal of the Fisheries Research Board of Canada, Vol. 36, pp. 152-157 (1979).

9-36 Roche, W. H., Biostimulation Studies in the Suisan Marsh, CA, Paper presented at a Workshop on Algal Nutrient Relationships in the San Francisco Bay and Delta (sponsored by California Department of Water Resources), Sacramento, CA, pp. 37-53 (November 1975).

9-37 LaraLara, J. R. y S. Alvarez Borrego, "Ciclo Anual de Clorofilas y Produccion Organica Primeria en Bahia San Quintin, B.C.," Ciencias Marinas, Vol. 2(1), pp. 77-97 (1975).

9-38 Hamilton, D. H., Jr., D. A. Flemer, C. W. Keefe and J. A. Mihursky, "Power Plants: Effects of Chlorination on Estuarine Primary Production," Science, Vol. 169, pp. 197-198 (1970).

9-39 Brook, A. J. and A. L. Baker, "Chlorination at Power Plants: Impact on Phytoplankton Productivity," Science, Vol. 176, pp. 1414-1415 (1972).

9-40 Briand, F. J.-P., "Effects of Power Plant Cooling Systems on Marine Phytoplankton," Marine Biology, Vol. 33, pp. 135-146 (1975).

9-41 Eppley, R. W., E. H. Renger and P. M. Williams, "Chlorine Reactions with Seawater Constituents and the Inhibition of Photosynthesis of Natural Marine Phytoplankton," Estuarine and Coastal Marine Science, Vol. 4, pp. 147-161 (1976).

9-42 Morgan, R. P. and R. G. Stross, "Destruction of Phytoplankton in the Cooling Water Supply of a Steam Electric Station," Chesapeake Science, Vol. 10, pp. 165-171 (1969).

9-43 Lawler, Matusky, and Skelly Engineers (9-1).

9-44 Goldman and Quinby (9-18).

9-45 Lawler, Matusky, and Skelly Engineers (9-1).

000790

9-46 Gonzalez (9-2).

9-47 Icanberry, J. W. and J. W. Warrick, Delayed Mortality of Entrained Copepods at Morro Bay Power Plant, Pacific Gas and Electric Company Department of Engineering Research - 7598.21-75, San Ramon, CA (July 1979).

9-48 Chadwick, H. K., Entrainment Survival Panel Discussion, Proceedings of the Fourth National Workshop on Entrainment and Impingement, Chicago, IL (December 1977).

9-49 Icanberry and Warrick (9-47).

9-50 Chadwick (9-48).

9-51 Boreman and Goodyear (9-13).

9-52 Blaxter, J. H. S. and G. Hempel, "Biologische Beobachtungen bei der Aufzucht von Heringsbrut," Helgoländer Wissenschaftliche Meeresuntersuchungen, Vol. 7, pp. 260-282 (1961).

9-53 Lasker, R., H. M. Feder, G. H. Theilacker and R. C. May, "Feeding, Growth and Survival of Engraulis mordax Larvae Reared in the Laboratory," Marine Biology, Vol. 5, pp. 345-353 (1970).

9-54 O'Connell, C. P. and L. P. Raymond, "The Effect of Food Density on Survival and Growth of Early Post Yolk-Sac Larvae of the Northern Anchovy (Engraulis mordax Girard) in the Laboratory," Journal of Experimental Marine Biology and Ecology, Vol. 5, pp. 187-197 (1970).

000791

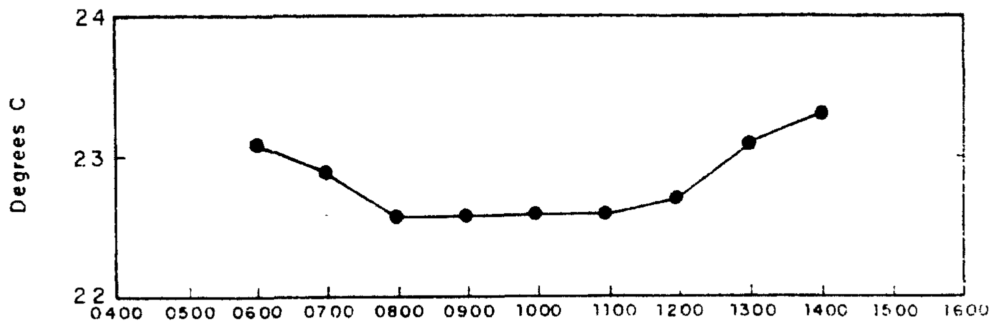
9-55 Theilacker, G. H., "Effect of Starvation on the Histological and Morphological Characteristics of Jack Mackerel, Trachurus symmetricus, Larvae," Fisheries Bulletin, Vol. 76, pp. 403-414 (1978).

9-56 Icanberry, J. W., Personal Communication, Pacific Gas and Electric Company Department of Engineering Research, San Ramon, CA (February 1980).

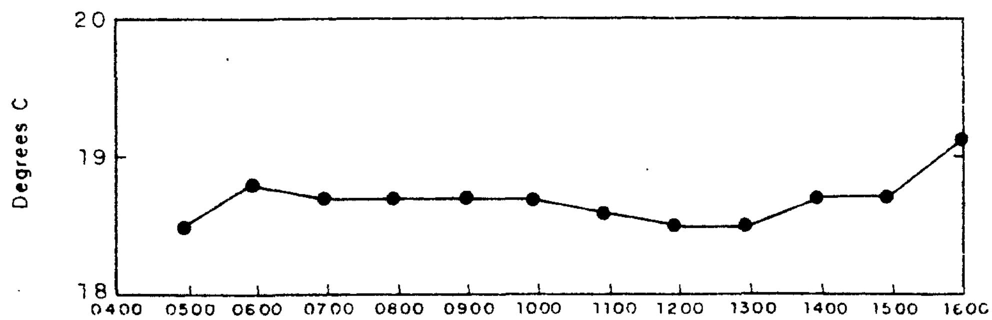
9-57 Lasker, R., Personal Communication, National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, CA (February 1980).

9-58 Ecological Analysts (9-3).

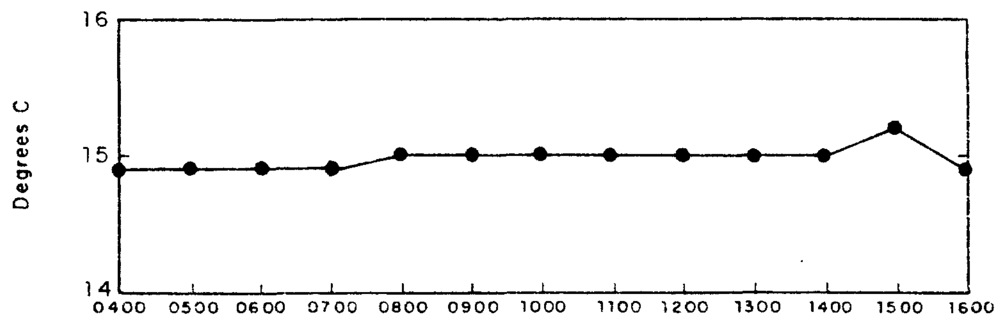
9-59 Boreman and Goodyear (9-13).



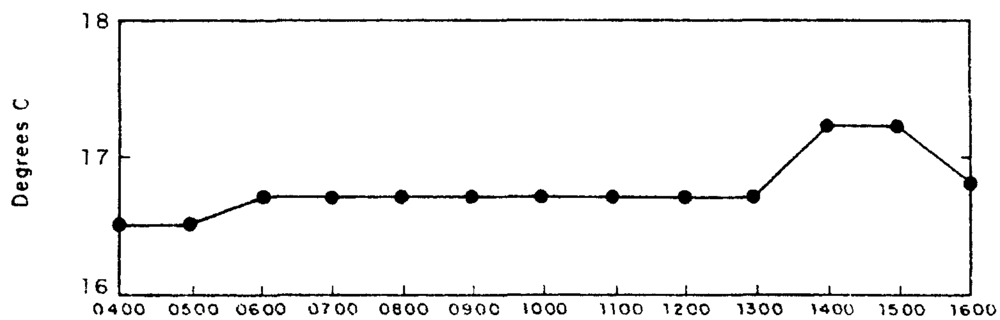
15 Sep 1979 run 8-hr incubation 0600-1400 No chlorination



27 Sep 1979 run 11-hr incubation 0500-1600 Chlorination



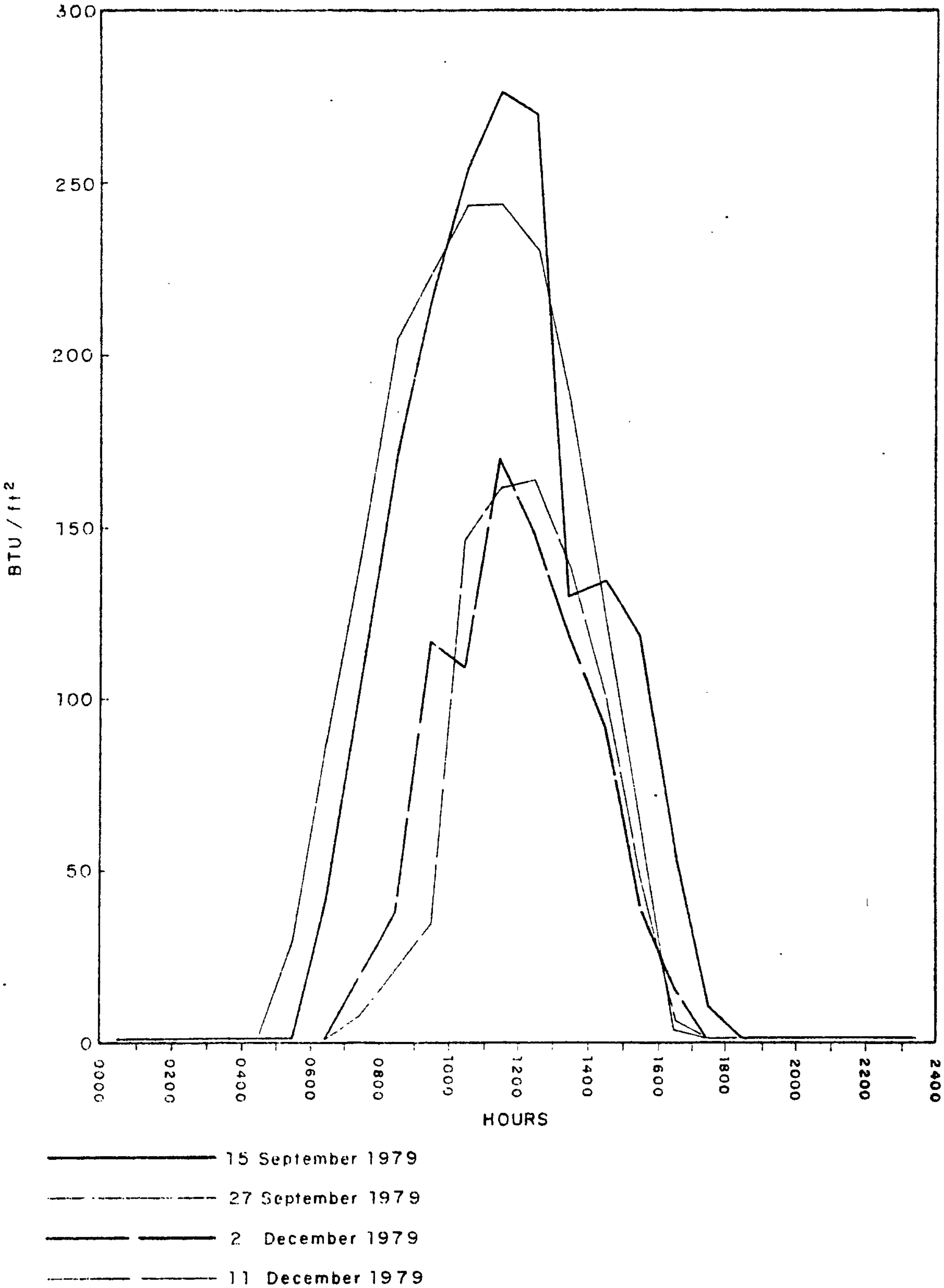
2 Dec 1979 run 12-hr incubation 0400-1600 No chlorination



11 Dec 1979 run 12-hr incubation 0400-1600 Chlorination

SAN DIEGO GAS & ELECTRIC COMPANY	
Incubation water temperatures during primary productivity assessments Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.4-1

000793



SAN DIEGO GAS & ELECTRIC COMPANY

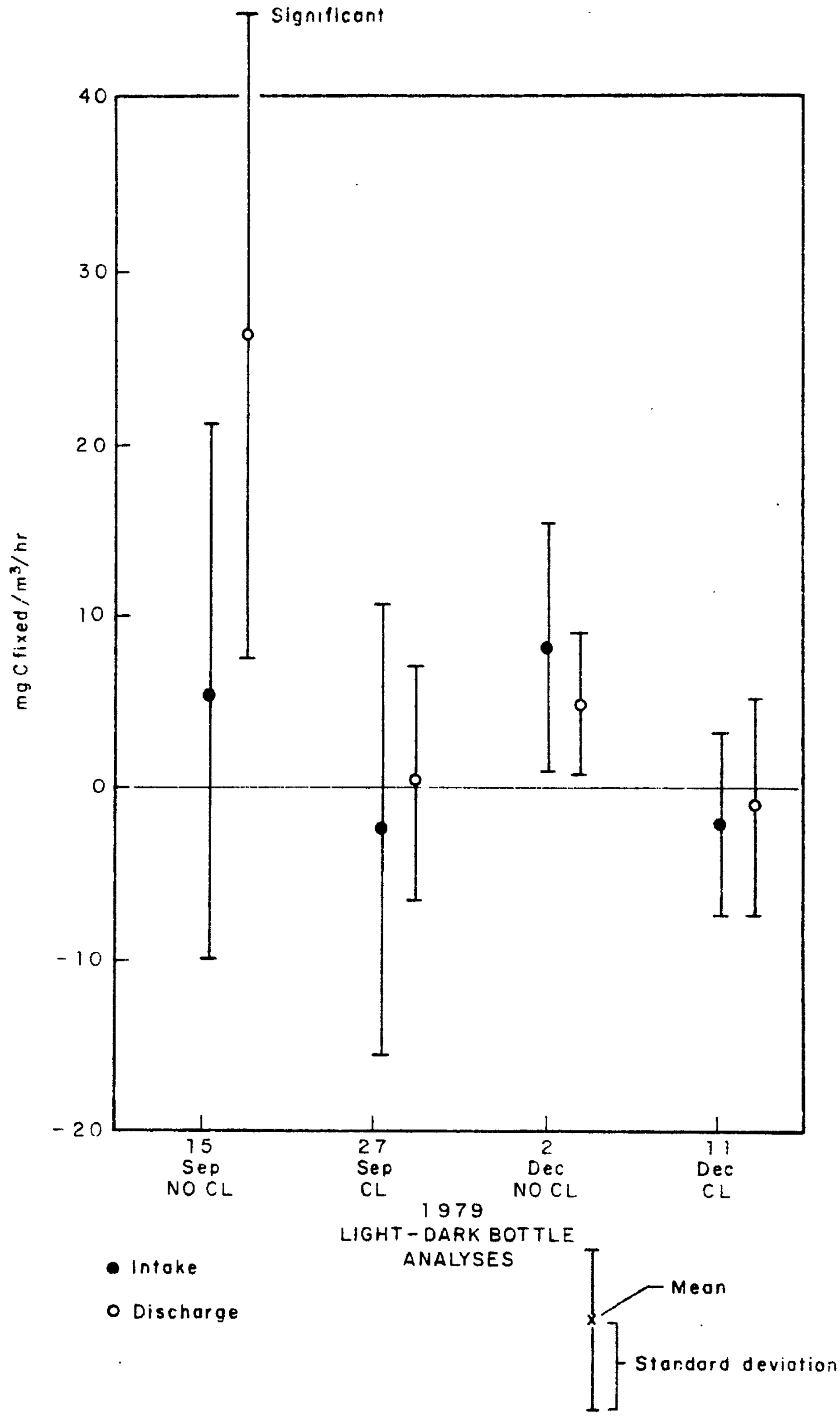
Insolation data during incubations for light-dark bottle analyses

Encina Power Plant - August 1, 1980

PREPARED BY: WOODWARD-CLYDE CONSULTANTS

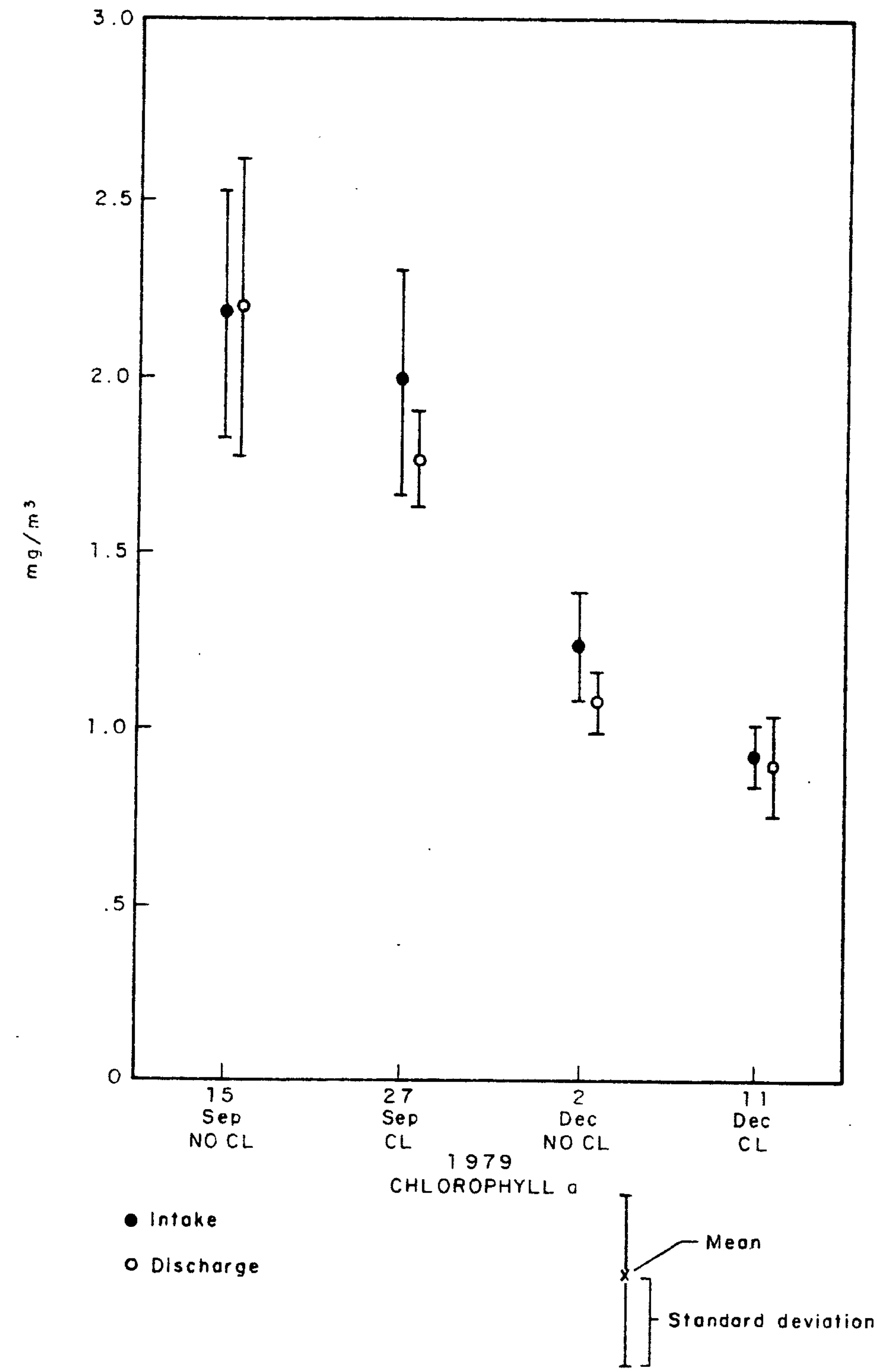
FIGURE NO. 9.4-2

000794



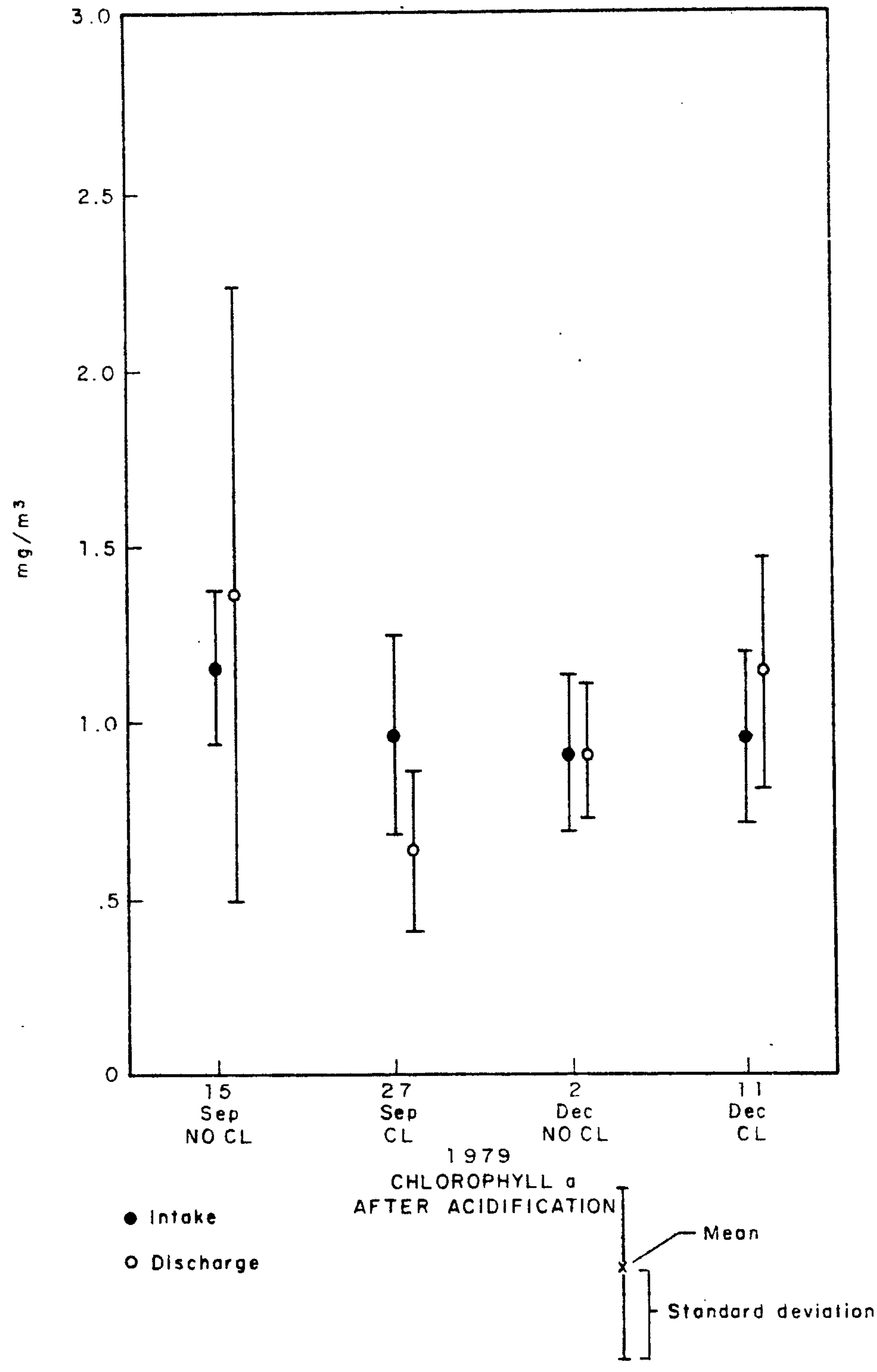
SAN DIEGO GAS & ELECTRIC COMPANY	
Results of light-dark bottle analyses: net productivity Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.4-3

000795



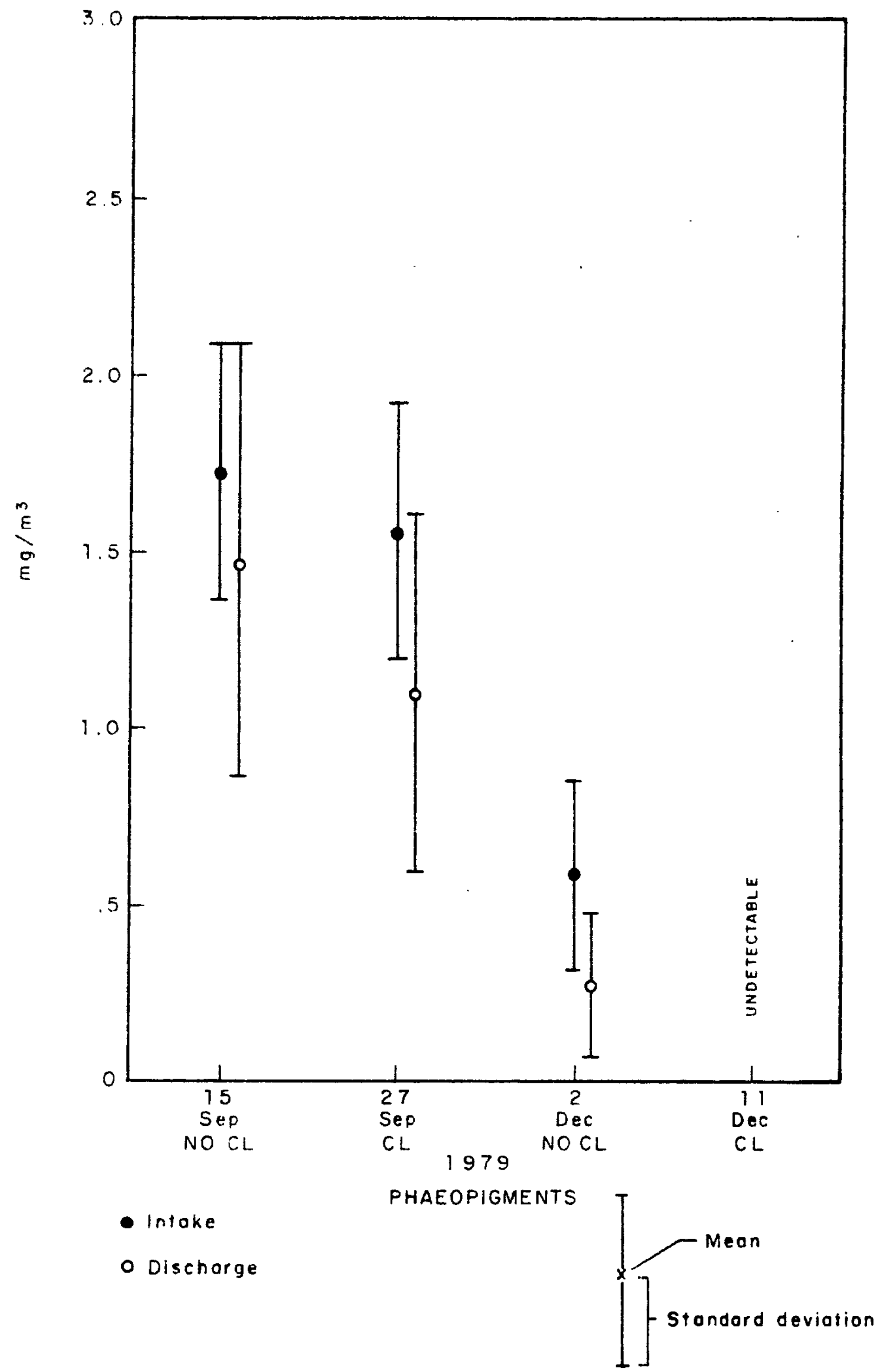
SAN DIEGO GAS & ELECTRIC COMPANY	
Trichromatic chlorophyll a Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.4-4

000796



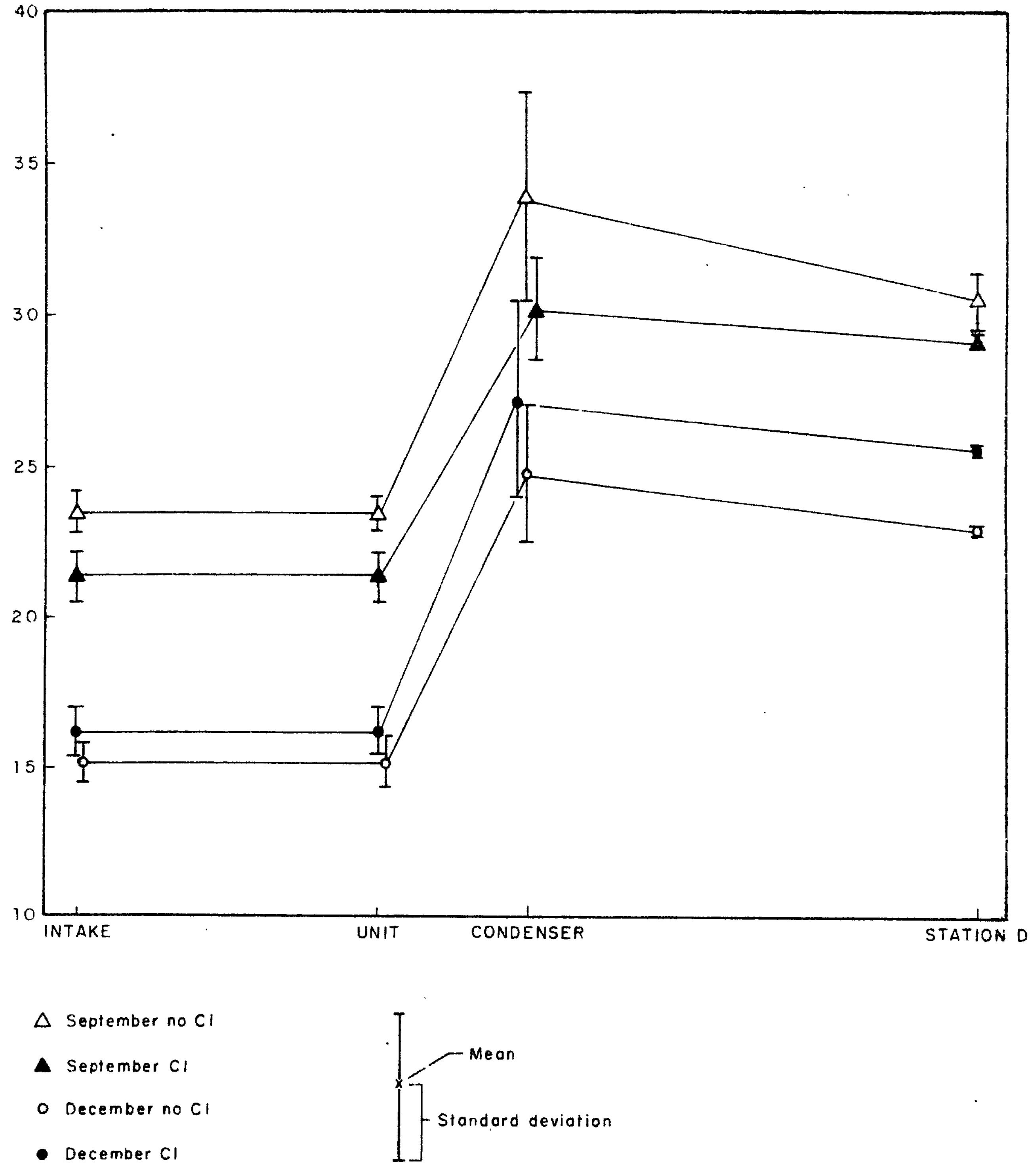
SAN DIEGO GAS & ELECTRIC COMPANY	
Chlorophyll a, after acidification Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.4-5

000797



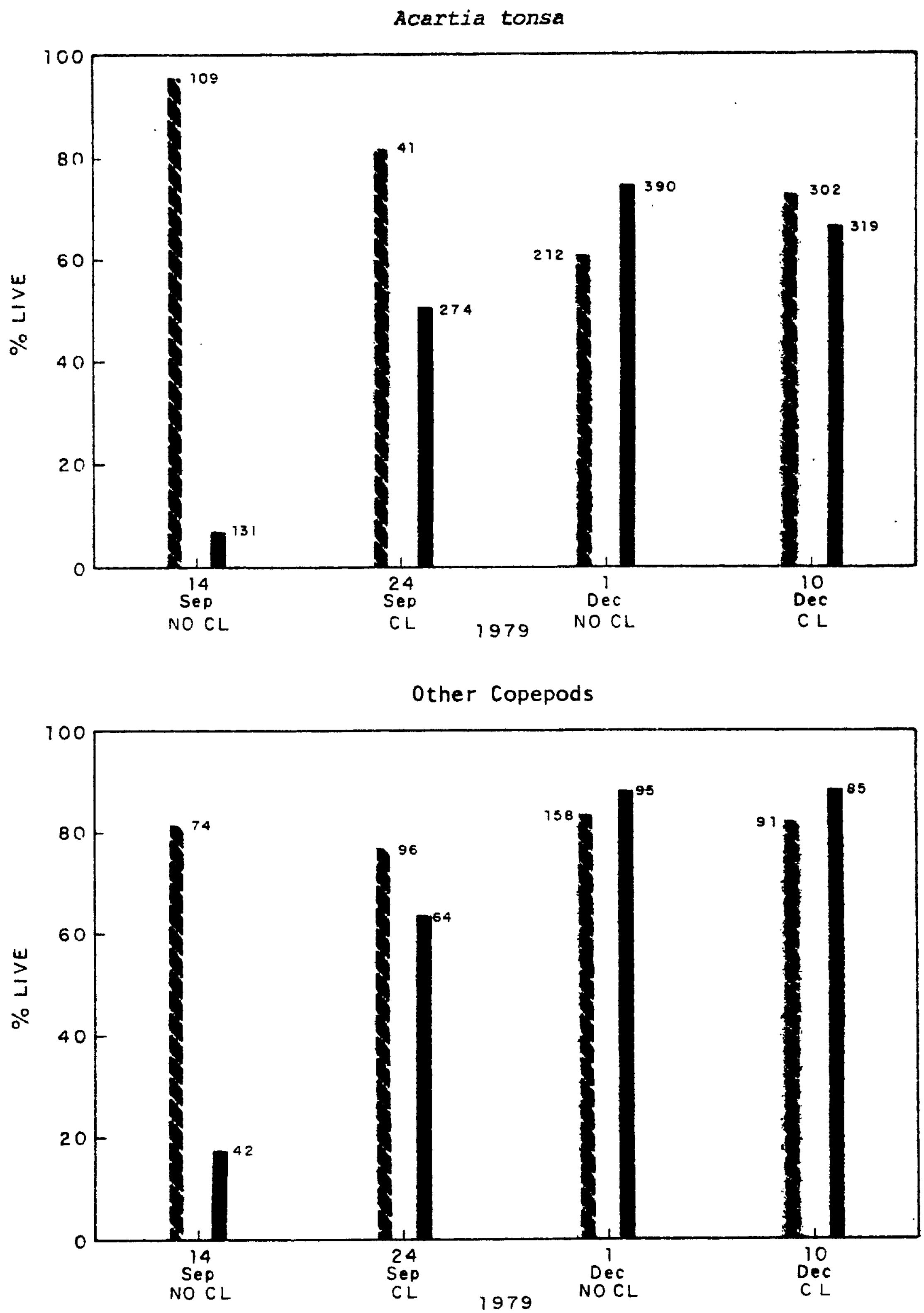
000798

SAN DIEGO GAS & ELECTRIC COMPANY	
Phaeopigment results Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.4-6



SAN DIEGO GAS & ELECTRIC COMPANY	
Temperature regimes during sampling for entrainment mortality studies Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-1

000799

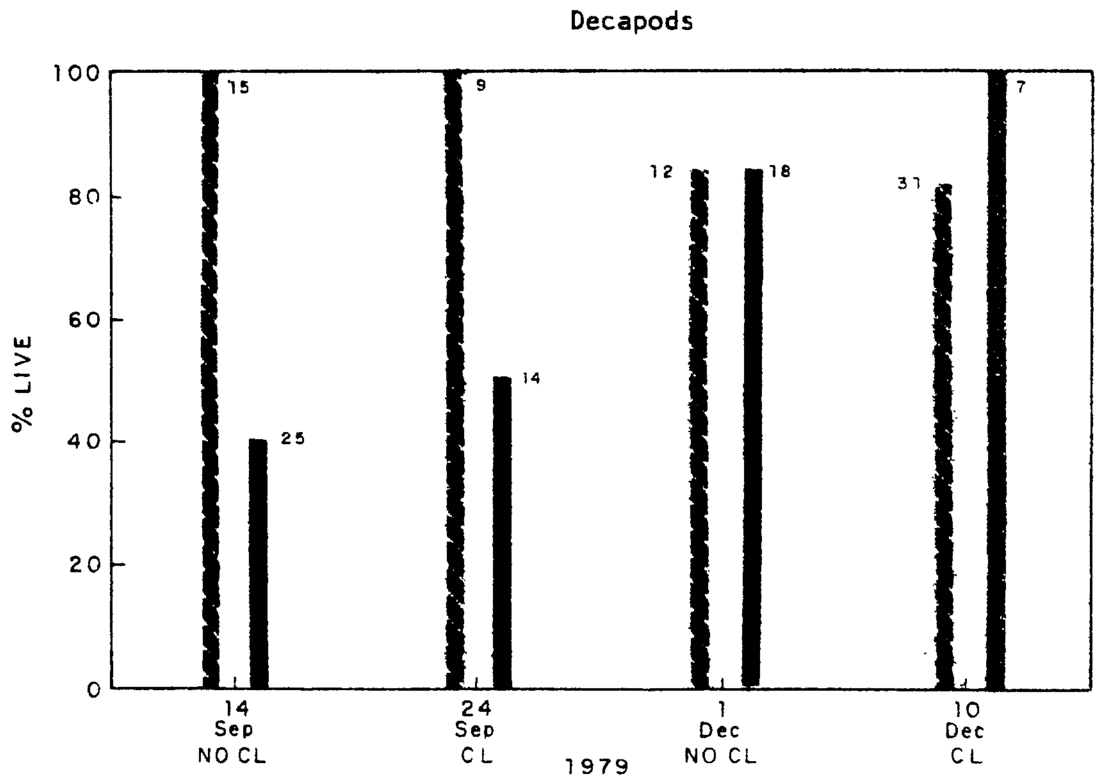


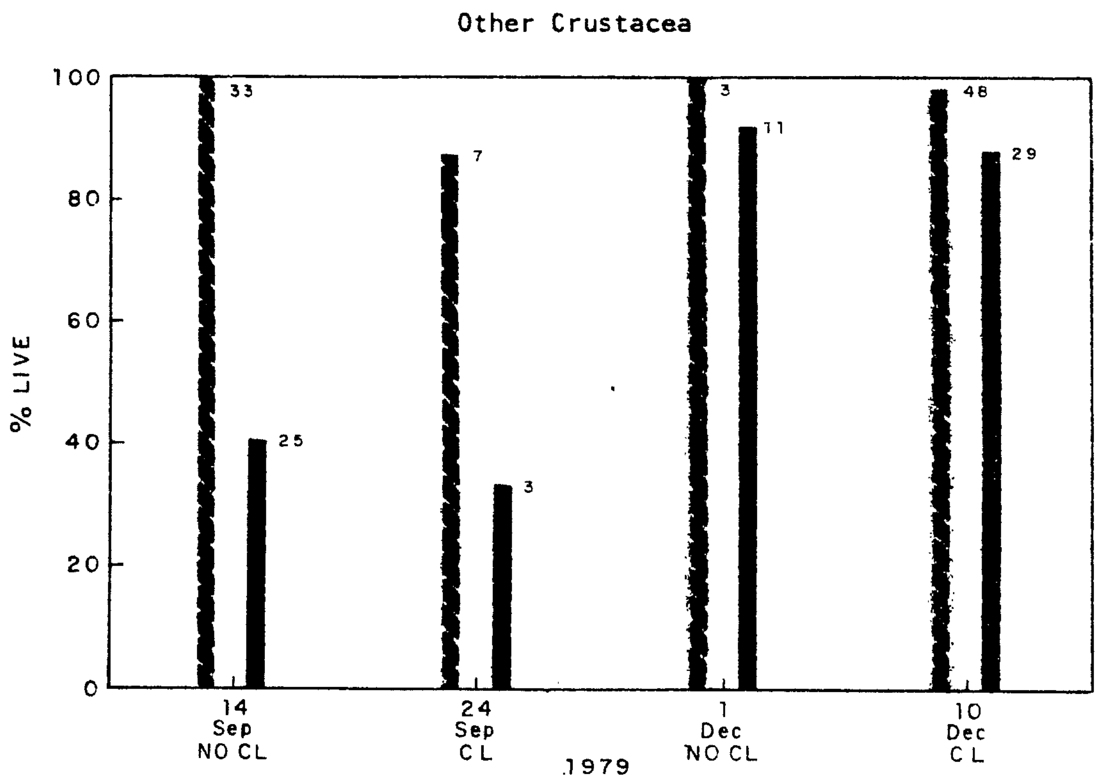
INTAKE

DISCHARGE

SAN DIEGO GAS & ELECTRIC COMPANY	
Results of initial mortality experiments for <u>Acartia</u> <u>tonsa</u> and copepods Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-2

000800

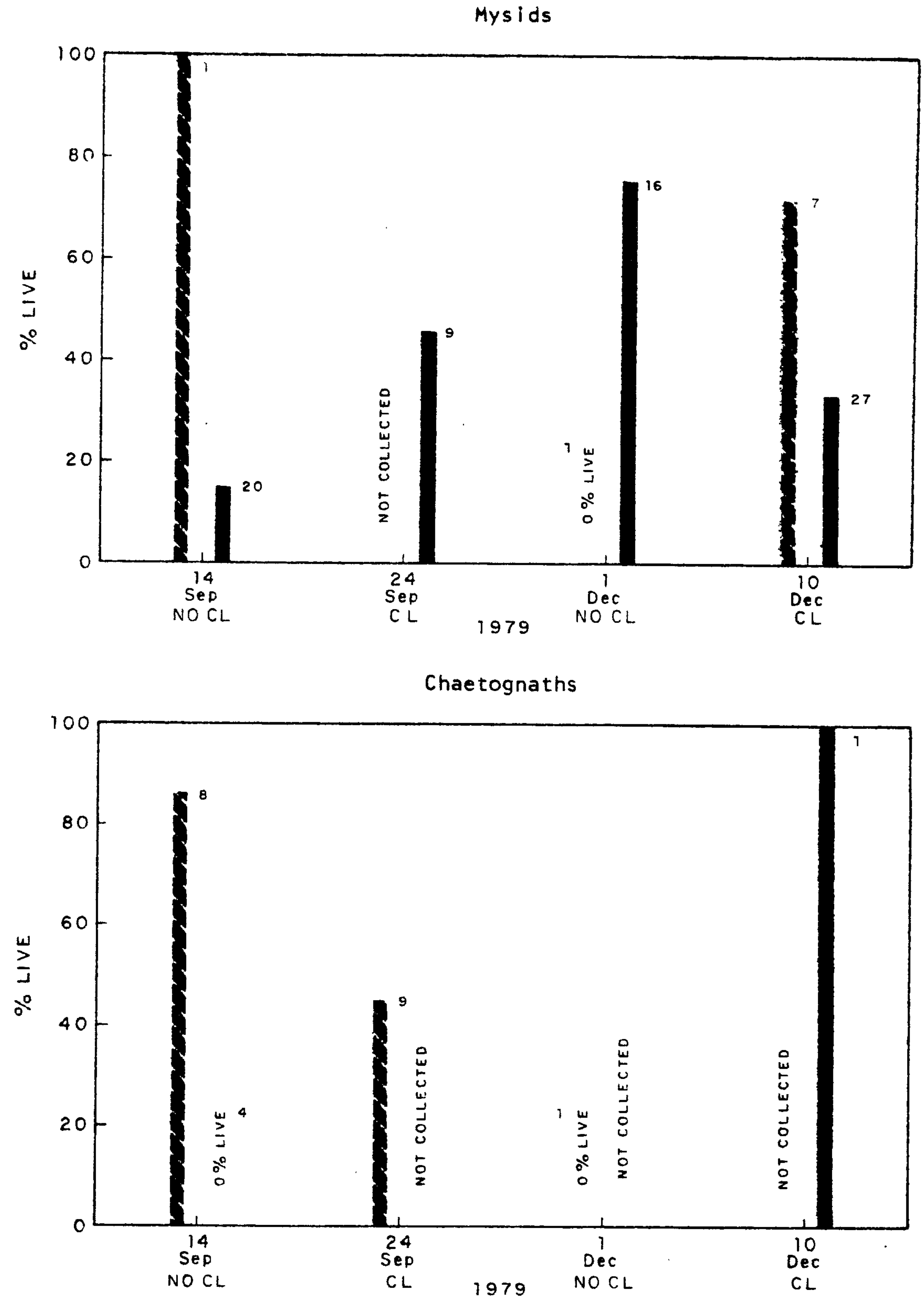




INTAKE

DISCHARGE

SAN DIEGO GAS & ELECTRIC COMPANY	
Results of initial mortality experiments for decapods and other crustacea Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-3

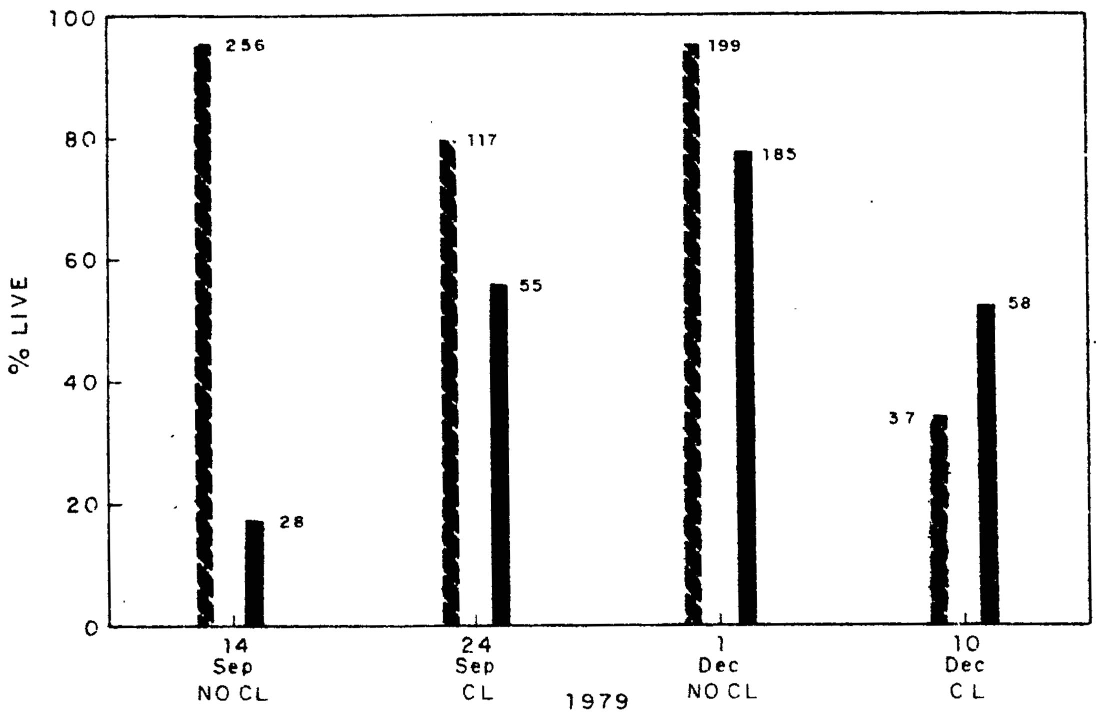


INTAKE

DISCHARGE

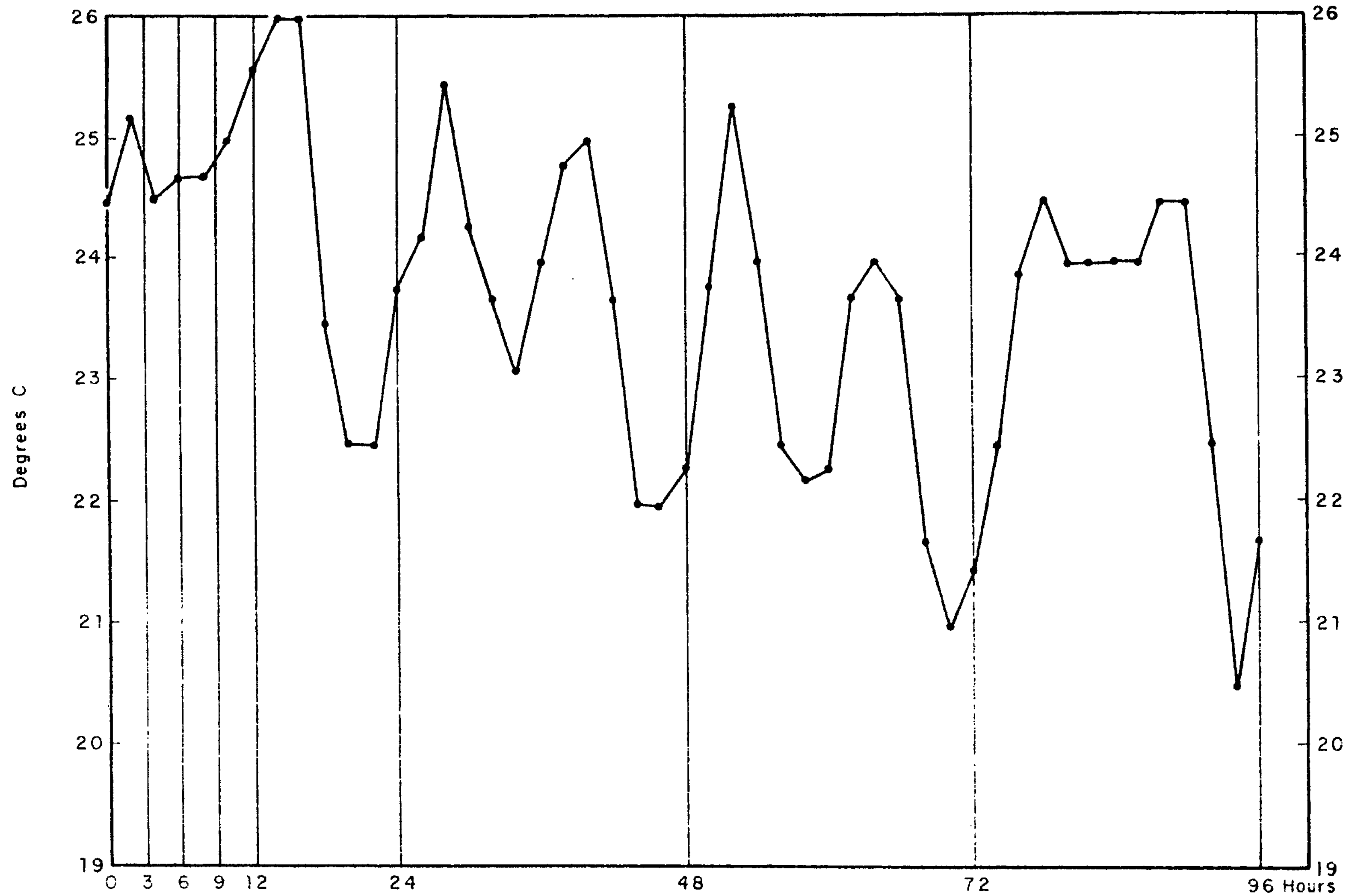
SAN DIEGO GAS & ELECTRIC COMPANY	
Results of initial mortality experiments for mysids and chaetognaths Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-4

Other Zooplankton



SAN DIEGO GAS & ELECTRIC COMPANY	
Results of initial mortality experiments for other zooplankton Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-5

000803



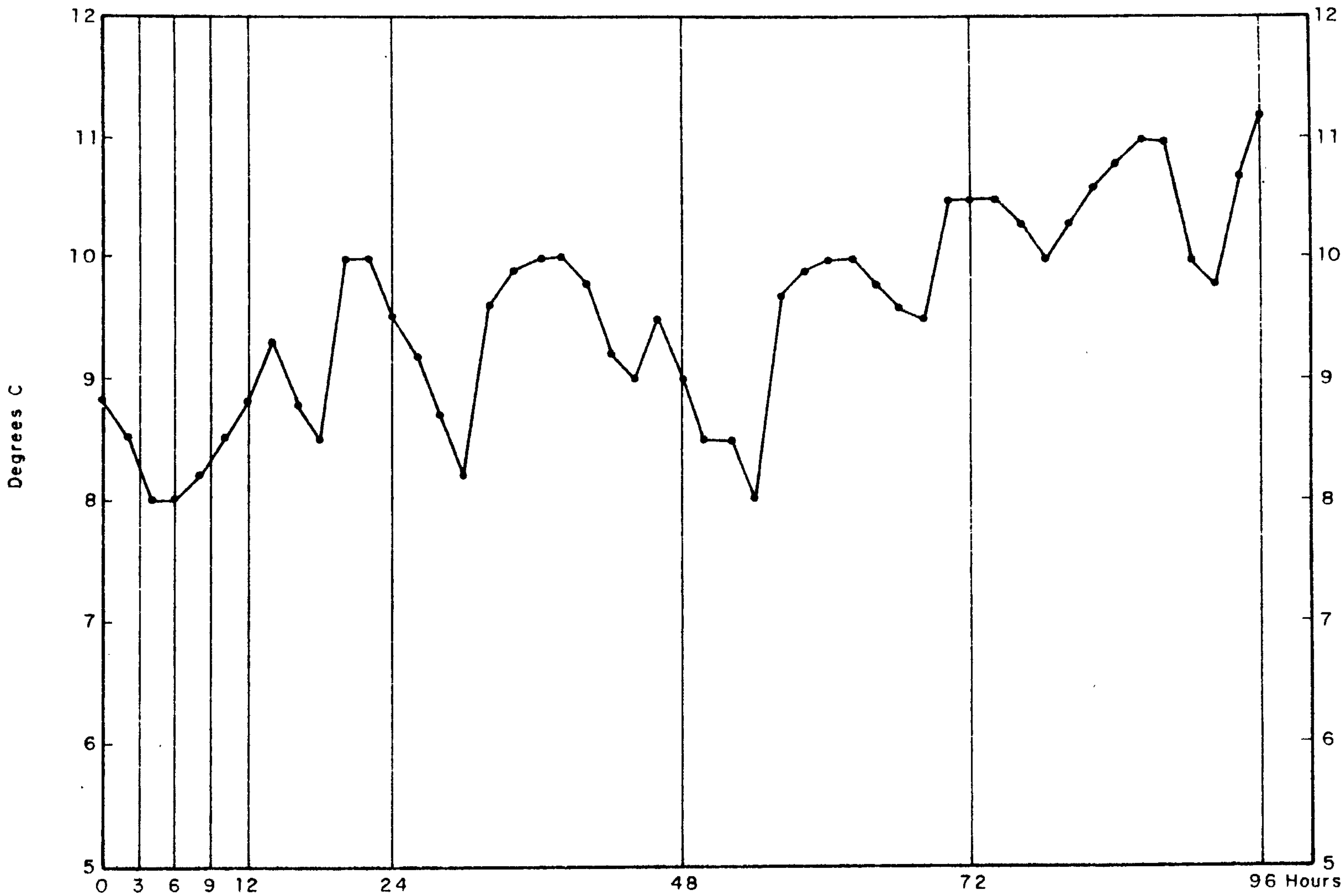
RANGE: 20.5-26.0°C

AVERAGE: 23.7 ± 1.3°C

14-19 September 1979.

SAN DIEGO GAS & ELECTRIC COMPANY	
Incubation temperatures, Sept. 14-19, 1979 delayed mortality study Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-6

000804

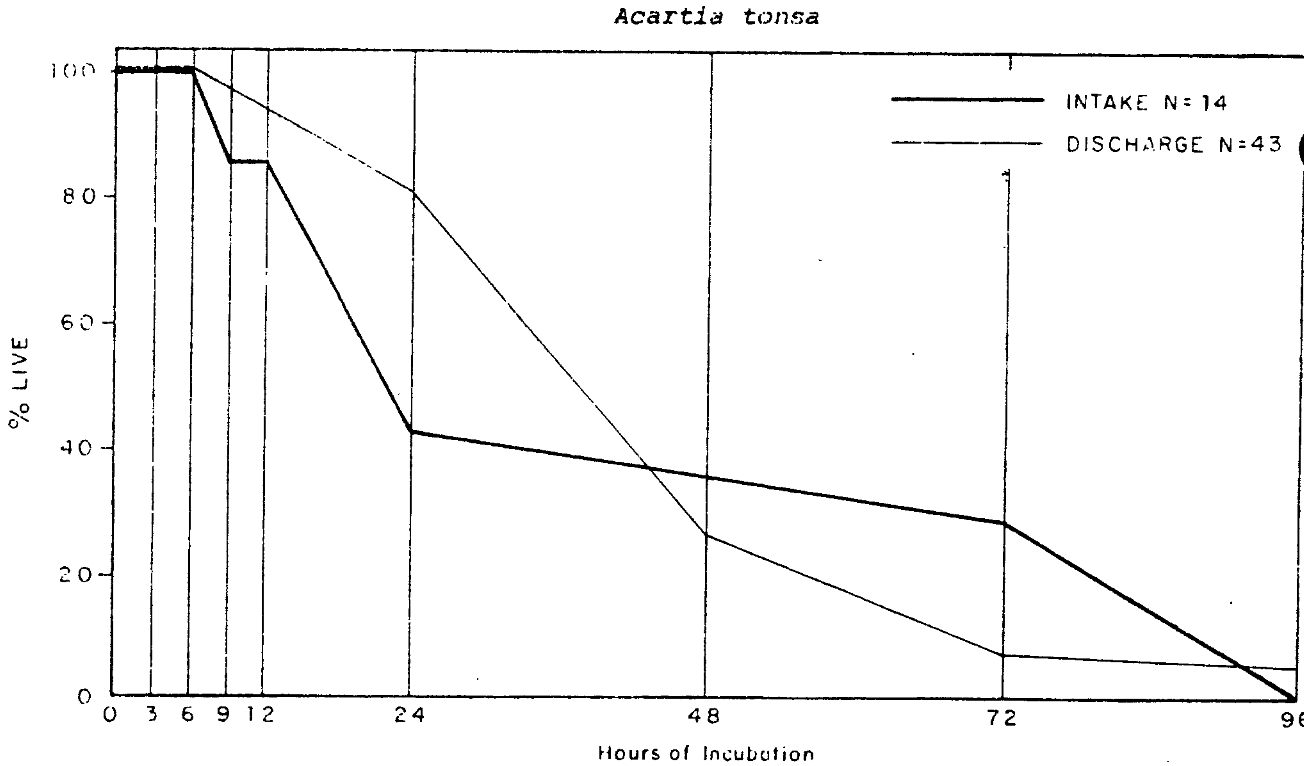


RANGE: 8 – 11.2 °C

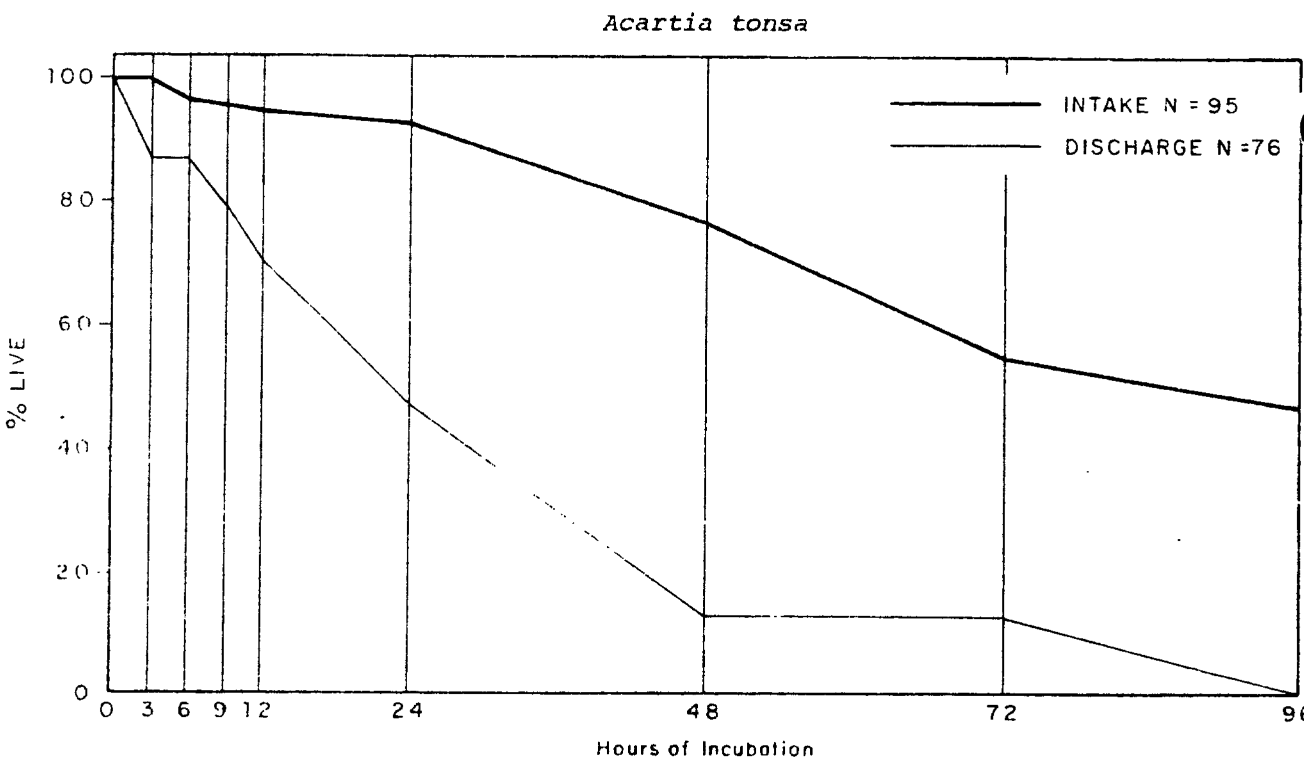
AVERAGE: 9.6 ± 0.9 °C

1 – 5 December 1979

SAN DIEGO GAS & ELECTRIC COMPANY	
Incubation temperatures, Dec. 1-5, 1979 delayed mortality study Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-7



14-18 September 1979 NO CL RUN

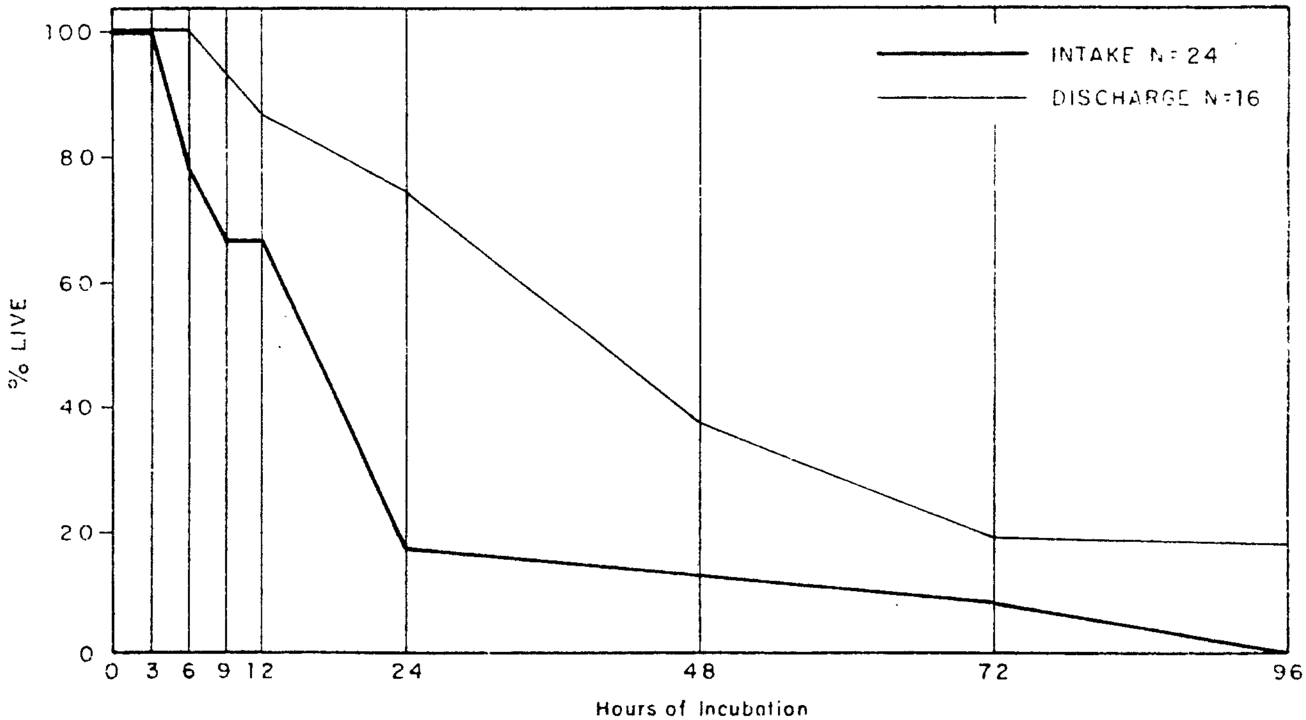


1-5 December 1979 NO CL RUN

SAN DIEGO GAS & ELECTRIC COMPANY	
Delayed mortality results for *Acartia tonsa*: no chlorination runs Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-8

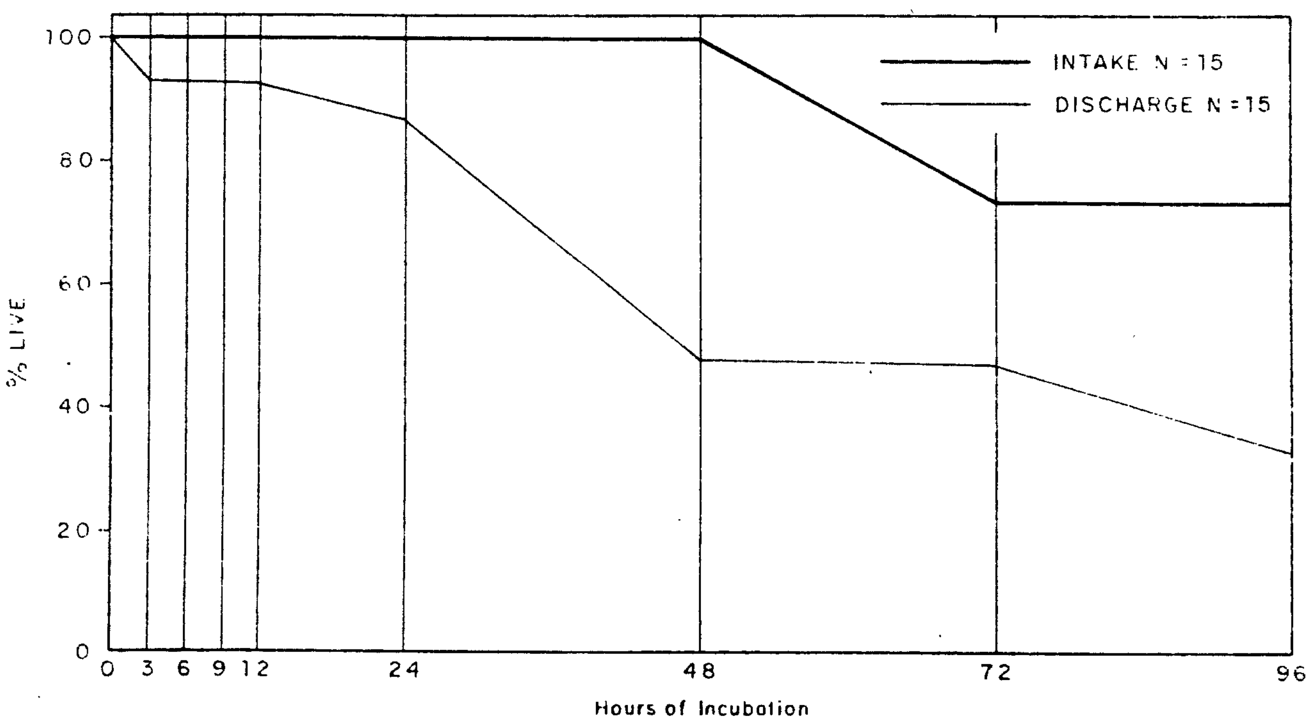
000806

Other Copepods



14-18 September 1979 NO CL RUN

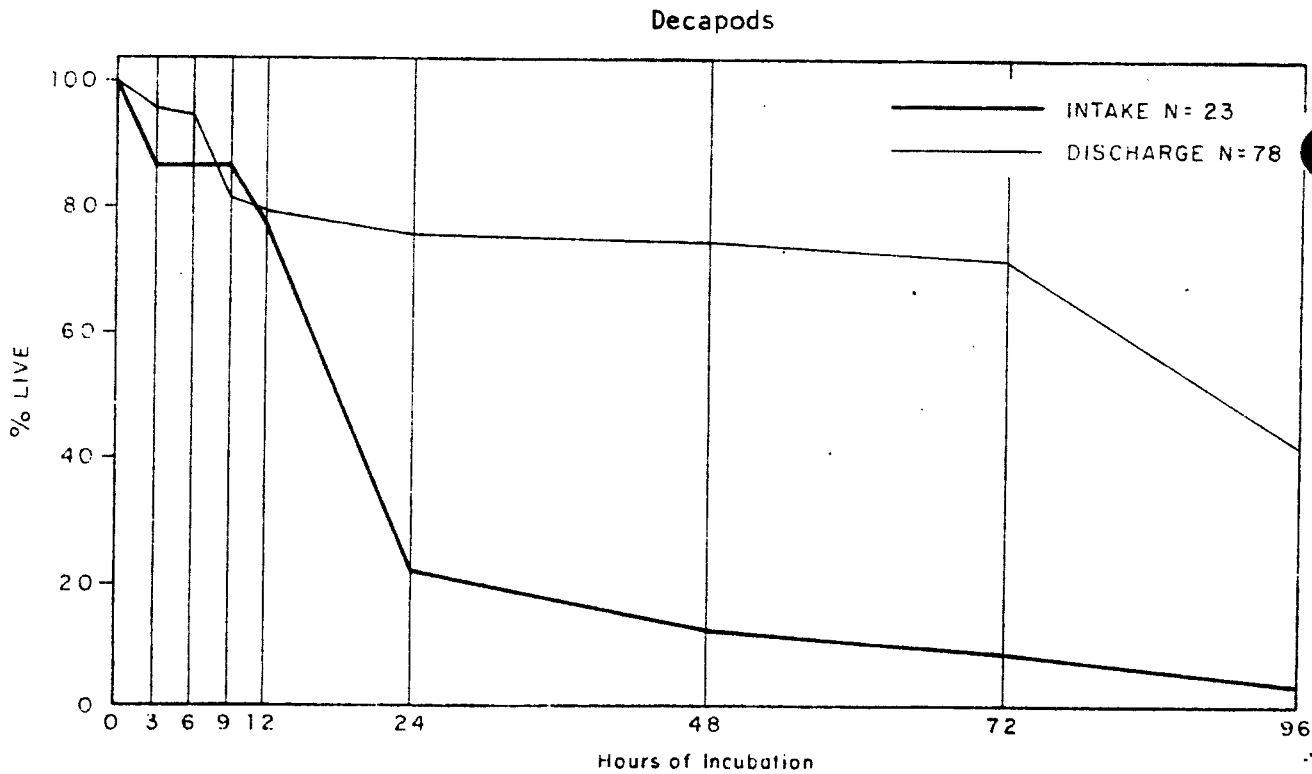
Other Copepods



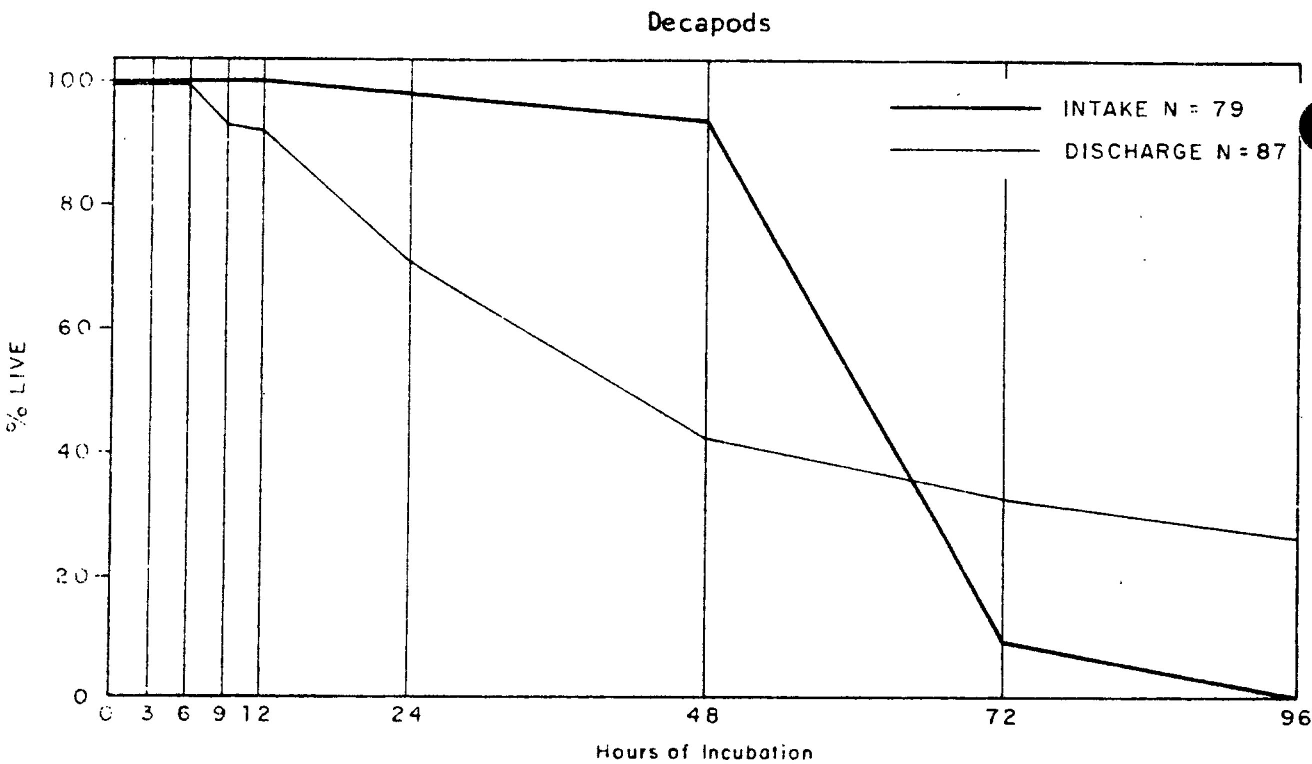
1-5 December 1979 NO CL RUN

SAN DIEGO GAS & ELECTRIC COMPANY	
Delayed mortality results for other copepods: no chlorination runs Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-9

000807



14-18 September 1979 NO CL RUN

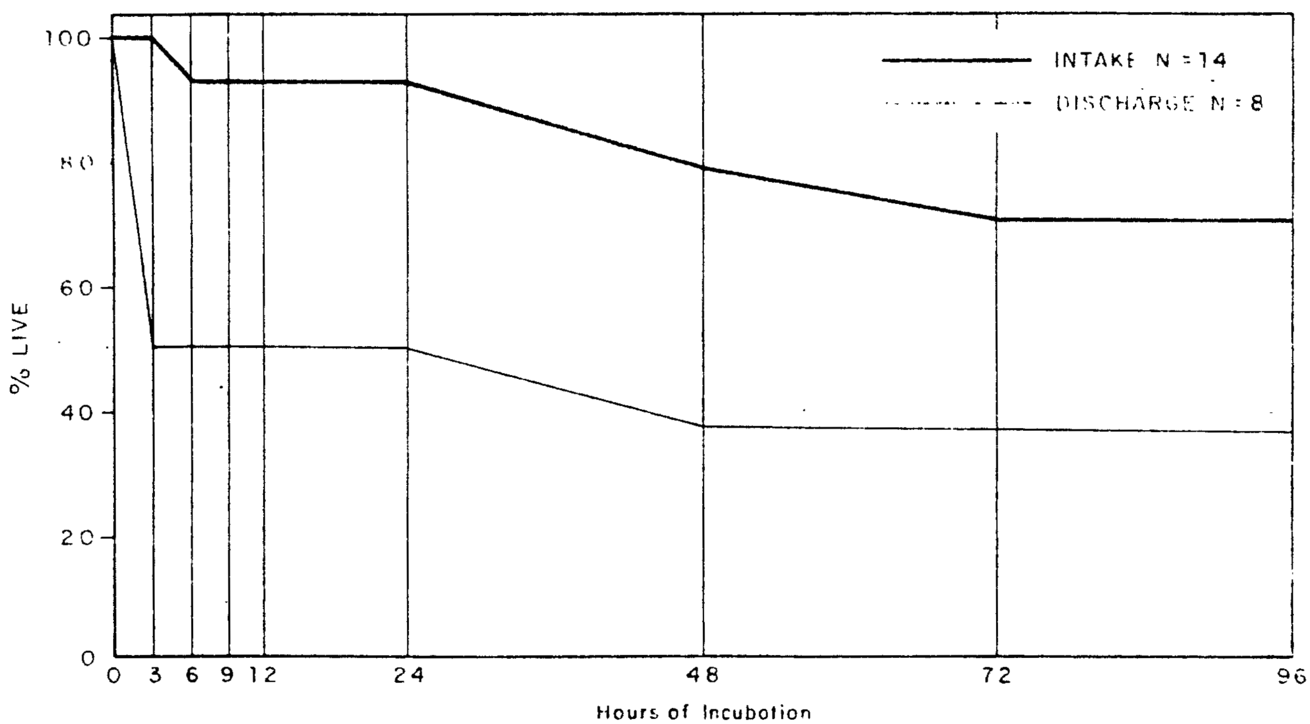


1-5 December 1979 NO CL RUN

000808

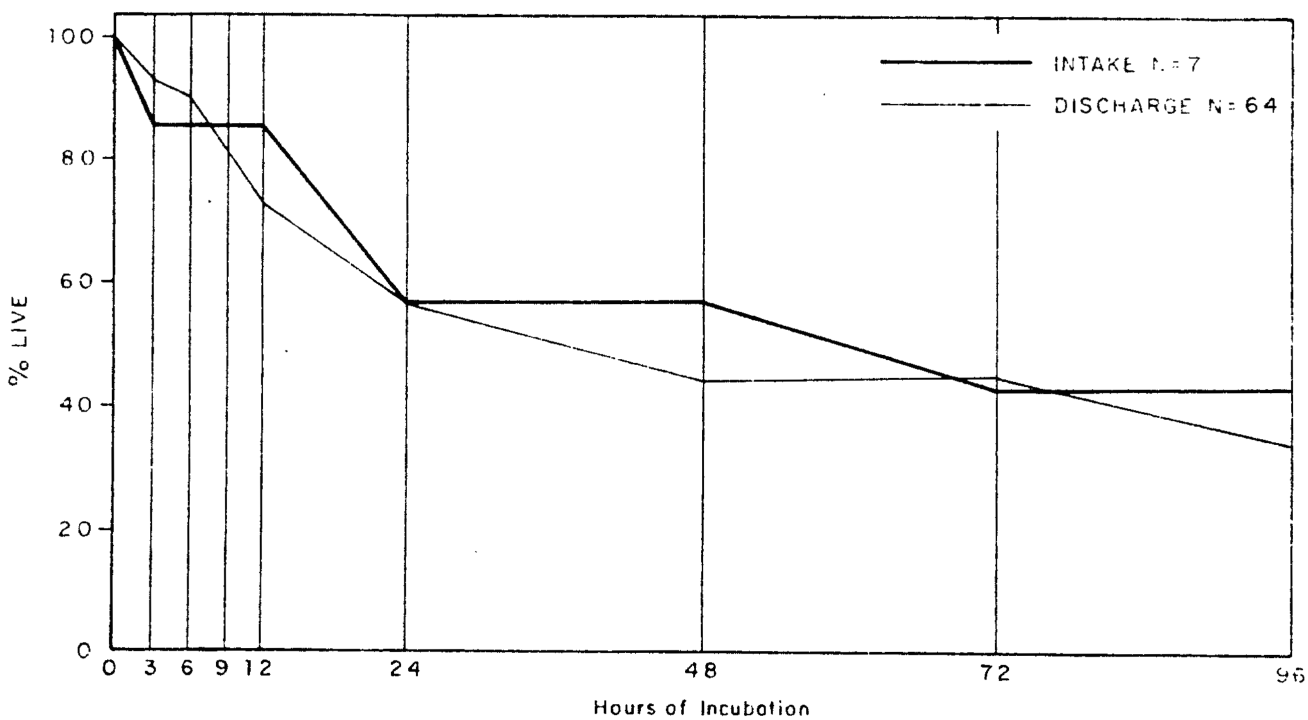
SAN DIEGO GAS & ELECTRIC COMPANY	
Delayed mortality results for decapods: no chlorination runs Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-10

Other Crustacea



14-18 September 1979 NO CL RUN

Other Crustacea

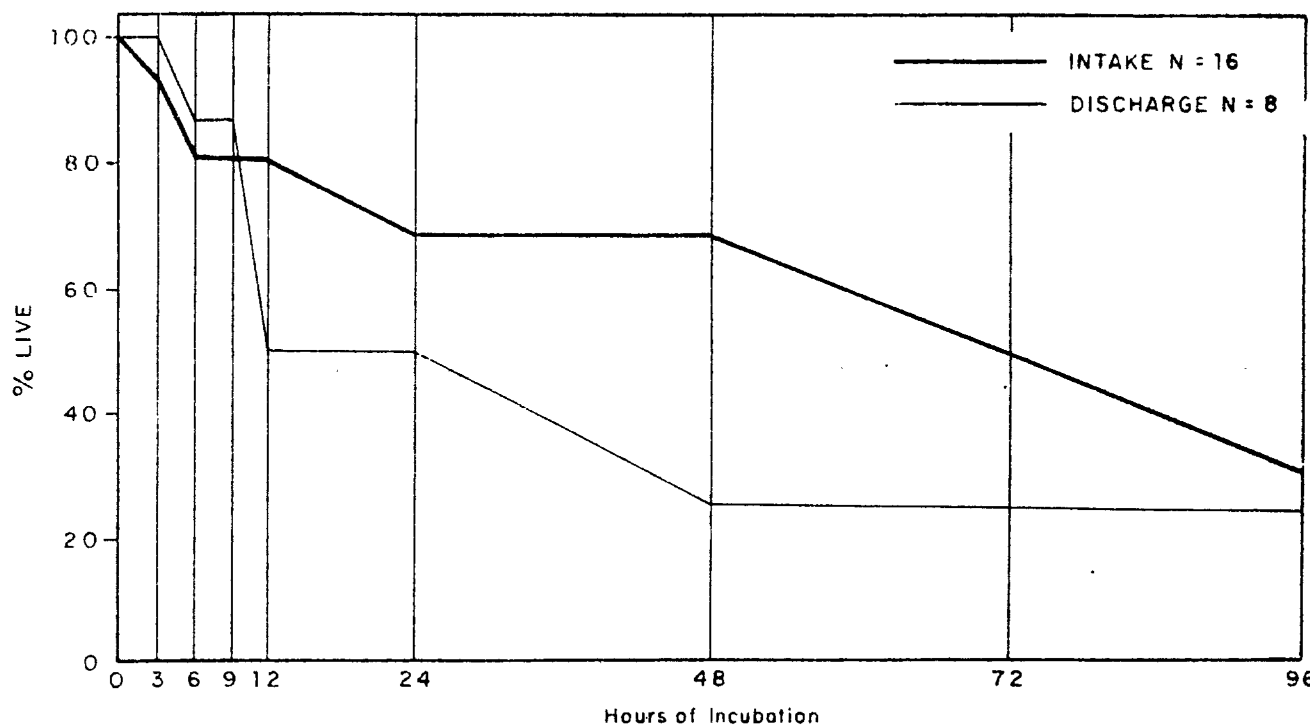


24-29 September 1979 CL RUN

SAN DIEGO GAS & ELECTRIC COMPANY	
Delayed mortality results for other crustacea: September runs Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-11

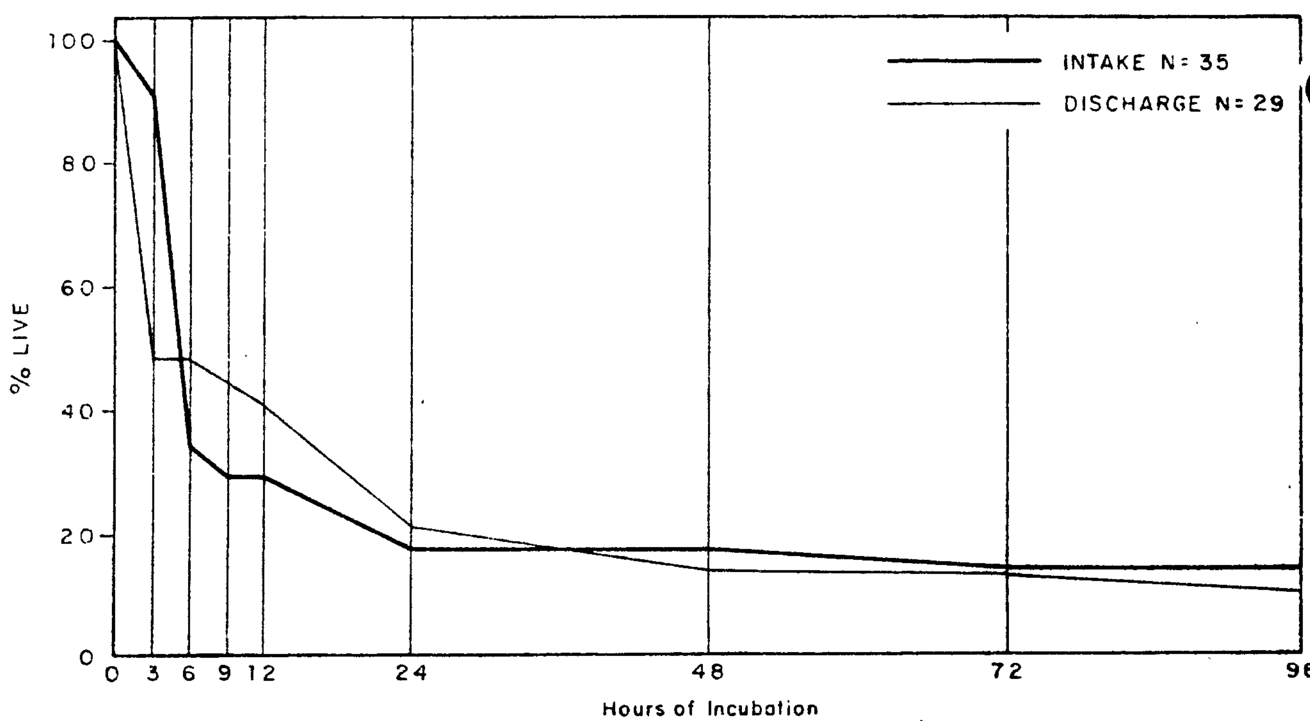
000809

Other Zooplankton



14-18 September 1979 NO CL RUN

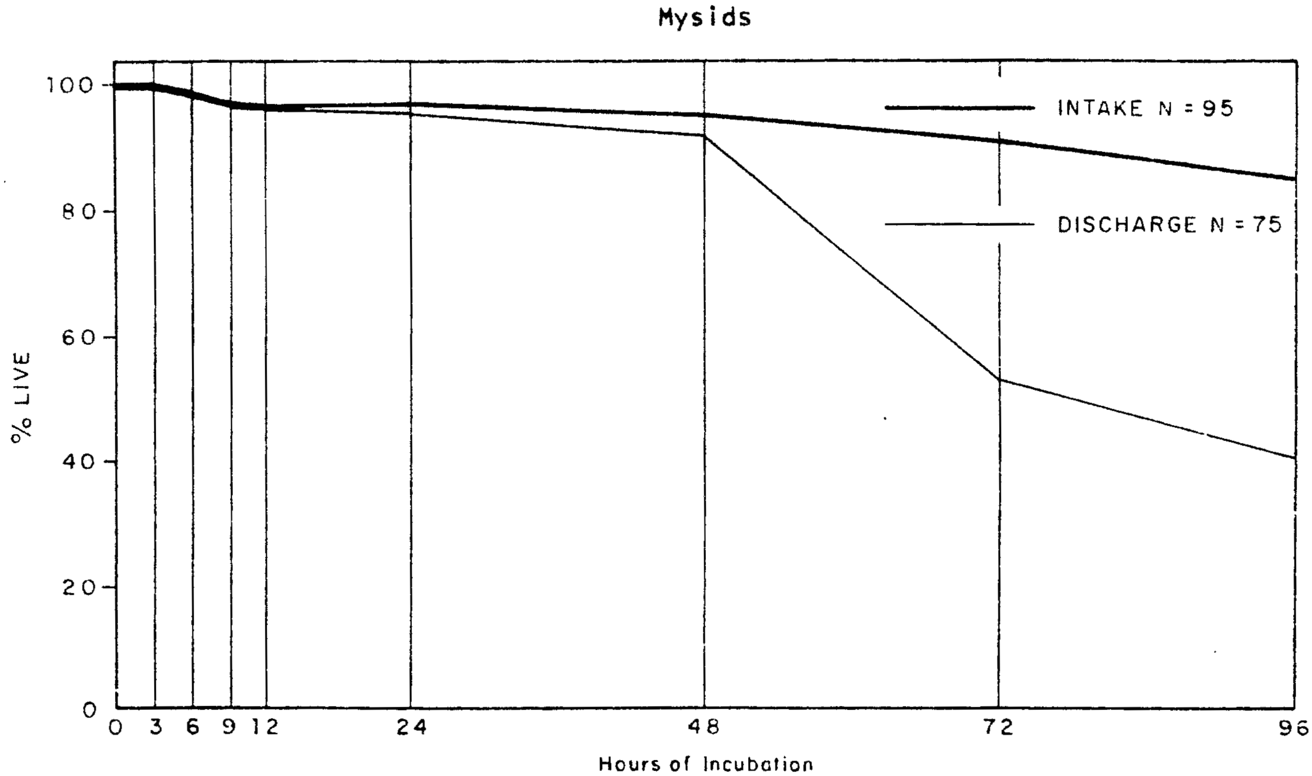
Other Zooplankton



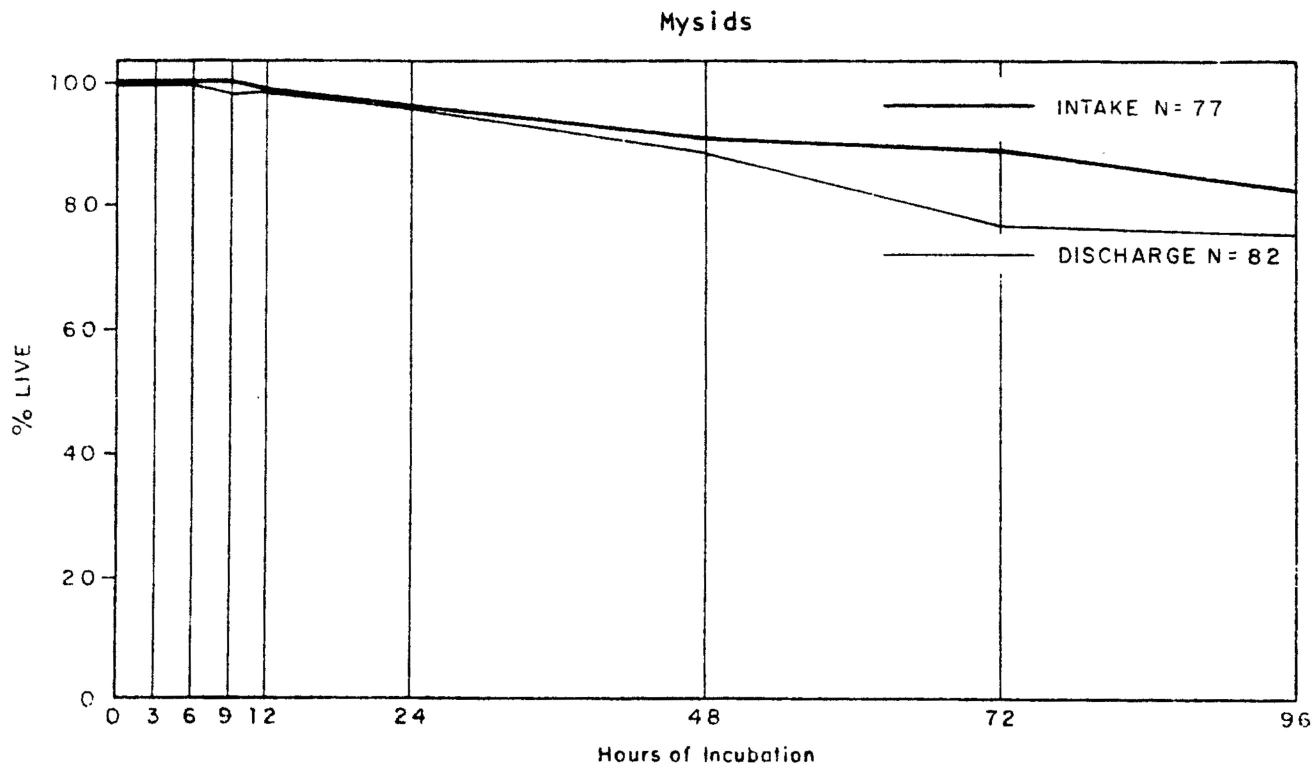
24-29 September 1979 CL RUN

000810

SAN DIEGO GAS & ELECTRIC COMPANY	
Delayed mortality results for other zooplankton: September runs Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-12



1-5 December 1979 NO CL RUN



10-14 December 1979 CL RUN

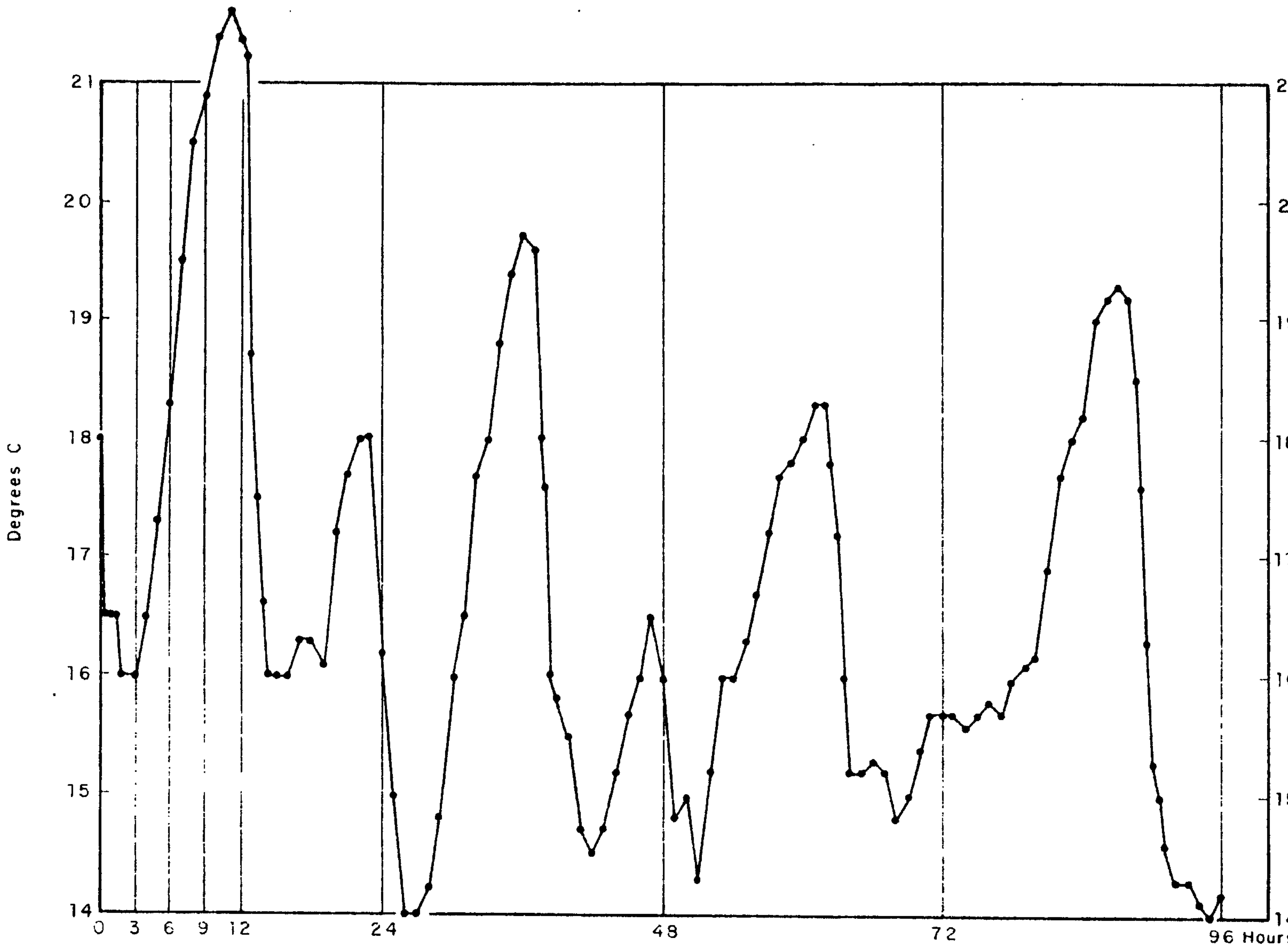
SAN DIEGO GAS & ELECTRIC COMPANY

Delayed mortality results for mysids: December runs

Encina Power Plant - August 1, 1980

PREPARED BY: WOODWARD-CLYDE CONSULTANTS

FIGURE NO. 9.5-13



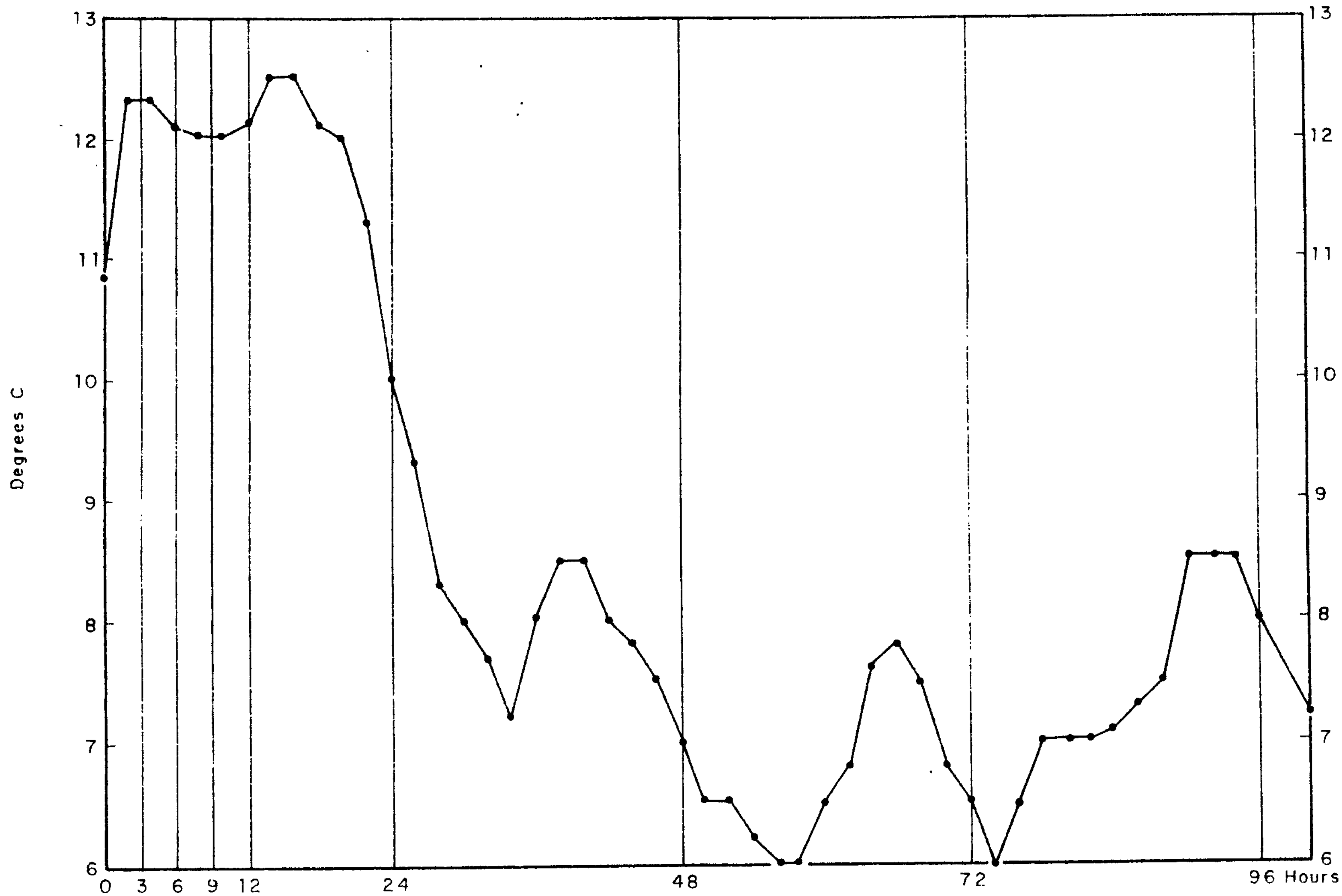
RANGE: 14-21.8 °C

AVERAGE: 17 ± 1.9°C

24-29 September 1979

SAN DIEGO GAS & ELECTRIC COMPANY	
Incubation temperatures, September 24-29, 1979 delayed mortality study	
Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-14

000312



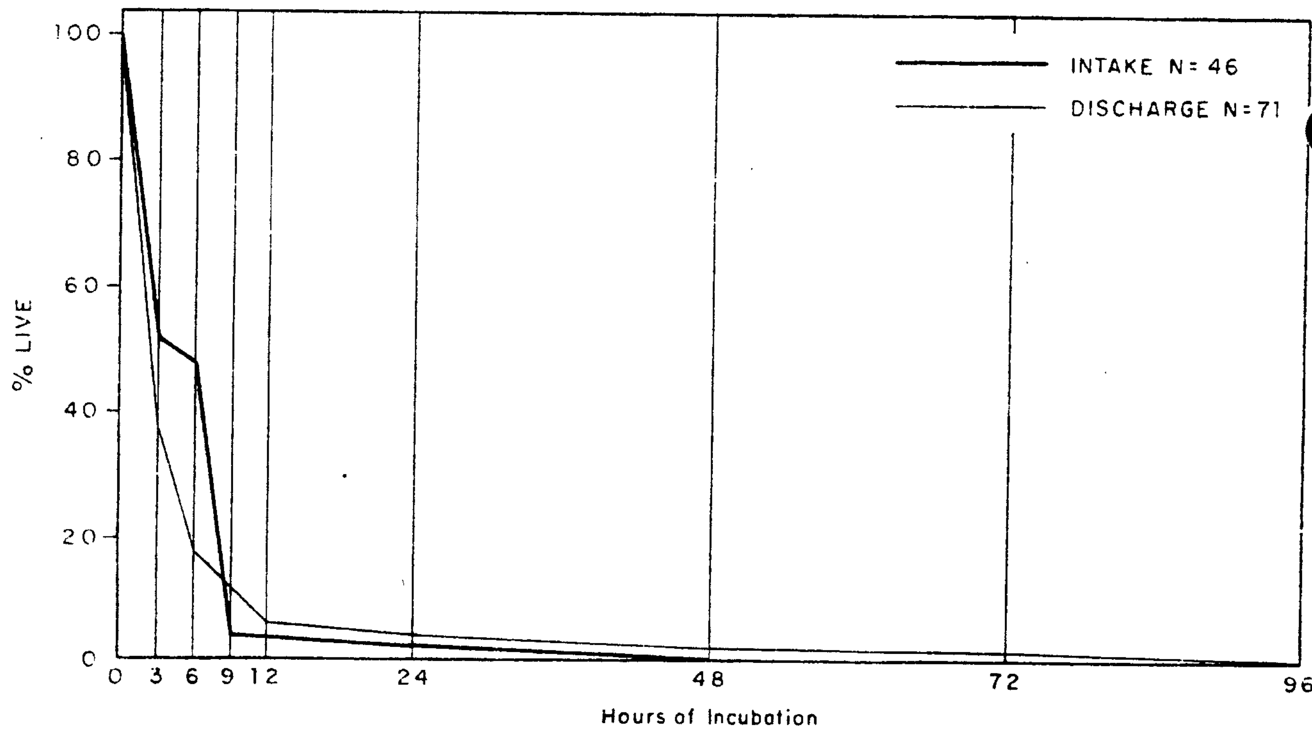
RANGE: 6 - 12.5 °C

AVERAGE: 8.5 ± 2.14°C

10 - 14 December 1979 run

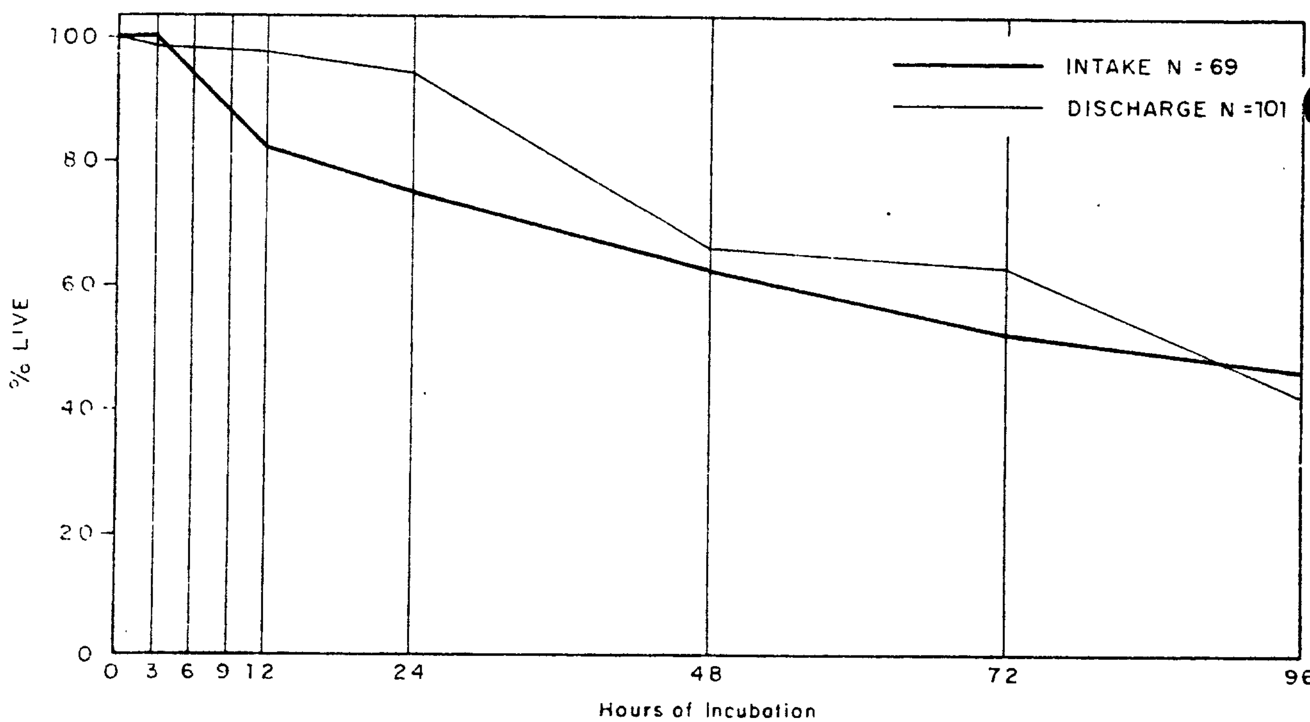
SAN DIEGO GAS & ELECTRIC COMPANY	
Incubation temperatures, December 10-14 delayed mortality study Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-15

Acartia tonsa



24-29 September 1979 CL Run

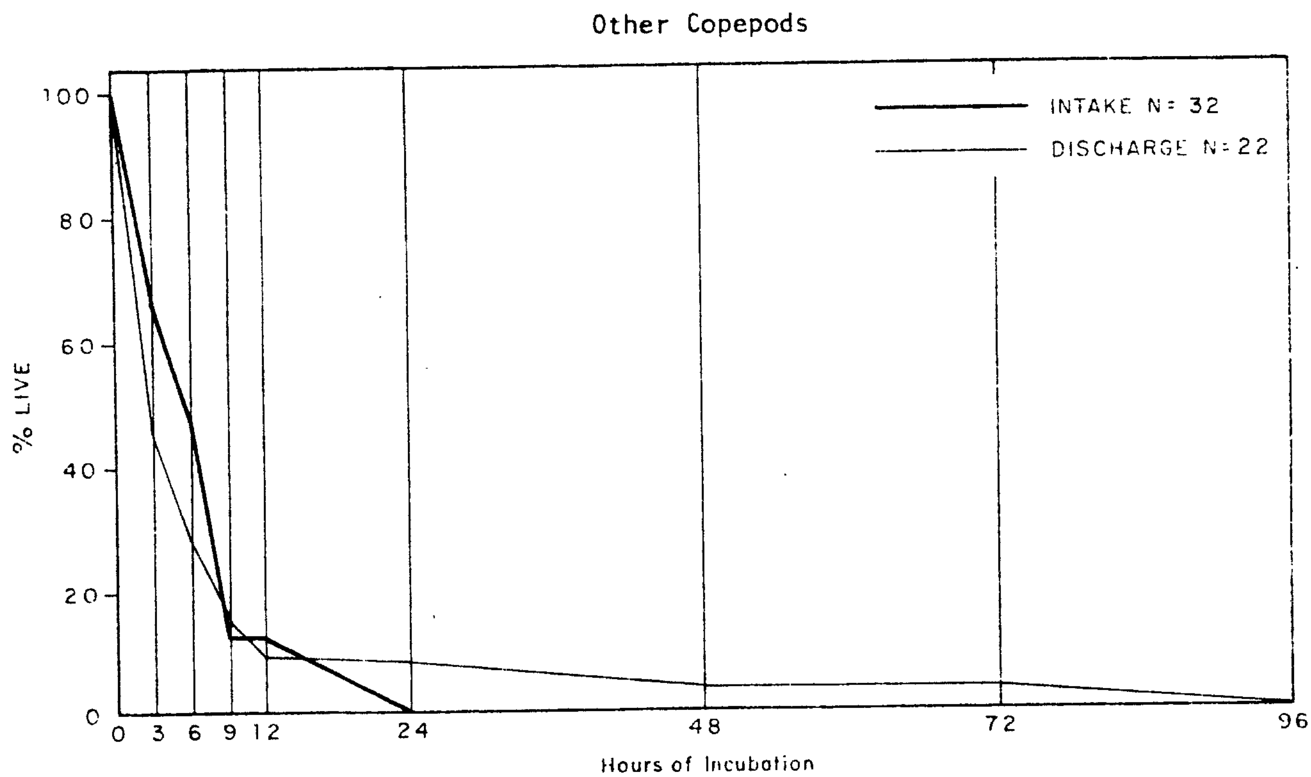
Acartia tonsa



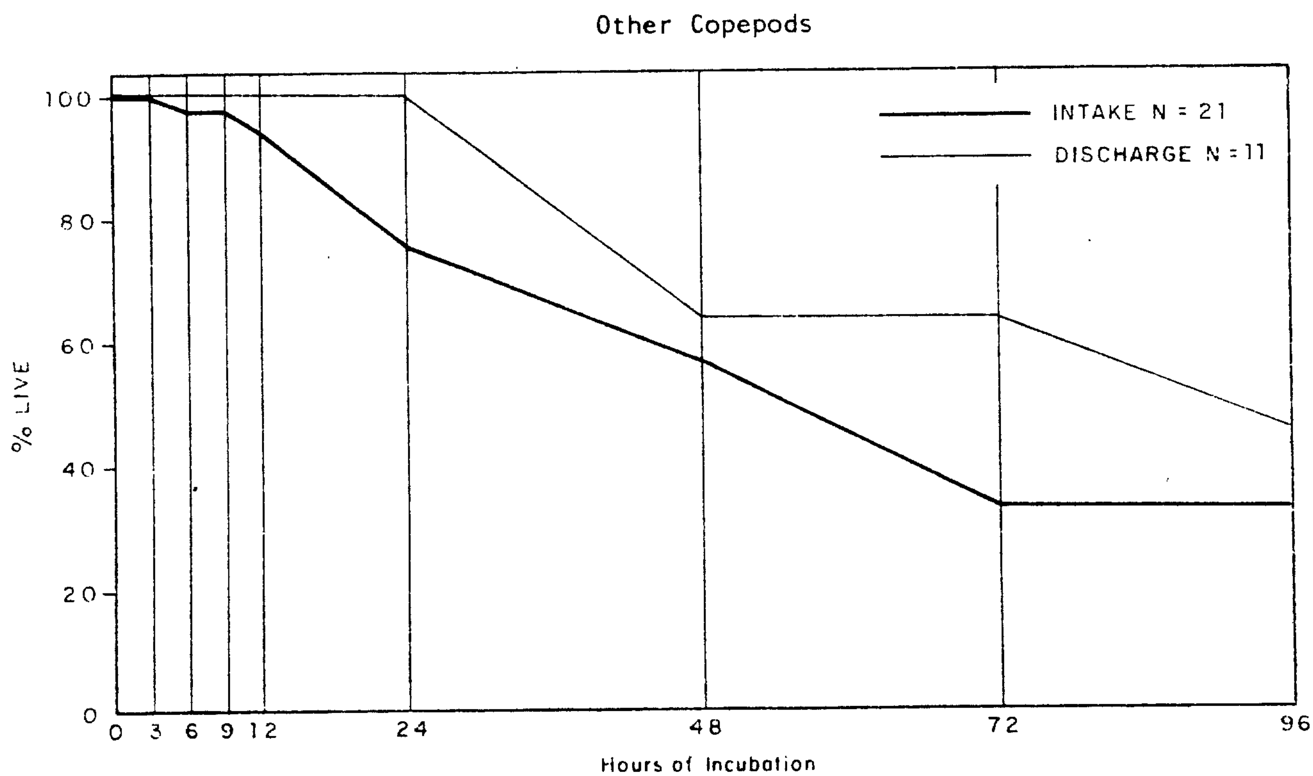
10-14 December 1979 CL RUN

SAN DIEGO GAS & ELECTRIC COMPANY	
Delayed mortality results for *Acartia tonsa*: chlorination runs Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-16

000814



24-29 September 1979 CL RUN

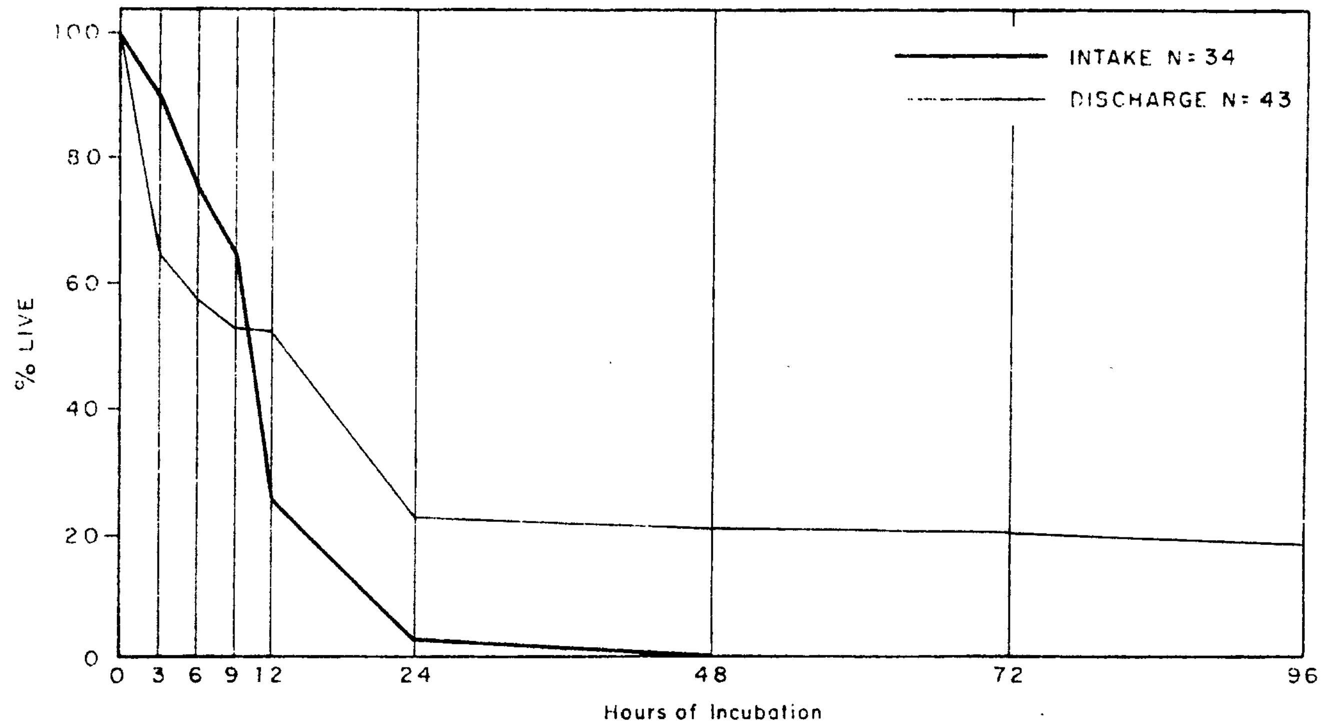


10-14 December 1979 CL RUN

SAN DIEGO GAS & ELECTRIC COMPANY	
Delayed mortality results for other copepods: chlorination runs Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.5-17

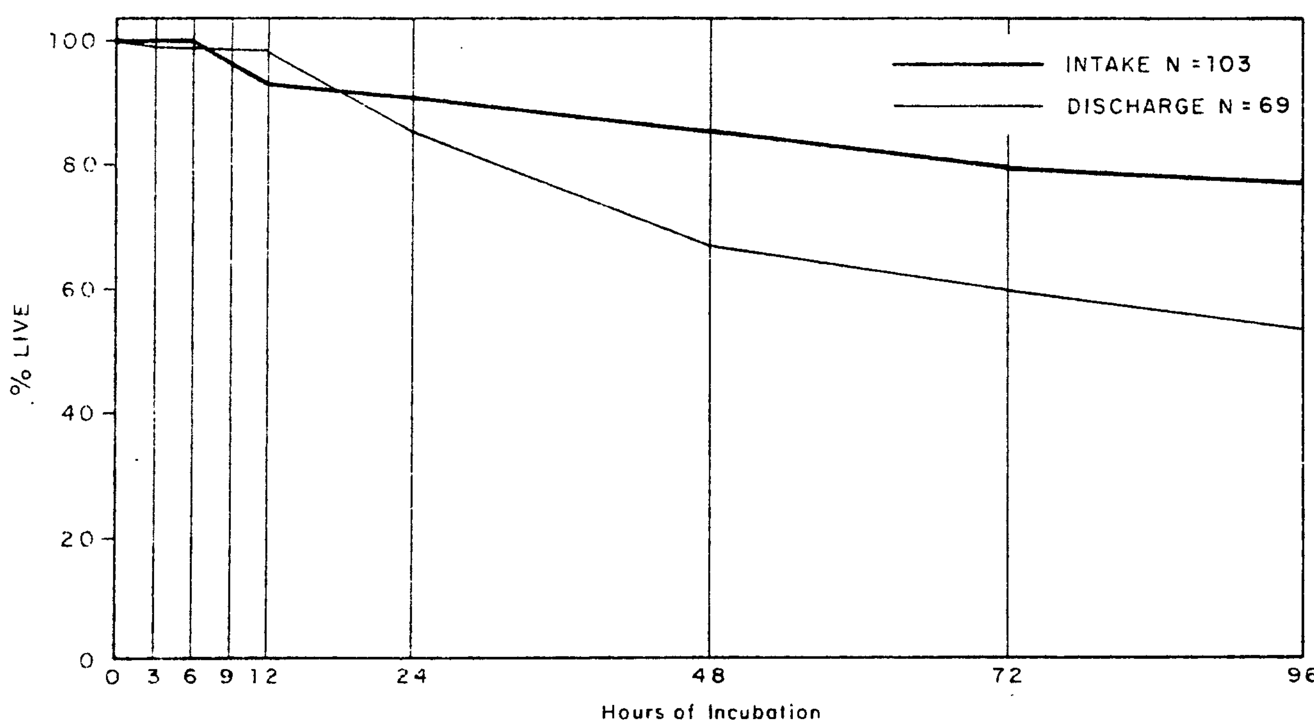
000815

Decapods



24-29 September 1979 CL RUN

Decapods

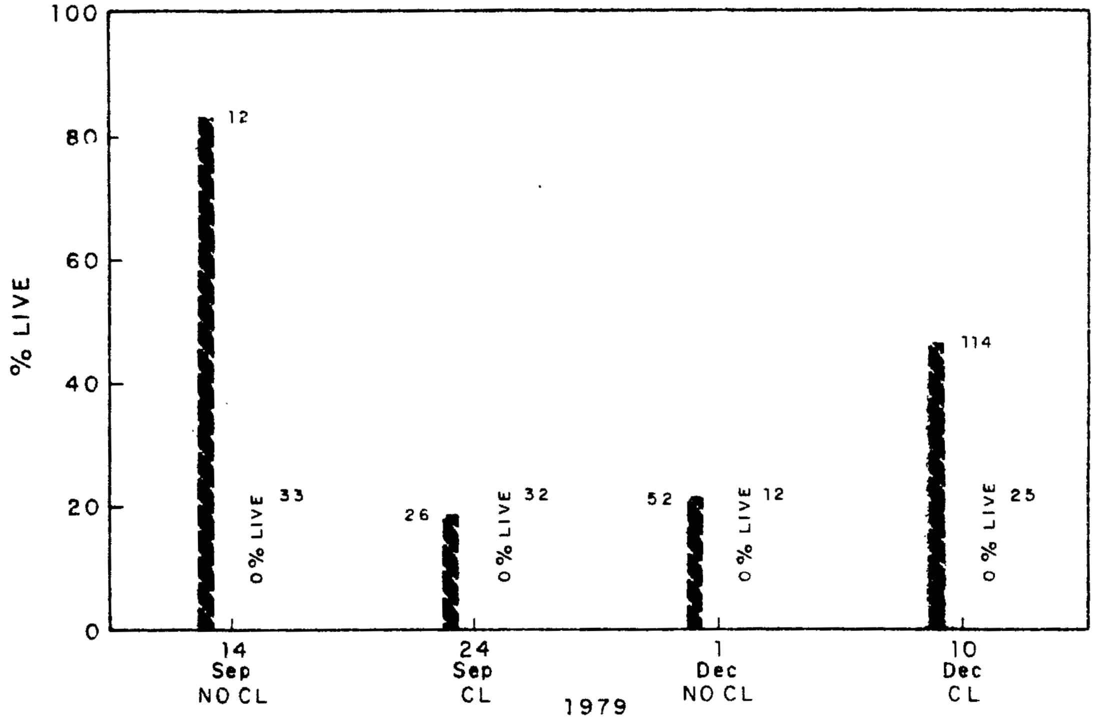


10-14 December 1979 CL RUN

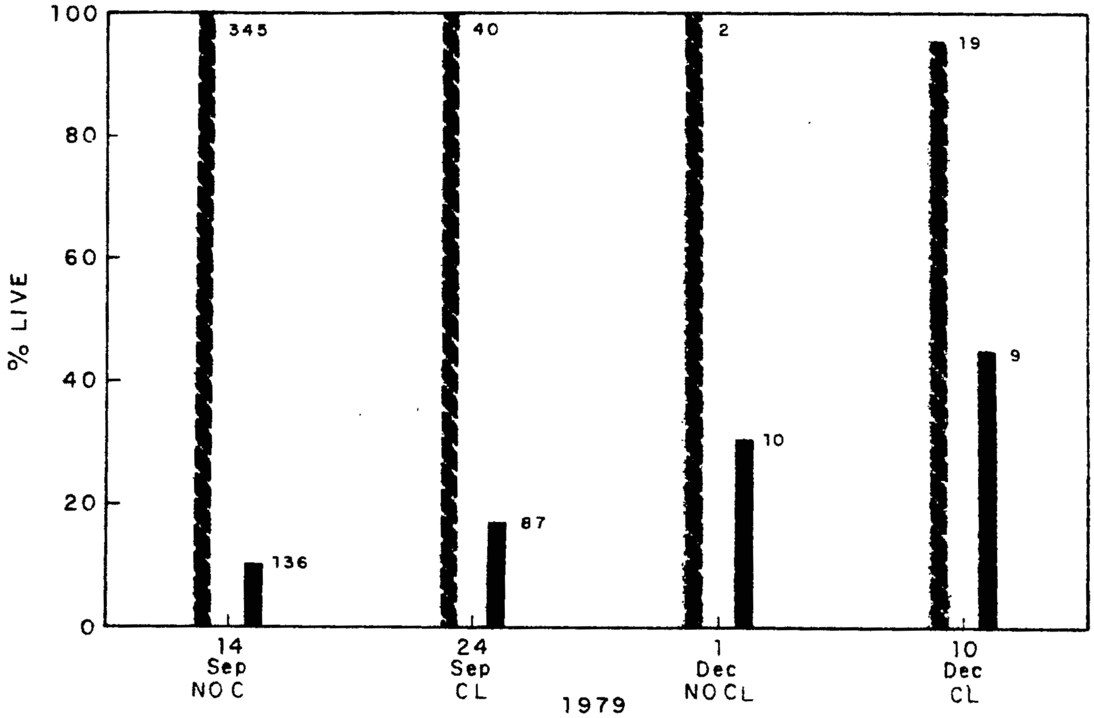
SAN DIEGO GAS & ELECTRIC COMPANY	
Delayed mortality results for decapods: chlorination runs	
Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. **9.5-18**

000816

Fish Larvae



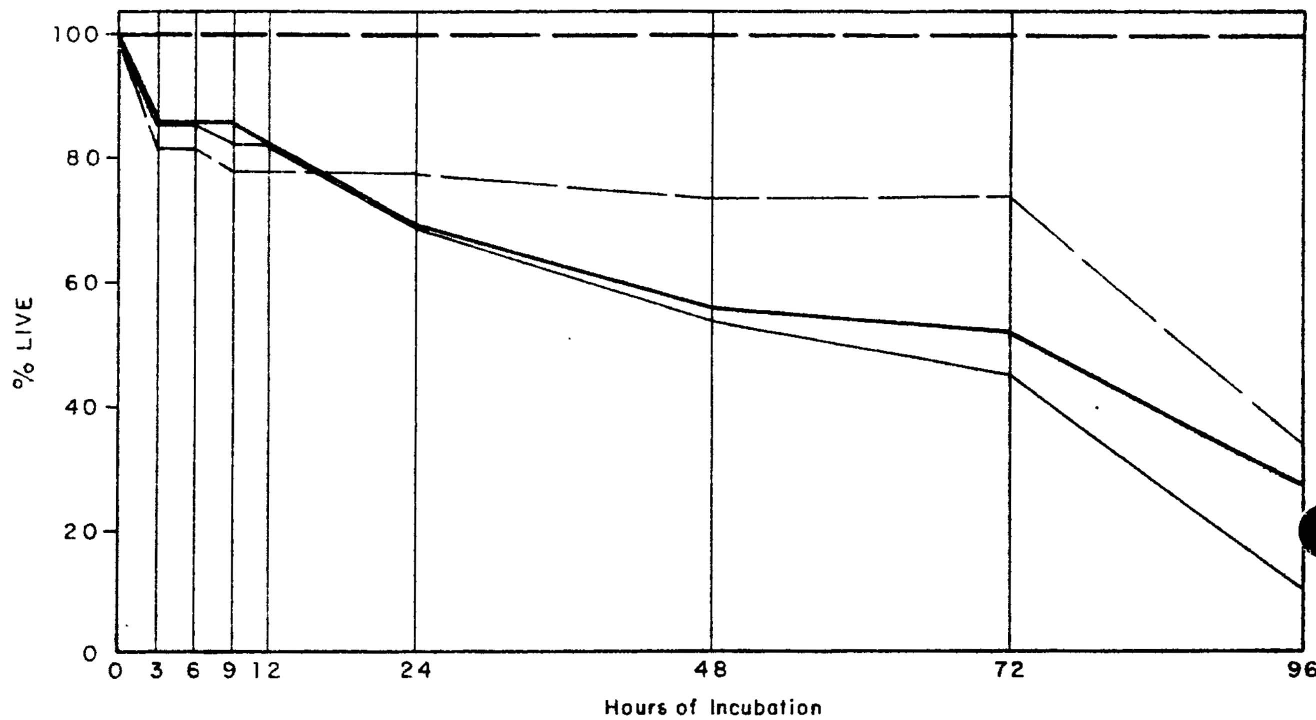
Fish Eggs



SAN DIEGO GAS & ELECTRIC COMPANY	
Initial mortality results for fish larvae and eggs Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.6-1

000817

Fish Larvae



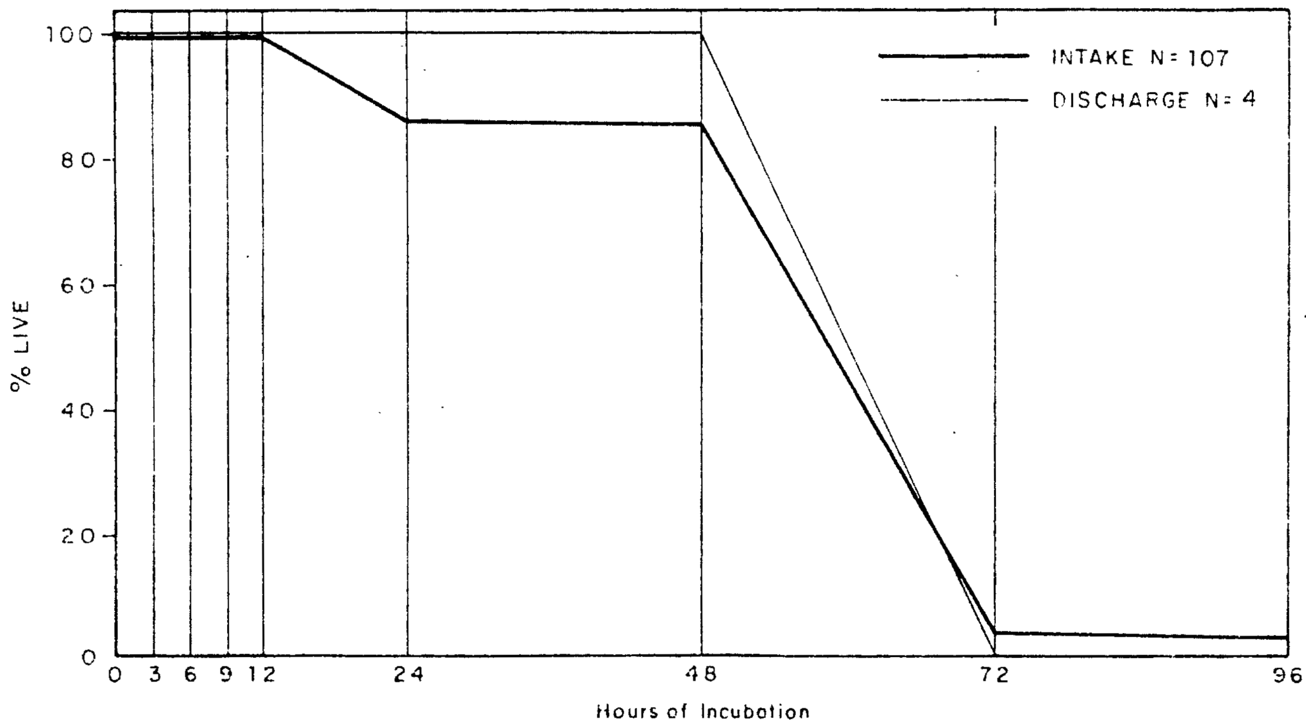
14-18 September 1979 No CL Run N=23
24-29 September 1979 CL Run N=4
1-5 December 1979 No CL Run N=35
10-14 December 1979 CL Run N=50

All Runs Intake Values

SAN DIEGO GAS & ELECTRIC COMPANY	
Delayed mortality results for fish larvae Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.6-2

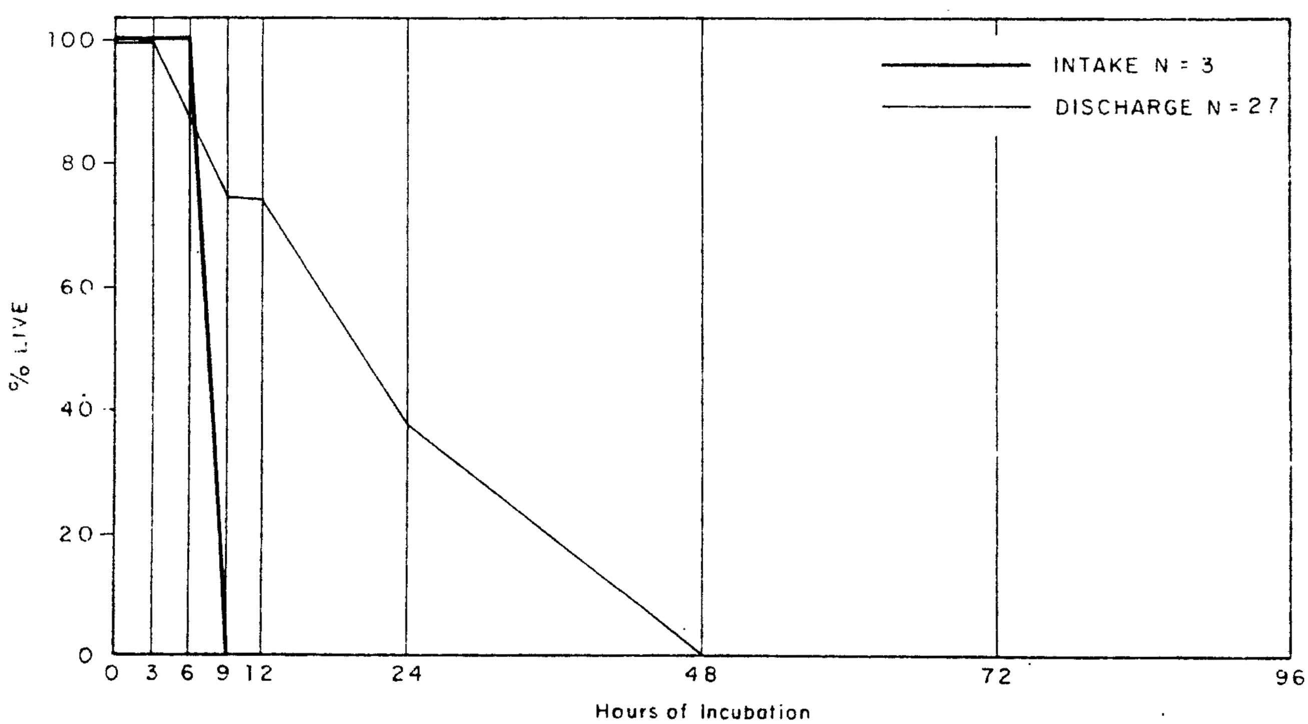
000818

Fish Eggs



14-18 September 1979 NO CL RUN

Fish Eggs

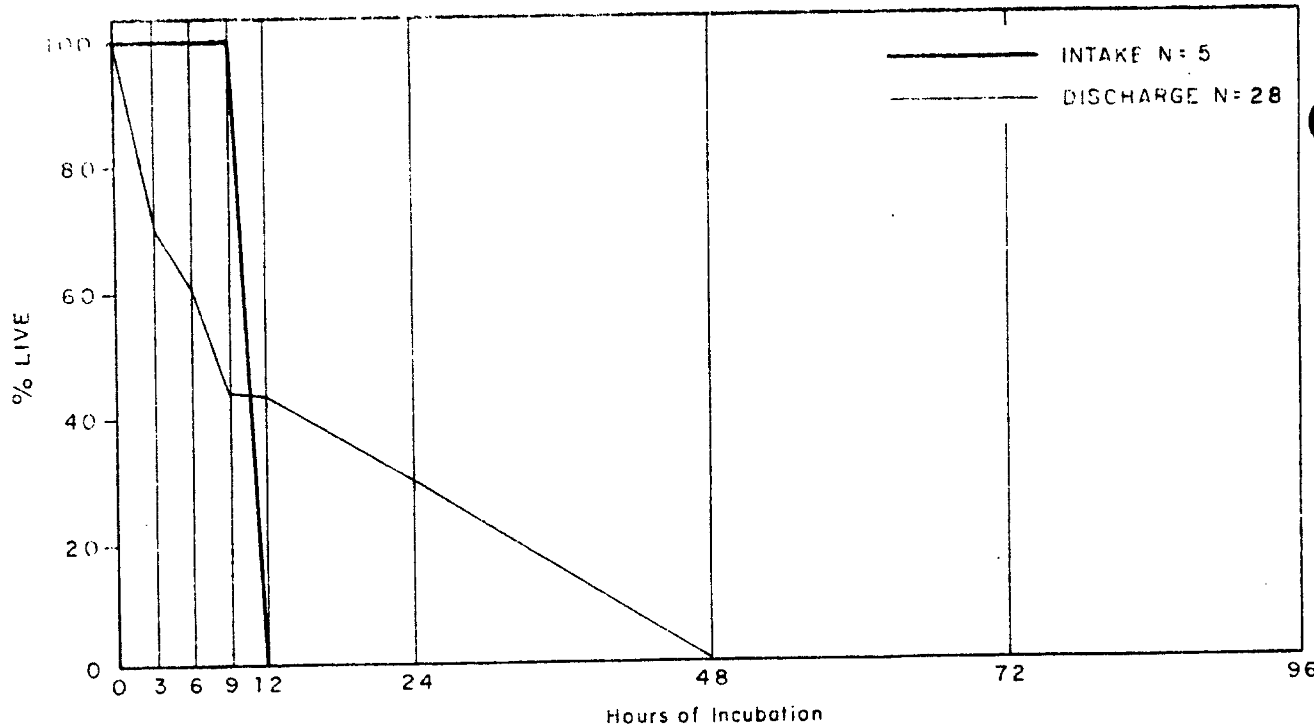


1-5 December 1979 NO CL RUN

000819

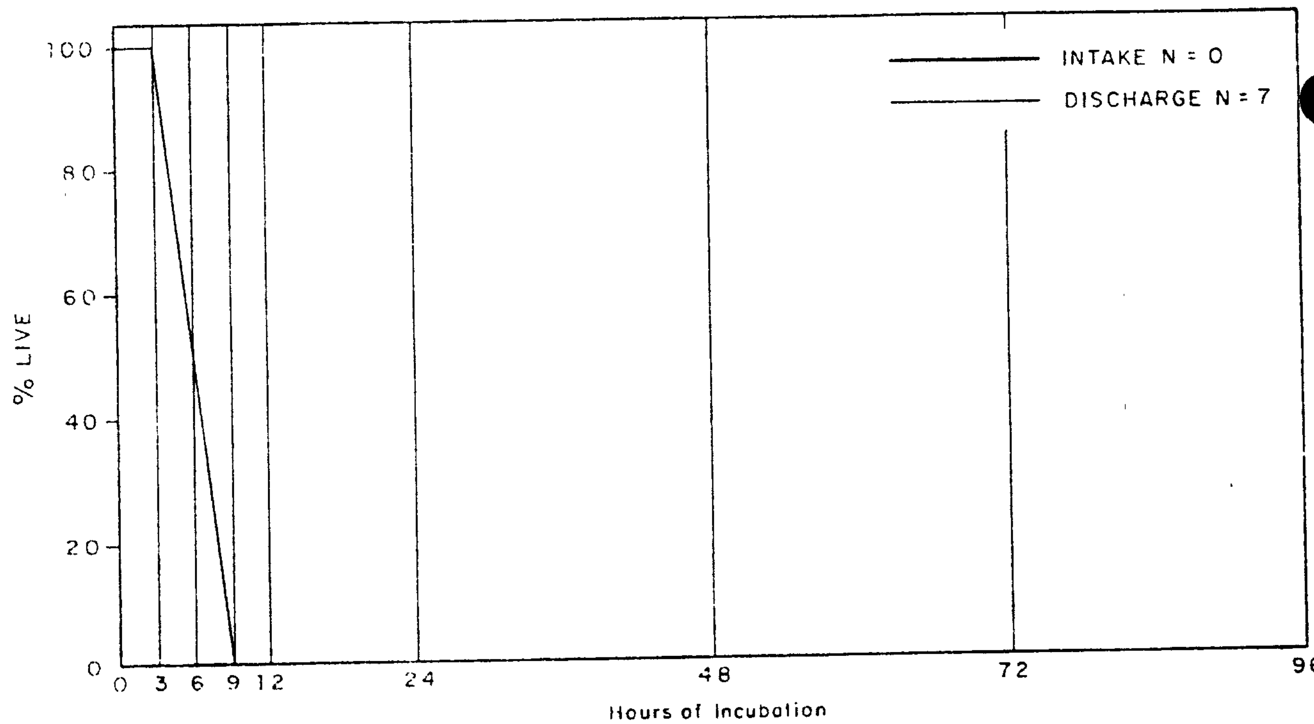
SAN DIEGO GAS & ELECTRIC COMPANY	
Delayed mortality results for fish eggs: no chlorination runs Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.6-3

Fish Eggs



24-29 September 1979 CL RUN

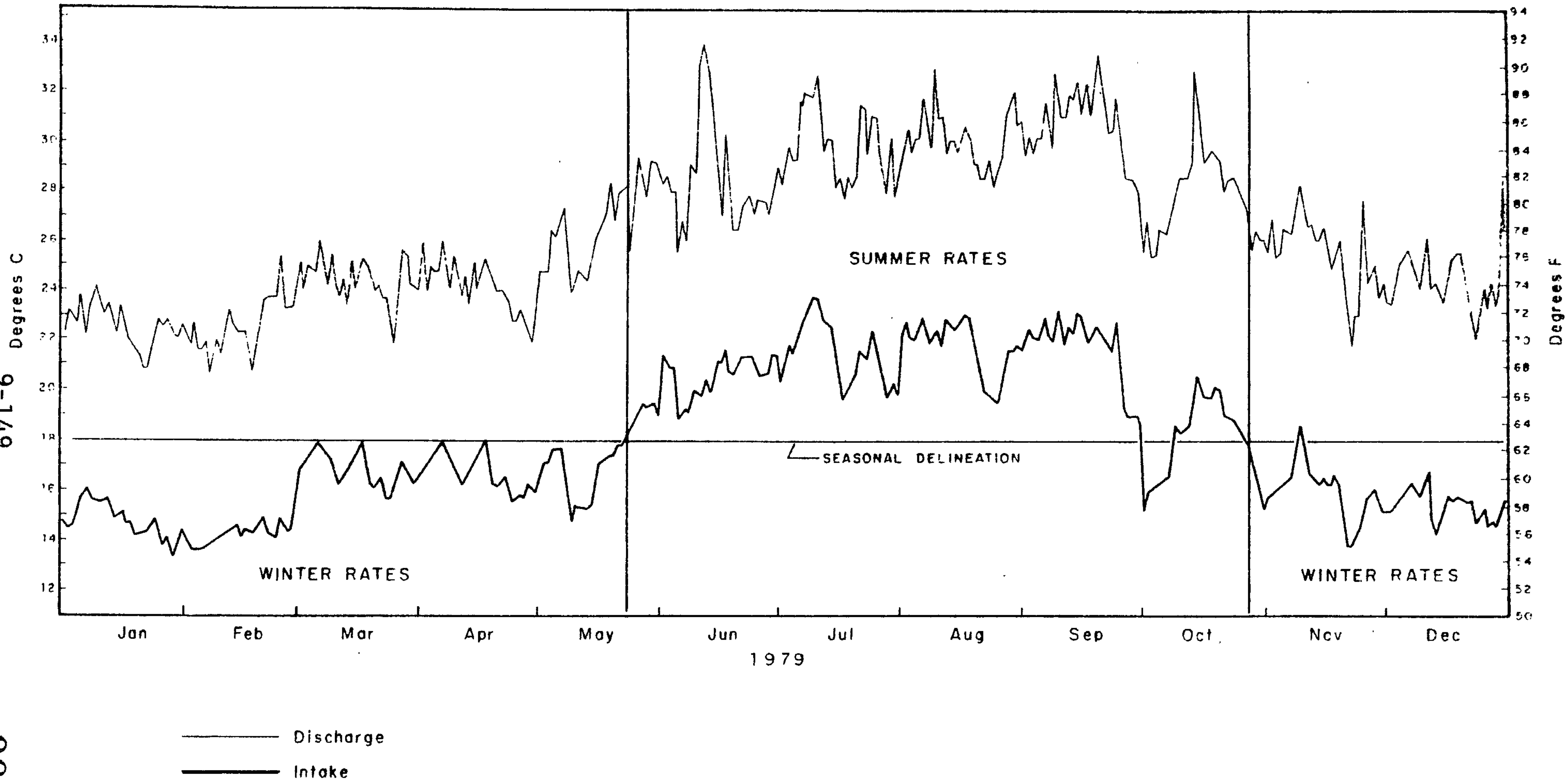
Fish Eggs



10-14 December 1979 CL RUN

000820

SAN DIEGO GAS & ELECTRIC COMPANY	
Delayed mortality results for fish eggs: chlorination runs Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.6-4



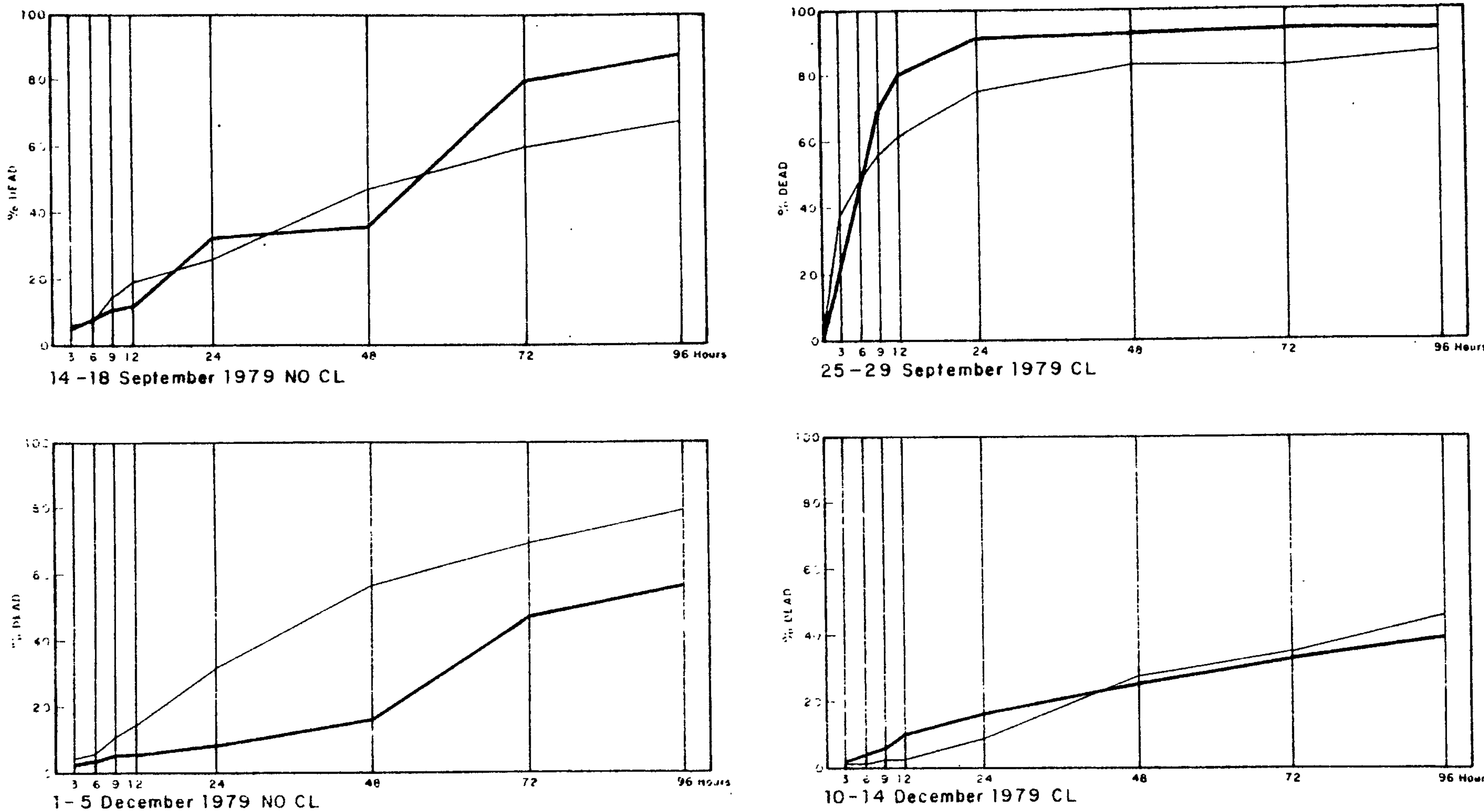
SAN DIEGO GAS & ELECTRIC COMPANY

Seasonal mortality rate delineations based on 1979 intake temperatures

Encina Power Plant - August 1, 1980

PREPARED BY: WOODWARD-CLYDE CONSULTANTS

FIGURE NO. 9.6-5



Intake

Discharge

SAN DIEGO GAS & ELECTRIC COMPANY	
Total mortality exhibited by test organisms during delayed mortality assessments Encina Power Plant - August 1, 1980	
PREPARED BY: WOODWARD-CLYDE CONSULTANTS	FIGURE NO. 9.8-1

10.0

ENVIRONMENTAL IMPACT ASSESSMENT

The purpose of this section is to assess the level and significance of environmental impact which occurs due to the operation of the Encina Power Plant and its intake system as now installed and operated. This assessment is based on the findings of the studies reported in preceding report sections and considers the loss of nekton and plankton organisms which can be attributed to the power plant operation. Comparisons of plant induced losses with losses to the populations in the cooling water source waters from other factors are applied to determine the relative significance of the power plant's present impact.

10.1 GENERAL INFORMATION

Fish removals can occur as the result of various factors:

- Commercial/recreational losses
- Natural losses
- Impingement
- Entrainment

Plankton removals can occur as a result of:

- Natural losses
- Entrainment
- Impingement (on small mesh screens)

The removals of nekton and plankton as a result of operation of the power plant were due to entrainment and impingement. These are discussed below relative to the other methods of removal.

10.2 FISH REMOVAL

Fish removals at the Encina Power Plant were a result of impingement on traveling screens and mortalities caused by thermal treatment and subsequent removals of the traveling screens.

All impinged fish were collected and counted twice daily for the one year study. All fish removed during the seven thermal treatments conducted during the year long study were collected and counted. Impingement sampling daily for 336 days collected 79,662 fish weighing 1548 Kg (3414 lb). Thermal treatments (7) during the year removed 108,102 fish weighing 2422 Kg (5341 lb). This amounted to a total fish removal for the year of 187,764 fish weighing 3817 Kg (8417 lb). A breakdown of the removals by species is given in Tables 10.2-1. The top ten ranked fish removed were: deepbody anchovy, topsmelt, northern anchovy, queenfish, shiner surfperch, California grunion, walleye surfperch, round stingray, giant kelpfish, and white surfperch in decreasing order of abundance. Of these ten fish, five were listed in the study plan as critical species, and four others were additional species treated as critical. Only white perch was not in either of these categories.

000824

10.2.1 Removal Versus Source Water Resources

Most of the species removed by the power plant are widespread along the southern California and Baja California coasts. If the estimates of abundances made for the study area were expanded to include this area of distribution for most species, annual removals would fall well below one percent of the standing crop.

Estimates of fish abundance for the study area offshore and in the lagoon were based on fish catches made in accordance with the study plan. A standing crop of 1,058,178 fishes was determined for the study area (Figure 6.5-15) as described in Section 6.5.7. The average daily power plant removal was only 0.02 percent of the estimated standing crop in the study area. The standing crop as cited here is an instantaneous estimate of numbers present at a given time and does not include recruitment of new fish to the population or migrations into or out of the study area from outside areas. Power plant removals include all removals for an average day.

10.2.2 Removal Versus Commercial/Recreational Losses

Commercial and recreational losses given below cover a much greater area than the study area as reported landings include much larger regions.

The Encina Power Plant removals amounted to 0.05 percent of the commercial landings in the San Diego area. Commercial marine landings in 1979 in California amounted to 728 million pounds.

Table 10.2-1.

ANNUAL REMOVAL OF FISH SPECIES BY THE ENCINA POWER PLANT
DUE TO IMPINGEMENT AND THERMAL TREATMENT DURING 1979

Common Name	Species Name	Impingement	Thermal Treatment	Total	Rank
Deepbody anchovy	*Anchoa compressa*	13299	23145	36441	1
Topsmelt	*Atherinops affinis*	10915	21788	32703	2
Northern anchovy	*Engraulis mordax*	7434	19567	27001	3
Queenfish	*Seriphus politus*	18681	3485	22166	4
Shiner surfperch	*Cymatogaster aggregata*	6545	12326	18871	5
California grunion	*Leuresthes tenuis*	8583	9671	18254	6
Walleye surfperch	*Hyperprosopon argenteum*	1877	8305	10182	7
Round stingray	*Urolophus halleri*	1626	1685	3311	8
Giant kelpfish	*Heterostichus rostratus*	1046	1429	2475	9
White surfperch	*Phanerodon furcatus*	1751	604	2355	10
Slough anchovy	*Anchoa delicatissima*	1758	464	2222	11
California halibut	*Paralichthys californicus*	1215	329	1544	12
Barred sand bass	*Paralabrax nebulifer*	189	518	707	13
Specklefin midshipman	*Porichthys myriaster*	362	345	707	13
Salema	*Xenistius californiensis*	538	161	699	14
Spotted sand bass	*Paralabrax maculatofasciatus*	73	616	689	15
Opaleye	*Girella nigricans*	64	617	681	16
Diamond turbot	*Hypsopsetta guttulata*	460	185	645	17
Kelp bass	*Paralabrax clathratus*	34	568	602	18
California barracuda	*Sphyraena argentea*	433	75	508	19
Yellowfin croaker	*Umbrina roncador*	55	306	361	20
Staghorn sculpin	*Leptocottus armatus*	245	82	327	21
Mussel blenny	*Hypsoblennius jenkinsi*	25	277	302	22
Pacific butterfish	*Peprilus simillimus*	283	15	298	23
Silversides	Atherinidae	---	288	288	24
White croaker	*Genyonemus lineatus*	153	125	278	25
Bat ray	*Myliobatus californica*	229	49	278	25
Rockpool blenny	*Hypsoblennius gilberti*	17	259	276	26
Sargo	*Anisotremus davidsoni*	172	79	251	27
Barred surfperch	*Amphistichus argenteus*	83	166	249	28
California butterfly ray	*Gymnura marmorata*	220	24	244	29
Thornback ray	*Platyrhinoidis triseriata*	175	8	183	30
California corbina	*Menticirrhus undulatus*	117	29	146	31
California tonguefish	*Symphurus atricauda*	140	1	141	32
Bay pipefish	*Syngnathus leptorhynchus*	107	24	131	33
Black surfperch	*Embiotoca jacksoni*	41	89	130	34

Table 10.2-1. (Continued)

Common Name	Species Name	Impingement	Thermal Treatment	Total	Rank
Pile surfperch	*Damalichthys vacca*	73	32	105	35
Threadfin shad	*Dorosoma petenense*	28	59	87	36
Striped mullet	*Mugil cephalus*	73	10	83	37
Jacksmelt	*Atherinopsis californiensis*	40	21	61	38
Anchovy	*Anchoa* sp.	60	---	60	39
Blenny	*Hypsoblennius* sp.	---	58	58	40
Blacksmith	*Chromis punctipinnis*	20	36	56	41
Black croaker	*Chiolotrema saturnum*	---	46	46	42
California needlefish	*Strongylura exilis*	41	3	44	43
Spotfin croaker	*Roncador stearnsii*	33	10	43	44
White seabass	*Cynoscion nobilis*	25	13	38	45
California killifish	*Fundulus parvipinnis*	14	21	35	46
Kelp pipefish	*Syngnathus californiensis*	32	---	32	47
California flying fish	*Cypselurus californicus*	31	---	31	48
Spotted turbot	*Pleuronichthys ritteri*	30	---	30	49
Gray smoothhound	*Mustelus californicus*	22	7	29	50
Zebraperch	*Hermosilla azurea*	2	21	23	51
Halfmoon	*Medialuna californiensis*	12	10	22	52
Pacific electric ray	*Torpedo californica*	21	1	22	52
Kelp surfperch	*Brachyistius frenatus*	7	7	14	53
Bay blenny	*Hypsoblennius gentilis*	7	7	14	53
Bass	*Paralabrax* sp.	13	---	13	54
Dwarf surfperch	*Micrometus minimus*	4	8	12	55
Pacific bonito	*Sarda chiliensis*	9	3	12	55
Island surfperch	*Cymatogaster gracilis*	12	---	12	55
Monterey spanish mackeral	*Scomberomorus concolor*	10	1	11	56
Plainfin midshipman	*Porichthys notatus*	10	---	10	57
Island kelpfish	*Alloclinus holderi*	10	---	10	57
California moray eel	*Gymnothorax mordax*	8	2	10	57
Rubberlip surfperch	*Rhacochilus toxotes*	8	---	8	58
Shovelnose guitarfish	*Rhinobatos productus*	7	---	7	59
Garibaldi	*Hypsypops rubicundus*	2	5	7	59
Unid. larval fish		7	---	7	59
Pacific mackerel	*Scomber japonicus*	---	6	6	60

Table 10.2-1. (Concluded)

Common Name	Species Name	Impingement	Thermal Treatment	Total	Rank
Fantail sole	*Xystreurys liolepis*	6	---	6	60
Longfin sanddab	*Citharichthys xanthostigma*	5	---	5	61
Sculpin/spotted scorpionfish	*Scorpaena guttata*	4	1	5	61
Leopard shark	*Triakis semifasciata*	4	---	4	62
Pacific herring	*Clupea harengus*	4	---	4	62
Yellow snake eel	*Ophichthus zophochir*	3	1	4	62
Jack mackerel	*Trachurus symmetricus*	3	1	4	62
Speckled sanddab	*Citharichthys stigmaeus*	4	---	4	62
Horn shark	*Heterodontus francisci*	3	---	3	63
Horneyhead turbot	*Pleuronichthys verticalis*	---	3	3	63
Spiney dogfish	*Squalus acanthias*	---	3	3	63
Pacific angel shark	*Squatina californica*	2	---	2	64
Mexican scad	*Decapterus hypodus*	2	---	2	64
Spotted kelpfish	*Gibbonsia elegans*	---	2	2	64
Brown smoothhound	*Mustelus henlei*	---	2	2	64
Painted greenling	*Oxylebius pictus*	---	2	2	64
Rosy sculpin	*Oligocottus rubellio*	1	---	1	65
Wooly sculpin	*Clinocottus analis*	---	1	1	65
Rock wrasse	*Halichoeres semicinctus*	---	1	1	65
Black bullhead	*Ictalurus melas*	---	1	1	65
Señorita	*Oxyjulis californica*	---	1	1	65
Bocaccio	*Sebastes paucispinis*	---	1	1	65
Wrasse rockfish	*Sebastes restrelliger*	---	1	1	65
	TOTALS -	79,662	108,102	187,764	

000828

San Diego area landings (Mexican border to San Clemente) were 156 million pounds. If tuna landings, most of which were caught in foreign waters, are removed from the catch total, the power plant removals amount to about 0.07 percent of the commercial landings in the San Diego area. If broken down by fishing vessel, the power plant removed about 48 percent of the fish caught (including tuna) by one fishing vessel for the year. This determination assumed approximately 900 fishing vessels in the San Diego area (10-2), dividing the catch equally among vessels. If tuna are excluded, the power plant removal amounted to approximately 66 percent of a single vessel's yearly catch.

Party boat landings during a one-year period between Imperial Beach and Dana Harbor were over 1,300,000 fish for the first ten months of 1979. This does not account for any fish taken from piers, jetties, private boats, or shorefishing for which there are no recent accurate published records. Surveys in 1964-1966 (10-1) for the southern California coastal area (Pt. Conception to the Mexican border) found that 77 percent of the total sportfishing effort was expended in areas other than party boats. Over 1,844,000 fish were taken from piers and jetties, 981,000 from private boats and 501,000 from the shoreline. The total catch including party boats was 7,326,000 fish. The sportfishing survey conducted as a part of the study plan in the vicinity of the Encina Power Plant (Agua Hedionda Lagoon and ocean beach) during 1979 for this report estimated 2,157 fish caught for the year. Based on the conservative application of party boat landings, estimates of private boat and shore fishermen, it can be safely assumed that power plant removals amounted to less than seven percent of the numbers of fish removed from the coastal zone by recreational activity or sportsfishermen in 1979 between the Mexican border and Dana Point.

10.2.3 Removal Versus Natural Losses

Power plant yearly removals (187,764 fish) are very small compared to annual mortality rates of 20-30 percent due to natural losses (10-3). Natural losses of fish populations were not measured in this study, however such losses are known to result from:

- Predation at all stages of development
- Limited food supply
- Disease
- Old age
- Environmental factors
- Natural toxins (i.e., "red tide")
- Others

These different forms of natural loss result from environmental effects such as temperature, physical effects such as currents and drift, and biological effects such as developmental, metabolic or density dependent factors.

Most marine fish have very large fecundities (up to two million eggs) which indicates a very large natural mortality since survival of only two eggs during the lifetime of a single male and female fish is all that would be required to maintain the population at a constant level. Gulland (10-3) reports annual mortalities for fish two to three years of age and older as 20-30 percent per year. The greatest losses occur in the early stages of development, where mortalities of over 99 percent are reported (10-3).

10.2.4 Removal Probabilities

Probabilities of removal for fish species are difficult to estimate as nekton species are free to move in or out of Agua Hedionda Lagoon. Once fish species enter the intake system, their probability of removal is high relative to species that have not entered the intake. Removals of fish entering the intake system could result from impingement or mortality suffered during thermal treatment (for those species which maintain themselves in the tunnels). It is possible for some species to exit the intake system at the entrance after entering and/or spending time within the intake tunnels. Removals during heat treatments indicated certain species are maintaining themselves for some time within the tunnel system as they are not captured during daily impingement sampling. These are primarily demersal forms (i.e., midshipmen, halibut, moray eel, octopus, etc.).

10.3 ENTRAINMENT

Not all organisms entrained are killed in passing through the power plant cooling water system. Entrainment effects are confined to those planktonic organisms which are small enough to pass through the traveling screens and transit the power plant's cooling water system. Mortalities of entrained organisms can be due to thermal, mechanical and chemical effects encountered during entrainment. In assessing the environmental impact of entrainment, a "worst case" estimate was used. These estimates were based on collections made with the 335μ plankton nets, which were consistently higher than the estimates obtained from the 505μ nets.

10.3.1 Effect on Invertebrate Population

The effect on the invertebrate population of 8.45×10^7 invertebrate organisms entrained daily is negligible as the mortality of 37 percent of these organisms (3.12×10^7) comprises only 0.2 percent of the number available within one day's travel time of the power plant.

Invertebrate populations entrained annually were estimated to be 3.09×10^{10} organisms. A breakdown by plankton groups of the number entrained is presented in Table 10.3-1. Acartia tonsa comprised 56 percent of the invertebrate species entrained.

10.3.2 Effect on Fish Populations

The effect on the fish populations (ichthyoplankton) of 1.82×10^7 fish larvae and eggs entrained daily was small. With

Table 10.3-1.

ANNUAL NUMBER OF INVERTEBRATE ORGANISMS ENTRAINED AND ENTRAINMENT MORTALITY ESTIMATES FOR 335μ MESH NET COLLECTION DATA ENCINA POWER PLANT - AUGUST 1, 1979

Plankton Group	Estimated Annual Entrainment	Estimated Annual Entrainment Mortality	Percent Mortality of Numbers Entrained
Acartia tonsa	1.74×10^{10}	6.67×10^{9}	38%
Other copepods	3.09×10^{9}	1.15×10^{9}	37%
Mysidacea	2.44×10^{8}	9.09×10^{7}	37%
Decapoda	4.84×10^{9}	1.80×10^{9}	37%
Other crustacea	2.54×10^{9}	9.46×10^{8}	37%
Chaetognatha	6.68×10^{8}	2.48×10^{8}	37%
Other zooplankton	2.07×10^{9}	7.71×10^{8}	37%
TOTAL -	3.09×10^{10}	1.17×10^{10}	37%

000833

a mortality of 66 percent (due to entrainment) of these organisms entrainment effects amount to 7.4 percent of the numbers available within one day's travel time of the power plant. Natural mortality rates during the egg and larval stages of most marine fish species is over 99 percent (10-3).

Ichthyoplankton annual entrainment was estimated to be 6.66×10^9 fish larvae and eggs (Table 10.3-2). Eggs comprised 86 percent of the total. Estimated mortality of fish eggs was 60 percent due to entrainment. For fish larvae 100 percent mortality resulted from entrainment. Because of the predominance of fish eggs in ichthyoplankton samples and their lower mortality percentage, the mortality of fish eggs and larvae combined (ichthyoplankton) was 66 percent.

Estimated annual mortality of entrained ichthyoplankton amounted to 4.4×10^9 fish eggs and larvae (Table 10.3-2).

10.3.3 Effect on Primary Productivity

The effects of entrainment on primary productivity were found to be insignificant.

Entrainment effects on primary productivity (phytoplankton) were examined utilizing chlorophyll a pigment analysis and light-dark bottle oxygen determinations.

Pigment concentrations for water entrained is given in Table 10.3-3. In most cases, the decreases in phytoplankton pigment levels were minimal (<14 percent) and in one case an increase was noted following entrainment (Table 10.3-3). In statistical analysis of pigment concentrations, in only one of the four

Table 10.3-2.

ANNUAL NUMBER OF FISH EGGS AND LARVAE ENTRAINED
AND ENTRAINMENT MORTALITY ESTIMATES FOR
335μ MESH NET COLLECTION DATA
ENCINA POWER PLANT - AUGUST 1, 1979

Plankton Group	Estimated Annual Entrainment	Estimated Annual Entrainment Mortality	Percent Mortality of Numbers Entrained
Fish eggs	5.74×10^9	3.48×10^9	60%
Fish larvae	9.19×10^8	9.19×10^8	100%
TOTAL -	6.66×10^9	4.40×10^9	66%

TABLE 10.3-3

PHOTOSYNTHETIC PIGMENT CONCENTRATIONS AND NET PRODUCTIVITY FOR PHYTOPLANKTON PRIOR TO, AND FOLLOWING ENTRAINMENT ENCINA POWER PLANT - AUGUST 1, 1980

Pigment Analysis	Experiment Dates	Pigment Conc. Prior to Entrainment	Pigment Conc. After Entrainment	Percent Change in Pigment After Entrainment	Statistically Significant Change
Chlorophyll a	09-15-79	2.18	2.19	+0.5%	No
	09-27-79	1.98	1.77	-11%	No
	12-02-79	1.25	1.08	-14%	Yes
	12-11-79	0.93	0.90	-3%	No
Light-Dark Bottle Oxygen Determinations		Net Productivity (Mg C fixed/m^3/hr.) Prior to Entrainment	Net Productivity (Mg C fixed/m^3/hr.) After Entrainment		
	09-15-79	5.4	26.2		Yes
	09-27-79	-2.5	0.2		No
	12-02-79	8.4	5.0		No
	12-11-79	-1.9	-0.9		No

000836

analyses was there a statistically significant change following entrainment.

In light-dark bottle determinations, net productivity values were low in magnitude. Negative respiration values confounded estimates of gross productivity. This problem is reported by other workers (10-4) in Agua Hedionda Lagoon. Statistical tests run on net productivity estimates indicated no statistically significant change in productivity following entrainment (Table 10.3-3) in all experiments but one. Because of the rapid regeneration time of primary producers and the low levels of change detected following entrainment, the effects of entrainment on primary production are considered to be insignificant. This is especially true in that the cooling waters are continuous with, and a part of, the Pacific Ocean.

10.3.4 Entrainment Probabilities

Isopleths of entrainment probabilities were drawn for a portion of the far-field (offshore) zone and the near field (Outer Agua Hedionda Lagoon Segment) (Figures 5.5-1 thru 5.5-7).

At the seaward entrance to Agua Hedionda Lagoon, a water parcel has a 34 percent probability of entering the lagoon; offshore probabilities must decrease with distance to the volume limit (2.0×10^6 m^3) where the probability for one-day entry is zero. The extent of this one day zone is approximately 26 km (16 mi.) upcoast (Figure 5.5-1).

Probability of entrainment for the majority of the near-field zone is greater than 10 percent. The 10 percent isopleth is consistently found near the northern and eastern extremities of the lagoon segment. This type of distribution permits planktonic forms a 90 percent probability of escaping entrainment. In other words, not all of the plankton drifting into the lagoon system can be entrained; a certain population must also return to the ocean on each ebb tide. Planktonic material has a more than even chance of not being entrained over most of the area of the lagoon segment. The 70 and 90 percent isopleths are usually located well within the southern third of the lagoon segment. The isopleths shift toward the seaward entrance on a flood tide, and toward the middle lagoon segment entrance on an ebb tide.

Using 70 percent entrainment probability isopleths to define intake effects, Figures 5.5-2 through 5.5-7 show that the maximum extent of the intake effect is about 304 m (1000 ft) into the southern end of the outer lagoon segment.

10.4 COMBINED EFFECTS OF FISH REMOVAL AND ENTRAINMENT

The annual removals by the Encina Power Plant amounted to 187,764 fish and 1.61×10^{10} plankton organisms. The plankton organisms were comprised of 1.17×10^{10} invertebrates and 4.4×10^{9} fish eggs and larvae. These numbers are extremely low relative to the numbers available in the source waters, as shown in Sections 10.2 and 10.3, where daily fish removals were shown to be 0.02 percent of the estimated standing crop in the study area, and average daily plankton losses amounted to 0.2 percent of plankton available within one day's travel time of the power plant.

10.5 DISCUSSION

Generally, the organisms impinged and entrained are species which occur throughout the ocean waters of southern California A majority of the ten most abundant impinged fishes (which account for 92 percent of the numbers impinged) are distributed from Baja California to Canada and the others are distributed along a large portion of the Pacific Coast (Table 10.5.1). They are species common to coastal waters.

The numbers which enter Agua Hedionda Lagoon and are impinged by the power plant are very small compared to the size of the population throughout its range. Of the ten most abundant species, only half have any commercial or recreational importance. Four (topsmelt, northern anchovy, walleye surfperch and white surfperch) are taken commercially. Four (topsmelt, California grunion, walleye surfperch, and white surfperch) are taken by sportsfishermen.

The removals by the Encina power plant are not expected to have any significant impact on fishing activity.

- The 32,000 topsmelt removed annually amount to 0.1 percent of the California commercial smelt catch (a minor fishery).
- The 27,000 northern anchovy removed annually amount to 0.0004 percent of the California commercial northern anchovy catch.
- The 12,537 perch (walleye and white perch) removed annually amount to 0.4 percent of the California commercial perch catch (10-5).

Table 10.5-1.

DISTRIBUTION OF THE TEN MOST ABUNDANT IMPINGED FISHES
AT THE ENCINA POWER PLANT
COLLECTED DURING 1979

Rank	Species	Common Name	Range of Distribution
1.	*Anchoa compressa*	Deepbody anchovy	Todos Santos Bay, Baja - Morro Bay, CA
2.	*Atherinops affinis*	Topsmelt	Gulf of Calif. - British Columbia
3.	*Engraulis mordax*	Northern anchovy	Cape San Lucas, Baja - British Columbia
4.	*Seriphus politus*	Queenfish	Uncle Sam Bank, Baja - Yaquina Bay, OR
5.	*Cymatogaster aggregata*	Shiner surfperch	Ensenada, Baja - Port Wrangle, Alaska
6.	*Leuresthes tenuis*	California grunion	Bahia Magdalena, Baja - Morro Bay, CA
7.	*Hyperprosopon argenteum*	Walleye surfperch	Santa Rosalia Bay, Baja - British Col.
8.	*Urolophus halleri*	Round stingray	Panama Bay, Panama - Humboldt Bay, CA
9.	*Heterostichus rostratus*	Giant kelpfish	Cape San Lucas, Baja - British Columbia
10.	*Phanerodon furcatus*	White surfperch	Pt. Cabras, Baja - British Columbia

Many of the causes of natural loss are related to population densities. Predation can be dependent on density as fishes present in large numbers are often easy prey for predators as opposed to species which are sparsely distributed or occur as solitary individuals. Natural losses due to limited food supply are dependent on the density of the consumer species, since a limited food supply will result in starvation of some individuals when they are too abundant. Natural losses due to the spread of disease can be dependent on densities of the infected population. Because of this density dependence a certain portion of most marine populations must be removed to allow the remaining organisms to survive to maturity by avoiding predation, finding adequate food, and not being killed by disease. If these numbers that must be removed are not decimated by one factor, another may prove lethal. In this sense, the power plant may serve as a method of cropping some of the excess individuals, providing the population is not already in a declining state.

Because of the small numbers impinged relative to the size of the populations, the numbers removed by fishing, and natural losses, the fish populations are not expected to be adversely affected by impingement at the power plant.

Plankton entrainment included all organisms able to pass through the 0.95 cm (3/8 in.) travelling screens. Invertebrate species included representatives of all major groups (Table 6.4-7), but were predominantly copepods. In spite of guidelines suggesting the impact of entrainment on plankton to be minimal (10-6, 10-7) studies were conducted to evaluate the effects of entrainment. The effects were evaluated in terms of percent cropping of the population in the source water body. The comparison was confined to the portion of the source water body which had a probability of being entrained in one day. Overall, 0.2 percent of the plankton organisms available within one day's travel time of the intake structure were "cropped" by the power plant. The percentage rates varied for the different plankton groups (Table 10.5-2). The highest cropping rates occurred for fish larvae (21.7 percent) and fish eggs (6.3 percent). Similar annual losses were reported for San Onofre Nuclear Generating Station (8.75×10^8) fish larvae as were found at Encina Power Plant (9.19×10^8) studies (10-8). However, the flow rate at Encina is approximately double the flow rate at San Onofre. With similar flow rates, it would appear that losses at San Onofre would be double those at Encina. Lowest losses (0.2 percent) at Encina occurred for zooplankton. Because of the heavy losses to plankton in early stages of their development and the low number of the equivalent adults which would result from these lost larvae compared to other losses (fishing, natural losses) discussed previously, no significant decrease in the number of plankton organisms is anticipated due to entrainment. It is likely that the abundance of fish larvae are underestimated in the source water body as this is the one plankton species most able to avoid the sampling gear.

Table 10.5-2

ESTIMATES OF PLANKTON ABUNDANCE FOR OUTER AGUA HEDIONDA LAGOON SEGMENT, OFFSHORE 1-DAY ENTRAINMENT ZONE AND PERCENT CROPPING DUE TO ENTRAINMENT ENCINA POWER PLANT - AUGUST 1, 1980

Plankton Group	Number in Lagoon	Number in 1-Day Offshore Entrainment Zone	Total Number Available in One Day	Number Killed by Entrainment Daily	Percent "Cropped" By Power Plant Daily From 1-Day Entrainment Zone
Fish eggs	$6.6x10^{7}$	$8.36x10^{7}$	$1.50x10^{8}$	$9.53x10^{6}$	6.3%
Fish Larvae	$8.4x10^{6}$	$3.22x10^{6}$	$1.16x10^{7}$	$2.52x10^{6}$	21.7%
Total Ichthyoplankton	$7.5x10^{7}$	$8.68x10^{7}$	$1.62x10^{8}$	$1.20x10^{7}$	7.4%
Acartia tonsa	$1.4x10^{9}$	$1.06x10^{10}$	$1.20x10^{10}$	$1.82x10^{7}$	0.2%
Other copepods	$9.1x10^{7}$	$1.87x10^{9}$	$1.96x10^{9}$	$3.15x10^{6}$	0.2%
Mysidacea	$4.6x10^{6}$	$1.52x10^{7}$	$1.98x10^{7}$	$2.49x10^{5}$	1.3%
Decapods	$1.0x10^{8}$	$1.24x10^{8}$	$2.24x10^{8}$	$4.93x10^{6}$	2.2%
Other crustacea	$6.7x10^{7}$	$1.78x10^{9}$	$1.84x10^{9}$	$2.59x10^{6}$	0.1%
Chaetognaths	$9.9x10^{6}$	$1.07x10^{8}$	$1.17x10^{8}$	$6.79x10^{5}$	0.6%
Other Zooplankton	$3.9x10^{7}$	$9.46x10^{8}$	$9.85x10^{8}$	$2.11x10^{6}$	0.2%
Total Zooplankton	$5.7x10^{8}$	$1.55x10^{10}$	$1.61x10^{10}$	$3.20x10^{7}$	0.2%
Total Plankton	$2.4x10^{9}$	$1.56x10^{10}$	$1.80x10^{10}$	$4.40x10^{7}$	0.2%

000844

Overall, the impacts of entrainment and impingement were found to be small and the populations should not diminish due to power plant effects.

References

10-1 Pinkas, L., Oliphant, M. S., and Haugen, C. W., Southern California Marine Sportfishing Survey: Private Boats, 1964; Shoreline, 1965-66, State of California, The Resources Agency, The Department of Fish and Game - Fish Bulletin 143, Sacramento, CA. 1968.

10-2 Oliphant, M. S., California Marine Fish Landings for 1976, State of California, The Resources Agency, The Department of Fish and Game - Fish Bulletin 170, Scaramento, CA. 1979.

10-3 Gulland, J. A., Survival of the Youngest Stages of Fish and its Relation to Year Class Strength, The International Commission for the Northwest Atlantic Fisheries - Special Publication No. 6 - ICNAF Environmental Symposium, Rome, Italy, 1964.

10-4 Bradshaw, J. S., Personal communication, University of San Diego, San Diego, CA., February 1980.

10-5 Pinkas, L., California Marine Fish Landings for 1975, State of California, The Resources Agency, The Department of Fish and Game - Fish Bulletin 168, Sacramento, CA. 1977.

10-6 Environmental Protection Agency, Guidance for Evaluating the Adverse Impact of Cooling Water Intake Structures on the Aquatic Environment: Section 316(b) P.L. 92-500, Office of Water Enforcement Permits Division, Industrial Permits Branch, Washington, D. C. May 1977.

10-7 Federal Water Pollution Control Act Amendments of 1972, P.L. 92-500, Sect. 316 33 U.S.C.A. 1326.

10-8 Southern California Edison Co., 1979 Annual Operation Report for San Onofre Nuclear Generating Station, Vol. 5: Biological and Oceanographical Data Analysis, Special Study: Ichthyoplankton, Southern California Edison Co. - 80-RD-100, Rosemead, CA, June 1980.

11.0

ECOLOGICAL EVALUATION OF EXISTING INTAKE SYSTEM

The existing intake system and its operation were described in Section 3.0. A description of the site and location of the power plant were given in Sections 2.1.1 and 2.1.2. This section will provide an ecological evaluation of the existing intake system with respect to:

- Location
- Design and Construction
- Capacity (Operation)

11.1 LOCATION

The location of the intake structure at the southern end of Outer Agua Hedionda Lagoon provides for several ecological advantages:

- It avoids direct impact on the greater population densities existent in offshore fish and plankton populations,
- Because of its flow maintenance requirements it enhances adequate tidal flushing of Agua Hedionda Lagoon,
- Due to its specific location it allows lagoon species an opportunity to pass into the middle and upper lagoon segments on flood tide, or offshore on ebb tide rather than enter the intake system,

000848

- Its location has permitted the development of a viable marine habitat and nursery area for fish and invertebrate species,
- and, considering the higher population densities offshore it effectively reduces impingement and entrainment that would result from an offshore location.

In conjunction with its ocean discharge, the present location of the intake structure in the outer segment of Agua Hedionda Lagoon serves to separate the intake structure from the discharge and works to prevent re-entrainment of cooling waters and their biological constituents.

In general, the location is considered to be a good one from an ecological point of view. None of the various coastal lagoons in San Diego County, with the exception of Agua Hedionda Lagoon, provide adequate habitat for marine species since they are usually closed to ocean flushing. Siltation from runoff has filled in portions of most of them, and reduced water depths in the remaining portions. Eutrophication and stagnation are common. Although some provide unique habitat for bird life and offer a sanctuary for important species, most are unsuitable for marine species and fish life. Agua Hedionda Lagoon, on the other hand, as a result of the location of the power plant intake and maintenance dredging, experiences adequate tidal flushing and provides quality marine habitat for over 90 species of fish. In addition, eel grass beds and habitats within the lagoon provide nursery areas for fish species which would not exist without the power plant intake being located within the lagoon, with its need for biennial maintenance dredging of the outer lagoon segment. Fish and plankton densities in the outer lagoon segment are lower than in the offshore area so that from an entrainment and impingement standpoint the lagoon location for the intake structure is environmentally more preferable than the offshore location. Location of the intake in the southern end of the outer lagoon segment minimizes impact on organisms entering the outer lagoon from offshore. The location of the ocean inlet to the lagoon in the northern end of the outer lagoon segment allows organisms an opportunity to enter the middle and upper lagoon segments at the midpoint of the outer lagoon before reaching the intake at the southern end.

11.2 DESIGN AND CONSTRUCTION

Because the design and construction of the Encina Power Plant are present in the area as an "as built" system, the ecological significance of these factors relate to historical ecological changes introduced by the plant. Design of the intake itself has additional ecological significance.

Agua Hedionda Lagoon was a closed system prior to construction of the Encina Power Plant (1952-1954). The entire lagoon system was dredged at that time to provide an adequate tidal prism for cooling water. The middle and upper segments of Agua Hedionda Lagoon were dry creek bed and riparian areas along the intermittent Agua Hedionda Creek, prior to dredging of their basins which flooded them with marine waters. This created a marine habitat where little or no aquatic habitat existed. Because there was no aquatic habitat prior to construction, no adverse effects to aquatic habitat resulted from construction of the intake system. Some terrestrial habitat was lost.

The design of the existing intake system permits organisms to enter the intake system and take up residence within the intake tunnels. The bar-rack provides 7.6 cm (3 in.) spacing between bars. This allows fairly large fish to pass through the bar rack into intake tunnels. Travelling screens are located approximately 200 m (650 ft), 300 m (975 ft) and 370 m (1,202 ft) downstream from the bar-rack for units 1-3, 4, and 5, respectively.

Flow rates and configuration within the system are such that fish species can maintain themselves for some time within the intake tunnels ahead of travelling screens. Certain species that are sedentary or demersal can maintain themselves indefinitely. There is approximately 2,834 m^2 (30,500 ft^2) of area within the intake tunnels ahead of travelling screens in which fish can reside. Average depths in the tunnels are approximately 3 m (8 ft). This provides the potential for substantial numbers of fish to reside in the tunnels. Fish species which are unable to maintain position against the current for a variety of reasons and come in contact with the travelling screens are impinged. Prior to installation of Unit 5 at Encina, a fish return system was in operation whereby impinged fish were washed from the screens and sluiced to the discharge tunnel for return to the Pacific Ocean. Fish return systems are sometimes installed in conjunction with travelling screens to return viable screened organisms to the source waters. The Encina Power Plant does not have a fish return system now, so all impinged organisms are collected for disposal. Rip-rap areas in the vicinity of the existing intake provide substrate for marine plant growth. This habitat coupled with the rip-rap areas represent, to some degree, an attractant to fish and invertebrate species in the vicinity of the entrance to the intake structure.

11.3 CAPACITY (OPERATION)

The ecological analysis of plant operations is generally focused on the cooling water flow through the system from trash rack to discharge. The cooling water system has a maximum capacity of 828 MGD. Flows can fluctuate below the maximum capacity depending on how many units are on-line.

The bar-rack at the entrance to the intake system is cleaned at approximatly four-hour intervals, or as needed. All marine plants and organisms impinged at the bar-rack are collected for approved disposal. Impingements at the bar-rack are predominately marine plants, and ocasionally some larger sharks and rays.

Fish impinged on travelling screens within the power plant system are washed off the screens and into a collecting basket. Approximately 79,000 fish are impinged annually during a dredge year (1979). Less may be expected in other years. Most of the impinged fish are alive when they reach the collector baskets. The number of impinged fish were noted to increase with increased flow. However, the changes in seasonal abundance must be taken into account when considering this increased impingement. It is possible to have maximum flow and have a lower level of impingement than might occur at a lower flow rate if the former occurs during a period of low relative fish abundance in the lagoon and the latter occurs during a period of high relative fish abundance. Dredging operations in the outer lagoon segment, which occur approximately every two years, serve as an attractant to fish species and this results in greater numbers impinged when dredging operations are being conducted.

Thermal treatment to prevent biofouling of intake tunnels is conducted at approximately six week intervals. Thermal treatments are usually conducted at nighttime on weekends. The treatment consists of closing off the intake system near the bar-rack and, through a by-pass from the discharge, recirculating the cooling water to gradually raise the water temperature up to 38°C (100°F). The temperature is maintained at 38°C (100°F) for approximately three hours, then gradually reduced to normal. The entire heat treatment operation takes about six hours. Fouling organisms on the tunnel surfaces are killed during heat treatment along with all fish resident within the intake system. This amounts to approximately 108,000 fish annually, which are removed by the travelling screens. Discharge of the heat treatment water at the conclusion of heat treatment is performed slowly to minimize fish mortalities in receiving waters.

The number of fish mortalities resulting from heat treatments is small compared to the size of the populations in the source waters and the numbers removed by fishing activity and natural losses. Experience at other cooling system installations indicate that biofouling predation of entrained organisms is quite high. Results at the Encina Power Plant indicates thermal treatment minimizes predation loss of entrained organisms.

All organisms in the cooling waters smaller than 0.95 cm (3/8 in.) pass through the traveling screens and are entrained through the cooling water system, being discharged back into the surf zone on the open coast. Approximately 63 percent of these entrained organisms survive the passage. A breakdown of the various groups entrained was given previously in Sections 10.3.1, and 10.3.2. Annual mortality from entrainment amounts to 1.61x 10^{10} organisms. These quantities are not considered to be significant from an ecological standpoint due to the high regenerative capacities of plankton organisms and the relatively small percentage of the total population entrained.

Chlorination of cooling water is conducted on a regular basis to minimize slime formation in condenser tubes. Chlorination is conducted for six minutes for each condenser on a timed two-hour cycle. Effects of chlorination, measured at the combined discharge for all Units, were found to be negligible on entrained organisms in most cases during the study. As the chlorine is injected intermittently at the circulating pump behind traveling screens, exposure to nekton is minimized. The chlorine dosage is regulated to minimize residual chlorine remaining after condenser passage. The effect upon organisms is minimized by chlorine application to only a fraction of the total cooling water flow.

12.0

REVIEW OF POTENTIAL ALTERNATIVE INTAKE TECHNOLOGIES FOR MINIMIZATION OF IMPACTS

Various power plant intake designs have been developed or designed to minimize loss of organisms due to entrainment and/or impingement. Table 12.1-1 presents a list of the technologies reviewed for this study (Appendix E, Section 17). These alternatives can be grouped into six broad categories based upon their mode of operation: (1) behavioral barriers, (2) diversion devices, (3) collection systems, (4) passive intakes, (5) fish-return systems, and (6) other alternatives. These categories are briefly described below.

1. Behavioral barriers take advantage of the natural behavioral characteristics of fish. Such barriers include, but are not limited to, electrical screens, air curtains, hanging chains, lights, sound, water jet curtains, and visual keys. For the purpose of this review, velocity caps also are considered part of the behavioral barrier category. Since the success of these barriers depends solely on active fish avoidance responses, they are not designed to reduce entrainment.

2. Diversion devices are physical structures designed to alter flow conditions at the intake in such a way that fish will be guided away from the main circulating water flow. Such devices include louvers, angled and horizontal traveling screens, revolving drum screens, and inclined plane screens. Except for horizontal traveling screens, diversion devices are potentially effective for diverting only juvenile and adult fin-fish. Equipped with a fine mesh, these devices can function as both diversion and collection systems.

3. Fish collection devices are designed to actively collect organisms entrapped within the intake

TABLE 12.1-1

LIST OF POTENTIAL ALTERNATIVE INTAKE TECHNOLOGIES FOR MINIMIZATION OF IMPACTS†

BEHAVIORAL BARRIERS
Electrical Screens
Air Bubble Curtains
Hanging Chains
Lights
Sound
Water Jet Curtain
Visual Keys
Chemical
Magnetic Fields
Velocity Cap Intake
DIVERSION DEVICES
Louvers
Angled Traveling Screens
Horizontal Traveling Screens
Stationary Angled Screens
Revolving Drum Screens
Inclined Plane Screens
FISH COLLECTION DEVICES
Fish Pumps
Fish Netting Devices
Traveling Water Screens
Center-flow Screens
Dual-Flow Screens
Modified, Through-Flow Traveling Screens
Drum Screens
Angled Traveling Screens
Fine Screening of Eggs and Larvae
PASSIVE INTAKES
Wedge-Wire Screens
Radial Wells
Rapid Filter Beds
Porous Dike
Barrier Nets
Fixed Screens
Rotating Disc Screens
FISH RETURN SYSTEMS
Bypass
Lifting Basket
Jet Pumps
Non-Clog Centrifugal Pumps
Pipeline
OTHER ALTERNATIVES
Offshore intake Locations
Variable Operating Conditions to Reduce Cooling Water Intake Volume

† These technologies are reviewed in detail in Appendix E, Section 17.

screenwell. These collection devices include fish pumps and netting devices, traveling water screens, center and dual flow screens, drum screens, angled traveling screens, and fine screens. Depending upon the size of screen mesh and mesh material used, these devices are designed to collect fish and planktonic organisms with varying degrees of effectiveness.

4. Passive intakes operate on the principal of achieving very low withdrawal velocities at the screening media and on locating the intake in a relatively high-velocity cross current. Organisms avoid the intake and get carried away with the cross current flow. Passive-type intake designs include wedge-wire screens, radial screen wells, rapid-filter beds, porous dikes, barrier nets, fixed screens, and rotating disc screens. Depending upon the porosity of the filter media, these technologies are designed to be effective in minimizing both impingement and entrainment losses.

5. Fish return systems are designed to return organisms collected at the intake to the source water with minimal mortality. Fish return systems are actually components of an overall intake design system and include by-pass systems, lifting baskets, jet pumps, non-clog centrifugal pumps, and pipelines. Some intake designs may provide sufficient head for gravity flow return via a pipeline or sluiceway while others may require additional energy (e.g., pumps) to bring the organisms to the release point.

6. Other alternatives considered were offshore intakes and flow reduction designs. Offshore intakes are designed to seek greater cooling water efficiency from deeper offshore waters, which may have lower densities of aquatic organisms than near-shore locations. The velocity cap design also was considered in conjunction with offshore intakes. Flow reduction systems are designed to reduce intake volume and velocities, seeking a reduction in the number of planktonic organisms entrained and adult fish impinged. Flow reduction can be accomplished by reducing operation of the circulating water pumps (CWP) at strategic time periods, installing variable speed controls on the CWP's, and/or installing a closed-cycle cooling system.

13.0

GLOSSARY

AMBIENT: The environment about a body but undisturbed or unaffected by it.

BENTHIC: Pertaining to the substratum (surface) upon which or in which an organism lives; pertaining to the bottom of the ocean.

BENTHOS: Bottom-dwelling forms of marine life.

BIOASSAY: A method of quantitatively determining the concentration of a substance by its effect on the growth of a suitable organism under controlled conditions.

BIOMASS: The weight per unit area or volume of living matter present in a species population or populations.

BOD BOTTLES: Bottles used to hold water in which the Biochecmical Oxygen Demand of anaerobic organisms is being measured.

BONGO NET: Two conically shaped plankton nets supported side by side and attached at their open end to a rigid frame (see Figure 16.2-4).

CHEMICAL EFFECTS: Chemically (chlorine and anticorrosive agents) induced stress and/or mortality on entrained organisms.

CHLORINATION: The introduction of chlorine into a system to aid in the reduction of biofouling.

CHLOROPHYLL: Generic name for any of several (chlorophyll a, b and c) oil-soluble green tetrapyrrole plant pigments which function as photoreceptors of light energy in photosynthesis.

COD END: The concentrating and collecting end of a conically shaped net (see Figure 16.2-4).

CONVERGENCE: The contraction of a vector field; the opposite of divergence.

CORRELATION COEFFICIENT: Normalized statistic between -1 and +1 which measures intensity of association between two variables. If the two variables are denoted by x and y, then the correlation coefficient, r, is given by

$$r = \frac{\Sigma xy}{\Sigma x^2 \ \Sigma y^2}$$

DELAYED MORTALITY: The latent mortality exhibited by entrained organisms at some designated time after condenser passage.

DEMERSAL: Living at or near the bottom of the sea.

DISCHARGE: The site at which the cooling water is returned to the source water.

DIURNAL: Active during daylight hours, having a daily cycle, recurring every day.

DIVERSITY: Number of species present in a given area.

ENTRAINMENT: Pumped passage of aquatic organisms through the cooling condensers.

ENTRAINMENT MORTALITY: Mortality exhibited by organisms after passage through the condensers.

EULERIAN COORDINATES: Any system of coordinates in which properties of a fluid are assigned to points in space at each given time or period. No attempt to identify individual fluid parcels from one time to the next is made in this system.

FLOWMETER: A propeller powered counter used to measure the flow rate and discharge rate of a liquid.

FORK LENGTH: Measure from anterior-most extremity of the fish to the tip of the median fin rays of the tail.

FORMALIN: An aqueous solution of formaldehyde (HCHO) used in preserving biological samples.

GILL NET: Typically a fixed net which captures fish when they become caught by the mesh of the net in trying to swim through; floats on top of net and weighted bottom to keep net vertical in water column.

HALF-METER NET: A conically shaped plankton net attached at its open end to a rigid circular frame one-half meter in diameter.

HYPOTHESIS: A statement which is thought to be true because its consequences can be shown to be true and the truth of the statement can be tested by sample evidence.

ICHTHYOPLANKTON: The pelagic eggs, larvae, and less frequently, the juveniles of marine fishes.

IMPINGEMENT: Occurs when fish or other aquatic organisms are caught or trapped by flowing water on the screens used to remove debris from cooling water as it enters a power plant.

INITIAL MORTALITY: Mortality of entrained organisms exhibited during or immediately after condenser passage.

ISOLATION: (Contracted from "incoming solar radiation") - generally, solar radiation received at earth's surface.

INTAKE: The location at which cooling water from the source water body enters the physical structure of the power plant for passage through the condensers.

IN VITRO: Pertaining to a biological reaction taking place in an artificial apparatus.

ISOPLETH: A line of equal or constant value of a given quantity with respect to either space or time.

JUVENILE: Individuals which are similar to adult organisms but are usually smaller and are not sexually mature.

KELP STAND: Group of *Macrocystis pyrifera* plants attached to the bottom and extending to the surface.

LAGOON: Shallow sound, pond, or lake generally near but separated from or communicating with the open sea.

LAGRANGIAN COORDINATES: A system of coordinates by which fluid parcels are identified for all time by assigning them coordinates which are invariant with time.

LARVA: An immature stage developed from a sterlizied egg, and one that needs to undergo a series of form and size changes before assuming characteristics of adults.

LITTORAL: That part of the shoreline between the low-tide line and the high-tide line.

LOWER HIGH WATER (LHW): The lower of the two high waters of any tidal day.

LOWER LOW WATER (LLW): The lower of the two low waters of any tidal day. The single low water occurring daily during periods when the tide is diurnal is considered to be a lower low water.

LOW TIDE (LOW WATER, LW): The minimum elevation reached by each falling tide.

MEAN HIGHER HIGH WATER (MHHW): The average height of the higher high waters over a 19-year period. For shorter periods of observation, corrections are applied to eliminate known variations and reduce the result to the equivalent of a mean 19-year value.

MEAN HIGH WATER (MHW): The average height of the high waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. All high water heights are included in the average where the type of tide is diurnal. So determined, mean high water in the latter case is the same as mean higher high water.

MEAN LOWER LOW WATER (MLLW): The average height of the lower low waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. All low water heights are included in the average where the type of tide is either semidirunal or mixed. Only lower low water heights are included in the average where the type of tide is diurnal. So determined, mean low water in the latter case is the same as mean lower low water.

MEAN SEA LEVEL: The average height of the surface of the sea for all stages of the tide over a 19-year period, usually determined from hourly height readings. Not necessarily equal to MEAN TIDE LEVEL.

000863

MEAN TIDE LEVEL: A plan midway between MEAN HIGH WATER and MEAN LOW WATER. Not necessarily equal to MEAN SEA LEVEL. Also called HALF-TIDE LEVEL.

MECHANICAL EFFECTS: Mechanically or abrasively induced stress and mortality on entrained organisms.

NEKTON: Free-swimming aquatic animals, independent of water movements.

OFFSHORE: Ocean waters, not including Agua Hedionda Lagoon.

OTTER TRAWL: A large sack-like net with otter boards or doors to assist in opening the net, towed behind a boat and used in collecting bottom organisms, especially fish.

PELAGIC: Pertaining to all ocean waters covering the benthic region and the organisms in these waters.

PHAEOPIGMENTS: Degradation products of chlorophylls.

PHOTOSYNTHESIS: The biological synthesis of chemical compounds in the presence of light.

PHYTOPLANKTON: Microscopic plant life drifting or swimming freely, but weakly, in an aquatic environment.

PLANKTON: Drifting organisms, usually microscopic, floating or swimming weakly in a body of water.

PLANKTON PUMP: An internal combustion gas powered pump used to transport and channel sea water to and through a plankton net (see Figure 16.2-8).

POPULATION: A group of organisms, usually of the same species, occupying a physically defined, specific area or habitat.

PRIMARY PRODUCTIVITY: The rate at which energy is stored by photosynthesizing organisms (chiefly green plants) in the form of organic substances.

RIPE: A fish that has eggs or sperm ready for fertilization.

ROSSBY WAVE: A wave on a uniform current in a two-dimensional non-divergent fluid system, rotating with varying angular speed about the local vertical.

SALINITY: The level of dissolved salt, principally sodium chloride in the water; usually measured in parts per thousand (‰).

SEINE: A fishing net with floats along the top edge and weights along the bottom; usually pulled along the shoreline by hand.

SHEAR: The variation of a vector field along a given direction in space.

SPAWNING: To produce or deposit eggs, sperm, or young.

SPECTROPHOTOMETER: An instrument that measures transmission or apparent reflectance of visible light as a function of wave/length.

STANDARD LENGTH: Length of fish measured from its anterior-most extremity to the hidden bases of the candal rays, where a groove forms when the tail is bent.

SUBSTRATUM: The ocean bottom or surface on or in which an organism lives.

THERMAL EFFECTS: Thermally induced stress and mortality on entrained organisms.

TIDAL CURRENT: The alternating horizontal movement of water associated with the rise and fall of the tide caused by the astronomical tide-producing forces.

TIDAL PRISM: The difference between the mean high water volume and the mean low water volume of a tidally induced body of water.

TOTAL LENGTH: Greatest length of a fish from its anterior-most extremity to the end of the tail fin.

TRAWL: A bag-like net dragged by boat along the bottom, or through the water.

TURBIDITY: A cloudy apperance in naturally clear water caused by suspension of fine solids.

UPWELLING: The rising of water toward the surface from sub-surface layers of a body of water.

WATER COLUMN: In reference to the area between the surface and bottom of a body of water.

WINKLER TITRATION: A chemical method for estimating the amount of dissolved oxygen in water.

ZOOPLANKTON: Microscopic animal life drifting or swimming freely, but weakly in the aquatic environment.

14.0 BIBLIOGRAPHY

Ahlstrom, E. H. and H. G. Moser, Distributional atlas of fish larvae in the California current region: Flatfishes 1955 through 1960, CALCOFI ATLAS No. 23, Marine Research Committee, State of Calif., La Jolla, Calif., 207 pp. (June 1975).

Alden, R. W. III., "Effects of a thermal discharge on the mortality of copepods in a subtropical estuary," Environmental Pollution, pp. 3-19 (1979).

Allen, G., A. Delacy and D. Gotshall, Quantitative sampling of marine fishes - a problem in fish behavior and fishing gear. College of Fisheries Contribution Number 70. University of Washington, Seattle (1960).

Allen, L. G. and M. H. Horn, "Abundance, diversity, and seasonality of fishes in Colorado lagoon, Alamitos Bay, California," Estuarine and Coastal Marine Sci. 3:371-380 (1975).

American Public Health Association, Standard Methods for the Examination of Water and Wastewater, 14th edition, American Public Health Association, Washington, D.C. (1976).

Anderson, R. D. and C. F. Bryan, "Age & Growth of 3 Surfperches Embiotocidae from Humboldt Bay California," Trans. Amer. Fish Soc. 99(3) (1970):475-482.

Arora, H. L., "An Investigation of the California Sanddab (Citharichthys sordidus)," Cal. Fish and Game 37(1):3-42 (1951).

Babel, J. S., "Reproduction, Life History, and Ecology of the Round Stingray Urolophus halleri Cooper." Calif. Dept. Fish and Game, Fish Bull. 137 (1967).

Bainbridge, J. C., "The Problem of Excluding Fish from Water Intakes," Ann. Appl. Biol., Vol. 53, pp. 505-508 (1964).

Bane, G. W., "Fishes of the Upper Newport Bay," Museum of Systematics Biology: Univ. Calif. Irvine, Research Studies, 3:1-115 (1968).

Bane, G. and M. Robinson, "Studies on the shiner perch, Cymatogaster aggregata, Gibbons, in Upper Newport Bay California," The Wassman Jour. of Biology 28(2):259-268 (1970).

Barnhart, P. S., Marine Fishes of Southern California, Univ. of Calif. Press, Berkeley, 209 pp. (1936).

Baxter, J. L., "Summary of Biological Information on the Northern Anchovy Engraulis mordax Girard," Calif. Coop. Oceanic Fish. Invest. Rep. (11):110-116 (1967).

Baxter, J. L., Inshore Fishes of California, Calif. Dept. of Fish and Game, Resources Agency, Sacramento, 78 pp. (1974).

Best, E. A., "Status of the Animal Food Fishery in Northern California, 1956 and 1957," Calif. Fish & Game 45(1):5-18 (1959).

Blaxter, J. H. S., "Swimming Speeds of Fish," Food Agr. Organiz., U. N. Fish Rep., Vol. 62, pp. 62-100 (1969).

Blaxter, J. H. S. and G. Hempel, "Biologische Beobachtungen bei der Aufzucht von Heringsbrut," Helgoländer Wissenschaftliche Meeresuntersuchungen, Vol. 7, pp. 260-282 (1961).

Boreman, J. and C. P. Goodyear, Biases in the Estimation of Entrainment Mortality. Paper Presented Before the Fifth National Workshop on Entrainment and Impingement, San Francisco, Ca. (May 1980).

Bowles, R. R., J. V. Merriner, G. C. Grant, Factors associated with accuracy in sampling fish eggs and larvae, U. S. Fish and Wildlife Service, Office of Biol. Services FWS/OBS - 78/83, 67 pp. (1978).

Bradshaw, J. S., Personal Communication, University of San Diego, San Diego, Ca. (February 1980).

Bradshaw, J., B. Browning, K. Smith, and J. Speth, The Natural Resources of Agua Hedionda Lagoon, U. S. Fish and Wildlife Service, Coastal Wetland Series No. 16 (1976).

Bradshaw, J. S. and G. N. Estberg, An Ecological Study of the Subtidal Marine Life in Agua Hedionda Lagoon, University of San Diego Environmental Studies Laboratory Technical Report, Prepared for San Diego Gas & Electric Company, San Diego, California (1973).

Brewer, G. D., "Reproduction and Spawning of the Northern Anchovy, Engraulis mordax, in San Pedro Bay, California." Calif. Fish and Game 64(3):175-184 (1978).

Briand, F. J.-P., "Effects of Power Plant Cooling Systems on Marine Phytoplankton," Marine Biology, Vol. 33, pp. 135-146 (1975).

Brook, A. J. and A. L. Baker, "Chlorination at Power Plants: Impact on Phytoplankton Productivity," Science, Vol. 176, pp. 1414-1415 (1972).

Budd, P. L., "Development of the Eggs and Early Larvae of Six California Fishes," Calif. Dept. Fish and Game, Fish Bull. No. 56, 53 pp. (1940).

BMF (Bureau of Marine Fisheries), "The commercial fish catch of California for the year 1947 with an historical review 1916-1947," Calif. Dept. Fish and Game, Fish Bull. No. 74, 267 pp. (1949).

Calif. Dept. Fish and Game, Preliminary Report of the California Partyboat Fleet 1978, Calif. Dept. Fish and Game, Sacramento (1979).

California State Water Resources Control Board (SWRCB), Guidance Document for the Conduct of 316(b) Studies in California, SWRCB, Sacramento, Ca. (1977).

Carlisle, J. G., Jr., J. W. Schott, and N. J. Abramson, "The Barred Surfperch (Amphisticus argenteus) in Southern California," Calif. Dept. Fish and Game, Fish Bull. No. 109, 79 pp. (1960).

Cassie, R. M., "Microdistribution of Plankton," Oceanogr. Mar. Biol. Annual Rev. 1:223-252 (1963).

Chadwick, H. K., Entrainment Survival Panel Discussion, Proceedings of the Fourth National Workshop on Entrainment and Impingement, Chicago, Il. (December 1977).

Christensen, S. W., "Quantitative Methodologies for Estimating the Probability of Mortality for Live Organisms Entrained by Power Plants," Bull. Ecol. Soc. Am. 58(2):39 (1977).

Clark, F. N., "Grunion in southern California," Calif. Fish and Game 24:49-54 (1938).

Clark, G. H., "California Halibut," Calif. Fish and Game 16(4): 315-317 (1930).

Clemens, W. A. and G. V. Wilby, "Fishes of the Pacific Coast of Canada," Fish Res. Bd. Can., Bulletin 68, 368 pp. (1946).

Collyer, R. D. and P. H. Young, "Progress report on a study of the kelp bass, Paralabrax clathratus," Calif. Fish and Game 39(2):191-208 (1953).

Colton, J. B., K. A. Honey, and R. F. Temple, "The effectiveness of sampling methods used to study the distribution of larval herring in the Gulf of Maine," J. Cons. Perm. Int. Explor. Mer. 26:180-190 (1961).

Connell, J. H., B. J. Mechalas, and J. A. Mihursky, Annual Report to the California Coastal Comm. Aug. 1976 - Aug. 1977, Appendix I Estimated effects of SONGS Unit 1 on Marine Organisms: Technical Analysis and Results. Marine Review Committee, MRC Doc. 77-09 No. 2. (1977).

Conover, R. J., "Oceanography of Long Island Sound 1952-54 VI Biology of *Acartia clausi* and *A. Tonsa*," Bull. Bringham Oceanog. Coll. 15:156-233 (1956).

Daugherty, A. E., "The Commercial Fish Catch for the Year 1947 with an Historical Review 1916-1947," Calif. Dept. Fish and Game, Fish. Bull. No. 74 (1949).

David, L. R., "Embryonic and Early Larval Stages of the Grunion, *Leuresthes tenuis*, and of the Sculpin, *Scorpaena guttata*," Copeia 2:75-81 (July 12, 1939).

Deevey, G. B., "The zooplankton of Tisbury Great Pond," Bull. Bringham Oceanog. Coll. 12:1-44 (1948).

Defant, A., *Physical Oceanography*, I, Pergamon Press, New York, N.Y., p. 418 (1961).

De Silva, S. S. and M. J. S. Wijeyaratne, "Studies on the Biology of the Young Grey Mullet, Mugil cephalus L.," II. Food and Feeding Aquaculture, 12:157-167 (1977).

Duodorff, P., "The resistance and acclimatization of marine fishes to temperature changes, II. Experiments with Fundulus and Atherinops," Biol. Bull. (88):194-206 (1945).

Ebert, E. E., C. H. Turner, "The Nesting Behavior, Eggs and Larvae of the Bluespot Goby," Calif. Fish and Game 48(4): 249-252 (1962).

Ecological Analysts, Inc., Potrero Power Plant Cooling Water Intake Structures 316(b) Demonstration (Prepared for Pacific Gas and Electric Company) (1980).

Electric Power Research Institute, (EPRI), Ecosystem Effects of Phytoplankton and Zooplankton Entrainment, EPRI - "EA-1038," Palo Alto, Ca. (1979).

Electric Power Research Institute, (EPRI), Methodology for Assessing Population and Ecosystem Level Effects Related to Intake of Cooling Waters, EPRI - "EA-1238," Palo Alto, Ca. (1979).

Emery, K. O., The Sea Off Southern California, John Wiley & Sons, Inc., New York, N.Y. (1960).

Environmental Protection Agency, Guidance for Evaluating the Adverse Impact of Cooling Water Intake Structures on the

Aquatic Environment: Section 316(b) P.L. 92-500, Office of Water Enforcement Permits Division, Industrial Permits Branch, Washington, D.C. (May 1977).

Eppley, R. W., E. H. Renger and P. M. Williams, "Chlorine Reactions With Seawater Constituents and the Inhibition of Photosynthesis of Natural Marine Phytoplankton," Estuarine and Coastal Marine Science, Vol. 4, pp. 147-161 (1976).

Esterly, C. O., "Pelagic Copepoda of the San Diego Region," Univ. Calif. Publ. Zool., Vol. 2 (1905).

Esterly, C. O., "The free swimming copepoda from San Francisco Bay," Univ. Calif. Publ. Zool. 26:81-129 (1924).

Evans, O. F., "Mass Transportation of Sediments on Subaqueous Terraces," J. Geol. 47:325 (1939).

Feder, H. M., C. H. Turner, and C. Limbaugh, "Observations on Fishes Associated with Kelp Beds in Southern California," Calif. Fish and Game, Fish Bull. No. 160 (1974).

Federal Water Pollution Control Act Amendments of 1972, P.L. 92-500, Sect. 316 33 U.S.C.A., 1326.

Fitch, J. E., Offshore Fishes of California, Calif. Dept. Fish and Game, Sacramento (1958).

Fitch, J. E., "A Review of the Fishes of the Genus Pleuronichthys," Los Angeles Co. Museum Contri. Sci. No. 76, 33 pp. (1963).

Fitch, J. E., R. J. Lavenberg, Marine Food and Game Fishes of California, Univ. of Calif. Press, Berkeley, 121 pp. (1971).

Fitch, J. E. and R. J. Lavenberg, "Tidepool and nearshore fishes of California," Univ. of Calif. Press, Calif. Natural History Guides No. 38, pp. 46-48 (1973).

Fleiss, J. L., Statistical Methods for Rates and Proportions, John Wiley and Sons, New York, N.Y. (1973).

Ford, R. F., Distribution, Population Dynamics and Behavior of Bothid Flatfish, Citarichthys stigmaeus. Ph.D. Thesis, Univ. of California, San Diego (1965).

Ford, R. F., D. G. Foreman, C. D. Kroll and D. G. Watts, Ecological Effects of Thermal Effluent from a Coastal Electric Generating Station on Benthic Marine Invertebrates, Phase III, Southern California Edison Company - 78-RD-56 (1978).

Frey, H. W., California Living Marine Resources and Their Utilization, Calif. Dept. Fish and Game, Sacramento, 148 pp. (1971).

Goldberg, S. R., "Seasonal Spawning Cycles of the Sciaenid Fishes Genyonemus lineatus and Seriphus politus," Fishery Bulletin 74(4):983-984 (1977).

Goldberg, S. R., "Reproductive Cycle of the White Sea Perch," Copeia (2):334-336 (1978).

Goldman, J. C. and H. L. Quinby, "Phytoplankton Recovery After Power Plant Entrainment," Journal of the Water Pollution Control Federation, Vol. 51(7), pp. 1816-1823 (1979).

Gonzalez, J. G., "Critical Thermal Maxima and Upper Lethal Temperatures for the Calanoid Copepods *Acartia tonsa* and *A. clausi*," Marine Biology, Vol. 27, pp. 219-223 (1974).

Gulland, J. A., Survival of the Youngest Stages of Fish and its Relation to Year Class Strength, The International Commission for the Northwest Atlantic Fisheries - Special Publication No. 6 - ICNAF Environmental Symposium, Rome, Italy (1964).

Hamilton, D. H., Jr., D. A. Flemer, C. W. Keefe and J. A. Mihursky, "Power Plants: Effects of Chlorination on Estuarine Primary Production," Science, Vol. 169, pp. 197-198 (1970).

Hart, J. L., "Pacific Fishes of Canada," Fisheries Research Board of Canada, Bulletin 180, 740 pp. (1973).

Hedgepeth, J. W., Ecological Aspects of the Laguna Madre, a Hypersaline Estuary, In: G. H. Lauff (ed.) Estuaries. Amer. Assoc. Advancement Science. Pub. #83, pp. 408-419 (1967).

Heinle, D. R., "Production of a calanoid copepod, Acartia tonsa, in the Patuxent River estuary," Chesapeake Sci. 7:59-74 (1966).

Herald, E. S., Living Fishes of the World, Doubleday, Garden City, N.Y. (1961).

Herald, E. S. and D. A. Simpson, "Fluctuations in Abundance of Certain Fishes in South San Francisco Bay as Indicated by Sampling at a Trash Screen," Calif. Fish and Game, Vol. 39 (2), pp. 271-278 (1955).

Hildebrand, S. F. and L. E. Cable, "Development and Life History of Fourteen Teleostean Fishes at Beaufort, N.C.," U.S. Bur. Fish., Bull. 46:382-488 (1930).

Hobson, E. S. and J. R. Chess, "Trophic Interactions Among Fishes and Zooplankters Near Shore at Santa Catalina," Fishery Bulletin 74(3):567-598 (1976).

Holloway, J. L., "Smoothing and Filtering of Time Series and Space Fields," Advances in Geophysics, Vol. 4, pp. 351-389 (1958).

Holm-Hansen, O. and B. Riemann, "Chlorophyll a Determination: Improvements in Methodology," OIKOS, Vol. 30, pp. 438-447 (1978).

Horn, M. L., and L. G. Allen, "Numbers of species and faunal resemblance of marine fishes in California bays and estuaries," Bull. of So. Calif. Acad. of Sci. 75(2):159-170 (1976).

Hulbrock, R., Lengths, Weights and Ages of 13 Southern California Marine Gamefish, Calif. Dept. Fish and Game, Resources Agency, Sacramento, 33 pp. (1974) (Revised 1976).

Hunter, J. R., "Behavior and survival of northern anchovy, *Engraulis mordax*, larvae," Calif. Coop. Oceanic Fish. Invest. Rept. 19:138-146 (1976).

Icanberry, J. W., Personal Communication, Pacific Gas and Electric Company Department of Engineering Research, San Ramon, Ca. (February 1980).

Icanberry, J. W. and J. W. Warrick, Delayed Mortality of Entrained Copepods at Morro Bay Power Plant, Pacific Gas and Electric Company Department of Engineering Research - 7598. 21-75, San Ramon, Ca. (July 1979).

Inman, D. L. and J. D. Frautschy, Littoral Processes and the Development of Shorelines, ASCE Coastal Engr. Proc. of Santa Barbara Specialty Conference, New York, N.Y., p. 511 (1966).

000878

Jacobs, J., "Animal behavior and water movement as co-determinants of plankton distribution in a tidal system," Sarsia (34):355-370 (1968).

Jensen, L. D., (ed.), Proceedings of the Second Entrainment and Intake Screening Workshop, Electric Power Research Institute, "EPRI Publication No. 74-049-00-5," Palo Alto, Ca., 347 pp. (1974).

Jensen, L. D., (ed.), Third National Workshop on Entrainment and Impingement: Section 316(b) - Research and Compliance, Ecological Analysts, Inc., Melville, N.Y., 425 pp. (1977).

Jensen, L. D., (ed.), Fourth National Workshop on Entrainment and Impingement, Ecological Analysts, Inc., Melville, N.Y., 424 pp. (1978).

Johnson, J. K., The Dynamics of an Isolated Population of Acartia tonsa Dana (Copepoda) in Yaquina Bay, Oregon. Masters Thesis, Oregon State Univ., Corvalis, Ore., 97 pp. (1974).

Johnson, M. E. and H. J. Snook, Seashore Animals of the Pacific Coast. Dover Publication Inc., New York, pp. 255 (1967).

Johnson, R. L., P. Dorn, K. Muench, and M. Hood, An Evaluation of Fish Entrapment Associated with the Offshore Cooling Water Intake System at the Redondo Beach Steam Generating Station, Phase II, Southern California Edison Company - 77-RD-12 (1976).

Jones, A. C., "The biology of the euryhaline fish Leptocottus armatus armatus, Girard," Univ. Calif. Pubs. Zool. (67): 321-368 (1962).

Joseph, D. E., "Growth Characteristics of Two Southern California Surffishes, the California Corbina and the Spotfin Croaker, Family Sciaenidae," Calif. Dept. Fish and Game, Fish Bull. No. 119, 54 pp. (1962).

Kauffman, T. A., J. A. Lindsay, and A. Carpenter, Impact of the Intake Conduit Biofouling Community, Paper Presented Before the Fifth National Workshop on Entrainment and Impingement, San Francisco, Ca. (May 1980).

Kerr, J. E., Studies of Fish Preservation at the Contra Costa Steam Plant of the Pacific Gas and Electric Company, State of California, The Resources Agency, The Department of Fish and Game - Fish Bull. 92, Sacramento, Ca. (1953).

Keulegan, G. H., Third Progress Report on Tidal Flow in Entrances, National Bureau of Standards - 1146 (1951).

King, D. B., Jr., The Dynamics of Inlets and Bays, Coastal and Engineering Laboratory, Univ. of Florida - TR22 (1974).

Kjelson, M. A., Estimating the Size of Juvenile Fish Populations in Southeastern Coastal-Plain Estuaries, In: W. Van Winkle (ed.) Proceedings of the conference on assessing the effects of power plant induced mortality on fish populations, Gatlinburg, Tennessee, pp. 71-89 (May 3-6, 1977).

Kjelson, M. and G. Johnson, "Catch efficiencies of a 6.1-meter otter trawl for estuarine fish populations," Trans. Am. Fish. Soc. 107(2):246-254 (1978).

Klima, E. F., and D. A. Wickham, "Attraction of Coastal Pelagic Fishes with Artificial Structures," Trans. Am. Fish. Soc., Vol. 100(1), pp. 86-99 (1971).

Kravitz, J., W. G. Pearcy, M. P. Guinn, "Food of Five Species of Co-occurring Flatfishes on Oregons Continental Shelf," Fish. Bull. 74(4):984-990 (1976).

Lane, E. D. and C. W. Hill, "The Marine Resources of Anaheim Bay," Calif. Fish and Game, Fish Bull. No. 165, 195 pp. (1975).

Lane, E. D., M. C. S. Kingsley and D. E. Thorton, "Daily Feeding and Food Conversion Efficiency of the Diamond Turbot: An Analysis Based on Field Data," Trans. Am. Fish. Soc. 108(6): 530-535 (1979).

LaraLara, J. R. y S. Alvarez Borrego, "Ciclo Anual de Clorofilas y Producción Orgánica Primeria en Bahiá San Quintín, B.C.," Ciencias Marinas, Vol. 2(1), pp. 77-97 (1975).

Lasker, R., Personal Communication, National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, Ca. (February 1980).

Lasker, R., H. M. Feder, G. H. Theilacker and R. C. May, "Feeding, Growth and Survival of Engraulis mordax Larvae Reared in the Laboratory," Marine Biology, Vol. 5, pp. 345-353 (1970).

Lasker, R. and P. E. Smith, "Estimation of the effects of environmental variations on eggs and larvae of the northern anchovy," Calif. Coop. Oceanic Fish. Invest., Rept. 19:128-137 (1977).

Lawler, J. P., Physical Measurements: Their Significance in the Prediction of Entrainment Effects, Third National Workshop on Entrainment and Impingement: Section 316(b) - Research and Compliance, (L. D. Jensen, ed.), pp. 59-91. Ecological Analysts, Melville, N.Y., 425 pp. (1976).

Lawler, Matusky, and Skelly Engineers, Ecosystem Effects of Phytoplankton and Zooplankton Entrainment, Electric Power Research Institute - EPRI-1038, Palo Alto, Ca. (April 1979).

Leithiser, R. M., K. F. Ehrlich, and A. B. Thum, "Comparison of a High Volume Pump and Conventional Plankton Nets for Collecting Fish Larvae Entrained in Power Plant Cooling Systems," J. Fish. Res. Board Can. 36:81-84 (1979).

Limbaugh, C., Fish Life in the Kelp Beds and the Effects of Kelp Harvesting, Univ. Calif. Inst. Mar. Resources IMR Reference 55-9 (Sept. 9, 1955).

Lifton, W. S. and J. F. Storr, The Effect of Environmental Variables on Fish Impingement, Fourth National Workshop on Entrainment and Impingement, Ecological Analysts, Inc., Melville, N.Y., 424 pp. (1978).

Longuet-Higgins, M. S. and R. W. Stewart, "Radiation Stress and Mass Transport in Gravity Waves with Application to Surf Beats," J. Fluid Mech. 13:481 (1962).

Longuet-Higgins, M. S. and R. W. Stewart, "Radiation Stress in Water Waves, A Physical Discussion with Applications," Deep-Sea Research 11(4):529 (1964).

Maloney, N. J. and K. M. Chan, "Physical Oceanography," A Summary of Knowledge of the Southern California Coastal Zone and Offshore Areas, I., p. 3-1 (1974).

Marine Advisers, Inc., A Statistical Summary of Ocean Wave Characteristics in Southern California Waters, La Jolla, Ca. (1961).

Marine Review Committee (MRC), Annual Report to the California Coastal Commission, August 1976 - August 1977, Appendix I, Estimated Effects of SONGS Unit I on Marine Organisms: Technical Analysis and Results, MRC Doc.77-09, No. 2 (1977).

Martin, D. F. and G. E. Drewry, Development of Fishes of the Mid-Atlantic Bight, An Atlas of Egg, Larval and Juvenile Stages. Vol. 6 Stromateidae Through Ogcocephalidae, U. S. Dept. of Interior, Fish and Wildlife Service, FWS/OBS - 78/12 Washington D.C., 416 pp. (1978).

Maxwell, W. D., "The Croakers of California," Calif. Dept. of Fish and Game, Resources Agency, Leaflet No. 8 (1975).

McAllister, R., "California Marine Fish Landings for 1973," Calif. Dept. Fish and Game, Fish Bull. No. 163, 53 pp. (1975).

McAllister, R., "California Marine Landings for 1974," Calif. Dept. Fish and Game, Fish Bull. No. 166, 53 pp. (1976).

McFadden, J. T., Environmental impact assessment for fish populations, In: R. K. Sharma, J. D. Buffington, and J. T. McFadden (eds.) Proc. Workshop Biol. Significance Environ. Impacts, NR-CONF-002. Nuclear Regulatory Commission, Washington, D.C., pp. 89-137 (1975).

McHugh, J. L., Estuarine Nekton, In: Haugh, G. H. (ed.) Estuaries, Amer. Assoc. Adv. Science, Pub. #83, Washington D.C., 757 pp. (1967).

Mearns, A. J. and M. J. Allen, Use of Small Otter Trawls in Coastal Biological Surveys, Southern California Coastal Water Research Project, Contribution #66, Long Beach (1978).

Miller, D. J., "A Field Guide to Some Common Ocean Sport Fishes of California Part 1," Calif. Dept. Fish and Game, 41 pp. (1959).

Miller, D. J., D. Gotshall and R. Nitsos, "A Field Guide to Some Common Ocean Sport Fishes of California, Part II," Calif. Dept. Fish and Game, Sacramento, 41 pp. (1961).

Miller, D. J. and R. N. Lea, "Guide to the Coastal Marine Fishes of California," Calif. Dept. Fish and Game, Fish Bull. No. 157, 249 pp. (1972).

Miller, J. N., The Present and Past Molluscan Faunas and Environments of Four Southern California Coastal Lagoons, Master's Thesis, Univ. of California, San Diego (1966).

Morgan, R. P. and R. G. Stross, "Destruction of Phytoplankton in the Cooling Water Supply of a Steam Electric Station," Chesapeake Science, Vol. 10, pp. 165-171 (1969).

Moyle, P. B., Inland Fishes of California, Univ. of Calif. Press, Berkeley, 405 pp. (1976).

N.M.F.S., Fisheries of the United States, 1979, Current Fishery Statistics No. 8000, U. S. Dept. Commerce, 131 pp. (1980).

National Ocean Survey, Tide Tables, West Coast of North and South America, p. 171 (1979).

Newmann, G. and W. J. Pierson, Jr., Principles of Physical Oceanography, Prentice-Hall, Inc., Englewood Cliffs, N.J., p. 400 (1966).

O'Connell, C. P., and L. P. Raymond, "The Effect of Food Density on Survival and Growth of Early Post Yolk-Sac Larvae of the Northern Anchovy (*Engraulis mordax* Girard) in the Laboratory," Journal of Experimental Marine Biology and Ecology, Vol. 5, pp. 187-197 (1970).

Odum, E. P., "Principles and concepts pertaining to organization at the community level," pp. 140-161, In: Fundamentals of Ecology. 3rd ed., W. B. Saunders Co., Philadelphia, 575 pp. (1971).

Odum, W. E., Utilization of the direct grazing and plant detritus food chains by the striped mullet *Mugil cephalus*. In: J. H. Steele (ed.) 1970 Marine Food Chains, Oliver and Boyd, pp. 222-240 (1970).

Oliphant, M. S., "California Marine Fish Landings for 1976," Calif. Dept. Fish and Game, Fish Bull. No. 170, 56 pp. (1979).

PBQ&D, Inc., Southwest Ocean Outfall, Pre-design Oceanographic Study, San Francisco, Ca., p. I-91 (1978).

Pacific Fishery Management Council and U. S. Department of Commerce National Marine Fisheries Service, Northern

Anchovy Fishery - Final Environmental Impact Statement and Fishery Management Plan, Washington D.C., 119 pp. (1978).

Pankhurst, R. J., Biological Identification with Computers, Academic Press, New York, pp. 83-87 (1975).

Pearcy, W. G., "Distribution and Abundance of Small Flatfishes and other Demersal Fishes in a Region of Diverse Sediments and Bathymetry Off Oregon," Fishery Bulletin 76(3):629-640 (1978).

Pearcy, W. G. and D. Hancock, "Feeding Habits of the Dover Sole, Microstomus pacificus; Rex Sole, Glyptocephalus zachirus; Slender Sole, Lyopsetta exilis and Pacific Sanddab, Citharichthys sordidus, in a Region of Diverse Sediments and Bathymetry Off Oregon," Fishery Bulletin 76(3):641-651 (1978).

Pinkas, L., "California Marine Fish Landings for 1975," Calif. Dept. Fish and Game, Fish Bull. No. 168, 550 pp. (1977).

Pinkas, L., M. S. Oliphant, C. W. Haugen, "Southern California marine sportfishing survey: private boats, 1974; Shoreline 1965-66," Calif. Fish and Game, Fish Bull. No. 143, 42 pp. (1968).

Prentice, E. F. and F. J. Ossiander, Fish Diversion Systems and Biological Investigations of Horizontal Traveling Screen Model III, Proceedings of the Second Entrainment and

Intake Screening Workshop, Baltimore, Md., pp. 205-214 (December, 1974).

Quast, J. C., "Observations of the Food and Biology of the Kelp Bass, Paralabrax clathratus, with Notes on its Sportfishery at San Diego, California," In: W. J. North and G. L. Hubbs (eds.) Utilization of kelp-bed resources in southern California," Calif. Dept. Fish and Game, Fish Bull. No. 139:81-108 (1968).

Quast, J. C., "Observations on the Food of the Kelp-Bed Fishes," Calif. Dept. Fish and Game, Fish Bull. No. 139:109-142 (1968).

Rechnityer, A. B. and C. Limbaugh, "Breeding Habits of Hyperprosopon argenteum, a Viviparous Fish of California," Copeia (1):41-42 (1952).

Reeve, M. R. and E. Cosper, The acute effects of heated effluents on the copepod (Acartia tonsa) from a sub-tropical bay and some problems of assessment, FAO Tech. Conf. on Mar. Poll. and its Effects on Living Resources and Fishing, FIR: MP/70/E-59, Rome, Italy, 4 pp. (1970).

Reynolds, W. W., D. A. Thompson and M. E. Casterlin, "Responses of young California grunion, Leuresthes tenuis, to gradients of temperature and light," Copeia 1977(1):144-149 (1977).

Riemann, B., "Carotenoid Interference in the Spectrophotometric Determination of Chlorophyll Degradation Products From Natural Populations of Phytoplankton," Limnology and Oceanography, Vol. 23, pp. 1059-1066 (1978).

Roche, W. H., "Biostimulation studies in the Suisan Marsh, Ca.," Paper presented at a Workshop on Algal Nutrient Relationships in the San Francisco Bay and Delta (sponsored by California Department of Water Resources) Sacramento, Ca., pp. 37-53 (November 1975).

Roedel, P. M., "Common Marine Fishes of California," Calif. Dept. Fish and Game, Fish Bull. No. 68, 150 pp. (1948).

Roedel, P. M., "Common Ocean Fishes of the California Coast," Calif. Dept. Fish and Game, Fish Bull. No. 91, 184 pp. (1953).

Schuler, V. J., Experimental Studies in Guiding Marine Fishes of Southern California with Screens and Louvers, Proceedings of the Second Entrainment and Intake Screening Workshop, Baltimore, Md., pp. 305-315 (December 1974).

Schuler, V. J. and L. E. Larson, "Improved Fish Protection at Intake Systems," J. Envir. Engin. Div., Am. Soc. Civil Engineer, Proc. Paper 11756, Vol. 101, pp. 897-910 (1975).

Shepard, F. P. and D. L. Inman, "Nearshore Water Circulation Related to Bottom Topography and Wave Refraction," Eos Trans. AGU 31(2):196 (1950).

Skogsberg, T., "The Fishes of the Family Sciaenidae (croakers) of California," Calif. Fish and Game, Fish Bull. No. 54:1-62 (1939).

Smith, P. E. and S. L. Richardson, Standard techniques for pelagic fish egg and larva surveys, FAO, Fish. Tech. Paper No. 175, Rome, 100 pp. (1977).

Snedecor, G. W. and W. G. Cochran, Statistical Methods, 6th edition, Iowa State University Press, Ames, Iowa (1972).

Sokal, R. R. and J. F. Rohlf, Biometry, W. H. Freeman and Co., San Francisco, Ca., pp. 392-393 (1969).

Sonu, C. J., "Tethered Balloons for Study of Coastal Dynamics," Proc. Symp. Earth Observ. Balloons, p. 91 (1969).

Sonu, C. J., "Field Observations of Nearshore Circulation and Meandering Currents," J. G. R. 77(18):3232 (1972).

Southern California Coastal Water Research Project, The Ecology of the Southern California Bight: Implications for Water Quality Management, SCCWRP-TR104, El Segundo, Ca. (1973).

Southern California Edison Co., 1979 Annual Operation Report for San Onofre Nuclear Generating Station, Vol. 5: Biological and Oceanographical Data Analysis, Special Study: Ichthyoplankton, Southern California Edison Company - 80-RD-100, Rosemead, Ca. (June 1980).

Spratt, J. D., "Growth rate of the northern anchovy, Engraulis mordax, in southern California waters, calculated from otoliths," Calif. Fish and Game 61(3):116-126 (1975).

Starks, E. C., "The Fishes of the Croaker Family (Sciaenidae) of California," Calif. Fish and Game 5(1):13-20 (1919).

Starks, E. C. and E. L. Morris, "The marine fishes of southern California," University of Calif. Publ. Zoology 3(11): 177 (1907).

Stauffer, R. E., G. F. Lee and D. E. Armstrong, "Estimating Chlorophyll Extraction Biases," Journal of the Fisheries Research Board of Canada, Vol. 36, pp. 152-157 (1979).

Stephens, J. S., Effects of Thermal Effluent of Southern California Edison's Redondo Beach Steam Generating Station on the Warm Temperate Fish Fauna of King Harbor Marina, Annual Report for Phase III, Southern California Edison Company - 78-RD-47 (1978).

Sumida, B. Y., E. H. Ahlstrom, H. G. Moser, "Early Development of Seven Flatfishes of the Eastern North Pacific with Heavily Pigmented Larvae," Fishery Bulletin 77(1):105-145 (1978).

Sunada, J. S., "Age and length composition of northern anchovies, *Engraulis mordax*, in the 1972-1973 season California anchovy reduction fishery," *Calif. Fish and Game* 61(3):133-143 (1975).

Szuwalski, A., Littoral Environment Observation Program in California, U. S. Army Corps of Engr. - 2-70, Coastal Engr. Res. Center, p. C-4 (1970).

Talmage, S. S. and C. C. Coutant, "Thermal Effects," *Journal of the Water Pollution Control Federation*, Vol. 51, pp. 1517-1554 (1979).

Tarp, F. H., "A Revision of the Family Embiotocidae (Surf-perches)," *Calif. Dept. Fish and Game*, *Fish Bull*. No. 88: 51-53 (1952).

Taylor, P. B., *The Venom and Ecology of the California Scorpion-fish, Scorpaena guttata Girard*, Univ. of Calif. SIO Dissertation, San Diego (1963).

Theilacker, G. H., "Effect of Starvation on the Hisological and Morphological Characteristics of Jack Mackerel, *Trachurus symmetricus*, Larvae," *Fisheries Bulletin*, Vol. 76, pp. 403-414 (1978).

Thomas, J. C., "Management of the White Seabass (*Cynocsion nobilis*) in California waters," *Calif. Dept. Fish and Game*, *Fish Bull*. No. 142, 34 pp. (1968).

Thomson, J. M., "Synopsis of Biological Data on the Grey Mullet, Mugil cephalus Linnaeus, 1758," CSIRO Fisheries and Oceanography (Australia) Fisheries Synopsis No. 1, 57 pp. (1963).

Thomson, J. M., "The Grey Mullets," Oceangr. Mar. Biol. Ann. Rev., 4:301-335 (1966).

Triplett, E. L., "Notes on the History of the Barred Surfperch (Amphisticus argenteus) and a Technique for Culturing Embiotocid Embryos," Calif. Dept. Fish and Game 46(4):433-439 (1960).

Tsuchiya, M., "Inshore Circulation in the Southern California Bight, 1974-1977," Deep-Sea Research, 27A:99 (1980).

Turner, C. H., E. E. Ebert, and R. R. Given, Man-made reef ecology, State of California, The Resources Agency, Department of Fish and Game - Fish Bulletin No. 146, Sacramento, Ca. (1969).

U. S. Environmental Protection Agency, Guidance for Evaluating the Adverse Impact of Cooling Water Intake Structures on the Aquatic Environment: Section 316(b) PL92-500, U. S. Environmental Protection Agency, Office of Water Enforcement, Washington D.C. (1977).

Uye, S. and A. Flemiger, "Effects of various environment factors on egg development of several species of Acartia in southern California," Mar. Biol. 38:253-262 (1976).

Voightlander, C., Assessment of Impingement Impacts on TVA Reservoirs, Third National Workshop on Entrainment and Impingement: Section 316(b) - Research and Compliance, Ecological Analysts, Inc., Melville, N.Y., 425 pp. (1977).

Walker, B. W., "A Guide to the Grunion," Cal. Fish and Game 38(3):144-149 (1952).

Warner, R. R., "The reproductive biology of the protopynous hermaphrodite, Pimelometopon pulchrum," Fishery Bulletin 73(2):262-283 (1975).

Weinstein, M. P., "Shallow marsh habitats as primary nurseries for fishes and shellfish, Cape Fear River, North Carolina," Fishery Bulletin 77(2):339-358 (1979).

Whitney, D. E., and W. M. Darley, "A Method for the Determination of Chlorophyll a in Samples Containing Degradation Products," Limnology and Oceanography, Vol. 24, pp. 183-186 (1979).

Wiebe, J. P., "The reproductive cycle of the viviparous seaperch, Cymatogaster aggregata, Gibbons," Canadian Jour. of Zoology (46):1221-1234 (1968).

Wiebe, P. H., "Small-scale spatial distribution in oceanic zooplankton," Limnol. Oceanogr. 15(2):205-217 (1970).

Wood, R. J., "Some observations on the vertical distribution of herring larvae," Rapp. P.-V. Réun. Cons. Perm. Int. Explor. Mer. 160:60-64 (1971).

Woodmansee, R. A., "The seasonal distribution of the zooplankton off Chicken Key in Biscayne Bay, Florida," Ecology (39):247-262 (1958).

Woodward-Envicon, Inc., Environmental Impact of Maintenance Dredging of Agua Hedionda Lagoon and Dredge Spoil Disposal, San Diego, Ca., p. 2-79 (March 1974).

Zar, J. H., Biostatistical Analysis, Prentice-Hall, Inc., Englewood Cliffs, N.J., 620 pp. (1974).

Zedler, J., T. Winfield and D. Mauriello, "Primary Production in a Southern California Estuary," Coastal Zone '78, Vol. 2, pp. 649-662 (1978).

15.0

ACKNOWLEDGEMENTS

The development of this report was accomplished through the coordinated effort of several individuals and organizations. In appreciation of those efforts these contributions are hereby acknowledged.

Among those on the project staff of Woodward-Clyde Consultants (WCC), were:

Mr. Robert D. Plunkett, Program Sponsor and Coordinator

Dr. Hong Chin, Physical Oceanographic Studies

Mr. Preston E. Porter, Biological Studies

Dr. Gordon Robilliard, Biological Studies

Mr. Robert E. Bonin, Biological Studies

Mr. Michael R. Piotrowski, Biological Studies

Mr. Donald M. LaVigne, Data Processing

Mr. Harry A. Malcolm, Graphic Production

The impingement studies program was designed and conducted by staff of San Diego State University Foundation (SDSUF):

Dr. Richard F. Ford

Mr. Jon C. Van Olst

Ms. Elaine M. Carlin

Review of the biological reports was performed by Ms. Susan M. Vergne, San Diego Gas & Electric (SDG&E).

Although too numerous to list, the input and information gained from many scientists, and engineers, in state and federal agencies, the utility industries, and other organizations concerned with programs of this kind are gratefully acknowledged.