CARLSBAD SEAWATER DESALINATION PROJECT

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

REGION 9, SAN DIEGO REGION

ORDER NO. R-9-2006-0065

NPDES NO. CA0109223

FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

March 27, 2009

CARLSBAD SEAWATER DESALINATION PROJECT

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EXECUTIVE SUMMARY

PLAN PURPOSE

The San Diego Regional Water Quality Control Board (Regional Board) adopted Order No. R9-2006-0065, NPDES No. CA0109223 (Permit) for Poseidon Resources Corporation's (Poseidon) Carlsbad Desalination Project's (CDP or the Project) discharge to the Pacific Ocean via the existing Encina Power Station (EPS) discharge channel. The CDP is planned to operate in conjunction with the EPS by using the EPS cooling water discharge as its source water whenever the power plant is operating, and to use the EPS intake structure when the EPS is not producing enough cooling water discharge to meet the CDP's feedstock requirements.

This Flow, Entrainment and Impingement Minimization Plan (Plan or Minimization Plan) was generated pursuant to Water Code Section 13142.5(b), which requires industrial facilities using seawater for processing to use the best available site, design, technology, *and* mitigation feasible to minimize intake and mortality to marine life. The Plan was required under Section VI C.2)e of the Permit, and incorporated therein. In accordance therewith, this Plan assesses the feasibility of site-specific plans, procedures, and practices to be implemented and/or mitigation measures to minimize the impacts to marine organisms when the CDP intake requirements exceed the volume of water being discharged by the EPS. The purpose of the Plan is to minimize the impingement and entrainment of marine life associated with the intake of seawater for desalination because mortality can result from such impingement and entrainment.

This Plan reviews the CDP's stand-alone operations and also ensures compliance with Water Code Section 13142.5(b) when the EPS is operating but producing less than 304 MGD, since intake and mortality under such circumstance would be less than when the CDP operates in stand-alone mode.

PLAN COMPLIANCE

As shown in Table ES-1, the Plan addresses each of the provisions of Water Code Section 13142.5(b). The site, design, technology, and mitigation measures proposed in this Plan represent a balanced approach to minimizing the potential for intake and mortality from the CDP under stand-alone operations, and individually and collectively satisfy the obligation under Section 13142.5(b) to employ best available and feasible measures to minimize such effects.

ES-1
Site, Design, Technology and Mitigation Measures to Minimize Impingement and Entrainment

Category	Feature	Result
1. Site	Proposed location at EPS	Best available site for the project, no feasible and less environmentally damaging alternative locations.
1. Design	Use of EPS discharge as source water	Minimizes entrainment and impingement impacts attributable to the CDP.
2. Design	Reduction in inlet screen velocity	Reduction of impingement of marine organisms.
3. Design	Reduction in fine screen velocity	Reduction of impingement of marine organisms.

ES-1 Site, Design, Technology and Mitigation Measures to Minimize Impingement and Entrainment		
Category	**Feature**	**Result**
4. Design	Ambient temperature processing	Eliminate entrainment mortality associated with elevated seawater temperature.
5. Design	Elimination of heat treatment	Eliminate mortality associated with heat treatment.
1. Technology	Installation of VFDs on CDP intake pumps	Reduce the total intake flow for the desalination facility to no more than that needed at any given time, thereby minimizing the entrainment of marine organisms.
1. Mitigation	Implementation of Marine Life Mitigation Plan developed pursuant to a state agency coordinated process.	Offset entrainment and impingement, in addition to that addressed by site, design and/or technology; enhance the coastal environment.

PROPOSED MITIGATION APPROACH

Poseidon is using all feasible site, design and technology to minimize impingement and entrainment attributable to the CDP. These approaches are likely to reduce Project-related intake and mortality to marine life to levels well below those estimated in Chapter 5. To offset any residual impingement and entrainment, Poseidon has committed to implementing the Marine Life Mitigation Plan (MLMP) described in Chapter 6 and incorporated therein as Part A.

REGULATORY ASSURANCE OF PLAN ADEQUACY

There are a number of regulatory assurances in place to confirm the adequacy of the MLMP and resulting restoration. The Regional Board and Coastal Commission have direct jurisdiction over the implementation of the MLMP. In addition, the Regional Board, Coastal Commission, and State Lands Commission will continue to have ongoing jurisdiction over the proposed Project.

Specifically, the Regional Board's approval will be necessary in order to obtain NPDES permit renewal for the Project in 2011. Poseidon must make additional coastal development permit applications to the Coastal Commission. In addition, ten years after the lease for the intake system is issued, CDP will be subject to further environmental review by the State Lands Commission to analyze all environmental effects of facility operations and consider alternative technologies that may further reduce intake and mortality of marine life. The State Lands Commission may impose additional requirements as are reasonable and as are consistent with applicable state and federal laws and regulations.

This multi-agency approach means that there are multiple safeguards to ensure that even when the CDP converts to stand-alone operations, it will continue to use the best available site, design, technology and mitigation feasible to minimize intake and mortality attributable to the Project.

CHAPTER 1

INTRODUCTION

1.1 PURPOSE OF THE PLAN

The San Diego Regional Water Quality Control Board (Regional Board) adopted Order No. R9-2006-0065, NPDES No. CA0109223 (Permit) for Poseidon Resources Corporation's (Poseidon) Carlsbad Desalination Project's (CDP) discharge to the Pacific Ocean via the existing Encina Power Station (EPS) discharge channel. The CDP is planned to operate in conjunction with the EPS by using the EPS cooling water discharge as its source water whenever the power plant is operating.

This Flow, Entrainment and Impingement Minimization Plan (Plan or Minimization Plan) reviews stand-alone operations and also ensures compliance with Section 13142.5(b), which requires industrial facilities using seawater for processing to use the best available site, design, technology, *and* mitigation feasible to minimize intake and mortality to marine life.[1] The Plan was required under Section VI C.2)e of the Permit, and incorporated therein. The Regional Board recognized that future EPS flows may not follow historical trends such that it would be able to meet all of the CDP's intake needs and required Poseidon prepare this Plan to assess the feasibility of site-specific plans, procedures, and practices to be implemented and/or mitigation measures to minimize the impacts to marine organisms when the CDP intake requirements exceed the volume of water being discharged by the EPS.[2] In accordance with Section 13142.5(b), the purpose of the Plan is to minimize the impingement and entrainment of marine life associated with the intake of seawater for desalination because mortality can result from such impingement and entrainment.

When operating in conjunction with the power plant and the power plant is producing sufficient feedwater to support the CDP's operations, the CDP will not cause any additional intake and mortality of marine life above and beyond that associated with the EPS's operations. To the extent the EPS's discharge is insufficient to meet the CDP's intake needs, only incremental additional marine life mortality is expected because the CDP will not increase the volume or the velocity of the power station cooling water intake beyond that provided for in EPS's permit, Order No. R9-2006-0043, NPDES No. CA0001350. In the event the EPS ceases operations, and the CDP independently operates the seawater intake and outfall for the benefit of the CDP, such independent operation may require additional review pursuant to Water Code Section

[1] See Permit at F-49. The full text of Water Code Section 13142.5(b) provides: "For each new or expanded coastal powerplant or other industrial installation using seawater for cooling, heating, or industrial processing, the best available site, design, technology, and mitigation measures feasible shall be used to minimize the intake and mortality of all forms of marine life."

[2] Permit at Section VI.2.e provides: "The Discharger shall submit a Flow, Entrainment and Impingement Minimization Plan within 180 days of adoption of the Order. The plan shall assess the feasibility of site-specific plans, procedures, and practices to be implemented and/or mitigation measures to minimize the impacts to marine organisms when the CDP intake requirements exceed the volume of water being discharged by the EPS. The plan is subject to the approval of the Regional Water Board and is modified as directed by the Regional Water Board."

13142.5(b), though the mitigation plan incorporated herein at Chapter 6, Part A accounts for a stand-alone operations.[3]

This Plan is developed in fulfillment of the above-stated requirements and contains site-specific activities, procedures, practices and mitigation measures which are planned to be implemented to minimize intake and mortality of marine organisms when the CDP intake requirements exceed the volume of water being discharged by the EPS.

1.2 PLAN ORGANIZATION

The Plan is organized so to sequentially analyze the steps that have been taken by Poseidon to address each of the provisions of Water Code Section 13142.5(b):

- Chapter 2 identifies the best available site feasible to minimize impingement and entrainment of marine life from the Project;
- Chapter 3 identifies the best available design feasible to minimize impingement and entrainment of marine life from the Project;
- Chapter 4 identifies the best available technology feasible to minimize impingement and entrainment of marine life from the Project;
- Chapter 5 estimates potential unavoidable impacts to marine life; and
- Chapter 6 identifies the best available mitigation feasible to minimize any residual impingement and entrainment, and is in addition to those measures addressed through site, design, and technology approaches.

1.3 PLAN DEVELOPMENT

In anticipation that the EPS might not always satisfy the CDP's source water demands, the Regional Board required Poseidon to submit the Plan within 180 days of the adoption of the Permit. The Permit states:[4]

> The Regional Board recognizes that future EPS flows may not follow historical trends. For this reason, it is warranted to require the Discharger prepare a Flow, Entrainment, and Impingement Minimization Plan. The Flow, Entrainment, and Impingement Minimization Plan shall be submitted within 180 days of adoption of the Order. The plan shall assess the feasibility of site-specific plans, procedures, and practices to be implemented and/or mitigation measures to minimize the impacts to marine organisms when the CDP intake requirements exceed the volume of water being discharge by the EPS. The plan shall be subject

[3] Permit at F-50.
[4] Permit at F-48 and F-49.

to the approval of the Regional Water Board and shall be modified as directed by the Regional Water Board.

The Plan has been under development since October 2006. The original Plan was submitted to the Regional Board on February 12, 2007. Shortly thereafter, the Regional Board posted the Plan and related correspondence on its website for public review and comment. Poseidon revised the Plan in response to comments received from the Regional Board and the public and resubmitted it to the Regional Board on July 2, 2007.

The Regional Board posted the revised Plan and related correspondence on its website for public review and comment. To supplement the Plan, Poseidon also submitted to the Regional Board a Coastal Habitat Restoration and Enhancement Plan (CHREP) that included a summary of projects to accomplish the mitigation element of the Plan. On February 19, 2008, the Regional Board provided Poseidon with written comments from its review of the revised Plan and CHREP. In response to Regional Board comments, Poseidon submitted a revised Plan dated March 6, 2008 to the Regional Board. The revised Plan was subject to the approval of the Regional Board.

On April 9, 2008, the Regional Board conditionally approved Poseidon's Plan (Resolution R9-2008-0039) and directed Poseidon to prepare an amendment to the Plan that included a proposal for a mitigation to be developed through an interagency process. On November 14, 2008, following an extensive interagency coordination process, Poseidon submitted the Marine Life Mitigation Plan (MLMP) that had been previously approved by the California Coastal Commission and State Lands Commission for the Regional Board's consideration.

On February 11, 2009, the Regional Board held a hearing to consider the MLMP. Following the hearing, the Regional Board continued the matter to its April 8, 2009 meeting for consideration of a proposed final resolution resolving the requirements of Section VI.C.2(e) of the Permit and granting final approval or disapproval to Poseidon's Minimization Plan and the proposed amendment to that Plan, the MLMP. This proposed resolution would address all required issues associated with these plans, including the findings for the Regional Board to adopt regarding compliance with Water Code Section 13142.5(b). This resolution would supersede Resolution No. R9-2008-0039 conditionally approving Poseidon's Plan. Pursuant to the Regional Board's direction, this final draft of Poseidon's Flow, Entrainment and Impingement Minimization Plan, dated March 9, 2009, has been revised to incorporate the terms of the MLMP, update the information presented, and otherwise conform to the direction received from the Regional Board.

CHAPTER 2

SITE

INTRODUCTION

Pursuant to Water Code Section 13142.5(b), this Chapter identifies the best available site feasible to minimize intake and mortality to marine life from the Project. This Chapter is broken down into five sections:

- *The first section describes the proposed site and existing power plant facilities.*
- *The second section describes alternative sites that were considered and rejected.*
- *The third section describes why the proposed Project location is the best available site feasible to minimize Project-related impacts to marine life.*
- *The fourth section addresses Poseidon's commitment to the preservation of Agua Hedionda Lagoon.*
- *The fifth section concludes that proposed location for the Project is the best available, and there are no feasible and less environmentally damaging alternative locations.*

2.1 PROPOSED SITE

The Carlsbad Desalination Project (CDP) is proposed to be located adjacent to the Encina Power Station (EPS) owned by Cabrillo Power I LLC (Cabrillo). An important consideration for this site selection is the availability of an existing seawater intake and discharge facilities as well as close proximity to the local regional water distribution systems. The desalination plant would be located on a site currently occupied by a surplus fuel oil storage tank. The tank would be removed, and the desalination plant would be constructed in its place. Integration of the operation of the desalination facility with the existing power plant operation would require two main points of interconnection – seawater intake and concentrate discharge.

The EPS withdraws cooling water from the Pacific Ocean via Agua Hedionda Lagoon. After passing through the intake structure (Figure 2-1), trash racks, and traveling screens, the cooling water is pumped through the condensers for the five steam generator units located on site. Depending on the number of generating units in operation, the amount of cooling water circulated through the plant ranges from zero to over 800 MGD.

Figure 2-1 Intake Structure

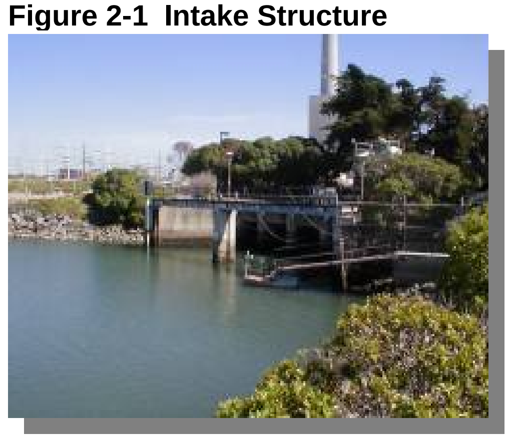
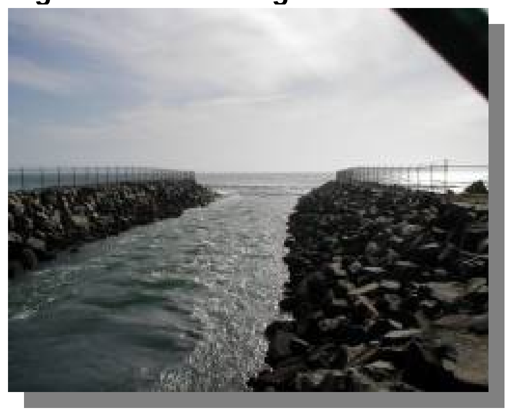


Figure 2-2 Discharge Pond

Figure 2-3 Discharge Channel



The primary diversion point for the source of water to the desalination plant will be downstream of the condenser outlet.

The seawater intake will divert seawater from the power plant's cooling water discharge channel to the inlet of the desalination facility. The intake facilities will consist of a diversion structure, pipeline, and a pump station to transport water from the cooling water discharge channel to the inlet of the desalination facility. The pump station will consist of high-volume, low-head vertical turbine pumps.

The EPS discharges seawater to the Pacific Ocean via a discharge pond (Figure 2-2) and channel that extends 500 feet west of Carlsbad Boulevard (Figure 2-3). The concentrated seawater from the desalination process will be mixed with power plant discharge. The discharge facilities will consist of a pipeline (up to 48-inch diameter) from the outlet of the desalination facility back to the existing discharge channel. The discharge point will be located downstream of the diversion point for the intake to prevent re-circulation of the concentrate back to the inlet of the desalination facility.

2.1.1 Existing Power Plant Facilities

The EPS is a once-through cooling power plant, which uses seawater to remove waste heat from the power generation process. Cooling water is withdrawn from the Pacific Ocean via the Aqua Hedionda Lagoon. The cooling water intake structure complex is located approximately 2,200 feet from the ocean inlet of the lagoon. Variations in the water surface level due to tide are from low -5.07 feet to a high +4.83 feet from the mean sea level (MSL). The intake structure is located in the lagoon approximately 525 feet north of the generating units.

The mouth of the intake structure is 49 feet wide. Water passes first trough metal coarse screens (trash racks with vertical bars spaced 3-1/2 inches apart) to screen large debris and marine life. The intake forebay tapers into two 12-foot wide intake tunnels. From these tunnels the seawater flow is split among four six-foot wide conveyance tunnels. Tunnels 1 and 2 deliver seawater to intakes for power plant generation Units 1, 2 and 3. Tunnels 3 and 4 carry cooling water to intakes for power plant generation Units 4 and 5, respectively. Vertical traveling screens are located ahead of each of the intakes of pumps.

Each pump intake consists of two circulating water pump cells and one or two service pump cells. During normal operation, one circulating pump serves each half of the condenser, i.e., when one unit is online, both pumps are in operation.

A total of seven vertical screens are installed to remove marine life and debris that have passed through the trash racks. The screens are conventional through-flow, vertically rotating, single entry-single exit, band-type metal screens which are mounted in the screen wells of the intake channel. Each screen consists of a series of baskets or screen panels attached to a chain drive. The screening surface is made of 3/8-inch stainless steel mesh panels, with the exception of the Unit 5 screens, which have 5/8-inch square openings.

The screens rotate automatically when the buildup of debris on the screening surface causes the water level behind the screen to drop below that of the water in front of the screen and a predetermined water level differential is reached. The screens can also be pre-set to rotate automatically at a present interval of time. The screen's rotational speed is 3 feet per minute, making one complete revolution in approximately 20 minutes. A screen wash system using seawater from the intake tunnel washes debris from the traveling screen into a debris trough. Accumulated debris are discharged periodically back to the ocean via the power plant discharge lagoon. Table 2-1 summarizes the capacity of the individual power plant intake pumps.

The EPS's intake pumping station consists of cooling water intake pumps that convey water through the condensers of the electricity generation units of the power plant and has a total capacity of 794.9 MGD (552,000 gpm). The service water pumps have a combined capacity is 62.1 MGD (43,200 gpm). During temporary shutdown of the power plant generation units, only the cooling water pumps are taken out of service. The service water pumps remain in operation at all times in order to maintain the functionality of the power plant. If the power plant is shut down permanently, service water pumps will no longer be operational.

The volume of cooling water passing through the power plant intake power station at any given time is dependent upon the number of cooling water pumps and service water pumps that are in operation. With all of the pumps in operation, the maximum permitted power plant discharge volume is 857 MGD, or about 595,000 gallons per minute (gpm).

TABLE 2-1

SUMMARY OF EPS'S POWER GENERATING CAPACITY AND FLOWS

Unit #	Date on Line*	Capacity (MW)	Number of Cooling Water Pumps	Cooling Water Flow (gpm)**	Service Pump Water Flow (gpm)**	Total (MGD)

1	1954	107	2	48,000	3,000	73
2	1956	104	2	48,000	3,000	73
3	1958	110	2	48,000	6,000	78
4	1973	287	2	200,000	13,000	307
5	1978	315	2	208,000	18,200	326
Gas turbine	1968	16	0	0	0	0
			Total:	**552,000**	**43,200**	**857**

* Encina Power Station NPDES Permit No. CA0001350, Order No. 2000-03, SDRWCB.
** Encina Power Station Supplemental 316(b) Report (EA Engineering, Science, and Technology 1997).

2.2 ALTERNATIVE SITES

There are only three possible sites in the City of Carlsbad that could accommodate a desalination project of this size. These are: (1) the Encina Power Station (EPS); (2) Encina Water Pollution Control Facility (EWPCF); and (3) Maerkle Reservoir. Among these, EPS is the only site in reasonable proximity to the seawater intake, the outfall, and key delivery points of the distribution system of the largest user of the desalinated seawater – the City of Carlsbad. The EPS site allows the Project to optimize the cost of delivery of the produced water and minimize the environmental impacts associated with construction and operation of the Project. This particular site also offers the advantage of avoiding the construction of major new intake and discharge facilities, which provides significant environmental and cost benefits.

The Project EIR analyzed the viability of alternative sites for the seawater desalination plant within the boundaries of the EPS and alternative sites within the boundaries of the EWPCF.[1] The Coastal Commission Staff requested an evaluation of other potential locations for the desalination facility and its associated infrastructure. As a result, Poseidon added the Maerkle Reservoir site to the list of alternative sites to be considered. The sites evaluated by Poseidon and the City of Carlsbad are the only parcels in the entire City of Carlsbad with compatible land use designations and sufficient space available to accommodate the desalination facility. The merits of each site are summarized below.

2.2.1 Encina Power Station.

Alternative sites at the EPS were found infeasible because the power plant owner has reserved the remaining portion of the site to accommodate future power plant modifications, upgrades or construction of new power plant facilities.

2.2.2 Encina Water Pollution Control Facility.

[1] See Final EIR – 03-05 for the Precise Development Plan and Desalination Plant Project SCH #2004041081, City of Carlsbad, p. 4.8-17, June 13, 2006, Section 6.0, Alternatives to the Proposed Action, Subsection 6.2 - Alternative Site Location, pages 6-1 and 6-2.

The site located within the boundaries of the EWPCF can only accommodate a desalination plant with a 10 MGD production capacity, due to outfall constraints. A desalination plant of 10 MGD production capacity will be inadequate to satisfy the demand of even one of the users of desalinated water from the Project – the City of Carlsbad, with a demand of up to 25 MGD. This deficiency renders the use of the EWPCF site infeasible. In addition, the use of this site would require construction of a 2-mile long, 72-inch diameter intake pipeline to convey the source seawater from the power plant cooling canal to the EWPCF site, which would have significant cost impacts on the Project and additional environmental and traffic impacts resulting from the construction of such a large pipeline. Installation of a new intake at the EWPCF site is cost-prohibitive.

2.2.3 Maerkle Reservoir.

Maerkle Reservoir is the only other area within the City of Carlsbad that offers compatible land use and is of suitable size to accommodate the Project. The Maerkle Reservoir site is owned by the City of Carlsbad and is located 10.6 miles east of the proposed Project site.

For a number of reasons, this location does not provide a feasible alternative site. First, the public rights-of-way between Maerkle Reservoir and the Pacific Ocean do not have sufficient space to accommodate a 72-inch intake pipeline and a 48-inch concentrate line (Poseidon, 2007). Second, it would be extremely disruptive to the public and the environment to acquire sufficient public and private property outside existing public rights-of-way to construct the pipelines. Third, over 100 MGD of seawater would have to be pumped to an elevation of 531 feet for processing, compared to pumping the seawater to an elevation of 70 feet at the proposed site. Fourth, because the Maerkle site is zoned as "Open Space," a "Public Utility" zoning designation would be incompatible with the Carlsbad General Plan and the proposed Project would be in direct conflict with the adjacent residential retirement community of Ocean Hills. Fifth, such a proposal would be in direct conflict with the City of Carlsbad's objective *"[t]o locate and design a desalination plant in a manner that maximizes efficiency for construction and operation and minimizes environmental effects."*

Finally, the additional construction and operating costs associated with piping and pumping the seawater and concentrate over this additional distance would represent a 20 percent increase in the cost of water. Such an increase in cost would render the Project infeasible while providing no measurable benefit to the public or the environment. An additional 10.6 miles of 72-inch seawater supply line would cost approximately $57.1 million. The enlarged pump station to accommodate the additional 461 feet of pump lift required to move the seawater to the alternative site would cost an additional $8.0 million. The additional cost of the 10.6 mile, 48-inch concentrate return line would be $29.6 million. In summary, the alternative Project site at Maerkle Reservoir would result in a $94.7 million (35 percent) increase in the capital budget for the Project (Poseidon, 2006).

Similarly, the alternative Project site at Maerkle Reservoir would result in three significant changes to the Project operating budget arising out of the increase in the amount of energy necessary to pump seawater to an inland location at a higher elevation, which would result in a net increase in operating cost for the Project. First, the cost to pump the seawater from the intake to the alternative plant site would increase $6.7 million per year. Second, the cost to pump the product water from the plant to the intended use area would decrease $3.0 million per year due to the fact that the product water is being pumped from a starting elevation of 511 feet rather than sea level. Finally, the energy recovery opportunity associated with the discharge of the concentrate from 511 feet down to sea level will result in an additional $1.1 million reduction in operating cost. The net increase in operating cost for the alternative Project located at Maerkle Reservoir would be $2.6 million per year (10 percent) (Poseidon, 2006).

The environmental issues associated with the construction of a 10.6-mile, 72-inch intake pipe and a 10.6-mile, 48–inch discharge line, compared to the proposed single 10.6-mile 48-inch product water conveyance pipeline, would be significant. There would be an approximately 225% increase in the volume of material that would need to be excavated. All of this material would need to be trucked offsite for disposal, resulting in over 200% increase in construction-related air quality impacts and traffic impacts over that already accounted for in the Project EIR due to the hauling of pipeline-related excavation material (Poseidon, 2007).

The 72-inch pipeline would likely be constructed in designated open-space or on private property for almost the entire length of the alignment due to the lack of space for additional utilities within existing rights-of-way. Construction-related activities could cause temporary disruption and impacts to an additional 40 feet of private property or public open space along the entire length of the pipeline. Much of this alignment is sensitive habitat such as coastal sage scrub which may prohibit the construction methods that are the basis of the cost estimates provided above. Alternatively, the construction impacts would require mitigation in the form of replacement habitat per the ratios set forth in section 4.3 of the EIR. Tunneling and mitigation costs associated with this alternative could be in the tens of millions of dollars. In addition, the carbon footprint associated with the long-distance water transport would be significant because significant additional energy would be required to accomplish it, thereby increasing greenhouse gas emissions associated with the Project, another potential adverse environmental impact.

For these reasons, the alternative Project location at Maerkle Reservoir is financially and environmentally infeasible. In addition, the alternative location is not properly zoned for a desalination facility.

2.3 BEST AVAILABLE SITE FEASIBLE

The proposed location for the CDP at the EPS is the best available site feasible for the Project for a number of reasons:

- The site is properly zoned and the proposed use is consistent with other uses in the area.
- The location of the proposed desalination facility adjacent to the existing EPS has a number of environmental and cost advantages that cannot be matched at any other

location within the service area to which water will be delivered. These advantages are as follows:

- Least environmental impacts;
- Lowest energy consumption;
- Least disruption to public and private property;
- Lowest construction cost; and
- Lowest operating cost.

The proposed site is the only feasible location for the proposed Project in the service area and presents a unique opportunity for minimizing environmental impacts in a cost-effective manner. Locating the desalination facility further inland increases costs, which would indirectly increase the cost of the water to consumers, and increases construction-related disruptions to the public and the environment due to the need to construct a 72-inch and 48-inch pipeline instead of a single 48-inch pipeline, with no clear environmental benefit. Any of the proposed alternatives to co-location would require fundamental changes to the Project, which in turn would require complete redesign and re-engineering, as well as new entitlements from the City of Carlsbad and a new NPDES permit from the Regional Board. Poseidon has already invested eight years developing and obtaining permits for the Project. The potential delays posed by the alternative locations also would preclude the successful completion of the Project within a reasonable time. Therefore, such alternatives are not feasible.

The City of Carlsbad determined that, from a land use planning perspective, the best site for the desalination facility in the entire City of Carlsbad was the parcel in the northwest corner of the power plant property where Fuel Oil Tank No. 3 is currently located.[2] This location was selected specifically to further the City of Carlsbad Redevelopment Plan goals related to facilitating the conversion and relocation of the power plant east of the railroad tracks and enhancement of commercial and recreational opportunities in the area west of the railroad tracks currently occupied by the existing power plant. This location leaves the majority of the site open for potential redevelopment at some future date and will create no significant impacts to relocation of the power plant to a site to the east of the railroad tracks or infrastructure needed to serve a power plant at this location.[3]

The Coastal Act provides for special consideration of coastal-dependent industrial facilities. Even if a coastal-dependent project is found to be inconsistent with certain Coastal Act goals, it can be approved upon application of a three part test – (1) that alternative locations are infeasible or more environmentally damaging; (2) that adverse environmental effects are mitigated to the maximum extent feasible; and (3) that to do otherwise (i.e., deny the project) would adversely affect the public welfare.[4]

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[2] Final EIR – 03-05 for the Precise Development Plan and Desalination Plant Project SCH #2004041081, City of Carlsbad, p. 4.8-17, June 13, 2006.
[3] Id.
[4] See Coastal Commission Recommended Revised Findings Coastal Development Permit for Poseidon Carlsbad Desalination Project, page 114 of 133; http://documents.coastal.ca.gov/reports/2008/8/W4a-8-2008.pdf

The Coastal Commission determined that Poseidon's proposed seawater desalination facility would be a coastal-dependent industrial facility, as it would need to be sited on or adjacent to the sea in order to function at all.[5] In applying the three tests above, the Commission found (1) that there are no feasible and less environmentally damaging alternative locations available the Project;[6] (2) that the proposed Project as conditioned mitigates its impacts to the maximum extent feasible;[7] and (3) that facility is a necessary part of the region's water portfolio and denial of the Project would adversely affect the public welfare.[8]

2.4 PRESERVATION OF AGUA HEDIONDA LAGOON

Agua Hedionda Lagoon currently supports a wide range of beneficial uses, including recreational activities, such as fishing, and water contact recreation. Nearly all of these uses are directly or indirectly supported by seawater flow and exchange created by circulation of seawater in the lagoon. The existing tidal exchange renews the Lagoon's water quality and flush nutrients, sediment and other watershed pollution, particularly from the Lagoon's upper reaches. In addition, the inflow of fresh supplies of ocean carry waterborne supplies of planktonic organisms that nourish the many organisms and food chains of the Lagoon, including the White Sea Bass restoration program of the Hubbs Sea World Research Institute and the aquaculture operations in the outer Lagoon.

The Lagoon is connected to the Pacific Ocean by means of a manmade channel that is artificially maintained. Seawater circulation throughout the outer, middle and inner lagoons is sustained both by routine dredging of the manmade entrance to prevent its closure. The name, Agua Hedionda, which means "stinking water" in Spanish, reflects a former stagnant condition that existed prior to the dredging of the mouth of the Lagoon. In the absence of continued dredging, Agua Hedionda Lagoon would be cutoff from tidal exchange in a few years and slowly return to its former condition.

Upon retirement of the EPS, Poseidon has committed to assuming responsibility for stewardship of Agua Hedionda Lagoon and the surrounding watershed, including maintenance dredging of the entrance to the lagoon to prevent its closure and deposit the sand dredged from the lagoon on adjacent beaches. Poseidon's lagoon preservation efforts will be aimed at ensuring the long-term health and vitality of the future water supply of 300,000 San Diego County residents. Agua Hedionda Lagoon and its associated beneficial uses will be the long-term beneficiaries of this preservation strategy.

[5] Id.
[6] See Recommended Revised Findings Coastal Development Permit for Poseidon Carlsbad Desalination Project, page 115 of 133; http://documents.coastal.ca.gov/reports/2008/8/W4a-8-2008.pdf
[7] Id.
[8] Id. at 124 and 133.

CHAPTER 3

DESIGN

INTRODUCTION

Pursuant to Water Code Section 13142.5(b), this Chapter identifies the best available design feasible to minimize impingement and entrainment of marine life from the Project. This Chapter is broken down into eight sections:

- *The first section provides a general description of the design features that have been incorporated into the CDP to minimize impingement and entrainment.*
- *The second section describes the desalination plant intake and discharge facilities and modes of operation.*
- *The third section describes the design feature of using the power plant discharge to the maximum extent feasible in order to minimize impingement and entrainment associated with the CDP's operations.*
- *The fourth section describes the design feature of reducing the velocity of seawater through the intake to the maximum extent feasible in order to minimize impingement and entrainment associated with the CDP's operations.*
- *The fifth section describes the design feature of reducing the velocity of seawater through the fine screens to the maximum extent feasible to minimize to minimize impingement and entrainment associated with the CDP's operations.*
- *The sixth section describes the design feature of processing ambient temperature seawater to the maximum extent feasible to minimize temperature-related marine life morality.*
- *The seventh section describes the design feature of eliminating heat treatment to the maximum extent feasible to minimize marine life mortality.*
- *The eighth section summarizes the design features and how they minimize intake and mortality of marine life.*

3.1 DESIGN FEATURES

The Carlsbad Desalination Project (CDP) incorporates a number of design features that would minimize impingement and entrainment associated with the CDP. The CDP is designed to use the existing intake and discharge facilities of the Encina Power Generation Station (EPS). When the EPS is producing electricity and using 304 MGD or more of seawater for once-through cooling, the proposed desalination plant operation would cause a *de minimis* increase in impingement and entrainment of marine organisms.

Under conditions when the EPS operation is temporarily or permanently discontinued, the desalination plant will continue to use the existing power plant intake and discharge facilities. Under this condition, the impingement and entrainment associated with the desalination plant's operations would be significantly lower than those caused by the EPS operations at the same intake flow, because the desalination plant will employ different plant intake design and operations than the power plant. The key differences are summarized below and described in the following sections:

1. **Use of EPS discharge as source water for the CDP.** In 2008 seawater pumping by the EPS would have met 88.6 percent of the CDP's flow requirements, corresponding to 88.6 percent less entrainment and impingement than is anticipated from stand-alone operation of the CDP.

2. **Reduction in inlet screen velocity.** The EPS intake structure has a permitted capacity of 857 MGD. The CDP will be operated at an intake flow of 304 MGD. There is an environmental benefit from operating an intake structure at flows well below the design capacity, as water velocities correspondingly are lower, making it easier for fish and other marine life to swim away from the intake structure. At 304 MGD, the velocity of the seawater entering the inlet channel is at or below 0.5 feet per second (fps), resulting in impingement losses at the inlet screens being reduced to an insignificant level.

3. **Reduction in fine screen velocity**. Under stand-alone operations, the CDP seawater supply would be pumped through an optimum combination of the existing fine screens and condensers serving the power plant so to minimize the velocity and turbulence of the water moving through the system. Lowering velocity and turbulence of the seawater would lessen the physical damage to marine life, resulting in a reduction of impingement and entrainment mortality.

4. **Ambient temperature processing.** One of the factors contributing to entrainment mortality of marine organisms during power plant operations is the increase of the seawater temperature during the once-through cooling process. Under stand-alone operations, the CDP would be designed to use ambient temperature seawater instead of heated seawater, which would eliminate entrainment mortality associated with the elevated seawater temperature.

5. **Elimination of heat treatment.** Periodic heat treatment of the power plant intake and discharge significantly contributes to entrainment and impingement mortality. Under stand-alone operations of the desalination plant, the heat treatment of the intake and discharge would be discontinued and associated entrainment and impingement mortality would be eliminated.

3.2 DESALINATION PLANT INTAKE AND DISCHARGE CONFIGURATION

The seawater desalination plant intake and discharge facilities would be located adjacent to the EPS. A key feature of the proposed design is the direct connection of the desalination plant intake and discharge facilities to the discharge canal of the power generation plant. This approach allows using the power plant cooling water as both source water for the seawater desalination plant and as a blending water to reduce the salinity of the desalination plant concentrate prior to discharge to the ocean.

Figure 3-1 illustrates the configuration of the desalination plant and the EPS intake and discharge facilities. As shown in this figure, under conditions when both the desalination facility and the power plant are operating, seawater collected from Agua Hedionda Lagoon enters the power plant intake facilities, passes through the 3.5-inch inlet screens at the mouth of the intake structure, and subsequently through the vertical travelling screens, and then it is pumped through the plant's condensers. The warm seawater released from the condensers is conveyed to the ocean via the discharge canal. The CDP intake structure would be connected to this discharge canal and would divert an average of 104 MGD of the cooling water for production of fresh water.

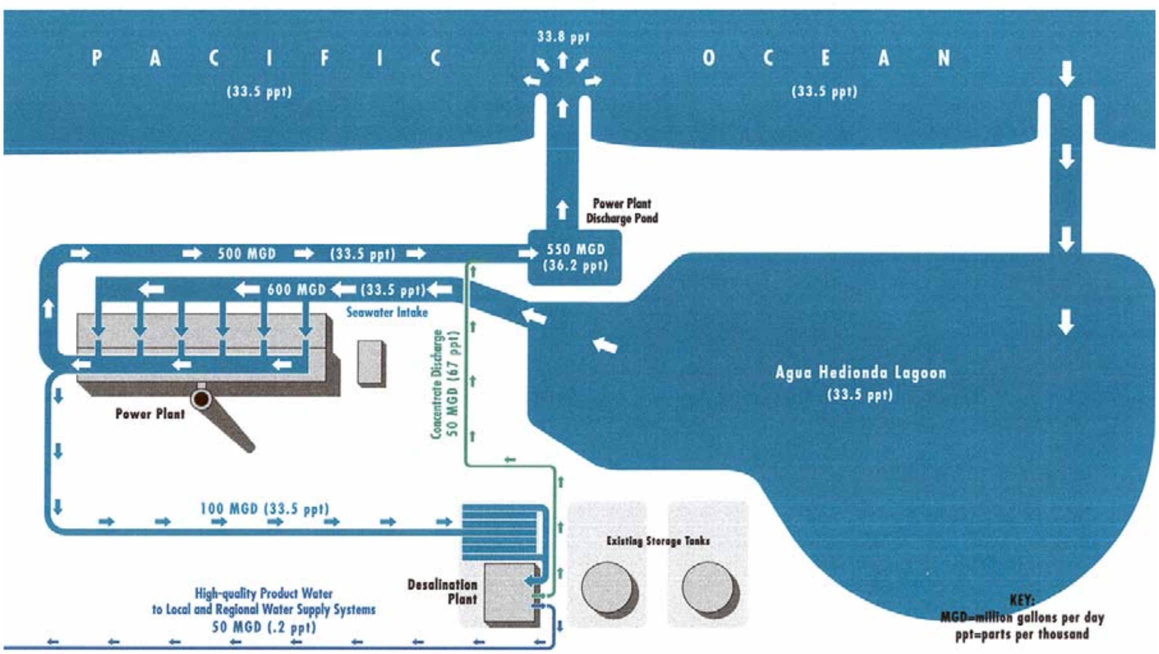


Figure 3-1 –Carlsbad Desalination Plant and Encina Power Station

Approximately 50 MGD of seawater would be desalinated via reverse osmosis treatment and conveyed for potable use. The remaining 54 MGD would have salinity approximately two times higher than that of the ocean water (64.5 ppt vs. 33.5 ppt). This seawater concentrate would be returned to the power plant discharge canal downstream of the point of intake for blending with the cooling water prior to conveyance to the Pacific Ocean. A minimum of 200 MGD of cooling water would be needed to blend with the 54 MGD of concentrate in order to reduce the desalination plant discharge salinity below the limit of 40/44 ppt (daily/hourly average) established by the CDP's Permit. Therefore, the total volume of cooling water required for normal operation of the desalination plant is 304 MGD.

If the power plant discharge flow is equal to or higher than 304 MGD, then the cooling water discharge volume is adequate to sustain desalination plant operations. Under this condition, since no additional seawater is collected for production of drinking water, the incremental impingement and entrainment from the desalination plant operations is minimal, especially taking into consideration that power plant operations are assumed to cause 100 percent mortality of the entrained marine organisms.

Under the conditions of temporary or permanent power plant shutdown, or curtailed power generation that results in cooling water discharge below 304 MGD, the existing power plant intake system would need to be operated to collect up to 304 MGD of seawater for the desalination plant. This seawater will pass sequentially through the power plant inlet screens (bar racks), the fine vertical screens, the power plant intake pumps and the power plant condensers before it reaches the desalination plant intake pump station. The features incorporated in the desalination plant design to reduce impingement, entrainment and flow under such "stand-alone" operating conditions are discussed below.

3.3 USE OF EPS DISCHARGE AS SOURCE WATER FOR CDP

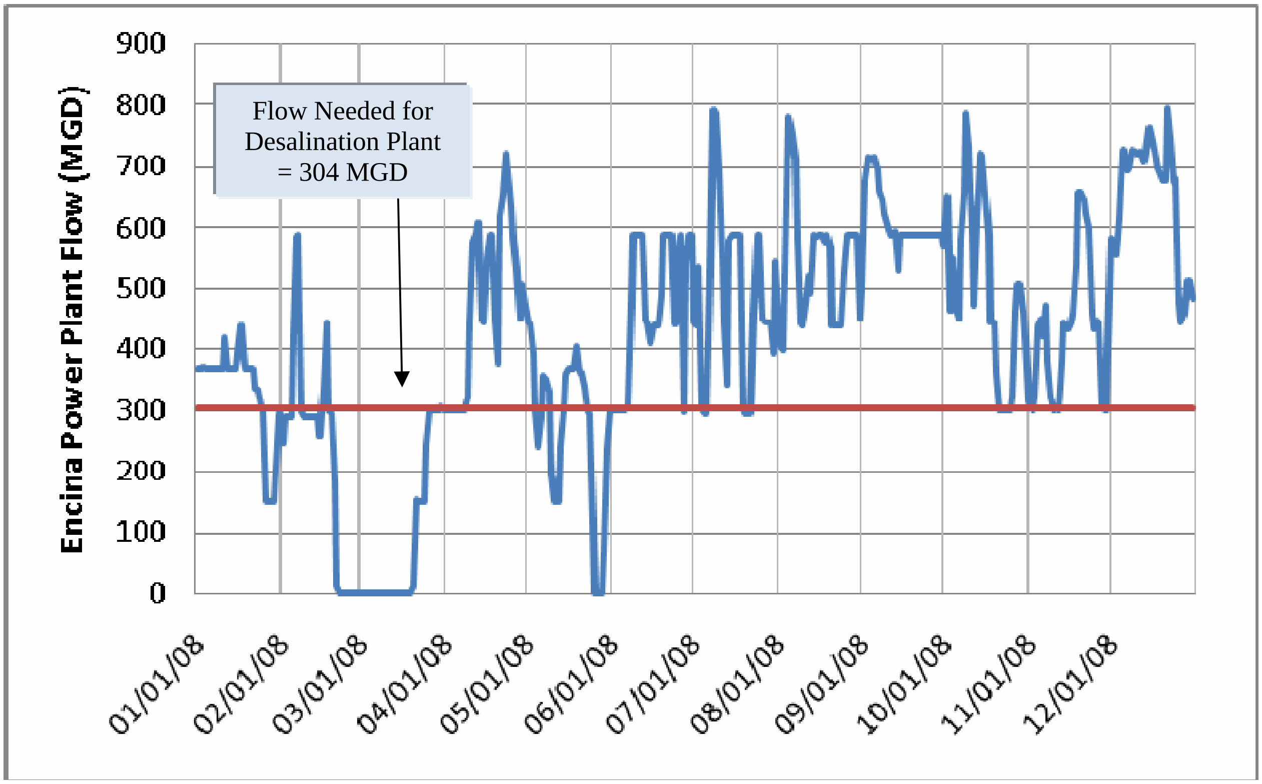
The CDP is designed to use the existing intake and discharge facilities of the EPS. When the EPS is producing electricity and using 304 MGD or more of seawater for once-through cooling, the proposed desalination plant operation would cause a *de minimis* increase in impingement and entrainment of marine organisms.

Under conditions when the EPS operation is temporarily or permanently discontinued, the desalination plant will continue to use the existing power plant intake and discharge facilities. Under this condition, the impingement and entrainment associated with the desalination plant operations would be significantly lower than those caused by the EPS operations at the same intake flow, due to a number of differences in the desalination plant and power plant intake design and operations.

Figure 3-2 provides a comparison of the 2008 EPS cooling water discharge to the flow needed to support the CDP's operations. Under 2008 operating conditions, the EPS discharge would have provided 88.6 percent of the CDP annual seawater intake requirements, and the CDP would have withdrawn an additional 11.4% percent of its source water from the EPS intake to make up the deficit in supply available from the EPS discharge. Under these operating conditions, the entrainment and impingement attributable to the desalination operations would be limited to approximately 11.4% of that identified in Chapter 5 for the stand-alone desalination facility operations. The CDP's direct use of the EPS discharge, coupled with other design and technology features described in Chapters 3 and 4, would result in a substantial reduction in entrainment and impingement.

FIGURE 3-2

2008 EPS COOLING WATER DISCHARGE VERSUS CDP FLOW REQUIREMENTS



3.4 REDUCTION IN INLET SCREEN VELOCITY

The CDP was designed for intake flow of 304 MGD (50 percent recovery) to minimize the impingement and entrainment of marine organisms under stand-alone operations. Higher intake flow, although preferable from a point of view of ease of desalination plant operations, would result in elevated potential for impingement and entrainment.

Impingement losses associated with the collection of seawater at the power plant intake would be reduced when the through-screen velocity at the inlet intake screens (bar racks) is equal to or less than 0.5 fps because this velocity would be low enough to allow some of the marine organisms to swim away from the inlet mouth and to avoid potential harm from impingement.

At the design flow of 304 MGD needed for the CDP's operations, the inlet screen velocity would be less than or equal to 0.5 fps, thereby creating flow conditions that would reduce impingement losses to a less than significant level.

3.5 REDUCE FINE SCREEN VELOCITY

During stand-alone operations, the power plant intake pumps and screens will be operated in modified configuration that minimizes the through-screen velocity and thereby reduces potential impingement of marine organisms that reach these screens.

3.5.1 Description of Power Plant Intake Screen and Pump System

A detailed description of the power plant intake system is provided in Section 2. After the seawater passes through the inlet screens (bar racks) the intake forebay tapers into two 12-foot wide intake tunnels. From these tunnels the seawater enters one of four 6-foot wide conveyance tunnels. Cooling water for conveyance tunnels 1 and 2 passes though two vertical traveling screens to prevent fish, grass, kelp, and debris from entering the intakes for power plant generation Units 1, 2 and 3. Conveyance tunnels 3 and 4 carry cooling water to intakes for power plant generation Units 4 and 5, respectively. Intakes for Unit 4 and 5 are equipped with two and three vertical travelling screens, respectively.

As electrical demand varies, the number of generating units in operation and the number of cooling water pumps needed to supply those units will also vary. Over the period of 2002 to 2005, the EPS has reported combined discharge flows ranging from 99.8 MGD to 794.9 MGD with a daily average of 600.4 MGD. Over the 20.5 year period of January 1980 to mid 2000 the average discharge flow was 550 MGD. In 2007 and 2008, the average annual intake flow was 276 MGD and 424 MGD, respectively. For comparison, the total intake flow needed for stand-alone operations of the desalination plant is 304 MGD.

3.5.2 Typical Mode of the EPS Vertical Screen and Intake Pump Operations

As discussed in the previous section, each of the five power generation units is equipped with two cooling water pumps both of which operate when a given generating unit is producing electricity. All six pumps of power generation units 1, 2 and 3 share two common vertical screens of identical size (3/8-inch) and capacity. The two pumps of unit 4 are serviced by two 3/8-inch screens, and the two pumps of unit 5 are serviced by three 5/8-inch screens located in a common channel upstream of the pumps. With all pumps in operation, the through screen velocity of the vertical screens typically is higher than 0.5 fps, thereby contributing to the impingement of marine organisms that may have reached these screens.

3.5.3 Modified Utilization of the EPS Intake Screens and Pumps During Stand-Alone Operations of the Desalination Plant

Desalination plant operation is independent from the power production process and therefore, the existing EPS intake pumps do not need to be operated coupled with the intake screens of a given unit. This design flexibility of the desalination plant allows a greater number of screens to collect the volume of water needed for the CDP operation. For example, if the power plant needs to generate 287 MW of electricity, typically unit 4 (see Table 2-1) would be used for power generation and both intake pumps and screens associated with this unit would be in service. Under this operational condition, the cooling water flow used would be 307 MGD.

If the desalination plant is operated in stand-alone condition (i.e. no power is generated) then there is greater pump selection flexibility. For example, rather than using two intake pumps of unit 4, the desalination plant would collect a similar amount of seawater by running only one pump of unit 4, and one pump of unit 5. However, in this case approximately the same amount of flow would be screened through five screens (the two screens of unit 4 and the three screens of unit 5), thereby reducing the through-screen velocity to at least one half of the EPS's operational velocity. This significant reduction of the through-screen velocity would reduce the impingement of marine life on the vertical screens as well. Such impingement reduction cannot be achieved if the power plant intake pumps are used to deliver cooling water for power generation because when a given power generation unit is used to generate electricity, then both cooling pumps must be in operation simultaneously to provide an adequate amount of cooling water for the normal operation of the unit. If the power plant discontinues power generation, then cooling pump operation can be decoupled from the operation of the condensers and this in turn allows the same flow through over a two times larger screening area and therefore reduce the through-screen velocity by more than half.

3.6 ELIMINATION OF HEAT-RELATED ENTRAINMENT MORTALITY

The seawater desalination plant will be designed with the flexibility to operate using warm water from the power plant condensers when they are in operation; and cold seawater when the power plant is not generating electricity. This design feature will also avoid the need to preheat the intake seawater in the future if and when the power plant once-through cooling operation is discontinued. Elevated seawater temperature may increase the mortality of the entrained marine life. Since under stand-alone conditions the source seawater will not be heated this entrainment mortality factor will be eliminated.

3.7 ELIMINATION OF HEAT TREATMENT RELATED MORTALITY

Under the current mode of operations, the power plant completes heat treatment of the intake facilities every 6 to 8 weeks for 6 to 8 hours per event. Since seawater is re-circulated during the heat treatment event (i.e. no new seawater is collected or discharged), there is 100% mortality of the marine organisms residing in the intake canals unless they are physically removed prior to exposure to elevated temperature. Desalination plant operations would not require heat treatment of the existing intake and discharge facilities and marine organism mortality associated with the heat treatment events will be eliminated. Instead, the power plant intake and discharge system will be cleaned periodically by circulation of plastic scrubbing balls that will be circulated through the system via the existing pumps in a close cycle process. The scrubbing balls will be introduced at the beginning of the cleaning process and captured at the end of the process. The size of the scrubbing balls is usually 0.5 inches and they will move freely within the channels and piping at relatively low velocity (3 to 5 fps).

3.8 SUMMARY OF DESALINATION PLANT DESIGN FEATURES TO MINIMIZE IMPINGEMENT AND ENTRAINMENT

The design features to be utilized in the CDP's operations to minimize impingement and entrainment of marine organisms are summarized in Table 3-1.

TABLE 3-1

DESIGN FEATURES TO MINIMIZE IMPINGEMENT AND ENTRAINMENT

Category	Feature	Result
1. Design	Use of the EPS discharge as source water for the CDP	Eliminates the entrainment and impingement independently attributable to the CDP when the EPS is discharging 304MGD
2. Design	Reduction in inlet screen velocity	Reduction of impingement of marine organisms
3. Design	Reduction in fine screen velocity	Reduction of impingement of marine organisms
4. Design	Ambient temperature processing	Eliminate entrainment mortality associated with the elevated seawater temperature
5. Design	Elimination of heat treatment	Entrainment and impingement mortality associated with heat treatment would be eliminated

CHAPTER 4

TECHNOLOGY

INTRODUCTION

Pursuant to Water Code Section 13142.5(b), this Chapter identifies the best available technology feasible to minimize the CDP's impingement and entrainment of marine life. This Chapter is broken down into five sections:

- *The first section describes constraints and opportunities associated with inclusion of technology features in the CDP to minimize intake and mortality of marine life.*
- *The second section assesses the feasibility of alternative intake technologies to minimize intake and mortality of marine life.*
- *The third section assesses the feasibility of alternative intake screening technologies to minimize impingement and entrainment.*
- *The fourth section assesses the feasibility of alternative desalination technologies to minimize intake and mortality of marine life.*
- *The fifth section summarizes the feasibility assessment of technology features and the resulting impact they have on minimizing intake and mortality of marine life.*

4.1 FEASIBILITY CONSIDERATIONS

Poseidon conducted a feasibility assessment of the best available technology to minimize entrainment and impingement. This assessment resulted in the identification of those technologies that are feasible for implementation under the site-specific conditions of the proposed CDP. For the purposes of this assessment, we relied upon the definition of feasible set forth in the California Environmental Quality Act (CEQA) Guidelines: "*'Feasible' means capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, legal, social, and technological factors*" (CEQA Guidelines, Section 15364). This definition is generally consistent with the principles underlying the Porter-Cologne Water Quality Control Act, which includes the term "feasible" in Water Code Section 13142.5(b), but does not define the term in Water Code Section 13050.

Site-specific conditions dictate that a fundamental feasibility constraint associated with potential entrainment and impingement reduction technologies is that the technology must be compatible with both the CDP's and the EPS's operations. On August 22, 2008, the State Lands Commission approved an amendment of the EPS intake and outfall lease to authorize use of these facilities by the CDP. That amendment recognized that entrainment and impingement minimization measures cannot interfere with, or interrupt ongoing power plant operations:[1]

> *12. Poseidon, without interference with, or interruption of, powerplant scheduled operations and at its sole cost and expense, shall use the best available design, technology, and mitigation measures at all times during with this Lease is in effect to minimize the intake (impingement and entrainment) and mortality of all forms of marine life associated with the desalination facility as determined by the San Diego Regional Water Quality Control Board or any other federal, state, or local entity having applicable jurisdiction.*

When the EPS permanently ceases use of the once-through cooling water system, additional entrainment and impingement technologies may become feasible. While no timeline has been established as to when this might occur, SLC's Lease Amendment requires that in ten years SLC would evaluate the feasibility of the implementation of those additional technologies it determines are appropriate in light of an environmental review it would undertake at that time:[2]

> *14. Within ten years from the effective date of this Amendment, or upon such earlier time as agreed to by the Lessor, or upon notice by Cabrillo that it will no longer require the use of the Lease Premises for the purpose of generating electrical power, Lessor will undertake an environmental review of the ongoing impacts of operation of the desalination facility to determine if additional requirements pursuant to Special Provision paragraph number 12, above, are required. Lessor, at its sole discretion, may hire a qualified independent environmental consultant, at the sole expense of Poseidon, with the intent to analyze all environmental effects of facility operations and alternative technologies that may reduce any impacts found. Lessor may require, and Poseidon shall comply with, such additional requirements as are reasonable and as are consistent with applicable state and federal laws and regulations and as Lessor determines are appropriate in light of the environmental review.*

The CDP design includes the best available technology that has been determined to be feasible for the site-specific conditions and size of this project and to minimize impingement and entrainment of marine organisms in the intake seawater. The selection of the desalination plant screening and intake technologies planned to be used for this project is based on thorough analysis and investigation of a number of alternative seawater screening and intake technologies.

The following intake alternatives were analyzed:

- Subsurface intake (vertical and horizontal beach wells, slant wells, and infiltration galleries);
- New open ocean intake;
- Modifications to the existing power plant intake system; and

[1] State Lands Commission October 24, 2007 recommended Amendment of Lease PRC 8727.1
[2] Id.

- Installation of variable frequency drives (VFDs) on seawater intake pumps.

Screening technologies compared to identify the best available technology feasible included:

- Fish net, acoustic and air bubble barriers upstream of the existing intake inlet mouth;
- New screening technologies to replace the existing inlet screens (bar racks) and fine vertical traveling screens.

The following intake technologies were found to be feasible impingement, entrainment and flow reduction technology measures for the site-specific conditions of the CDP:

Installation of VFDs on Desalination Plant Intake Pumps. The desalination plant intake pump station design will incorporate VFDs to reduce the total intake flow for the desalination facility to no more than that needed at any given time, thereby minimizing the entrainment of marine organisms.

The assessment of the various technologies considered for impingement, entrainment and flow reduction is presented below.

4.2 ALTERNATIVE DESALINATION PLANT INTAKE TECHNOLOGIES

4.2.1 Desalination Plant Subsurface Intakes

The feasibility of using subsurface intakes (beach wells, slant wells, horizontal wells, and filtration galleries) was evaluated in detail during the EIR and Coastal Commission review phases of this project. A thorough review of the site-specific applicability of subsurface intakes and a comprehensive hydrogeological study of the use of subsurface intakes in the vicinity of the proposed desalination plant site indicate that subsurface intakes are not viable due to limited production capacity of the subsurface geological formation, the potential to trigger subsidence in the vicinity of the site and the poor water quality of the collected source water. The geotechnical evaluation relied on drilling and testing information and near shore sediment surveys to assess the feasibility of using vertical, slant, and horizontal wells as seawater intake structures for the proposed project.

Vertical Intake Wells: Vertical intake wells consist of water collection systems that are drilled vertically into a coastal aquifer. A well yield of about 2,100 gallons per minute (gpm) would be expected from a properly constructed, large diameter production well at the test well location in Agua Hedionda Lagoon. Modeling results indicate that up to nine vertical wells could be placed in the 700 foot wide alluvial channel, each pumping about 2,100 gpm. Therefore, the maximum production from vertical wells placed under optimum conditions would be about 20,000 gpm (28.8 MGD). Given that the test well was placed in the optimum location, this would represent the upper limit of expected well yields from the alluvial deposits in the coastal basins of San Diego County, which is consistent with historic observations.

To meet the 304 MGD seawater demand of the project, 253 wells of a 1.5 MGD intake capacity each would have to be constructed. As shown in Figure 4-1, the vertical well intake system would impact 7.2 miles of coastline to collect and transport the water to the proposed desalination facility. As a result, the vertical well intake system is not the environmentally preferred alternative.

Use of vertical intake wells is not viable for the site-specific conditions of this project due to the limited transmissivity and yield capacity of the wells. The implementation of this scenario would require installation of very large number of wells (253) for which beach property is not available. The length of beach that would be occupied by desalination plant intake using vertical wells would be over seven miles and the total cost of the implementation of such intake would be approximately $650 million. See Attachment 2 for a detailed cost estimate. In summary, the vertical well intake alternative is not the environmentally preferred alternative, is technically infeasible, and cost prohibitive.

Slant Wells. Slant wells are subsurface intake wells drilled at an angle and extending under the ocean floor to maximize the collection of seawater and the beneficial effect of the filtration of the collected water through the ocean floor sediments. Collection of the 304 MGD of seawater needed for this project would require the use of 76 slant intake wells with a capacity of 5 MGD each. The total length of beach occupied by slant wells would be over 4 miles and the construction costs for implementation of this alternative would exceed $410 million. See Attachment 2 for a detailed cost estimate.

The use of slant wells does not offer any advantage in this setting. The well field for which maximum production rates were calculated for vertical wells is located on a sand spit located approximately 100 ft from Agua Hedionda Lagoon and 300 ft from the Pacific Ocean. Those

Figure 4-1 – Vertical Beach Well Intake System

constant head conditions were taken into account when assessing the yield of this type of subsurface intake.

The use of slant wells increases the screened thickness of saturated sediment slightly (a 45 degree well would result in a 20 percent increase in screened thickness over a vertical well) and places the screened section more directly below the constant head lagoon or ocean boundary condition. The close proximity of the well field to the constant head condition already achieves this, with a little increase in yield resulting from the slant well. Due to the site-specific hydrogeological conditions (low transmissivity of the ocean floor sediments and near shore aquifer) the use of slant wells is also not viable for the CDP. In summary, the slant well intake alternative is not the environmentally preferred alternative, is technically infeasible, and cost prohibitive.

Horizontal Wells. Horizontal wells are subsurface intakes which have a number of horizontal collection arms that extend into the coastal aquifer from a central collection caisson in which the source water is collected. The water is pumped from the caisson to the desalination plant intake pump station, which in turn pumps it through the plant pretreatment system.

The use of horizontal wells, if the alluvial channel can be tapped offshore and the well can be kept inside this alluvial channel, can theoretically produce greatly increased yields by markedly increasing the screened length of the well in contact with permeable sediments.

However, the diameter of the collection arms of the horizontal wells is limited to 12 inches (and most are 8-inch or smaller), in turn limiting the production rate to 1,760 gpm (2.5 MGD) per well.
This conclusion was also confirmed by the Dana Point Ocean Desalination Project test well that documented a yield of 1,660 gpm (2.4 MGD) from a 12 inch diameter well in that location. Analysis of the sediment properties indicates that this would be achieved with a horizontal well extending approximately 200 ft below the Pacific Ocean or Agua Hedionda Lagoon. Because of the constant head boundary at the ocean bottom or bottom of Agua Hedionda Lagoon, there would be minimal interference between multiple horizontal wells, but the practicalities of drilling horizontal wells limit the space to no less than about 50 ft. Given the limited width of the alluvial channel, only about 14 horizontal wells could be placed in the channel, for a total production rate of 28,000 gpm (40 MGD), still far below the project demand of 304 MGD. This approach assumes that additional exploration work will prove that elevated TDS concentrations in groundwater in the most permeable strata can be overcome.

Even if ideal conditions for this type of wells are assumed to exist (i.e., each well could collect 5 MGD rather than the 2.5 MGD determined based on actual hydrogeological data), horizontal well intake construction would include the installation of a total of 76 wells. The total length of coastal seashore impacted by this type of well intake would be 4.3 miles. As shown in Figures 4-2 and 4-3, the horizontal intake system would include nine large pump stations located on Tamarack State Beach and would impact 500 acres of shoreline and sensitive nearshore habitat. As a result, the horizontal intake system is not the environmentally preferred alternative. The cost for construction of a horizontal well intake system for collection of 304 MGD of seawater needed for the desalination plant operation is estimated at $438 million. See Attachment 2 for a

Figure 4-2 – Horizontal Drain Intake System

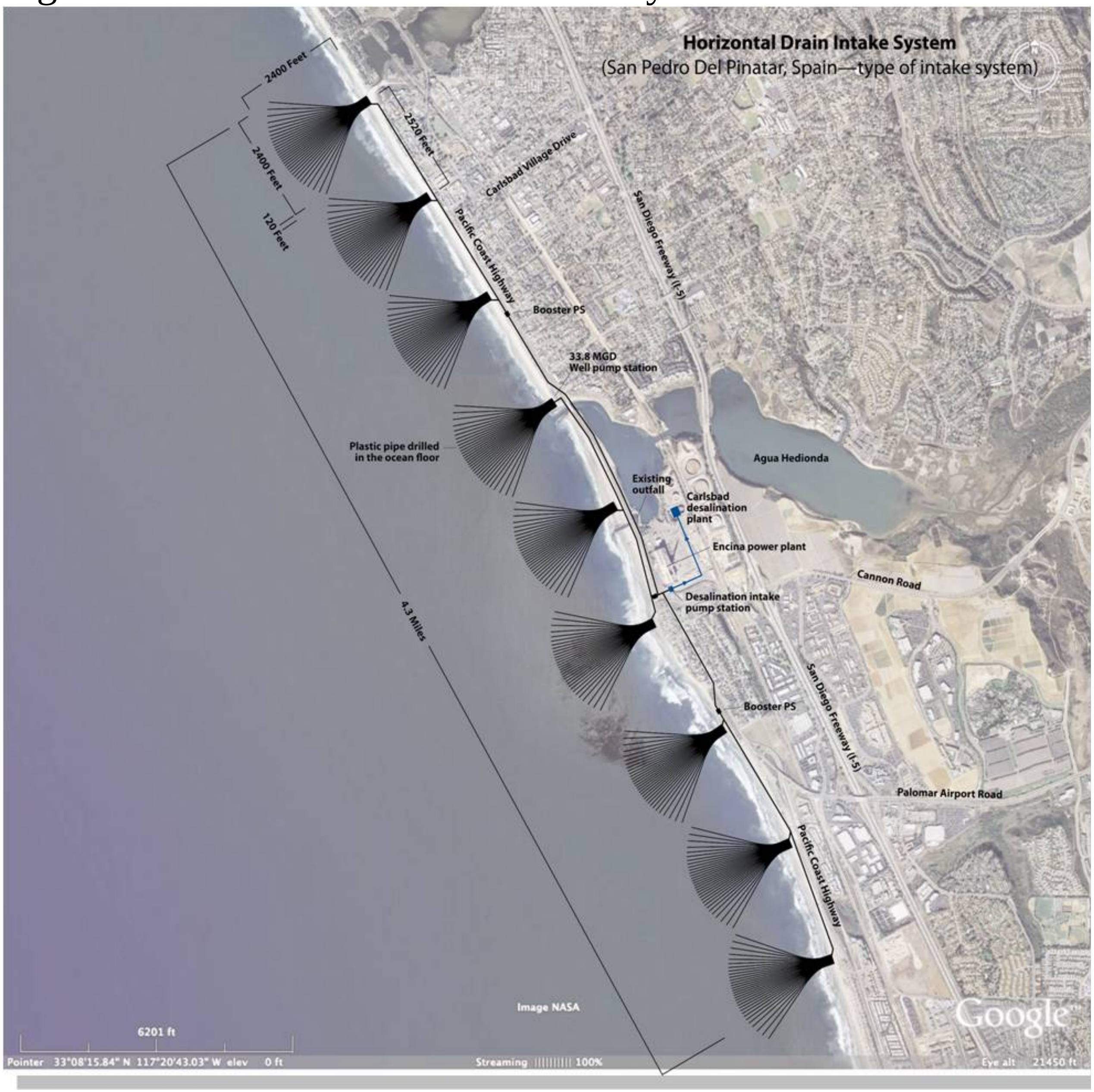


Figure 4-3 – Pump Stations with Horizontal Intakes

detailed cost estimate. In summary, the horizontal intake alternative is not the environmentally preferred alternative, and is technically infeasible, and cost prohibitive.

Subsurface Infiltration Gallery (Fukuoka Type Intake). The subsurface infiltration gallery intake system consists of a submerged slow sand media filtration system located at the bottom of the ocean in the near-shore surf zone, which is connected to a series of intake wells located on the shore. As such, seabed filter beds are sized and configured using the same design criteria as slow sand filters. The design surface loading rate of the filter media is typically between 0.05 to 0.10 gpm/sq ft. Approximately one inch of sand is removed from the surface of the filter bed every 6 to 12 months for a period of three years, after which the removed sand is replaced with new sand to its original depth. As it can be seen on Figures 4-4 and 4-5, the ocean floor has to be excavated to install the intake piping of the wells and pipes are buried at the bottom of the ocean floor.

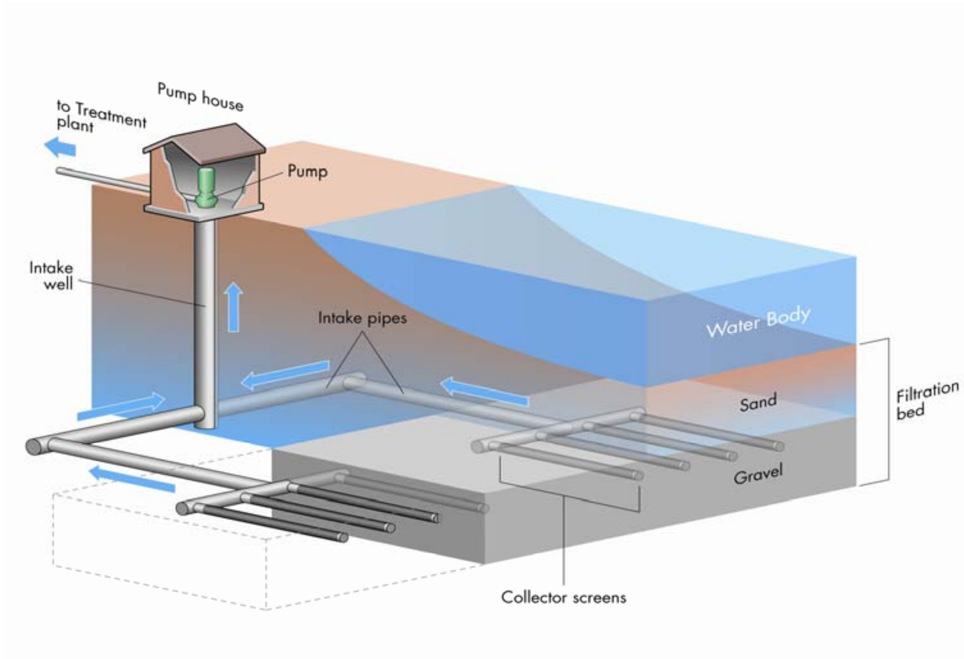


Figure 4-4 – Subsurface Infiltration Gallery (Fukuoka Type Intake)

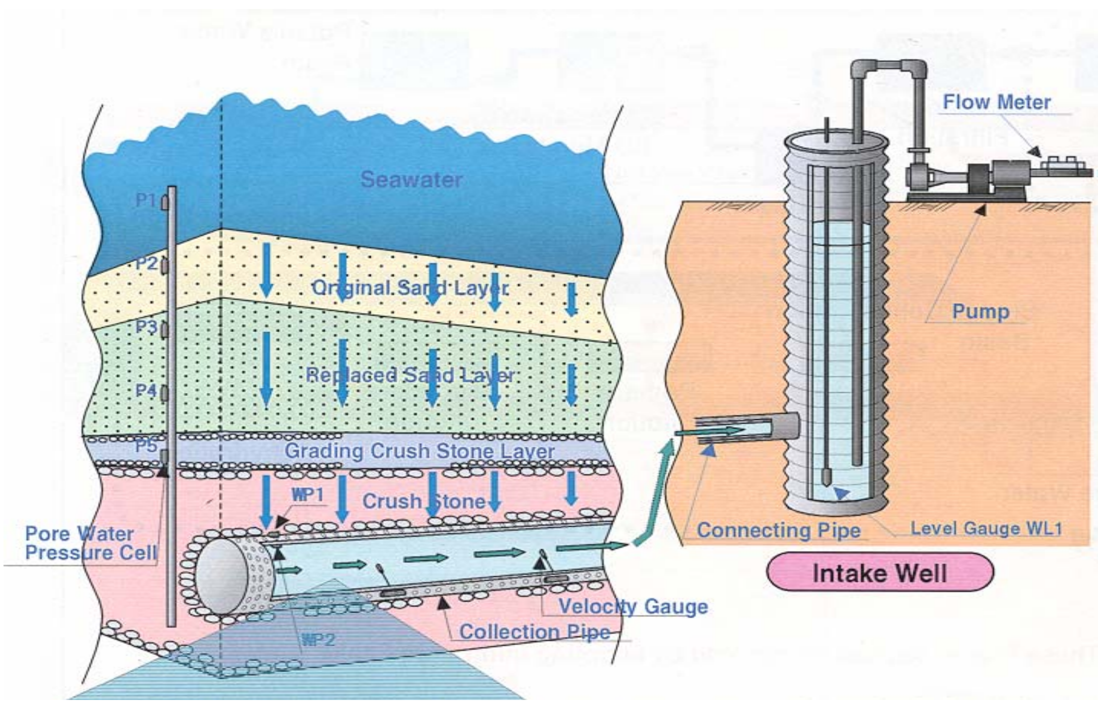


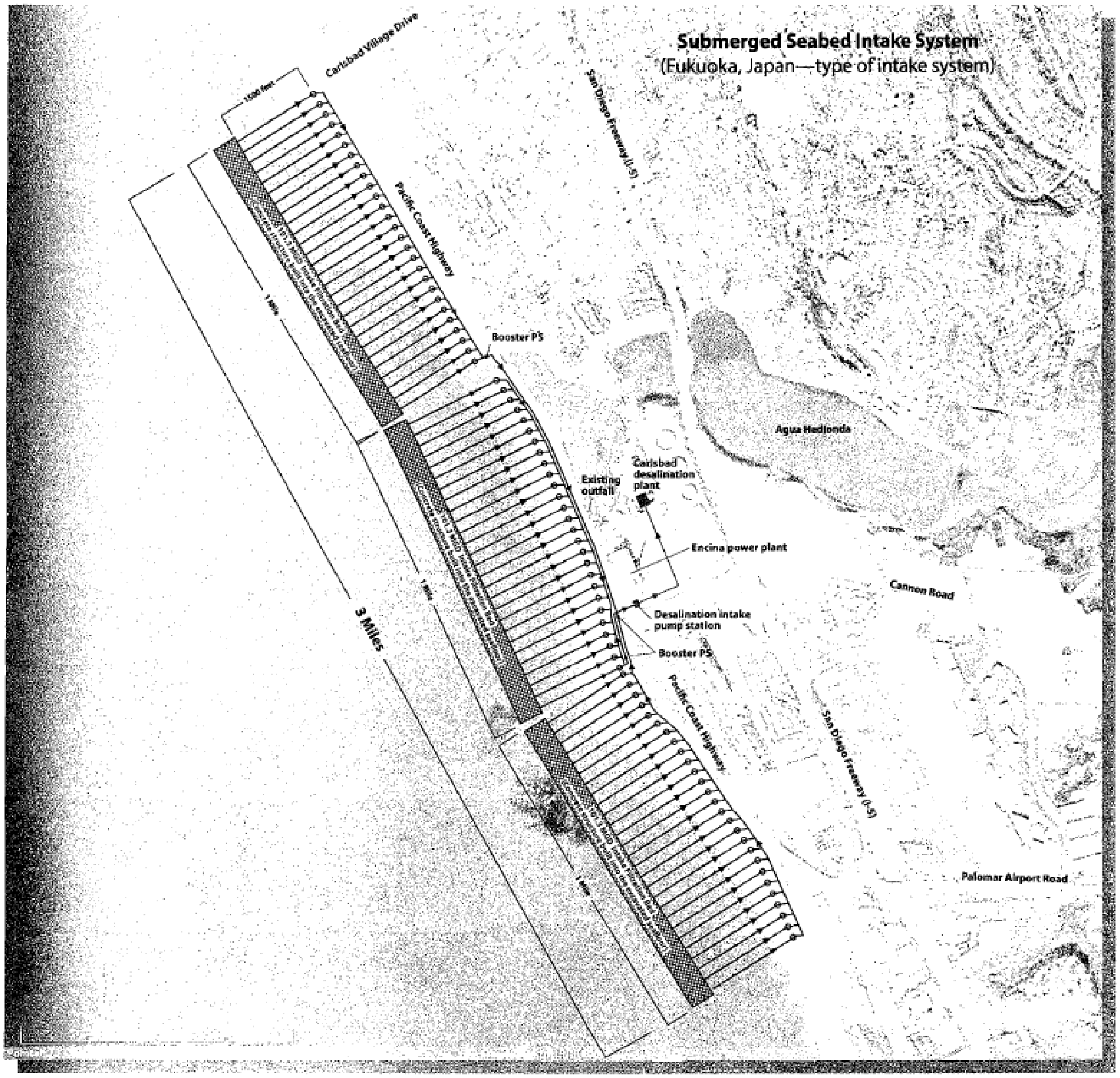
Figure 4-5 – A Cross-Section of Subsurface Infiltration Gallery

For the source water intake feed rate of 304 MGD needed for the CDP the total area of the ocean floor needed to be excavated to build a seabed intake system of adequate size is 146 acres. As shown in Figure 4-6, a submerged seabed intake system sized to meet the needs of the CDP would impact three linear miles of sensitive nearshore hard bottom kelp forest habitat. The excavation of a 146 acre/3-mile long strip of the ocean floor at depth of 15 feet in the surf zone to install a seabed filter system of adequate size to supply the CDP, would result in a very significant impact on the benthic marine organisms in this location. In addition, the subsurface seabed intake system would have a similar effect on Tamarack State Beach. To collect the seawater from the filter bed and transfer it to the CDP, the intake system would require 78 collector pipelines on the ocean floor connected to 78 pump stations that would be installed on the State beach.

The cost for construction of subsurface seabed intake system for collection of the 304 MGD of seawater needed for the desalination plant operation is estimated at $647 million. See Attachment 2 for a detailed cost estimate. In summary, the subsurface seabed intake alternative is not the environmentally preferred alternative, is technically infeasible, and cost prohibitive.

Water Quality Issues for Subsurface Intakes. Based on the results of actual intake well test completed in the vicinity of the EPS, a key fatal flaw of the beach well water quality was the high salinity of this water. The total dissolved solids (TDS) concentration in the water was on the order of 60,000 mg/L, nearly twice that of typical seawater (33,500 mg/L). The test well water also had elevated iron and suspended solids content. The pumping test was extended for nearly a month at 330 gpm (0.5 MGD) to determine if additional pumping would cause the TDS,

Figure 4-6 – Submerged Seabed Intake System



iron and suspended solids concentrations to approach that of the nearby seawater. After 30 days of pumping, the quality of the water withdrawn from the well did not improve significantly.

Summary Evaluation of Subsurface Intake Feasibility. The site-specific hydrogeologic studies used to evaluate the feasibility of the use of alternative subsurface intakes for the CDP demonstrate that the alternative intakes that were evaluated are incapable of providing sufficient seawater to support the CDP. None of the subsurface intake systems considered (vertical wells, slant wells, or horizontal wells) can deliver the 304 MGD of seawater needed for environmentally safe operation of the CDP. The maximum capacity that could be delivered using subsurface intakes is 28,000 gpm (40 MGD), which is substantially below the needed intake flow. Additionally, the quality of the water available from the subsurface intake (salinity twice that of seawater, excessive iron and high suspended solids) would be untreatable. Further, the alternative subsurface intake systems were determined not to be the environmentally preferred alternative. Taking into account economic, environmental and technological factors, the alternative subsurface intakes are not capable of being accomplished in a successful manner within a reasonable period of time; and therefore, have been determined to be infeasible. The Coastal Commission Findings approving the CDP's coastal development permit concur with this conclusion: "find that subsurface intakes are an infeasible alternative."[3]

4.2.2 Construction of New Open Ocean Intake for the CDP

Poseidon also evaluated whether the construction and operation of a new offshore intake to serve the seawater supply needs of the CDP would be a viable alternative to the use of the existing intake at the EPS and whether this approach would result in reduced impingement and entrainment.

Specifically, Poseidon studied whether an offshore intake would reduce the frequency of dredging of Agua Hedionda Lagoon under the stand-alone CDP operation; and whether the construction of a new intake would reduce environmental impacts compared to the use of the existing EPS intake under the stand-alone desalination facility operation. The analysis included the review of the environmental impact report (EIR) for the Agua Hedionda Inlet Jetty Extension Project (Jetty EIR). This EIR identified an offshore intake as an environmentally preferred alternative to the proposed extension of the inlet jetty. Poseidon prepared two studies which demonstrate that the construction of a new offshore intake would not reduce the frequency of dredging of Agua Hedionda Lagoon and it is not the environmentally preferred alternative.

The first study addresses whether an offshore intake would reduce the frequency of dredging of Agua Hedionda Lagoon under the stand-alone desalination facility operation.[4] This study concluded that the dredging frequency needed for normal operation of the stand-alone desalination facility would be approximately once every three years when adhering to present dredging practices. Under the "no power plant and no desalination project" scenario, the

[3] See Coastal Commission Recommended Revised Findings Coastal Development Permit for Poseidon Carlsbad Desalination Project, page 62 of 133; http://documents.coastal.ca.gov/reports/2008/8/W4a-8-2008.pdf
[4] *Comparative Analysis of Intake Flow Rate on Sand Influx Rates at Agua Hedionda Lagoon: Low-Flow vs. No-Flow Alternatives*, Jenkins and Wysal, September 28, 2007

minimum dredging volume required to keep Agua Hedionda Lagoon open to the Pacific Ocean would be about 15 percent less than for the stand-alone desalination facility. This 15 percent reduction however, would not be sufficient to allow the dredge frequency to be extended beyond once every three years due to schedule limitations that prohibit dredging during least tern nesting season. Given the variability in the actual sand transport from year to year and the accuracy of the modeling, there is not any discernable difference between the estimated dredging frequency and related environmental impacts associated with the operation of a stand-alone desalination facility versus the "no power plant, nor desalination project" scenario.

The second study addresses whether an offshore intake would result in fewer environmental impacts than the use of the existing EPS intake under the stand-alone desalination facility operation.[5] Here the authors evaluate the Jetty EIR and conclude that the draft EIR did not adequately evaluate the environmental impacts associated with constructing an offshore intake. The Jetty EIR did not assess the biological impacts of installing a large diameter pipe 1000 feet offshore which, depending on placement, would potentially destroy existing rocky reef outcroppings occurring offshore. The Jetty EIR did not evaluate the down coast effects of an intake structure on habitat, sand flow, or sedimentation.

Further, the Jetty EIR did not adequately evaluate entrainment and impingement effects. Based on the environmental analysis of the area for potential location of a new offshore intake, Poseidon is of the opinion that an offshore intake has the potential to affect a greater diversity of adult and juvenile organisms as well as both phyto- and zooplankton species than are currently impacted by the existing intake at the EPS. The estimated cost of the new offshore intake shown in Figure 4-7 is approximately $150 million (see Attachment 2).

In conclusion, construction of a new open ocean water intake would not result in significant reduction in dredging frequency, would cause permanent construction related impacts to the marine environment and would shift entrainment to a more sensitive area of the marine environment that would affect a greater diversity of species. As compared to the environmental impacts caused by the existing EPS intake, a new offshore intake is not the environmentally preferred alternative. Taking into account economic, environmental and technological factors, the alternatives intake is not capable of being accomplished in a successful manner within a reasonable period of time; and therefore, has been determined to be infeasible. The Coastal Commission draft findings agree with this conclusion: "determined that alternative intakes that might avoid or minimize environmental impacts are infeasible or would cause greater environmental damage."[6]

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[5] *Issues Related to the Use of the Agua Hedionda Inlet Jetty Extension EIR to Recommend An Alternative Seawater Intake for the Carlsbad Desalination Project*, Graham, Le Page and Mayer, October 8, 2007
[6] See Coastal Commission Recommended Revised Findings Coastal Development Permit for Poseidon Carlsbad Desalination Project, page 80 of 133; http://documents.coastal.ca.gov/reports/2008/8/W4a-8-2008.pdf

Figure 4-7 – Open Ocean Intake System

4.3 ALTERNATIVE POWER PLANT INTAKE & SCREENING TECHNOLOGIES

A number of alternative intake and screening technologies were evaluated to determine whether they offer a viable and cost-effective reduction of impingement and entrainment associated with the CDP's operations under the conditions of a complete shutdown of EPS operations. As indicated previously, under these conditions, the EPS intake facilities (combination of screens and pumps) will be operated to collect a total flow of 304 MGD which is 38 percent of the installed EPS intake pump capacity.

Under the stand-alone desalination plant operations, the existing power plant intake facilities will be operated at reduced flow and fewer pumps will be collecting water through the same existing intake screening facilities. The velocity of the water flowing into the intake would be reduced to 0.5 fps or less. This alone will substantially reduce the impingement associated with the CDP operations.

Technologies listed in Table 4-1 have been evaluated based upon feasibility for implementation at the facility, including the following:

- Ability to achieve a significant reduction in impingement and entrainment (IM&E) for all species, taking into account variations in abundance of all life stages;
- Feasibility of implementation at the facility;
- Cost of implementation (including installed costs and annual O&M costs);
- Impact upon facility operations.

4.3.1 Fish Screens and Fish Handling and Return System

This alternative would include the replacement of the existing traveling screens within the tunnel system with new traveling screens that have features which could enhance fish survival and are designed with the latest fish removal features, including the Fletcher type buckets on the screen baskets (Ristroph-type screens), dual pressure spray systems (low pressure to remove fish, and high pressure to remove remaining debris), and separate sluicing systems for discarding trash and returning the impinged fish back to the Aqua Hedionda Lagoon (AHL) or the ocean.

TABLE 4-1

POTENTIAL IMPINGEMENT/ENTRAINMENT REDUCTION TECHNOLOGIES

Technology	**Reduction Potential**	
	Impingement	**Entrainment**
Modified traveling screens with fish return	Yes	No
Replacement of existing traveling screens with fine mesh screens	Yes	Yes
New fine mesh screening structure	Yes	Yes
Cylindrical wedge-wire screens – fine slot width	Yes	Yes
Fish barrier net	Yes	No
Aquatic filter barrier (e.g. Gunderboom)	Yes	Yes
Fine mesh dual flow screens	Yes	Yes
Modular inclined screens	Yes	No
Angled screen system – fine mesh	Yes	Yes
Behavior barriers (e.g. light, sound, bubble curtain)	Maybe	No

The modified screening system could potentially improve impingement survival. This system however will have a negative effect in terms of entrainment reduction, because the intake pumps will need to collect more source water (3 MGD) to service the dual pressure spray system of the new screens. In addition, a fish return system is required as part of this scenario to transport fish washed from the screens alive back to the water body to a location where they would not be subject to re-entrainment into the intake.

The capital cost associated with this impingement reduction alternative is estimated at: $5.7 million. The annual O&M costs for such system are estimated at $200,000 over the costs of operation of the existing intake screening system.

Poseidon considers this alternative to be infeasible for the following reasons:

- The impingement associated with the CDP's operations has been found by the CEQA lead agency to be insignificant.
- Substantial construction costs for a limited benefit;
- The implementation of this alternative will result in increased entrainment because of the significant volume of additional seawater needed to be collected to operate the screen.
- Uncertain survival of the captured marine organisms.

4.3.2 New Power Plant Intake and Fine Mesh Screening Structure

Fine mesh traveling screens have been tested and found to retain and collect fish larvae with some success. Application of fine mesh traveling screen technology for the EPS would require the construction of a complete new screen structure located at the south shore of the lagoon, including both coarse and fine mesh traveling screen systems and fish collection and return systems. This alternative would replace the existing trash rack structure with a much larger screening structure. Major modifications to the existing tunnel system would be required. Additionally, an appropriate and suitable location to return collected fish, shellfish, and their eggs and larvae would have to be constructed.

The demolition of the existing intake structure; removal of the existing screens; construction of a new intake structure; and installation of new coarse and fine mesh screens equipped with fish collection and return systems; would require a total construction expenditure of $53.3 million. Similar to the previous technology, the implementation of this alternative will also require additional intake flow (4 MGD to 5 MGD) for the operation of the coarse and fine mesh screen organism retrieval and return systems. The additional O&M costs associated with the operation of this system are $300,000 per year.

Poseidon considers this alternative infeasible for the following reasons:

- The impingement and entrainment associated with the CDP have been found by the CEQA lead agency to be insignificant.
- Poseidon has committed to restore and enhance at least 37 acres of marine wetlands habitat that significantly overcompensates for the limited impact of the CDPto marine resources.
- Uncertain survival of the captured marine organisms.
- Substantial increase in CDP construction costs for a very limited benefit.

4.3.3 Cylindrical Wedge-Wire Screens – Fine Slot Width

Wedge-wire screens are passive intake systems, which operate on the principle of achieving very low approach velocities at the screening media. Wedge-wire screens installed with small slot openings reduce impingement and entrainment and are an EPA-approved technology for compliance with the US EPA 316(b) Phase II rule provided the following conditions exist:

- The cooling water intake structure is located in a freshwater river or stream;
- The cooling water intake structure is situated such that sufficient ambient counter currents exist to promote cleaning of the screen face;

- The through screen design intake velocity is 0.5 ft/s or less;
- The slot size is appropriate for the size of eggs, larvae, and juveniles of any fish and shellfish to be protected at the site; and
- The entire water flow is directed through the technology.

Wedge-wire screens are designed to be placed in a water body where significant prevailing ambient cross flow current velocities (≥ 1 ft/s) exist. This cross flow allows organisms that would otherwise be impinged on the wedge-wire intake to be carried away with the flow. An integral part of a typical wedge-wire screen system is an air burst back-flush system, which directs a charge of compressed air to each screen unit to blow off debris and impinged organisms back into the water body where they would be carried away from the screen unit by the ambient cross flow currents.

The EPS, located on the tidal Agua Hedionda Lagoon, would not meet the first two EPA criteria discussed above. First, the intake is not located on a freshwater river. Second, there is not sufficient crosscurrent in the lagoon to sweep organisms and debris away from the screen units; so debris and organisms back-flushed from the screens would immediately re-impinge on the screens following the back-flush cycle. For these reasons, Poseidon considers this alternative infeasible.

4.3.4 Fish Net Barrier

A fish net barrier, as it would be applied to the EPS intake system, is a mesh curtain installed in the source water body in front of the exiting intake structure such that all flow to the intake screens passes through the net, blocking entrance to the intake of all aquatic life forms large enough to be blocked by the net mesh. The net barrier is sized large enough to have very low approach and through net velocities to preclude impingement of juvenile fish with limited swimming ability. The mesh size must be large enough to preclude excessive fouling during operation, while at the same time small enough to keep the marine organisms out of the intake system. These conditions typically limit the mesh size such that adult and a percentage of juvenile fish can be blocked. The mesh is not fine enough to block most larvae and eggs. The fish net barrier could potentially reduce impingement; however, it would not meet reduce the entrainment of eggs and larvae.

The fish net barrier technology is still experimental, with very few successful installations. Using a 20 gpm/ft^2 design loading rate, a net area of approximately 30,000 ft^2 would be required for the EPS. Maintaining such a large net moored in the lagoon is not practical. In addition, the fish barrier is a passive screening device, which is subject to fouling and has no means for self-cleaning. This technology would be rapidly clogged with kelp and other debris. The services of a diving contractor would be required to remove the net for cleaning onshore and to replace the fouled net with a clean net on each cleaning cycle. For these reasons, this technology is not practically feasible for implementation at the EPS and further evaluation is not warranted.

4.3.5 Aquatic Filter Barrier

An aquatic filter barrier system, such as the Gunderboom Marine Life Exclusion System (MLES)™, is a moored water permeable barrier with fine mesh openings that is designed to prevent both impingement and entrainment of ichthyoplankton and juvenile aquatic life. An integral part of the MLES is an air-burst back flush system similar in concept to the air burst system used with wedge-wire screen systems to back flush impinged organisms and debris into the water body to be carried away by ambient cross currents.

The MLES has much smaller mesh openings and would block fish eggs and larvae from being entrained into the intake. These smaller organisms would be impinged permanently on the barrier due to the lack of cross currents to carry them away. Consequently, this technology is not feasible for implementation at the existing EPS intake and further evaluation is not warranted.

4.3.6 Fine Mesh Dual Flow Screens

A modified dual flow traveling water screen is similar to the through flow design, but this type of screen would be turned 90 degrees to the direction of the flow so that its two faces would be parallel to the incoming water flow. When equipped with fine mesh screening media, the average 0.5 fps approach velocity to the screen face would have to be met by the dual flow screen design. Water flow enters the dual flow screen through both the ascending and the descending screen faces, and then flows out between the two faces. All of the fish handling features of the Ristroph screen design would be incorporated in the dual flow screen design.

The dual flow screen configuration has been shown to produce low survival rates for fish larvae. This is because of the longer impingement time endured by organisms impinged on the descending face of the screen. This longer impingement time is suspected to result in higher mortality rates than similar fine mesh screens with a flow through screen design.

The primary advantage of this screen configuration is the elimination of debris carryover into the circulating water system. Also, because both ascending and descending screen faces are utilized, there is greater screening area available for a given screen width than with the conventional through-flow configuration.

However, the dual flow screen can create adverse flow conditions in the approach flow to the circulating water pumps. The flow exiting the dual flow screens is turbulent with an exit velocity of greater than 3 fps. Modifications to the pump bays downstream of the screens, usually in the form of baffles to break up and laterally distribute the concentrated flow prior to reaching the circulating water pumps would be required.

The implementation of this technology to the EPS cooling water intake system would require an entirely new intake screen structure similar to the fine mesh through flow intake screen structure discussed previously. The dual flow fine mesh screen configuration offers no advantages in terms reduction of impingement and entrainment mortality as compared to through flow fine mesh traveling screens discussed above and in fact would probably not perform as well as the through flow design. The design concept for the dual flow screen structure would be similar to the through flow fine mesh screen structure with trash racks, coarse mesh traveling screens and fine mesh traveling screens in each screen train. The implementation cost and operation and maintenance costs for this facility would be of the same order of magnitude as for the through flow screen structure. Dual flow screen technology does not offer a significant performance or cost advantage as compared with through flow screen technology. Therefore, the use of this technology for the EPS is not recommended.

4.3.7 Modular Inclined Screens

Modular Inclined Screen (MIS) is a fish protection technology for water intakes developed and tested by the Electric Power Research Institute (EPRI). This technology was developed specifically to bypass fish around turbines at hydro-electric stations. The MIS is a modular design including an inclined section of wedge-wire screen mounted on a pivot shaft and enclosed within a modular structure. The pivot shaft enables the screen to be tilted to back-flush debris from the screen. The screen is enclosed within a self-contained module, designed to provide a uniform velocity distribution along the length of the screen surface. Transition guide walls taper in along the downstream third of the screen, which guide fish to a bypass flume. A full size prototype module would be capable of screening up to 800 cfs (518 MGD) at an approach velocity of 10 ft/sec.

The MIS design underwent hydraulic model studies and biological effectiveness testing at Alden Research Laboratory to refine the hydraulic design and test its capability to divert fish alive. Eleven species of freshwater fish were tested including Atlantic salmon smolt, coho salmon, Chinook salmon, brown trout, rainbow trout, blueback herring, American shad and others. After some refinements in the design were made during this testing, the results showed that most of these species and sizes of fish can be safely diverted.

Following laboratory testing, the MIS design was field tested at the Green Island Hydroelectric Project on the Hudson River in New York in the fall of 1995. In addition to the MIS, the effectiveness of a strobe light system was also studied to determine its ability to divert blueback herring from the river to the MIS. Results for rainbow trout, golden shiner and blueback herring, which were released directly into the MIS module were similar to the laboratory test results in terms of fish survivability. The limited amount of naturally entrained blueback herring did not allow reliable evaluation of test results.

The MIS technology, as tested, does not address entrainment of eggs and larvae. Also, this technology has never been tested for, or installed in, a power station with a seawater intake system. Further research would be required to evaluate the efficacy of this technology for application to a seawater intake system. MIS is not a suitable and proven technology, at this time, for retrofit to the EPS intake system. Therefore, this technology is not found viable the desalination plant intake impact.

4.3.8 Angled Screen System – Fine Mesh

Angled screens are a special application of through-flow screens where the screen faces are arranged at an angle of approximately 25 degrees to the incoming flow. The conventional through-flow screen arrangement would place the screen faces normal or 90 degrees to the incoming flow. The objective of the angled-screen arrangement is to divert fish to a fish bypass system without impinging them on the screens. Most fish would not be lifted out of the water but would be diverted back to the receiving water by screw-type centrifugal or jet pumps.

Using fine screen mesh on the traveling screens minimizes entrainment, but increases potential for impingement of organisms that would have otherwise passed through the power plant condenser tubes. Application of this technology would require construction of new angled screen structure at the south shore of the lagoon similar to the new fine mesh screen intake structure discussed previously. The angled screen facility would not provide a significant performance advantage in terms of reducing impingement and entrainment as compared to the fine mesh screen structure, and would be at least as large and a significantly more complex structure. This facility would be potentially more costly to implement and maintain than the fine mesh screen facility. Therefore, further evaluation of this technology for the EPS is not warranted.

4.3.9 Behavior Barriers

A behavioral barrier relies on avoidance or attraction responses of the target aquatic organisms to a specific stimulus to reduce the potential of entrainment or impingement. Most of the stimuli tested to date are intended to repulse the organism from the vicinity of the intake structure.

Nearly all the behavioral barrier technologies are considered to be experimental or limited in effectiveness to a single target species. There are a large number of behavioral barriers that have been evaluated at other sites, and representative examples these are discussed separately below.

4.3.10 Offshore Intake Velocity Cap

This is a behavioral technology associated with a submerged offshore intake structure(s). The velocity cap redirects the area of water withdrawal for an offshore intake located at the bottom of the water body. The cap limits the vertical extent of the offshore intake area of withdrawal and avoids water withdrawals from the typically more productive aquatic habitat closer to the surface of the water body.

This technology operates by redirecting the water withdrawal laterally from the intake (rather than vertically from an intake on the bottom), and as a result, the water entering the intake is accelerated laterally and is more likely to provide horizontal velocity cues to fish and allow fish to respond and move away from the intake. Potentially susceptible juvenile and adult fish that are able to identify these changes in water velocity as a result of their lateral line sensory system are able to respond and actively avoid the highest velocity areas near the mouth of the intake structure.

This technology potentially reduces impingement of fish by stimulating a behavioral response. The technology does not necessarily reduce entrainment, except when the redirected withdrawal takes water from closer to the bottom of the water body and where that location has lower plankton abundance.

Application of this technology to the EPS, to be fully effective, would require development of an entirely new intake system with a submerged intake structure and connecting intake conduit system installed out into the Pacific Ocean. For the reasons previously discussed, this is not a practically feasible consideration for the EPS. Therefore, further evaluation of this technology is not warranted.

4.3.11 Air Bubble Curtain

Air bubble curtains have been tested alone and in combination with strobe lights to elicit and avoidance response in fish that might otherwise be drawn into the cooling water intake. Generally, results of testing the bubble curtain have been poor based on testing completed by EPRI. Therefore, further evaluation of this technology is not warranted.

4.3.12 Strobe Lights

There has been a great deal of research with this stimulus over the last 15 years to guide fish away from intake structures. EPRI has co-funded a series of research projects and reviewed the results of research in this field as well. In both laboratory studies and field applications, strobe lights were shown to effectively move selected species of fish away from the flashing lights. Most of the studies conducted to date have been with riverine fish species and for projects associated with hydroelectric generating facilities. One early study was conducted at the Roseton Generating Facility on the Hudson River in New York, another study was conducted on Lake Cayuga in New York, and others for migratory stages of Atlantic and Pacific salmon. Few species similar to those occurring in the Agua Hedionda Lagoon have been tested for avoidance response either in the lab or in actual field studies.

Laboratory testing was done for an application of strobe lights for the San Onofre Nuclear Generating Facility. Testing was conducted for white croaker, Pacific sardine and northern anchovy. The testing demonstrated no conclusive results and the Coastal Commission found this device not useful at this station. Therefore, further evaluation of this technology is not warranted.

4.3.13 Other Lighting

Incandescent and mercury vapor lights have also been tested as a behavioral stimulus to direct fish away from an intake structure. Mercury lights have generally been tested as a means of drawing fish to a safe bypass of the intake structure as generally the light has an attractive effect on fish. Tests have not demonstrated a uniform and clearly repeatable pattern of attraction for all fish species. The mercury lights have been somewhat effective in attracting European eel, Atlantic salmon, and Pacific salmon. But results with other species including American shad, blue back herring and alewife had more variable results. One test with different life stages of Coho salmon shows both attraction and repulsion from the mercury light for the different life stages of the coho. Testing with incandescent, sodium vapor and fluorescent lamps was more limited but also had variable and species specific results.

Other lighting systems, as with most all the behavioral barrier alternatives, have not been tested with the species of fish common in Agua Hedionda Lagoon. As a result there is no basis to recommend these lights systems as an enhancement to reduce impingement or entrainment at the EPS.

4.3.14 Sound

Sound has also been extensively tested in the last 15 years as a method to alter fish impingement rates at water intake structures. Three basic groups of sound systems including percussion devices (hammer, or poppers), transducers with a wide range of frequency output, and low frequency or infrasound generators, have all been tested on a variety of fish species.

Of all the recently studied behavioral devices the sound technology has demonstrated some success with at least one group of fish species. Clupeids, such as alewife, demonstrate a clear repulsion to a specific range of high frequency sound. A device has been installed in the Fitzpatrick Nuclear Generating station on Lake Ontario in New York, which has been effective in reducing impingement of landlocked alewives. The results were repeated with alewife at a coastal site in New Jersey. Similar results with a high frequency generator also reported a strong avoidance response for another clupeid species, the blue back herring, in a reservoir in South Carolina.

Testing of this high frequency device on many other species including weakfish, spot, Atlantic croaker, bay anchovy, American shad, blue back herring, alewife, white perch, and striped bass demonstrated a similar and strong avoidance response by American shad and blue back herring. Alewife and sockeye salmon have also been reported to be repelled by a hammer percussion device at another facility. But testing of this same device at other facilities with alewife did not yield similar results.

Although high frequency sound has potential for eliciting an avoidance response by the Alosid family of fish species, there is no data to demonstrate a clear avoidance response for the species of fish common to the Agua Hedionda Lagoon. Therefore there is no basis to use sound as a viable method to reduce impingement of fish at the EPS.

4.3.15 Installation of Variable Frequency Drives on Existing Power Plant Intake Pumps

Under this alternative, VFDs would be installed on the EPS intake cooling water pumps to minimize the volume of water collected for the desalination plant operations. As indicated previously, the total volume of seawater that is required for the normal operation of the desalination plant is 304 MGD. Of this flow, 104 MGD will be collected for production of fresh water, while the remaining 200 MGD of seawater will be used to dilute the concentrated seawater from the desalination plant.

As indicated in Table 2-1, the EPS has ten cooling water pumps of total capacity of 794.9 MGD. Currently, all of these pumps are equipped with constant speed motors. Each of the five existing power generation units is coupled with two cooling pumps per unit and both pumps are operated when a given power generator is in service. Because the individual power generation units are designed to operate efficiently only at a steady-state near constant rate of electricity production and therefore, near constant thermal discharge load, reducing cooling flow by VFDs in order to diminish entrainment would result in an increased temperature of the thermal discharge which in turn would have a detrimental effect on the marine organisms in the discharge area. The installation of VFDs is also limited by physical site constraints. The VFD units would need to be located near the pump motors in the existing concrete pump pit, which would need to be enlarged in order to accommodate this equipment. The cost associated with such major structural modifications along with the cost of the VFDs would exceed $8.5 million. Taking into consideration the limited useful life of the existing power plant, such large expenditures at this time are not prudent.

Under stand-alone operational conditions of the desalination plant, the power plant intake pumps would be operated as described in the previous Chapter (Chapter 3 – Design). The cooling water pump operations will be decoupled from the condenser operations, which would substantially reduce the seawater velocity through screens. Under these conditions, the intake flow of the desalination plant (and associated entrainment) would be controlled by the VFD system of the desalination plant intake pump station. Installing an additional VFD system on the power plant intake pumps would have a negligible benefit.

In summary, installation of VFDs on existing power plant intake pumps would provide limited benefits to marine life while significantly interfering with ongoing power plant operations. Taking into account economic, environmental and technological factors, this alternative has been determined to be infeasible.

4.3.16 Summary Evaluation of Power Plant Intake and Screening Alternatives

Implementation of the alternatives associated with the modification of the existing power plant intake and screening facilities were found to be infeasible because they would interfere with, or interrupt, power plant operations. Such significant modifications of the existing intake, and prolonged periods of power plant downtime are difficult to justify given the limited environmental benefit. The extended disruption to power plant operations and significant expenditures associated with such modifications would not yield commensurate benefits for the following key reasons:

1. **Impingement.** The complex and costly intake modifications to reduce this already minimal impingement are not prudent. In addition, operational modifications of the existing EPS intake system under stand-alone CDP operation would reduce the fine screen-flow through velocity to further minimize impingement.

2. **Entrainment.** The entrainment associated with stand-alone CDP operation is mainly driven by the volume of intake flow needed to produce fresh drinking water. In contrast with power plant operations, where water is not essential to produce electricity, in seawater desalination, seawater has to be collected and used to produce fresh water. Therefore, CDP entrainment effects cannot be avoided completely or minimized drastically by modifying the existing power plant intake facilities. Quite the opposite, many of the impingement reduction scenarios (see Sections 4.3.1, 2 &3 and 4.3. 6, 7&8) could increase the total flow needed for stand-alone desalination plant operations, thereby trading negligible impingement reduction benefits for incremental increase in entrainment.

Taking into account these economic, environmental and technological factors, the power plant intake screening alternatives are not capable of being accomplished in a successful manner within a reasonable period of time, and have been determined to be infeasible.

When the EPS permanently ceases the use of the once-through cooling water system, additional entrainment and impingement technologies may become feasible. While no timeline has been established as to when this might occur, SLC staff is recommending that in ten years Poseidon would be required to evaluate and implement those additional technologies it determines are appropriate in light of an environmental review it would undertake at that time:[7] The draft SLC lease would require, ten years after the lease is issued, that the CDP be subject to further environmental review to ensure its operations at that time are using technologies that may reduce any impacts.

4.4 DESALINATION TECHNOLOGIES FOR IMPROVED SURVIVAL OF MARINE LIFE

Seawater desalination treatment processes and technologies differ significantly from those used in once-trough cooling power generation. In power plant installations, all of the entrained organisms pass through a complex system of power generation equipment and piping, and are exposed to thermal stress caused by high-temperature heat exchangers before they exit the power plant with the discharge. Therefore, typically a 100 percent mortality of marine organisms is assumed during the once-through cooling power generation process. State-of-the art reverse osmosis seawater desalination plants, such as the CDP, differ because seawater is not heated in order to produce drinking water, which eliminates the thermal stress of marine organisms entrained in the source water flow.

In the April 2008 version of the Plan previously submitted to the Regional Board, Poseidon proposed the installation of micro screens ahead of seawater pretreatment facilities and the use of a low pressure membrane pretreatment system to increase the potential to capture marine organisms and to successfully return them to the ocean. Subsequent to that proposal, Poseidon, with the assistance of the Coastal Commission and the Commission's Scientific Advisory Panel, discovered that these technology measures would not be effective in returning viable organisms to the ocean, and would not result in any minimization or reduction of entrainment. Therefore, Poseidon considers these technological features ineffective and thus they are no longer incorporated into the Plan. A more detailed explanation of this modification is included in Attachment 10.

The incorporation of the following technology feature, in addition to providing up to 55.4 acres of estuarine wetland restoration under the conditions and performance standards prescribed by the MLMP, will fully minimize the entrainment of marine organisms.

4.4.1 Installation of Variable Frequency Drives on Desalination Plant Intake Pumps

The desalination plant intake pump station will be equipped with a VFD system to closely control the volume of the collected seawater. As water demand decreases during certain periods of the day and the year, the VFD system will automatically reduce the intake pump motor speed thereby decreasing intake pump flow to the minimum level needed for water production.

As in any other water treatment plant, the desalination plant production would vary diurnally and seasonally in response to water demand fluctuations. If a VFD system is not available, the CDP intake pumps would collect a constant flow corresponding to the highest flow requirements of

[7] State Lands Commission August 22, 2008 Amendment of Lease PRC 8727.1.

the CDP. The installation of a VFD system at the intake pump station would reduce the total intake flow of the desalination plant compared to constant speed-design, which in turn would result in proportional decrease in entrainment associated with desalination plant operations.

4.5 SUMMARY OF THE FEASIBILITY ASSESSMENT OF TECHNOLOGY FEATURES TO MINIMIZE IMPINGEMENT AND ENTRAINMENT

As shown in Table 4-2, installation of VFDs on the CDP intake pumps was found to be a feasible technology feature to minimize impingement and entrainment.

TABLE 4-2

DESIGN FEATURES TO MINIMIZE IMPINGEMENT AND ENTRAINMENT

Category	Feature	Result
Technology	Installation of VFDs on CDP intake pumps	Reduce the total intake flow for the desalination facility to no more than that needed at any given time, thereby minimizing the entrainment of marine organisms.

In addition, taking into account economic, environmental and technological factors previously discussed, the following intake technology alternatives are not capable of being accomplished in a successful manner within a reasonable period of time; and therefore, have been determined to be infeasible:

- **Installation of subsurface intakes** (beach wells, slant wells, infiltration galleries, etc.) is infeasible for the site-specific conditions of the CDP because of the limited production capacity, poor water quality of the coastal aquifer, extensive environmental damage associated with the implementation of such intakes and excess cost.

- **Construction of new open ocean intake** in the vicinity of the project site was found more environmentally damaging than the use of the existing intake located in Agua Hedionda Lagoon. This alternative is also cost prohibitive.

- **Major physical or structural modifications to the existing power plant intake** facilities were found to be infeasible because of the very limited potential of impingement and entrainment benefits they could offer as well as practical constraints with their implementation while the power plant is in operation.

- **Installation of variable frequency drives on existing power plant intake pumps** would provide limited benefits to marine life while significantly interfering with ongoing power plant operations. Taking into account economic, environmental and technological factors, this alternative has been determined to be infeasible.

CHAPTER 5

QUANTIFICATION OF INTAKE AND MORTALITY OF MARINE LIFE

INTRODUCTION

This Chapter quantifies the estimated intake and mortality of marine life, i.e., impingement and entrainment, associated with the CDP's stand-alone operations. It includes four sections:

- *The first section describes Poseidon's approach to the quantification of the entrainment and impingement associated with the Project in stand-alone mode.*
- *The second section quantifies the impingement associated with the desalination facility's stand-alone operations.*
- *The third section quantifies the entrainment associated with the desalination facility's stand-alone operation.*
- *The fourth section summaries the assessment of impingement and entrainment associated with the desalination facility's stand-alone operations.*

5.1 ESTIMATES OF PROJECTED IMPINGEMENT AND ENTRAINMENT ARE CALCULATED FOR STAND-ALONE OPERATIONS

As explained in Chapter 2, the CDP will use the EPS's existing intake and discharge facilities. So long as the EPS is operating, the CDP's source water needs will largely be met by using the cooling water effluent discharged by the EPS that would otherwise be discharged directly into the Pacific Ocean as the CDP's source water. To the extent that the flow through the EPS meets or exceeds the needs of the CDP, the CDP's operations will not trigger the need for additional technology or mitigation measures to minimize the intake and mortality of marine life[1].

[1] Order No. R9-2006-0065, NPDES No. CA0109223, Attachment F – Fact Sheet, VII. B. 4.b. Intake Regulation, p. F-49-50 explains:

> The CDP is planned to operate in conjunction with the EPS by using the EPS cooling water discharge as its source water. When operating in conjunction with the power plant, the desalination plant feedwater intake would not increase the volume or the velocity of the power station cooling water intake nor would it increase the number of organisms impinged by the Encina Power Station cooling water intake structure. Recent studies have shown that nearly 98 percent of the larvae entrained by the EPS are dead at the point of the desalination plant intake. As a result, a *de minimis* of organisms remain viable which potentially would be lost due to the incremental entrainment effect of the CDP operation. Due to the fact that the most frequently entrained species are very abundant in the area of the EPS intake, Agua Hedionda Lagoon and the Southern California Bight, species of direct recreational and commercial value would constitute less than 1 percent of all the organisms entrained by the EPS. As a result, the incremental entrainment effects of the CDP operation in conjunction with the EPS would not trigger the need for additional technology or mitigation to minimize impacts to marine life.

In the event the EPS were to cease operations, however, the CDP will need to independently operate the EPS's seawater intake and outfall for the benefit of its desalination operations. Under this stand-alone mode of operation, the CDP's estimated entrainment will be no greater than that associated with EPS operations at the same intake flow, and the impingement is expected to be lower due to reduced intake velocities and the elimination of heat treatment practices.

5.2 ESTIMATED IMPINGEMENT ASSOCIATED WITH STAND-ALONE OPERATIONS

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The impingement assessment provided herein is based on an analysis of the most recent biological data available for the EPS intake structure (Attachment 3). These data were collected and analyzed by Tenera Environmental in accordance with a sampling plan and methodology approved by the San Diego Regional Water Quality Control Board (See Attachment 4).

5.2.1 The EPS'S Impingement

EPS's impingement was calculated by collecting 52 biological samples collected over a 52-week period and noting the EPS's flow volume for each sample day.[2]

The abundance and biomass of fishes, sharks, rays and invertebrates impinged on the EPS traveling screens were documented in an extensive study as part of the 316(b) Cooling Water Intake assessment submitted to the San Diego Regional Water Quality Control Board by Cabrillo Power, LLC in January 2008.[3] All impingement sampling data collected during this study are provided in Attachment 3 of the Minimization Plan. This attachment contains data collected for all individual sampling events, including the dates and times of the sampling events.

Table 5-1 represents the total number and weight of organisms (i.e., bony fishes, invertebrates, and sharks and rays) that were impinged by the EPS's normal operations during the 52-week sampling period of 2004/2005. The last row reveals that, on average, the EPS's operations resulted in the impingement of 7.2 kg per day of fish (fish, sharks and rays) biomass.

TABLE 5-1

Number and weight of fishes (bony fishes, sharks and rays) and invertebrates impinged during normal operations at EPS from June 2004 to June 2005 on the sample days

	Daily Volume (MGD)	**Fishes (Bony Fishes & Sharks + Rays)**		**Invertebrates**	
		Number	Weight (g)	Number	Weight (g)
6/24/2004	632	287	4,355.6	7	66.1
6/30/2004	620	419	4,666.3	6	106.4

[2] See Attachment 8. Tables A details the numbers and biomass of the fish species collected during the sampling period; Table B provides the same information for invertebrates.

[3] "CLEAN WATER ACT SECTION 316(b) IMPINGEMENT MORTALITY AND ENTRAINMENT CHARACTERIZATION STUDY—Effects on the Biological Resources of Agua Hedionda Lagoon and the Nearshore Ocean Environment—January 2008"

TABLE 5-1

Number and weight of fishes (bony fishes, sharks and rays) and invertebrates impinged during normal operations at EPS from June 2004 to June 2005 on the sample days

	Daily Volume (MGD)	Fishes (Bony Fishes & Sharks + Rays)		Invertebrates	
		Number	Weight (g)	Number	Weight (g)
7/7/2004	671	209	3,590.1	6	54.0
7/14/2004	856	842	12,377.4	4	272.1
7/21/2004	817	263	7,264.0	3	21.1
7/28/2004	751	255	6,479.3	2	32.5
8/4/2004	676	70	3,951.0	2	7.4
8/11/2004	857	679	11,898.7	7	45.1
8/18/2004	857	86	3,999.7	3	24.9
8/25/2004	626	100	3,809.5	5	26.4
9/1/2004	735	34	1,489.8	2	4.7
9/8/2004	857	250	4,010.0	1	2.5
9/15/2004	771	96	1,348.4	8	62.6
9/22/2004	793	167	2,092.4	6	50.1
9/29/2004	840	122	1,581.4	15	115.9
10/6/2004	823	218	2,908.8	28	116.5
10/13/2004	550	17	323.6	21	118.8
10/20/2004	419	258	2,942.3	16	70.2
10/27/2004	477	206	4,724.5	37	254.0
11/3/2004	477	99	488.5	12	100.1
11/10/2004	550	21	129.0	29	196.6
11/17/2004	544	61	965.6	12	117.9
11/22/2004	550	43	1,350.5	37	156.2
12/1/2004	813	1,947	9,782.8	21	142.5
12/8/2004	784	324	2,899.0	22	335.0
12/15/2004	710	207	2,570.5	20	161.3
12/20/2004	710	66	678.9	20	197.7
12/29/2004	710	1,146	10,427.0	45	189.8
1/5/2005	566	528	7,280.2	40	385.6
1/12/2005	560	5,001	109,526.0	95	2,583.5
1/19/2005	599	600	6,914.1	49	444.0
1/26/2005	632	306	8,330.4	39	414.0
2/2/2005	560	246	3,196.5	26	678.4
2/9/2005	632	227	5,696.6	19	133.5
2/16/2005	497	23	1,186.0	714	2,153.6
2/23/2005	307	1,274	29,531.0	42	4,199.8
3/2/2005	497	48	3,638.2	20	424.6
3/9/2005	497	132	6,586.5	74	629.9
3/16/2005	497	30	887.6	16	62.0
3/23/2005	673	282	7,722.8	65	295.8
3/30/2005	674	240	9,163.4	37	162.5
4/6/2005	673	109	7,150.5	49	343.0
4/13/2005	673	220	11,137.4	184	631.4
4/20/2005	745	96	2,734.5	23	288.1

TABLE 5-1

Number and weight of fishes (bony fishes, sharks and rays) and invertebrates impinged during normal operations at EPS from June 2004 to June 2005 on the sample days

	Daily Volume (MGD)	**Fishes (Bony Fishes & Sharks + Rays)**		**Invertebrates**	
		Number	Weight (g)	Number	Weight (g)
4/27/2005	745	102	3,891.5	8	24.4
5/4/2005	706	280	4,241.8	7	28.6
5/11/2005	576	200	6,343.4	11	328.4
5/18/2005	706	312	7,347.4	20	96.6
5/25/2005	632	195	4,444.6	20	107.0
6/1/2005	700	228	5,925.4	19	52.9
6/8/2005	778	234	4,626.6	5	13.0
6/15/2005	563	37	1,912.7	8	24.5
EPS Totals (52 days)	**34,167**	**19,442**	**372,520**	**1,987**	**17,554**
EPS Daily Averages	**657**	**374**	**7,163.8**	**38**	**337.6**

5.2.2 The CDP's Projected Impingement

The CDP's projected stand-alone impingement can be estimated using a variety of approaches, which are explained and described in Attachments 5 and 9.[4] Using the 2004-2005 EPS data set, the various approaches produce a range of projected estimated impingement associated with stand-alone operations from 1.57 kg/day to 7.16 kg/day, with the lower end of the range reflecting more likely values under the conditions most relevant for project planning purposes and those expected to prevail the vast majority of the time.

Table 5-2 shows the ranges of stand-alone impingement estimates that are associated with the various estimation approaches, depending on the probability value assigned to the outliers.[5]

TABLE 5-2

Impingement Estimation Ranges for Various Approaches and Outlier Probability Values

Estimation Approaches	**Outlier Probability Value**	
	0%	**100%**
Regression (1-A)	1.57 kg/day	1.57 kg/day
Regression (1-B)	1.57 kg/day	4.18 kg/day
Equivalence (2)	4.67 kg/day	7.16 kg/day
Proportional (3-A)	2.11 kg/day	3.74 kg/day
Proportional (3-B)	2.11 kg/day	4.70 kg/day

Table 5-3 shows CDP's estimated stand-alone impingement based on Proportional Approach 3-B, not discounting for probability of the outliers. The third-to-last row reflects the prorated

[4] Attachment 9 incorporates the hydrological analyses of Drs. Chang and Jenkins into the various estimation approaches identified in Attachment 5.
[5] *See* Attachment 9 at 6.

calculation for the 50 flow-related events (discounted for the CDP's reduced flow of 304 MGD); the second-to-last row reflects the non-prorated average of the two non-flow-related sampling events. The last column provides the resulting calculation of the approach. It indicates that the weighted flow-proportioned approach estimates that CDP's operations would have resulted in the impingement of 4.70 kg per day of fish (fish, sharks and rays) biomass.

TABLE 5-3

Weighted Flow-Proportioned Impingement Estimate
Based on EPS's 2004/2005 sampling data and a projected flow of 304 MGD

		Invertebrates				Bony Fishes & Sharks + Rays			
		Number		Weight (g)		Number		Weight (g)	
	CDP's Daily Flow Volume (MGD)	Concentration (# Inverts / MG)	# Inverts Impinged	Concentration (Grams / MG)	Weight in Grams	Concentration (# Fish & Sharks + Rays / MG)	# Fish & Sharks + Ray Impinged	Concentration (Grams / MG)	Weight in Grams
1/12/2005	**Non-Flow Related Events**	0.1369	95	4.6097	2,583.5	8.9232	5001	195.4258	109,526.0
2/23/2005		0.0111	42	13.6926	4,199.8	4.1536	1274	96.2800	29,531.0
6/24/2004	304	0.0111	3	0.1045	31.8	0.4538	138	6.8869	2,093.6
6/30/2004	304	0.0097	3	0.1716	52.2	0.6758	205	7.5267	2,288.1
7/7/2004	304	0.0089	3	0.0805	24.5	0.3114	95	5.3492	1,626.2
7/14/2004	304	0.0047	1	0.3180	96.7	0.9840	299	14.4655	4,397.5
7/21/2004	304	0.0037	1	0.0258	7.8	0.3218	98	8.8884	2,702.1
7/28/2004	304	0.0027	1	0.0433	13.2	0.3398	103	8.6330	2,624.4
8/4/2004	304	0.0030	1	0.0110	3.3	0.1036	31	5.8477	1,777.7
8/11/2004	304	0.0082	2	0.0526	16.0	0.7922	241	13.8827	4,220.3
8/18/2004	304	0.0035	1	0.0291	8.8	0.1003	31	4.6666	1,418.7
8/25/2004	304	0.0080	2	0.0421	12.8	0.1596	49	6.0811	1,848.7
9/1/2004	304	0.0027	1	0.0064	1.9	0.0462	14	2.0258	615.8
9/8/2004	304	0.0012	0	0.0029	0.9	0.2917	89	4.6786	1,422.3
9/15/2004	304	0.0104	3	0.0812	24.7	0.1245	38	1.7485	531.5
9/22/2004	304	0.0076	2	0.0632	19.2	0.2106	64	2.6386	802.1
9/29/2004	304	0.0179	5	0.1379	41.9	0.1452	44	1.8820	572.1
10/6/2004	304	0.0340	10	0.1416	43.1	0.2650	81	3.5364	1,075.1
10/13/2004	304	0.0382	12	0.2159	65.6	0.0309	9	0.5880	178.7
10/20/2004	304	0.0382	12	0.1676	50.9	0.6158	187	7.0227	2,134.9
10/27/2004	304	0.0776	24	0.5326	161.9	0.4319	131	9.9061	3,011.5
11/3/2004	304	0.0252	8	0.2099	63.8	0.2076	63	1.0243	311.4
11/10/2004	304	0.0527	16	0.3572	108.6	0.0382	12	0.2344	71.3
11/17/2004	304	0.0221	7	0.2167	65.9	0.1121	34	1.7746	539.5
11/22/2004	304	0.0672	20	0.2838	86.3	0.0781	24	2.4538	746.0

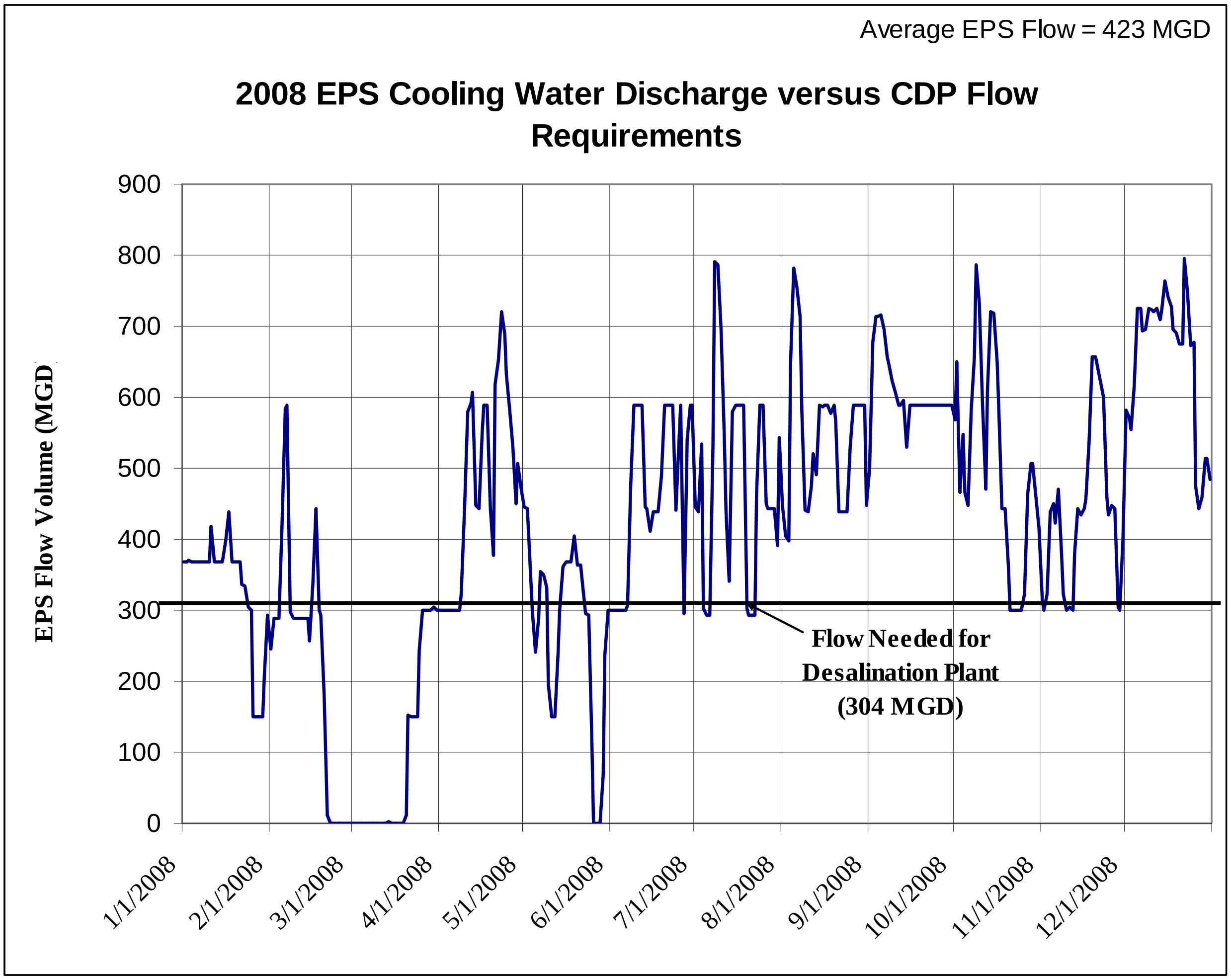
	CDP's Daily Flow Volume (MGD)	**Invertebrates**				**Bony Fishes & Sharks + Rays**			
		Number		Weight (g)		Number		Weight (g)	
		Concentration (# Inverts / MG)	# Inverts Impinged	Concentration (Grams / MG)	Weight in Grams	Concentration (# Fish & Sharks + Rays / MG)	# Fish & Sharks + Ray Impinged	Concentration (Grams / MG)	Weight in Grams
12/1/2004	304	0.0258	8	0.1752	53.3	2.3936	728	12.0269	3,656.2
12/8/2004	304	0.0281	9	0.4275	130.0	0.4135	126	3.6994	1,124.6
12/15/2004	304	0.0282	9	0.2271	69.0	0.2915	89	3.6194	1,100.3
12/20/2004	304	0.0282	9	0.2784	84.6	0.0929	28	0.9559	290.6
12/29/2004	304	0.0634	19	0.2672	81.2	1.6136	491	14.6816	4,463.2
1/5/2005	304	0.0706	21	0.6810	207.0	0.9325	283	12.8578	3,908.8
1/19/2005	304	0.0818	25	0.7408	225.2	1.0011	304	11.5364	3,507.1
1/26/2005	304	0.0617	19	0.6546	199.0	0.4838	147	13.1717	4,004.2
2/2/2005	304	0.0464	14	1.2105	368.0	0.4389	133	5.7035	1,733.9
2/9/2005	304	0.0300	9	0.2111	64.2	0.3589	109	9.0072	2,738.2
2/16/2005	304	1.4372	437	4.3349	1317.8	0.0463	14	2.3873	725.7
3/2/2005	304	0.0403	12	0.8547	259.8	0.0966	29	7.3233	2,226.3
3/9/2005	304	0.1490	45	1.2679	385.4	0.2657	81	13.2579	4,030.4
3/16/2005	304	0.0322	10	0.1248	37.9	0.0604	18	1.7866	543.1
3/23/2005	304	0.0966	29	0.4397	133.7	0.4192	127	11.4791	3,489.7
3/30/2005	304	0.0549	17	0.2410	73.3	0.3560	108	13.5914	4,131.8
4/6/2005	304	0.0728	22	0.5098	155.0	0.1620	49	10.6285	3,231.1
4/13/2005	304	0.2735	83	0.9385	285.3	0.3270	99	16.5546	5,032.6
4/20/2005	304	0.0309	9	0.3868	117.6	0.1289	39	3.6716	1,116.2
4/27/2005	304	0.0107	3	0.0328	10.0	0.1370	42	5.2251	1,588.4
5/4/2005	304	0.0099	3	0.0405	12.3	0.3967	121	6.0092	1,826.8
5/11/2005	304	0.0191	6	0.5699	173.2	0.3470	106	11.0073	3,346.2
5/18/2005	304	0.0283	9	0.1368	41.6	0.4420	134	10.4087	3,164.3
5/25/2005	304	0.0316	10	0.1692	51.4	0.3083	94	7.0276	2,136.4
6/1/2005	304	0.0271	8	0.0756	23.0	0.3258	99	8.4662	2,573.7
6/8/2005	304	0.0064	2	0.0167	5.1	0.3010	91	5.9504	1,808.9
6/15/2005	304	0.0142	4	0.0435	13.2	0.0657	20	3.3954	1,032.2
Prorated Value for (50) Flow-Related Events		0.0651	20	0.3670	111.6	0.3809	116	6.9434	**2,110.8**
Average of (2) Non-Flow-Related Events		0.0740	69	9.1512	3391.7	6.5384	3138	145.8529	**69,528.5**
Weighted Average		0.0655	22	0.7049	237.7	0.6177	232	12.2861	**4,703.8**

As explained in Attachment 9, Proportional Approach 3-B is predicated on the very conservative assumption that the average of the impingement values recorded on the two outlier days (January 12 and February 23, 2005) will recur every year for 14 days per year (i.e., outlier probability value = 100%). Therefore, the impingement estimates that fall below this value are more reflective of conditions expected to prevail over the project lifetime. As shown in Attachment 9 and Table 5-2, however, the various estimation approaches should be adjusted to discount the outliers by their probability. For example, a reasonable value for project planning purposes is 2.11 kg/day, shown in the middle column of the last row in Table 5-2 and the last column of the third-to-last row in Table 5-3. This value represents the impingement for the 50 sampling events adjusted to account for the CDP's reduced flow volume and not including the storm-related outliers. If, consistent with the recurrence probability of these events, it is assumed that the average of outlier impingement values will recur for fourteen days only every 20 years (i.e., 5% probability), the outlier events add very little to the 2.11 kg/day impingement estimate that can be expected from more typical events, resulting in an adjusted value of 2.24 kg/day – a value at the low end of the range of impingement estimates.

5.2.3 Percent of CDP's Flow Needs Met That Would Have Been Met By EPS Discharge in 2008 Had CDP Been Operating in 2008 Based on 2008 EPS Flow Data (Without Corresponding Biological Data)

Figure 5-1 provides a comparison of the 2008 EPS cooling water discharge to the flow needed to support CDP operations. This figure indicates that EPS's average monthly and annual flows continue to exceed the CDP's projected requirement of 304 MGD of seawater in 2008.

FIGURE 5-1



While the EPS average monthly and annual flow exceeded the average monthly and annual flow requirements of CDP, on a daily basis this was not always the case. Table 5-4 represents the amount of additional flow required in each month during 2008 to maintain a continuous 304 MGD flow to the desalination facility. Attachment 1 presents EPS's actual daily flow volumes for 2008.

TABLE 5-4
EPS's 2008 Flow, Daily Analysis

Month	EPS Flow (MG)	Required Flow for Desalination Facility (MG)	Desalination Flow Not Met By EPS (MG)	Percent of Desalination Plant Needs Met	# days deficit between 0.1-10.9 mgd	# days deficit between 11-100 mgd	# days deficit between 101-200 mgd	# days deficit between 201-304 mgd
January	10268	9424	728.5	92.30%	2	1	4	0
February	6558	8816	3117.4	65.00%	3	11	1	9
March	2661	9424	6762.6	28.00%	6	1	4	20

TABLE 5-4
EPS's 2008 Flow, Daily Analysis

Month	EPS Flow (MG)	Required Flow for Desalination Facility (MG)	Desalination Flow Not Met By EPS (MG)	Percent of Desalination Plant Needs Met	# days deficit between 0.1-10.9 mgd	# days deficit between 11-100 mgd	# days deficit between 101-200 mgd	# days deficit between 201-304 mgd
April	14231	9120	35.6	99.60%	8	0	0	0
May	8422	9424	1947.3	79.30%	5	5	4	4
June	13966	9120	34.6	99.60%	7	0	0	0
July	14909	9424	54.6	99.40%	7	0	0	0
August	16840	9424	0	100.00%	0	0	0	0
September	18248	9120	0	100.00%	0	0	0	0
October	15673	9424	22.3	99.80%	5	0	0	0
November	12984	9120	9	99.90%	5	0	0	0
December	20241	9424	0	100.00%	0	0	0	0
Total	**155001**	**111264**	**12711.9**		**48**	**18**	**13**	**33**
		Average		**88.58%**				

Under this operating scenario, the EPS discharge would provide 88.6 percent of the CDP annual seawater intake requirements and the CDP would pump the remaining source water required to support the desalination plant operations from the EPS intake. The CDP's direct use of the EPS discharge and variable frequency drives on the desalination plant intake pumps would result in a substantial reduction in entrainment and impingement from the CDP.

5.3 CALCULATION OF ENTRAINMENT IMPACT

5.3.1 Background Data Used for Preparation of Entrainment Assessment

The entrainment assessment associated with the desalination plant operations is based on comprehensive data collection completed at the existing intake of the EPS following a San Diego Regional Water Quality Control Board (Regional Board) approved data collection protocol during the Period of June 01, 2004 and May 31, 2005 (see Attachment 3). All samples used for the entrainment assessment were collected in front of the EPS intake with a boat-towed plankton net. This is the most up-to-date entrainment assessment available for this facility.

Tenera Environmental estimated the proportional entrainment mortality of the most commonly entrained larval fish living in Agua Hedionda Lagoon by applying the Empirical Transport Model (ETM) to the complete data set from the sampling period of June 01, 2004 and May 31, 2005. The potential entrainment of the CDP was computed based on a total flow of 304 MGD (104 MGD flow to the desalination facility and 200 MGD for dilution of the concentrated seawater).

5.3.2 Entrainment Effects Model

The Empirical Transport Model (ETM) calculated entrainment based on a concept called Area of Production Foregone ("APF"), which is based on principles used in fishery management. The number of days that the larvae are subject to entrainment, or the number of days the desalination facility is operating, is estimated using the size range of the larvae entrained. This number of operating days is then combined with the entrainment mortality (*PE*) to estimate the total mortality due to entrainment for a study period. These estimates for each study period can then be combined to calculate the average proportional mortality due to entrainment for an entire year.

The *ETM* has been proposed by the U.S. Fish and Wildlife Service to estimate mortality rates resulting from cooling water withdrawals by power plants. The *ETM* model provides an estimate of incremental mortality (a conditional estimate in absence of other mortality imposed on local larval populations by using an empirical measure of proportional entrainment (*PE*) rather than relying solely on demographic calculations. Proportional entrainment (*PE*) (an estimate of the daily mortality) to the source water population from entrainment is expanded to predict regional effects on appropriate adult populations using the *ETM*, as described below.

Empirical transport modeling permits the estimation of conditional mortality due to entrainment while accounting for the temporal variability in distribution and vulnerability of each life stage to power plant withdrawals.

The general equation to estimate *PE* for a day on which entrainment was sampled is:

$$\hat{PE} = \frac{\hat{N}_{Ei}}{\hat{N}_{Si}}$$

Where:

$\hat{N}_{Ei}$ = estimated number of larvae entrained during the day in survey i, calculated as (estimated density of larvae in the water entrained that day) $\times$ (design specified daily cooling water intake volume),

$\hat{N}_{Si}$ = estimated number of larvae in the source water that day in survey i (estimated density of larvae in the souce water that day) $\times$ (source water volume).

A source water volume is used because: 1) cooling water flow is measured in volume per time, and 2) biological sampling measures larval concentration in terms of numbers per sample volume. Entrained numbers of larvae are estimated using the volume of water withdrawn.

A source population is similarly estimated using the source water volume. If one assumes that larval concentrations at the point of entrainment are the same as larval concentrations in the source population volume then it follows that:

$$\hat{P}E = \frac{\hat{V}_{Ei}}{\hat{V}_{Si}},$$

Where :

$\hat{V}_{Ei}$ = design specified daily cooling water intake volume,

$\hat{V}_{Si}$ = estimated source water volume.

The ratio of daily entrainment volume to source volume can thus serve as an estimate of daily mortality. The *PE* value is estimated for each larval duration period over the course of a year by using a source water estimate from an advection model described below.

If larval entrainment mortality is constant throughout the period and a larva is susceptible to entrainment over a larval duration of *d* days, then the proportion of larvae that escape entrainment in period *i* is:

$$(1-\hat{P}E_i)^{\hat{d}}.$$

A larval duration of 23 days from hatching to entrainment was calculated from growth rates using the length representing the upper 99^{th} percentile of the length measurements from larval CIQ gobies collected from entrainment samples during 316(b) study completed by Tenera Environmental. The value for *d* was computed by dividing an estimate of growth rate into the change in length based on this 99^{th} percentile estimate. The minimum size used for computing the larval duration was determined after removing the smallest 1 percent of the values.

It is possible that aging was biased, even though standard lengths of larval fishes (i.e., measurements of minimum, mean, and maximum), and larval growth rates were applied to estimate the ages of the entrained larvae. It was assumed that larvae shorter than the minimum length were just hatched and therefore, aged at zero days. Subsequent ages were estimated using this length. Other reported data for various species suggest that hatching length can be either smaller or larger than the size estimated from the samples, and indicate that the smallest observed larvae represent either natural variation in hatch lengths within the population or shrinkage following preservation. The possibility remains that all larvae from the observed minimum length to the greatest reported hatching length (or to some other size) could have just hatched, leading to overestimation of ages for all larvae.

Sixteen larval duration periods over the course of a year were used to estimate larval mortality (P_M) due to entrainment using the following equation:

$$\hat{P}_M = \frac{1}{16}\sum_{i=1}^{16} 1-(1-\hat{P}E_i)^{\hat{d}}$$

Where:

$\hat{P}E_i$ = estimate of proportional entrainment for the *i*th period and

$\hat{d}$ = the estimated number of days of larval life.

The estimate of the population-wide probability of entrainment ($\hat{P}E_i$) is the central feature of the *ETM* approach. If a population is stable and stationary, then $\hat{P}_M$ estimates the effects on the fully-recruited adult age classes when uncompensated natural mortality from larva to adult is assumed.

Assumptions associated with the estimation of P_M include the following:

1) Lengths and applied growth rate of larvae accurately estimate larval duration,
2) A source population of larvae is defined by the region from which entrainment is possible,
3) Source water volume adequately describes the population, and
4) The currents used to calculate the source water volume are representative of other years.

The ratio of daily entrainment volume to source volume is used as an estimate of daily mortality. The *ETM* method estimates the source population using an estimate of the source volume of water from which larvae could possibly be entrained. It has been noted that if some members of the target group lie outside the sampling area, the *ETM* will overestimate the population mortality.

Recent work by Largier showed the value of advection and diffusion modeling in the study of larval dispersal, which is central to the *ETM* method. Ideally, three components could be considered in estimating entrainable populations: advection, diffusion, and biological behavior. An *ad hoc* approach, developed by the Technical Working Group during the Diablo Canyon Power Plant (DCPP) 316(b) study, modeled the three components using a single offshore current meter. For the present analysis, lagoon and coastal source water populations were treated separately.

Larval populations in the Agua Hedionda lagoon were computed using the lagoon segment volumes, described below. Nearshore populations were defined using the *ad hoc* approach developed by the DCPP Technical Working Group.

5.3.3 Source Water Volume Used for AHL Calculations

Agua Hedionda Lagoon is comprised of three segments: "outer", "middle", and "inner". The lagoon segments were originally dredged to a mean depth of 2.4 m (8 ft) relative to mean water level (MWL) in 1954. The horizontal areas of the outer, middle, and inner segments at MHW are 267,000 m^2 (66 acres), 110,000 m^2 (27 acres) and 1,200,000 m^2 (295 acres), respectively (Table 5-5). The tidal prism of the outer segment was calculated as 246,696 m^3 (200 acre ft) and for the middle and inner segments as 986,785 m^3 (800 acre ft). The individual volumes of the middle and inner tidal prisms were estimated to be 82,860 m^3 and 903,925 m^3 using weighting by areas. The volumes of the three segments below mean water level were computed as the volume below mean high water minus half the tidal prism (Table 5-5).

TABLE 5-5
Volumes of the Outer, Middle, and Inner Segments of the Agua Hedionda Lagoon

	Design Depth (m re: MWL)	Area (m^2 re: MHW)	Volume (m^3 re: MHW)	Volume (MWL) (m^3 MHW-.5 Prism)
Outer	2.4	267,000	791,356	668,006
Middle	2.4	110,000	326,027	284,597
Inner	2.4	1,200,000	3,556,656	3,104,696
Total		**1,577,000**	**4,674,039**	**4,057,299**

Figure 5-1 shows the sampling blocks used to calculate near shore source water volume. Sampling done in five (the "N" blocks) of the nine blocks was assumed to be representative of alongshore and offshore variation in abundances and therefore the volume from all nine blocks was used in calculating source water abundances. The volumes for these sampling blocks were calculated from bathymetric data for the coastal areas around Carlsbad using ArcGIS software. The total volume in these nine blocks was estimated at 283,303,115 m^3 (Table 5-6).

SDG&E completed a three-month deployment (June, August, and November 1979) of two Endeco current meter seaward of the outer lagoon entrance. Highest current speeds occurred further offshore, with 10.06 cm/s being the average current speed. The furthest offshore station was over a bottom depth of about 24.4 m (80 ft) at California State plane 355,800 N and 6,625,000 E. The meter was set –3 m below the surface. SCCWRP reported similar current speeds with median offshore currents at Carlsbad of 8.6 cm/s in winter and 7.0–9.5 cm/s in summer from a mid-depth position over a 45 m bottom from 1979–1990.

TABLE 5-6
VOLUMES OF NEAR SHORE SAMPLING BLOCKS USED IN CALCULATING SOURCE WATER ABUNDANCES

Block	Depth (m re: MWL)	Area (m^2 re: MHW)	Volume (m^3 re: MHW)
N1	-5.3	1,195,366	5,959,236
N2	-6.4	1,653,677	9,840,181
N3	-5.6	1,775,546	9,247,259
SW1	-14.8	1,055,516	15,633,525
N4	-18.5	1,359,040	25,081,478
SW2	-17.9	1,711,379	30,499,399
SW3	-27.8	1,312,832	36,386,864
N5	-38.5	1,661,891	63,329,174
SW4	-42.8	2,046,985	87,325,998
Total		**13,772,232**	**283,303,115**

The three months of currents reported in SDG&E in 1980 were rotated to the coastline direction at the Encina Power Station (36 degrees W of N). The average current vector components were 1.702 cm/s downcoast and 0.605 cm/s offshore.

A current meter was placed in the near shore between Stations N4 and N5. The data from the meter was used to characterize currents in the near shore area that would directly affect the dispersal of planktonic organisms that could be entrained by the power plant. The data were used to define the size of the near shore component of the source water by using the current speed and the estimated larval durations of the entrained organisms.

Source water volume and depths of Agua Hedionda Lagoon were very carefully determined based on recent hydrodynamic studies of Agua Hedionda Lagoon.

5.3.4 ETM Modeling for the CDP

1. <u>The Empirical Transport Model Calculates APF</u>

The Empirical Transport Model ("ETM") is a widely used model to estimate mortality rates resulting from water intake systems.[6] The ETM calculates what is known as the Area of Production Foregone (APF)—a value that represents the number of acres of habitat that must be created or restored to mitigate for the small marine organisms (e.g., fish larvae) that pass through the intake screens and become entrained in a water intake system

[6] This approach makes it possible to establish a definitive habitat value for the source water, and is consistent with the approach taken by the California Energy Commission and their independent consultants for the AES Huntington Beach Power Generation Plant and the Morro Bay Power Plant (MBPP) in assessing and mitigating the entrainment effects of the proposed combined cycle project. The situation in Morro Bay is very analogous to the proposed Carlsbad Project because both projects are drawing water from enclosed bays.

2. Model: APF = SWB x Pm

The ETM is an algebraic model that incorporates two basic variables: Source Water Body (SWB) and Proportional Mortality (Pm).

The Source Water Body (SWB) represents the number of acres in which egg and larvae populations are subject to entrainment. The SWB value is limited to the area in which mature fish produce eggs and larvae. If mature fish do not spawn in a given area, that area will contain no entrainable organisms—i.e., no eggs or larvae to be drawn into and entrained by the intake system.

Proportional Mortality (Pm) represents the percentage of the population of a marine species in a given water body that will be drawn in and entrained by a water intake system. The Pm ratio is calculated by dividing (a) the number of marine organisms that are entrained in a water intake system by (b) the number of marine organisms in the same water body that are subject to entrainment.

3. Source Water Body (SWB) = 302 acres

The estimated acres of lagoon habitat for these species are based on a 2000 Coastal Conservancy Inventory of Agua Hedionda Lagoon habitat shown in Table 5-7.

TABLE 5-7

WETLAND PROFILE: AGUA HEDIONDA LAGOON

Approximate Wetland Habitat Acreage

Habitat	Acres	Vegetation Source
Brackish / Freshwater	3	Cattail, bulrush and spiny rush were dominant
Mudflat / Tidal Channel	49	Not specified / Estuarine flats
Open Water	253	Eelgrass occurred in all basins
Riparian	11	Not specified
Salt Marsh	14	Not applicable
Upland	61	Not applicable
TOTAL	**391**	

The entrainment associated with the CDP's stand-alone operations will only affect those areas of Agua Hedionda Lagoon that support the three most commonly entrained lagoon fish larvae.[7] These areas include 49 acres of mudflat/tidal channel and 253 acres of open water. Because CDP's operations will only minimally affect species that reside in the other lagoon habitats (e.g.,

[7] Ninety-eight percent of the fish larvae that would be entrained by the CDP stand-alone operations are gobies, blennies and hypsopops.

brackish/freshwater, riparian, salt marsh or upland habitats), it is reasonable to exclude those areas from the source water body estimation.

4. Proportional Mortality (Pm) = 0.122

The major sources of variance in *ETM* results have been shown to include variance in estimates of larval entrainment concentrations, source water concentrations, and larval duration, in this order. Variance in estimates of entrainment and source water concentrations of fish larvae is due to spatial differences among stations, day and night diurnal changes, and temporal changes between surveys

Estimates of desalination intake and source water populations for the fish taxa evaluated are presented in Table 5-8 were based on entrainment and source water data for the sampling period of June 10, 2004 to May 19, 2005. The following documents related to Poseidon's Entrainment Study are enclosed.

- Attachment 4 – Proposal for Information Collection Clean Water Act Section 316(b), Encina Power Station, Cabrillo Power I LLC, NPDES Permit No. CA0001350, April 1, 2006

- Attachment 6 – Carlsbad Desalination Facility – Summary of Fish and Target Shellfish Larvae Collected for Entrainment and Source Water Studies in the Vicinity of Agua Hedionda Lagoon from June 2005 through May 2006.

TABLE 5-8

ETM VALUES FOR ENCINA POWER STATION LARVAL FISH ENTRAINMENT FOR THE PERIOD OF 01 JUN 2004 TO 31 MAY 2005 BASED ON STEADY ANNUAL INTAKE FLOW OF 304 MGD

	ETM	**ETM**	**ETM**	**ETM**
	Estimate	**Std.Err.**	**+ SE**	**- SE**
ETM Model Data for 3070 - Gobies	0.21599	0.30835	0.52434	-0.09236
ETM Model Data for 1495 - Blennies	0.08635	0.1347	0.22104	-0.04835
ETM Model Data for 1849 - Hypsopops	0.06484	0.13969	0.20452	-0.07485
AVERAGE	**0.122393**			
ETM Model Data for 3062 – White Croaker	0.00138	0.00281	0.00419	-0.00143
ETM Model Data for 1496 – Northern Anchovy	0.00165	0.00257	0.00422	-0.00092
ETM Model Data for 1219 – California Halibut	0.00151	0.00238	0.00389	-0.00087
ETM Model Data for 1471 - Queenfish	0.00365	0.00487	0.00852	-0.00123
ETM Model Data for 1494 – Spot Fin Croaker	0.00634	0.01531	0.02165	-0.00896
AVERAGE	**0.002906**			

FIGURE 5-2
Nearshore sampling blocks used to calculate source water volumes

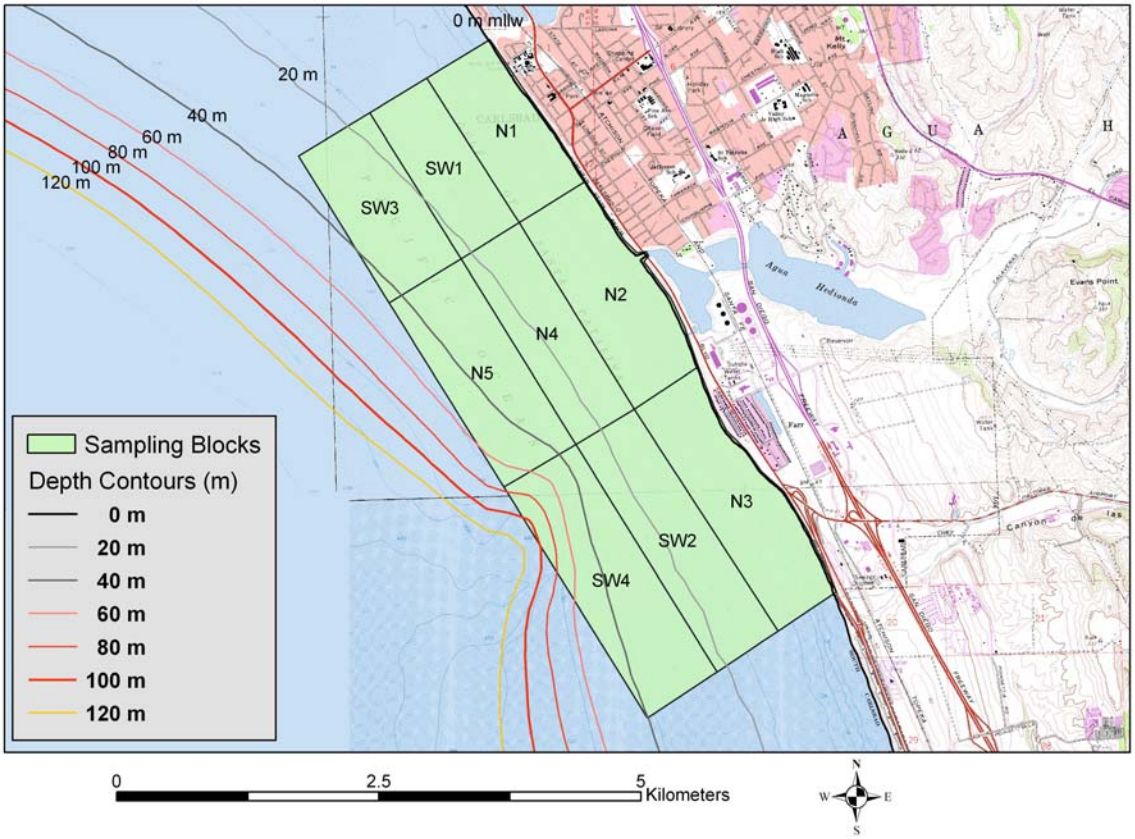


Table 5-8 reveals that the average Pm value for the three most commonly entrained species living in Agua Hedionda Lagoon is 0.1224 (12.2 percent).

5. Initial APF Result = 36.8 acres

Based on a SWB estimate of 302 acres and a Pm calculation of 0.122, Poseidon initially concluded that the entrainment associated with its withdrawal of 304 MGD from Agua Hedionda Lagoon would result in an Area of Production Foregone (APF) of approximately 37 acres.

APF = 302 acres x 0.122 = 36.8 acres.

6. Final APF Result = 55.4 acres

In March 2008, Poseidon provided a copy of its entrainment study to the Coastal Commission as required by Special Condition 8 of the Project's coastal development permit. Coastal Commission staff forwarded the study to Dr. Pete Raimondi[8] for his review and

[8] Pete Raimondi is an independent scientist described by the Coastal Commission as "California's leading expert on entrainment analysis." Dr. Raimondi has been a key participant and reviewer of most of the entrainment studies

recommendations. During the course of his review of Poseidon's entrainment study, Dr. Raimondi made two important revisions that resulted in his upward revision of the APF estimate to 55.4 acres.[9]

First, Dr. Raimondi added open ocean water species (e.g., the northern anchovy) to the entrainment model, even though he recognized that the intake system's entrainment impact on ocean species is very small. By adding ocean species, Dr. Raimondi's approach forces Poseidon to mitigate for a number of species that will be only minimally affected by the Project's operations. The addition of ocean species to the entrainment model adds an extra layer of resource protection to the Project's mitigation obligation.[10]

Second, Dr. Raimondi applied an 80% confidence level APF as the basis for mitigation. This approach ensures that the MLMP plan will fully account for the Project's entrainment impacts. Whereas Poseidon based its APF calculation on a 50% confidence interval—i.e., the level of confidence that past entrainment studies have generally used —Dr. Raimondi used the higher 80% figure. Thus, to an 80% degree of certainty, the mitigation plan comprehensively identifies and accounts for any entrainment impacts.

5.3.5 Significance of Entrainment Impacts

As the CEQA lead agency on the Project EIR, the City of Carlsbad found that the entrainment impacts associated with the stand-alone operation of the proposed desalination facility are insignificant and therefore no mitigation is required.[11]

The Coastal Act applies a different standard of review for projects of this nature. The Coastal Act provides that "[m]arine resources shall be maintained, enhanced, and where feasible restored." [12] Additionally, the adverse effects of entrainment shall be minimized where feasible.[13] In its approval of the Coastal Development permit for the proposed Project, the Coastal Commission found that Poseidon is "using all feasible methods to minimize or reduce its entrainment impacts" and conditioned the Project to include compensatory mitigation to lessen the effects of unavoidable entrainment and impingement impacts. [14] With the inclusion of this Special Condition 8, the Commission found that all project related entrainment will be fully mitigated and that marine resources and the biological productivity of the coastal waters, wetlands and estuaries will be enhanced and restored.[15]

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done along the California coast during the past decade, including those done for the AES Huntington Beach Generating Station, the Morro Bay Power Plant, and Moss Landing Plant.

[9] Recommended Revised Condition Compliance Findings November 21, 2008, page 14.

[10] The incorporation of ocean water species into the ETM has been used to help determine mitigation in several recent California power plant siting cases (e.g., Huntington Beach (00-AFC-13), Morro Bay (00-AFC-12)).

[11] See Final Environmental Impact Report EIR 03-05

[12] Coastal Act Sections 30230.

[13] Coastal Act Sections 30231.

[14] See Coastal Commission draft findings for Poseidon Carlsbad Desalination Project, pages 53 of 108; http://documents.coastal.ca.gov/reports/2008/3/W25a-3-2008.pdf

[15] See Coastal Commission draft findings for Poseidon Carlsbad Desalination Project, pages 3 and 4 of 108; http://documents.coastal.ca.gov/reports/2008/3/W25a-3-2008.pdf

5.4 SUMMARY AND CONCLUSIONS

The Coastal Commission found that Poseidon is using all feasible methods to minimize or reduce impingement and entrainment. These methods are likely to reduce the Project-related intake and mortality to marine life well below the levels identified herein. Nevertheless, as described in Chapter 6, Poseidon has committed to restore and enhance sufficient coastal habitat to more than compensate for the Project's impingement and entrainment prior to consideration of benefits to be derived from other minimization measures.

Ten years after the lease is issued, the CDP will be subject to further environmental review by the State Lands Commission (SLC) to analyze all environmental effects of facility operations and alternative technologies that may reduce any impacts found. SLC may require additional requirements as are reasonable and as are consistent with applicable state and federal laws and regulations. This approach will ensure that the CDP's stand-alone operations continue to use the best technologies feasible to minimize intake and mortality of marine life, and that impingement and entrainment are minimized using feasible and available means.

CHAPTER 6

MITIGATION

Pursuant to Water Code Section 13142.5(b), the best available site, design, technology, and mitigation measures feasible will be used to minimize marine life intake and mortality associated with an ocean-water intake system. This Chapter describes the mitigation measures associated with the CDP and incorporates a **Marine Life Mitigation Plan ("MLMP")** into this Flow, Entrainment and Impingement Minimization Plan, attached hereto as Part A. The MLMP requires Poseidon to construct up to 55.4 acres of mitigation wetlands to offset intake and mortality of marine life. As explained below, even in the event CDP operates in stand-alone mode, its estimated impingement and entrainment impacts will be fully offset by the mitigation wetlands, not taking into consideration the design and technology measures that will diminish marine life mortality still further. Thus, in combination, by using the best available site, design, technology, and mitigation measures feasible, as described in this Minimization Plan, CDP will not only minimize the intake and mortality of marine life, but it will at least zero out any such losses and will likely result in additional biological productivity. The requirements of Section 13142.5(b) will be met and exceeded under the terms of this Minimization Plan.

- *Section 6.1 introduces and incorporates the MLMP generally.*
- *Section 6.2 explains how the mitigation requirement was established based on the CDP's estimated entrainment and impingement, not taking into account design and technology measures.*
- *Section 6.3 describes how the MLMP works.*
- *Section 6.4 describes the site selection.*
- *Section 6.5 describes the performance measures.*
- *Section 6.6 provides for the Regional Board and Executive Officer's MLMP enforcement and administration authority.*

6.1 MARINE LIFE MITIGATION PLAN

The MLMP, incorporated in this Chapter at Part A, provides for the construction of up to 55.4 acres of highly productive estuarine wetlands in the Southern California Bight, created in two phases. During Phase I, a period expected to correspond with EPS's continued operations, Poseidon will create 37 acres of wetlands. During Phase II, when CDP may be operating in stand-alone mode, the agencies will consider whether Poseidon will be required to create an additional 18.4 acres of wetlands, or whether instead, it may offset some or all of this further mitigation requirement by employing additional technology measures at the intake system, or undertaking dredging in Agua Hedionda Lagoon in a manner that warrants mitigation credit.

6.2 ESTABLISHING MITIGATION REQUIREMENT

Although Water Code Section 13142.5(b) only requires that the Project use the best available site, design, technology, and mitigation measures feasible to *minimize* intake and mortality of marine life, the MLMP takes a more environmentally conservative approach, requiring sufficient mitigation to completely *zero out* intake and mortality, i.e., impingement and entrainment.

6.2.1 COMPARISON OF ESTIMATED IMPINGEMENT AND PROJECTED BIOLOGICAL PRODUCTIVITY OF MITIGATION PLAN

The CDP's projected impingement for stand-alone operations was estimated in a variety of ways, producing a range of values from 1.57 to 4.7 kg per day, or 766.5 to 1,715.5 kg per year, with the lower end values most likely to reflect future conditions.

As explained in Attachment 7, the fish biomass productivity of intertidal mudflat and subtidal habitat is approximately 9.35 g DW/m^2/yr or 151.35 kg WW per acre per year. Accordingly, a mitigation acreage of 37 acres of such habitat will have a fish biomass productivity of 5,600 kg WW/yr, and a mitigation of 55.4 acres of such habitat will have a fish biomass productivity of 8,385 kg ww/yr. Although in addition to intertidal and subtidal habitat, the MLMP calls for the mitigation site(s) to contain a mixed habitat containing some amount of salt marsh, which has an uncalculated fish biomass productivity, all of the sites contemplated in the MLMP will provide habitat with sufficient productivity to fully offset the estimated range of impinged biomass. The precise habitat composition of the mitigation site(s) will be determined and vetted at the design stage of the mitigation planning, and the proposed mitigation site(s) will be reviewed to confirm that it will provide no less than 1,715.5 kg per year of fish biomass productivity. This 1715.5 kg per year of predicted fish biomass productivity shall be calculated in a manner which excludes the predicted biomass for entrained lagoon fish species (i.e., gobies, blennies, and garibaldi). Thus, the MLMP assures that the Project will result in a net productivity of fish biomass.

6.2.2 ENTRAINMENT MITIGATION

Chapter 5 explains how CDP's projected entrainment for stand-alone operations was conservatively estimated based on the Empirical Transport Model (ETM), which estimated the portion of the larvae of each target fish species at risk of entrainment.[1] Multiplying the average percent of populations at risk by the physical area from which the fish larvae might be entrained yields an estimate of the amount of habitat that must be restored to replace the lost fish larvae. This estimate is referred to as the area (acreage) of habitat production foregone (APF).

In order to calculate the APF, the amount of lagoon habitat acreage occupied by the three most commonly entrained lagoon fish larvae[2] was multiplied by the average Proportional Entrainment Mortality (PM) for the three lagoon species identified in Chapter 5 (12.2 percent). The estimated

[1] See Section 5.3 of Chapter 5.

[2] Ninety-eight percent of the fish larvae that would be entrained by the CDP stand-alone operations are gobies, blennies and hypsopops.

acres of lagoon habitat for these species are based on a 2000 Coastal Conservancy Inventory of Agua Hedionda Lagoon habitat shown in Table 6-1.

TABLE 6-1

WETLAND PROFILE: AGUA HEDIONDA LAGOON

Approximate Wetland Habitat Acreage

Habitat	Acres	Vegetation Source
Brackish / Freshwater	3	Cattail, bulrush and spiny rush were dominant
Mudflat / Tidal Channel	49	Not specified / Estuarine flats
Open Water	253	Eelgrass occurred in all basins
Riparian	11	Not specified
Salt Marsh	14	Not applicable
Upland	61	Not applicable
TOTAL	**391**	

The areas of Agua Hedionda Lagoon that have potential to be impacted by the CDP operations are those habitats occupied by the three most commonly entrained lagoon fish larvae. These habitats include 49 acres of mudflat/tidal channel and 253 acres of open water. It is not appropriate to include the other lagoon habitats in the APF calculation, such as brackish/freshwater, riparian, salt marsh or upland habitats that are not occupied by the impacted species. By definition, the APF equals the acres of the lagoon habitat that have the potential to be impacted by the intake operations (302 acres) multiplied by the the average PM:

APF = 302 acres x 0.122 = 36.8 acres.

Thus, entrainment effect of the stand-alone operation of the desalination plant extends over 12.2 percent, or 36.8 acres of Agua Hedionda Lagoon. From this, Poseidon concluded that the entrainment caused by the 304 MGD of water withdrawn by the desalination facility would result in an APF of 37 acres in Agua Hedionda Lagoon.

The Coastal Commission adopted a more conservative approach, based on the ETM but using more conservative assumptions and higher confidence levels, to determine the amount of mitigation needed to zero out the CDP's estimated entrainment.[3] The Coastal Commission concluded that by providing up to 55.4 acres of estuarine wetland restoration under the conditions and performance standards prescribed by the MLMP, the CDP's entrainment impacts will be mitigated and marine resources will be maintained, enhanced and restored in conformity with the Coastal Act's marine life protection policies.[4]

[3] Discussed in detail in Chapter 5 at Section 5.3; see also, http://documents.coastal.ca.gov/reports/2008/12/w16a-12-2008.pdf, see pages 13 and 14 of 18.
[4] Id.

As a result of the Coastal Commission's conservative assumptions, the restoration requirements established in the MLMP will compensate under worst-case conditions[5] when the power plant is no longer operating and the existing pumps are operated solely to deliver 304 MGD of seawater for the operation of the desalination plant and no additional design or technology measures are implemented to further reduce the entrainment impacts of stand-alone operations. This approach will result in over mitigation as long as the power plant continues to operate.

This is because the restored habitat will provide significant environmental benefits that extend well beyond compensating for the entrainment impacts. For example, the APF calculation does not take into account the enormous ecological value of the restored acreage that will accrue to valuable wetland species completely unaffected by the intake, such as the numerous riparian birds, reptiles, benthic organisms and mammals that will utilize the habitat for foraging, cover and nesting. Nor does the calculation consider the myriad of phytoplankton, zooplankton and invertebrate species that are largely unaffected by the intake operations and benefit directly from the restored wetlands.

As a result, the mitigation required under the MLMP assures that the biological loss associated with CDP's stand-alone estimated entrainment will not only be zeroed out, but will result in a net enhancement of the coastal habitat.

Therefore, the requirements of Section 13142.5(b) for stand-alone operations will be met and exceeded under terms of this Minimization Plan. Because additional analysis under Section 13142.5(b) will be required if the EPS ceases to operate, however, impingement and entrainment will reevaluated at that time, and the agencies will have an opportunity to adjust the Project requirements if warranted by additional data or the changed circumstances.

6.3 HOW THE MLMP WORKS

Pursuant to Water Code Section 13225, and the Regional Board's April 9, 2008 Resolution,[6] the MLMP was developed through an interagency process involving several federal and state agencies, including the Regional Board and the Coastal Commission. The MLMP attached hereto is the final version approved by the Coastal Commission and therefore provides enforcement and administrative authority specifically to the Coastal Commission and its Executive Director. By incorporating the MLMP into the Minimization Plan, the MLMP similarly is enforceable by the Regional Board and its Executive Officer. The Regional Board's specific authorities with regard to the MLMP are described in detail in section 6.5 below.

The MLMP describes the completion of specified tasks on a timeframe based upon the Coastal Commission's issuance of a coastal development permit for the CDP – an event that is expected to occur in the second quarter of 2009. Within 9 months of receiving the coastal development permit for the CDP, Poseidon shall submit to the Coastal Commission for its review and approval a proposed mitigation site or sites, and a preliminary restoration plan for 37 acres of

[5] As noted in Chapter 3, the EPS discharge would have provided 88.6 percent of the CDP seawater intake requirements in 2008 and 61% in 2007.
[6] R9-2006-0039.

wetlands for its review and approval.[7] Under this Minimization Plan, Poseidon shall make the same submission to the Regional Board for its review and approval. Poseidon may elect to complete all 55.4 acres of wetlands during this Phase I period, but must complete at least 37 acres. Within 6 months of the Commission's approval of the site and restoration plan, subject to Poseidon's having obtained the necessary permits, Poseidon must begin construction of the wetlands.[8] An application for a coastal development permit for the Phase I site or sites must be submitted to the Coastal Commission within two years of receiving the coastal development permit for the CDP itself. Specific requirements for the coastal development permit applications for Phases I and II are detailed in Section 4.0 of the MLMP.

If Poseidon does not elect to complete 55.4 acres of wetlands in Phase I, it will need to seek a coastal development permit for the additional mitigation wetlands (18.4 acres) within 5 years of receiving the coastal development permit for the Phase I wetlands. In the alternative, Poseidon may seek authorization to substitute intake technology and/or dredging of Agua Hedionda Lagoon for all or a portion of the 18.4 acres.

6.4 SITE SELECTION

The mitigation site or sites may be selected from among the 11 sites identified during the interagency process and listed in the MLMP, or may be one recommended by the California Department of Fish & Game as a high-priority wetlands restoration project, or one proposed by Poseidon and added to the list with the approval of the Coastal Commission's Executive Director and the Regional Board's Executive Officer. The 11 identified sites are: (1) Tijuana Estuary; (2) San Dieguito River Valley; (3) Agua Hedionda Lagoon; (4) San Elijo Lagoon; (5) Buena Vista Lagoon; (6) Huntington Beach Wetland; (7) Anaheim Bay; (8) Santa Ana River; (9) Los Cerritos Wetland; (10) Ballona Wetland; and, (11) Ormond Beach. Additional narrative detail about the sites in incorporated into this chapter at Part B. The selected site(s) must meet the detailed requirements of Section 3.0 of the MLMP, which are not reprinted here.

Sites located within the boundaries of the Regional Water Quality Control Board, San Diego Region, shall be considered priority sites. If Poseidon proposes one or more mitigation sites outside of these boundaries, it first shall demonstrate to the Board that the corresponding mitigation could not feasibly be implemented within the boundaries, such as when the criteria established in Section 3.0 of the MLMP are not satisfied.

Figure 1 is a map showing identified sites within San Diego County. Figure 2 is a map showing sites located within Orange, Los Angeles, and Ventura Counties.

[7] MLMP § 2.0.
[8] MLMP § 4.2.

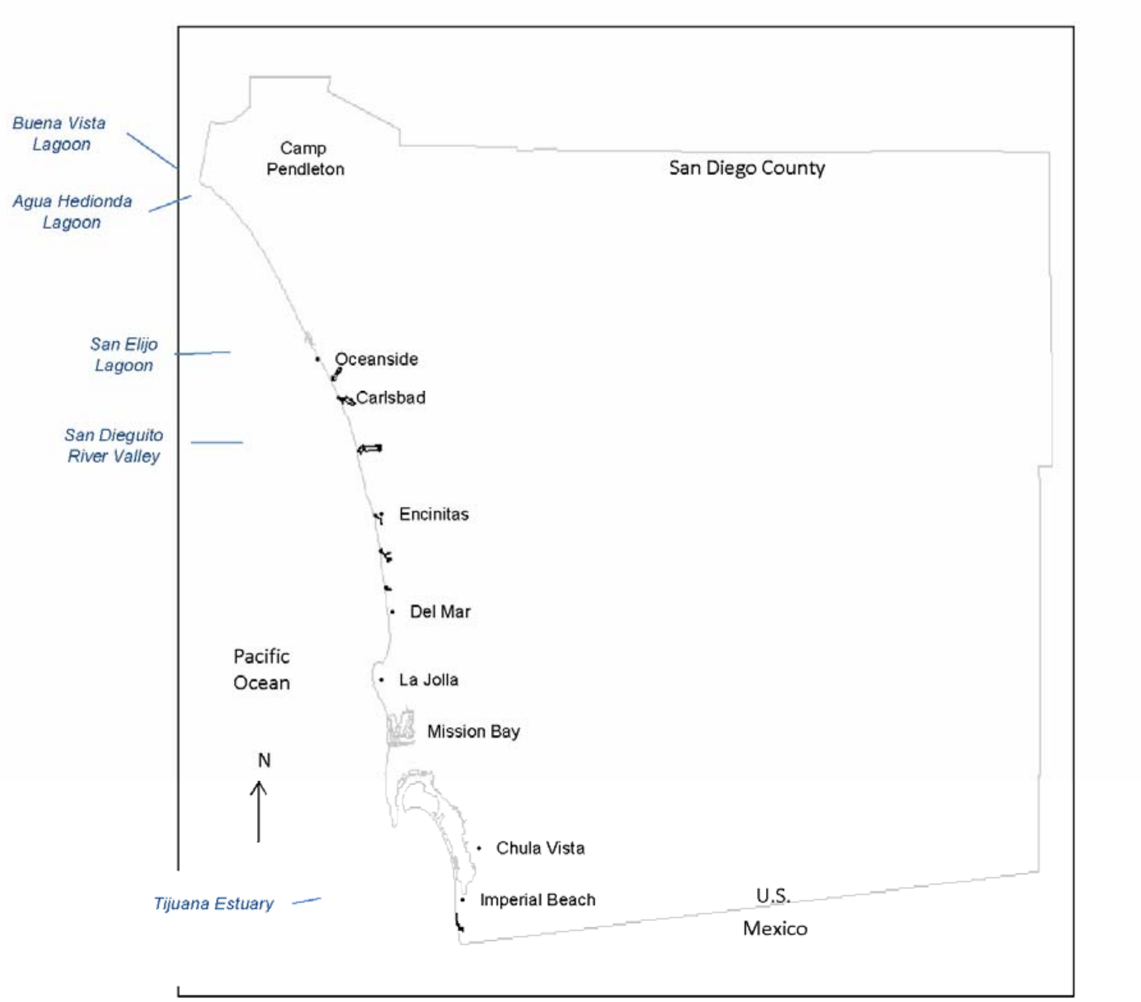

Figure 1 – Location of Mitigation Sites in San Diego County, California

Figure 2 – Location of Mitigation Sites in Orange County, Los Angeles County, and Ventura County, California

6.5 PERFORMANCE MEASURES

In addition to specific standards for mitigation site selection, the performance of the site(s) will be enforced by strict performance standards, which are substantially the same as those approved for mitigation of marine life mortality associated with Southern California Edison's San Onofre Nuclear Generating Station. Among other things, the standards require that, within five years of the start of construction, the wetlands must match habitat values within a 95% confidence level for four undisturbed wetlands to be identified per the MLMP. The performance measures are detailed in Section 5.0 of the MLMP and are not reprinted here.

6.6 REGIONAL BOARD AUTHORITY

The Regional Board's authority with regard to the MLMP shall be very similar to the Coastal Commission's, except where it would lead to unnecessary duplication of effort, or unnecessary burden on Poseidon. The table below identifies each section of the MLMP in which an action by, or in consultation with, the Coastal Commission is contemplated. The specific language of the MLMP referring to the Regional Board's corresponding authority is identified.

MLMP Section	**Coastal Commission Authority**	**Regional Board's Corresponding Authority**
2.0 Site Selection	"In consultation with Commission staff, the permittee shall select a wetland restoration site or sites for mitigation in accordance with the following process and terms."	In consultation with Commission staff <u>and Regional Board staff</u>, the permittee shall select a wetland restoration site or sites in accordance with the following process and terms.
	"Within 9 months of the effective date of this permit, the permittee shall submit the proposed site(s) and preliminary wetland restoration plan to the Commission for its review and approval or disapproval."	Within 9 months of the effective date of the coastal development permit for the CDP, the permittee shall submit the proposed site(s) and preliminary wetland restoration plan to the Commission <u>and the Regional Board</u> for their review and approval or disapproval.
	"Other sites proposed by the permittee may be added to this list with the Executive Director's approval."	Other sites proposed by the permittee may be added to this list with the Executive Director's <u>and Executive Officer's</u> approval.

MLMP Section	Coastal Commission Authority	Regional Board's Corresponding Authority
3.0 Plan Requirements	"In consultation with Commission staff, the permittee shall develop a wetland restoration plan for the wetland site(s) identified through the site selection process."	In consultation with Commission staff and Regional Board staff, the permittee shall develop a wetland restoration plan for the wetland site(s) identified through the site selection process.
4.1 Coastal Development Permit Applications	"The Executive Director may grant an extension to these time periods [for submittal of coastal development applications] at the request of and upon demonstration of good cause by the permittee."	The Executive Officer shall recognize any such extension.
4.3 Timeframe for Resubmittal of Project Elements	"If the Commission does not approve any element of the project (i.e. site selection, restoration plan), the Commission will specify the time limits for compliance relative to selection of another site or revisions to the restoration plan."	If the Commission and the Regional Board do not approve any element of the project (i.e. site selection, restoration plan), the Commission, in concert with the Regional Board, will specify the time limits for compliance relative to selection of another site or revisions to the restoration plan. The Regional Board shall recognize, and shall act consistently with, any such time limits.
5.0 Wetland Monitoring, Management and Remediation	"A monitoring and management plan will be developed in consultation with the permittee and appropriate wildlife agencies, concurrently with the preparation of the restoration plan to provide an overall framework to guide the monitoring work."	No change.
5.4	"Upon completion of construction of the wetland(s), monitoring shall be conducted to measure the success of the wetland(s) in achieving stated restoration goals (as specified in the restoration plan(s)) and in achieving performance standards, specified below. The permittee shall be fully responsible for any failure to meet these goals and standards during the facility's full operational years. Upon	Upon completion of construction of the wetland(s), monitoring shall be conducted to measure the success of the wetland(s) in achieving stated restoration goals (as specified in the restoration plan(s)) and in achieving performance standards, specified below. The permittee shall be fully responsible for any failure to meet these goals and standards during the facility's full operational years. Upon

MLMP Section	Coastal Commission Authority	Regional Board's Corresponding Authority
	determining that the goals or standards are not achieved, the Executive Director shall prescribe remedial measures, after consultation with the permittee, which shall be immediately implemented by the permittee with Commission staff direction. If the permittee does not agree that remediation is necessary, the matter may be set for hearing and disposition by the Commission."	determining that the goals or standards are not achieved, the Executive Director or the Executive Officer shall prescribe remedial measures, after consultation with each other and the permittee, which shall be immediately implemented by the permittee with Commission staff direction. If the permittee does not agree that remediation is necessary, the matter may be set for hearing and disposition by the Commission or the Regional Board or both, as determined by the Executive Director and Executive Officer."
Condition B: Administrative Structure Section 1.0 Administration	"Personnel with appropriate scientific or technical training and skills will, under the direction of the Executive Director, oversee the mitigation and monitoring functions identified and required by Condition A. The Executive Director will retain scientific and administrative support staff needed to perform this function, as specified in the work program. "This technical staff will oversee the preconstruction and post-construction site assessments, mitigation project design and implementation (conducted by permittee), and monitoring activities (including plan preparation); the field work will be done by contractors under the Executive Director's direction. The contractors will be responsible for collecting the data, analyzing and interpreting it, and reporting to the Executive Director. "The Executive Director shall convene a Scientific Advisory Panel to provide the Executive Director	"Personnel with appropriate scientific or technical training and skills will, under the direction of the Executive Director, and in coordination with Regional Board staff, oversee the mitigation and monitoring functions identified and required by Condition A. The Executive Director will retain scientific and administrative support staff needed to perform this function, as specified in the work program. "This technical staff will oversee the preconstruction and post-construction site assessments, mitigation project design and implementation (conducted by permittee), and monitoring activities (including plan preparation); the field work will be done by contractors under the Executive Director's direction. The contractors will be responsible for collecting the data, analyzing and interpreting it, and reporting to the Executive Director. "The Executive Director shall convene a Scientific Advisory Panel to provide the Executive Director and the

MLMP Section	**Coastal Commission Authority**	**Regional Board's Corresponding Authority**
	with scientific advice on the design, implementation and monitoring of the wetland restoration. The panel shall consist of recognized scientists, including a marine biologist, an ecologist, a statistician and a physical scientist."	Executive Officer with scientific advice on the design, implementation and monitoring of the wetland restoration. The panel shall consist of recognized scientists, including a marine biologist, an ecologist, a statistician and a physical scientist."
Section 2.0 Budget and Work Program	"The funding necessary for the Commission and the Executive Director to perform their responsibilities pursuant to these conditions will be provided by the permittee in a form and manner reasonably determined by the Executive Director to be consistent with requirements of State law, and which will ensure efficiency and minimize total costs to the permittee. The amount of funding will be determined by the Commission on a biennial basis and will be based on a proposed budget and work program, which will be prepared by the Executive Director in consultation with the permittee, and reviewed and approved by the Commission in conjunction with its review of the restoration plan. If the permittee and the Executive Director cannot agree on the budget or work program, the disagreement will be submitted to the Commission for resolution. The budget to be funded by the permittee will be for the purpose of reasonable and necessary costs to retain personnel with appropriate scientific or technical training and skills needed to assist the Commission and the Executive Director in carrying out the mitigation and lost resource compensation conditions. In addition, reasonable	The funding necessary for the Commission and the Executive Director, and the Regional Board and the Executive Officer, to perform their responsibilities pursuant to these conditions will be provided by the permittee in a form and manner reasonably determined by the Executive Director and the Executive Officer to be consistent with requirements of State law, and which will ensure efficiency and minimize total costs to the permittee. The amount of funding will be determined by each of the Commission and the Regional Board on a biennial basis and will be based on a proposed budget and work program, which will be prepared by the Executive Director and Executive Officer in consultation with the permittee, and reviewed and approved by the Commission and the Regional Board in conjunction with their respective reviews of the restoration plan. If the permittee and the Executive Director cannot agree on the budget or work program, the disagreement will be submitted to the Commission for resolution. If the permittee and the Executive Officer cannot agree on the budget or work program, the disagreement will be submitted to the Regional Board for resolution. The budget to be funded by the

MLMP Section	Coastal Commission Authority	Regional Board's Corresponding Authority
	funding will be included in this budget for necessary support personnel, equipment, overhead, consultants, the retention of contractors needed to conduct identified studies, and to defray the costs of members of any scientific advisory panel(s) convened by the Executive Director for the purpose of implementing these conditions. Costs for participation on any advisory panel shall be limited to travel, per diem, meeting time and reasonable preparation time and shall only be paid to the extent the participant is not otherwise entitled to reimbursement for such participation and preparation. The amount of funding will be determined by the Commission on a biennial basis and will be based on a proposed budget and work program, which will be prepared by the Executive Director in consultation with the permittee, and reviewed and approved by the Commission in conjunction with its review of the restoration plan. If the permittee and the Executive Director cannot agree on the budget or work program, the disagreement will be submitted to the Commission for resolution. Total costs for such advisory panel shall not exceed $100,000 per year adjusted annually by any increase in the consumer price index applicable to California. The work program will include: a. A description of the studies to be conducted over the subsequent two year period, including the	permittee will be for the purpose of reasonable and necessary costs to retain personnel with appropriate scientific or technical training and skills needed to assist the Commission and the Executive Director, and the Regional Board and the Executive Officer, in carrying out the mitigation and lost resource compensation conditions. In addition, reasonable funding will be included in this budget for necessary support personnel, equipment, overhead, consultants, the retention of contractors needed to conduct identified studies, and to defray the costs of members of any scientific advisory panel(s) convened by the Executive Director for the purpose of implementing these conditions. The Executive Officer may offer comment to the Executive Director regarding the scientific advisory panel(s), but will not convene a science panel in addition to that panel convened by the Executive Director. No additional corresponding authority.

MLMP Section	Coastal Commission Authority	Regional Board's Corresponding Authority
	number and distribution of sampling stations and samples per station, methodology and statistical analysis (including the standard of comparison to be used in comparing the mitigation project to the reference sites); b. A description of the status of the mitigation projects, and a summary of the results of the monitoring studies to that point; c. A description of four reference sites; d. A description of the performance standards that have been met, and those that have yet to be achieved; e. A description of remedial measures or other necessary site interventions; f. A description of staffing and contracting requirements; and, g. A description of the Scientific Advisory Panel's role and time requirements in the two year period. The Executive Director may amend the work program at any time, subject to appeal to the Commission."	
3.0 Annual Review and Public Workshop Review	"The permittee shall submit a written review of the status of the mitigation project to the Executive Director no later than April 30 each year for the prior calendar year. The written review will discuss the previous year's activities and overall status of the mitigation project, identify	The permittee shall submit a written review of the status of the mitigation project to the Executive Director <u>and the Executive Officer</u> no later than April 30 each year for the prior calendar year. The written review will discuss the previous year's activities and overall status of the mitigation

MLMP Section	Coastal Commission Authority	Regional Board's Corresponding Authority
	problems and make recommendations for solving them, and review the next year's program. To review the status of the mitigation project, the Executive Director will convene and conduct a duly noticed public workshop during the first year of the project and every other year thereafter unless the Executive Director deems it unnecessary. The meeting will be attended by the contractors who are conducting the monitoring, appropriate members of the Scientific Advisory Panel, the permittee, Commission staff, representatives of the resource agencies (CDFG, NMFS, USFWS), and the public. Commission staff and the contractors will give presentations on the previous biennial work program's activities**,** overall status of the mitigation project, identify problems and make recommendations for solving them, and review the next upcoming period's biennial work program. The public review will include discussions on whether the wetland mitigation project has met the performance standards, identified problems, and recommendations relative to corrective measures necessary to meet the performance standards. The Executive Director will use information presented at the public review, as well as any other relevant information, to determine whether any or all of the performance standards have been met, whether revisions to the standards are necessary, and whether remediation is required. Major revisions shall be	project, identify problems and make recommendations for solving them, and review the next year's program. To review the status of the mitigation project, the Executive Director and Executive Officer will convene and conduct a duly noticed public workshop during the first year of the project and every other year thereafter unless the Executive Director and Executive Officer deem it unnecessary. The meeting will be attended by the contractors who are conducting the monitoring, appropriate members of the Scientific Advisory Panel, the permittee, Commission staff, Regional Board staff, representatives of the resource agencies (CDFG, NMFS, USFWS), and the public. Commission staff and the contractors will give presentations on the previous biennial work program's activities**,** overall status of the mitigation project, identify problems and make recommendations for solving them, and review the next upcoming period's biennial work program. The public review will include discussions on whether the wetland mitigation project has met the performance standards, identified problems, and recommendations relative to corrective measures necessary to meet the performance standards. The Executive Director and Executive Officer will use information presented at the public review, as well as any other relevant information, to determine whether any or all of the performance standards have been met, whether revisions to the standards are necessary, and whether remediation is

MLMP Section	Coastal Commission Authority	Regional Board's Corresponding Authority
	subject to the Commission's review and approval. The mitigation project will be successful when all performance standards have been met each year for a three-year period. The Executive Director shall report to the Commission upon determining that all of the performance standards have been met for three years and that the project is deemed successful. If the Commission determines that the performance standards have been met and the project is successful, the monitoring program will be scaled down, as recommended by the Executive Director and approved by the Commission. A public review shall thereafter occur every five years, or sooner if called for by the Executive Director. The work program shall reflect the lower level of monitoring required. If subsequent monitoring shows that a standard is no longer being met, monitoring may be increased to previous levels, as determined necessary by the Executive Director. The Executive Director may make a determination on the success or failure to meet the performance standards or necessary remediation and related monitoring at any time, not just at the time of the workshop review."	required. Major revisions shall be subject to the Commission's and Regional Board's review and approval. The mitigation project will be successful when all performance standards have been met each year for a three-year period. The Executive Director shall report to the Commission upon determining that all of the performance standards have been met for three years and that the project is deemed successful. The Executive Officer shall similarly report to the Regional Board; in making his report, the Executive Officer may rely upon the Executive Director's report. If the Commission and the Executive Officer determine that the performance standards have been met and the project is successful, the monitoring program will be scaled down, as recommended by the Executive Director and approved by the Commission. A public review shall thereafter occur every five years, or sooner if called for by the Executive Director or the Executive Officer. The work program shall reflect the lower level of monitoring required. If subsequent monitoring shows that a standard is no longer being met, monitoring may be increased to previous levels, as determined necessary by the Executive Director. The Executive Director and the Executive Officer may make a determination on the success or failure to meet the performance standards or necessary remediation and related monitoring at any time, not just at the time of the workshop review.

MLMP Section	Coastal Commission Authority	Regional Board's Corresponding Authority
4.1 Dispute Resolution	"In the event that the permittee and the Executive Director cannot reach agreement regarding the terms contained in or the implementation of any part of this Plan, the matter may be set for hearing and disposition by the Commission."	In the event that the permittee and the Executive Director cannot reach agreement regarding the terms contained in or the implementation of any part of this Plan, the matter may be set for hearing and disposition by the Commission. In the event that the permittee and the Executive Officer cannot reach agreement regarding the terms contained in or the implementation of any part of this Plan, the matter may be set for hearing and disposition by the Regional Board.
4.2 Time Extensions	"Any of the time limits established under this Plan may be extended by the Executive Director at the request of the permittee and upon a showing of good cause."	The Executive Officer may provide timely comment to the Executive Director on any such time limits, and shall recognize any time limits extended by the Executive Director.
Condition C: SAP Maintenance	"The permittee shall make available on a publicly-accessible website all scientific data collected as part of the project. The website and the presentation of data shall be subject to Executive Director review and approval."	The permittee shall make available on a publicly-accessible website all scientific data collected as part of the project. The website and the presentation of data shall be subject to the review and approval of the Executive Director and the Executive Officer.

6.7 CONCLUSION

As described in the preceding sections, the mitigation measures of the MLMP are expected to result in biological productively that will offset the potential intake and mortality of marine life from the stand-alone operations of the CDP. The offsetting benefits to marine life associated with the MLMP fully minimize intake and mortality. In fact, with full implementation of the MLMP, a net positive production of marine life is anticipated, underscoring the efficacy of the proposed mitigation measures. In other words, while the CDP has the potential to cause impingement and entrainment, this potential is more than offset by the reasonably anticipated biological productivity of the planned mitigation wetlands.

Compliance with the MLMP will be enforced by the Regional Board and the Coastal Commission as provided in Section 6.6.[9] Thus, Poseidon has met its burden under Water Code Section 13142.5(b) to minimize intake and mortality from the proposed CDP and has incorporated mitigation measures into its project that satisfy this statute fully. In sum, the site, design, technology, and mitigation measures proposed in this Plan represent a balanced approach to minimizing the potential for intake and mortality from the CDP under stand-alone operations, and individually and collectively satisfy the obligation under Section 13142.5(b) to employ best available and feasible measures to minimize such effects.

[9] The MLMP will also be enforced by the State Lands Commission under the terms of the lease for the intake system. State Lands Commission, Amendment of Lease PRC 8727.1., ¶¶ 11-24.

Part A

Marine Life Mitigation Plan

Submitted to the Regional Board November 14, 2008

POSEIDON RESOURCES MARINE LIFE MITIGATION PLAN

INTRODUCTION

Poseidon's Carlsbad desalination facility will be co-located with the Encina Power Station and will use the power plant's once-through cooling intake and outfall structures. The desalination facility is expected to use about 304 million gallons per day (mgd) of estuarine water drawn through the structure. The facility will operate both when the power plant is using its once-through cooling system and when it is not.

This Marine Life Mitigation Plan (the Plan) will result in mitigation necessary to address the entrainment impacts caused by the facility's use of estuarine water. The Plan includes two phases of mitigation – Poseidon is required during Phase I to provide at least 37 acres of estuarine wetland restoration, as described below. In Phase II, Poseidon is required to provide an additional 18.4 acres of estuarine wetland restoration. However, as described below, Poseidon may choose to provide all 55.4 acres of restoration during Phase I. Poseidon may also choose during Phase II to apply for a CDP to reduce or eliminate the required 18.4 acres of mitigation and instead conduct alternative mitigation by implementing new entrainment reduction technology or obtaining mitigation credit for conducting dredging.

CONDITION A: WETLAND RESTORATION MITIGATION

The permittee shall develop, implement and fund a wetland restoration project that compensates for marine life impacts from Poseidon's Carlsbad desalination facility.

1.0 PHASED IMPLEMENTATION

Phase I: Poseidon is to provide at least 37 acres of estuarine wetland restoration. Within two years of issuance of the desalination facility's coastal development permit (CDP), Poseidon is to submit a complete CDP application for a proposed restoration project, as described below.

Phase II: Poseidon is to provide an additional 18.4 acres of estuarine wetland restoration. Within five years of issuance of the Phase I CDP, Poseidon is to submit a complete CDP application proposing up to 18.4 acres of additional restoration, subject to reduction as described below.

2.0 SITE SELECTION

In consultation with Commission staff, the permittee shall select a wetland restoration site or sites for mitigation in accordance with the following process and terms.

Within 9 months of the effective date of this permit, the permittee shall submit the proposed site(s) and preliminary wetland restoration plan to the Commission for its review and approval or disapproval.

The location of the wetland restoration project(s) shall be within the Southern California Bight. The permittee shall select from sites including, but not limited to, the following eleven sites:

Tijuana Estuary in San Diego County; San Dieguito River Valley in San Diego County; Agua Hedionda Lagoon in San Diego County; San Elijo Lagoon in San Diego County; Buena Vista Lagoon in San Diego County; Huntington Beach Wetland in Orange County, Anaheim Bay in Orange County, Santa Ana River in Orange County, Los Cerritos Wetland in Los Angeles County, Ballona Wetland in Los Angeles County, and Ormond Beach in Ventura County. The permittee may also consider any sites that may be recommended by the California Department of Fish & Game as high priority wetlands restoration projects. Other sites proposed by the permittee may be added to this list with the Executive Director's approval.

The basis for the selection shall be an evaluation of the site(s) against the minimum standards and objectives set forth in subsections 3.1 and 3.2 below. The permittee shall take into account and give serious consideration to the advice and recommendations of the Scientific Advisory Panel (SAP) established and convened by the Executive Director pursuant to Condition B.1.0. The permittee shall select the site(s) that meet~~s~~ the minimum standards and best meet~~s~~ the objectives.

3.0 PLAN REQUIREMENTS

In consultation with Commission staff, the permittee shall develop a wetland restoration plan for the wetland site(s) identified through the site selection process. The wetland restoration plan shall meet the minimum standards and incorporate as many as feasible of the objectives in subsections 3.1 and 3.2, respectively.

3.1 Minimum Standards

The wetland restoration project site(s) and preliminary plan(s) must meet the following minimum standards:

a. Location within Southern California Bight;

b. Potential for restoration as tidal wetland, with extensive intertidal and subtidal areas;

c. Creates or substantially restores a minimum of 37 acres and up to at least 55.4 acres of habitat similar to the affected habitats in Agua Hedionda Lagoon, excluding buffer zone and upland transition area;

d. Provides a buffer zone of a size adequate to ensure protection of wetland values, and at least 100 feet wide, as measured from the upland edge of the transition area.

e. Any existing site contamination problems would be controlled or remediated and would not hinder restoration;

f. Site preservation is guaranteed in perpetuity (through appropriate public agency or nonprofit ownership, or other means approved by the Executive Director), to protect against future degradation or incompatible land use;

g. Feasible methods are available to protect the long-term wetland values on the site(s), in perpetuity;

h. Does not result in a net loss of existing wetlands; and

i. Does not result in an adverse impact on endangered animal species or an adverse unmitigated impact on endangered plant species.

3.2 Objectives

The following objectives represent the factors that will contribute to the overall value of the wetland. The selected site(s) shall be determined to achieve these objectives. These objectives shall also guide preparation of the restoration plan.

a. Provides maximum overall ecosystem benefits, e.g. maximum upland buffer, enhancement of downstream fish values, provides regionally scarce habitat, potential for local ecosystem diversity;

b. Provides substantial fish habitat compatible with other wetland values at the site(s);

c. Provides a buffer zone of an average of at least 300 feet wide, and not less than 100 feet wide, as measured from the upland edge of the transition area.

d. Provides maximum upland transition areas (in addition to buffer zones);

e. Restoration involves minimum adverse impacts on existing functioning wetlands and other sensitive habitats;

f. Site selection and restoration plan reflect a consideration of site specific and regional wetland restoration goals;

g. Restoration design is that most likely to produce and support wetland-dependent resources;

h. Provides rare or endangered species habitat;

i. Provides for restoration of reproductively isolated populations of native California species;

j. Results in an increase in the aggregate acreage of wetland in the Southern California Bight;

k. Requires minimum maintenance;

l. Restoration project can be accomplished in a reasonably timely fashion; and,

m. Site(s) in proximity to the Carlsbad desalination facility.

3.3 Restrictions

a. The permittee may propose a wetland restoration project larger than the minimum necessary size specified in subsection 3.1(c) above, if biologically appropriate for the site(s), but the additional acreage must (1) be clearly identified, and (2) must not be the portion of the project best satisfying the standards and objectives listed above.

b. If the permittee jointly enters into a restoration project with another party: (1) the permittee's portion of the project must be clearly specified, (2) any other party involved cannot gain mitigation credit for the permittee's portion of the project, and (3) the permittee may not receive mitigation credit for the other party's portion of the project.

c. The permittee may propose to divide the mitigation requirement between a maximum of two wetland restoration sites, unless there is a compelling argument, approved by the Executive Director, that the standards and objectives of subsections 3.1 and 3.2 will be better met at more than two sites.

4.0 PLAN IMPLEMENTATION

4.1 Coastal Development Permit Applications

The permittee shall submit complete Coastal Development Permit applications for the Phase I and Phase II restoration plan(s) that shall include CEQA documentation and local or other state agency approvals. The CDP application for Phase I shall be submitted within 24 months following the issuance of the Coastal Development Permit for the Carlsbad desalination facility. The CDP application for Phase II shall be submitted within 5 years of issuance of the CDP for Phase I. The Executive Director may grant an extension to these time periods at the request of and upon a demonstration of good cause by the permittee. The restoration plans shall substantially conform to Section 3.0 above and shall include, but not be limited to the following elements:

a. Detailed review of existing physical, biological, and hydrological conditions; ownership, land use and regulation;

b. Evaluation of site-specific and regional restoration goals and compatibility with the goal of mitigating for Poseidon's marine life impacts;

c. Identification of site opportunities and constraints;

d. Schematic restoration design, including:

    1. Proposed cut and fill, water control structures, control measures for stormwater, buffers and transition areas, management and maintenance requirements;
    2. Planting program, including removal of exotic species, sources of plants and or seeds (local, if possible), protection of existing salt marsh plants, methods for preserving top soil and augmenting soils with nitrogen and other necessary soil amendments before

planting, timing of planting, plans for irrigation until established, and location of planting and elevations on the topographic drawings;
3. Proposed habitat types (including approximate size and location);
4. Assessment of significant impacts of design (especially on existing habitat values) and net habitat benefits;
5. Location, alignment and specifications for public access facilities, if feasible;
6. Evaluation of steps for implementation e.g. permits and approvals, development agreements, acquisition of property rights;
7. Cost estimates;
8. Topographic drawings for final restoration plan at 1" = 100 foot scale, one foot contour interval; and
9. Drawings shall be directly translatable into final working drawings.

g. Detailed information about how monitoring and maintenance will be implemented;

h. Detailed information about construction methods to be used;

i. Defined final success criteria for each habitat type and methods to be used to determine success;

j. Detailed information about how Poseidon will coordinate with the Scientific Advisory Panel including its role in independent monitoring, contingency planning review, cost recovery, etc.;

k. Detailed information about contingency measures that will be implemented if mitigation does not meet the approved goals, objectives, performance standards, or other criteria; and,

l. Submittal of "as-built" plans showing final grading, planting, hydrological features, etc. within 60 days of completing initial mitigation site construction.

4.2 Wetland Construction Phase

Within 6 months of approval of the Phase I restoration plan, subject to the permittee's obtaining the necessary permits, the permittee shall commence the construction phase of the wetland restoration project. The permittee shall be responsible for ensuring that construction is carried out in accordance with the specifications and within the timeframes specified in the approved final restoration plan and shall be responsible for any remedial work or other intervention necessary to comply with final plan requirements.

4.3 Timeframe for Resubmittal of Project Elements

If the Commission does not approve any element of the project (i.e. site selection, restoration plan), the Commission will specify the time limits for compliance relative to selection of another site or revisions to the restoration plan.

5.0 WETLAND MONITORING, MANAGEMENT AND REMEDIATION

Monitoring, management (including maintenance), and remediation shall be conducted over the "full operating life" of Poseidon's desalination facility, which shall be 30 years from the date "as-built" plans are submitted pursuant to subsection 4.1(1).

The following section describes the basic tasks required for monitoring, management and remediation. Condition B specifies the administrative structure for carrying out these tasks, including the roles of the permittee and Commission staff.

5.1 Monitoring and Management Plan

A monitoring and management plan will be developed in consultation with the permittee and appropriate wildlife agencies, concurrently with the preparation of the restoration plan to provide an overall framework to guide the monitoring work. It will include an overall description of the studies to be conducted over the course of the monitoring program and a description of management tasks that are anticipated, such as trash removal. Details of the monitoring studies and management tasks will be set forth in a work program (see Condition B).

5.2 Pre-restoration site monitoring

Pre-restoration site monitoring shall be conducted to collect baseline data on the wetland attributes to be monitored. This information will be incorporated into and may result in modification to the overall monitoring plan.

5.3 Construction Monitoring

Monitoring shall be conducted during and immediately after each stage of construction of the wetland restoration project to ensure that the work is conducted according to plans.

5.4 Post-Restoration Monitoring and Remediation

Upon completion of construction of the wetland(s), monitoring shall be conducted to measure the success of the wetland(s) in achieving stated restoration goals (as specified in the restoration plan(s)) and in achieving performance standards, specified below. The permittee shall be fully responsible for any failure to meet these goals and standards during the facility's full operational years. Upon determining that the goals or standards are not achieved, the Executive Director shall prescribe remedial measures, after consultation with the permittee, which shall be immediately implemented by the permittee with Commission staff direction. If the permittee does not agree that remediation is necessary, the matter may be set for hearing and disposition by the Commission.

Successful achievement of the performance standards shall (in some cases) be measured relative to approximately four reference sites, which shall be relatively undisturbed, natural tidal wetlands within the Southern California Bight. The Executive Director shall select the reference sites. The standard of comparison, i.e., the measure of similarity to be used (e.g., within the range, or within the 95% confidence interval) shall be specified in the work program.

In measuring the performance of the wetland project, the following physical and biological performance standards will be used:

a. **Longterm Physical Standards.** The following long-term standards shall be maintained over the full operative life of the desalination facility:

   1. ***Topography.*** The wetland(s) shall not undergo major topographic degradation (such as excessive erosion or sedimentation);
   2. ***Water Quality.*** Water quality variables [to be specified] shall be similar to reference wetlands;
   3. ***Tidal prism.*** If the mitigation site(s) require dredging, the tidal prism shall be maintained and tidal flushing shall not be interrupted; and,
   4. ***Habitat Areas.*** The area of different habitats shall not vary by more than 10% from the areas indicated in the restoration plan(s).

b. **Biological Performance Standards.** The following biological performance standards shall be used to determine whether the restoration project is successful. Table 1, below, indicates suggested sampling locations for each of the following biological attributes; actual locations will be specified in the work program:

   1. ***Biological Communities.*** Within 4 years of construction, the total densities and number of species of fish, macroinvertebrates and birds (see Table 1) shall be similar to the densities and number of species in similar habitats in the reference wetlands;
   2. ***Vegetation.*** The proportion of total vegetation cover and open space in the marsh shall be similar to those proportions found in the reference sites. The percent cover of algae shall be similar to the percent cover found in the reference sites;
   3. ***Spartina Canopy Architecture.*** The restored wetland shall have a canopy architecture that is similar in distribution to the reference sites, with an equivalent proportion of stems over 3 feet tall;
   4. ***Reproductive Success.*** Certain plant species, as specified by in the work program, shall have demonstrated reproduction (i.e. seed set) at least once in three years;
   5. ***Food Chain Support.*** The food chain support provided to birds shall be similar to that provided by the reference sites, as determined by feeding activity of the birds; and
   6. ***Exotics.*** The important functions of the wetland shall not be impaired by exotic species.

Table 1: Suggested Sampling Locations

	Salt Marsh			Open Water			Tidal
	Spartina	Salicornia	Upper	Lagoon	Eelgrass	Mudflat	Creeks
1) Density/spp:							
– Fish				X	X	X	X
– Macroinvert-				X	X	X	X

ebrates							
– Birds	X	X	X	X		X	X
2) % Cover							
Vegetation	X	X	X		X		
algae	X	X				X	
3) Spartina architecture	X						
4) Reproductive success	X	X	X				
5) Bird feeding				X		X	X
6) Exotics	X	X	X	X	X	X	X

6.0 ALTERNATIVE MITIGATION

As part of Phase II, Poseidon may propose in its CDP application alternatives to reduce or eliminate the required 18.4 acres of mitigation. The alternative mitigation proposed may be in the form of implementing new entrainment reduction technology or may be mitigation credits for conducting dredging, either of which could reduce or eliminate the 18.4 acres of mitigation.

CONDITION B: ADMINISTRATIVE STRUCTURE

1.0 ADMINISTRATION

Personnel with appropriate scientific or technical training and skills will, under the direction of the Executive Director, oversee the mitigation and monitoring functions identified and required by Condition A. The Executive Director will retain scientific and administrative support staff needed to perform this function, as specified in the work program.

This technical staff will oversee the preconstruction and post-construction site assessments, mitigation project design and implementation (conducted by permittee), and monitoring activities (including plan preparation); the field work will be done by contractors under the Executive Director's direction. The contractors will be responsible for collecting the data, analyzing and interpreting it, and reporting to the Executive Director.

The Executive Director shall convene a Scientific Advisory Panel to provide the Executive Director with scientific advice on the design, implementation and monitoring of the wetland restoration. The panel shall consist of recognized scientists, including a marine biologist, an ecologist, a statistician and a physical scientist.

2.0 BUDGET AND WORK PROGRAM

The funding necessary for the Commission and the Executive Director to perform their responsibilities pursuant to these conditions will be provided by the permittee in a form and manner reasonably determined by the Executive Director to be consistent with requirements of State law, and which will ensure efficiency and minimize total costs to the permittee. The amount of funding will be determined by the Commission on a biennial basis and will be based on a proposed budget and work program, which will be prepared by the Executive Director in consultation with the permittee, and reviewed and approved by the Commission in conjunction with its review of the restoration plan. If the permittee and the Executive Director cannot agree on the budget or work program, the disagreement will be submitted to the Commission for resolution.

The budget to be funded by the permittee will be for the purpose of reasonable and necessary costs to retain personnel with appropriate scientific or technical training and skills needed to assist the Commission and the Executive Director in carrying out the mitigation and lost resource compensation conditions. In addition, reasonable funding will be included in this budget for necessary support personnel, equipment, overhead, consultants, the retention of contractors needed to conduct identified studies, and to defray the costs of members of any scientific advisory panel(s) convened by the Executive Director for the purpose of implementing these conditions.

Costs for participation on any advisory panel shall be limited to travel, per diem, meeting time and reasonable preparation time and shall only be paid to the extent the participant is not otherwise entitled to reimbursement for such participation and preparation. The amount of funding will be determined by the Commission on a biennial basis and will be based on a proposed budget and work program, which will be prepared by the Executive Director in consultation with the permittee, and reviewed and approved by the Commission in conjunction with its review of the restoration plan. If the permittee and the Executive Director cannot agree on the budget or work program, the disagreement will be submitted to the Commission for resolution. Total costs for such advisory panel shall not exceed $100,000 per year adjusted annually by any increase in the consumer price index applicable to California.

The work program will include:

h. A description of the studies to be conducted over the subsequent two year period, including the number and distribution of sampling stations and samples per station, methodology and statistical analysis (including the standard of comparison to be used in comparing the mitigation project to the reference sites);

i. A description of the status of the mitigation projects, and a summary of the results of the monitoring studies to that point;

j. A description of four reference sites;

k. A description of the performance standards that have been met, and those that have yet to be achieved;

l. A description of remedial measures or other necessary site interventions;

m. A description of staffing and contracting requirements; and,

n. A description of the Scientific Advisory Panel's role and time requirements in the two year period.

The Executive Director may amend the work program at any time, subject to appeal to the Commission.

3.0 ANNUAL REVIEW AND PUBLIC WORKSHOP REVIEW

The permittee shall submit a written review of the status of the mitigation project to the Executive Director no later than April 30 each year for the prior calendar year. The written review will discuss the previous year's activities and overall status of the mitigation project, identify problems and make recommendations for solving them, and review the next year's program.

To review the status of the mitigation project, the Executive Director will convene and conduct a duly noticed public workshop during the first year of the project and every other year thereafter unless the Executive Director deems it unnecessary. The meeting will be attended by the contractors who are conducting the monitoring, appropriate members of the Scientific Advisory Panel, the permittee, Commission staff, representatives of the resource agencies (CDFG, NMFS, USFWS), and the public. Commission staff and the contractors will give presentations on the previous biennial work program's activities**,** overall status of the mitigation project, identify problems and make recommendations for solving them, and review the next upcoming period's biennial work program.

The public review will include discussions on whether the wetland mitigation project has met the performance standards, identified problems, and recommendations relative to corrective measures necessary to meet the performance standards. The Executive Director will use information presented at the public review, as well as any other relevant information, to determine whether any or all of the performance standards have been met, whether revisions to the standards are necessary, and whether remediation is required. Major revisions shall be subject to the Commission's review and approval.

The mitigation project will be successful when all performance standards have been met each year for a three-year period. The Executive Director shall report to the Commission upon determining that all of the performance standards have been met for three years and that the project is deemed successful. If the Commission determines that the performance standards have been met and the project is successful, the monitoring program will be scaled down, as recommended by the Executive Director and approved by the Commission. A public review shall thereafter occur every five years, or sooner if called for by the Executive Director. The work program shall reflect the lower level of monitoring required. If subsequent monitoring shows that a standard is no longer being met, monitoring may be increased to previous levels, as determined necessary by the Executive Director.

The Executive Director may make a determination on the success or failure to meet the performance standards or necessary remediation and related monitoring at any time, not just at the time of the workshop review.

4.0 ADDITIONAL PROCEDURES

4.1 Dispute Resolution

In the event that the permittee and the Executive Director cannot reach agreement regarding the terms contained in or the implementation of any part of this Plan, the matter may be set for hearing and disposition by the Commission.

4.2 Extensions

Any of the time limits established under this Plan may be extended by the Executive Director at the request of the permittee and upon a showing of good cause.

CONDITION C: SAP DATA MAINTENANCE

The permittee shall make available on a publicly-accessible website all scientific data collected as part of the project. The website and the presentation of data shall be subject to Executive Director review and approval.

PART B: MLMP'S 11 IDENTIFIED SITES

TIJUANA ESTUARY

Tijuana Estuary is located in the extreme southwestern corner of the U.S. in San Diego County (Figure 1). Wetland restoration planning and implementation at Tijuana Estuary has been ongoing for over 20 years, beginning in 1986 with a 495-acre restoration plan for the south arm of the estuary funded by the California Coastal Conservancy. In 2003, the Coastal Conservancy funded a renewed look at restoration of the south arm. Completed in 2008, the Tijuana Estuary-Friendship Marsh Restoration Feasibility and Design Study (Tierra Environmental Services March 2008) identified approximately 250 acres of restored tidal wetlands. Restoration was planned in phases dependent upon funding. Phase 1 includes 39 acres; Phase 2 - 37.2 acres; Phase 3 - 74.9 acres; Phase 4- 31.7 acres; and Phase 5 – 67.3 acres.

An EIR will be required for the project. To date no action has been taken regarding preparation of an EIR. In addition, a number of discretionary permits are required for the project, including, but not limited to, a U.S. Army Corps of Engineers Section 404 permit and a California Coastal Commission Coastal Development Permit. To date, no action has been taken on permit acquisition.

SAN DIEGUITO RIVER VALLEY

San Dieguito Lagoon is located in the City of Del Mar at the terminus of the San Dieguito River (Figure 1). Wetland restoration planning at San Dieguito Lagoon has been on-going since the late 1970s when the City of Del Mar and the California Coastal Conservancy prepared a plan for revitalizing and managing the lagoon and surrounding areas. In the 1991, the California Coastal Commission adopted new operating conditions for the San Onofre Nuclear Generating Station (SONGS) Units 2 and 3 operated by Southern California Edison (SCE). These conditions required SCE to restore 150 acres of tidal wetland as mitigation for impacts to the marine environment from operation of SONGS units 2 and 3. In 2000, the San Dieguito Wetland Restoration EIR/EIS was competed. That document was based on the final Coastal Commission conditions that SCE submit a plan for a total of 150 acres of credit, including creation or substantial restoration of 115 acres of tidal wetland with up to 35 acres credit for perpetual maintenance of the tidal inlet of the lagoon. SCE began construction of the restoration project in 2006.

In 2007, Poseidon Resources identified San Diegutio Lagoon as a potential site to mitigate for impacts to the marine environment from the proposed operation of its Carlsbad Desalination Plant in Carlsbad, California. Conceptual plans for approximately 42 acres of tidal wetland creation were developed and submitted to the Coastal Commission pursuant to Poseidon's application for a Coastal Development Permit. A project-specific EIR and a number of discretionary permits would be required for Poseidon to accomplish mitigation requirements at San Dieguito Lagoon. To date there has been no action on the environmental document or required permits.

SAN ELIJO LAGOON

San Elijo Lagoon is located in the City of Encinitas at Cardiff-by-the-Sea (Figure 1). In 2001, The City of Encinitas funded the San Elijo Lagoon Inlet Relocation Plan (Coastal Environments 2001) that examined three restoration alternatives, including the infrastructure improvements associated with the tidal inlet, railroad and Highway 101. In 2006, the U.S. Army Corps of Engineers prepared the Encinitas/Solana Beach Shoreline Protection and San Elijo Lagoon Environmental Restoration Feasibility Study which included detailed analysis of a selected restoration for the lagoon. This plan was rejected by the resource agencies for not providing analysis of restoration alternatives to compare to the selected restoration plan. Thus, there is currently no accepted plan for restoration at San Elijo Lagoon.

Any restoration plan for San Elijo Lagoon will require a project-specific EIR and the suite of discretionary permits typical of coastal projects. To date, no action has been taken on these required items.

AQUA HEDIONDA LAGOON

Aqua Hedionda Lagoon is located in the City of Carlsbad at the terminus of Aqua Hedionda and Macario creeks (Figure 1). The majority of the lagoon is owned and maintained by Cabrillo Power II, which operates the 900-megawatt Encina Power Station located on the outer basin of the lagoon. The lagoon was created in the early 1950s to provide the Encina plant with seawater for cooling. Poseidon’s Carlsbad Desalination Plant (CDP) is located at Aqua Hedionda Lagoon with the intent of using Encina cooling water for desalination while Encina continues to operate. The entire 400-acre lagoon was completely re-dredged in 1998-1999 to an average depth of 8 -11 feet.

In August 2007, Poseidon developed a Request for Expressions of Interest which was sent to a number of organizations associated with the Carlsbad Watershed Network in an attempt to identify mitigation opportunities at Aqua Hedionda Lagoon. Three proposals were received as presented below.

1. Expansion of the Aqua Hedionda Lagoon Ecological Reserve. This project includes the acquisition and preservation of land north of the existing Ecological Reserve.
2. Eradication of Invasive Exotic Plants and Restoration with Native Vegetation. This project was proposed by the Aqua Hedionda Lagoon Foundation.
3. Aqua Hedionda Lagoon Abalone Stock Enhancement. This project proposed creation of a 100,000 abalone stock at the Carlsbad Aquafarm and use of this stock to replenish abalone populations near the lagoon.

It was determined that none of the proposed projects meet the goals and objectives of the Coastal Commission. Thus, there is currently no accepted restoration plan for the lagoon.

BUENA VISTA LAGOON

Buena Vista Lagoon is located between the cities of Oceanside and Carlsbad in San Diego County (Figure 1). The lagoon is comprised of four basins as a result of road and railroad crossings. Constriction of tidal flows from these crossing in conjunction with increased sedimentation from upstream sources and decreased water quality has resulted in a degraded freshwater lagoon. A concrete weir built across the ocean inlet in 1972 controls the minimum water level in the lagoon.

The problem of accelerated sedimentation in the lagoon was acknowledged as early as the 1970s. The Southern California Wetland Recovery Project funded the Buena Vista Lagoon Restoration Feasibility Analysis which was completed in 2004 (Everest International Consultants, 2004). The restoration feasibility analysis identified three primary restoration alternatives: the Freshwater Alternative; the Salt Water Alternative; and, the Mixed Water Alternative, with restored tidally influenced wetlands ranging from 0 to 180 acres.

In 2007, the USFWS and CDFG issued a Notice of Intent to prepare an EIS with the Salt Water alternative identified as the preferred alternative and the Freshwater Alternative and Mixed Water Alternative identified as alternatives considered but rejected. A contractor was selected and work on the EIS was initiated; however, work on that document was halted and there is currently no environmental documentation for the proposed restoration.

ANAHEIM BAY

Anaheim bay is located within the city limits of Seal Beach and Huntington Beach in Orange County (Figure 2). There are approximately 956 acres of wetland habitats associated with the Bay, nearly all of them contained within Seal Beach National Wildlife Refuge located within the Seal Beach Naval Weapons Station. In 1990, approximately 116 acres of wetlands adjacent to the Seal Beach National Wildlife Refuge were restored at Anaheim Bay as mitigation for impacts associated with construction of a 147-acre landfill at the Port of Long Beach.

In 2007, the U.S. Fish and Wildlife Service (USFWS) published a Notice of Intent to prepare a Comprehensive Conservation Plan (CCP) for the refuge. The CCP is intended to act as a "blueprint" for management of the Refuge over the next 15 years. In August 2008, the USFWS published an update on the CCP. That update presented three draft alternatives for the CCP:

- Alternative A – No Action;
- Alternative B – Maximum Salt Marsh Restoration, Continue Current Public Use Program;
- Alternative C – Optimize Upland and Wetland restoration, Improve Opportunities for Wildlife Observation (Preferred Alternative).

Under Alternative C, the preferred alternative, approximately 10 acres of coastal sage scrub habitat, 15 acres of wetland/upland transition habitat, and 8 acres of salt marsh would be restored. The update did not detail the tidal condition of the 8-acre restoration. The selection of Alternative C as the preferred alternative is considered a draft decision, subject to a final decision during public review of the draft document. Restoration of eight acres of salt marsh is not sufficient to meet Coastal Commission requirements as stated on November 14, 2008.

SANTA ANA RIVER

The Santa Ana River wetlands are located south of the Huntington Beach wetlands south of the Santa Ana River mouth (Figure 2). The area consists of approximately 170 acres of wetlands situated in four main sites within the greater Santa Ana River wetlands complex. It is estimated that the historic acreage of wetlands at the mouth of the river was 2,900 acres. The site has been degraded by agriculture, oil extraction activities and other human uses.

In 1987, the Marsh Restoration, Lower Santa Ana River Channel, Orange County, California (Simon Li & Associates 1987) was prepared for the U.S. Army Corps of Engineers (USACOE), Los Angeles District. The restoration plan identified three alternative restoration scenarios for a 92-acre portion of the wetlands owned by the USACOE. The restoration was subsequently implemented in 1989 as mitigation for biological impacts associated with the Lower Santa Ana River Improvement Project. In 1991, Orange County adopted an enhancement plan for South Talbert and Fairview/North Talbert parks, renamed Talbert Nature Preserve in 1995. In 1991, the Orange County Environmental Management Agency (OCEMA) developed a draft Local Coastal Plan (LCP) for restoration on land owned by Mobile Oil. OCEMA did complete processing of the LCP.

There have been no official wetland restoration plans formulated for the Santa Ana River Mouth wetlands since the 1990s. Any restoration activity at this site would require extensive study, land acquisition and infrastructure removal (primarily oil extraction infrastructure), detailed engineering, an environmental document and the usual suite of discretionary permits.

HUNTINGTON BEACH WETLANDS

Huntington Beach Wetlands are located between Brookhurst Street and the Santa Ana River along the Pacific Coast Highway in the City of Huntington Beach (Figure 2). Wetland restoration planning at Huntington Beach Wetlands began in the mid 1980s with the inception of the Huntington Beach Wetlands Conservancy (HBWC). The HBWC and the California Coastal Conservancy collaborated on the restoration of the 27-acre Talbert Marsh, a portion of the Huntington Beach Wetlands, in 1990. In 2005, a report entitled Development and Analysis of Restoration Alternatives was prepared for the HBWC and Coastal Conservancy (Moffatt & Nichol et al. 2005). In 2006, the same authors produced the Huntington Beach Wetlands Conceptual Restoration Plan that identified the preferred restoration plan. A Mitigated Negative Declaration (MND) was prepared pursuant to CEQA in December 2007 and was adopted by the County of Orange in January 2008.

Huntington Beach Wetlands consist of Talbert Marsh (27 acre), Brookhurst Marsh (67 acres), Magnolia Marsh, including Upper Marsh (43 acres), and Newland Marsh (54 acres). As stated previously, Talbert Marsh was restored in 1990. Brookhurst Marsh is currently being restored

(Chris Webb, Moffat & Nichol, pers. comm.). Newland Marsh is owned by the California Department of Transportation (Caltrans) and is not currently available for restoration by another entity. Thus, the 43-acre Magnolia Marsh is the only component available for restoration by Poseidon (Chris Webb, Moffat & Nichol, pers. comm.).

An adopted MND exists for the project and seven of eight discretionary permits identified in the Conceptual Restoration Plan have been acquired. Only a County of Orange Flood Control Agency Encroachment Permit remains to be acquired.

BALLONA WETLANDS

Ballona Wetlands, located south of Playa del Rey and east of Jefferson Boulevard (Figure 2), is the last major wetland remaining in Los Angeles County. In 2004, CDFG took title to approximately 540 acres of former wetlands. The State Lands Commission owns approximately 60 acres of created freshwater marsh and muted tidal salt marsh.

In 2005, the California State Coastal Conservancy funded the Ballona Wetlands Restoration Feasibility Study (PWA et al., 2008). This study culminated in the development of five restoration scenarios, ranging from minimal wetland creation coupled with maximum upland restoration to maximum wetland restoration. Maximum wetland restoration would include the removal of Ballona Creek Flood Control Channel, modification of several existing roads, and relocation of pipelines and other infrastructure. The area of tidally-influenced wetland habitat restored varies from approximately 165 to 375 acres.

A project-specific EIR and a number of discretionary permits would be required for restoration at Ballona. To date there has been no action on an environmental document or required permits.

LOS CERRITOS WETLANDS

Los Cerritos Wetlands is a degraded relic wetland area flanking the lower San Gabriel River in Los Angeles County (Figure 2). A number of stakeholders have been involved with restoration planning of the wetlands. In 2005, a conceptual restoration plan for approximately 496 acres at Los Cerritos was prepared by Moffat & Nichol for California Earth Corps, a local stakeholder. The restoration plan includes primarily conceptual-level engineering and hydrology, but does not include analysis of biological resources other resources. The conceptual restoration plan identifies three phases: Phase I (171.9 acres); Phase II (137 acres); and Phase 3 (187.2 acres).

The conceptual plan does not specify acreages of habitats to be created. Of the approximately 496 acres included in the restoration plan, potentially 25% (124 acres) would be restored as subtidal habitat; 55% (273 acres) as intertidal wetlands; and 20% (99) acres a supratidal habitat located above the mean high tide line. However, these numbers are conceptual only. The conceptual plan includes a bridge over the San Gabriel River as well as removal of existing levees and oil extraction infrastructure.

Restoration of Los Cerritos will require additional studies, including refined engineering plans, biological resources impact analysis, preparation of an environmental document, and acquisition of discretionary permits. Acquisition of privately-owned land is fundamental to implementation of the conceptual plan. To date, such acquisition has been an impediment to a unified restoration strategy

ORMOND BEACH

The Ormond Beach Restoration Project is a State Coastal Conservancy-funded project located in Ventura County adjoining the cities of Port Hueneme and Oxnard (Figure 2). Approximately 1,500 acres of Ormond Beach is undeveloped and includes a mix of degraded wetlands, beach and dunes, agriculture, and mixed industry, including an abandoned metals-processing plant and an existing electricity generating plant. A 560-acre duck club with artificially maintained ponds and remnant intertidal habitat exists to the north of Ormond Beach. The goal of the Ormond Beach Restoration Project is the acquisition of 1,100 acres at Ormond Beach and the 560 acres of the duck club for a total restoration of approximately 1,600 acres. While restoration can be accomplished with less than the 1,100 acre goal, the property acquisitions are crucial to reducing total restoration costs and accommodating sea level rise.

To date the Coastal Conservancy has acquired 540 acres at Ormond Beach. Prior to the planned restoration, the Conservancy must acquire 210–340 acres of the Southland Sod Farm. Sale of a portion (210 acres) of this farm has been offered by the owner, contingent upon completion of the City of Oxnard’s Specific Plan for Ormond Beach.

The 50-acre Reliant Power Plant is situated on fill that was formerly coastal lagoon. This parcel divides the proposed restoration in half, obstructing potential hydrologic and biological connectivity. This plant is expected to cease operation within the next five years due to fundamental inefficiencies and adverse effects on marine life caused by its intake and outfall (P. Brand, Coastal Conservancy).

The 40-acre Halaco metals processing facility also occupies former coastal lagoon. The goal of the restoration plan is to acquire the Halaco property and restore the former wetlands after the EPA has remediated this Superfund site.

The Ormond Beach Restoration Feasibility Study, funded by the Coastal Conservancy, was not available at the time of this analysis. The plan is expected to be released early 2009. The focus of the Ormond Beach restoration plan appears to be based primarily on land acquisition. Considerable effort will be required prior to restoration, including refined engineering, environmental documentation, and permitting.

CHAPTER 7

CONCLUSION

7.1 PLAN PURPOSE

The Regional Board adopted the Permit for the CDP's discharge to the Pacific Ocean via the existing EPS discharge channel. The CDP is planned to operate in conjunction with the EPS by using the EPS cooling water discharge as its source water whenever the power plant is operating and producing at least 304 MGD of cooling water discharge.

In the event that the EPS were to cease operations, and Poseidon were to independently operate the seawater intake and outfall for the benefit of the CDP, such independent operation will require additional review pursuant to Water Code Section 13142.5(b). Water Code Section 13142.5(b) requires industrial facilities using seawater for processing to use the best available site, design, technology, *and* mitigation feasible to minimize intake and morality of marine life. This Plan reviews stand-alone operations and also ensures compliance with Section 13142.5(b) when the EPS is operating but producing less than 304 MGD, since intake and mortality under that circumstance would be less than when the CDP operates in stand-alone mode.

This Plan is developed in fulfillment of the above-stated requirements and contains site-specific activities, procedures, practices and mitigation plans which Poseidon proposes to implement to minimize intake and mortality of marine organisms when the CDP intake requirements exceed the volume of water being discharged by the EPS.

7.2 PLAN COMPLIANCE

As shown in Table 7-1, the Plan addresses each of the provisions of Water Code Section 13142.5(b):

- Identifies the best available site feasible to minimize impingement and entrainment of marine life from the CDP;
- Identifies the best available design feasible to minimize impingement and entrainment of marine life from the CDP
- Identifies the best available technology feasible to minimize feasible to minimize impingement and entrainment of marine life from the CDP;
- Quantifies impingement and entrainment that may occur even after the application of best available site, design and some technology; and
- Identifies the best available mitigation measures feasible to minimize any residual impingement and entrainment, and is in addition to those measures addressed through site, design, and technology approaches.

Table 7-1 Site, Design, Technology and Mitigation Measures to Minimize Intake and Mortality		
Category	**Feature**	**Result**
6. Site	Proposed location at EPS	Best available site for the CDP, no feasible and less environmentally damaging alternative locations.
1. Design	Use of EPS discharge as source water	Eliminates entrainment and impingement attributable to the CDP when the EPS is discharging at least 304 MGD
2. Design	Reduction in inlet screen velocity	Reduction of impingement of marine organisms
3. Design	Reduction in fine screen velocity	Reduction of impingement of marine organisms
4. Design	Ambient temperature processing	Eliminate entrainment mortality associated with the elevated seawater temperature
5. Design	Elimination of heat treatment	Eliminate mortality associated with heat treatment.
1. Technology	Installation of VFDs on the CDP's intake pumps	Reduce the total intake flow for the desalination facility to no more than that needed at any given time, thereby minimizing the entrainment of marine organisms.
1. Mitigation	Implementation of the MLMP developed pursuant to a state agency coordinated process.	Compensates for unavoidable entrainment and impingement and enhances the coastal environment.

7.3 PROPOSED MITIGATION APPROACH

Poseidon will the best available site, design and technology feasible to minimize or reduce impingement and entrainment associated with the CDP's operations. These methods are likely to reduce the CDP's impingement and entrainment to marine life well below the levels identified in Chapter 5. To minimize unavoidable CDP-related impingement and entrainment of marine life, Poseidon has committed to implementing the MLMP described in Chapter 6.

7.4 REGULATORY ASSURANCE OF PLAN ADEQUACY

There are a number of regulatory assurances in place to confirm the adequacy of the MLMP and resulting restoration. The Regional Board and Coastal Commission have direct jurisdiction over the implementation of the MLMP. In addition, the Regional Board, Coastal Commission, and State Lands Commission will continue to have ongoing jurisdiction over the CDP.

Specifically, the Regional Board's approval will be necessary in order to achieve NPDES permit renewal for the Project in 2011. Poseidon must make additional coastal development permit applications to the Coastal Commission. In addition, ten years after the lease for the intake system is issued, the CDP will be subject to further environmental review by the State Lands Commission to analyze all environmental effects of facility operations and consider alternative technologies that may further reduce intake and mortality of marine life. The State Lands Commission may impose additional requirements as are reasonable and as are consistent with applicable state and federal laws and regulations.

This multi-agency approach means that there are multiple safeguards to ensure that even when the CDP converts to stand-alone operations, it will continue to use the best available site, design, technology and mitigation feasible to minimize intake and mortality attributable to the CDP.

7.5 CONCLUSION

The CDP will use the best available site, design, technology and mitigation measures feasible to minimize the intake and mortality of marine life associated with the intake of seawater to support the CDP's desalination operations.

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- City of Carlsbad Ordinance No. NS-805-SP 144 (H)
- City of Carlsbad Ordinance No. NS-806-PDP 00-02
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- Planning Commission Resolution No. 6092 – CDP 04-41
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CARLSBAD SEAWATER DESALINATION PROJECT

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

ORDER NO. R9-2006-0065

NPDES NO. CA0109223

FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

CERTIFICATION PAGE

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Peter MacLaggan — March 27, 2009

Peter M. MacLaggan
Senior Vice President, Poseidon Resources Corporation

March 27, 2009

CARLSBAD SEAWATER DESALINATION PROJECT

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

REGION 9, SAN DIEGO REGION

ORDER NO. R-9-2006-0065

NPDES NO. CA0109223

FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

ATTACHMENT 1 - EPS's 2008 DAILY FLOW DATA

March 27, 2009

January 2008

Date	PLNTCWI	PLNTCWO	PLNTFCW	Required Flow	Deficit	% CDP Needs Met
1/1/2008 0:00	55.07805	58.33641	368.6666	304	0	
1/2/2008 0:00	55.2725	59.08809	368.6668	304	0	
1/3/2008 0:00	55.35299	59.66739	371.4668	304	0	
1/4/2008 0:00	55.80088	59.45156	368.6666	304	0	
1/5/2008 0:00	56.46123	60.02015	368.6668	304	0	
1/6/2008 0:00	56.28431	63.84409	368.6672	304	0	
1/7/2008 0:00	56.22501	60.24764	368.6666	304	0	
1/8/2008 0:00	55.59047	60.71466	368.6666	304	0	
1/9/2008 0:00	55.75674	62.03756	368.6666	304	0	
1/10/2008 0:00	55.75027	62.57749	368.6666	304	0	
1/11/2008 0:00	55.87138	62.14746	417.8601	304	0	
1/12/2008 0:00	55.88246	59.6866	368.6666	304	0	
1/13/2008 0:00	56.24724	60.03067	368.6666	304	0	
1/14/2008 0:00	56.03892	70.03946	368.6666	304	0	
1/15/2008 0:00	55.76051	62.1322	368.6666	304	0	
1/16/2008 0:00	56.15384	61.44526	397.3273	304	0	
1/17/2008 0:00	55.56296	60.90459	437.806	304	0	
1/18/2008 0:00	55.13159	61.85826	368.667	304	0	
1/19/2008 0:00	55.39122	59.99569	368.6671	304	0	
1/20/2008 0:00	55.3815	59.18981	368.6668	304	0	
1/21/2008 0:00	56.17168	60.38311	368.6666	304	0	
1/22/2008 0:00	56.2164	59.68777	337.4108	304	0	
1/23/2008 0:00	56.17308	61.74458	334.1349	304	0	
1/24/2008 0:00	56.05611	60.52076	305.3748	304	0	
1/25/2008 0:00	56.20764	59.84949	299.547	304	-4.453	
1/26/2008 0:00	56.16829	56.51907	150.4457	304	-153.554	
1/27/2008 0:00	56.88367	56.88367	149.7868	304	-154.213	
1/28/2008 0:00	56.6849	57.02176	149.7869	304	-154.213	
1/29/2008 0:00	55.60788	56.71876	149.7868	304	-154.213	
1/30/2008 0:00	55.04952	57.06168	206.3035	304	-97.6965	
1/31/2008 0:00	55.18898	59.77982	293.787	304	-10.213	
			10268.16	9424	-728.556	92.30%

February 2008

Date	PLNTCWI	PLNTCWO	PLNTFCW	Required Flow	Deficit	% CDP Needs Met
2/1/2008 0:00	55.57801	59.39231	245.0037	304	-58.9963	
2/2/2008 0:00	56.67244	59.12341	287.997	304	-16.003	
2/3/2008 0:00	56.40946	58.99786	287.997	304	-16.003	
2/4/2008 0:00	55.46999	62.97731	287.997	304	-16.003	
2/5/2008 0:00	54.97696	62.01561	425.3046	304	0	
2/6/2008 0:00	54.94157	60.8064	585.2242	304	0	
2/7/2008 0:00	55.8646	60.17717	587.5468	304	0	
2/8/2008 0:00	56.23401	58.85453	297.5316	304	-6.4684	
2/9/2008 0:00	56.59497	58.49124	287.997	304	-16.003	
2/10/2008 0:00	56.81399	58.50042	287.997	304	-16.003	
2/11/2008 0:00	57.22502	60.06532	287.997	304	-16.003	
2/12/2008 0:00	57.6266	61.15209	287.997	304	-16.003	
2/13/2008 0:00	57.55003	61.87146	287.997	304	-16.003	
2/14/2008 0:00	56.14261	61.15022	288.5891	304	-15.4109	
2/15/2008 0:00	54.88246	58.22489	257.7229	304	-46.2771	
2/16/2008 0:00	55.79207	61.03833	337.4456	304	0	
2/17/2008 0:00	56.56862	61.65587	443.5468	304	0	
2/18/2008 0:00	57.08358	57.36781	299.9981	304	-4.0019	
2/19/2008 0:00	57.61677	57.51239	293.7568	304	-10.2432	
2/20/2008 0:00	57.5015	57.41328	181.5235	304	-122.477	
2/21/2008 0:00	57.32145	57.37921	10.4864	304	-293.514	
2/22/2008 0:00	56.37622	57.15201	0	304	-304	
2/23/2008 0:00	56.39339	56.8757	0	304	-304	
2/24/2008 0:00	56.53044	57.31523	0	304	-304	
2/25/2008 0:00	57.19412	57.45111	0	304	-304	
2/26/2008 0:00	57.41716	57.59307	0	304	-304	
2/27/2008 0:00	58.88443	57.97806	0	304	-304	
2/28/2008 0:00	57.9394	58.28061	0	304	-304	
2/29/2008 0:00	58.93759	58.95886	0	304	-304	
			6557.656	8816	-3117.41	65%

March 2008

Date	PLNTCWI	PLNTCWO	PLNTFCW	Required Flow	Deficit	% CDP Needs Met
3/1/2008 0:00	58.91458	59.1802	0.000	304	-304.000	
3/2/2008 0:00	58.68497	59.26756	0.000	304	-304.000	
3/3/2008 0:00	58.66419	59.45766	0.000	304	-304.000	
3/4/2008 0:00	58.30763	58.99884	0.000	304	-304.000	
3/5/2008 0:00	58.86707	59.38344	0.000	304	-304.000	
3/6/2008 0:00	59.50711	59.66997	0.000	304	-304.000	
3/7/2008 0:00	60.04725	60.04725	0.000	304	-304.000	
3/8/2008 0:00	59.58791	59.58791	0.000	304	-304.000	
3/9/2008 0:00	59.94574	59.94574	0.000	304	-304.000	
3/10/2008 0:00	60.74195	60.74195	0.000	304	-304.000	
3/11/2008 0:00	60.92848	60.92848	0.000	304	-304.000	
3/12/2008 0:00	60.58068	60.58068	0.000	304	-304.000	
3/13/2008 0:00	61.09229	61.09229	0.000	304	-304.000	
3/14/2008 0:00	62.1689	62.1689	1.218	304	-302.782	
3/15/2008 0:00	61.38614	61.5463	0.000	304	-304.000	
3/16/2008 0:00	60.45404	60.80823	0.000	304	-304.000	
3/17/2008 0:00	59.58599	59.7747	0.000	304	-304.000	
3/18/2008 0:00	59.97375	59.97375	0.000	304	-304.000	
3/19/2008 0:00	60.50861	60.50861	0.000	304	-304.000	
3/20/2008 0:00	60.85982	60.85982	12.482	304	-291.518	
3/21/2008 0:00	60.70847	62.56878	152.622	304	-151.379	
3/22/2008 0:00	61.04084	63.49205	149.787	304	-154.213	
3/23/2008 0:00	61.33122	64.11586	149.787	304	-154.213	
3/24/2008 0:00	61.41052	67.0659	149.787	304	-154.213	
3/25/2008 0:00	61.73997	65.85082	242.886	304	-61.114	
3/26/2008 0:00	62.4066	63.52229	299.551	304	-4.449	
3/27/2008 0:00	62.4224	64.60538	299.551	304	-4.449	
3/28/2008 0:00	61.84665	64.88508	299.551	304	-4.449	
3/29/2008 0:00	62.13234	64.5055	299.551	304	-4.449	
3/30/2008 0:00	62.05178	64.29836	305.112	304	1.112	
3/31/2008 0:00	61.79003	65.16395	299.547	304	-4.453	
			2661.431	9424	-6762.569	28%

April 2008

Date	PLNTCWI	PLNTCWO	PLNTFCW	Required Flow	Deficit	% CDP Needs Met
4/1/08 12:00 AM	61.42534	65.29865	299.5468	304	-4.4532	
4/2/08 12:00 AM	61.7788	65.00555	299.5468	304	-4.4532	
4/3/08 12:00 AM	61.87854	65.12094	299.5468	304	-4.4532	
4/4/08 12:00 AM	61.21001	65.75201	299.5468	304	-4.4532	
4/5/08 12:00 AM	60.81943	64.37872	299.5468	304	-4.4532	
4/6/08 12:00 AM	61.3461	63.1697	299.5468	304	-4.4532	
4/7/08 12:00 AM	61.62393	66.74051	299.5453	304	-4.4547	
4/8/08 12:00 AM	61.32157	63.42287	299.5424	304	-4.4576	
4/9/08 12:00 AM	61.70842	67.89263	323.5591	304	0	
4/10/08 12:00 AM	61.1647	62.92852	443.5429	304	0	
4/11/08 12:00 AM	61.69075	67.26661	578.4263	304	0	
4/12/08 12:00 AM	61.52929	71.08752	590.7708	304	0	
4/13/08 12:00 AM	61.4532	70.07043	607.3224	304	0	
4/14/08 12:00 AM	62.11076	65.27399	447.8595	304	0	
4/15/08 12:00 AM	62.77756	64.75684	443.5429	304	0	
4/16/08 12:00 AM	62.98117	66.65923	549.3768	304	0	
4/17/08 12:00 AM	63.32564	66.03699	587.5429	304	0	
4/18/08 12:00 AM	62.86544	65.64173	587.5429	304	0	
4/19/08 12:00 AM	61.79207	63.10685	445.9535	304	0	
4/20/08 12:00 AM	61.89238	68.48481	376.6715	304	0	
4/21/08 12:00 AM	62.14897	67.89709	619.0527	304	0	
4/22/08 12:00 AM	62.4975	66.05768	652.6207	304	0	
4/23/08 12:00 AM	63.06746	66.09991	720.1985	304	0	
4/24/08 12:00 AM	63.78792	66.80898	689.4841	304	0	
4/25/08 12:00 AM	64.28423	67.96157	632.4067	304	0	
4/26/08 12:00 AM	64.92619	66.76136	582.0537	304	0	
4/27/08 12:00 AM	65.34881	67.19794	528.8038	304	0	
4/28/08 12:00 AM	65.12825	69.85673	450.1709	304	0	
4/29/08 12:00 AM	65.45698	70.18975	505.6866	304	0	
4/30/08 12:00 AM	64.23721	67.25736	472.293	304	0	
			14231.25	9120	-35.6315	99.60%

May 2008

Date	PLNTCWI	PLNTCWO	PLNTFCW	Required Flow	Deficit	% CDP Needs Met
5/1/2008 0:00	64.61558	66.509	444.3535	304	0	
5/2/2008 0:00	65.39342	69.26369	442.3814	304	0	
5/3/2008 0:00	65.71856	66.70947	392.1693	304	0	
5/4/2008 0:00	65.96294	68.63574	299.5372	304	-4.4628	
5/5/2008 0:00	65.74392	69.31657	241.6122	304	-62.3878	
5/6/2008 0:00	64.66403	66.57507	288.0376	304	-15.9624	
5/7/2008 0:00	64.34969	66.80865	355.3748	304	51.3748	
5/8/2008 0:00	64.48176	67.32543	349.7588	304	0	
5/9/2008 0:00	64.17638	66.88145	330.7442	304	0	
5/10/2008 0:00	65.61623	69.89885	195.8734	304	-108.1266	
5/11/2008 0:00	66.31684	72.06525	149.7774	304	-154.2226	
5/12/2008 0:00	65.63977	71.15765	149.7774	304	-154.2226	
5/13/2008 0:00	66.31445	71.58556	239.2173	304	-64.7827	
5/14/2008 0:00	67.16641	70.84717	299.5372	304	-4.4628	
5/15/2008 0:00	68.25648	73.79187	360.6296	304	0	
5/16/2008 0:00	69.3455	73.49152	368.6576	304	0	
5/17/2008 0:00	70.40887	75.16502	368.6632	304	0	
5/18/2008 0:00	71.74605	75.75825	368.6666	304	0	
5/19/2008 0:00	72.18816	75.67088	405.4915	304	0	
5/20/2008 0:00	70.85508	73.82998	362.9068	304	0	
5/21/2008 0:00	69.78146	71.3932	362.9629	304	0	
5/22/2008 0:00	68.56917	68.56917	339.9668	304	0	
5/23/2008 0:00	66.84357	66.84357	295.7311	304	-8.2689	
5/24/2008 0:00	66.15652	66.15652	293.787	304	-10.213	
5/25/2008 0:00	66.88851	66.88851	111.9299	304	-192.0701	
5/26/2008 0:00	67.22431	67.22431	0	304	-304	
5/27/2008 0:00	67.99783	67.99783	0.001116	304	-303.998884	
5/28/2008 0:00	67.78217	67.78217	0	304	-304	
5/29/2008 0:00	67.99413	67.99413	68.06091	304	-235.93909	
5/30/2008 0:00	68.06082	69.87752	236.917	304	-67.083	
5/31/2008 0:00	68.70628	69.60764	299.5424	304	-4.4576	
			8422.066	9424	-1947.286074	79.30%

June 2008

Date	PLNTCWI	PLNTCWO	PLNTFCW	Required Flow	Deficit	% CDP Needs Met
6/1/08 0:00	68.56467	70.92802	299.5424	304	-4.4576	
6/2/08 0:00	68.78783	72.44921	299.5424	304	-4.4576	
6/3/08 0:00	68.65149	72.28214	299.5424	304	-4.4576	
6/4/08 0:00	67.63558	71.31238	299.5424	304	-4.4576	
6/5/08 0:00	67.77032	70.54779	299.5424	304	-4.4576	
6/6/08 0:00	68.41267	71.50294	299.5424	304	-4.4576	
6/7/08 0:00	68.22495	72.54205	306.9591	304	0	
6/8/08 0:00	68.40237	71.56978	476.9141	304	0	
6/9/08 0:00	68.24685	75.53003	587.5429	304	0	
6/10/08 0:00	67.8114	72.05092	587.5429	304	0	
6/11/08 0:00	67.98354	72.70866	587.5429	304	0	
6/12/08 0:00	69.11913	72.54916	587.5429	304	0	
6/13/08 0:00	68.53925	70.55152	446.4762	304	0	
6/14/08 0:00	68.03593	69.17938	443.5429	304	0	
6/15/08 0:00	67.49313	67.49313	411.1665	304	0	
6/16/08 0:00	67.98725	69.18384	437.7859	304	0	
6/17/08 0:00	68.98224	72.43056	437.786	304	0	
6/18/08 0:00	69.30067	75.12554	437.7862	304	0	
6/19/08 0:00	69.74646	76.93282	488.3961	304	0	
6/20/08 0:00	71.57615	78.35528	587.5473	304	0	
6/21/08 0:00	73.03625	79.85528	587.5543	304	0	
6/22/08 0:00	74.22292	79.7974	587.5566	304	0	
6/23/08 0:00	74.91967	79.0774	587.5567	304	0	
6/24/08 0:00	74.11199	75.88902	441.4715	304	0	
6/25/08 0:00	73.01502	75.67887	541.5715	304	0	
6/26/08 0:00	72.65965	76.38613	587.5566	304	0	
6/27/08 0:00	73.28844	73.28844	296.1609	304	-7.8391	
6/28/08 0:00	73.29789	76.51698	540.0733	304	0	
6/29/08 0:00	72.25826	76.6291	587.5468	304	0	
6/30/08 0:00	70.15701	75.33709	587.5468	304	0	
			13966.38	9120	-34.5847	99.60%

July 2008

time	PLNTCWI	PLNTCWO	PLNTFCW	Required Flow	Deficit	% CDP Needs Met
7/1/08 0:00	69.26075	69.34013	444.5124	304		
7/2/08 0:00	66.9312	68.09121	437.7871	304		
7/3/08 0:00	66.55471	69.51628	534.4029	304		
7/4/08 0:00	68.28378	68.28378	302.8804	304	-1.1196	
7/5/08 0:00	68.59873	68.59873	293.7874	304	-10.2126	
7/6/08 0:00	68.71511	68.71511	293.787	304	-10.213	
7/7/08 0:00	68.90102	75.0793	532.7188	304		
7/8/08 0:00	68.41464	72.54078	791.1448	304		
7/9/08 0:00	68.51984	73.51691	786.2287	304		
7/10/08 0:00	69.72729	72.11263	696.0239	304		
7/11/08 0:00	70.61313	71.96081	547.5894	304		
7/12/08 0:00	71.52317	73.29843	440.6471	304		
7/13/08 0:00	72.12312	74.10944	341.3943	304		
7/14/08 0:00	71.44798	74.4016	580.2341	304		
7/15/08 0:00	71.60821	75.29295	587.5508	304		
7/16/08 0:00	70.81606	74.24728	587.5508	304		
7/17/08 0:00	69.27651	70.71427	587.5508	304		
7/18/08 0:00	69.26743	72.15658	587.5508	304		
7/19/08 0:00	70.81091	70.81091	301.519	304	-2.481	
7/20/08 0:00	71.9041	71.9041	293.7911	304	-10.2089	
7/21/08 0:00	72.51208	72.51208	293.791	304	-10.209	
7/22/08 0:00	72.4714	73.71244	293.791	304	-10.209	
7/23/08 0:00	73.04682	73.89774	461.5403	304		
7/24/08 0:00	73.1693	77.17729	587.5508	304		
7/25/08 0:00	73.27043	77.91094	587.5508	304		
7/26/08 0:00	73.03407	74.44376	449.0009	304		
7/27/08 0:00	73.43362	74.48878	443.5509	304		
7/28/08 0:00	73.39298	74.49374	443.5509	304		
7/29/08 0:00	73.20356	73.91309	443.5509	304		
7/30/08 0:00	73.36878	76.53268	391.8008	304		
7/31/08 0:00	73.52863	77.22065	544.2435	304		
			14908.57	9424	-54.6531	99.40%

August 2008

Date	PLNTCWI	PLNTCWO	PLNTFCW	Required Flow	Deficit	% CDP Needs Met
8/1/2008 0:00	73.87272	82.01569	447.3778	304	0	
8/2/2008 0:00	72.63963	73.1339	405.0647	304	0	
8/3/2008 0:00	72.83848	72.83848	398.0869	304	0	
8/4/2008 0:00	73.93726	77.90284	647.3771	304	0	
8/5/2008 0:00	74.64707	78.43299	781.1832	304	0	
8/6/2008 0:00	75.12785	79.50541	753.5826	304	0	
8/7/2008 0:00	74.78503	78.91151	713.9354	304	0	
8/8/2008 0:00	74.46336	78.45973	579.1943	304	0	
8/9/2008 0:00	75.17652	75.17652	441.5101	304	0	
8/10/2008 0:00	74.86446	74.86446	437.7942	304	0	
8/11/2008 0:00	73.79217	75.0275	474.815	304	0	
8/12/2008 0:00	71.84259	74.34873	519.7842	304	0	
8/13/2008 0:00	70.82098	73.64205	491.3175	304	0	
8/14/2008 0:00	69.89922	73.54463	587.5508	304	0	
8/15/2008 0:00	69.68029	72.57944	585.8342	304	0	
8/16/2008 0:00	70.53196	74.55497	587.5508	304	0	
8/17/2008 0:00	70.8702	76.42634	587.5485	304	0	
8/18/2008 0:00	70.44783	70.75332	578.2968	304	0	
8/19/2008 0:00	69.49757	71.16972	587.5468	304	0	
8/20/2008 0:00	69.85083	72.20028	567.0242	304	0	
8/21/2008 0:00	70.51065	72.12764	437.7871	304	0	
8/22/2008 0:00	71.26172	73.29593	437.7871	304	0	
8/23/2008 0:00	71.60268	74.44488	437.7892	304	0	
8/24/2008 0:00	71.68455	75.06197	437.791	304	0	
8/25/2008 0:00	71.34303	75.53971	530.2989	304	0	
8/26/2008 0:00	72.20048	76.98933	587.5508	304	0	
8/27/2008 0:00	72.63307	78.15834	587.5508	304	0	
8/28/2008 0:00	72.24301	78.73959	587.5508	304	0	
8/29/2008 0:00	71.90331	78.8375	587.5508	304	0	
8/30/2008 0:00	72.32967	77.50846	587.5509	304	0	
8/31/2008 0:00	73.13903	74.69556	448.6342	304	0	
			16840.217	9424	0	100.00%

September 2008

time	PLNTCWI	PLNTCWO	PLNTFCW	Required Flow	Deficit	% CDP Needs Met
9/1/2008 0:00	73.46597	77.41521	498.907	304	0	
9/2/2008 0:00	73.70034	82.81483	676.4471	304	0	
9/3/2008 0:00	73.8959	82.80732	714.6807	304	0	
9/4/2008 0:00	73.71344	82.97657	713.7727	304	0	
9/5/2008 0:00	73.26717	81.90447	716.7726	304	0	
9/6/2008 0:00	72.00927	78.75995	695.7285	304	0	
9/7/2008 0:00	71.18194	75.43146	657.8719	304	0	
9/8/2008 0:00	71.86323	75.53347	644.7444	304	0	
9/9/2008 0:00	72.73914	77.73425	622.1209	304	0	
9/10/2008 0:00	72.63593	79.37876	606.7407	304	0	
9/11/2008 0:00	71.98448	79.31849	587.5605	304	0	
9/12/2008 0:00	70.60006	74.95802	587.7325	304	0	
9/13/2008 0:00	69.17329	71.64708	594.3686	304	0	
9/14/2008 0:00	68.17056	72.08846	530.2965	304	0	
9/15/2008 0:00	67.61982	73.11609	587.5546	304	0	
9/16/2008 0:00	67.32845	70.83434	587.5508	304	0	
9/17/2008 0:00	69.01248	73.38031	587.5508	304	0	
9/18/2008 0:00	69.98489	75.77675	587.554	304	0	
9/19/2008 0:00	70.20558	75.23483	587.5605	304	0	
9/20/2008 0:00	68.91873	71.71415	587.5605	304	0	
9/21/2008 0:00	68.47094	71.67462	587.5587	304	0	
9/22/2008 0:00	68.51076	73.10765	587.5567	304	0	
9/23/2008 0:00	69.08582	76.36146	587.5566	304	0	
9/24/2008 0:00	69.59718	78.22449	587.5566	304	0	
9/25/2008 0:00	69.92791	78.00694	587.5566	304	0	
9/26/2008 0:00	70.07438	76.0927	587.5566	304	0	
9/27/2008 0:00	69.37527	74.80439	587.5582	304	0	
9/28/2008 0:00	67.21702	72.6103	587.5605	304	0	
9/29/2008 0:00	65.93478	72.17042	587.5566	304	0	
9/30/2008 0:00	65.90041	73.16554	587.5566	304	0	
			18248.65	9120	0	100%

October 2008

time	PLNTCWI	PLNTCWO	PLNTFCW	Required Flow	Deficit	% CDP Needs Met
10/1/2008 0:00	66.88644	73.66633	568.4257	304	0	
10/2/2008 0:00	67.38724	70.33056	649.9763	304	0	
10/3/2008 0:00	68.86626	71.86623	465.2539	304	0	
10/4/2008 0:00	69.31333	70.5933	548.2203	304	0	
10/5/2008 0:00	68.69636	71.28494	465.5761	304	0	
10/6/2008 0:00	67.70061	71.8491	448.6005	304	0	
10/7/2008 0:00	67.33462	73.99841	581.3925	304	0	
10/8/2008 0:00	67.96429	75.83421	656.6758	304	0	
10/9/2008 0:00	68.29241	74.037	786.8566	304	0	
10/10/2008 0:00	69.04738	74.15051	732.7805	304	0	
10/11/2008 0:00	67.91972	72.38598	591.4966	304	0	
10/12/2008 0:00	66.43777	70.49062	471.434	304	0	
10/13/2008 0:00	65.33334	70.81139	608.0908	304	0	
10/14/2008 0:00	64.30106	70.07391	720.1362	304	0	
10/15/2008 0:00	63.81651	68.756	718.8624	304	0	
10/16/2008 0:00	63.45768	68.58735	649.7229	304	0	
10/17/2008 0:00	63.0916	69.186	587.3802	304	0	
10/18/2008 0:00	64.30014	67.53129	443.5468	304	0	
10/19/2008 0:00	64.32057	68.45527	443.547	304	0	
10/20/2008 0:00	64.17648	70.24873	360.9469	304	0	
10/21/2008 0:00	63.99141	69.0218	299.5444	304	-4.4556	
10/22/2008 0:00	64.70663	73.87731	299.5468	304	-4.4532	
10/23/2008 0:00	64.75873	71.91666	299.5468	304	-4.4532	
10/24/2008 0:00	64.0321	71.23408	299.5468	304	-4.4532	
10/25/2008 0:00	63.61649	67.47097	299.5497	304	-4.4503	
10/26/2008 0:00	64.33142	68.82366	322.2509	304	0	
10/27/2008 0:00	64.35463	72.85677	463.8752	304	0	
10/28/2008 0:00	64.39629	74.90448	506.9115	304	0	
10/29/2008 0:00	64.90869	76.22089	506.9114	304	0	
10/30/2008 0:00	66.0414	75.43958	461.6366	304	0	
10/31/2008 0:00	66.21015	71.72424	414.9231	304	0	
			15673.17	9424	-22.2655	99.80%

November 2008

time	PLNTCWO	PLNTCWI	PLNTFCW	Required Flow	Deficit	% CDP Needs Met
11/1/2008 0:00	66.6207	78.00092	312.771	304	8.771	
11/2/2008 0:00	67.29136	73.00135	299.5447	304	-4.4553	
11/3/2008 0:00	65.86248	73.33528	323.7018	304	0	
11/4/2008 0:00	64.83785	76.49862	437.7816	304	0	
11/5/2008 0:00	63.45343	75.2961	449.7746	304	0	
11/6/2008 0:00	62.66989	72.74438	422.0697	304	0	
11/7/2008 0:00	62.69248	71.74911	471.5352	304	0	
11/8/2008 0:00	62.97219	65.98486	379.9033	304	0	
11/9/2008 0:00	62.81376	67.29513	322.5084	304	0	
11/10/2008 0:00	61.96257	67.78148	299.5468	304	-4.4532	
11/11/2008 0:00	61.83131	72.95371	304.4149	304	0	
11/12/2008 0:00	62.10519	71.28798	299.5468	304	-4.4532	
11/13/2008 0:00	61.92614	66.74232	379.9802	304	0	
11/14/2008 0:00	61.95608	71.13152	443.5468	304	0	
11/15/2008 0:00	61.94434	66.85366	433.3043	304	0	
11/16/2008 0:00	61.55023	65.57481	443.547	304	0	
11/17/2008 0:00	61.71801	67.37799	457.7726	304	0	
11/18/2008 0:00	61.67519	68.87621	536.5715	304	0	
11/19/2008 0:00	62.4016	69.67127	656.6765	304	0	
11/20/2008 0:00	62.46395	67.27613	656.6799	304	0	
11/21/2008 0:00	62.36002	69.6424	644.7799	304	0	
11/22/2008 0:00	62.51728	68.54761	622.6329	304	0	
11/23/2008 0:00	62.75745	67.7694	599.2608	304	0	
11/24/2008 0:00	62.50464	69.51618	458.6566	304	0	
11/25/2008 0:00	62.73479	67.16589	433.4379	304	0	
11/26/2008 0:00	62.55614	65.51408	446.8938	304	0	
11/27/2008 0:00	62.36171	64.90089	443.5605	304	0	
11/28/2008 0:00	62.01764	66.14619	304.8605	304	0	
11/29/2008 0:00	61.64797	66.4062	299.5605	304	-4.4395	
11/30/2008 0:00	62.17727	65.78579	399.7512	304	0	
			12984.57	9120	-9.0302	99.90%

December 2008

Date	PLNTCWI	PLNTCWO	PLNTFCW	Required Flow	Deficit	% CDP Needs Met
12/1/2008 0:00	61.94685	68.25079	581.8007	304	0	
12/2/2008 0:00	62.20314	68.68632	570.4798	304	0	
12/3/2008 0:00	62.00037	69.35277	554.7913	304	0	
12/4/2008 0:00	62.13548	70.41676	615.83	304	0	
12/5/2008 0:00	61.94967	68.59374	725.7966	304	0	
12/6/2008 0:00	61.50977	67.91967	725.7966	304	0	
12/7/2008 0:00	61.93102	68.59146	694.0562	304	0	
12/8/2008 0:00	61.29079	68.58578	696.1841	304	0	
12/9/2008 0:00	60.32462	71.05241	725.7966	304	0	
12/10/2008 0:00	59.89472	68.49173	723.4006	304	0	
12/11/2008 0:00	59.97142	70.50692	721.3646	304	0	
12/12/2008 0:00	60.50012	68.73678	724.4446	304	0	
12/13/2008 0:00	60.47525	67.53049	709.0979	304	0	
12/14/2008 0:00	58.65944	67.55898	722.9084	304	0	
12/15/2008 0:00	58.11467	71.72564	764.1207	304	0	
12/16/2008 0:00	58.1417	68.89165	741.4246	304	0	
12/17/2008 0:00	56.70695	66.76089	726.5045	304	0	
12/18/2008 0:00	56.06829	67.80674	695.3405	304	0	
12/19/2008 0:00	56.03612	68.61907	691.2405	304	0	
12/20/2008 0:00	56.19368	67.29748	676.0798	304	0	
12/21/2008 0:00	56.626	64.3372	675.1315	304	0	
12/22/2008 0:00	56.88247	66.06559	794.9113	304	0	
12/23/2008 0:00	56.51031	64.44772	747.3035	304	0	
12/24/2008 0:00	56.03827	62.37111	673.3627	304	0	
12/25/2008 0:00	56.70229	60.3209	677.6148	304	0	
12/26/2008 0:00	55.74463	60.77301	475.6706	304	0	
12/27/2008 0:00	54.36066	58.67835	443.5509	304	0	
12/28/2008 0:00	54.40261	58.84012	458.5671	304	0	
12/29/2008 0:00	54.86269	60.0157	512.6716	304	0	
12/30/2008 0:00	55.36657	61.55184	512.6716	304	0	
12/31/2008 0:00	55.69797	60.36811	483.2073	304	0	
			20241.12	9424	0	100%

2008 Summary								
Month	**EPS Flow (MG)**	**Required Flow for CDP (MG)**	**CDP Flow Not Met By EPS (MG)***	**% CDP Needs Met****	**# days deficit between 0.1-10.9 mgd**	**# days deficit between 11-100 mgd**	**# days deficit between 101-200 mgd**	**# days deficit between 201-304 mgd**
January	10268	9424	728.5	92.30%	2	1	4	0
February	6558	8816	3117.4	65.00%	3	11	1	9
March	2661	9424	6762.6	28.00%	6	1	4	20
April	14231	9120	35.6	99.60%	8	0	0	0
May	8422	9424	1947.3	79.30%	5	5	4	4
June	13966	9120	34.6	99.60%	7	0	0	0
July	14909	9424	54.6	99.40%	7	0	0	0
August	16840	9424	0	100.00%	0	0	0	0
September	18248	9120	0	100.00%	0	0	0	0
October	15673	9424	22.3	99.80%	5	0	0	0
November	12984	9120	9	99.90%	5	0	0	0
December	20241	9424	0	100.00%	0	0	0	0
Total	**155001**	**111264**	**12711.9**		**48**	**18**	**13**	**33**
Average				88.58%				

*While the EPS monthly flow exceeded the monthly requirements of the desalination facility, on a daily basis this was not always the case. This figure represents the amount of additional flow required in each month during 2008 to maintain a continuous 304 MGD flow the desalination facility. See monthly data sheets for the details.

** Calculated as follows: % Desalination Plant Needs Met = (1-D/C)100

Attachment 1- EPS's 2008 Flow Data

CARLSBAD SEAWATER DESALINATION PROJECT

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

REGION 9, SAN DIEGO REGION

ORDER NO. R-9-2006-0065

NPDES NO. CA0109223

FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

ATTACHMENT 2 - COST ESTIMATE OF SUBSURFACE INTAKE ALTERNATIVES

March 27, 2009

304 MDG Intake Cost Estimates - October 2007

VERTICAL BEACH WELLS

Total Capacity =		304	MGD
Individual Intake Well Capacity =		1.5	MGD
Duty Number of Intake Wells Needed =		203	
Additional Standby Intakes Needed @ 25 % =		51	
Total Intake Wells Needed =		253	
Minimum Distance Between Wells (Best Case)=		150	ft
Length of Beach Occupied by Wells =		7.2	miles
Land Needed to Install Wells & Support Facilities		8.6	acres
Cost of Installation of Individual Well =	$	1,200,000	per well
Total Costs of Well Installation =	$	304,000,000	
Cost of Seawater Conveyance Pipelines @US$500/ft =	$	18,925,000	
Cost of Intake Booster Pump Stations - =	$	30,400,000	
Cost of Electrical Power Supply for Well Pumps =	$	50,160,000	
Total Construction (Direct) Costs =	**$**	**403,485,000**	
Indirect Costs			
Acquisition of Land to Install Wells & Support Struct. =	$	4,304,408	
Engineering, Design and Procurement @ 25 % =	$	100,871,250	
Environmental Mitigation Costs @ 15 % =	$	60,522,750	
Contingency @ 20 % =	$	80,697,000	
TOTAL INDIRECT COSTS	**$**	**246,395,407.71**	
TOTAL PROJECT EPC COSTS =	**$**	**649,880,408**	

SLANT WELLS - Similar to Dana Point Desal Plant

Total Capacity =		304	MGD
Individual Intake Well Capacity =		5	MGD
Duty Number of Intake Wells Needed =		61	
Additional Standby Intakes Needed @ 25 % =		15	
Total Intake Wells Needed =		76	
Minimum Distance Between Wells (Best Case)=		300	ft
Length of Beach Occupied by Wells =		4.3	miles
Land Needed to Install Wells & Support Facilities		17.4	acres
Cost of Installation of Individual Well =	$	2,400,000	per well
Total Costs of Well Installation =	$	182,400,000	
Cost of Seawater Conveyance Pipelines @US$500/ft =	$	11,250,000	
Cost of Intake Booster Pump Stations - =	$	30,400,000	
Cost of Electrical Power Supply for Well Pumps =	$	31,920,000	
Total Construction (Direct) Costs =	**$**	**255,970,000**	
Indirect Costs			
Acquisition of Land to Install Wells & Support Struct. =	$	8,723,600	
Engineering, Design and Procurement @ 25 % =	$	63,992,500	
Environmental Mitigation Costs @ 15 % =	$	38,395,500	
Contingency @ 20 % =	$	51,194,000	
TOTAL INDIRECT COSTS	**$**	**162,305,600**	
TOTAL PROJECT EPC COSTS =	**$**	**418,275,600**	

HORIZONTAL RANNEY WELLS

Total Capacity =		304	MGD
Individual Intake Well Capacity =		5	MGD
Duty Number of Intake Wells Needed =		61	
Additional Standby Intakes Needed @ 25 % =		15	
Total Intake Wells Needed =		76	
Minimum Distance Between Wells (Best Case)=		400	ft
Length of Beach Occupied by Wells =		5.7	miles
Land Needed to Install Wells & Support Facilities		17.4	acres
Cost of Installation of Individual Well =	$	2,500,000	per well
Total Costs of Well Installation =	$	190,000,000	
Cost of Seawater Conveyance Pipelines @US$500/ft =	$	15,000,000	
Cost of Intake Booster Pump Stations - =	$	30,400,000	
Cost of Electrical Power Supply for Well Pumps =	$	33,060,000	
Total Construction (Direct) Costs =	**$**	**268,460,000**	
Indirect Costs			
Acquisition of Land to Install Wells & Support Struct. =	$	8,723,600	
Engineering, Design and Procurement @ 25 % =	$	67,115,000	
Environmental Mitigation Costs @ 15 % =	$	40,269,000	
Contingency @ 20 % =	$	53,692,000	
TOTAL INDIRECT COSTS	**$**	**169,799,600**	
TOTAL PROJECT EPC COSTS =	**$**	**438,259,600**	

SUBSURFACE INFILTRATION GALLERY (FUKUOKA TYPE INTAKE)

Total Capacity =		304	MGD
Capacity of Individual Intake Galleries =		101.3	MGD
Duty Intake Galleries Needed =		3	
Additional Standby Intakes Needed @ 0 % =		0	
Total Intake Galleries Needed =		3	
Length x Width x Depth Each Gallery =		5280x400x15	ft
Total Length of Intake System =		3.0	miles
Land Needed to Install Wells & Support Facilities		17.9	acres
Cost of Installation of Individual Gallery =	$	120,000,000	per 100 MGD gallery
Total Costs of Gallery Installation =	$	360,000,000	
Cost of Seawater Conv. Pipelines @US$500/ft =	$	7,922,606	
Cost of Intake Booster Pump Stations - =	$	12,160,000	
Cost of Electrical Power Supply for Well Pumps =	$	18,608,000	
Total Construction (Direct) Costs =	**$**	**398,690,606**	
Indirect Costs			
Acquisition of Land to Install Intake & Support Struct. =	$	8,956,114	
Engineering, Design and Procurement @ 25 % =	$	99,672,652	
Environmental Mitigation Costs @ 15 % =	$	59,803,591	
Contingency @ 20 % =	$	79,738,121	
TOTAL INDIRECT COSTS	**$**	**248,170,478**	
TOTAL PROJECT EPC COSTS =	**$**	**646,861,084**	

NEW OPEN INTAKE - 1,000 FT INTAKE LINE W/ LOW-VELOCITY INTAKE STRUCTURE

Total Capacity =		304 MGD
Length of Intake Pipe =		1000 ft
Land Needed to Install Wells & Support Facilities		2.3 acres
Cost of Installation of Intake Pipe @ US$45,000/ft =	$	45,000,000
Cost of Construction of Ocean Intake Structure =	$	10,500,000
Cost of New Intake Screens =	$	8,000,000
Cost of New Intake Pump Station =	$	24,320,000
Cost of Power Supply for New Pump Station =	$	5,223,000
Total Construction (Direct) Costs =	**$**	**93,043,000**
Indirect Costs		
Acquisition of Land to Install Intake & Support Struct. =	$	1,147,842
Engineering, Design and Procurement @ 25 % =	$	23,260,750
Environmental Mitigation @ 15 % =	$	13,956,450
Contingency @ 20 % =	$	18,608,600
TOTAL INDIRECT COSTS	**$**	**56,973,642.06**
TOTAL PROJECT EPC COSTS =	**$**	**150,016,642**

CARLSBAD SEAWATER DESALINATION PROJECT

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

REGION 9, SAN DIEGO REGION

ORDER NO. R-9-2006-0065

NPDES NO. CA0109223

FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

ATTACHMENT 3 - IMPINGEMENT RESULTS, G1 - TRAVELING SCREEN AND BAR RACK WEEKLY SURVEYS, G2 - HEAT TREATMENT SURVEYS

March 27, 2009

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA001 | **Survey Date: June 24 - 25, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	186	40-84	1.3-15.3	729.7
Engraulis mordax	northern anchovy	46	37-90	0.4-10.5	69.2
Heterostichus rostratus	giant kelpfish	8	81-113	4.1-8.2	47.9
Heterostichus spp.	kelpfish	7	81-118	4.0-12.2	47.8
Anchoa compressa	deepbody anchovy	6	31-107	0.1-11.6	13.7
Engraulidae	anchovies	4	-	1.6	1.6
Atherinops affinis	topsmelt	3	54-115	0.9-18.8	25.5
Porichthys myriaster	specklefin midshipman	3	300-378	210	210.0
unidentified fish	unid. fish	3	34	0.5-2.0	4.4
Hyporhamphus rosae	California halfbeak	2	111-125	10.9-11.7	22.6
Paralabrax spp.	sand bass	2	33-55	0.7-2.0	2.7
Anchoa delicatissima	slough anchovy	1	-	3.0	2.8
Atherinopsidae	silverside	1	46	1.0	1.0
Hypsoblennius spp.	blennies	1	252	267	267.0
Pleuronichthys verticalis	hornyhead turbot	1	291	227	226.5
Sphyraena argentea	California barracuda	1	136	0.8	0.8
Syngnathus leptorhynchus	bay pipefish	1	290	9.7	9.7
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	9	253-410	143-521	1,984.7
Urolophus halleri	round stingray	2	285-337	244-444	688.0
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	7	15-34	2.0-18.0	66.1
	Total:	**294**			

Survey: EPSIA002 | **Survey Date: June 30 - July 1, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	242	40-115	1.6-31.0	957.0
Roncador stearnsi	spotfin croaker	51	33-205	0.6-106	260.4
Engraulis mordax	northern anchovy	36	35-103	0.2-14.0	57.6
Heterostichus rostratus	giant kelpfish	33	74-128	3.4-16.0	209.8
Atherinops affinis	topsmelt	29	34-115	0.5-15.2	117.3
Strongylura exilis	California needlefish	5	95-142	0.6-2.0	6.1
Hypsopsetta guttulata	diamond turbot	3	104-140	27.7-79.4	173.4
Porichthys myriaster	specklefin midshipman	3	250-305	160-312	633.0
Anchoa delicatissima	slough anchovy	2	65	1.1-3.1	4.2
Paralichthys californicus	California halibut	2	55-95	2.9-11.5	14.4
Sphyraena argentea	California barracuda	2	78-85	2.0-3.6	5.6
Anchoa compressa	deepbody anchovy	1	43	2.2	2.2
Paralabrax nebulifer	barred sand bass	1	230	312	312.0
Seriphus politus	queenfish	1	102	15.7	15.7
unidentified fish	unid. fish	1	-	0.1	0.1
unidentified fish, damaged	unid. damaged fish	1	-	0.4	0.4
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	5	224-505	112-600	1,505.6
Myliobatis californica	bat ray	1	295	392.0	391.5
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	5	19-47	5.7-47.6	96.3
Octopus spp.	octopus	1	-	10.1	10.1
	Total:	**425**			

Encina Power Station Impingement Abundance:.: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA003 — **Survey Date: July 07 - 08, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	83	45-66	2.5-7.0	363.0
Roncador stearnsi	spotfin croaker	31	35-52	0.7-2.0	40.1
Heterostichus rostratus	giant kelpfish	29	75-123	3.2-14.9	181.2
Anchoa compressa	deepbody anchovy	17	35-99	0.9-10.5	64.1
Strongylura exilis	California needlefish	13	75-135	0.3-9.5	64.4
Engraulis mordax	northern anchovy	9	42-46	0.5-1.3	6.5
Atherinops affinis	topsmelt	4	60-110	2.2-28.8	43.4
Anchoa delicatissima	slough anchovy	3	-	1.3	1.3
Paralichthys californicus	California halibut	3	43-63	1.5-3.8	7.3
Engraulidae	anchovies	2	-	1.2	1.2
Porichthys myriaster	specklefin midshipman	2	249-270	200-250	450.0
Anchoa spp.	anchovy	1	65	2.5	2.5
Cheilotrema saturnum	black croaker	1	48	1.8	1.8
Gibbonsia montereyensis	crevice kelpfish	1	88	8.3	8.3
Hypsopsetta guttulata	diamond turbot	1	285	400	400.0
Sardinops sagax	Pacific sardine	1	35	0.4	0.4
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	7	225-293	165-375	1,715.1
Myliobatis californica	bat ray	1	245	240	239.5
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	6	26-34.5	6.2-12.1	54.0
	Total:	**215**			

Survey: EPSIA004 — **Survey Date: July 14 - 15, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Engraulis mordax	northern anchovy	228	34-109	0.4-11.0	186.9
Cymatogaster aggregata	shiner surfperch	191	45-228	2.3-326	1,327.3
Atherinops affinis	topsmelt	126	45-139	0.8-26.9	472.1
Heterostichus rostratus	giant kelpfish	119	57-137	1.5-19.6	834.0
Roncador stearnsi	spotfin croaker	38	37-226	0.8-149	306.5
Anchoa delicatissima	slough anchovy	28	33-42	0.2-1.5	24.4
Seriphus politus	queenfish	25	35-60	0.7-3.3	41.7
Strongylura exilis	California needlefish	17	84-375	0.6-45.4	91.8
Sardinops sagax	Pacific sardine	15	35-59	0.4-2.3	15.4
Anchoa compressa	deepbody anchovy	10	60-116	2.5-22.5	76.1
Porichthys myriaster	specklefin midshipman	7	164-354	53.3-369.3	1,692.9
Paralichthys californicus	California halibut	5	41-99	1.3-10.6	32.5
Syngnathus spp.	pipefishes	4	103-179	0.8-4.2	11.6
Hypsopsetta guttulata	diamond turbot	1	145	79.1	79.1
Scomber japonicus	Pacific mackerel	1	63	2.2	2.2
Symphurus atricauda	California tonguefish	1	90	7.3	7.3
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	20	268-421	179-600	5,135.9
Urolophus halleri	round stingray	1	85	29.7	29.7
Myliobatis californica	bat ray	5	248-317	236.7-531.3	2,010.0
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	3	21-33	5.8-16.1	32.7
Octopus spp.	octopus	1	-	239.4	239.4
	Total:	**846**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA005 **Survey Date: July 21 - 22, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	70	51-71	3.5-10.0	459.0
Sardinops sagax	Pacific sardine	64	40-68	0.5-4.0	90.5
Engraulis mordax	northern anchovy	35	41-106	0.5-9.6	35.1
Seriphus politus	queenfish	20	36-499	0.9-97.6	160.4
Heterostichus rostratus	giant kelpfish	13	81-116	3.6-12.5	93.9
Atherinops affinis	topsmelt	9	54-129	0.8-20.1	56.6
Roncador stearnsi	spotfin croaker	9	46-76	2.4-7.7	35.2
Porichthys myriaster	specklefin midshipman	6	233-378	132-600	1,766.6
Anchoa delicatissima	slough anchovy	5	45	0.6	4.5
Cheilotrema saturnum	black croaker	5	43-52	1.3-2.3	9.3
Syngnathus spp.	pipefishes	4	137-207	0.8-3.8	8.0
Anchoa compressa	deepbody anchovy	3	80-116	5.9-19.9	32.7
Atractoscion nobilis	white seabass	2	79-83	7.6-11.4	19.0
Hypsopsetta guttulata	diamond turbot	2	141-163	73-124	196.7
unidentified fish	unid. fish	2	50-58	1.4-1.6	3.0
Paralichthys californicus	California halibut	1	54	2.2	2.2
Scomber japonicus	Pacific mackerel	1	89	7.8	7.8
Strongylura exilis	California needlefish	1	377	39.3	39.3
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	11	273-618	191-1212	4,244.2
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	3	21-42	2.2-14.8	21.1
	Total:	**266**			

Survey: EPSIA006 **Survey Date: July 28 - 29, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Seriphus politus	queenfish	95	41-240	1.1-156	530.0
Cymatogaster aggregata	shiner surfperch	53	52-109	2.2-25.5	341.2
Heterostichus rostratus	giant kelpfish	23	45-116	1.9-12.9	130.0
Engraulis mordax	northern anchovy	22	41-93	0.4-7.8	28.0
Atherinops affinis	topsmelt	17	55-107	1.2-11.9	86.1
Strongylura exilis	California needlefish	11	76-372	0.4-55.7	90.4
Porichthys myriaster	specklefin midshipman	8	285-380	226-410	2,608.8
Anchoa delicatissima	slough anchovy	4	65-84	3.4-6.5	17.9
Sardinops sagax	Pacific sardine	3	55-72	1.5-5.1	9.4
Anchoa spp.	anchovy	2	-	7.4	7.4
Paralichthys californicus	California halibut	2	87-114	8.6-16.3	24.9
Anchoa compressa	deepbody anchovy	1	66	2.9	2.9
Cheilotrema saturnum	black croaker	1	50	2.9	2.9
Sphyraena argentea	California barracuda	1	45	0.3	0.3
Syngnathus spp.	pipefishes	1	175	1.1	1.1
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	8	265-368	160-410	1,898.7
Urolophus halleri	round stingray	2	160-170	217-278	495.0
Myliobatis californica	bat ray	1	254	204.3	204.3
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	2	25-42	8.4-24.1	32.5
	Total:	**257**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA007 **Survey Date: August 04 - 05, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Seriphus politus	queenfish	19	43-80	1.4-6.3	63.0
Atherinops affinis	topsmelt	13	57-100	0.9-9.8	38.0
Cymatogaster aggregata	shiner surfperch	11	55-99	2.9-21.1	77.4
Heterostichus rostratus	giant kelpfish	3	83-115	5.1-11.4	26.6
Porichthys myriaster	specklefin midshipman	3	294-309	242-331	872.5
Hypsopsetta guttulata	diamond turbot	2	139-270	69.5-282.5	352.0
Strongylura exilis	California needlefish	2	62-131	0.1-1.1	1.2
Anchoa compressa	deepbody anchovy	1	104	15.9	15.9
Anchoa delicatissima	slough anchovy	1	92	9.4	9.4
Engraulis mordax	northern anchovy	1	70	4.0	4.0
Sardinops sagax	Pacific sardine	1	57	1.4	1.4
Sciaenidae unid.	croaker	1	25	0.1	0.1
Syngnathus spp.	pipefishes	1	186	1.4	1.4
unidentified fish	unid. fish	1	315	700	700.0
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	7	252-296	133-213	1,250.8
Myliobatis californica	bat ray	3	240-250	175.4-183.9	537.3
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	1	25	6.3	6.3
Loxorhynchus crispatus	moss crab	1	7.3	1.1	1.1
	Total:	**72**			

Survey: EPSIA008 **Survey Date: August 11 - 12, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinops affinis	topsmelt	375	37-156	0.5-40.8	1,068.2
Cymatogaster aggregata	shiner surfperch	97	56-109	5.1-29.4	895.0
Anchoa compressa	deepbody anchovy	43	64-169	3.1-19.9	426.7
Seriphus politus	queenfish	28	35-167	1.0-62.1	239.2
Heterostichus rostratus	giant kelpfish	24	73-137	2.9-21.6	175.2
Sardinops sagax	Pacific sardine	17	59-92	2.5-9.3	65.8
Syngnathus spp.	pipefishes	16	145-210	0.5-2.8	23.3
Engraulis mordax	northern anchovy	12	54-95	1.7-7.7	37.6
Strongylura exilis	California needlefish	12	78-297	0.8-20.2	59.6
Porichthys myriaster	specklefin midshipman	9	53-309	1.9-306.2	1,556.9
Leuresthes tenuis	California grunion	8	52-71	1.4-2.9	17.9
Anchoa delicatissima	slough anchovy	2	75-101	4.6-11.1	15.7
Cheilotrema saturnum	black croaker	2	62-119	3.7-20.7	24.4
Hypsopsetta guttulata	diamond turbot	2	91-202	8.4-190	198.1
Anisotremus davidsonii	sargo	1	243	341.2	341.2
Hyperprosopon argenteum	walleye surfperch	1	153	96.9	96.9
Paralabrax spp.	sand bass	1	32	0.9	0.9
Pleuronichthys verticalis	hornyhead turbot	1	152	97.3	97.3
Roncador stearnsi	spotfin croaker	1	164	57.1	57.1
Sciaenidae unid.	croaker	1	38	2.7	2.7
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	8	259-341	150-297	1,595.1
Urolophus halleri	round stingray	8	124-242	133-600	2,290.9
Myliobatis californica	bat ray	9	230-315	111.6-404.8	2,602.8
Platyrhinoidis triseriata	thornback	1	53	10.2	10.2
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	3	25.3-36	8.0-21.1	38.7
Loxorhynchus crispatus	moss crab	1	11	0.8	0.8
Hemigrapsus oregonensis	yellow shore crab	2	18-20	0.9-2.8	3.7
Pelia tumida	dwarf teardrop crab	1	13	1.9	1.9
	Total:	**686**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA009 — **Survey Date: August 18 - 19, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinops affinis	topsmelt	18	56-124	1.7-15.8	81.2
Heterostichus rostratus	giant kelpfish	14	66-158	3.4-33.2	122.2
Strongylura exilis	California needlefish	13	87-170	0.4-3.7	28.3
Sardinops sagax	Pacific sardine	10	65-85	3.0-9.4	90.6
Cymatogaster aggregata	shiner surfperch	5	57-75	5.0-11.3	41.6
Seriphus politus	queenfish	5	57-70	3.5-5.5	22.9
Anchoa delicatissima	slough anchovy	2	70-71	3.6-4.4	8.0
Hermosilla azurea	zebra perch	2	53-260	4.8-600	604.8
Paralichthys californicus	California halibut	2	81-103	6.9-16.0	22.9
Porichthys myriaster	specklefin midshipman	2	75-268	5.5-200	205.5
unidentified fish	unid. fish	2	37-44	2.1-2.6	4.7
Hypsoblennius gentilis	bay blenny	1	95	14.7	14.7
Hypsopsetta guttulata	diamond turbot	1	136	57.9	57.9
Leuresthes tenuis	California grunion	1	146	19.9	19.9
Syngnathus spp.	pipefishes	1	184	2.5	2.5
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	2	270-288	162-190	352.2
Urolophus halleri	round stingray	2	133-230	95-123	218.0
Myliobatis californica	bat ray	1	340	550	550.0
Ophichthus zophochir	yellow snake eel	1	420	51.8	51.8
Platyrhinoidis triseriata	thornback	1	630	1,500	1,500.0
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	2	22-30	6.1-15.6	21.7
Pyromaia tuberculata	tuberculate pea crab	1	15	3.2	3.2
Octopus spp.	octopus	-	-	-	-
	Total:	89			

Survey: EPSIA010 — **Survey Date: August 25 - 26, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Anchoa compressa	deepbody anchovy	24	39-115	0.7-16.1	110.5
Seriphus politus	queenfish	13	46-121	1.5-20.2	80.6
Atherinops affinis	topsmelt	9	64-133	2.1-17.0	68.0
Heterostichus rostratus	giant kelpfish	9	74-125	3.1-15.8	60.8
Sardinops sagax	Pacific sardine	8	-	8.0	36.8
Cymatogaster aggregata	shiner surfperch	7	64-80	6.3-11.3	60.7
Leuresthes tenuis	California grunion	6	59-81	1.6-3.4	13.4
Engraulis mordax	northern anchovy	3	54-56	1-1.8	4.4
Porichthys myriaster	specklefin midshipman	3	275-314	180-350	725.8
Hermosilla azurea	zebra perch	2	35-70	1.1-8.1	9.2
Hypsopsetta guttulata	diamond turbot	2	188-216	39.1-254	293.4
Strongylura exilis	California needlefish	2	105-508	1.2-290	291.2
Paralabrax nebulifer	barred sand bass	1	57	2.6	2.6
Roncador stearnsi	spotfin croaker	1	280	500	500.0
unidentified fish	unid. fish	1	-	20.1	20.1
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	3	260-300	145-220	546.2
Urolophus halleri	round stingray	3	125-147	89.4-148	353.4
Myliobatis californica	bat ray	2	208-240	148-185	332.4
Rhinobatos productus	shovelnose guitarfish	1	410	300	300.0
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	4	18.5-39	0.8-24.3	25.1
Lophopanopeus spp.	black-clawed crabs	1	14	1.3	1.3
	Total:	105			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA011 — **Survey Date: September 01 - 02, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Heterostichus rostratus	giant kelpfish	10	80-97	3.8-10.1	60.6
Anchoa delicatissima	slough anchovy	4	60-73	2.1-4.0	10.4
Leuresthes tenuis	California grunion	4	65-112	2.2-13.5	25.7
Seriphus politus	queenfish	3	55-63	2.3-5.9	11.9
Cymatogaster aggregata	shiner surfperch	2	68-70	8.2-8.9	17.1
Paralichthys californicus	California halibut	2	59-118	3.1-25.8	28.9
Anchoa compressa	deepbody anchovy	1	79	7.4	7.4
Paralabrax spp.	sand bass	1	39	1.1	1.1
Porichthys myriaster	specklefin midshipman	1	400	550	550.0
Sardinops sagax	Pacific sardine	1	75	3.6	3.6
Strongylura exilis	California needlefish	1	-	1.8	1.8
Syngnathus spp.	pipefishes	1	152	0.6	0.6
unidentified fish, damaged	unid. damaged fish	1	-	137.4	137.4
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	1	327	233.3	233.3
Myliobatis californica	bat ray	1	340	400	400.0
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	1	25	4.0	4.0
Taliepus nuttallii	globose kelp crab	1	11	0.7	0.7
	Total:	**36**			

Survey: EPSIA012 — **Survey Date: September 08 - 09, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Anchoa compressa	deepbody anchovy	93	42-94	0.2-12.3	301.0
Leuresthes tenuis	California grunion	43	54-73	1.0-5.0	94.7
Seriphus politus	queenfish	29	32-155	0.6-53.0	218.0
Heterostichus rostratus	giant kelpfish	24	60-122	2.1-16.2	172.7
Engraulis mordax	northern anchovy	15	52-71	1.2-4.1	29.5
Cymatogaster aggregata	shiner surfperch	7	53-95	4.9-25.0	79.0
Porichthys notatus	plainfin midshipman	5	53-400	1.6-420	723.6
Sphyraena argentea	California barracuda	5	48-73	0.6-3.3	10.2
Xenistius califoriensis	salema	4	31-55	0.7-2.3	4.9
Paralabrax nebulifer	barred sand bass	3	46-124	2.0-28.4	43.5
Sardinops sagax	Pacific sardine	3	68-75	3.5-4.1	11.2
Cheilotrema saturnum	black croaker	2	35-55	1.2-4.3	5.5
Phanerodon furcatus	white surfperch	2	85-93	19.7-20.0	39.7
Porichthys myriaster	specklefin midshipman	2	54-360	1.8-410	411.8
Atherinops affinis	topsmelt	1	103	9.9	9.9
Hypsopsetta guttulata	diamond turbot	1	231	380	380.0
Paralichthys californicus	California halibut	1	105	19.0	19.0
Pleuronectiformes unid.	flatfishes	1	-	54.7	54.7
Roncador stearnsi	spotfin croaker	1	250	380	380.0
Strongylura exilis	California needlefish	1	138	2.0	2.0
Syngnathus spp.	pipefishes	1	133	0.9	0.9
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	4	254-599	137-265	708.2
Myliobatis californica	bat ray	1	-	110	110.0
Urolophus halleri	round stingray	1	-	200	200.0
INVERTEBRATES					
Hemigrapsus oregonensis	yellow shore crab	1	18	2.5	2.5
	Total:	**251**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA013
Sample Count: 19

Survey Date: September 15 - 16, 2004

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	24	55-100	5.1-29.6	216.5
Leuresthes tenuis	California grunion	15	48-124	0.9-15.8	72.3
Anchoa delicatissima	slough anchovy	10	40-70	0.5-3.5	22.4
Anchoa compressa	deepbody anchovy	9	58-86	2.0-5.7	30.9
Heterostichus rostratus	giant kelpfish	8	82-124	3.4-15.8	59.2
Sphyraena argentea	California barracuda	4	81-90	2.8-3.6	13.3
Trachurus symmetricus	jack mackerel	4	36-40	0.6-0.9	3.0
Atherinops affinis	topsmelt	3	79-101	3.9-9.8	19.5
Strongylura exilis	California needlefish	3	184-410	4.0-64.8	89.5
Porichthys myriaster	specklefin midshipman	2	57-229	1.8-247	248.8
Sardinops sagax	Pacific sardine	2	67-73	3.1-3.2	6.3
Seriphus politus	queenfish	2	71-73	4.0-5.2	9.2
Xenistius califoriensis	salema	2	37-40	0.8-1.2	2.0
Brachyistius frenatus	kelp surfperch	1	95	28.9	28.9
Cheilotrema saturnum	black croaker	1	43	0.6	0.6
Engraulis mordax	northern anchovy	1	72	2.6	2.6
Paralichthys californicus	California halibut	1	60	3.1	3.1
Umbrina roncador	yellowfin croaker	1	37	1.0	1.0
unidentified fish, damaged	unid. damaged fish	1	-	20.3	20.3
SHARKS/RAYS					
Myliobatis californica	bat ray	2	299-422	201-298	499.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	5	30-58	2.5-17.5	33.2
Pachygrapsus crassipes	striped shore crab	2	18-35	0.5-24.8	25.3
Pugettia spp.	kelp crabs	1	22	4.1	4.1
	Total:	**104**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA014 **Survey Date: September 22 - 23, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Anchoa compressa	deepbody anchovy	52	22-94	0.8-9.3	119.4
Seriphus politus	queenfish	34	22-82	0.1-8.4	102.1
Leuresthes tenuis	California grunion	20	49-115	1.0-17.1	89.4
Cymatogaster aggregata	shiner surfperch	17	56-90	5.6-18.3	162.5
Anchoa delicatissima	slough anchovy	5	50-76	1.8-4.0	12.3
Sardinops sagax	Pacific sardine	4	62-80	2.8-10.6	20.3
Anisotremus davidsonii	sargo	3	42-72	1.9-10.6	16.9
Heterostichus rostratus	giant kelpfish	3	90-98	5.2-7.3	17.7
Roncador stearnsi	spotfin croaker	3	90-93	9.6-17.7	42.3
Xenistius califoriensis	salema	3	30-41	0.6-1.9	4.2
Atractoscion nobilis	white seabass	2	36-75	0.5-3.4	3.9
Cheilopogon pinnatibarbatus	spotted flyingfish	2	310-313	291-310	601.1
Cheilotrema saturnum	black croaker	2	62-87	5.9-14.4	20.3
Engraulis mordax	northern anchovy	2	57-58	1.1-1.5	2.6
Paralabrax nebulifer	barred sand bass	2	43-50	1.5-3.0	4.5
Sphyraena argentea	California barracuda	2	72-111	2.3-8.3	10.6
Strongylura exilis	California needlefish	2	118-225	1.7-12.5	14.2
Umbrina roncador	yellowfin croaker	2	50-55	2.5-3.6	6.1
Atherinopsis californiensis	jacksmelt	1	125	22.1	22.1
Menticirrhus undulatus	California corbina	1	108	18.9	18.9
Oxylebius pictus	painted greenling	1	66	4.8	4.8
Porichthys myriaster	specklefin midshipman	1	163	41.2	41.2
Syngnathus spp.	pipefishes	1	505	50.0	50.0
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	1	340	330	330.0
Myliobatis californica	bat ray	1	297	375	375.0
INVERTEBRATES					
Loligo opalescens	market squid	3	75-129	7.4-10.8	26.2
Callinectes spp.	crab	1	26	13.8	13.8
Pachygrapsus crassipes	striped shore crab	1	28	10.1	10.1
Pyromaia tuberculata	tuberculate pea crab	1	12	-	-
	Total:	**173**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA015 **Survey Date: September 29 - 30, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Seriphus politus	queenfish	28	35-78	0.5-7.0	77.4
Leuresthes tenuis	California grunion	16	57-150	1.5-36.0	136.0
Engraulis mordax	northern anchovy	11	33-116	0.2-14.0	24.7
Anchoa compressa	deepbody anchovy	10	45-81	0.5-5.0	22.0
Hyperprosopon argenteum	walleye surfperch	10	49-85	2.0-15.0	80.5
Xenistius califoriensis	salema	10	35-63	0.5-4.0	19.5
Anchoa delicatissima	slough anchovy	5	56-77	1.0-5.0	14.0
Anisotremus davidsonii	sargo	4	38-58	1.0-5.0	9.5
Heterostichus rostratus	giant kelpfish	4	95-121	4.0-22.0	45.0
Sphyraena argentea	California barracuda	4	88-115	4.0-10.0	24.0
Strongylura exilis	California needlefish	4	139-325	0.7-42.0	54.7
Atherinops affinis	topsmelt	2	64-78	3.0-6.0	9.0
Embiotoca jacksoni	black surfperch	2	164-175	170-200	370.0
Paralichthys californicus	California halibut	2	120-133	20.0-35.0	55.0
Sardinops sagax	Pacific sardine	2	71-75	2.0-3.5	5.5
Atherinopsis californiensis	jacksmelt	1	181	47.0	47.0
Atractoscion nobilis	white seabass	1	145	45.0	45.0
Genyonemus lineatus	white croaker	1	100	2.1	2.1
Paralabrax maculatofasciatus	spotted sand bass	1	81	10.5	10.5
Peprilus simillimus	Pacific butterfish	1	130	50.0	50.0
Roncador stearnsi	spotfin croaker	1	115	20.0	20.0
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	1	292	190	190.0
Urolophus halleri	round stingray	1	272	270	270.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	7	18-33	2.5-9.0	36.2
Cancer antennarius	brown rock crab	2	11-25	0.2-1.7	1.9
Lophopanopeus frontalis	molarless crestleg crab	2	11-13	0.4	0.8
Cancer productus	red rock crab	1	26	3.4	3.4
Loligo opalescens	market squid	1	70	7.0	7.0
Panulirus interruptus	California spiny lobster	1	-	66.0	66.0
Pyromaia tuberculata	tuberculate pea crab	1	9	0.6	0.6
	Total:	**137**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA016
Sample Count: 19

Survey Date: October 06 - 07, 2004

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinopsidae	silverside	57	48-130	0.5-20.8	289.5
Seriphus politus	queenfish	47	35-98	1.0-14.8	222.3
Anchoa compressa	deepbody anchovy	35	45-95	1.0-10.7	141.8
Cymatogaster aggregata	shiner surfperch	19	57-82	5.0-13.7	175.2
Engraulis mordax	northern anchovy	17	50-103	1.2-8.9	30.5
Xenistius califoriensis	salema	17	27-58	0.5-4.0	22.6
Anchoa delicatissima	slough anchovy	5	53-85	1.0-6.0	14.0
Sphyraena argentea	California barracuda	4	96-435	3.0-110	139.9
Porichthys myriaster	specklefin midshipman	3	87-390	7.2-460	822.2
Heterostichus rostratus	giant kelpfish	2	72-275	1.0-195	196.0
Paralichthys californicus	California halibut	2	128-133	39.0-40.0	79.0
Strongylura exilis	California needlefish	2	73-82	0.3	0.7
Leuresthes tenuis	California grunion	1	68	2.0	2.0
Paralabrax maculatofasciatus	spotted sand bass	1	29	1.5	1.5
Sardinops sagax	Pacific sardine	1	66	3.0	3.0
SHARKS/RAYS					
Urolophus halleri	round stingray	3	60-154	13.6-195	368.6
Myliobatis californica	bat ray	2	294	400	400.0
INVERTEBRATES					
Loligo opalescens	market squid	11	47-66	4.0-10.0	70.6
Portunus xantusii	Xantus' swimming crab	10	10-50	0.5-9.0	38.9
Taliepus nuttallii	globose kelp crab	2	5-6	0.5	1.0
Cancer spp.	cancer crabs	1	24	2.6	2.6
Pachygrapsus crassipes	striped shore crab	1	12	2.5	2.5
Pachygrapsus spp.	shore crab	1	15	0.9	0.9
Pugettia producta	northern kelp crab	1	8	-	-
Pyromaia tuberculata	tuberculate pea crab	1	6	-	-
	Total:	**246**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA017 **Survey Date: October 13 - 14, 2004**
Sample Count: 13

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinopsidae	silverside	5	55-65	1.2-3.0	2.0
Atractoscion nobilis	white seabass	2	252	140-144	1.2
Engraulis mordax	northern anchovy	2	48-51	1.2	2.4
Seriphus politus	queenfish	2	43-65	1.1-3.9	1.3
Anchoa compressa	deepbody anchovy	1	56	2.0	4.6
Anchoa delicatissima	slough anchovy	1	58	1.2	3.1
Cymatogaster aggregata	shiner surfperch	1	74	8.1	8.1
Sardinops sagax	Pacific sardine	1	77	3.1	11.9
unidentified fish	unid. fish	1	-	4.6	284.0
Xenistius califoriensis	salema	1	44	1.3	5.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	20	23-41	2.6-12.9	113.4
Pugettia producta	northern kelp crab	1	80	5.4	5.4
Taliepus nuttallii	globose kelp crab				
	Total:	**38**			

Survey: EPSIA018 **Survey Date; October 20 - 21, 2004**
Sample Count: 13

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinopsidae	silverside	114	52-193	1.4-32.0	905.9
Seriphus politus	queenfish	35	28-77	0.4-7.1	61.0
Xenistius califoriensis	salema	32	30-50	0.4-2.0	30.0
Anchoa compressa	deepbody anchovy	18	40-68	1.3-3.7	41.0
Engraulis mordax	northern anchovy	16	54-70	1.8-4.0	42.6
Brachyistius frenatus	kelp surfperch	14	62-102	6.0-25.0	135.6
Atractoscion nobilis	white seabass	4	223-243	135.2-185.0	640.2
Lepomis cyanellus	green sunfish	4	104-126	26.0-68.0	194.7
Ameiurus natalis	yellow bullhead	3	162-175	65.0-80.0	220.0
Paralichthys californicus	California halibut	3	110-151	21.0-45.0	111.0
Strongylura exilis	California needlefish	3	370-397	67.0-84.0	221.0
Acanthogobius flavimanus	yellowfin goby	2	115-148	18.0-37.2	55.2
Anisotremus davidsonii	sargo	2	44-69	1.8-7.0	8.8
Anchoa spp.	anchovy	1	-	6.8	6.8
Cymatogaster aggregata	shiner surfperch	1	84	7.5	7.5
Hypsopsetta guttulata	diamond turbot	1	125	53.0	53.0
Paralabrax clathratus	kelp bass	1	48	2.0	2.0
Porichthys myriaster	specklefin midshipman	1	47	1.0	1.0
Sardinops sagax	Pacific sardine	1	65	3.0	3.0
Sphyraena argentea	California barracuda	1	72	2.0	2.0
SHARKS/RAYS					
Myliobatis californica	bat ray	1	300	200	200.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	6	21-46	2.1-12.4	38.4
Pugettia producta	northern kelp crab	6	4-15	0.1-1.4	2.8
Loxorhynchus spp.	spider crabs	2	5	0.1-0.5	0.6
Brachyuran unid.	unidentified crab	1	8	0.4	0.4
Caridean unid.	unidentified shrimp	1	159	28.0	28.0
	Total:	**274**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA019 | **Survey Date: October 27 - 28, 2004**
Sample Count: 13

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinopsidae	silverside	64	52-134	1.0-27.0	256.5
Xenistius califoriensis	salema	41	19-45	0.3-1.7	43.8
Seriphus politus	queenfish	32	32-78	1.3-6.4	94.4
Lepomis cyanellus	green sunfish	10	95-117	30.5-77.5	442.8
Micropterus salmoides	large mouth bass	9	49-57	2.4-3.4	26.9
Cymatogaster aggregata	shiner surfperch	8	63-82	5.9-11.6	66.0
Engraulis mordax	northern anchovy	8	59-64	2.1-2.7	19.0
Strongylura exilis	California needlefish	5	392-577	70.0-230	635.0
Anchoa delicatissima	slough anchovy	4	42-66	1.7-7.1	22.2
Lepomis macrochirus	bluegill	3	34-121	1.8-55.5	111.3
Anchoa compressa	deepbody anchovy	2	60-77	2.5-5.7	8.2
Paralichthys californicus	California halibut	2	42-44	1.2-1.3	2.5
Phanerodon furcatus	white surfperch	2	89-119	13.5-27.4	40.9
Sphyraena argentea	California barracuda	2	48-63	0.9-1.6	2.5
Tilapia spp.	tilapia	2	27-46	2.4-4.2	6.6
Trachurus symmetricus	jack mackerel	2	37-38	1.1	2.2
Rhacochilus vacca	pile surfperch	1	263	465	465.0
Heterostichus rostratus	giant kelpfish	1	96	5.4	5.4
Porichthys myriaster	specklefin midshipman	1	342	221	221.0
Porichthys notatus	plainfin midshipman	1	385	460	460.0
Syngnathus spp.	pipefishes	1	161	1.3	1.3
unidentified fish, damaged	unid. damaged fish	1	-	16.0	16.0
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	4	272-550	165-1,100	1,775.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	31	7-41	0.9-13.9	195.5
Octopus bimaculatus	California two-spot octopus	4	-	5.2-25.3	58.1
Loxorhynchus crispatus	moss crab	1	7	0.3	0.3
Pugettia spp.	kelp crabs	1	2	0.1	0.1
	Total:	**243**			

Survey: EPSIA020 | **Survey Date: November 03 - 04, 2004**
Sample Count: 13

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Anchoa compressa	deepbody anchovy	35	37-85	0.9-7.1	101.6
Engraulis mordax	northern anchovy	30	57-76	1.9-4.6	85.8
Atherinopsidae	silverside	20	50-147	1.1-33.0	148.5
Seriphus politus	queenfish	9	34-66	0.8-4.3	19.8
Xenistius califoriensis	salema	2	37-42	0.9-1.3	2.1
Cymatogaster aggregata	shiner surfperch	1	70	8.7	8.7
Trachurus symmetricus	jack mackerel	1	-	2.0	2.0
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	1	304	120	120.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	8	21-29	3.8-9.7	58.4
Brachyuran unid.	unidentified crab	1	17	2.8	2.8
Crangon spp.	bay shrimp	1	107	20.9	20.9
Loligo opalescens	market squid	1	-	-	-
Rhithropanopeus harrisii	Harris' mud crab	1	30	18.0	18.0
	Total:	**111**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA021 **Survey Date: November 10 - 11, 2004**
Sample Count: 13

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinopsidae	silverside	14	62-164	2.0-21.3	76.0
Seriphus politus	queenfish	5	46-82	1.4-7.1	13.9
Scorpaena guttata	spotted scorpinfish	1	110	38.0	38.0
Xenistius califoriensis	salema	1	40	1.1	1.1
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	26	15-60	0.9-15.7	193.5
Pachygrapsus crassipes	striped shore crab	2	12-27	0.5	0.5
Cycloxanthops novemdentatus	ninetooth pebble crab	1	19	2.6	2.6
	Total:	50			

Survey: EPSIA022 **Survey Date: November 17 - 18, 2004**
Sample Count: 13

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinopsis californiensis	jacksmelt	29	45-146	0.8-33.0	123.9
Seriphus politus	queenfish	18	37-89	0.8-11.1	41.6
Atherinops affinis	topsmelt	4	70-124	2.5-17.6	27.3
Hyperprosopon argenteum	walleye surfperch	2	135-160	61.5-101	162.0
Paralichthys californicus	California halibut	2	49-132	1.8-35.6	37.3
Anchoa compressa	deepbody anchovy	1	66	3.5	3.5
Cheilotrema saturnum	black croaker	1	127	38.6	38.6
Leuresthes tenuis	California grunion	1	63	1.7	1.7
Sarda chiliensis	Pacific bonito	1	336	500	500.0
Xenistius califoriensis	salema	1	48	2.0	2.0
SHARKS/RAYS					
Urolophus halleri	round stingray	1	80	27.7	27.7
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	9	16-36	2.0-17.0	68.4
Pachygrapsus crassipes	striped shore crab	3	32-35	15.0-18.8	49.5
	Total:	73			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA023 **Survey Date; November 22 - 23, 2004**
Sample Count: 13

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Leuresthes tenuis	California grunion	12	59-155	1.6-31.2	70.1
Seriphus politus	queenfish	11	30-82	0.7-6.7	22.3
Anchoa compressa	deepbody anchovy	5	55-70	1.5-4.8	12.9
Atherinopsis californiensis	jacksmelt	3	62-160	2.3-45.3	56.1
Atractoscion nobilis	white seabass	2	255-291	200-302	502.1
Engraulis mordax	northern anchovy	2	65	2.0-2.9	4.9
Hypsoblennius spp.	blennies	1	50	3.5	3.5
Menticirrhus undulatus	California corbina	1	72	5.1	5.1
Micrometrus minimus	dwarf surfperch	1	70	8.3	8.3
Paralabrax clathratus	kelp bass	1	40	1.7	1.7
Paralichthys californicus	California halibut	1	50	1.7	1.7
unidentified fish, damaged	unid. damaged fish	1	250	200	200.0
Xenistius califoriensis	salema	1	47	1.8	1.8
SHARKS/RAYS					
Myliobatis californica	bat ray	1	400	460	460.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	34	18-46	2.4-18.2	154.9
Cancer magister	dungeness crab	1	-	-	-
Pugettia richii	cryptic kelp crab	1	12	1.3	1.3
Pugettia spp.	kelp crabs	1	-	-	-
	Total:	**80**			

Survey: EPSIA024 **Survey Date: December 01 - 02, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Anchoa compressa	deepbody anchovy	801	50-112	0.7-12.1	2,471.4
Xenistius califoriensis	salema	514	40-60	1.1-5.3	1,404.0
Seriphus politus	queenfish	320	29-100	0.5-19.3	1,941.7
Cymatogaster aggregata	shiner surfperch	212	61-94	5.1-18.1	2,343.6
Leuresthes tenuis	California grunion	65	31-125	0.3-18.5	265.2
unidentified fish, damaged	unid. damaged fish	6	-	-	-
Anisotremus davidsonii	sargo	4	51-70	2.9-8.3	22.5
Atherinops affinis	topsmelt	4	57-118	1.2-14.2	19.2
Atherinopsis californiensis	jacksmelt	4	63-108	2.2-10.5	19.8
Sardinops sagax	Pacific sardine	3	82-91	4.8-7.5	17.2
Genyonemus lineatus	white croaker	1	115	30.0	30.0
Heterostichus rostratus	giant kelpfish	1	65	5.3	5.3
Hypsoblennius gentilis	bay blenny	1	56	2.6	2.6
Hypsoblennius gilberti	rockpool blenny	1	70	4.3	4.3
Menticirrhus undulatus	California corbina	1	74	5.0	5.0
Paralichthys californicus	California halibut	1	160	60.1	60.1
Sphyraena argentea	California barracuda	1	115	7.4	7.4
Strongylura exilis	California needlefish	1	462	115.1	115.1
Syngnathus spp.	pipefishes	1	249	3.0	3.0
Umbrina roncador	yellowfin croaker	1	67	5.4	5.4
SHARKS/RAYS					
Platyrhinoidis triseriata	thornback	2	181-192	305-342	647.0
Urolophus halleri	round stingray	2	149-155	183-210	393.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	13	20-65	2.7-23.6	110.9
Loligo opalescens	market squid	4	88-114	-	-
Pachygrapsus crassipes	striped shore crab	3	6-35	0.2-19.5	31.3
Pugettia spp.	kelp crabs	1	9	0.3	0.3
	Total:	**1,968**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA025 **Survey Date: December 08 - 09, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Leuresthes tenuis	California grunion	96	49-130	1.1-26.5	440.8
Seriphus politus	queenfish	90	27-175	0.5-58.9	512.7
Anchoa compressa	deepbody anchovy	71	53-111	0.9-12.6	223.8
Xenistius califoriensis	salema	23	20-70	0.9-5.6	51.4
Cymatogaster aggregata	shiner surfperch	16	65-105	7.1-25.1	223.8
Sardinops sagax	Pacific sardine	10	73-108	3.7-13.3	70.9
Atherinops affinis	topsmelt	7	63-140	2.2-11.0	30.7
unidentified fish, damaged	unid. damaged fish	4	-	14.8	14.8
Strongylura exilis	California needlefish	2	455-482	120-125	245.0
Chromis punctipinnis	blacksmith	1	105	27.0	27.0
Micrometrus minimus	dwarf surfperch	1	54	4.4	4.4
Paraclinus integripinnis	reef finspot	1	65	3.7	3.7
SHARKS/RAYS					
Myliobatis californica	bat ray	1	305	400	400.0
Platyrhinoidis triseriata	thornback	1	490	650	650.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	14	23-60	3.0-19.0	101.5
Pachygrapsus crassipes	striped shore crab	4	5-40	0.1-20.9	29.7
Pugettia spp.	kelp crabs	2	10-13	0.4-1.1	1.5
Octopus spp.	octopus	1	-	200	200.0
Pyromaia tuberculata	tuberculate pea crab	1	22	2.3	2.3
	Total:	**346**			

Survey: EPSIA026 **Survey Date: December 15 - 16, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Leuresthes tenuis	California grunion	99	20-124	0.6-21.2	341.8
Seriphus politus	queenfish	44	47-102	1.4-13.5	268.2
Xenistius califoriensis	salema	28	38-57	1.1-3.5	55.3
Cymatogaster aggregata	shiner surfperch	11	64-83	7.8-16.5	112.9
Atractoscion nobilis	white seabass	8	229-295	150-310	1,655.0
Engraulis mordax	northern anchovy	6	38-109	0.5-13.6	24.1
Anchoa compressa	deepbody anchovy	5	55-92	1.0-8.6	15.4
Atherinops affinis	topsmelt	2	53-84	1.4-6.2	7.6
Chromis punctipinnis	blacksmith	1	39	1.0	1.0
Hyperprosopon argenteum	walleye surfperch	1	140	75.4	75.4
Sardinops sagax	Pacific sardine	1	86	4.1	4.1
Umbrina roncador	yellowfin croaker	1	94	9.7	9.7
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	15	25-83	3.6-11.0	103.1
Pachygrapsus crassipes	striped shore crab	3	9-42	0.5-28.0	33.6
Loligo opalescens	market squid	1	52	24.1	24.1
Pugettia spp.	kelp crabs	1	9	0.5	0.5
	Total:	**227**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA027 **Survey Date: December 20 - 21, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Seriphus politus	queenfish	25	23-95	0.5-11.7	102.4
Anchoa compressa	deepbody anchovy	16	40-112	0.8-14.3	93.7
Leuresthes tenuis	California grunion	10	57-113	1.5-10.3	37.5
Atherinopsis californiensis	jacksmelt	6	62-133	2.4-23.6	37.3
Atherinopsidae	silverside	3	73-105	2.3-8.3	13.5
Sardinops sagax	Pacific sardine	2	80-89	4.5-5.7	10.2
Anchoa delicatissima	slough anchovy	1	68	3.3	3.3
Atractoscion nobilis	white seabass	1	290	265	265.0
Hyperprosopon argenteum	walleye surfperch	1	169	115	115.0
Xenistius califoriensis	salema	1	37	1.0	1.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	17	23-61	2.8-19.6	166.1
Cancer spp.	cancer crabs	1	26	28.0	28.0
Pachygrapsus crassipes	striped shore crab	1	15	2.2	2.2
Pugettia spp.	kelp crabs	1	11	1.4	1.4
	Total:	**86**			

Survey: EPSIA028 **Survey Date: December 29 - 30, 2004**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinopsidae	silverside	721	43-145	1.2-28.2	2,746.2
Xenistius califoriensis	salema	283	39-59	0.5-3.0	529.6
Anchoa compressa	deepbody anchovy	57	19-105	0.3-10.0	204.5
Cymatogaster aggregata	shiner surfperch	29	70-110	7.9-21.3	409.1
Sardinops sagax	Pacific sardine	21	72-85	2.8-5.2	83.7
Seriphus politus	queenfish	8	40-140	0.9-31.6	67.2
Strongylura exilis	California needlefish	5	400-508	79.4-160	532.0
Paralabrax clathratus	kelp bass	2	45-73	1.7-7.2	8.9
Syngnathus spp.	pipefishes	2	171-194	1.4-2.4	3.8
Atherinops affinis	topsmelt	1	-	-	-
Chub unid.	unid. chub	1	75	7.3	7.3
Citharichthys stigmaeus	speckled sanddab	1	69	4.6	4.6
Hypsopsetta guttulata	diamond turbot	1	225	250	250.0
Lepomis spp.	sunfishes	1	102	29.9	29.9
Micrometrus minimus	dwarf surfperch	1	56	4.5	4.5
Paralichthys californicus	California halibut	1	65	3.0	3.0
Phanerodon furcatus	white surfperch	1	69	9.4	9.4
Porichthys myriaster	specklefin midshipman	1	73	3.3	3.3
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	6	337-478	425-1,100	4,395.0
Myliobatis californica	bat ray	3	321-500	255-500	1,135.0
INVERTEBRATES					
Cancer spp.	cancer crabs	18	16-33	0.1-2.3	18.7
Pachygrapsus crassipes	striped shore crab	8	10-31	0.2-9.5	26.8
Portunus xantusii	Xantus' swimming crab	8	21-58	0.2-24.9	55.4
Pugettia spp.	kelp crabs	5	5-22	0.1-4.1	7.4
Loligo opalescens	market squid	3	78-100	19.4-34.7	80.8
Taliepus nuttallii	globose kelp crab	2	7-8	0.2-0.5	0.7
Brachyuran unid.	unidentified crab	1	-	-	-
	Total:	**1,191**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA029 **Survey Date: January 05 - 06, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinops affinis	topsmelt	344	48-137	0.9-33.5	2,151.8
Leuresthes tenuis	California grunion	60	53-159	1.2-36.4	361.6
Xenistius califoriensis	salema	42	41-55	1.1-3.3	80.9
Cymatogaster aggregata	shiner surfperch	14	78-100	6.5-27.2	240.6
Anchoa delicatissima	slough anchovy	10	55-81	1.6-4.4	24.8
Strongylura exilis	California needlefish	10	408-563	90.0-270	1,620.0
unidentified fish, damaged	unid. damaged fish	10	50-65	0.4-2.4	26.5
Sardinops sagax	Pacific sardine	7	44-88	0.7-4.7	25.1
Anisotremus davidsonii	sargo	4	48-81	2.5-11.6	30.1
Anchoa compressa	deepbody anchovy	3	60-100	2.0-12.2	23.7
Seriphus politus	queenfish	3	44-144	1.2-34.0	40.4
Atractoscion nobilis	white seabass	2	270	85.0-180	265.0
Engraulis mordax	northern anchovy	2	42-45	0.6	1.3
Paralabrax clathratus	kelp bass	2	62-64	2.8-5.1	7.9
Phanerodon furcatus	white surfperch	2	179-224	115-240	355.2
Hyperprosopon argenteum	walleye surfperch	1	98	20.7	20.7
Hyperprosopon spp.	surfperch	1	165	115	115.0
Hypsopsetta guttulata	diamond turbot	1	28	0.5	0.5
Lepomis macrochirus	bluegill	1	114	45.0	45.0
Lepomis spp.	sunfishes	1	106	35.6	35.6
Symphurus atricauda	California tonguefish	1	92	8.1	8.1
Syngnathus spp.	pipefishes	1	248	4.5	4.5
SHARKS/RAYS					
Myliobatis californica	bat ray	2	274-307	320-410	730.0
Ophichthus zophochir	yellow snake eel	2	489-520	120	240.0
Gymnura marmorata	California butterfly ray	1	465	648	648.0
Platyrhinoidis triseriata	thornback	1	-	178.0	177.9
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	22	19-55	2.6-19.7	198.2
Pachygrapsus crassipes	striped shore crab	5	10-31	0.4-10.2	18.7
Pugettia spp.	kelp crabs	3	7-25	1.1-6.1	8.7
Callianassa californiensis	ghost shrimp	2	41-49	1.0-1.9	2.9
Cancer jordani	hairy rock crab	2	21-30	1.3-5.8	7.1
Octopus spp.	octopus	2	-	20.4-114.8	135.2
Cancer antennarius	brown rock crab	1	21	2.3	2.3
Cancer productus	red rock crab	1	37	10.5	10.5
Pugettia producta	northern kelp crab	1	15	1.5	1.5
Taliepus nuttallii	globose kelp crab	1	10	0.5	0.5
	Total:	**568**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA030 **Survey Date: January 12 - 13, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinops affinis	topsmelt	2,551	35-184	0.5-67.1	23,391.9
Anchoa delicatissima	slough anchovy	861	38-127	0.9-17.0	2,654.2
Hyperprosopon argenteum	walleye surfperch	460	57-195	4.0-128	18,405.7
Anchoa compressa	deepbody anchovy	222	50-122	1.1-20.8	2,131.7
Paralabrax maculatofasciatus	spotted sand bass	181	43-240	1.4-310	1,596.9
Cymatogaster aggregata	shiner surfperch	118	38-136	1.9-54.9	2,175.8
Seriphus politus	queenfish	86	37-225	0.7-165	773.4
Paralabrax clathratus	kelp bass	79	44-154	1.0-70.0	526.4
Micrometrus minimus	dwarf surfperch	47	54-91	4.0-19.8	484.8
Menticirrhus undulatus	California corbina	39	58-341	3.0-580	1,599.6
Phanerodon furcatus	white surfperch	38	83-227	13.9-350	2,830.4
Paralabrax nebulifer	barred sand bass	33	43-88	1.2-35.0	185.7
Amphistichus argenteus	barred surfperch	32	68-195	8.6-220	1,242.5
Paralichthys californicus	California halibut	28	45-255	1.1-261	593.3
Sardinops sagax	Pacific sardine	28	73-180	2.5-65.0	364.7
Xenistius califoriensis	salema	26	36-74	0.6-6.5	45.0
Anisotremus davidsonii	sargo	21	51-244	2.0-370	834.4
Hypsopsetta guttulata	diamond turbot	15	22-240	14.1-310	2,128.0
Roncador stearnsi	spotfin croaker	15	51-421	2.0-1,500	5,531.5
Atractoscion nobilis	white seabass	12	127-316	26.4-350	2,846.4
Fundulus parvipinnis	California killifish	9	49-79	1.8-7.1	48.0
Engraulis mordax	northern anchovy	8	65-86	1.4-5.5	26.7
Umbrina roncador	yellowfin croaker	7	55-298	3.1-355	398.5
Chub unid.	unid. chub	4	62-81	4.5-7.6	24.5
Heterostichus rostratus	giant kelpfish	4	98-161	8.7-28.5	70.9
Citharichthys stigmaeus	speckled sanddab	3	49-65	1.5-3.6	6.6
Hermosilla azurea	zebra perch	3	66-71	7.3-11.9	27.3
Sphyraena argentea	California barracuda	3	198-224	55.4-68.5	181.4
Albula vulpes	bonefish	2	320-340	590-602	1,192.0
Ictaluridae	unid. catfish	2	162-177	55.0-100.5	155.5
Citharichthys sordidus	Pacific sanddab	1	50	0.5	0.5
Cynoscion parvipinnis	shortfin corvina	1	412	900	900.0
Rhacochilus vacca	pile surfperch	1	176	160	160.0
Genyonemus lineatus	white croaker	1	43	1.0	1.0
Hypsoblennius gentilis	bay blenny	1	65	5.0	5.0
Hypsoblennius gilberti	rockpool blenny	1	65	5.0	5.0
Scorpaena guttata	spotted scorpinfish	1	110	38.0	38.0
Strongylura exilis	California needlefish	1	716	90.0	90.0
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	33	275-525	185-1,520	24,459.0
Urolophus halleri	round stingray	10	146-206	180-630	3,834.0
Ophichthus zophochir	yellow snake eel	6	526-800	115-600	1,920.0
Mustelus californicus	gray smoothhound	3	442-687	300-1,100	1,850.0
Myliobatis californica	bat ray	3	355-447	640-1,300	3,240.0
Platyrhinoidis triseriata	thornback	1	186	550	550.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	73	13-58	1.5-42.0	492.1
Octopus spp.	octopus	10	-	40.0-700	2,011.5
Pachygrapsus crassipes	striped shore crab	5	11-35	0.5-9.0	25.7
Cancer productus	red rock crab	2	32-33	4.2-6.0	10.2
Cancer antennarius	brown rock crab	1	36	7.2	7.2
Lophopanopeus spp.	black-clawed crabs	1	80	8.0	8.0
Pandalus platyceros	spot shrimp	1	55	1.8	1.8
Pugettia richii	cryptic kelp crab	1	28	11.0	11.0
Sicyonia ingentis	Ridgeback rock shrimp	1	-	16.0	16.0
	Total:	**5,096**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA031
Sample Count: 19

Survey Date: January 19 - 20, 2005

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinops affinis	topsmelt	492	50-179	1.0-30.0	2,256.5
Sardinops sagax	Pacific sardine	32	55-127	2.5-15.5	180.4
Atractoscion nobilis	white seabass	18	80-235	40.0-160	1,521.0
Anchoa delicatissima	slough anchovy	12	55-79	1.0-5.0	29.7
Anchoa compressa	deepbody anchovy	8	60-96	2.5-10.0	36.0
Cymatogaster aggregata	shiner surfperch	6	69-110	9.0-35.0	103.0
Xenistius califoriensis	salema	5	39-55	1.0-3.0	10.0
Hyperprosopon argenteum	walleye surfperch	4	106-141	33.0-72.0	189.0
Paralabrax clathratus	kelp bass	4	53-66	3.0-6.0	20.0
Anisotremus davidsonii	sargo	2	55	2.5-7.0	9.5
Paralabrax maculatofasciatus	spotted sand bass	2	65-79	4.5-9.5	14.0
Paralabrax nebulifer	barred sand bass	2	63-75	4.0-8.0	12.0
Seriphus politus	queenfish	2	47-74	1.0-5.0	6.0
Citharichthys stigmaeus	speckled sanddab	1	38	1.0	1.0
Hypsoblennius spp.	blennies	1	70	7.0	7.0
Hypsopsetta guttulata	diamond turbot	1	253	350	350.0
Leuresthes tenuis	California grunion	1	91	5.0	5.0
Micrometrus minimus	dwarf surfperch	1	67	7.5	7.5
Pleuronichthys ritteri	spotted turbot	1	70	6.5	6.5
SHARKS/RAYS					
Myliobatis californica	bat ray	2	182-404	460-850	1,310.0
Platyrhinoidis triseriata	thornback	2	159-349	200-260	460.0
Gymnura marmorata	California butterfly ray	1	392	380	380.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	40	12-60	1.0-22.0	286.0
Pachygrapsus crassipes	striped shore crab	5	12-33	1.0-10.0	24.5
Blepharipoda occidentalis	spiny mole crab	1	24	9.0	9.0
Cancer productus	red rock crab	1	35	7.0	7.0
Octopus bimaculatus	California two-spot octopus	1	80	110	110.0
Pugettia spp.	kelp crabs	1	32	7.5	7.5
	Total:	649			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA032 **Survey Date; January 26 - 27, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinops affinis	topsmelt	243	46-277	1.0-65.0	1,435.4
Anchoa compressa	deepbody anchovy	16	70-111	3.0-15.0	146.9
Seriphus politus	queenfish	11	35-96	1.0-13.0	75.5
Atractoscion nobilis	white seabass	9	159-284	50.0-210	722.0
Cymatogaster aggregata	shiner surfperch	5	62-110	7.0-38.0	86.0
Hypsopsetta guttulata	diamond turbot	3	162-225	85.0-310	615.0
Sardinops sagax	Pacific sardine	3	79-145	5.0-29.0	56.0
Xenistius califoriensis	salema	3	38-52	1.5-3.0	6.5
Phanerodon furcatus	white surfperch	2	87-95	16.0-23.0	39.0
Anchoa delicatissima	slough anchovy	1	61	2.0	2.0
Heterostichus rostratus	giant kelpfish	1	75	3.1	3.1
Hyperprosopon argenteum	walleye surfperch	1	98	21.0	21.0
Micrometrus minimus	dwarf surfperch	1	74	16.0	16.0
Paralabrax clathratus	kelp bass	1	-	0.5	0.5
Paralabrax maculatofasciatus	spotted sand bass	1	65	5.5	5.5
unidentified fish, damaged	unid. damaged fish	1	182	70.0	70.0
SHARKS/RAYS					
Myliobatis californica	bat ray	2	309-395	400-490	890.0
Gymnura marmorata	California butterfly ray	1	365	390	390.0
Torpedo californica	Pacific electric ray	1	311	3,750.0	3,750.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	30	24-51	1.5-23.5	325.0
Pachygrapsus crassipes	striped shore crab	4	12-50	2.0-18.0	42.0
Cancer spp.	cancer crabs	2	28-32	2.0-3.0	5.0
Cancer productus	red rock crab	1	35	5.0	5.0
Caridean unid.	unidentified shrimp	1	-	7.0	7.0
Panulirus interruptus	California spiny lobster	1	-	30.0	30.0
	Total:	**345**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA033 — **Survey Date: February 20 - 03, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinops affinis	topsmelt	189	38-325	0.5-270	1,381.3
Sardinops sagax	Pacific sardine	19	66-124	4.8-16.0	153.7
Anchoa compressa	deepbody anchovy	10	62-116	3.0-16.0	70.5
Xenistius califoriensis	salema	6	45-59	1.0-4.0	11.5
Hyperprosopon argenteum	walleye surfperch	5	122-165	50.0-100	339.6
Syngnathus spp.	pipefishes	4	162-224	1.1-4.0	9.3
Anisotremus davidsonii	sargo	3	57-69	4.0-7.0	17.5
Micrometrus minimus	dwarf surfperch	2	62-67	7.5-9.0	16.5
Anchoa delicatissima	slough anchovy	1	75	5.0	5.0
Atractoscion nobilis	white seabass	1	307	360	360.0
Cymatogaster aggregata	shiner surfperch	1	77	10.0	10.0
Rhacochilus vacca	pile surfperch	1	214	280	280.0
Paralabrax clathratus	kelp bass	1	65	5.6	5.6
Peprilus simillimus	Pacific butterfish	1	79	11.0	11.0
Phanerodon furcatus	white surfperch	1	87	15.0	15.0
Sarda chiliensis	Pacific bonito	1	362	510	510.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	17	20-58	2.0-18.0	137.8
Pugettia spp.	kelp crabs	4	6-23	0.4-9.0	11.9
Cancer jordani	hairy rock crab	1	33	8.5	8.5
Cancer productus	red rock crab	1	56	17.0	17.0
Dosidicus gigas	jumbo squid	1	625	500	500.0
Pachygrapsus crassipes	striped shore crab	1	10	0.2	0.2
Podochela hemphilli	Hemphill's kelp crab	1	20	3.0	3.0
	Total:	**272**			

Survey: EPSIA034 — **Survey Date: February 09 - 10, 2005**
Sample Count: 13

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinops affinis	topsmelt	115	58-302	2.0-205	903.8
Anchoa delicatissima	slough anchovy	25	39-98	0.3-9.5	60.9
Anchoa compressa	deepbody anchovy	17	73-112	3.0-17.0	192.2
Seriphus politus	queenfish	16	45-112	1.0-20.0	82.7
Cymatogaster aggregata	shiner surfperch	14	70-113	11.0-31.0	251.6
Umbrina roncador	yellowfin croaker	8	74-96	7.0-14.5	82.5
Atractoscion nobilis	white seabass	5	190-265	70.0-245	675.0
Engraulis mordax	northern anchovy	5	42-89	1.0-5.5	14.4
Xenistius califoriensis	salema	5	50-60	2.0-3.5	13.9
Hyperprosopon argenteum	walleye surfperch	4	101-135	45.0-70.0	235.0
Sardinops sagax	Pacific sardine	2	108-111	9.0-12.0	21.0
Hypsopsetta guttulata	diamond turbot	1	206	270	270.0
Paralabrax clathratus	kelp bass	1	65	5.0	5.0
Paralabrax nebulifer	barred sand bass	1	51	2.0	2.0
Paralichthys californicus	California halibut	1	94	13.0	13.0
Roncador stearnsi	spotfin croaker	1	57	3.0	3.0
Syngnathus spp.	pipefishes	1	163	0.6	0.6
unidentified fish, damaged	unid. damaged fish	1	-	100	100.0
SHARKS/RAYS					
Myliobatis californica	bat ray	2	272-530	305-2,000	2,305.0
Ophichthus zophochir	yellow snake eel	1	638	295	295.0
Urolophus halleri	round stingray	1	140	170	170.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	14	16-78	3.0-14.0	99.6
Pachygrapsus crassipes	striped shore crab	3	8-18	0.4-3.0	4.9
Cancer productus	red rock crab	2	33-49	12.0-17.0	29.0
	Total:	**246**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA035 **Survey Date: February 16 - 17, 2005**
Sample Count: 13

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Anchoa compressa	deepbody anchovy	5	-	40.2	40.2
Seriphus politus	queenfish	5	44-52	3.0	15.0
Atherinops affinis	topsmelt	4	-	8.7	8.7
Hyperprosopon argenteum	walleye surfperch	2	131-134	45.0-81.0	126.0
Paralabrax maculatofasciatus	spotted sand bass	2	-	14.6	14.6
Paralabrax nebulifer	barred sand bass	2	50-84	3.2-14.0	17.2
Atherinopsis californiensis	jacksmelt	1	273	160	160.0
Hypsoblennius jenkinsi	mussel blenny	1	57	4.3	4.3
Porichthys myriaster	specklefin midshipman	1	380	800	800.0
INVERTEBRATES					
Pachygrapsus spp.	shore crab	417	-	50.0	871.0
Pachygrapsus crassipes	striped shore crab	274	3-37	0.5-21.5	768.5
Cancer productus	red rock crab	13	10-55	1.0-22.0	130.1
Portunus xantusii	Xantus' swimming crab	7	20-35	2.0-7.0	30.0
Brachyuran unid.	unidentified crab	1	-	150-200	350.0
Pugettia producta	northern kelp crab	1	22	3.5	3.5
Pugettia spp.	kelp crabs	1	-	0.5	0.5
	Total:	737			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA036 **Survey Date: February 23 - 24, 2005**
Sample Count: 13

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Anchoa compressa	deepbody anchovy	306	54-120	2.0-21.0	3,203.2
Atherinops affinis	topsmelt	304	57-171	1.2-54.7	4,887.9
Cymatogaster aggregata	shiner surfperch	189	72-188	8.9-61.0	5,211.9
Chub unid.	unid. chub	91	62-164	3.0-100	845.5
Paralabrax maculatofasciatus	spotted sand bass	88	43-315	2.0-670	1,318.9
Paralabrax nebulifer	barred sand bass	64	42-94	2.0-15.0	439.8
Hyperprosopon argenteum	walleye surfperch	36	110-164	36.0-116.4	2,564.4
Ictaluridae	unid. catfish	33	124-259	60.0-300	4,123.0
Fundulus parvipinnis	California killifish	31	66-91	4.0-12.0	235.5
Anchoa delicatissima	slough anchovy	24	57-74	2.0-5.0	73.5
Seriphus politus	queenfish	21	49-172	2.0-79.0	410.5
Lepomis macrochirus	bluegill	16	42-135	2.0-86.9	513.7
Lepomis cyanellus	green sunfish	15	47-168	3.0-138	532.0
Anisotremus davidsonii	sargo	10	53-81	3.5-13.0	68.4
Hypsopsetta guttulata	diamond turbot	7	25-233	0.8-260	956.8
Paralichthys californicus	California halibut	6	47-221	1.5-170	200.8
Atractoscion nobilis	white seabass	4	239-432	155-260	775.0
Pylodictis olivaris	flathead catfish	4	158-210	90.0-170	480.0
Chromis punctipinnis	blacksmith	3	55-101	4.0-21.0	32.0
Phanerodon furcatus	white surfperch	3	156-191	85.8-180	385.8
unidentified fish, damaged	unid. damaged fish	3	40-95	1.0-60.0	62.5
Paralabrax clathratus	kelp bass	2	65-90	5.0-14.0	19.0
Ameiurus nebulosus	brown bullhead	1	149	100	100.0
Citharichthys stigmaeus	speckled sanddab	1	45	3.0	3.0
Embiotoca jacksoni	black surfperch	1	225	370	370.0
Heterostichus rostratus	giant kelpfish	1	183	50.0	50.0
Lepomis spp.	sunfishes	1	141	130	130.0
Micrometrus minimus	dwarf surfperch	1	57	5.0	5.0
Micropterus dolomieu	smallmouth bass	1	186	150	150.0
Pleuronectiformes unid.	flatfishes	1	38	0.5	0.5
Syngnathus spp.	pipefishes	1	105	1.0	1.0
Xenistius califoriensis	salema	1	48	1.8	1.8
SHARKS/RAYS					
Ophichthus zophochir	yellow snake eel	4	549-769	150-450	1,380.0
INVERTEBRATES					
Octopus spp.	octopus	17	17-117	16.0-520	3,170.0
Portunus xantusii	Xantus' swimming crab	15	11-52	1.3-14.0	73.8
Pachygrapsus crassipes	striped shore crab	6	11-22	1.0-4.0	13.0
Octopus bimaculatus	California two-spot octopus	3	90-95	240-370	940.0
Blepharipoda occidentalis	spiny mole crab	1	18	3.0	3.0
	Total:	**1,316**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA037 **Survey Date; March 02 - 03, 2005**
Sample Count: 13

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Seriphus politus	queenfish	18	47-74	1.2-5.5	45.4
Atherinops affinis	topsmelt	8	65-112	0.4-13.7	55.7
Roncador stearnsi	spotfin croaker	5	70-550	5.5-1,700	3,024.6
Anchoa compressa	deepbody anchovy	3	64-98	3.0-8.6	20.0
Phanerodon furcatus	white surfperch	3	79-175	10.9-130.8	179.1
Citharichthys stigmaeus	speckled sanddab	2	60-68	3.4-4.0	7.4
Anisotremus davidsonii	sargo	1	61	4.5	4.5
Cymatogaster aggregata	shiner surfperch	1	107	26.5	26.5
Dorosoma petenense	threadfin shad	1	69	3.4	3.4
Hypsopsetta guttulata	diamond turbot	1	215	226	226.0
Micrometrus minimus	dwarf surfperch	1	69	7.9	7.9
Paralabrax nebulifer	barred sand bass	1	65	5.7	5.7
Paralichthys californicus	California halibut	1	128	30.3	30.3
Syngnathus spp.	pipefishes	1	127	0.5	0.5
unidentified fish, damaged	unid. damaged fish	1	-	1.2	1.2
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	13	19-48	1.3-15.2	84.2
Pachygrapsus crassipes	striped shore crab	6	8-42	0.6-48.5	73.9
Octopus spp.	octopus	1	95	266.5	266.5
	Total:	**68**			

Survey: EPSIA038 **Survey Date: March 09 - 10, 2005**
Sample Count: 13

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Seriphus politus	queenfish	36	45-80	1.7-7.4	124.6
Atherinops affinis	topsmelt	25	60-152	2.0-33.5	299.9
Cymatogaster aggregata	shiner surfperch	17	76-119	12.0-35.5	350.7
Hypsopsetta guttulata	diamond turbot	10	185-235	160-281	2,126.3
Paralabrax clathratus	kelp bass	6	49-65	2.2-5.6	22.9
Paralabrax maculatofasciatus	spotted sand bass	5	43-80	2.0-11.1	33.2
Paralabrax nebulifer	barred sand bass	4	50-83	2.5-14.1	27.5
Anchoa compressa	deepbody anchovy	3	90-110	9.1-12.8	34.7
Roncador stearnsi	spotfin croaker	3	67-81	4.8-9.5	20.4
Anchoa delicatissima	slough anchovy	2	58-62	2.3-2.8	5.1
Atherinopsis californiensis	jacksmelt	2	110-158	14.8-31.8	46.6
Engraulis mordax	northern anchovy	2	35-38	0.3-0.5	0.8
Anisotremus davidsonii	sargo	1	56	3.9	3.9
Citharichthys stigmaeus	speckled sanddab	1	60	5.2	5.2
Fundulus parvipinnis	California killifish	1	65	4.9	4.9
Gillichthys mirabilis	longjaw mudsucker	1	125	34.4	34.4
Leptocottus armatus	Pacific staghorn sculpin	1	98	15.1	15.1
Micrometrus minimus	dwarf surfperch	1	64	7.3	7.3
Peprilus simillimus	Pacific butterfish	1	85	13.8	13.8
Phanerodon furcatus	white surfperch	1	123	35.9	35.9
Porichthys myriaster	specklefin midshipman	1	330	500	500.0
Sardinops sagax	Pacific sardine	1	114	8.9	8.9
unidentified fish	unid. fish	1	39	0.9	0.9
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	2	347-423	362-671	1,032.7
Platyrhinoidis triseriata	thornback	2	196-395	365-371	735.8
Myliobatis californica	bat ray	1	343	647.0	647.3
Urolophus halleri	round stingray	1	180	448.0	447.7
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	66	16-46	1.1-9.4	260.7
Pachygrapsus crassipes	striped shore crab	5	10-40	0.5-36.8	49.7
Pyromaia tuberculata	tuberculate pea crab	2	5-8	0.2-0.4	'
Octopus spp.	octopus	1	90	319.5	319.5
	Total:	**206**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA039 **Survey Date: March 16 - 17, 2005**
Sample Count: 13

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinops affinis	topsmelt	6	76-138	4.2-28.4	138.6
Anchoa delicatissima	slough anchovy	3	63-72	2.7-3.8	9.5
Cymatogaster aggregata	shiner surfperch	3	40-120	1.4-45.6	83.4
Roncador stearnsi	spotfin croaker	3	57-71	4.7-7.1	17.8
Seriphus politus	queenfish	3	55-65	2.0-3.7	9.3
Hypsopsetta guttulata	diamond turbot	2	210-235	233-281	513.5
Anchoa compressa	deepbody anchovy	1	58	1.7	1.7
Brachyistius frenatus	kelp surfperch	1	80	17.0	17.0
Fundulus parvipinnis	California killifish	1	70	5.4	5.4
Hyperprosopon argenteum	walleye surfperch	1	129	51.2	51.2
Leuresthes tenuis	California grunion	1	74	3.1	3.1
Lyopsetta exilis	slender sole	1	124	25.9	25.9
Paralabrax maculatofasciatus	spotted sand bass	1	54	2.7	2.7
Paralabrax nebulifer	barred sand bass	1	62	3.9	3.9
Syngnathus spp.	pipefishes	1	190	1.8	1.8
Xenistius califoriensis	salema	1	53	2.8	2.8
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	10	21-44	1.0-11.3	30.8
Pachygrapsus crassipes	striped shore crab	6	10-28	1.1-8.4	31.2
	Total:	**46**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA040 **Survey Date: March 23 - 24, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinops affinis	topsmelt	77	60-155	2.0-50.2	776.2
Cymatogaster aggregata	shiner surfperch	62	33-123	0.8-41.6	1,385.7
Seriphus politus	queenfish	31	35-111	1.3-14.0	155.4
Anchoa compressa	deepbody anchovy	25	54-80	1.6-5.4	73.2
Anchoa delicatissima	slough anchovy	14	55-70	2.3-3.7	40.6
Roncador stearnsi	spotfin croaker	9	64-83	3.0-12.4	57.6
Syngnathus spp.	pipefishes	9	183-235	1.6-3.5	22.0
Strongylura exilis	California needlefish	6	330-538	37.5-181	592.8
Genyonemus lineatus	white croaker	4	31-34	0.6	2.7
Leuresthes tenuis	California grunion	4	70-104	3.3-9.2	20.9
Paralabrax nebulifer	barred sand bass	4	59-64	3.8-5.2	18.3
Hypsopsetta guttulata	diamond turbot	3	205-224	184.4-203.0	574.8
Leptocottus armatus	Pacific staghorn sculpin	3	60-105	3.3-18.8	28.6
Phanerodon furcatus	white surfperch	3	41-166	8.8-87.7	116.2
Anisotremus davidsonii	sargo	2	55-59	4.3-5.0	9.3
Chromis punctipinnis	blacksmith	2	119-125	32.7-35.0	67.7
Hyperprosopon argenteum	walleye surfperch	2	39-177	1.5-190	191.1
Paralabrax clathratus	kelp bass	2	74-76	5.6-8.0	13.6
Pleuronectiformes unid.	flatfishes	2	55-60	3.2-3.7	6.9
Citharichthys stigmaeus	speckled sanddab	1	60	2.9	2.9
Engraulis mordax	northern anchovy	1	87	3.9	3.9
Fundulus parvipinnis	California killifish	1	66	5.2	5.2
Hypsoblennius gilberti	rockpool blenny	1	70	6.3	6.3
Paralabrax maculatofasciatus	spotted sand bass	1	53	2.6	2.6
Peprilus simillimus	Pacific butterfish	1	87	14.3	14.3
Pleuronichthys verticalis	hornyhead turbot	1	138	68.9	68.9
Porichthys myriaster	specklefin midshipman	1	370	350	350.0
Umbrina roncador	yellowfin croaker	1	70	5.4	5.4
unidentified fish	unid. fish	1	156	77.6	77.6
unidentified fish, damaged	unid. damaged fish	1	65	1.6	1.6
Xenistius califoriensis	salema	1	51	2.9	2.9
SHARKS/RAYS					
Ophichthus zophochir	yellow snake eel	2	750-752	393-457	849.4
Urolophus halleri	round stingray	2	119-120	95.2-98.0	193.2
Gymnura marmorata	California butterfly ray	1	395	185.0	185.0
Rhinobatos productus	shovelnose guitarfish	1	775	1,800.0	1,800.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	56	9-46	0.9-19.0	200.2
Pachygrapsus crassipes	striped shore crab	9	15-40	1.0-31.9	95.6
	Total:	**347**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA041
Sample Count: 19

Survey Date: March 30 - 31, 2005

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinops affinis	topsmelt	85	58-135	2.5-21.7	552.4
Seriphus politus	queenfish	44	40-130	1.8-33.4	258.7
Cymatogaster aggregata	shiner surfperch	36	32-125	0.6-43.9	798.4
Anchoa compressa	deepbody anchovy	13	65-111	1.6-17.3	98.9
Paralabrax nebulifer	barred sand bass	11	49-75	2.4-8.6	50.9
Hyperprosopon argenteum	walleye surfperch	8	27-43	0.5-1.8	10.8
Anchoa delicatissima	slough anchovy	5	58-69	2.0-3.4	13.3
Anisotremus davidsonii	sargo	5	54-68	3.8-7.0	26.7
Embiotoca jacksoni	black surfperch	5	46-64	3.0-6.8	20.5
Leuresthes tenuis	California grunion	5	64-131	1.2-17.0	43.3
Umbrina roncador	yellowfin croaker	5	65-108	4.8-20.0	45.2
Paralichthys californicus	California halibut	2	70-176	2.2-33.7	35.9
Phanerodon furcatus	white surfperch	2	41-50	1.8-2.5	4.3
Genyonemus lineatus	white croaker	1	45	1.6	1.6
Hypsoblennius gentilis	bay blenny	1	42	1.6	1.6
Menticirrhus undulatus	California corbina	1	262	277.5	277.5
Paralabrax maculatofasciatus	spotted sand bass	1	80	9.6	9.6
Roncador stearnsi	spotfin croaker	1	77	7.5	7.5
Strongylura exilis	California needlefish	1	324	26.3	26.3
Syngnathus spp.	pipefishes	1	207	3.6	3.6
Xenistius califoriensis	salema	1	55	3.1	3.1
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	2	330-398	305-550	855.2
Urolophus halleri	round stingray	2	104-108	56.0-62.1	118.1
Platyrhinoidis triseriata	thornback	1	279	1,500.0	1,500.0
Rhinobatos productus	shovelnose guitarfish	1	1126	4,400.0	4,400.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	20	15-58	0.9-16.8	77.1
Pachygrapsus crassipes	striped shore crab	17	5-40	0.3-31.9	85.4
	Total:	277			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA042 **Survey Date: April 6 - 7, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	29	42-131	3.0-65.2	732.7
Atherinops affinis	topsmelt	23	60-127	3.0-24.0	238.0
Seriphus politus	queenfish	17	55-81	4.0-10.0	94.5
Hyperprosopon argenteum	walleye surfperch	6	40-161	2.0-100	204.0
Anchoa compressa	deepbody anchovy	4	68-78	4.0-6.5	19.0
Atherinopsis californiensis	jacksmelt	4	75-252	5.0-140	177.0
Leuresthes tenuis	California grunion	4	78-151	3.8-28.0	58.8
Embiotoca jacksoni	black surfperch	3	53-218	4.5-452	464.0
Porichthys myriaster	specklefin midshipman	3	370-410	800-1,250	2,950.0
Paralabrax nebulifer	barred sand bass	2	50-56	3.0-4.0	7.0
Amphistichus argenteus	barred surfperch	1	42	2.0	2.0
Anchoa delicatissima	slough anchovy	1	63	3.5	3.5
Anisotremus davidsonii	sargo	1	68	8.5	8.5
Chromis punctipinnis	blacksmith	1	95	18.5	18.5
Engraulis mordax	northern anchovy	1	57	2.5	2.5
Genyonemus lineatus	white croaker	1	110	21.0	21.0
Paralabrax maculatofasciatus	spotted sand bass	1	65	7.0	7.0
Sardinops sagax	Pacific sardine	1	128	19.5	19.5
Strongylura exilis	California needlefish	1	345	45.0	45.0
Syngnathus leptorhynchus	bay pipefish	1	208	4.0	4.0
Xenistius califoriensis	salema	1	52	4.0	4.0
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	2	415-462	600-1,050	1,650.0
Urolophus halleri	round stingray	1	168	420	420.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	40	17-70	1.5-20.0	300.0
Pachygrapsus crassipes	striped shore crab	8	17-32	3.0-13.5	43.0
Hippolytidae unid.	hippolytid shrimps	1	-	-	-
	Total:	**158**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA043 | **Survey Date: April 13 - 14, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	93	48-143	6.9-59.8	1,565.9
Atherinops affinis	topsmelt	35	65-155	3.0-39.9	415.6
Anisotremus davidsonii	sargo	13	40-91	3.9-25.2	127.2
Paralabrax maculatofasciatus	spotted sand bass	10	65-263	3.9-259.1	398.9
Anchoa compressa	deepbody anchovy	9	80-120	6.6-22.5	123.9
Leuresthes tenuis	California grunion	6	110-160	7.6-23.1	83.4
Hyperprosopon argenteum	walleye surfperch	5	40-50	1.6-2.5	10.1
Atherinopsis californiensis	jacksmelt	3	194-325	61.4-223	462.1
Paralabrax clathratus	kelp bass	3	65-75	3.2-5.6	12.5
Seriphus politus	queenfish	3	61-84	3.5-7.7	15.2
Chromis punctipinnis	blacksmith	2	154-156	106.6-143.1	249.7
Embiotoca jacksoni	black surfperch	2	56-58	4.3-4.4	8.7
Girella nigricans	opaleye	2	140-190	86.0-260.1	346.1
Hermosilla azurea	zebra perch	2	73-255	10.9-445	455.9
Hypsopsetta guttulata	diamond turbot	2	155-198	107.3-185.1	292.4
Leptocottus armatus	Pacific staghorn sculpin	2	58-66	3.5	7.0
Porichthys myriaster	specklefin midshipman	2	263-352	271-673	943.5
Roncador stearnsi	spotfin croaker	2	80-222	9.5-174.1	183.6
Anchoa delicatissima	slough anchovy	1	70	3.8	3.8
Genyonemus lineatus	white croaker	1	169	92.6	92.6
Heterostichus rostratus	giant kelpfish	1	88	4.9	4.9
Hypsoblennius gentilis	bay blenny	1	58	4.7	4.7
Hypsoblennius jenkinsi	mussel blenny	1	91	13.0	13.0
Paralabrax nebulifer	barred sand bass	1	221	266.7	266.7
Paralichthys californicus	California halibut	1	107	18.2	18.2
Phanerodon furcatus	white surfperch	1	213	215.1	215.1
Umbrina roncador	yellowfin croaker	1	60	4.6	4.6
unidentified fish, damaged	unid. damaged fish	1	-	91.8	91.8
Xenistius califoriensis	salema	1	50	2.4	2.4
SHARKS/RAYS					
Urolophus halleri	round stingray	9	96-198	37.6-521.1	2,298.0
Gymnura marmorata	California butterfly ray	2	365-393	443.8-512.9	956.7
Myliobatis californica	bat ray	2	352-354	673-790	1,463.2
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	170	7-31	0.3-14.8	544.1
Portunus xantusii	Xantus' swimming crab	13	18-51	1.5-19.2	85.9
Cancer productus	red rock crab	1	19	-1.4	1.4
	Total:	**404**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA044 **Survey Date: April 20 - 21, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	32	43-122	1.9-31.8	477.6
Anchoa compressa	deepbody anchovy	16	65-119	3.2-18.7	159.0
Hyperprosopon argenteum	walleye surfperch	11	41-225	1.7-275.3	465.4
Anisotremus davidsonii	sargo	7	60-75	4.8-9.0	46.8
Atherinops affinis	topsmelt	7	73-133	3.7-23.3	112.1
Seriphus politus	queenfish	6	68-99	4.7-15.7	48.3
Anchoa delicatissima	slough anchovy	4	65-74	2.6-4.9	14.9
Porichthys myriaster	specklefin midshipman	2	270-335	227-482	708.8
Cheilopogon pinnatibarbatus	spotted flyingfish	1	114	2.9	2.9
Leptocottus armatus	Pacific staghorn sculpin	1	65	4.6	4.6
Leuresthes tenuis	California grunion	1	110	11.0	11.0
Paralabrax nebulifer	barred sand bass	1	50	2.3	2.3
Phanerodon furcatus	white surfperch	1	36	1.0	1.0
Porichthys spp.	midshipman	1	-	200	200.0
Roncador stearnsi	spotfin croaker	1	77	8.6	8.6
Strongylura exilis	California needlefish	1	390	57.9	57.9
unidentified fish, damaged	unid. damaged fish	1	-	200	200.0
SHARKS/RAYS					
Urolophus halleri	round stingray	2	100	63.3-150	213.3
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	12	18-40	1.5-13.7	65.9
Pachygrapsus crassipes	striped shore crab	10	4-50	0.2-53.0	82.5
Octopus spp.	octopus	1	-	139.7	139.7
	Total:	**119**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA045 **Survey Date: April 27 - 28, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	63	39-122	1.2-42.0	810.1
Atherinops affinis	topsmelt	10	78-136	6.1-23.7	135.0
Hyperprosopon argenteum	walleye surfperch	5	39-115	1.1-49.3	103.2
Leptocottus armatus	Pacific staghorn sculpin	4	70-80	4.9-7.7	27.5
Paralabrax nebulifer	barred sand bass	4	53-91	4.4-14.0	28.4
Anchoa compressa	deepbody anchovy	3	80-100	2.3-13.3	21.9
Anchoa delicatissima	slough anchovy	2	61-97	2.9-9.1	12.0
Anisotremus davidsonii	sargo	2	63-72	5.7-10.3	16.0
Paralabrax clathratus	kelp bass	2	61-76	5.1-8.1	13.2
Mugil cephalus	striped mullet	1	57	3.4	3.4
Paralichthys californicus	California halibut	1	101	14.6	14.6
Peprilus simillimus	Pacific butterfish	1	47	2.2	2.2
Porichthys myriaster	specklefin midshipman	1	252	190.0	189.5
Seriphus politus	queenfish	1	71	6.9	6.9
Xenistius califoriensis	salema	1	70	7.6	7.6
SHARKS/RAYS					
Myliobatis californica	bat ray	1	566	2,500.0	2,500.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	6	19-33	1.8-4.9	18.1
Pachygrapsus crassipes	striped shore crab	2	11-12	2.9-3.4	6.3
	Total:	**110**			

Survey: EPSIA046 **Survey Date: May 4 - 5, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	169	29-148	0.6-78.6	1,251.5
Anchoa compressa	deepbody anchovy	35	48-100	1.5-13.7	145.2
Atherinops affinis	topsmelt	23	60-126	2.0-26.0	211.4
Hyperprosopon argenteum	walleye surfperch	14	48-157	2.2-94.9	162.4
Seriphus politus	queenfish	6	60-91	2.6-10.3	38.0
Leuresthes tenuis	California grunion	5	71-112	3.5-17.4	37.3
Paralabrax nebulifer	barred sand bass	5	61-80	4.7-11.6	38.1
Paralabrax maculatofasciatus	spotted sand bass	4	75-82	9.1-90.0	122.6
Sebastes atrovirens	kelp rockfish	4	68-90	5.6-16.4	39.8
Paralichthys californicus	California halibut	3	22-80	6.2-9.3	21.9
Citharichthys stigmaeus	speckled sanddab	2	70-79	5.5-6.4	11.9
Leptocottus armatus	Pacific staghorn sculpin	2	73-84	5.3-7.3	12.6
Porichthys myriaster	specklefin midshipman	2	80-82	9.9-12.1	22.0
Anisotremus davidsonii	sargo	1	64	7.4	7.4
Heterostichus rostratus	giant kelpfish	1	85	2.9	2.9
Strongylura exilis	California needlefish	1	400	66.0	66.0
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	1	555	1,508.0	1,508.0
Ophichthus zophochir	yellow snake eel	1	-	17.8	17.8
Urolophus halleri	round stingray	1	204	525	525.0
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	4	10-30	1.3-4.8	9.2
Portunus xantusii	Xantus' swimming crab	3	40-50	2.2-11.9	19.4
	Total:	**287**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA047
Sample Count: 19

Survey Date: May 11 - 12, 2005

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	89	33-112	0.7-39.2	1,120.1
Phanerodon furcatus	white surfperch	30	30-161	0.7-90.6	179.2
Atherinops affinis	topsmelt	20	45-145	0.7-74.5	232.0
Anchoa compressa	deepbody anchovy	11	75-110	4.1-15.2	103.7
Leptocottus armatus	Pacific staghorn sculpin	9	68-94	5.7-15.7	82.5
Seriphus politus	queenfish	8	71-91	4.6-12.5	64.5
Amphistichus argenteus	barred surfperch	4	53-62	3.7-6.0	18.1
Hyperprosopon argenteum	walleye surfperch	3	50-138	2.8-65.0	72.6
Leuresthes tenuis	California grunion	3	64-140	2.3-17.8	25.7
Porichthys myriaster	specklefin midshipman	3	179-422	258-1,141	1,729.3
Xenistius califoriensis	salema	3	56-70	3.7-7.4	18.1
Anchoa delicatissima	slough anchovy	2	60	2.3-2.4	4.7
Strongylura exilis	California needlefish	2	465-509	105-181	286.0
Anisotremus davidsonii	sargo	1	66	8.7	8.7
Engraulis mordax	northern anchovy	1	40	0.7	0.7
Hypsoblennius gentilis	bay blenny	1	40	1.5	1.5
Paralabrax maculatofasciatus	spotted sand bass	1	73	6.9	6.9
Paralabrax nebulifer	barred sand bass	1	76	8.7	8.7
Syngnathus leptorhynchus	bay pipefish	1	223	2.9	2.9
SHARKS/RAYS					
Urolophus halleri	round stingray	7	119-250	100-541	2,377.5
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	6	15-56	2.1-21.8	43.0
Pachygrapsus crassipes	striped shore crab	4	12-36	1.3-27.9	59.8
Octopus spp.	octopus	1	110	226.0	225.6
	Total:	**211**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA048 **Survey Date: May 18 - 19, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	211	30-127	0.5-34.9	782.1
Phanerodon furcatus	white surfperch	21	31-72	0.8-7.1	66.6
Anchoa compressa	deepbody anchovy	11	62-116	2.8-18.1	102.1
Hyperprosopon argenteum	walleye surfperch	11	33-117	0.8-31.2	69.0
Atherinops affinis	topsmelt	9	31-134	7.6-24.5	138.8
Porichthys myriaster	specklefin midshipman	9	245-315	167-392	2,419.8
Paralabrax nebulifer	barred sand bass	4	65-73	4.4-7.2	23.5
Seriphus politus	queenfish	4	70-83	4.8-8.4	25.2
Roncador stearnsi	spotfin croaker	3	59-76	3.5-7.4	16.9
Anchoa delicatissima	slough anchovy	2	65-77	3.4-4.8	8.2
Heterostichus rostratus	giant kelpfish	2	63-87	1.7-4.0	5.7
Leptocottus armatus	Pacific staghorn sculpin	2	68-69	6.2-6.7	12.9
Anchoa spp.	anchovy	1	-	1.8	1.8
Anisotremus davidsonii	sargo	1	74	10.3	10.3
Atractoscion nobilis	white seabass	1	155	37.2	37.2
Citharichthys stigmaeus	speckled sanddab	1	63	3.6	3.6
Hypsopsetta guttulata	diamond turbot	1	53	3.6	3.6
Leuresthes tenuis	California grunion	1	40	0.7	0.7
Paralichthys californicus	California halibut	1	50	1.5	1.5
Strongylura exilis	California needlefish	1	470	145.0	145.2
Syngnathus leptorhynchus	bay pipefish	1	221	1.9	1.9
Umbrina roncador	yellowfin croaker	1	95	14.1	14.1
SHARKS/RAYS					
Urolophus halleri	round stingray	13	74-200	23.7-504	3,456.7
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	11	12-24	1.2-9.7	42.6
Portunus xantusii	Xantus' swimming crab	5	25-45	3.9-11.2	40.1
Cancer productus	red rock crab	1	24	2.2	2.2
Loxorhynchus crispatus	moss crab	1	5	0.2	0.2
Pugettia producta	northern kelp crab	1	20	5.2	5.2
Pugettia spp.	kelp crabs	1	23	6.3	6.3
	Total:	**332**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA049 **Survey Date: May 25 - 26, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	94	33-110	0.9-30.1	539.1
Seriphus politus	queenfish	20	55-94	2.9-11.8	160.7
Anchoa compressa	deepbody anchovy	18	66-160	2.8-20.5	194.0
Atherinops affinis	topsmelt	14	47-132	1.0-32.8	151.8
Phanerodon furcatus	white surfperch	7	50-75	2.9-6.6	31.8
Hyperprosopon argenteum	walleye surfperch	6	55-147	3.6-88.1	184.8
Porichthys myriaster	specklefin midshipman	6	73-311	5.8-425	994.7
Leptocottus armatus	Pacific staghorn sculpin	5	73-95	7.7-15.4	54.1
Roncador stearnsi	spotfin croaker	5	90-337	13.3-780	840.5
Amphistichus argenteus	barred surfperch	3	54-70	4.7-6.8	18.1
Anchoa delicatissima	slough anchovy	2	61-63	2.7-3.1	5.8
Strongylura exilis	California needlefish	2	281-367	22.8-58.4	81.2
Anisotremus davidsonii	sargo	1	81	11.9	11.9
Rhacochilus vacca	pile surfperch	1	71	10.1	10.1
Embiotoca jacksoni	black surfperch	1	65	7.1	7.1
Engraulis mordax	northern anchovy	1	77	3.3	3.3
Paralabrax clathratus	kelp bass	1	65	4.8	4.8
Paralabrax maculatofasciatus	spotted sand bass	1	62	4.3	4.3
Paralabrax nebulifer	barred sand bass	1	111	30.4	30.4
Paralichthys californicus	California halibut	1	117	22.2	22.2
Sardinops sagax	Pacific sardine	1	165	47.7	47.7
Syngnathus spp.	pipefishes	1	85	0.2	0.2
SHARKS/RAYS					
Urolophus halleri	round stingray	2	119-176	87.3-378	465.1
Gymnura marmorata	California butterfly ray	1	395	581	580.9
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	13	10-40	0.4-40.0	82.6
Portunus xantusii	Xantus' swimming crab	5	23-29	1.1-5.7	18.2
Cancer productus	red rock crab	2	26-30	2.5-3.7	6.2
	Total:	**215**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA050 **Survey Date: June 1 - 2, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	140	27-110	1.2-29.4	693.4
Phanerodon furcatus	white surfperch	19	51-78	3.1-8.7	115.6
Atherinops affinis	topsmelt	11	86-130	4.6-26.9	105.4
Anchoa compressa	deepbody anchovy	9	76-105	4.8-14.2	90.2
Porichthys myriaster	specklefin midshipman	6	240-280	134-281	1,152.8
Seriphus politus	queenfish	6	38-81	0.7-7.6	17.7
Anchoa delicatissima	slough anchovy	5	35-67	0.8-3.2	8.2
Hyperprosopon argenteum	walleye surfperch	5	51-60	3.6-5.3	22.8
Paralichthys californicus	California halibut	4	40-155	2.9-41.1	106.3
Citharichthys stigmaeus	speckled sanddab	3	41-71	1.0-5.7	10.5
Paralabrax clathratus	kelp bass	3	57-75	3.8-6.2	15.8
Genyonemus lineatus	white croaker	2	82-86	9.0-10.7	19.7
Heterostichus rostratus	giant kelpfish	2	75-122	2.8-12.0	14.8
Paralabrax nebulifer	barred sand bass	2	63	4.2-5.9	10.1
Atractoscion nobilis	white seabass	1	441	980	980.0
Hypsopsetta guttulata	diamond turbot	1	55	3.0	3.0
Leuresthes tenuis	California grunion	1	51	1.1	1.1
Paralabrax maculatofasciatus	spotted sand bass	1	250	293.0	292.5
Sardinops sagax	Pacific sardine	1	40	1.0	1.0
SHARKS/RAYS					
Gymnura marmorata	California butterfly ray	2	226-339	119-274	393.0
Urolophus halleri	round stingray	2	171-297	276-460	735.7
Myliobatis californica	bat ray	1	940	975	975.0
Rhinobatos productus	shovelnose guitarfish	1	374	160.8	160.8
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	10	12-25	1.5-3.6	26.9
Pyromaia tuberculata	tuberculate pea crab	4	10-18	1.0-3.3	7.8
Portunus xantusii	Xantus' swimming crab	2	30-37	3.9-8.6	12.5
Cancer spp.	cancer crabs	1	28	3.0	3.0
Majidae	spider crabs	1	13	1.8	1.8
Pugettia spp.	kelp crabs	1	11	0.9	0.9
	Total:	**247**			

Encina Power Station Impingement Abundance: Traveling Screen and Bar Rack Survey Data

Survey: EPSIA051 **Survey Date: June 8 - 9, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	129	30-93	1.1-19.1	491.1
Atherinops affinis	topsmelt	28	18-209	0.8-51.2	366.3
Anchoa compressa	deepbody anchovy	14	24-82	0.4-7.3	28.5
Paralichthys californicus	California halibut	11	50-128	2.1-30.3	163.3
Engraulis mordax	northern anchovy	10	36-110	0.2-10.5	19.9
Seriphus politus	queenfish	10	68-110	4.6-19.2	95.4
Porichthys myriaster	specklefin midshipman	7	235-413	156-739	1,796.8
Phanerodon furcatus	white surfperch	4	48-67	3.2-7.6	19.6
Amphistichus argenteus	barred surfperch	3	60-74	5.5-10.9	25.7
Leptocottus armatus	Pacific staghorn sculpin	3	81-85	8.5-13.7	35.3
Strongylura exilis	California needlefish	3	368-534	42.3-225	430.6
Heterostichus rostratus	giant kelpfish	2	80-95	3.6-6.0	9.6
Sardinops sagax	Pacific sardine	2	131-132	23.7-25.6	49.3
Anchoa spp.	anchovy	1	-	8.5	8.5
Hyperprosopon argenteum	walleye surfperch	1	57	4.2	4.2
Hypsoblennius gentilis	bay blenny	1	69	6.4	6.4
Hypsopsetta guttulata	diamond turbot	1	54	3.7	3.7
SHARKS/RAYS					
Myliobatis californica	bat ray	2	206-255	188-290	477.8
Ophichthus zophochir	yellow snake eel	1	787	595.0	594.6
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	5	18-20	0.9-5.5	13.0
	Total:	**239**			

Survey: EPSIA052 **Survey Date: June 15 - 16, 2005**
Sample Count: 19

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	19	45-109	2.2-25.2	105.4
Engraulis mordax	northern anchovy	4	59-67	1.0-2.6	7.4
Porichthys myriaster	specklefin midshipman	3	230-290	142-243	594.3
Atherinops affinis	topsmelt	2	90-95	4.5-5.3	9.8
Heterostichus rostratus	giant kelpfish	2	61-95	1.3-5.6	6.9
Anchoa compressa	deepbody anchovy	1	-	4.2	4.2
Atractoscion nobilis	white seabass	1	340	411	411.0
Citharichthys stigmaeus	speckled sanddab	1	70	4.9	4.9
Paralabrax maculatofasciatus	spotted sand bass	1	300	761.0	761.4
Phanerodon furcatus	white surfperch	1	60	5.8	5.8
Seriphus politus	queenfish	1	50	1.6	1.6
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	7	15-27	0.5-6.6	18.4
Portunus xantusii	Xantus' swimming crab	1	35	6.1	6.1
	Total:	**45**			

Encina Power Station Impingement Abundance: Heat Treatment Survey Data

Survey: EPSTS001
Survey Date: July 03-04, 2004

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	6,554	47-115	2.9-31.1	31,301.3
Anchoa compressa	deepbody anchovy	6,439	65-120	2.2-20.5	61,726.7
Atherinops affinis	topsmelt	5,061	52-108	1.1-15.0	16,090.2
Sardinops sagax	Pacific sardine	4,401	47-106	0.8-8.5	8,798.2
Heterostichus rostratus	giant kelpfish	532	47-122	1.1-19.4	3,587.8
Atractoscion nobilis	white seabass	75	108-366	19.0-650	16,045.0
Girella nigricans	opaleye	72	44-221	3.0-390	6,223.0
Seriphus politus	queenfish	54	83-188	8.0-80.0	2,293.0
Strongylura exilis	California needlefish	53	102-630	1.0-480	806.0
Paralabrax maculatofasciatus	spotted sand bass	49	100-358	30.0-980	8,941.7
Embiotoca jacksoni	black surfperch	39	82-197	17.0-270	1,754.0
Porichthys myriaster	specklefin midshipman	28	124-403	140-820	8,733.0
Chromis punctipinnis	blacksmith	26	65-163	6.0-140	720.0
Hypsoblennius gentilis	bay blenny	26	40-91	3.0-25.0	354.3
Syngnathus spp.	pipefishes	25	128-251	1.0-3.0	29.3
Hypsoblennius spp.	blennies	23	35-54	1.0-3.0	46.7
Ophichthus zophochir	yellow snake eel	14	488-790	110-650	4,750.0
Roncador stearnsi	spotfin croaker	12	80-145	11.0-48.0	395.0
Hyperprosopon argenteum	walleye surfperch	8	78-150	12.0-60.0	366.0
Paralabrax nebulifer	barred sand bass	8	119-252	40.0-320	819.0
Hypsopsetta guttulata	diamond turbot	4	195-228	210-300	980.0
Hypsypops rubicundus	garibaldi	3	122-169	73.0-230	523.0
Trachurus symmetricus	jack mackerel	3	111-142	17.0-40.0	78.0
Umbrina roncador	yellowfin croaker	2	137-150	43.0-61.0	104.0
Xenistius califoriensis	salema	2	88-98	17.0-60.0	77.0
Anisotremus davidsonii	sargo	1	130	44.0	44.0
Cheilotrema saturnum	black croaker	1	48	3.0	3.0
Paraclinus integripinnis	reef finspot	1	49	3.0	3.0
Paralabrax clathratus	kelp bass	1	157	82.0	82.0
Pleuronichthys ritteri	spotted turbot	1	152	98.0	98.0
Scorpaenidae	scorpionfishes	1	122	62.0	62.0
Sphyraena argentea	California barracuda	1	91	5.0	5.0
SHARKS/RAYS					
Urolophus halleri	round stingray	439	125-230	100-700	118,655.1
Myliobatis californica	bat ray	64	221-660	140-4,700	29,566.1
Gymnura marmorata	California butterfly ray	12	240-550	120-950	4,321.8
Mustelus californicus	gray smoothhound	1	575	520	520.0
Triakis semifasciata	leopard shark	1	411	260	260.0
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	49	32-46	22.0-45.0	269.0
Octopus spp.	octopus	20	-	2,500.0	2,500.0
Pyromaia tuberculata	tuberculate pea crab	19	-	-	-
Panulirus interruptus	California spiny lobster	1	176	120	120.0
Pugettia spp.	kelp crabs	1	42	26.0	26.0
	Total:	**24,127**			

Encina Power Station Impingement Abundance: Heat Treatment Survey Data

Survey: EPSTS002
Survey Date: August 28, 2004

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Anchoa compressa	deepbody anchovy	5,324	72-120	5.9-20.9	59,754.9
Atherinops affinis	topsmelt	3,201	51-100	1.0-10.6	17,701.4
Cymatogaster aggregata	shiner surfperch	2,801	56-104	5.0-24.5	28,011.1
Sardinops sagax	Pacific sardine	1,206	65-130	1.8-25.0	7,355.5
Leuresthes tenuis	California grunion	998	43-115	0.8-10.4	2,058.8
Heterostichus rostratus	giant kelpfish	299	78-185	2.9-53.6	3,440.4
Seriphus politus	queenfish	265	65-225	2.3-172.3	12,690.8
Atractoscion nobilis	white seabass	64	115-265	40.4-260.7	7,425.4
Cheilotrema saturnum	black croaker	38	64-155	4.8-53.2	617.9
Strongylura exilis	California needlefish	27	109-478	1.0-145.2	1,624.8
Paralabrax maculatofasciatus	spotted sand bass	20	43-335	1.5-925	7,724.0
Hypsoblennius jenkinsi	mussel blenny	18	39-95	0.8-14.7	97.8
Sciaenidae unid.	croaker	17	120-200	32.8-138.0	1,212.0
Chromis punctipinnis	blacksmith	15	55-165	7.0-105	458.8
Girella nigricans	opaleye	14	55-211	4.5-321	1,567.7
Scomber japonicus	Pacific mackerel	14	67-187	14.5-86.8	650.0
Hermosilla azurea	zebra perch	13	35-68	1.1-8.7	41.8
Hypsoblennius gentilis	bay blenny	11	42-95	1.4-15.5	99.5
Paralabrax nebulifer	barred sand bass	11	160-278	82.3-490	2,866.9
Syngnathus spp.	pipefishes	11	154-208	1.0-2.0	16.0
Ophichthus zophochir	yellow snake eel	10	262-900	7.6-750	4,045.4
Hypsoblennius gilberti	rockpool blenny	8	55-101	3.2-29.4	77.1
Paralichthys californicus	California halibut	8	201-322	142-600	2,482.0
Embiotoca jacksoni	black surfperch	7	70-345	15.0-500	1,049.7
Hypsoblennius spp.	blennies	7	45-85	1.3-10.5	20.6
Anisotremus davidsonii	sargo	6	38-180	1.0-142	389.3
Paralabrax spp.	sand bass	6	43-75	1.5-5.8	18.5
Xenistius califoriensis	salema	6	87-132	11.4-34.5	117.0
Atherinopsidae	silverside	5	47-55	1.1-2.9	11.3
Pleuronichthys ritteri	spotted turbot	5	197-220	200-250	1,158.0
Seriola lalandi	yellowtail jack	4	33-99	1.0-32.0	56.0
Sphyraena argentea	California barracuda	4	245-268	55.9-78.2	272.6
Trachurus symmetricus	jack mackerel	4	90-160	7.1-46.8	105.6
Engraulis mordax	northern anchovy	3	64-65	1.8-2.2	5.9
Porichthys myriaster	specklefin midshipman	3	255-328	151-260	586.0
Umbrina roncador	yellowfin croaker	2	150-165	43.9-63.3	107.2
unidentified fish, damaged	unidentified damaged fish	2	165-308	21.6-200	221.6
Hyperprosopon argenteum	walleye surfperch	1	140	64.2	64.2
Menticirrhus undulatus	California corbina	1	510	1,600.0	1,600.0
Paralabrax clathratus	kelp bass	1	138	48.6	48.6
Peprilus simillimus	Pacific butterfish	1	117	33.4	33.4
SHARKS/RAYS					
Urolophus halleri	round stingray	198	198-355	75.0-412	39,361.7
Myliobatis californica	bat ray	31	230-484	200-900	12,310.0
Gymnura marmorata	California butterfly ray	3	265-460	120-700	1,220.0
Mustelus californicus	gray smoothhound	2	805-905	1,400-1,600	3,000.0
Dasyatis dipterura	diamond stingray	1	274	850	850.0

(table continued)

Encina Power Station Impingement Abundance: Heat Treatment Survey Data

Survey: EPSTS002 (continued)
Survey Date: August 28, 2004

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
INVERTEBRATES					
Lophopanopeus spp.	black-clawed crabs	26	10-16	0.3-1.8	27.1
Octopus spp.	octopus	17	27-470	1.1-450	1,851.3
Pachygrapsus crassipes	striped shore crab	15	17-35	2.3-24.1	139.7
Panulirus interruptus	California spiny lobster	6	180-211	125-229	944.9
Cancer spp.	cancer crabs	5	21-32	1.7-6.2	16.9
Pugettia producta	northern kelp crab	2	12.5-25	1.3-8.7	10.0
Pandalus spp.	unidentified shrimp	1	42	0.7	0.7
	Total:	**14,768**			

Encina Power Station Impingement Abundance: Heat Treatment Survey Data

Survey: EPSTS003
Survey Date: October 23, 2004

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinopsis californiensis	jacksmelt	4,450	59-150	1.7-37.9	44,009.9
Leuresthes tenuis	California grunion	4,296	56-124	1.5-22.5	25,732.5
Anchoa compressa	deepbody anchovy	1,694	67-114	3.7-19.8	20,669.4
Xenistius califoriensis	salema	718	40-68	1.4-7.7	1,510.9
Cymatogaster aggregata	shiner surfperch	512	58-96	4.5-20.5	6,092.9
Sardinops sagax	Pacific sardine	507	65-242	3.2-150	6,274.8
Cheilotrema saturnum	black croaker	249	93-132	16.8-61.5	8,408.2
Paralabrax nebulifer	barred sand bass	207	55-173	4.5-160.7	4,308.5
Paralabrax maculatofasciatus	spotted sand bass	188	45-170	2.1-122.3	3,038.3
Anisotremus davidsonii	sargo	185	54-95	2.6-28.8	1,974.4
Paralabrax clathratus	kelp bass	128	28-96	0.6-23.2	876.0
Hyperprosopon argenteum	walleye surfperch	116	90-152	30.6-118.5	8,891.7
Atractoscion nobilis	white seabass	100	140-264	90.0-320	18,017.0
Hypsoblennius spp.	blennies	83	-	-	422.0
Hypsoblennius jenkinsi	mussel blenny	65	30-80	2.0-16.0	332.0
Engraulis mordax	northern anchovy	59	64-82	2.4-4.9	194.9
Heterostichus rostratus	giant kelpfish	58	80-200	5.1-79.4	1,531.1
Medialuna californiensis	halfmoon	49	43-117	2.5-54.6	1,278.5
Seriphus politus	queenfish	43	40-160	1.0-80.0	1,428.0
Hermosilla azurea	zebra perch	36	37-71	1.7-11.4	216.0
Sphyraena argentea	California barracuda	36	135-233	16.9-74.4	1,250.4
Girella nigricans	opaleye	24	49-256	2.8-740	6,270.3
Seriola lalandi	yellowtail jack	17	80-194	7.8-145.7	922.3
Strongylura exilis	California needlefish	17	400-574	80.0-360	2,650.0
Ophichthus zophochir	yellow snake eel	13	560-790	170-520	4,589.0
Phanerodon furcatus	white surfperch	11	69-120	8.6-39.3	195.0
Chromis punctipinnis	blacksmith	10	47-83	6.1-13.1	96.2
Hyperprosopon spp.	surfperch	7	-	-	552.0
Embiotoca jacksoni	black surfperch	6	78-163	13.7-171.1	525.3
Fundulus parvipinnis	California killifish	3	-	-	6.9
Menticirrhus undulatus	California corbina	3	210-340	110-550	860
Amphistichus argenteus	barred surfperch	1	96	25.4	25.4
Hyporhamphus rosae	California halfbeak	1	-	-	-
Mugil cephalus	striped mullet	1	152	53.9	53.9
Pleuronichthys ritteri	spotted turbot	1	185	180	180.0
Sarda chiliensis	Pacific bonito	1	340	540	540.0
Scomber japonicus	Pacific mackerel	1	250	230	230.0
Trachurus symmetricus	jack mackerel	1	144	39.6	39.6
SHARKS/RAYS					
Urolophus halleri	round stingray	55	230-350	130-560	13,610.0
Myliobatis californica	bat ray	4	280-480	320-1,700	2,930.0
Mustelus californicus	gray smoothhound	1	790	1,500.0	1,500.0
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	375	20-40	1.5-10.1	2,489.6
Octopus bimaculatus	California two-spot octopus	74	-	2.1-230	2,805.9
Octopus spp.	octopus	36	-	1,562.0	1,562.0
Cancer antennarius	brown rock crab	18	-	18.0	18.0
Cancer productus	red rock crab	11	15-55	1.2-10.5	40.0
Pilumnus spinohirsutus	retiring hairycrab	4	9-23	0.6-2.5	4.6
Pugettia producta	northern kelp crab	4	21-28	1.7-4.3	11.3
Portunus xantusii	Xantus' swimming crab	2	45	4.0-6.1	10.1
Panulirus interruptus	California spiny lobster	1	21	8.1	8.1
	Total:	**14,482**			

Encina Power Station Impingement Abundance: Heat Treatment Survey Data

Survey: EPSTS004
Survey Date: February 13-14, 2005

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Atherinops affinis	topsmelt	3,847	62-151	1.5-90.0	17,444.3
Atherinopsidae	silverside	2,100	-	-	8,650.0
Hyperprosopon argenteum	walleye surfperch	1,828	110-177	34.9-135	80,128.0
Atractoscion nobilis	white seabass	1,375	104-352	65.5-600	289,213.3
Anchoa compressa	deepbody anchovy	643	58-122	1.9-18.8	5,786.5
Xenistius califoriensis	salema	602	43-70	1.4-10.0	2,102.3
Sardinops sagax	Pacific sardine	437	45-184	1.6-71.0	3,190.0
Paralabrax nebulifer	barred sand bass	416	50-127	2.4-43.4	3,323.5
Cymatogaster aggregata	shiner surfperch	343	11-134	1.1-72.8	10,082.7
Leuresthes tenuis	California grunion	330	56-82	1.4-4.8	706.0
Paralabrax clathratus	kelp bass	293	53-102	2.2-20.5	2,397.8
Hypsoblennius gentilis	bay blenny	288	38-102	1.3-23.7	1,334.3
Paralabrax maculatofasciatus	spotted sand bass	271	43-265	1.4-440	3,222.3
Anisotremus davidsonii	sargo	195	49-352	3.4-1,300	33,558.2
Girella nigricans	opaleye	171	28-240	1.6-510	2,674.8
Seriphus politus	queenfish	57	38-292	0.1-225	641.0
Atherinopsis californiensis	jacksmelt	18	112-299	10.9-210	1,142.0
Roncador stearnsi	spotfin croaker	13	238-555	300-3,400	13,831.0
Hypsopsetta guttulata	diamond turbot	12	36-246	1.0-350	2,694.6
Syngnathus spp.	pipefishes	12	146-233	0.3-4.4	20.5
Chromis punctipinnis	blacksmith	11	46-102	2.2-79.5	179.2
Ophichthus zophochir	yellow snake eel	11	394-758	32.7-470	3,222.7
Embiotoca jacksoni	black surfperch	10	105-255	40.9-600	1,403.2
Amphistichus argenteus	barred surfperch	9	96-227	27.3-377.6	680.4
Heterostichus rostratus	giant kelpfish	9	90-225	5.1-110.0	322.1
Genyonemus lineatus	white croaker	8	80-95	8.2-14.3	68.8
Anchoa delicatissima	slough anchovy	7	51-60	0.9-1.9	9.7
Chub, unid.	unid. chub	7	68-81	4.5-7.8	43.7
Hermosilla azurea	zebra perch	7	50-365	2.8-590	2,481.3
Brachyistius frenatus	kelp surfperch	6	76-120	11.0-55.8	198.4
Engraulis mordax	northern anchovy	6	80-125	3.8-15.2	54.1
Pleuronichthys ritteri	spotted turbot	5	200-230	215-250	1,145.0
Mugil cephalus	striped mullet	4	345-400	800-1,100	3,800.0
Phanerodon furcatus	white surfperch	4	112-126	37.7-55.0	190.4
Umbrina roncador	yellowfin croaker	4	185-280	70.0-300	730.0
Paraclinus integripinnis	reef finspot	3	58-70	2.0-4.0	9.2
Paralichthys californicus	California halibut	3	222-350	113-700	1,433.0
Sphyraena argentea	California barracuda	3	167-222	21.9-65.0	127.6
Trachurus symmetricus	jack mackerel	3	95-110	10.0-17.0	42.4
Fundulus parvipinnis	California killifish	2	7.5-7.8	0.4	0.8
Porichthys myriaster	specklefin midshipman	2	395-396	820-900	1,720.0
Strongylura exilis	California needlefish	2	480-490	120-150	270.0
Albula vulpes	bonefish	1	380	900	900.0
Citharichthys spp.	sanddabs	1	-	3.4	3.4
Medialuna californiensis	halfmoon	1	234	410	410.0
Sarda chiliensis	Pacific bonito	1	-	0.1	0.1
Scorpaenidae	scorpionfishes	1	44	1.9	1.9
unidentified fish, damaged	unidentified damaged fish	-	-	-	1,543.2

(table continued)

Encina Power Station Impingement Abundance: Heat Treatment Survey Data

Survey: EPSTS004 (continued)
Survey Date: February 13-14, 2005

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
SHARKS/RAYS					
Urolophus halleri	round stingray	10	135-245	101-530	2,576.1
Myliobatis californica	bat ray	4	335-460	200-1,500	3,130.0
Gymnura marmorata	California butterfly ray	2	430-450	800	1,600.0
INVERTEBRATES					
Portunus xantusii	Xantus' swimming crab	44	20-67	1.1-34.4	337.5
Cancer jordani	hairy rock crab	18	28-47	3.2-16.3	85.5
Octopus bimaculatus	California two-spot octopus	11	19-180	12-590	2,424.3
Pachygrapsus crassipes	striped shore crab	9	13-23	1.0-4.4	16.6
Cancer antennarius	brown rock crab	8	40-50	14.9-27.8	138.2
Cancer magister	dungeness crab	1	50	18.1	18.1
Caridean unid.	unidentified shrimp	1	-	-	-
Octopus spp.	octopus	1	30	300	300.0
Pandalus spp.	unidentified shrimp	1	12	2.3	2.3
Panulirus interruptus	California spiny lobster	1	93	150	150.0
Pugettia producta	northern kelp crab	1	17	1.8	1.8
	Total:	13,494			

Encina Power Station Impingement Abundance: Heat Treatment Survey Data

Survey: EPSTS005
Survey Date: April 10, 2005

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Cymatogaster aggregata	shiner surfperch	2,372	90-120	18.0-46.0	93,799.4
Leuresthes tenuis	California grunion	1,443	75-145	3.5-37.9	12,351.6
Anchoa compressa	deepbody anchovy	1,112	58-120	2.0-21.0	10,598.8
Paralabrax nebulifer	barred sand bass	508	54-97	2.6-98.0	4,270.9
Seriphus politus	queenfish	306	56-152	3.1-49.6	2,284.2
Hyperprosopon argenteum	walleye surfperch	298	101-167	30.2-119	19,132.6
Paralabrax clathratus	kelp bass	181	50-94	3.4-18.3	1,546.0
Anisotremus davidsonii	sargo	180	55-100	3.6-30.3	22,582.2
Paralabrax maculatofasciatus	spotted sand bass	139	50-185	3.0-140.3	2,564.2
Hypsoblennius jenkinsi	mussel blenny	92	25-90	1.1-11.6	516.3
Umbrina roncador	yellowfin croaker	90	73-290	7.4-474.2	20,568.5
Xenistius califoriensis	salema	90	50-74	2.1-7.4	409.2
Girella nigricans	opaleye	72	33-197	1.4-309	13,859.1
Hypsopsetta guttulata	diamond turbot	51	75-260	11.2-424	11,199.9
Hypsoblennius gentilis	bay blenny	27	65-105	4.5-23.5	172.7
Porichthys myriaster	specklefin midshipman	24	320-440	100-1,300	20,380.0
Amphistichus argenteus	barred surfperch	19	110-130	26.2-66.4	1,562.7
Chromis punctipinnis	blacksmith	12	60-115	6.4-41.2	294.7
Brachyistius frenatus	kelp surfperch	9	95-145	20.9-65.7	324.9
Strongylura exilis	California needlefish	9	336-490	45.5-148.4	733.3
Engraulis mordax	northern anchovy	7	67-120	2.9-16.5	41.6
Hermosilla azurea	zebra perch	6	104-249	16.2-535	778.7
Syngnathus spp.	pipefishes	5	160-340	1.4-12.5	20.4
Roncador stearnsi	spotfin croaker	4	85-285	10.5-407	574.8
Atractoscion nobilis	white seabass	3	251-320	211-440	1,010.5
Embiotoca jacksoni	black surfperch	3	55-138	5.0-103	199.6
Leptocottus armatus	Pacific staghorn sculpin	3	60-65	3.0-5.0	12.9
Medialuna californiensis	halfmoon	3	117-147	43.6-77.6	175.5
Trachurus symmetricus	jack mackerel	3	115-430	15.9-270	360.5
Ophichthus zophochir	yellow snake eel	2	379-664	29.4-319	348.7
Citharichthys stigmaeus	speckled sanddab	1	115	29.5	29.5
Fundulus parvipinnis	California killifish	1	53	3.2	3.2
Genyonemus lineatus	white croaker	1	79	10.0	10.0
Halichoeres semicinctus	rock wrasse	1	124	32.5	32.5
Heterostichus rostratus	giant kelpfish	1	176	46.1	46.1
Menticirrhus undulatus	California corbina	1	305	430	430.0
Phanerodon furcatus	white surfperch	1	115	56.0	56.0
Pleuronichthys ritteri	spotted turbot	1	175	163.7	163.7
Pleuronichthys verticalis	hornyhead turbot	1	55	3.7	3.7
SHARKS/RAYS					
Urolophus halleri	round stingray	25	100-450	50.0-634	8,199.8
Gymnura marmorata	California butterfly ray	12	256-568	150-1,714	6,682.1
Myliobatis californica	bat ray	6	258-420	230-2,189	5,049.5
Heterodontus francisci	horn shark	1	460	850	850.0
Mustelus californicus	gray smoothhound	1	975	1,800.0	1,800.0

(table continued)

Encina Power Station Impingement Abundance: Heat Treatment Survey Data

Survey: EPSTS005 (continued)
Survey Date: April 10, 2005

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
INVERTEBRATES					
Pachygrapsus crassipes	striped shore crab	38	8-43	0.1-45.1	125.2
Cancer spp.	cancer crabs	31	20-30	1.2-3.4	70.4
Portunus xantusii	Xantus' swimming crab	13	20-50	2.1-18.1	95.4
Octopus bimaculatus	California two-spot octopus	6	25-80	5.6-100	233.7
Pugettia producta	northern kelp crab	2	20-30	4.0-11.5	15.5
Cancer antennarius	brown rock crab	1	46	14.2	14.2
Crangon nigromaculata	spotted bay shrimp	1	60	3.7	3.7
	Total:	**7,219**			

Encina Power Station Impingement Abundance: Heat Treatment Survey Data

Survey: EPSTS006
Survey Date: June 05, 2005

Taxon	Common Name	Survey Count	Length Range (mm)	Weight Range (g)	Total Weight (g)
FISHES					
Anchoa compressa	deepbody anchovy	8,144	29-130	1.3-24.3	95,729.6
Cymatogaster aggregata	shiner surfperch	5,779	37-100	1.1-28.1	50,780.1
Atherinops affinis	topsmelt	3,587	30-105	0.2-12.5	16,261.1
Paralabrax maculatofasciatus	spotted sand bass	869	52-204	3.2-255	82,072.6
Paralabrax nebulifer	barred sand bass	843	60-115	5.4-42.0	17,169.5
Anisotremus davidsonii	sargo	396	44-135	1.2-42.6	9,980.1
Paralabrax clathratus	kelp bass	372	45-136	2.1-63.1	8,328.2
Hyperprosopon argenteum	walleye surfperch	296	20-159	0.3-300	16,851.8
Seriphus politus	queenfish	204	26-170	2.1-105	2,053.4
Porichthys myriaster	specklefin midshipmar	161	190-440	49.3-1,085	35,440.5
Xenistius californiensis	salema	159	45-175	4.7-60.5	1,937.9
Hypsoblennius gentilis	bay blenny	88	50-100	2.4-19.0	853.0
Chromis punctipinnis	blacksmith	77	60-186	8.0-100	2,682.2
Roncador stearnsi	spotfin croaker	77	85-140	15.1-55.2	2,359.5
Strongylura exilis	California needlefish	50	260-543	28.4-294	5,815.3
Hypsopsetta guttulata	diamond turbot	45	121-300	146-374	9,509.2
Phanerodon furcatus	white surfperch	37	60-100	5.0-23.1	381.5
Umbrina roncador	yellowfin croaker	29	95-125	16.3-42.7	889.7
Sardinops sagax	Pacific sardine	27	70-178	1.8-56.5	648.0
Engraulis mordax	northern anchovy	17	36-129	0.7-19.4	77.5
Menticirrhus undulatus	California corbina	11	125-388	30.4-806	2,034.7
Fundulus parvipinnis	California killifish	10	-	-	30.2
Paralichthys californicus	California halibut	10	72-264	6.7-172	854.2
Heterostichus rostratus	giant kelpfish	9	60-203	1.1-75.2	160.8
Amphistichus argenteus	barred surfperch	5	60-160	6.2-75.2	259.3
Embiotoca jacksoni	black surfperch	4	65-155	15.2-151	435.1
Syngnathus spp.	pipefishes	3	20-217	0.4-1.8	3.8
Brachyistius frenatus	kelp surfperch	2	115-130	23.1-51.9	75.0
Girella nigricans	opaleye	2	160-180	87.6-140.9	228.5
Hypsypops rubicundus	garibaldi	2	222-232	668-705	1,373.7
Leptocottus armatus	Pacific staghorn sculpin	2	75	5.2-8.3	13.5
Sphyraena argentea	California barracuda	2	95-105	4.7-6.6	11.3
Atractoscion nobilis	white seabass	1	252	345.0	344.8
Ophichthus zophochir	yellow snake eel	1	650	347	347.0
Pleuronichthys verticalis	hornyhead turbot	1	197	248.0	247.7
Trachurus symmetricus	jack mackerel	1	200	75.8	75.8
Zoarcidae	eelpouts	1	152	17.1	17.1
SHARKS/RAYS					
Urolophus halleri	round stingray	363	105-239	54.3-800	118,389.8
Gymnura marmorata	California butterfly ray	41	244-609	182-1,629	22,997.3
Myliobatis californica	bat ray	23	226-649	205-1,925	15,585.9
Mustelus californicus	gray smoothhound	17	460-882	225-2,100	13,056.0
Dasyatis dipterura	diamond stingray	1	275	618.0	617.6
Triakis semifasciata	leopard shark	1	455	428.0	428.4
INVERTEBRATES					
Cancer productus	red rock crab	491	10-55	1.8-12.8	2,835.9
Pachygrapsus crassipes	striped shore crab	8	19-29	3.7-10.5	61.3
Majidae	spider crabs	6	10-15	2.1-5.2	20.2
Octopus spp.	octopus	2	20-45	9.7-86.2	95.9
Pugettia producta	northern kelp crab	2	22-30	2.4-5.4	7.8
	Total:	22,279			

CARLSBAD SEAWATER DESALINATION PROJECT

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

REGION 9, SAN DIEGO REGION

ORDER NO. R-9-2006-0065

NPDES NO. CA0109223

FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

ATTACHMENT 4 - PROPOSAL FOR INFORMATION COLLECTION CLEAN WATER ACT SECTION 316(B), ENCINA POWER STATION, CABRILLO POWER I LLC, NPDES PERMIT NO. CA0001350, APRIL 1, 2006.

March 27, 2009

PROPOSAL FOR INFORMATION COLLECTION
CLEAN WATER ACT SECTION 316(B)

ENCINA POWER STATION
CABRILLO POWER I LLC

NPDES PERMIT NO. CA0001350

Project No. 1009704003

April 1, 2006

Prepared for:

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Acronyms and Abbreviations

AEL	Adult Equivalent Loss
AFC	Application for Certification
AHL	Agua Hedionda Lagoon
amsl	above mean sea level
BTA	Best Technology Available
CCC	California Coastal Commission
CDFG	California Department of Fish & Game
CDS	Comprehensive Demonstration Study
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CWA	Clean Water Act
CWIS	Cooling Water Intake Structure
DCTP	Design & Construction Technology Plan
E	entrainment
EAM	Equivalent Adult Model
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
EPS	Encina Power Station
ETM	Empirical Transport Model
FH	Fecundity Hindcasting
F&WS	Fish and Wildlife Service

Acronyms and Abbreviations (continued)

fps	feet per second
gpm	gallons per minute
HEA	Habitat Equivalency Analysis
hrs	hours
IM&E	Impingement Mortality and/or Entrainment
JWPCP	Joint Water Pollution Control Plant
MBC	MBC Applied Environmental Sciences
MGD	million gallons per day
mi	miles
min	minute
MLES	Marine Life Exclusion System
MLLW	mean lower low water
mm	millimeter
MW	megawatt
N	North
NMFS	National Marine Fisheries Service
NOAA	National Oceanic & Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRDA	National Resources Defense Council
O&M	Operation and Maintenance
OBGS	Ormond Beach Generating Station
PIC	Proposal for Information Collection
psig	pounds per square inch gauge
QA/QC	Quality Assurance/Quality Control
RP	Restoration Plan
SAP	sampling and analysis plan
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric Company
SDRWQCB	San Diego Regional Water Quality Control Board
SGS	Scattergood Generating Station
TAG	Technical Advisory Group
TDD	Technical Development Document
TIOP	Technology Installation & Operation Plan
USFWS	U.S. Fish & Wildlife Service
W	West
y^3	cubic yard
°F	degrees Fahrenheit

1.0 Introduction

Section 316(b) of the Clean Water Act (CWA) requires that the location, design, construction, and capacity of cooling water intake structures (CWIS) reflect the best technology available (BTA) to minimize adverse environmental impacts due to the impingement (IM) of aquatic organisms (i.e., fish, shellfish, and other forms of aquatic life) on intake structures and the entrainment (E) of eggs and larvae through cooling water systems. On July 9, 2004, the U.S. Environmental Protection Agency (EPA) promulgated regulations in the Federal Register applicable to large existing power plants (Phase II facilities) that use large amounts of cooling water. These regulations, published in the Code of Federal Regulations (CFR) Chapter 40 Part 125 Subpart J, became effective on September 7, 2004.

The Phase II regulations establish performance standards for CWIS of existing power plants that withdraw more than 50 million gallons per day (MGD) of surface waters and use more than 25 percent of the withdrawn water for cooling purposes. The new rule requires all large existing power plants to reduce impingement mortality by 80 – 95 percent and to reduce the number of smaller aquatic organisms drawn through the cooling system by 60 – 90 percent. The water body type on which the facility is located, the capacity utilization rate, and the magnitude of the design intake flow relative to the waterbody flow determine whether a facility will be required to meet the performance standards for IM or both IM&E. The final rule allows these performance standards to be met through using a combination of the existing intake design, additional intake technologies, operational modifications, and using restoration measures. This approach also provides flexibility by allowing site-specific performance standards, if economic conditions do not justify the full cost of meeting the standards.

The EPA 316(b) Phase II rule requires that each affected facility develop and submit a *Proposal for Information Collection (PIC)* to the applicable permitting agency prior to implementation of data collection activities. The PIC must include the following key elements:

- A description of the proposed and/or implemented technologies, operational measures, and/or restoration measures to help develop a compliance strategy to meet the performance standards;
- A description of any historical studies characterizing IM&E and/or the physical and biological conditions in the vicinity of the CWIS and their relevance to the proposed study;
- A summary of any past or ongoing consultations with regulatory agencies and other stakeholders that are relevant to the study; and

- A sampling and analysis plan (SAP) for any new field studies needed to estimate IM&E.

This PIC serves as a study plan for a Comprehensive Demonstration Study (CDS), which provides the information to:

- Determine the baseline calculations of IM&E to be compared with performance standards;
- Evaluate combinations of technologies, operational measures and/or restoration measures, which may be implemented to meet the performance standards; and
- Evaluate whether a site-specific BTA determination is warranted and can be justified using a cost/cost or cost/benefit test.

1.1 Regulatory Applicability

The Encina Power Station (EPS) is located adjacent to the *Agua Hedionda Lagoon* (or AHL) on the Pacific Ocean. Because of its location near the ocean, the facility is subject to the following national performance standards (Table 1-1) for the reduction of IM&E resulting from the operation of the CWIS:

Table 1-1
IM&E Performance Standards for Phase II Facilities

Standard	Reduction Requirement
Impingement mortality	80 – 95%
Entrainment	60 – 90%

The EPA 316(b) Phase II rule generally requires that facilities subject to the rule submit the CDS with the application for renewal of the National Pollutant Discharge Elimination System (NPDES) permit. Facilities with NPDES permits expiring prior to July 9, 2008 may request an extension for submittal of the CDS no later than January 7, 2008. The current EPS NPDES permit has expired on February 5, 2005. A timely application for renewal was submitted to the San Diego Regional Water Quality Control Board (SDRWQCB) on June 23, 2004. The EPS has submitted a letter to the SDRWQCB on January 6, 2005 requesting the following schedule for submittal of the two reports required under the EPA 316(b) Phase II Rule:

- Proposal for Information Collection – submittal due April 1, 2006
- Comprehensive Demonstration Study – submittal due January 7, 2008

1.2 Purpose

The purpose of this document is to meet or exceed the requirement for the preparation and submittal of the PIC in accordance with 40 CFR 125.95(b)(1). This Plan is being submitted for agency review and comment in advance of implementation. However, information collection activities may be initiated prior to receipt of agency comments.

2.0 Facility Description

The EPS has been owned and operated by Cabrillo Power I LLC (Cabrillo) since May 22, 1999. The power plant was previously owned by San Diego Gas and Electric Company (SDG&E).

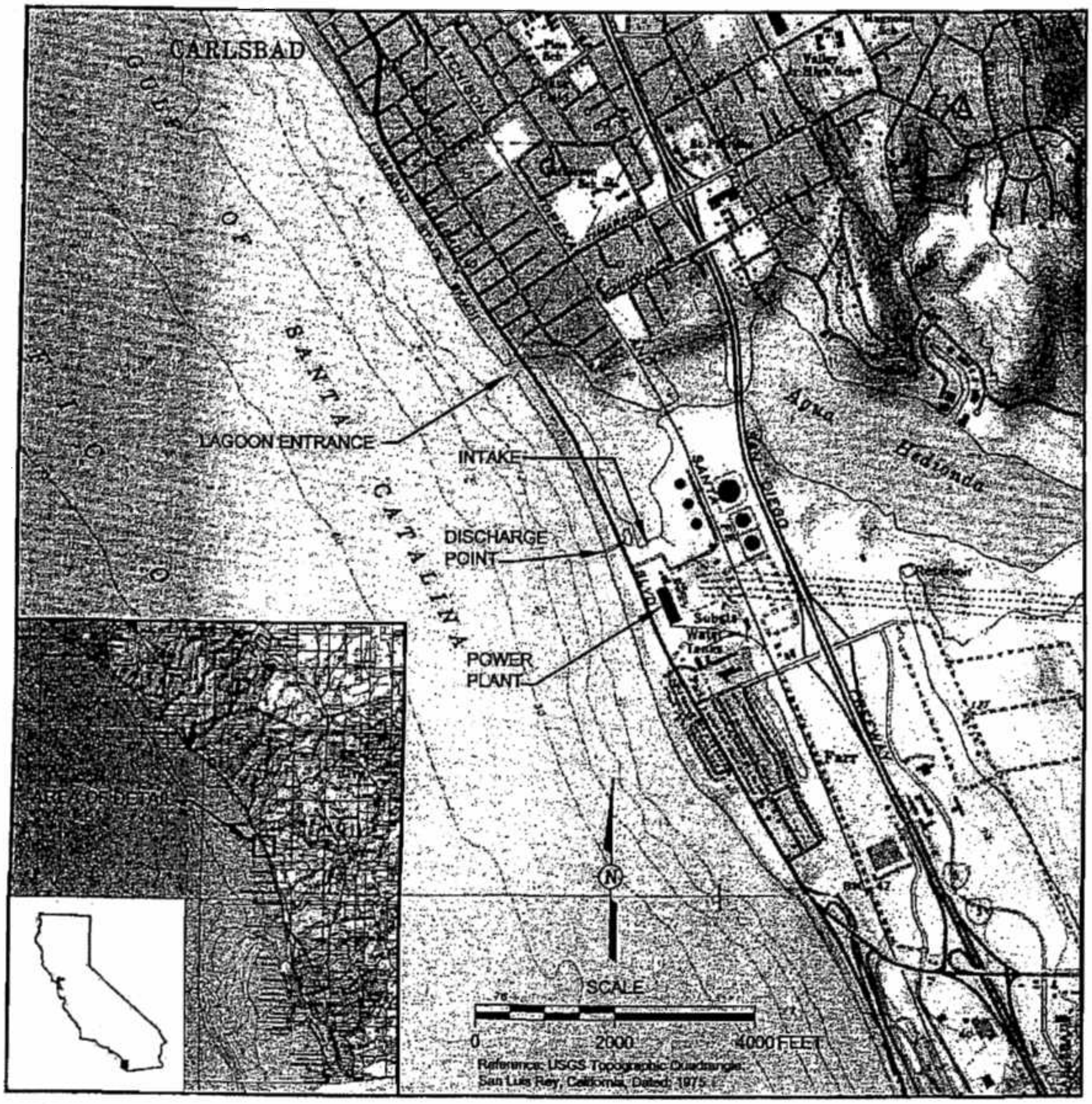
The EPS is a fossil-fueled steam electric power generating station that began operation in 1954. Thermal energy provided by the combustion of the fossil-fuels is used to generate steam to drive five steam turbine generators. The plant also has one air-cooled gas turbine generator achieving a combined nominal thermal energy output capacity for the plant of 939 megawatts. Waste heat generated at EPS is discharged to the Pacific Ocean. The combined cooling and service water design flow is 857.29 MGD.

Cooling water is withdrawn from the Pacific Ocean via the AHL. 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 range from a low of –3.52 feet to a high of +4.79 feet [elevation "0" being mean sea level, (msl)], based on measurements made by Coastal Environments (2005). The intake structure is located in the lagoon, in front of the generating units.

2.1 Facility Location

The EPS is located at 4600 Carlsbad Boulevard, in the southwest area of the City of Carlsbad, California, adjacent to the AHL on the Pacific Ocean in Section 18, Township 12 South, Range 4 West of the San Bernardino Baseline Meridian. Figure 2-1 depicts the location of the facility and the location of the cooling water intake and discharge points relative to the shoreline.

Figure 2-1
Encina Power Station Location Map



2.2 Source Water Body Description

The environmental setting of AHL, the primary source water body for the EPS, is discussed in detail in Bradshaw et al (1976), SDG&E (1980), and summarized in EA Engineering, Science and Technology (1997). The following is a description of the physical and ecological characteristics of the AHL, on which the EPS is located.

2.2.1 Physical Characteristics

Agua Hedionda is the third largest watershed within the Carlsbad Hydrologic Unit. The watershed, dominated by Agua Hedionda Creek, extends approximately 10.62 miles (mi) inland from the coast and is about 18,837 acres in area, comprising 14 percent of the Carlsbad Hydrologic Unit. Agua Hedionda Creek originates on the southwestern slopes of the San Marcos Mountains in west central San Diego County and discharges into the Pacific Ocean via AHL. The highest elevation within the watershed is 1,500 feet above mean sea level (amsl), located in the San Marcos Mountains.

The EPS is located on the AHL, which is a man-enhanced coastal lagoon that extends 1.7 mi inland and is up to 0.5 mi wide. The lagoon is located along the Pacific Coast in San Diego County approximately 26 mi north of the City of San Diego. The lagoon was constructed in 1954 to provide cooling water for the power plant. The construction enhancement involved a permanent opening of the connection of the lagoon with the ocean. Prior to this, the lagoon was ephemerally connected to the ocean when creek flows were high. A railroad trestle and the Interstate Highway 5 bridge separate AHL into three interconnected segments: an Outer, Middle, and Inner lagoon. The surface areas of the Outer, Middle, and Inner lagoons are 53, 24, and 190 acres, respectively based on measurements made by Coastal Environments (2005). The lagoon is separated from the ocean by Carlsbad Boulevard and a narrow inlet 151 feet wide and 9 feet deep at the northwest end of the Outer Lagoon that passes under the highway and allows tidal exchange of water with the ocean.

Circulation and input into AHL is dominated by semi-diurnal tides that bring approximately 1,454 acre feet of seawater through the entrance to the Outer Lagoon on flood tides based on measurements made by Coastal Environments (2005). Approximately half of this tidal volume flows into the Middle and Inner lagoons. On ebb tides this same tidal volume flows out through the entrance to the ocean. As a result of this tidal flushing, the lagoon is largely a marine environment. Although freshwater can enter the lagoon through Agua Hedionda Creek, which drains an 18,500 acre watershed, for most of the year freshwater flow is minimal. Heavy rainfall in the winter can increase freshwater flows, reducing salinity, especially in the Inner Lagoon. The lagoon system is kept open to the ocean by routine dredging of the Outer Lagoon and the channel to the ocean.

Bottom sediments in the lagoon reflect the speed and location of the periodic tidal currents. The Outer Lagoon sediments consist of coarser gravel and sands in areas of highest current velocities. The Middle Lagoon consists of an inter-tidal zone largely comprised of mud. The largest water body segment, the Inner Lagoon, consists of mostly finer sands, silt, and clay with organic detritus, especially at the far eastern end of the lagoon. Some narrow sand beaches and rock rip-rap substrate are also present in the Inner Lagoon.

AHL is tidally flushed through the small inlet in the Outer Lagoon by waters from the Pacific Ocean. The physical oceanographic processes of the southern California Bight that influence the lagoon includes, the tides, currents, winds, swell, temperature, dissolved oxygen, salinity, nutrients. These are most affected by the daily tidal exchange of coastal seawater. Near the mouth of the lagoon the mean tide range is 3.7 feet with a diurnal range of 5.3 feet. Waves breaking on the shore generally range in height from 2 to 4 feet, although larger waves (6 to 10 feet) are not uncommon. Larger waves exceeding 15 feet occur infrequently and are usually associated with winter storms. Surface water in the local area ranges from a minimum of 57 degrees Fahrenheit (°F) to a maximum of 72°F with an average annual temperature between 63°F and 66°F.

2.2.2 Agua Hedionda Lagoon Ecological Characteristics

The AHL is listed by the State of California as a Section 303(d) impaired waterbody largely due to sedimentation/siltation and coliform contamination resulting from multiple non-point source discharges in Agua Hedionda watershed. Sedimentation of the lagoon can occur both from sediment flows within the watershed and from tidal flows from the Pacific Ocean. The bacterial contamination is likely from multiple sources within the watershed.

In November of 2000, the U. S. Fish and Wildlife Service (F&WS), under the Endangered Species Act of 1973, as amended, designated AHL as critical habitat for the tidewater goby (*Eucyclogobius newberryi*), a federally listed endangered species. However, no tidewater gobies have been observed in the AHL since the 1950's when the lagoon was originally dredged as the power plant cooling water source and the lagoon is no longer viable habitat for the species. Based on that fact, Cabrillo Power I LLC filed for declaratory and injunctive relief in federal district court on August 31, 2001, against the F&WS for failing to base the AHL and Creek critical habitat designation on best scientific data and failing to analyze the economic and other impacts of the designation. On February 28, 2003, based upon a stipulated settlement, the United States District Court ordered that the tidewater goby critical habitat designation for AHL and Creek be vacated without prejudice.

Land use within the watershed is dominated by urban development. Natural habitats are scattered and occur in a matrix of agricultural and urban development, however, several relatively large patches of native vegetation occur in the eastern portion of the watershed and in the central area just inland from AHL.

A study on the ecological resources of Agua Hedionda showed that it has good water quality and supports diverse benthic infauna, bird, and fish communities (MEC Analytical 1995). Eelgrass was found in all three lagoon segments, but was limited in the Inner Lagoon to depths above approximately –6.5 feet mean lower low water (MLLW) because water turbidity reduced penetration of light for photosynthesis in deeper areas. The eelgrass beds provide a valuable habitat for benthic organisms that are fed upon by birds and fishes. Although eelgrass beds were less well developed in areas of the Inner Lagoon, it was found to provide a wider range of habitats, including mud flats, salt marsh, and seasonal ponds than elsewhere in Aqua Hedionda. As a result, bird and fish diversity was highest in the Inner Lagoon.

A total of 35 species of fishes was found during the 1994 and 1995 sampling conducted by MEC (MEC Analytical 1995). The Middle and Inner lagoons had more species and higher abundances than the Outer Lagoon. During the 1995 survey, only four species were collected in the Outer Lagoon, compared to 14 to 18 species in the Middle and Inner lagoons. Silversides (Atherinopsidae) and gobies (Gobiidae) were the most abundant fishes collected. Silversides, including jacksmelt and topsmelt, that occur in large schools in shallow waters where water temperatures are warmest were most abundant in the shallower Middle and Inner lagoons. Gobies were most abundant in the Inner Lagoon, which has large shallow mudflat areas that are their preferred habitat.

An impingement and entrainment study was conducted at EPS in 1979-1980 (SDG&E 1980). In the impingement study, fishes and invertebrates were collected and quantified from the traveling screens and bar rack system of the power plant. Seventy-six species of fishes, 45 species of macroinvertebrates, and 7 species of algae and marine plants were impinged. There were also seven thermal treatments (intake tunnel heat shock treatments) sampled during the year and 90 percent of the fishes collected consisted of nine species: deepbody anchovy, topsmelt, northern anchovy, shiner surfperch, California grunion, walleye surfperch, queenfish, round stingray, and giant kelpfish.

The recent assessment of the ecological resources of Agua Hedionda (MEC Analytical 1995) did not find any tidewater gobies (*Eucyclogobius newberryi*). This federally endangered species was once recorded as occurring in the lagoon prior to construction of the Outer Lagoon in the early 1950s. The present marine-influenced environment in the lagoon would not tend to support tidewater gobies because they prefer brackish water habitats. No listed fish species were collected in the recent study.

2.2.3 Pacific Ocean Ecological Resources

The outer coast has a diversity of marine habitats and includes zones of intertidal sandy beach, subtidal sandy bottom, rocky shore, subtidal cobblestone, subtidal mudstone and water column. Organisms typical of sandy beaches include polychaetes, sand crabs, isopods, amphipods, and clams. California grunion utilize the beaches around EPS during spawning season from March through August. Numerous infaunal species occur in subtidal sandy bottoms with mollusks, polychaetes, arthropods, and echinoderms comprising the dominant invertebrate fauna. Typical fishes in the sandy subtidal include queenfish, white croaker, several surfperch species, speckled sanddab, and California halibut. Also, California spiny lobster and *Cancer* spp. crabs forage over the sand. Many of the typically outer coast species can occasionally occur within AHL, carried by incoming tidal currents.

The rocky habitat at the discharge canal and on offshore reefs supports various kelps and invertebrates including barnacles, snails, sea stars, limpets, sea urchins, sea anemones, and mussels. Giant kelp (*Macrocystis*) forests are an important community in the area offshore from Agua Hedionda. Kelp beds provide habitat for a wide variety of invertebrates and fishes. The water column and kelp beds are known to support many fish species, including northern anchovy, jack smelt, queenfish, white croaker, garibaldi, rockfishes, kelp bass, white seabass, surfperches, and halibut.

Marine-associated wildlife that occur in the Pacific waters off AHL are numerous and include birds such as brown pelican, surf scoter, cormorants, western grebe, gulls, terns and loons. Marine mammals, including porpoise, sea lions, and migratory gray whales, also frequent the adjacent coastal area.

2.3 Cooling Water Intake Structure Design

Cooling water is withdrawn from the Pacific Ocean via the AHL. The CWIS complex is located approximately 2,200 feet from the ocean inlet to the lagoon. The intake structure is located on the lagoon, to the north of the generating units as shown on Figure A-1 included in Appendix A.

As the water flows into the intake structure, it passes through trash racks made up of metal bars spaced about 3½ inches apart, which prevent passage of large debris into the intake. The trash rack inlet structure is shown on Figure A-2 included in Appendix A. The intake downstream of the trash rack 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 one of two vertical traveling screens to prevent fish, grass, kelp, and debris from entering pump intakes for generating units 1, 2, and 3.

Conveyance tunnels 3 and 4 carry cooling water to the intakes for generating units 4 and 5, respectively. Traveling water screens are located at the intake of pump 4 and the intake of pump 5. A detailed plan layout of the entire tunnel system is shown on Figure A-1 included in Appendix A.

Each cooling water intake consists of two circulating water pumps and one or two service pumps. During normal operation, one circulating water pump serves each half of the condenser, so when a unit is generating power, both pumps are in operation.

There are a total of seven traveling screens that remove any debris which has passed through the trash racks. Two screens service the combined flows of generating Units 1, 2, and 3. Unit 4 has two traveling water screens, while Unit 5 has three traveling water screens. 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. 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 front of the intake screenwell 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 tunnel) to wash the debris from the traveling screen. At the head of the screen, matter is removed from the baskets by a spray of water, which is evenly distributed over the entire basket width. The jet spray washes the accumulated material into a trough and the trough conveys the debris into debris collection baskets. Accumulated organic debris is discharged to the outfall structure.

Characteristics and specifications of the CWIS are presented in Table 2-1.

Table 2-1
Design Characteristics of EPS Cooling Water Intake Structure

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Latitude	33° 08' 16" N	33° 08' 16" N	33° 08' 16" N	33° 08' 16" N	33° 08' 16" N
Longitude	117° 20' 16" W	117° 20' 16" W	117° 20' 16" W	117° 20' 16" W	117° 20' 16" W
Number of circulating water pumps	2	2	2	2	2
Pump capacity (per pump)	24,000 gpm	24,000 gpm	24,000 gpm	100,000 gpm	104,000 gpm
Service water	3000 gpm	3000 gpm	6000 gpm	13,000 gpm	18,200 gpm
Trash bar opening	3 ½ inch	3 ½ inch	3 ½ inch	3 ½ inch	3 ½ inch
Number of traveling water screens	2 (shared)	2 (shared)	2 (shared)	2	3
Screen type	Standard through flow	Standard through flow	Standard through flow	Standard through flow	Standard through flow
Screen mesh opening	3/8 inch	3/8 inch	3/8 inch	3/8 inch	5/8 inch
Screen height (in water, high tide)	24.8 feet	24.8 feet	24.8 feet	24.8 feet	24.8 feet
Approach velocity (low tide)	1.2 fps	1.2 fps	1.2 fps	1.6 fps	1.1 fps
Through-screen velocity (low tide)	2.1 fps	2.1 fps	2.1 fps	2.9 fps	2.0 fps
Screen rotation	Automatic on ΔP	Automatic on ΔP	Automatic on ΔP	Automatic on ΔP	Automatic on ΔP
Screen wash pressure	70 psig	70 psig	70 psig	70 psig	70 psig

2.4 Cooling Water Intake Structure Operation

During normal operation, one circulating water pump serves each half of the condenser, so when a unit is generating power, 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. At the beginning of each work shift (0600, 1800), the screens are turned on and the automatic start is checked to ascertain that the screens are functioning properly.

The plant produces its own sodium hypochlorite electrolytically from seawater for use in chlorination of the cooling water system. A bromide additive (sodium bromide), which reacts with chlorine to form hypobromous acid, and a bio-dispersant are also used with the sodium hypochlorite as enhancers.

The treatment solution is injected to the channel immediately upstream of the once-through cooling water and saltwater service pump suctions for each unit. Each injection point is individually controlled. Chlorination is conducted for about five minutes per hour per unit on a timed cycle each day. This method of chlorination results in a minimal chlorine residual in the cooling water being discharged to the ocean.

The intake tunnels are thermally treated (tunnel re-circulation) approximately every five weeks. 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 six-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 re-circulation treatment process prevents encrusting organisms from developing to any significant size or quantity. The treatment causes the encrusting organisms to release from the surfaces and wash through the condensers to the ocean with the circulating water discharge, reducing the need for maintenance outages for normal 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 and reducing thermal load to the ocean.

Thermal treatment is performed by restricting the flow of cooling water from the lagoon and re-circulating 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 two hours has proven to be effective in removing encrusting organisms. The total time required for the thermal treatment operation, including temperature buildup and cool down, is approximately six hours.

2.5 Calculation Baseline

EPA, in its 316(b) Phase II rule for existing facilities, requires reductions in IM&E when compared against a "calculation baseline." This calculation baseline is the level of IM&E that would occur if the CWIS were designed with the following characteristics:

- Once-through cooling system;
- Opening of CWIS located at, and the face of the traveling screens is oriented parallel to, the shoreline near the surface of the source waterbody;

- Conventional traveling screens with 3/8 inch mesh; and
- No structural or operational controls to reduce IM&E.

The EPS intake system is equivalent in terms of entrainment of aquatic organisms and impingement of organisms on screens to the baseline shoreline intake with no fish protection features defined by the Environmental Protection Agency in the new Section 316(b) Phase II Existing Facilities Rule (National Pollutant Discharge Elimination System-Final Regulations). The EPS CWIS design has a few deviations from these baseline conditions. The traveling water screens on Unit 5 have 5/8" screens and each of the 7 sets of traveling water screens are set well back from the shoreline of the lagoon. The recent IM&E study performed at the EPS will provide the necessary information for determining a representative calculation baseline for the station.

3.0 Historical Studies

EPA Phase II 316(b) regulations [40 CFR 125.95(b)(1)(ii)] require that the PIC includes a list and description of any historical studies characterizing IM&E, as well as physical and biological conditions in the vicinity of the facility CWIS. The following sections provide a summary of previous entrainment and impingement studies conducted at the EPS and within AHL.

The following sections also present a discussion of the relevance of the data to the current conditions and the IM&E studies at the EPS.

3.1 EPS Impingement Mortality and Entrainment Characterization Studies

The following sections summarize previous IM&E characterization studies performed at the EPS.

3.1.1 1980 EPS 316(b) Demonstration

In 1980, SDG&E owned and operated the EPS (SDG&E, 1980). A 316(b) demonstration was conducted for the facility (SDG&E 1980) as required at the time by the SDRWQCB. The study included descriptions of the facility, descriptions of the physical and biological environment of AHL and surroundings, studies of entrainment, impingement, and entrainment survival at the plant, and an environmental impact assessment that also evaluated the feasibility of alternative intake technologies to reduce IM&E.

A list of taxa ("critical species") that included 16 fishes, 11 ichthyoplankton, and one zooplankter, were selected based on six criteria and approved by the SDRWQCB for detailed study during the program (Table 3-1). Some additional species that were found to be common in the subsequent sampling were also added to the list. The report reviewed the life histories of the critical species.

3.1.1.1 Entrainment

A one-year entrainment and source water characterization study was conducted beginning in 1979 as part of the 316(b) demonstration studies at the EPS. Plankton samples were collected monthly at five offshore stations using 505 and 335 micron mesh nets attached to a 2 feet diameter bongo net system. Collections were also made monthly in the Middle and Upper lagoon segments and every two weeks in the Outer Lagoon using 1.6 feet diameter nets (505 and 335 micron mesh size). The procedures specified the use of a depressor weight connected to the towing apparatus but there was no indication at what depths the plankton samples were typically taken. Tows were targeted at 10 minutes at a speed of 1.5 to 2 knots. Entrainment samples were also collected every two weeks using a plankton pumping system in front of the intakes.

Although most samples were collected during daylight hours some samples were occasionally taken in the evening or early morning hours.

Table 3-1
Critical Species Studied During 1979-1980

"Critical Species"	Common Name
Adult fishes	
Engraulis mordax	northern anchovy
Atherinops affinis	topsmelt
Paralabrax clathratus	kelp bass
Paralabrax maculatofasciatus	potted sand bass
Paralabrax nebulifer	barred sand bass
Cynoscion nobilis	white seabass
Menticirrhus undulatus	California corbina
Seriphus politus	queenfish
Amphistichus argenteus	barred surfperch
Hyperprosopon argenteum	walleye surfperch
Semicossyphus pulcher	California sheephead
Mugil cephalus	striped mullet
Citharichthys sordidus	Pacific sanddab
Paralichthys californicus	California halibut
Pleuronichthys verticalis	hornyhead turbot
Heterostichus rostratus	giant kelpfish
Ichthyoplankton	
Anchoa compressa	deepbody anchovy
Engraulis mordax	northern anchovy
Cottidae	sculpins
Serranidae	sea basses
Sciaenidae	croakers
Coryphopterus nicholsi	blackeye goby
Gobiidae	gobies
Citharichthys stigmaeus	spotted sanddab
Paralichthys californicus	California halibut
Pleuronectidae	righteye flounders
Hypsopsetta guttulata	diamond turbot
Atherinopsidae	silversides
Zooplankton	
Acartia tonsa	copepods

Anchovies (primarily deep body and northern) were the most abundant larval forms in both the source water and entrainment samples, followed by croakers and sanddabs (Table 3-2). There were fewer fish eggs and more goby larvae in the entrainment samples whereas kelp and sand bass larvae were substantially more abundant in the combined source water samples from the Lagoon and offshore. Overall the average composition between the entrainment and source water data sets were very similar for the ten most abundant taxa. Only English sole, *Parophrys vetulus*, larvae were among the top ten entrainment taxa not represented in the top ten source water taxa.

Table 3-2
Average Annual Densities of the Ten Most Abundant Ichthyoplankton Taxa per 100 m^3 (26,417 gal) In Source Water (lagoon and offshore stations combined) & Entrainment (pump sampling) Collections for 335μ Mesh Nets During 1979

	Taxon	Source Water	Entrainment
anchovies	Engraulidae	952.7	855.2
croakers	Sciaenidae	341.7	400.6
speckled sanddab	*Citharichthys* sp.	73.2	82.7
fish eggs	unidentified fish egg	33.8	20.2
gobies	Gobiidae	29.2	42.9
silversides	Atherinidae	8.3	10.8
wrasses	Labridae	6.4	4.0
combtooth blennies	*Hypsoblennius* sp.	6.1	5.7
sea basses	Serranidae	5.1	0.9
rockfishes	*Sebastes* sp.	2.8	2.5
English sole	*Parophrys vetulus*	0	1.9

Note: English Sole not collected in source waterbody.

Entrainment losses were calculated for each two-week sampling interval by multiplying the average plankton densities at the intake by the volume of cooling water drawn through the plant during that period. Annual, monthly, and daily rates were estimated by averaging the entrainment estimates for all sampling periods and calculating values for the indicated duration. Annual estimates for total zooplankton entrainment were 7.4×10^9 (505μ net data) and 30.9×10^9 (335μ net data) individuals. The copepod *Acartia tonsa* was the most abundant species in the entrainment collections (Table 3-3).

Annual estimates of the abundance of ichthyoplankton entrained through the power plant were 4.15×10^9 (505µ net data) and 6.66×10^9 (335µ net data) individuals per year. Fish eggs comprised 98 percent and 86 percent of the total annual ichthyoplankton entrainment using the 505µ and 335µ net estimates, respectively. Through-plant entrainment mortality was assumed to be 100% for larvae and 60% for eggs based on survival experiments that were conducted. The report presented average annual densities of the critical species by net type and daily entrainment estimates for selected plankton groups (Table 3-3).

Table 3-3
Average Daily Entrainment Estimates at EPS Based On Daily Plant Circulating Water Flow of 795 MGD

	Daily Entrainment		Mean Percent
Plankton Group	335 µ	505 µ	of Total
Acartia tonsa (copepod)	4.77×10^7	7.63×10^6	41.2%
fish eggs	1.57×10^7	1.11×10^7	19.9%
Decapoda	1.32×10^7	4.44×10^6	13.1%
other Copepoda	8.47×10^6	2.16×10^6	7.9%
other Crustacea	6.95×10^6	2.70×10^6	7.2%
other Zooplankton	5.68×10^6	4.55×10^5	4.6%
Chaetognatha	1.83×10^6	1.56×10^6	2.5%
fish larvae	2.52×10^6	2.46×10^5	2.1%
Mysidacea	6.70×10^5	1.34×10^6	1.5%
			100.0%

Entrainment impacts were assessed by qualitative comparisons of entrainment losses to the estimated numbers of larvae in nearby source waters, comparisons of additional power plant mortality to natural mortality rates, entrainment probabilities based on current studies, and primary productivity studies. It was concluded that the entrainment of 1.82×10^7 fish larvae and eggs daily was small compared to the egg and larval concentrations measured in monthly plankton tows in the source water body. It was estimated that average daily losses of planktonic organisms amounted to about 0.2% of the plankton available within one day's travel time from the power plant by current transport. At the seaward entrance to AHL, a water parcel was estimated to have a 34% probability of entering the lagoon. The 10% probability of entrainment isopleth was calculated to lie near the northern and eastern extremities of AHL, and the 70% and 90% entrainment probability isopleths were calculated to be near the intakes and well within the southern third of the Outer Lagoon. The modeled isopleths shifted toward the seaward entrance on a flood tide and toward the Middle Lagoon on an ebb tide. Using the 70% entrainment probability isopleth to define intake effects, it was shown that the maximum extent of intake effects was about 1000 feet into the southern end of the Outer Lagoon segment. With natural mortality rates assumed to be 99% for egg and larval stages of most marine fish species it was concluded that additional mortality from the EPS was not significant. There was no modeling of entrainment impacts on larvae using demographic or proportional loss models. It was also concluded, based on results of light-dark bottle experiments, that entrainment effects on source water primary productivity were negligible.

3.1.1.2 Impingement

Impingement of fishes and invertebrates on the traveling screens and bar rack system of the EPS were monitored daily during normal operations for 336 consecutive days in 1979. The main method was to obtain abundance and weights from samples accumulated over two 12-hour periods (daylight and night) each day for all three screening systems at the plant. During this period there were a total of 79,662 fishes from 76 taxonomic categories weighing a total of 3,076 lbs collected (Table 3-4). The six highest-ranking fishes by numbers impinged were queenfish, deepbody anchovy, topsmelt, California grunion, northern anchovy, and shiner surfperch. These are all open water forms that occur in schools. These six species represented 82% of all fishes impinged during normal operations sampling.

There were also seven heat treatments conducted during the study period. Heat treatments are operational procedures designed to eliminate mussels, barnacles, and other fouling organisms growing in the cooling water conduit system. During a heat treatment, heated effluent water from the discharge is redirected to the intake conduit via cross-connecting tunnels until the water temperature rises to approximately 105°F in the screenwell area. This water temperature is maintained for at least one hour, during which time all biofouling organisms, as well as fishes and invertebrates living within the cooling water system, succumb to the heated water. During heat treatment surveys, all material impinged onto the traveling screens are removed from the forebay. Fishes and macroinvertebrates were separated from incidental debris, identified, and counted. During the 1979 studies, the total weight of fishes impinged during these operations was 5,340 lb (Table 3-4). Over 90% of the fishes collected consisted of nine species: deepbody anchovy, topsmelt, northern anchovy, shiner surfperch, California grunion, walleye surfperch, queenfish, round stingray, and giant kelpfish. The numbers of fishes resident in the tunnels during heat treatments was greatest in winter and least in summer.

Macroinvertebrates that ranked high in the total numbers impinged included yellow crab (*Cancer anthonyi*) with 2,540 individuals, swimming crab (*Portunus xantusii*) with 884, lined shore crab (*Pachygrapsus crassipes*) with 866, and market squid (*Loligo opalescens*) with 522. The yellow crab and market squid both have commercial fishery value whereas the other two species are small and are not fished commercially. California spiny lobster, the most valuable invertebrate in the local commercial fishery, was rare in the samples with only two individuals impinged during the entire year-long study period.

Table 3-4
Impingement Summary Of Fishes Collected During Normal And Heat Treatment Surveys Conducted From January 1979 To January 1980 at the EPS

		Normal		Heat Treatment	
Common Name	Scientific Name	Count	Weight (lb [kg])	Count	Weight (lb [kg])
queenfish	*Seriphus politus*	18,681	201 (91.3)	3,483	212 (96.3)
deepbody anchovy	*Anchoa compressa*	13,299	142 (64.3)	23,142	402 (182.2)
topsmelt	*Atherinops affinis*	10,915	248 (112.3)	21,788	366 (166.1)
California grunion	*Leuresthes tenuis*	8,583	75 (33.8)	9,671	180 (81.7)
northern anchovy	*Engraulis mordax*	7,434	32 (14.6)	19,567	207 (94.0)
shiner surfperch	*Cymatogaster aggregata*	6,545	118 (53.3)	12,326	607 (275.5)
walleye surfperch	*Hyperprosopon argenteum*	1,877	111 (50.4)	8,305	1153 (522.8)
white surfperch	*Phanderodon furcatus*	1,751	37 (17.0)	604	19 (8.6)
round stingray	*Urolophus halleri*	1,686	410 (185.9)	1,685	891 (404.2)
California halibut	*Paralichthys californicus*	1,215	126 (57.1)	329	117 (53.0)
all others		7,676	1,577 (715.2)	7,200	1,366 (619.7)
Total		79,662	3,076 (1,395.2)	108,102	5,340 (2,422.4)

Note: The top 10 species by number are listed.

Impacts caused by impingement were assessed by comparing the numbers and biomass of fishes lost to plant operations to the abundance and biomass of fishes resident in the nearby source waters of AHL, nearshore habitats, and the San Diego coastal area. Samples of adult and juvenile fishes in the nearby source water were collected monthly with beach seines, otter trawls and gill nets. Seventeen of the 27 fish species were taken by all three types of gear. The role of gear selectivity in determining actual population sizes of the critical species was recognized. The ten most abundant species collected by all types of gear were California grunion (49%), topsmelt (17%), deepbody anchovy (7%), slough anchovy (6%), northern anchovy (3%), queenfish (3%), walleye surfperch (2%), speckled sanddab (2%), shiner surfperch (1%), and California halibut (1%). Most of the species removed by the power plant are widespread along the southern California and Baja California coasts and losses were small relative to these populations. On a local scale, it was calculated that the average daily power plant removal, including normal operations and heat treatment operations averaged throughout the year, was about 0.02% of the estimated standing crop in the local study area that extended along a shoreline distance of 3.6 miles out to a depth of 60 feet (1,211 acres). The removals also represented about 0.07% of local commercial fish landings by weight (excluding tuna) from the area between San Clemente and the Mexican border, and less than 7% of the recreational fishing landings by numbers annually in the area between Dana Point and the Mexican border.

3.1.2 1997 EPS Supplemental 316(b) Assessment Report

The SDRWQCB issued Order 94-58 in 1994 requiring SDG&E to conduct additional analyses of data from the 316(b) study conducted in 1979-1980 (EA Science and Technology, 1997). The supplemental analyses were completed in 1997. The purpose of the study was to further evaluate the effects of the EPS cooling water intake on the designated beneficial uses of AHL and the Southern California Bight using additional analysis methods. The three Special Conditions of the Order were:

1. Analysis of Family-Specific Entrainment Losses of Fish Eggs and Larvae—*Analysis shall include the estimated monthly and annual entrainment losses for each ichthyoplankton RIF (Representative Important Families) (i.e. identify the specific fish larvae and egg removals for each ichthyoplankton family considered in this study).*

2. Estimation of Combined Impingement Losses for Each of the Target Species—*The specific ichthyoplankton losses shall be evaluated using such factors as the importance of that species in food web structure, natural mortality, and plant selectivity for that species, and potential mitigating factors to reduce the kill of that species.*

3. Estimation of Annual Equivalent Adult Losses From Both Entrainment And Impingement—*Ichthyoplankton losses shall be evaluated using such factors as the importance of that species in the marine food web and its importance as a commercial or recreational species. This assessment shall include the use of a time reference for impact assessment longer than the 1-day entrainment zone. SDG&E may use the existing zone. SDG&E may use the existing data collected during the original demonstration project, but shall propose an alternative approach to assess the long-term effect of plankton removal.*

Estimates of loss were calculated for 17 selected species that included the original 16 "critical species" identified in the original 316(b) report and also tidewater goby, the only endangered aquatic species likely to occur in the area. Estimates of adult equivalent loss were calculated for the three representative species with the highest estimates of entrainment or impingement loss: northern anchovy, topsmelt, and queenfish. The modeling uses life stage-specific estimates of total mortality and yields estimates of the number of individual adult fishes which would have resulted from the young lost to entrainment and impingement under the conservative assumption of equal survival.

In order to put the entrainment losses in perspective and evaluate the magnitude of potential impacts, the report considered the life history characteristics of each target species (reproductive ability, geographic distribution, migratory capabilities) as well as estimates of current population size or harvest by commercial or sport fishermen. Although the original report touched on these topics, the 1997 report went into greater detail to evaluate potential impacts. Impacts were considered at three levels: individual population, overall community, and designated beneficial uses of the source waterbody.

The report concluded that the potential for adverse impacts from the EPS CWIS on individual target species was small compared to the sizes of the existing populations and the effects of fisheries. It similarly concluded that operation of the EPS cooling water intake has not, and will not, adversely affect the continued maintenance of balanced aquatic communities or designated beneficial uses of AHL or the Pacific Ocean in the vicinity of the EPS. Finally, the report stated that since the existing intake is not causing any adverse environmental impacts as defined under the CWA 316(b) guidelines that were in effect in 1997, it should be designated as best technology available.

3.1.3 2004-2005 EPS 316(b) Demonstration

In 2004 the EPS initiated new IM&E studies prior to the publication of the new Phase II rules to take advantage of sampling synergies associated with the permitting of a desalination facility planned for construction on the EPS property. A study plan for the desalination facility studies was submitted to the San Diego Regional Water Quality Control Board (SDRWQCB) staff. The desalination facility study plan was designed to provide information on the larval fish and target invertebrates contained in the source of feedwater for the desalination facility, which is the power plant's cooling water discharge, that would be at risk to entrainment by the desalination plant, and information on the larval fish and target invertebrates contained in the power plant's source waterbody and intake flows. Data being collected for the desalination facility on the power plant's source population of entrainable larval fish and target invertebrates was similar to the information required under the new Phase II rules.

A plan for IM&E studies that directly addressed the requirement of 316(b) was submitted to the San Diego Regional Water Quality Control Board in September 2004 following the final publication of the new Rules in July 2004. The IM&E study plan was submitted as a first step in the facility's compliance with the new Phase II rule. The study plan was reviewed by the Board staff and their consultants, Tetra Tech Inc., and was approved contingent on certain comments and questions. Comments on the study plan were resolved and the studies continued through

June 2005 under the direction of a Technical Advisory Group comprised of staff from the Board, state and federal resource agencies, EPS, and their consultants. A summary of the 2004-2005 IM&E studies is presented in Section 9.0. The final report on the studies is being prepared and will be submitted as part of the CDS.

3.2 Survey of Ecological Resources of Agua Hedionda Lagoon (MEC Analytical Systems, Inc., 1995)

A series of field studies was completed in 1995 in AHL to characterize ecological resources of the lagoon prior to a proposed maintenance dredging project. The study delineated the extent of eelgrass and saltmarsh habitats in the lagoon, and provided quantitative information on the distribution and abundance of birds, fishes and benthic invertebrates. The studies occurred over a 14-month period from April 1994 to June 1995.

The fish surveys were conducted during two different seasons, spring and summer. A total of 29 species of fishes were collected during the two surveys (Table 3-5). Fewer taxa occurred in the Outer Lagoon compared to the Middle and Inner lagoons. The species composition recorded was indicative of the proximity of each lagoon segment to the outer coast with a higher proportion of nearshore species found in the Outer Lagoon samples and more estuarine/bay species in the Inner Lagoon. Mean total densities ranged from 0.016 fish per m^2 (10.76 $feet^2$) in the Outer Lagoon in April 1995 to 7.90 per m^2 (10.76 $feet^2$) in the east Inner Lagoon, also in April 1995. Overall densities were higher in the April than July for all lagoon segments. Silversides and gobies comprised over 90% of the individuals collected. The high densities recorded in the spring survey were due to recruitment of juveniles.

Although 29 species of fishes were found in the 1994-1995 surveys by MEC Analytical Systems, earlier studies (Bradshaw et al. 1976) reported a total of 42 species from occasional surveys and from intake screen collections from the power plant. A similar distribution pattern of increased diversity in the Inner Lagoon compared to the Outer Lagoon was also found in the SDG&E study. MEC Analytical Systems (1995) noted a lower abundance of California halibut in the lagoon than in previous surveys. California halibut were one of the most abundant species reported by Bradshaw and Estberg (1973), and were only collected in the Inner Lagoon in their survey. Studies by Kramer (1990) demonstrated the importance of the Middle and Inner lagoons as nursery habitat for California halibut.

Table 3-5
Mean Density per m^2 and Percent Composition Of Fish Species Collected In Aqua Hedionda Lagoon During Two Surveys By Benthic Trawl, Beach Seine, And Otter Trawl

Species	Common Name	AHL Mean	Percent
Gobiidae (< 25 mm)	gobies (< 25 mm)	0.550	31.54
Atherinopsidae (< 25 mm)	silversides (< 25 mm)	0.520	29.80
Atherinops affinis	topsmelt	0.325	18.64
Gobiidae	goby, unid.	0.076	4.33
Acanthogobius flavimanus	yellowfin goby	0.050	2.87
Hypsopsetta guttulata	diamond turbot	0.040	2.30
Clevlandia ios	arrow goby	0.037	2.15
Quietula y-cauda	shadow goby	0.021	1.21
Fundulus parvipinnis	California killifish	0.019	1.06
Cymatogaster aggregata	shiner surfperch	0.013	0.75
Syngnathus sp.	pipefish, unid.	0.013	0.75
Heterostichus rostratus	giant kelpfish	0.013	0.74
Paralichthys californicus	California halibut	0.012	0.70
Gillichthys mirabilis	longjaw mudsucker	0.012	0.67
Leptocottus armatus	staghorn sculpin	0.010	0.54
Paralabrax maculatofasciatus	spotted sandbass	0.009	0.52
Syngnathus auliscus	barred pipefish	0.005	0.28
Engraulis mordax	northern anchovy	0.005	0.27
Hypsoblennius gentilis	bay blenny	0.004	0.22
Ilypnus gilberti	cheekspot goby	0.004	0.20
Syngnathus leptorhynchus	bay pipefish	0.003	0.19
Seriphus politus	queenfish	0.003	0.17
Anchoa compressa	deepbody anchovy	0.002	0.10
Mustelus californicus	grey smoothhound shark	*	
Gymnura marmorata	California butterfly ray	*	
Paralabrax clathratus	kelp bass	*	
Micropterus dolomieui	small mouth bass	*	
Umbrina roncador	yellowfin croaker	*	
Sphyraena argentea	California barracuda	*	
Citharichthys stigmaeus	speckled sanddab	*	

Table 3-5 (Continued)
Mean Density per m^2 and Percent Composition Of Fish Species Collected In Aqua Hedionda Lagoon During Two Surveys By Benthic Trawl, Beach Seine, And Otter Trawl.

Species	Common Name	AHL Mean	Percent
Pleuronichthys ritteri	spotted turbot	*	
Symphurus atricauda	California tonguefish	*	

**Indicates species with no quantitative summary data included in report (from MEC 1995, Table 3.5).*
M^2 = 10.76 feet^2

Tidewater gobies (*Eucyclogobius newberryi*) were collected from AHL historically, but were not found in the 1994–1995 sampling. It is thought that the dredging and opening of the lagoon to higher saline marine waters in the 1950s significantly affected the tidewater goby population, which is adapted to primarily brackish water conditions.

A total of 143 macroinvertebrate taxa were collected with beam trawls in AHL during the MEC study. Very few of these taxa would be susceptible to impingement from EPS because of their primarily benthic habitat requirements. The most abundant taxa included the cockle (*Laevicardium substriatum*), a non-native mussel (*Musculista senhousi*); bubble snails (*Acteocina inculta, Bulla gouldiana, Haminaea vesicular*), mud dwelling snails, and several species of small crustaceans including amphipods, isopods, mysids, and shrimps. Differences in abundance of several taxa among the three lagoon segments was noted in the sampling and was attributed mainly to predominantly coarser sediments in the Outer Lagoon and finer sediments in the eastern inner portion of the Inner Lagoon.

A total 76 infaunal taxa was collected using a small coring apparatus with the sediments sieved through a 0.04 inches mesh screen. It was concluded that benthic infaunal populations were generally more diverse and abundant in the eelgrass beds than in non-vegetated sediments or in areas where currents deposited littoral sands.

Speckled scallop, *Argopecten circularis*, is a protected species that was known to occur in AHL. Only one individual was collected by MEC during the 1994-95 studies. The species had been studied previously by the California Department of Fish and Game (CDF&G) at AHL from March 1984 to October 1986 to obtain basic life history data (Haaker et al. 1988). Monthly samples of scallops were collected, measured, and released to obtain length frequency data for estimates of growth, life span, and spawning period. In 1984 large concentrations of speckled scallops were found on the sand-silt bottom of the lagoon, closely associated with eelgrass. During the course of the study the numbers of scallops declined, until their virtual disappearance at the end of 1986. Monthly length frequency plots from 24,375 scallop measurements indicate that this is a rapidly growing species with a short life span.

Special studies were done in conjunction with the new IM&E studies done in 2004 and 2005 to supplement the information on fishes provided in the MEC report. The MEC studies did not include sampling of mudflats in the Inner Lagoon and rocky habitat in the Outer Lagoon. The fishes in these two habitats produce large numbers of larvae at risk to entrainment. The data from these studies will be combined with data from the MEC study to provide more accurate estimates of the populations of fishes in the lagoon that will help provide some context for the estimates of EPS entrainment.

4.0 Agency Consultations

As required by the EPA 316(b) Phase II regulation [40 CFR 125.95 (b)(1)(iii)], a summary of any past and ongoing consultations with federal and state Fish and Wildlife Agencies relevant to the development of the PIC for this facility is presented in this section. All communications related to the IM&E issues at the EPS have been conducted through the SDRWQCB with federal and state resource agencies providing input on the IM&E studies as described below.

IM&E studies at EPS were started in June 2004 prior to the publication of the new Phase II rules to take advantage of entrainment sampling that was being done as part of the permitting for a desalination facility planned for construction on the EPS property. A plan for IM&E studies that directly addressed the requirements of 316(b) under the new Phase II rule was submitted to the San Diego Regional Water Quality Control Board on September 2, 2004. The IM&E study plan was submitted as a first step in the facility's compliance with the new Phase II rule. The study plan was reviewed by the Board staff and their consultants, Tetra Tech Inc., and was approved contingent on certain comments and questions that did not affect the sampling procedures being used in the studies. A copy of the September 30, 2004 Tetra Tech review of the study is included as in Attachment B. A copy of the EPS response to the Tetra Tech comments, dated January 10, 2005 is included in Attachment B.

One of the recommendations of the Tetra Tech review was that the SDRWQCB staff and other resource agencies be involved in approving certain aspects of the study including the selection of the target organism that would be used in the final assessment of cooling water system effects. In response to these comments a Technical Advisory Group (TAG) was formed to provide guidance on the IM&E studies. The TAG consists of staff from the SDRWQCB, the National Marine Fisheries Service, the CDF&G, the EPS and their consultants, Tenera Environmental and Dr. Scott Jenkins, an oceanographer from the University of California, San Diego Scripps Institute of Oceanography. The functions of the TAG included the following:

- providing input and review on selection of target organisms for assessment;
- providing input and review on the definition of the source water for entrainment assessment modeling;
- providing input on special studies and other data sources that may be available for assessing source water populations; and
- providing review on reports.

The SDRWQCB and resource agencies' staff participated in three TAG meetings in March, June and in September of 2005. Details on discussion topics of PICs and conclusions from each meeting are presented in Table 4-1. Based on preliminary analyses of the IM&E data, a suite of target fishes and shellfishes for detailed analysis in the IM&E Characterization Study Final Report were selected by the TAG at the September 2005 meeting.

On January 6, 2005, EPS submitted a letter to the SDRWQCB requesting a schedule for submittal of information required to comply with the EPA 316(b) Phase II rule. The letter requested a schedule for submittal of the PIC on April 1, 2006 and for submittal of the CDS on January 7, 2008. A copy of the subject correspondence is included in Attachment B.

Table 4-1
Technical Advisory Group Meetings Held on Impingement Mortality and Entrainment Studies at EPS

Date	Attendees	Discussion Topics	Conclusions
March 14, 2005	Tim Hemig, Sheila Henika - EPS John Steinbeck, David Mayer - Tenera John Phillips, Peter Michael - SDRWQCB Bob Hoffman - NMFS Bill Paznokas - CDF&G	Discussion of study design, assessment models, and methods for defining the source water for the study. Description of special studies on fishes of Agua Hedionda Lagoon that will help fill in data gaps from previous studies.	Agency representatives agreed with the sampling design since it follows the same model used for the South Bay Power Plant and Huntington Beach Generating Station studies.
June 13, 2005	Tim Hemig, Sheila Henika - EPS John Steinbeck, David Mayer - Tenera John Phillips, Paul Richter - SDRWQCB Bob Hoffman - NMFS Bill Paznokas - CDF&G Scott Jenkins - Scripps	Updates on impingement and entrainment sampling, and special studies. Presentation of population model for source water target organisms that accounts for the reduced residency time in Agua Hedionda Lagoon which limits the period of time that larvae are exposed to entrainment.	Agency representatives agreed with the need for more complicated population model and approach used for special studies
Sept. 29, 2005	Tim Hemig, Sheila Henika - EPS John Steinbeck, David Mayer, John Hedgepeth - Tenera Charles Cheng - SDRWQCB Bob Hoffman - NMFS Bill Paznokas - CDF&G Scott Jenkins - Scripps	Presentation of preliminary impingement and entrainment sampling results and recommendations for target organisms that will be analyzed in final report. Presentation of results from studies on the hydrodynamics of AH Lagoon and the use of the results in assessment models.	Agreement on target organisms that will be analyzed in detail for cooling water system effects in the final report.

5.0 Evaluation of Intake Technology Alternatives

The EPA Phase II 316(b) regulation requires in 40 CFR 125.95(b)(1(i) that the PIC include a description of technologies which will be evaluated further to determine feasibility of implementation and effectiveness in meeting IM&E performance standards at the facility. The EPS CWIS, being located on a tidal/estuarine waterbody, must meet the performance standards for reduction in both IM&E.

A preliminary screening of technologies has been conducted to determine which alternatives offer the greatest potential for application at the EPS facility and therefore warrant further evaluation. Technologies have been screened based upon feasibility for implementation at the facility, biological effectiveness (i.e. ability to achieve reductions in both IM&E), and cost of implementation (including capital, installation, and annual operations and maintenance costs). Table 5-1 includes a list of technologies for which a preliminary screening was conducted.

Table 5-1
Fish Protection Technologies

Technology	Fish Protection Potential	
	Impingement Mortality	Entrainment
Modified traveling screens with fish return	Yes	No
Replacement of existing traveling screens with fine mesh screens	Yes	Yes
New fine mesh screening structure	Yes	Yes
Cylindrical wedge-wire screens – fine slot width	Yes	Yes
Fish barrier net	Yes	No
Aquatic filter barrier (e.g. Gunderboom)	Yes	Yes
Fine mesh dual flow screens	Yes	Yes
Modular inclined screens	Yes	No
Angled screen system – fine mesh	Yes	Yes
Behavior barriers (e.g. light, sound, bubble curtain)	Maybe	No

In a cursory analysis of the industry costs of implementing the new 316(b) Performance Rule, the EPA has selected retrofit of Fish Screens and a Fish Handling and Return Systems as an applicable technology for the EPS intake system.

The technologies selected for further consideration, which address both impingement and entrainment, as well as those determined not to warrant further consideration are discussed below.

5.1 Technologies Selected For Further Evaluation

A technology, which may be feasible for achieving performance standards, in whole or in part, for reduction in IM&E will be evaluated on the basis of the following:

- Ability to achieve required reductions in both IM&E for all species, taking into account variations in abundance of all life stages;
- Feasibility of implementation at the facility;
- Cost of implementation (including installed costs and annual O&M costs); and
- Impact upon facility operations.

The evaluation will involve the following:

- Comprehensive review of facility CWIS design and operation;
- Engineering design of proposed CWIS upgrades and/or equipment replacements;
- Development of design drawings;
- Analysis of capital and installation costs; and
- Assessment of level of IM&E reductions expected.

After reviewing the site conditions, the following design and construction technologies were selected for further evaluation for the feasibility of implementation to meet, in whole or in part, IM&E reduction standards:

- Modified traveling screens with fish return
- New fine mesh screening structure

5.1.1 Fish Screens, Fish Handling, and Return Systems

Traveling screens that are modified to enhance fish survival are designed with the latest fish removal features, including the Fletcher type buckets on the screen baskets, dual pressure spray systems (low pressure to remove fish, and high pressure to remove remaining debris), and separate sluicing systems for discarding trash and returning the impinged fish back to the water body. Impingement survival may be improved with the use of continuously operating modified traveling water screens. A fish return system is required as part of this system to transport fish washed from the screens alive back to the water body to a location where they would not be subject to re-entrainment into the intake.

Installation of modified Ristroph traveling screens at the EPS CWIS would consist of replacing the existing traveling water screens within the tunnel system with the screens as described above. A fish return system would be installed to return fish collected on the traveling water screens to the lagoon. The replacement screens would be equipped with the same 3/8 inch mesh size as the existing traveling screens.

The feasibility of replacing the existing traveling screens at the EPS CWIS with modified Ristroph traveling screens with conventional 3/8 inch mesh, fish handling and fish return systems will be evaluated. The evaluation will include an assessment of the additional reduction in IM that may be expected through implementation of this technology. Additionally, the feasibility of transporting the collected fish back to a location that would be an appropriate habitat and not result in likely re-entrainment into the intake will be assessed.

5.1.2 New Fine Mesh Screening Structure

Fine mesh traveling water screens have been tested and found to retain and collect fish larvae alive with some success. Fine mesh traveling water screens have been installed at a few large-scale steam electric cooling intakes including marine applications at Big Bend Station in Tampa, Florida (EPRI, 1986), and at an operating nuclear generating station at Prairie Island on the Mississippi River (Kuhl, 1988). Results from field studies of fine-mesh traveling water screens generally show higher survival at lower approach velocities and with shorter impingement duration (EPRI, 1986). In addition, many regulatory agencies have in the past adopted an expectation that traveling water screen approach velocities should be 0.5 feet per second (fps) or less. The National Pollutant Discharge Elimination System - Final Regulations to Establish Requirements for Cooling Water Intake Structures at Phase II Facilities in Section VII A states a maximum through screen design intake velocity of 0.5 fps as the acceptable design standard. This would require a screen approach velocity of 0.25 fps or less depending on the percent open area of the screen mesh used.

Application of fine mesh traveling water screen technology for EPS would likely require a complete new screen structure constructed at the south shore of the lagoon, including both trash racks and fine mesh traveling screen systems and fish collection and return systems; and would replace the existing trash rack structure with a much larger screening structure. It appears that there may be adequate space at the shore for a new fine mesh screen structure, but additional evaluation is still necessary. The approach velocities to the existing traveling screens, as discussed in subsection 2.3 above, are currently well above 0.5 fps and adding sufficient additional screens to the intake tunnel system to reduce approach velocities to 0.5 fps or less would require major modifications to the tunnel system, which may not be feasible. Additionally, an appropriate and suitable location to return collected fish, shellfish, and their eggs and larvae would have to be identified, as well as an assessment of the feasibility of constructing such a return system.

Design layouts and cost estimates for implementation and operation and maintenance will be developed for the above described fine mesh screen structure, as part of the CDS evaluation.

5.2 Technologies Considered Infeasible and Eliminated From Further Evaluation

5.2.1 Replacement of Existing Traveling Screens with Fine Mesh Screens

As discussed above in section 5.1.2, simple replacement of the existing traveling screens in the tunnel system with fine mesh Ristroph screens is not feasible due to high screen approach velocities. Therefore, further evaluation of this technology for implementation at the EPS CWIS will not be conducted.

5.2.2 Cylindrical Wedge-Wire Screens – Fine Slot Width

Wedge-wire screens are passive intake systems, which operate on the principle of achieving very low approach velocities at the screening media. Wedge-wire screens installed with small slot openings may enable a facility to meet performance standards for both IM&E. The wedge-wire screen is an EPA-approved technology for compliance with the EPA 316(b) Phase II rule provided the following conditions exist:

- The cooling water intake structure is located in a freshwater river or stream;
- The cooling water intake structure is situated such that sufficient ambient counter currents exist to promote cleaning of the screen face;
- The through screen design intake velocity is 0.5 fps or less;
- The slot size is appropriate for the size of eggs, larvae, and juveniles of any fish and shellfish to be protected at the site; and
- The entire main condenser cooling water flow is directed through the technology.

Wedge-wire screens are designed to be placed in a water body where significant prevailing ambient cross flow current velocities (≥ 1 fps) exist. This cross flow allows organisms that would otherwise be impinged on the wedge-wire intake to be carried away with the flow. An integral part of a typical wedge-wire screen system is an air burst back-flush system, which directs a charge of compressed air to each screen unit to blow off debris and impinged organisms back into the water body where they would be carried away from the screen unit by the ambient cross flow currents.

The EPS CWIS, located on the tidal AHL would not meet the first two EPA criteria discussed above. The intake is not located on a freshwater river and there are not sufficient ambient crosscurrents in the lagoon to sweep organisms and debris away from the screen units. Debris and organisms back-flushed from the screens would immediately re-impinge on the screens following the back-flush cycle because the principal water current in the outer lagoon would be the station intake flow toward the screen units. For these reasons, wedge-wire screen technology is not considered feasible for application at the EPS.

5.2.3 Fish Barrier Net

A fish net barrier, as it would be applied to a power station intake system, is a mesh curtain installed in the source water body in front of intake structures such that all flow to the intakes passes through the net, blocking entrance to the intake of all aquatic life forms large enough to be blocked by the net mesh. The net barrier is sized large enough to have very low approach and through net velocities to preclude impingement of juvenile fish with limited swimming ability. The mesh size must be large enough to preclude excessive fouling during normal station operation while at the same time small enough to effectively block entrainment of organisms into the intake system. These conditions typically limit the mesh size such that adult and a percentage of juvenile fish can be blocked. The mesh is not fine enough to block most larvae and eggs. The fish net barrier could potentially meet the performance requirements of the EPA Phase II Existing Facilities Rule for impingement; however, it would not meet the performance requirements for reduction of entrainment of eggs and larvae.

The fish net barrier technology is still experimental, with very few successful installations at power station intakes. Using a 20 gpm/ft^2 design loading rate, a net area of approximately 30,000 feet^2 would be required for EPS. Maintaining such a large net moored in the lagoon is not practical. In addition, the fish barrier is a passive screening device, which is subject to fouling and has no means for self-cleaning. This technology would be rapidly clogged due to fouling. The services of a diving contractor would be required to remove the net for cleaning onshore and to replace the fouled net with a clean net on each cleaning cycle. For these reasons, this technology is not practically feasible for implementation at EPS and further evaluation is not warranted.

5.2.4 Aquatic Filter Barrier

An aquatic filter barrier system, such as the Gunderboom Marine Life Exclusion System (MLES)™ (Gunderboom), is a moored water permeable barrier with fine mesh openings that is designed to prevent both impingement and entrainment of ichthyoplankton and juvenile aquatic life. An integral part of the MLES is an air-burst back flush system similar in concept to the air burst system used with wedge-wire screen systems to back flush impinged organisms and debris into the water body to be carried away by ambient cross currents.

A MLES has been installed and tested at the Lovett Station on the Hudson River. This test installation was applied to a cooling system of significantly smaller capacity than the EPS intake system and in a very different environment on the Hudson River, as opposed to the lagoon intake of the EPS.

Although the MLES has much smaller mesh openings and will block fish eggs and larvae from being entrained into the intake, these smaller organisms will be impinged permanently on the barrier due to the lack of cross currents to carry them away. This system therefore offers no significant advantage over other technologies such as the fish net barrier concept and would offer no biological improvement over the barrier net design. For these reasons, this technology is not practically feasible for implementation at EPS and further evaluation is not warranted.

5.2.5 Fine Mesh Dual Flow Screens

A modified dual flow traveling water screen is similar to the through flow design, but the screen would be turned 90 degrees so that its two faces would be parallel to the incoming water flow. When equipped with fine mesh screening media, the average 0.5 fps approach velocity to the screen face would have to be met by the dual flow screen design. Water flow enters the dual flow screen through both the ascending and the descending screen faces, and then flows out between the two faces. All of the fish handling features of the Ristroph screen design would be incorporated in the dual flow screen design. However, the dual flow screen configuration has been shown to produce low survival rates for fish larvae. This is because of the longer impingement time endured by organisms impinged on the descending face of the screen. This longer impingement time is suspected to result in higher mortality rates than similar fine mesh screens with a flow through screen design.

The primary advantage of this screen configuration is the elimination of debris carryover into the circulating water system. Also, because both ascending and descending screen faces are utilized, there is greater screening area available for a given screen width than with the conventional through-flow configuration. However, the flow pattern and therefore the velocity distribution along the screen face is not uniform and is concentrated toward the back or downstream end of the screen. The dual flow screen can also create adverse flow conditions in the approach flow to the circulating water pumps. The flow exiting the dual flow screens is turbulent with an exit velocity of greater than 3 fps. Modifications to the pump bays downstream of the screens, usually in the form of baffles to break up and laterally distribute the concentrated flow prior to reaching the circulating water pumps, are usually required. This would not be the case for EPS if a new fine mesh dual flow screen structure were constructed at the lagoon, similar to the through flow fine mesh screen structure discussed in Section 5.1 above.

For similar reasons, as discussed above for through flow fine mesh screens, implementation of this technology to the EPS CWIS would require an entirely new screen structure similar to the fine mesh through flow screen structure discussed in Section 5.1 above. The dual flow fine mesh screen configuration offers no advantages in terms reduction of impingement and entrainment mortality as compared to through flow fine mesh traveling screens discussed above and in fact would probably not perform as well as the through flow design. The design concept for the dual flow screen structure would be similar to the through flow fine mesh screen structure with trash racks, coarse mesh traveling screens and fine mesh traveling screens in each screen train. The implementation cost and operation and maintenance costs for this facility would be of the same order of magnitude as for the through flow screen structure. Dual flow screen technology does not offer a significant performance or cost advantage as compared with through flow screen technology. Therefore, further evaluation of this technology for the EPS is not warranted.

5.2.6 Modular Inclined Screens

Modular Inclined Screen (MIS) is a fish protection technology for water intakes developed and tested by the Electric Power Research Institute (EPRI) (Amaral, 1994). This technology was developed specifically to bypass fish around turbines at hydro-electric stations. The MIS is a modular design including an inclined section of wedge-wire screen mounted on a pivot shaft and enclosed within a modular structure. The pivot shaft enables the screen to be tilted to back-flush debris from the screen. The screen is enclosed within a self-contained module, designed to provide a uniform velocity distribution along the length of the screen surface. Transition guide walls taper in along the downstream third of the screen, which guide fish to a bypass flume. A full size prototype module would be capable of screening up to 800 cfs (360,000 gpm) at an approach velocity of 10 fps.

The MIS design underwent hydraulic model studies and biological effectiveness testing at Alden Research Laboratory to refine the hydraulic design and test its capability to divert fish alive. Eleven species of freshwater fish were tested including Atlantic salmon smolt, coho salmon, Chinook salmon, brown trout, rainbow trout, blueback herring, American shad and others. After some refinements in the design were made during this testing, the results showed that most of these species and sizes of fish can be safely diverted (Amaral, 1994).

Following laboratory testing the MIS design was field tested at the Green Island Hydroelectric Project on the Hudson River in New York in the fall of 1995 (Shires, 1996). In addition to the MIS, the effectiveness of a strobe light system was also studied to determine its ability to divert blueback herring from the river to the MIS. Results for rainbow trout, golden shiner and blueback herring, which were released directly into the MIS module were similar to the laboratory test results in terms of fish survivability. The limited amount of naturally entrained blueback herring did not allow reliable evaluation of test results (Amaral, 1994).

The MIS technology, as tested, does not address entrainment of eggs and larvae. Also, this technology has never been tested for, or installed in, a power station with a seawater intake system. Further research would be required to evaluate the efficacy of this technology for application to a seawater intake system. MIS is not a suitable and proven technology, at this time, for retrofit to the EPS intake system. Therefore, further evaluation of this technology for the EPS is not warranted.

5.2.7 Angled Screen System – Fine Mesh

Angled screens are a special application of through-flow screens where the screen faces are arranged at an angle of approximately 25 degrees to the incoming flow. The conventional through-flow screen arrangement would place the screen faces normal or 90 degrees to the incoming flow. The objective of the angled-screen arrangement is to divert fish to a fish bypass system without impinging them on the screens. Most fish would not be lifted out of the water but would be diverted back to the receiving water by screw-type centrifugal or jet pumps. Using fine screen mesh on the traveling screens minimizes entrainment, but increases potential for impingement of organisms that would have otherwise passed through the condenser.

Application of this technology would require construction of new angled screen structure at the south shore of the lagoon similar to the fine mesh screen structure discussed above in Section 5.1. The angled screen facility would not provide a significant performance advantage in terms of reducing IM&E as compared to the proposed fine mesh screen structure as presented above and would be at least as large and a significantly more complex structure. This facility would be potentially more costly to implement and maintain than the fine mesh screen facility. Therefore, further evaluation of this technology for the EPS is not warranted.

5.2.8 Behavior Barriers

A behavioral barrier relies on avoidance or attraction responses of the target aquatic organisms to a specific stimulus to reduce the potential of entrainment or impingement. Most of the stimuli tested to date are intended to repulse the organism from the vicinity of the intake structure. Nearly all the behavioral barrier technologies are considered to be experimental or limited in effectiveness to a single target species. There are a large number of behavioral barriers that have been evaluated at other sites, and representative examples these are discussed separately below.

Offshore Intake Velocity Cap – This is a behavioral technology associated with a submerged offshore intake structure(s). The velocity cap redirects the area of water withdrawal for an offshore intake located at the bottom of the water body. The cap limits the vertical extent of the offshore intake area of withdrawal and avoids water withdrawals from the typically more productive aquatic habitat closer to the surface of the water body.

This technology operates by redirecting the water withdrawal laterally from the intake(rather than vertically from an intake on the bottom), and as a result, water entering the intake is accelerated laterally and more likely to provide horizontal velocity cues that allow fish to respond and move away from the intake. Potentially entrainable fish are able to identify these changes in water velocity as a result of their lateral line sensory system and are able to respond and actively avoid the highest velocity areas near the mouth of the intake structure.

This technology reduces impingement of fish by stimulating a behavioral response. The technology does not necessarily reduce entrainment, except when the redirected withdrawal takes water from closer to the bottom of the water body and where that location has lower plankton abundance.

Application of this technology to the EPS CWIS, to be fully effective, would require development of an entirely new intake system with a submerged intake structure and connecting intake conduit system installed out into the Pacific Ocean similar to the offshore intake system at the El Segundo Generating Station (Weight, 1958). This is not a practically feasible consideration for the EPS. Also, this technology would probably not be capable of meeting the performance requirements of the EPA Phase II Existing Facilities Rule for reduction of entrainment of larvae, eggs and plankton. Therefore, this technology is not potentially applicable for the EPS CWIS and further evaluation of this technology is not warranted.

Air Bubble Curtain – Air bubble curtains have been tested alone and in combination with strobe lights to elicit and avoidance response in fish that might otherwise be drawn into the cooling water intake. Generally, results of testing the bubble curtain have been poor (EPRI, 1986). Tests have been conducted with smelt, alewife, striped bass, white perch, menhaden, spot, gizzard shad, crappie, freshwater drum, carp, yellow perch, and walleye. Many species exhibited some avoidance response to the air bubble or the combination air bubble and light combination. However, there has been little if no testing of species common to the AHL.

This technology has some potential to enhance fish avoidance response in some species of fish. However, there is no reliable data for the species that are subject to impingement at the EPS and no way to estimate what type of reaction fish would have to the existing intake with the addition of a bubble curtain. Unless some type of testing were conducted, this technology does not appear suitable for the EPS. As a result, there is no basis to recommend an air curtain as an enhancement to reduce impingement or entrainment at the EPS CWIS. Therefore, further evaluation of this technology for the EPS is not warranted.

Strobe Lights – There has been a great deal of research with this stimulus over the last 15 years to guide fish away from intake structures. The Electric Power Research Institute has co-funded a series of research projects (EPRI 1988, EPRI 1990, EPRI 1992) and reviewed the results of research in this field by others (EPRI 1986, EPRI 1999). In both laboratory studies and field applications strobe lights were shown to effectively move selected species of fish away from the flashing lights. Most of the studies conducted to date have been with riverine fish species and for projects associated with hydroelectric generating facilities. One early study was conducted at the Roseton Generating Facility on the Hudson River in New York, another study was conducted on Lake Cayuga in New York, and others for migratory stages of Atlantic and Pacific salmon. Few species similar to those occurring in the AHL have been tested for avoidance response either in the lab or in actual field studies.

Laboratory testing was done for an application of strobe lights for the San Onofre Nuclear Generating Facility. Testing was conducted for white croaker, Pacific sardine and northern anchovy. Limited availability of test specimens and limited testing demonstrated no conclusive results and the California Coastal Commission (2000) found this device not useful at this station.

Before strobe lights could be seriously considered for use at the EPS CWIS, a series of lab and or field studies on their effectiveness for the species most likely to be entrained into the EPS CWIS would need to be completed. Based on studies of strobe lights conducted to date, it is likely that these studies would show differential effectiveness based on background light conditions (day vs. night), ambient seawater turbidity, and most likely there would also be great differences in species specific response. As a result there is no basis to recommend these strobe lights as an enhancement to reduce impingement or entrainment at the EPS CWIS. Therefore, further evaluation of this technology for the EPS is not warranted.

Other Lighting – Incandescent and mercury vapor lights have also been tested as a behavioral stimulus to direct fish away from an intake structure. Mercury lights have generally been tested as a means of drawing fish to a safe bypass of the intake structure as generally the light has an attractive effect on fish. Tests have not demonstrated a uniform and clearly repeatable pattern of attraction for all fish species. The mercury lights have been somewhat effective in attracting European eel, Atlantic salmon, and Pacific salmon. But results with other species including American shad, blue back herring and alewife had more variable results. One test with different life stages of Coho salmon shows both attraction and repulsion from the mercury light for the different life stages of the coho.

Testing with incandescent, sodium vapor and fluorescent lamps was more limited but also had variable and species specific results.

Other lighting systems, as with most all the behavioral barrier alternatives, have not been tested with the species of fish common in AHL. As a result, there is no basis to recommend these lights systems as an enhancement to reduce impingement or entrainment at the EPS CWIS. Therefore, further evaluation of this technology for the EPS is not warranted.

Sound – Sound has also been extensively tested in the last 15 years as a method to alter fish impingement rates at water intake structures. Three basic groups of sound systems including percussion devices (hammer, or poppers), transducers with a wide range of frequency output, and low frequency or infrasound generators, have all been tested on a variety of fish species.

Of all the recently studied behavioral devices the sound technology has demonstrated some clear success with at least one group of fish species. Clupeids, such as alewife, demonstrate a clear repulsion to a specific range of high frequency sound. A device has been installed in the Fitzpatrick Nuclear Generating station on Lake Ontario in New York State, which has been effective in reducing impingement of landlocked alewives. The results were repeated with alewife at a coastal site in New Jersey. Similar results with a high frequency generator also reported a strong avoidance response for another clupeid species, the blue back herring, in a reservoir in South Carolina. Testing of this high frequency device on many other species including weakfish, spot, Atlantic croaker, bay anchovy, American shad, blue back herring, alewife, white perch, and striped bass only demonstrated a similar and strong avoidance response by American shad and blue back herring.

Alewife and sockeye salmon have also been reported to be repelled by a hammer percussion device at another facility. But testing of this same device at other facilities with alewife did not yield similar results.

Although high frequency sound has potential for eliciting an avoidance response by the Alosid family of fish species, there is no data to demonstrate a clear avoidance response for the species of fish common to the AHL. Therefore there is no basis to recommend sound as a method to reduce impingement of fish at the EPS CWIS. Therefore, further evaluation of this technology for the EPS is not warranted.

6.0 Evaluation of Operational Measures

The EPA 316(b) Phase II regulation [40 CFR 125.95(b)(1)(i)] requires that the PIC should include a description of operational measures which will be evaluated further to determine feasibility of implementation and effectiveness in meeting IM&E performance standards at the facility. A preliminary screening of such measures has been conducted to determine those which offer the greatest potential for application at the facility and therefore warrant further evaluation. Operational measures have been screened based upon feasibility for implementation at the facility, biological effectiveness (i.e. ability to achieve reductions in IM&E), and cost of implementation (including additional power requirements and loss in generating capacity and unit availability).

Several operational measures have been proven effective in reducing IM&E at CWIS. Such measures include:

- CWIS flow reductions (e.g. capping capacity utilization rate)
- Variable speed drives for CWIS pumps
- Other cooling water efficiency improvements

The following is a discussion of operational measures for which further evaluation will be conducted in the CDS to determine their potential for reducing IM&E at EPS. The results of the evaluation of such measures will be utilized to develop the plan for implementation of technologies, operational and/or restoration measures that will be proposed to achieve IM&E performance standards at the facility. Upon selection of the most appropriate operational measures, engineering design calculations and drawings, as well as estimates of expected reductions in IM&E and a schedule for implementation will be developed. This information will become part of the Design and Construction Technology Plan (DCTP) (or Site-Specific Technology Plan in the event that the facility chooses to seek a site-specific determination of BTA) and Technology Installation and Operation Plan (TIOP) that will be included in the CDS to be submitted for the facility. The DCTP explains the intake technologies or operational measures selected for use at EPS to meet the E&I performance standards for the Phase II Rule. The compliance with the performance standards will be measured and monitored through documentation of the TIOP.

6.1 Circulating Water Flow Reduction / Caps

Circulating water flow caps are an operational control measure which would include administratively limiting the total withdrawal of cooling water from the AHL to an agreed upon value. The flow reductions may be scheduled for periods of the year when entrainment or impingement are highest to achieve a greater reduction to impingement and entrainment. Any reduction in flow reduces both entrainment and impingement effects associated with the operation of the plant. If flow reductions are concentrated during the seasons of the year that plankton life stages of species of concern are present, the overall seasonal reductions in fisheries impacts can greatly exceed the quantity of the flow reduction. Utilizing variable speed drive technology on the circulating water pumps could be an effective means of controlling total annual flow withdrawal.

6.2 Variable Speed Drives For Circulating Water Pumps

Variable-speed drives for circulating water pumps allow reduction in cooling water flow during periods when the unit is not operating at full-rated capacity, or during known periods of high entrainment. With this technology it would be possible to vary the speed of the motor from 10% to 100% and reduce the cooling water intake flow by up to 90%. Any reduction in flow reduces both entrainment and impingement effects associated with the operation of the plant. The lower pumping capacity allows for a lower approach velocity at the traveling screens and reduces the number of entrainable organisms drawn into the cooling water system. In addition, if flow reductions are concentrated during the seasons of the year that plankton life stages of species of concern are present, the overall seasonal reductions in fisheries impacts can greatly exceed the quantity of the flow reduction. The installation of variable speed drives will be evaluated further to determine the effectiveness in reducing IM&E at the EPS CWIS.

6.3 Heat Treatment Operational Changes

Potential operational and procedural enhancements to reduce impingement during heat treatment events will also be evaluated. In the CDS, EPS will evaluate a couple of alternative biofouling control measures that might reduce the number, or eliminate the need for, heat treatments in the intake tunnels. In addition, EPS will also evaluate a couple of modifications of the existing heat treatment procedures that might reduce the numbers of fish impinged during these events, but still provide effective heat treatment removal of fouling organisms in the intake and intake tunnels.

7.0 Evaluation of Restoration Alternatives

The EPA Phase II 316(b) regulation [40 CFR 125.95(b)(1)(i)] allows the consideration of restoration measures as one of the options that may be implemented, either alone or in combination with technology and/or operational measures, to achieve performance standards for reduction in IM&E losses. Facilities may propose restoration measures that will result in increases in the numbers of fishes and shellfishes in the waterbody that would be similar to those achieved with meeting performance standards through the implementation of technologies and/or operational measures. EPS will conduct an evaluation of potential restoration measures that may be implemented in the event that it is determined that meeting performance standards through the implementation of technologies and/or operational measures alone is less feasible, less cost-effective, or less environmentally desirable than use of restoration measures.

7.1 Potential Restoration Measures

This section introduces the type of habitat restoration projects that could potentially be used to offset IM&E losses at EPS. The offsets that will later be calculated for each project will be based on a numerical comparison of IM&E losses resulting from the operation of EPS, and the expected production of equivalent adults of the affected species resulting from the restoration efforts using various habitat models.

Any specific conservation, enhancement, or restoration project that is to be used for this purpose should have a nexus (i.e. relationship between the environmental impacts and the proposed project) to the impingement and entrainment effects of the power plant. The projects that will be evaluated to offset potential EPS IM&E losses fall into three general categories:

- Projects that would directly restore or enhance habitat in AHL;
- Projects that would preserve, restore, or enhance the AHL watershed; and
- Projects that enhance the nearshore coastal environment in the vicinity of EPS Power Station.

The following is a list of some of the potential restoration measures, in each of the above categories, which will be evaluated to determine their feasibility of implementation, and potential efficacy in meeting IM&E performance standards at the EPS:

I. Restoration or Enhancement of AHL

- Invasive species removal and prevention
- Restoration of historic sediment elevations to promote reestablishment of eelgrass beds
- Enhancement of AHL State Reserve
- Marine fish hatchery enhancement
- Community outreach soliciting public agency and landowner participation

II. Restoration or Enhancement of Agua Hedionda Watershed

- Erosion control projects along upland watercourses
- Construction of catchment basins, swales, and other sediment containment features
- Land acquisition for purposes of creating conservation easements
- Minimizing runoff from development activities
- Restoration of floodplain habitat
- Invasive species removal and prevention

III. Restoration or Enhancement of Nearshore Coastal Areas

- Marine fish hatchery stocking program
- Artificial reef development
- Marine Protected Area establishment
- Kelp bed enhancement

The "value" of the ecological services or benefits that will result from implementation of any of these restoration projects will be assessed using various habitat models to demonstrate that the ecological "credits" gained through restoration will outweigh the ecological "debits" caused by the IM&E losses. A preliminary screening of these potential restoration measures will be conducted to determine which projects warrant further evaluation. Selected projects will be evaluated further based upon the criteria described below.

7.2 Project Selection Criteria

A set of restoration project selection criteria has been developed to aid in the evaluation of potential projects. The project selection criteria include:

- Location
- Nexus to EPS IM&E effects
- Basic need or justification for project
- Nature and extent of ecological benefits
- Stakeholder acceptance
- Consistency with ongoing resource agency work and environmental planning

- Administrative considerations
- Implementation costs
- Cost effectiveness
- Ability to measure performance
- Success of comparable projects
- Length of time before benefits accrue
- Technical feasibility
- Opportunities for leveraging of funds/availability of matching funds
- Legal requirements (e.g., permits, access)
- Likely duration of benefits

Depending on the nature of a particular project, the relative importance and weighting of these criteria may vary. As a general proposition, however, projects will be selected so as to maximize the ecological benefits to AHL and adjacent nearshore areas. This process will ensure that the most effective projects are assigned the highest priority.

8.0 Other Compliance Options for EPS

Two additional compliance alternatives that EPS may pursue in the course of developing the most appropriate CDS for the EPS CWIS include a site-specific determination of BTA and a trading approach for cooperative restoration solutions. The site-specific determination option would be undertaken if the implementation of some combination of an intake technology, operation change or restoration is significantly greater in cost than that estimated by US EPA or the costs are significantly greater than the benefits of such measures. The trading program compliance alternative would involve EPS teaming with other water users in the area to develop a more comprehensive solution to reduce or mitigate for IM&E with a cooperatively funded technology or restoration alternative. EPS has no specific plans and has not developed potential teaming partners to pursue this compliance alternative at this time. However, EPS will remain open to exploring this compliance alternative if the right opportunity is identified prior to submittal of the CDS.

8.1 Site-Specific Determination of BTA

The intent of the EPS approach to compliance is to meet the entrainment and impingement performance standards established by the EPA when the new rule was promulgated. That is, EPS hopes to demonstrate that the EPS intake has reduced the effects of entrainment by 60 to 90% and reduced the effects of station operation on impingement mortality by 80 to 95% from the calculation baseline. However, EPS also recognizes that if the costs of reaching these goals cannot reasonably be achieved that the EPA 316(b) Phase II regulation allows a somewhat lower IM&E reduction standard. Specifically the new rule would allow EPS to demonstrate that the EPS facility is eligible for a site-specific determination of BTA to minimize IM&E and that EPS has selected, installed, and is properly operating and maintaining, or will install and properly operate and maintain, design and construction technologies, operational measures, and/or restoration measures that the Director has determined to be the BTA to minimize adverse environmental impact of the EPS cooling water operations.

This compliance alternative allows the EPS facility to request a site-specific determination of BTA for minimizing IM&E if EPS can demonstrate that the costs for compliance with the new rule are significantly greater than those considered by EPA in the development of the rule (cost/cost test) or that the costs associated with compliance are significantly greater than the benefits (cost/benefit test) that would accrue to the environment.

8.1.1 Cost/Cost Test

If EPS chooses to seek a site-specific determination of BTA, a cost/cost test will be performed to compare the cost of implementing options to achieve full compliance with the 316(b) Phase II standards to costs estimated by the EPA for the EPS facility for achieving full compliance. In the 316 (b) Phase II rule, the EPA has assumed that the EPS facility would add a fish handling and return system to the existing traveling water screen system. There was no expectation in that recommendation that the EPS facility would need to meet the entrainment performance standards. Therefore EPA has projected compliance capital costs for the EPS facility of $2,841,330 (Federal Register, Vol. 69 – 7/9/2004, page 41677 – see Facility ID# AUT0625). This same source cites an expected existing baseline O&M annual cost of $104,168 and a post construction O&M annual cost of $380,113 for EPS.

If pursuit of this compliance option is justified, EPS will conduct its evaluation following a three-step method, as follows:

1. Identification of feasible options for achieving full compliance (e.g. combinations of engineering, operational, and restoration actions);
2. Estimation of the dollar costs of implementing these actions (including capital, O&M, and lost generation revenue due to extended outages); and
3. Comparison of the total estimated cost of compliance based upon the compliance options identified with EPA's estimated cost of compliance for the facility in question.

One thing that has not been fully resolved by EPA is what constitutes "significant" compared to the costs that EPA projected for the EPS. EPS will develop its perspective on what constitutes significant during the development of the CDS. It is likely that significance will be judged from the perspective of the capital and operating costs and revenues from the operation of EPS.

8.1.2 Cost/Benefit Test

A cost/benefit test may also be performed for EPS to compare the total costs of achieving compliance with the environmental benefits through implementation of the required technologies, operational, and/or restoration measures. Costs are the sum of direct costs and the indirect costs of any intake, operational or restoration mitigation actions. Direct costs include the costs of implementing compliance alternatives, including capital, O&M, and lost generation revenue due to extended outages. Indirect costs include any costs associated with impairment of navigation, higher energy prices, and negative ecological effects of the mitigation actions on the waterbody. An initial phase of the cost/benefit test will identify whether any of these indirect cost elements are relevant at the EPS. The cost/benefit test would specify the nature of the relevant direct and indirect cost components at the facility.

The benefits arise from reducing IM&E by the full amount of the 316(b) Phase II rule's performance standard relative to baseline conditions. The economic benefits of reductions in IM&E have been specified by the EPA in its evaluation of the national benefits of the rule. The classes of benefits identified by EPA in its assessment include direct use benefits (e.g. those from commercial and recreational fishing), indirect use benefits (e.g. increased forage organisms), and existence, or passive use benefits (e.g. improved biodiversity). These benefits are based on standard definitions of value used by economists in cost/benefit analysis. Methods for quantifying benefits to commercial and recreational fishing and other changes in natural resources have been widely employed by environmental and natural resource economists over the past several decades.

The exact nature of the data and methods required for a cost/benefit analysis will vary depending upon the magnitude of the potential IM&E effects on a local and regional scale, the availability of existing economic benefit studies that may be applied, as well as the comments of the regulators and natural resource agencies involved with reviewing this PIC. These can vary widely and will not really be well understood until the results of the IM&E study are complete. When the IM&E study is complete, the numbers of each species affected by operation of the intake can be quantified, and then a value for each species affected by IM&E at the EPS CWIS can be developed.

The benefit studies would be undertaken using a phased approach. Following an initial scoping phase to determine the approach to conducting a cost/benefit analysis, an outline of a benefits assessment approach will be determined. EPS will develop an approach to conducting a benefits valuation for use in supporting a site-specific determination of BTA if that becomes the selected approach for meeting compliance with the new rule. The approach will address the following requirements for such a study as outlined in the Phase II rule:

1. Description of the methodologies to be used to value commercial, recreational, and other ecological benefits;
2. Documentation of the basis for any assumptions and quantitative estimates; and
3. Analysis of the effects of significant sources of uncertainty.

If restoration is a component of the compliance approach, the ability of the restoration project(s) to generate benefits to offset impingement and/or entrainment effects must be demonstrated. This requires specification of a metric that can be used to quantify restoration benefits in a manner comparable to entrainment and impingement effects in the ecosystem.

Habitat assessment methods will be used for assessing the relative value of restoration actions. The approach taken will be to:

1. Identify the key species of concern affected by the facility;
2. Identify critical factors or habitat needs for those species;
3. Identify technically feasible and cost-effective restoration actions that address such critical factors and needs factors; and
4. Choose an appropriate ecological metric for scaling effects of mitigation and/or enhancing habitat needs within the adjacent ecosystem or area.

For example, if it is determined that the restoration project needs to compensate for entrainment of a species for which spawning habitat is a limiting factor, then creation of sufficient new spawning habitat to increase the population by the amount of entrainment would be required for full compliance with the Rule. This would then translate to acreage of created habitat with certain required structural characteristics.

If entrainment losses are of key concern, and the population of associated fish is of less concern, then biomass could also serve as the metric. The present value of the entrained biomass would be computed as the ecological debit. Then, a wetland or other habitat creation project could be scaled in size to produce the equivalent present value of biomass from the primary productivity of the wetland or new habitat.

8.1.3 Evaluation of a Site-Specific BTA

The 316(b) Phase II Rule allows facilities to seek site-specific determinations of BTA if it can be demonstrated that the costs of achieving full compliance with the IM&E performance criteria at a facility are either:

1. Significantly greater than those considered by the EPA in development of the rule (cost/cost test), or
2. Significantly greater than the net environmental benefits to be achieved (cost/benefit test).

If either of these methods is implemented, EPS may propose this as the compliance approach if the costs are significantly higher than either the expected costs at the time the rule was promulgated or, for the amount of benefits that would be derived.

8.2 Trading For Cooperative Mitigation Solutions

In the preamble to the EPA 316(b) Phase II rule, as published in the Federal Register (Vol. 69, No. 131, pgs 41576 - 41693), there is a discussion of the role of trading under the rule (VII. F.2). The preamble describes how trading "...raises complex issues on how to establish appropriate units of trade and how to measure these units effectively given the dynamic nature of the populations of aquatic organisms subject to impingement mortality and entrainment." However, EPA suggests that delegated authorities responsible for implementing the 316(b) Phase II rule wishing to develop trading options "...would be best off focusing on programs based on metric of compatibility between fish and shellfish gains and losses among trading facilities.". This section of the rule also states that if the delegated NPDES authority can demonstrate to the EPA Administrator that they have adopted a NPDES program within a watershed that provides for comparable reductions in IM&E, then the EPA Administrator must approve such alternative compliance alternative requirements.

EPS may consider a watershed-approach trading program as a possible compliance alternative if the right combination of coastal water users identify mutual goals for achieving compliance, either in whole or in part, with the new rule. EPS has not developed any specific alliance of water dependent organizations to implement such a watershed-approach trading compliance alternative. However, EPS expects that after field studies have characterized CWIS effects, that restoration may be the most feasible and cost-effective measure to meet the performance standards. This might be done alone, or in combination with other intake technologies or operational modifications. However, it might well be that different technologies implemented to achieve CWIS compliance at different electric generating facilities may result in mutual benefits for the regional ecosystem. If mutual benefits of mitigation are identified among different generating facilities, then EPS would then consider establishing a trading program with other generating facilities to achieve the lowest cost, most comprehensive and effective method to comply with the new 316 b rule.

EPS will remain open to seeking comprehensive solutions to the IM&E issues in the region and develop a plan for compliance with the possible cooperation of other water users such that the issue is addressed in the most comprehensive manner for the regional ecosystem.

9.0 Impingment Mortality & Entrainment Sampling

An IM&E sampling program was conducted to characterize the fishes and shellfishes affected by impingement and entrainment by the CWIS at the EPS. The data from the study will be used in calculating baseline levels of IM&E against which compliance with performance standards will be measured. A detailed IM&E sampling plan was developed for the IM&E studies (Attachment C) and was previously submitted to the SDRWQCB in August 2004. The sampling plan was approved by the SDRWQCB and the sampling was done for one year starting in June 2004 and continued into June 2005. The report is in the final stages of preparation.

As required in 40 CFR 125.95(b)(3), the results of the IM&E sampling program will be summarized in a report submitted as part of the CDS that includes the following:

- Taxonomic identifications of all life stages of fishes, shellfishes, and any threatened or endangered species collected in the vicinity of the CWIS and are susceptible to IM&E;
- Characterization of all life stages of the target taxa in the vicinity of the CWIS and a description of the annual, seasonal, and diel variations in IM&E; and
- Documentation of the current level of IM&E of all life stages of the target taxa.

The goal of the study was to characterize the fishes and shellfishes affected by impingement and entrainment by the EPS CWIS. The studies examined losses at the EPS resulting from impingement of juvenile and adult fishes and macroinvertebrates on traveling screens during normal operations and during heat treatment operations and entrainment of ichthyoplankton and invertebrates into the cooling water intake system. The sampling methodologies and analysis techniques were derived from recent impingement and entrainment studies conducted for the AES Huntington Beach Generating Station (MBC and Tenera 2005), and the Duke Energy South Bay Power Plant (Tenera 2004). The studies at Huntington Beach were performed as part of the CEC California Environmental Quality Act (CEQA) process for permitting power plant modernization projects, while the South Bay project was for 316(b) compliance.

9.1 Assessment of Cooling Water Intake System Effects

Considerable effort among regulatory agencies and the scientific community has been expended on the evaluation of power plant intake effects over the past three decades. Power plant intake effects occur due to impingement of larger organisms onto the intake screens and entrainment of smaller organisms through the CWIS that are smaller than the screen mesh on the intake screens. For the purposes of the EPS study we assumed that both processes lead to mortality of all impinged and entrained organisms. The variety of approaches developed to assess the CWIS impacts reflects the many differences in power plant locations and resource settings (MacCall et al. 1983). The various approaches have been divided into those that offer a judgment on the presence or absence of impact and those that describe the sensitivity of populations to varying operational conditions. These efforts have helped to establish the context for the modeling approaches being used to estimate impingement and entrainment effects at the EPS.

Impact assessment approaches that will be used in the analysis of the entrainment data include:

- Adult-Equivalent Loss (*AEL*) (Horst, 1975; Goodyear, 1978);
- Fecundity Hindcasting (*FH*) proposed by Alec MacCall, NOAA/NMFS, and is related to the adult-equivalent loss approach; and
- Empirical Transport Model (ETM), which is similar to the approach described by MacCall et al. (1983), and used by Parker and DeMartini (1989).

The application of several models to estimate power plant effects is not unique (Murdoch et al. 1989; PSE&G 1993; Tenera 2000a; Tenera 2000b). Equivalent Adult Modeling (*AEL* and *FH*) is an accepted method that has been used in many 316(b) demonstrations (PSE&G 1993; Tenera 2000a; Tenera 2000b). The advantage of demographic models like *AEL* and *FH* is that they translate losses into adult fishes that are familiar units to resource managers. Estimates of entrainment losses from these demographic models can be combined with estimated losses to adult and juvenile organisms due to impingement to provide combined estimates of cooling water system effects. The U.S. Fish and Wildlife Service proposed the empirical transport model (*ETM*) to estimate mortality rates resulting from cooling water withdrawals at power plants (Boreman et al. 1978, 1981). The *ETM* estimates the conditional mortality due to entrainment while accounting for spatial and temporal variability in distribution and vulnerability of each life stage to power plant withdrawals. The *ETM* provides an estimate of power plant effects that may be less subject to inter-annual variation than demographic model estimates. It also provides an estimate of population-level effects not provided by demographic approaches. But the *ETM* calculations require information about the composition and abundance of larval organism from the source water, necessitating the collection of samples from additional stations. A description of each of these models and how they will be used to evaluate data collected in the IM&E study is included in the study plan (Attachment C).

The assessment approach used in the final report in the CDS for the EPS will also depend upon the facility's baseline calculations and its method(s) of compliance with the 316(b) Phase II performance standards for reductions in impingement mortality and entrainment. Compliance at EPS may be achieved by implementing either singly, or in combination the following: technological or operational changes to the CWIS (TIOP), restoration methods, or site-specific BTA standards. To demonstrate compliance through the TIOP it is only necessary to analyze impingement and entrainment data to determine baseline levels and assess those levels against the improvements achieved through the implementation of the TIOP. In the case where restoration is limited to only commercially or recreationally important species (use species), impingement and entrainment data may also be adequate to assess the levels of restoration necessary to offset impingement and entrainment losses, assuming that scientifically valid population models exist for the species providing the lost benefits. In assessing compliance with the performance standard in whole or in part through restoration of habitat to include non-recreational and non-commercial species (non-use species) in addition to the losses of use species it is necessary to assess the impingement and entrainment losses also from the source water using a combination of assessment methods to determine the commensurate level of restoration. The same source water and entrainment data, and assessment methods would also be used to determine a site-specific BTA standard based on cost-benefit analysis of entrainment losses to all use and non-use species. Source water data would not be necessary for cost-benefit analysis based simply on the value of use species losses.

9.2 Target Species

Analysis of CWIS effects will be done on the most abundant organisms in the samples, and commercially or recreationally important species from entrainment and impingement samples. All fishes and shellfishes during the impingement sampling were identified and up to fifty individuals of each species of fishes, crabs, shrimp, lobsters, octopus, and squid were measured and weighed. In instances where more than fifty individual of any one species were collected, the first fifty were measured and the rest were counted and then weighted as a group. All other invertebrates were recorded as present. The following marine organisms were sorted, identified and enumerated from entrainment intake and source water plankton samples:

Vertebrates:

- Fishes (all life stages beyond egg)

Invertebrates:

- Rock crab megalopal larvae (*Cancer* spp.)
- California spiny lobster phyllosoma larvae (*Panulirus interruptus*)

These groups were also analyzed in most of the recent entrainment studies in southern California, including the AES Huntington Beach Generating Station. Fishes and rock crab larvae were selected because of their respective ecological roles or commercial and/or recreational fisheries importance. The California spiny lobster was selected because of its commercial and/or recreational importance in the area.

The organisms analyzed will be limited to taxa that are sufficiently abundant to provide reasonable assessment of impacts. For the purposes of this study plan, we will limit the analysis to the most abundant taxa that comprise 90 percent of all larvae entrained and/or juveniles and adults impinged by the EPS. The most abundant organisms are used in the assessment because they provide the most robust and reliable estimates of CWIS effects. Since the most abundant organisms may not necessarily be the organisms that experience the greatest effects on the population level, the data will be examined carefully before the final selection of target species to determine if additional species should be included in the assessment. This may include commercially or recreationally important species, and species with limited habitats.

9.3 Impingement

The following is a summary of the methods used to collect impingement samples at the EPS. More complete details are included in the attached 316(b) Cooling Water Intake Effects Entrainment and Impingement Sampling Plan (Attachment C). Sampling was completed during both normal operations periods and tunnel recirculation (heat treatment) events.

Each normal operations impingement survey was conducted over a 24-hour period one day each week from mid June 2004 through mid June 2005. Prior to each survey any accumulated debris and organisms on the bar racks and traveling screens was removed and discarded. Each 24-hour survey was divided into six 4-hour cycles. The traveling screens at EPS take approximately 30-35 minutes to complete a complete rotation and washing. The traveling screens generally remained stationary for a period of about 3.5 hours and then are rotated and washed for 30-35 minutes depending on traveling screen rotation speed. All impinged material rinsed from the traveling screens was rinsed into its respective collection basket. The impinged material was removed from these baskets and all organisms removed from the debris. Due to the design of the intake traveling screens, there are three collection basket assemblies, one for Units 1-3, one for Unit 4, and one for Unit 5. All impinged material from each set of screens was processed and recorded separately. Length and weight of up to 50 individual of each taxa of impinged fishes, crabs, lobsters, shrimp, gastropods, some pelecypods, octopus, and squid were recorded. If more than 50 individuals of any taxa were impinged on any set of screens during a single cycle, this extra group was counted and its total bulk weight was determined and recorded. All other invertebrates were recorded as present when observed. The amount and general identity of the debris collected during each screen cycle was also recorded. The number of circulating water pumps in operation during each survey, obtained from operator logs was used to calculate the volume of water passing through the traveling screens during each survey. The number of screens rotated during each cycle was also recorded during the screen washing periods.

EPS conducts tunnel recirculations to control biofouling organisms growing on the intake conduits. During these events, all impinged organism washed off the traveling screens and rinsed into the collection baskets were removed from debris and identified, counted, and measured using the same procedures used during the normal operations surveys. A total of six tunnel recirculations took place during this 2004-2005 study period.

The abundance and biomass of the organisms impinged during the once per week normal operations sampling will be used to estimate the impingement for the entire year by first estimating the weekly impingement. This is done by combining the information on the impinged organisms with the total circulating water flow for the period between surveys. These weekly estimates are then combined to estimate the annual impingement rate during normal operations. All organism impinged during tunnel recirculation events are combined with those impinged during normal operations to generate an estimate of the overall annual impingement of the CWS.

9.4 Entrainment

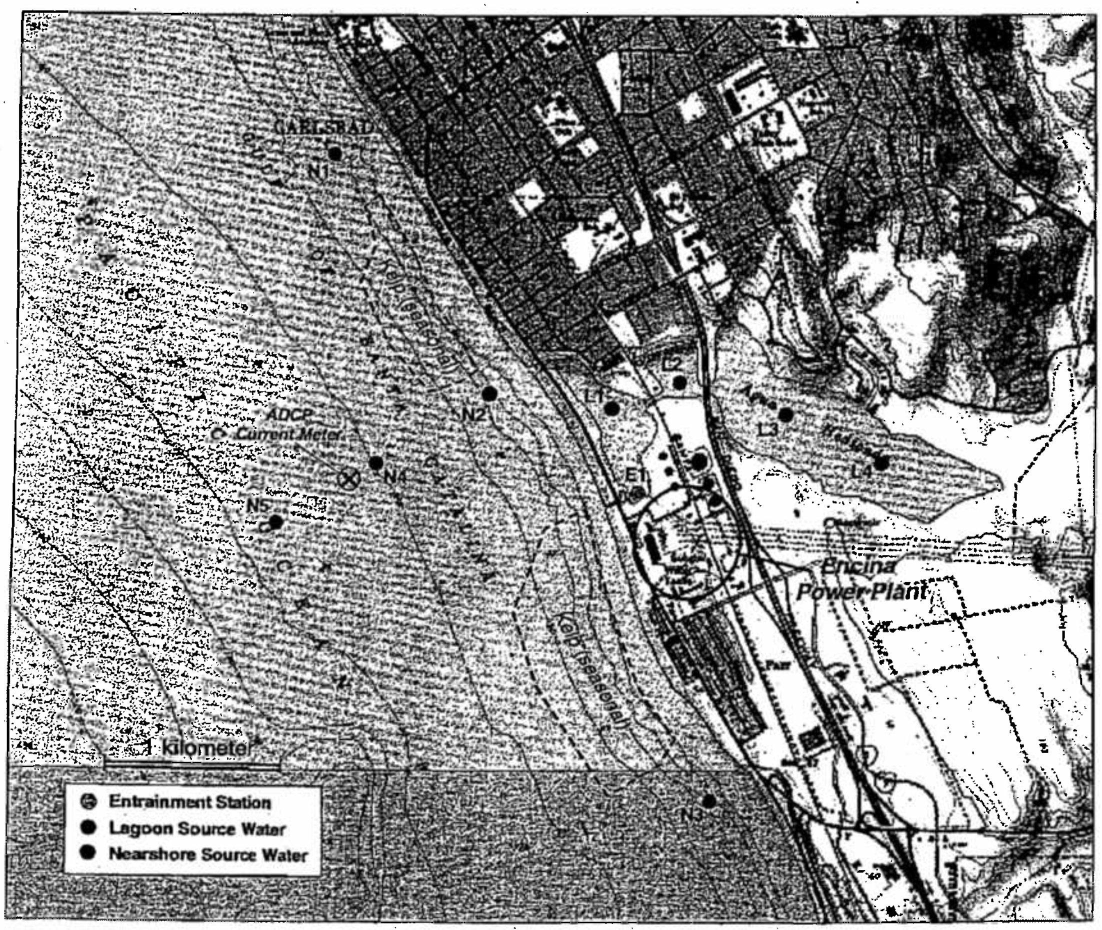
The following is a summary of the methods used to collect entrainment and source water plankton samples at the EPS. More complete details are included in the attached 316(b) Cooling Water Intake Effects Entrainment and Impingement Sampling Plan (Attachment C).

Sampling to determine the composition and abundance of larval fishes, *Cancer* spp. megalopae, and spiny lobster larvae at the EPS intake structure and in the local vicinity began in June 2004. The sampling was completed monthly thereafter, with the final sampling being completed in May 2005. Samples during each of these monthly surveys were collected over a 24-hour period, with sampling being divided into four 6-hour periods. Sampling was conducted near the intake structure to estimate larval entrainment, and at eight nearby stations in two sub-areas (~~three~~ Four stations in the AHL and five stations in the nearshore) to estimate larvae in the source water (Figure 7-1).

The samples at the entrainment location (E1), at all the nearshore stations (N#), and at the Outer Lagoon station (L1) were collected using a bongo net frame equipped with two 0.71 m (2.33 feet) diameter opening with attached 335 µm (0.013 in) mesh plankton nets and codends. Each net had a calibrated flowmeter that was used to determine the volume of water filtered during sample collection. Samples were collected by first lowering the frame and nets from the surface to as close to the bottom as practical without contacting it, and then moving the boat forward and retrieving the nets at an oblique angle. The target volume of the combined volume filter through both nets was at least 2,120 feet^3 (60 m^3). After retrieving the nets from the water, all collected material was rinsed into the codend. The collected material from both nets was placed into a labeled jar and preserved.

Due to the shallow depths in the vicinity of the Middle (L2) and Inner Lagoon (L3 and L4) stations, especially during low tides, samples at these stations were collected using a different sampling protocol. These stations are sampled using a single plankton net and frame attached to the bow of a small boat that pushes the net through the water and collects a sample from approximately the upper 1 meter of water. By placing the net on the bow of the boat, the net collects a sample from undisturbed water. The collected material was rinsed into the codend and then placed into a labeled jar and preserved.

Figure 9-1
Location of EPS Entrainment (E1) and Source Water Stations (L1 through L4, and N1 through N5).



10.0 Summary

This PIC has been prepared in accordance with 40 CFR 125.95(b)(1) and is being submitted to the SDRWQCB prior to implementation of information collection activities. The following is a brief summary of the information collection activities described in this document that will be undertaken to support the development of the CDS, the plan for compliance with IM&E performance standards outlined in the EPA 316(b) Phase II Rule.

10.1 Evaluation of IM&E Reduction Measures

The EPS has selected several intake technologies, operational measures, and restoration measures that will be evaluated to determine effectiveness and feasibility of implementation, either alone or in combination, to achieve the required reductions in IM&E. In summary, these include the following:

Intake Technologies:

- Modified traveling screens with fish return
- New fine mesh screening structure

Operational Measures:

- Circulating water flow reductions / caps
- Variable speed drives for circulating water pumps
- Heat Treatment Operational Changes

Restoration Measures:

- Restoration or Enhancement of AHL various)
- Restoration or Enhancement of Agua Hedionda Watershed (various)
- Restoration or Enhancement of Nearshore coastal projects (various)

Preliminary assessments of these IM&E reduction measures will be conducted to determine those which warrant further evaluation. A more detailed evaluation of those measures will be conducted and a combination of the most feasible measures proposed to meet IM&E performance standards will be presented in the CDS.

10.2 Impingement Mortality & Entrainment Sampling Plan

The IM&E Characterization Study Plan that was the basis for the 2004-2005 EPS IM&E Study is included in Attachment C. The study plan described the collection, analysis, and evaluation methodologies for the twelve months of impingement and entrainment sampling data at the EPS.

The following are the main components of the sampling effort:

Impingement:

1. Weekly impingement sampling at each CWIS during normal plant operations
2. Impingement sampling at the CWIS during each heat treatment cycle

Entrainment:

1. Monthly entrainment sampling at the CWIS
2. Source waterbody sampling at five near shore source water locations and four lagoon source water locations

The characterization study plan also describes the sampling, quality assurance / quality control (QA/QC), and data management procedures that will be used in the study. Results of the study will be used to:

1. Determine the current level of IM&E occurring at the CWIS.
2. Compare the level of IM&E occurring due to the location, design, and operation of each existing CWIS with that which would occur if the CWIS were designed as a "calculation baseline" intake.
3. Determine the additional level of reduction in IM&E that would be required to meet performance standards.
4. Assist in the determination of the most feasible combination of intake technologies, operational measures, and/or restoration measures that may be implemented to reduce IM&E to vulnerable species.

10.3 Agency Review of PIC

As required by the EPA 316(b) Phase II regulation, this PIC is being submitted in accordance with the schedule requested by EPS in a letter dated January 6, 2005 to the SDRWQCB. The regulation requires that the SDRWQCB *"provide their comments expeditiously (i.e. within 60 days) to allow facilities time to make response modifications in their information collection plans"* (Federal Register, Vol. 69, No. 131, Pg. 41635). EPS has completed the IM&E sampling following its approved plan (Attachment C) and is working toward completing the final study report. The EPS PIC represents the rest of the requirement information to comply with the PIC requirements of Phase II 316(b) and EPS respectfully requests that SCRWQCB approve the PIC within 60 days such that work may begin on the CDS in order to meet the January 8, 2008 due date.

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Attachment A
Structural Design Drawings

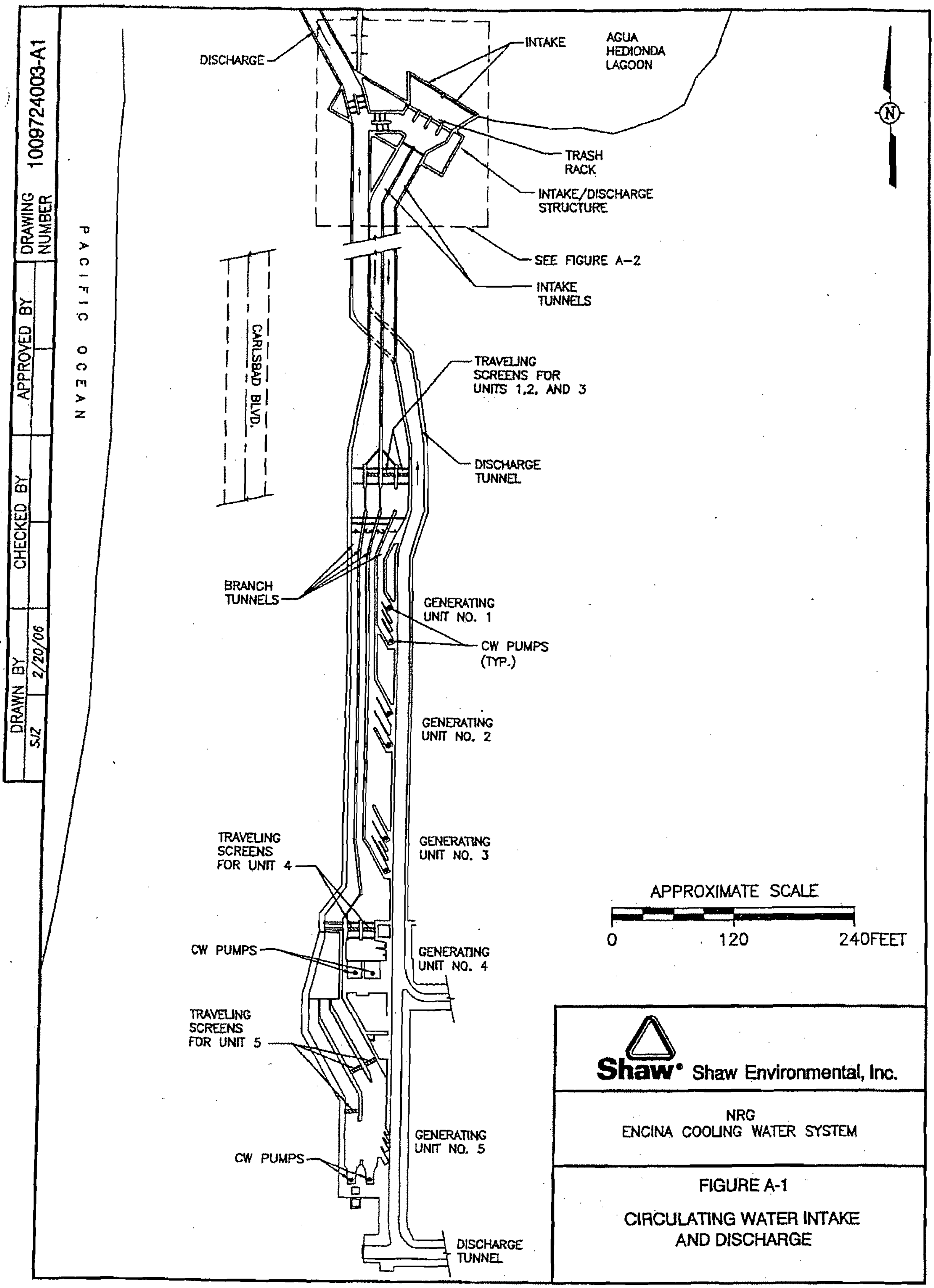
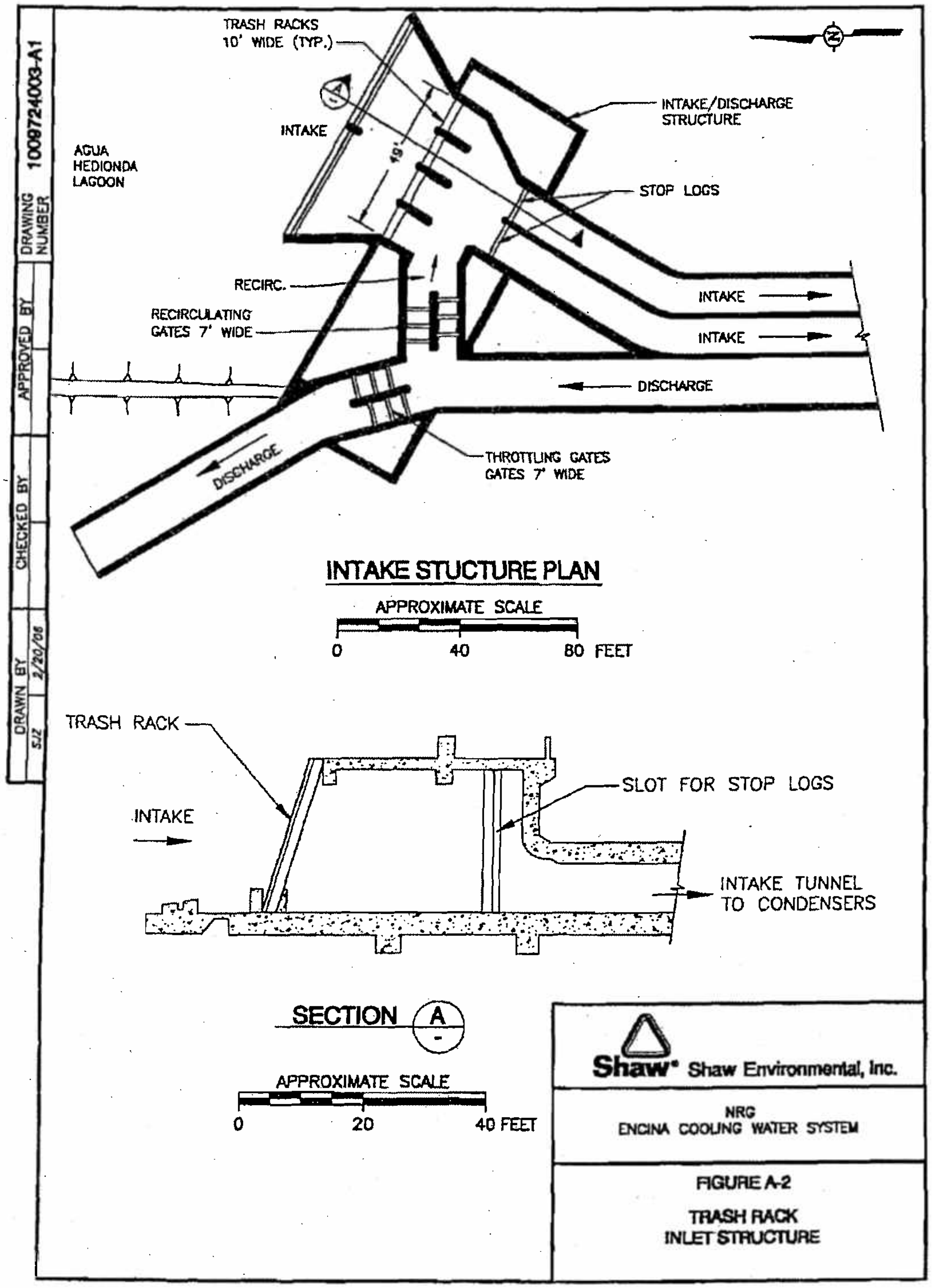


FIGURE A-1

CIRCULATING WATER INTAKE AND DISCHARGE


DRAWING NUMBER 10097240003-A1
APPROVED BY
CHECKED BY
DRAWN BY SJZ 2/20/08
TRASH RACKS 10' WIDE (TYP.)
INTAKE
AGUA HEDIONDA LAGOON
49'
INTAKE/DISCHARGE STRUCTURE
STOP LOGS
RECIRC.
RECIRCULATING GATES 7' WIDE
INTAKE
INTAKE
DISCHARGE
DISCHARGE
THROTTLING GATES GATES 7' WIDE
INTAKE STUCTURE PLAN
APPROXIMATE SCALE
0 40 80 FEET
TRASH RACK
INTAKE
SLOT FOR STOP LOGS
INTAKE TUNNEL TO CONDENSERS
SECTION A
APPROXIMATE SCALE
0 20 40 FEET
Shaw Environmental, Inc.
NRG
ENCINA COOLING WATER SYSTEM
FIGURE A-2
TRASH RACK
INLET STRUCTURE

Encina Power Station
4600 Carlsbad Boulevard
Carlsbad, CA 92008-4301

Direct: (760) 268-4000
Fax: (760) 268-4026

NRG CABRILLO POWER OPERATIONS INC.

January 10, 2005

Mr. John Phillips
San Diego Regional Water Quality Control Board
9174 Sky Park Court, Suite 100
San Diego, CA 92123-4340

RE: Cabrillo Power I LLC – Encina Power Station; Request for Schedule to Submit Information to Comply with the Phase II 316(b) Rule (40 CFR Part 125 Subpart J)

Ref: NPDES Permit Number CA0001350, Order No. 2000-03

Dear Mr. Phillips,

By this letter Cabrillo Power I LLC (Cabrillo) requests a schedule for submitting the information required by EPA's new Phase II 316(b) Rule for cooling water intake structures for the Encina Power Station (EPS). For the reasons to be presented in the following letter, Cabrillo requests your approval to allow the information required by 40 CFR 125.95 to be submitted to you no later than January 7, 2008. In our circumstances, this date is as "expeditious as practicable." The basis for our request is explained below.

As you know, on July 9, 2004, EPA published its final rule prescribing how "existing facilities" may comply with Section 316(b) of the Clean Water Act.[1] For most existing facilities, this rule will require a large amount of data to establish "best technology available" for the facility's intake structure and to demonstrate compliance with the rule.

EPS is a "Phase II existing facility" within the meaning of 40 CFR 125.91. As such, it is required to comply with the Phase II rule, and in particular to submit the studies and information required by 40 CFR 125.95.

Section 125.95 of the new rule requires detailed studies and other information to establish what intake structure technology or other measures will be used to comply with the rule. Ordinarily this material is to be submitted with the facility's next application for renewal of its NPDES permit.[2] For permits that expire less than four years after the rule was published on July 9, 2004 (that is, before July 9, 2008), the facility may have up to three and half years to submit the information, so long as it is submitted "as expeditiously as practicable."[3] The facility may

[1] 69 Fed. Reg. 41575, 41683 (July 9, 2004).
[2] 40 CFR 125.95, 122.21(r)(1)(ii), 122.21(d)(2).
[3] 40 CFR 125.95(a)(2)(ii).

have even longer, until the end of the permit term, under 40 CFR 122.21(d)(2)(i), if the permitting agency agrees.

The current NPDES permit for EPS expires on February 9, 2005, well before July 9, 2008. Therefore, Cabrillo hereby requests that you authorize the information called for in 125.95 to be submitted as expeditiously as practicable, which, as explained below, will require until January 7, 2008.

In order to satisfy the "expeditiously as practicable" requirement, it should be noted that Cabrillo began the process of collecting the necessary information even before the final rule was published. Cabrillo actually began as early as 2003 to begin collecting information and conducting internal evaluations on how the, at that time draft, requirements could be complied with at EPS. Such information collection included preliminary technology assessments and research into existing data and information. Cabrillo also initiated an impingement and entrainment sampling program in June 2004 that is scheduled to conclude toward the end of 2005.

Despite our early efforts, we will still need until January 7, 2008, to complete the studies and collect the information required by 40 CFR 125.95. Our detailed explanation is presented below by first summarizing the significant number of informational requirements that must be submitted and then concludes by presenting the schedule by which the information would be submitted.

Cooling Water System Data

First, all facilities covered by the Phase II Rule must submit "cooling water system data" as required by 40 CFR 122.21(r)(5). This includes a narrative description of the operation of the cooling water system, its relationship to cooling water intake structures, the proportion of the design intake flow that is used in the system, the number of days of the year the cooling water system is in operation, and the seasonal changes in the operation of the system, if applicable. It also includes design and engineering calculations prepared by a qualified professional and supporting data to support the description of the operation of the cooling water system.[4] This information must be submitted at the same time as the Comprehensive Demonstration Study as discussed below.[5]

Proposal for Information Collection

Under 40 CFR 125.95(a)(1), Cabrillo must also submit a Proposal for Information Collection (PIC). Preparing the PIC is a large undertaking. The PIC must contain the items listed in 40 CFR 125.95(b)(1), including a description of proposed and/or implemented technologies, operational measures, and/or restoration measures to be evaluated, a list and description of historical studies characterizing impingement mortality and entrainment and/or the

[4] 40 CFR 122.21(R)(5)(i) and (ii).
[5] 40 CFR 125.95(a)(2).

physical and biological conditions in the vicinity of the cooling water intake structures and their relevance to the proposed study. For existing data, it must demonstrate the extent to which the data are representative of current conditions and that the data were collected using appropriate quality assurance/quality control procedures. The PIC must also include a summary of past or ongoing consultations with federal, state and tribal fish and wildlife agencies and a copy of their written comments, as well as a sampling plan for any new field studies describing all methods and quality assurance/quality control procedures for sampling and data analysis. As you know, Cabrillo already submitted the sampling plan portion of the PIC on September 2, 2004, which was later approved by the San Diego Regional Water Quality Control Board (Regional Board). The impingement and entrainment sampling actually commenced in June 2004 and is expected to conclude toward the end of 2005.

Because of the magnitude and specialized nature of the information to be submitted in the PIC, Cabrillo will have to contract with an outside consulting firm to obtain qualified personnel to perform the work and to handle the increased workload. Cabrillo's contractor procurement process has precise steps that must be undertaken to conform to internal policies and procedures and applicable law.

Including the time it takes to contract with a qualified consulting firm and to develop the PIC using the impingement and entrainment data collected during 2004 and 2005, Cabrillo believes a comprehensive PIC could not be submitted for the Regional Board's review and approval any earlier than April 1, 2006. Cabrillo asks that the Regional Board either approve it or advise us of any needed changes within 60 days as described in 40 CFR 125.95(a)(1), 125.95(b)(1).

Comprehensive Demonstration Study

The Comprehensive Demonstration Study (CDS), as described in 40 CFR 125.95(b), includes many mandatory sections that require substantial effort and time to develop and submit. Many sections of the CDS require that the information collection process described in the PIC be completed prior to being able to initiate those sections of the CDS. Because the PIC data collection will not be completed until early 2006, as described below in the Impingement Mortality and/or Entrainment Characterization Study section, much of the CDS will have to be completed during calendar years 2006 and 2007. This will most likely be a significant time constraint due to the level of work required by the Phase II 316(b) regulation. Below, ESP will describe each section of the CDS in detail, providing ample justification that Cabrillo's proposed complete CDS submission schedule is "as expeditiously as practicable."

<u>Source Water Flow Information</u>

Because EPS does not operate on a river or a lake, no specific source waterbody flow information is required to be submitted.[6]

<u>Impingement Mortality and/or Entrainment Characterization Study</u>

Cabrillo must provide, pursuant to 40 CFR 125.95(b)(3), an Impingement Mortality and/or Entrainment Characterization Study. This study must include (i) taxonomic identifications of all life stages of fish, shellfish, and any species protected under federal, state, or tribal law that are in the vicinity of the cooling water intake structures and are susceptible to impingement and entrainment; (ii) a characterization of all life stages of fish, shellfish, and any protected species, including a description of the abundance and temporal and spatial characteristics in the vicinity of the cooling water intake structures, based on sufficient data to characterize annual, seasonal, and diel variations in impingement mortality and entrainment (e.g., related to climate and weather differences, spawning, feedings, and water column migration). These may include historical data that are representative of current operation of the facility and of biological conditions at the site.

Cabrillo must also document the current impingement mortality and entrainment of all life stages of fish, shellfish, and protected species and provide an estimate of impingement mortality and entrainment to be used as the "calculation baseline."[7] This may include historical data representative of the current operation of the facility and of biological conditions at the site. Impingement mortality and entrainment samples to support the calculations must be collected during periods of representative operational flows for the cooling water intake structure, and the flows associated with the samples must be documented.

Cabrillo expects to submit, within the PIC document, justification for using the historical and representative impingement and entrainment data as well as the new data being collected during calendar years 2004 and 2005. As described above, impingement and entrainment sampling at EPS was initiated in June 2004 and is expected to continue through the end of 2005, which includes the necessary time to complete taxonomic identification, modeling, and development of draft and final reports.

Cabrillo plans on submitting its final PIC after submittal and review of the Impingement and Entrainment Characterization Study Final Report so that all of the collected information and its results can be incorporated into the development of the PIC. This appears to be the most efficient and complete way to produce the PIC, as the information from that study is necessary to complete the other components of the PIC, as described above. Since the Impingement and Entrainment Characterization Study Final Report is not expected to be complete until the end of 2005, the most expeditious submittal date for the final PIC is April 1, 2006.

[6] 40 CFR 125.95(b)(2) only requires source water information for facilities that withdraw water from rivers or lakes other than the Great Lakes. Although not specifically required, a characterization of the source water will be provided in the report on the results of the Impingement and Entrainment Characterization Study.
[7] 40 CFR 125.95(b)(3)(iii).

Design and Construction Technology Plan

Another analysis that must be provided is the Design and Construction Technology Plan.[8] If Cabrillo decides to use design and construction technologies and/or operational measures to comply with the Phase II rule, a plan must be submitted that provides the capacity utilization rate for the intake structure at EPS and provide supporting data (including the average annual net generation of the facility in MWh) measured over a five-year period (if available) of representative operating conditions and the total net capacity of the facility in MW, along with the underlying calculations. The plan must explain the technologies and/or operational measures that Cabrillo has in place and/or have selected to meet the requirements of the rule.

This Design and Construction Technology Plan must contain a large amount of information, as described in 40 CFR 125.95(b)(4)(A)-(D). This information includes (A) a narrative description of the design and operation of all design and construction technologies and/or operational measures, including fish handling and return systems, and information that demonstrates the efficacy of the technologies and/or operational measures; (B) a narrative description of the design and operation of all design and construction technologies and/or operational measures and information that demonstrates the efficacy of the technologies and/or operational measures for entrainment; (C) calculations of the reduction in impingement mortality and entrainment of all life stages of fish and shellfish that would be achieved by the technologies and/or operational measures we have selected; and (D) design and engineering calculations, drawings, and estimates prepared by a qualified professional to support the descriptions described above.

Technology Installation and Operation Plan (TIOP)

Assuming Cabrillo decides that the best way to comply with the Phase II rule is to use design and construction technologies and/or operational measures, in whole or in part, we must submit to you the following information, in accordance with 40 CFR 125.95(b)(4)(ii): (A) A schedule for the installation and maintenance of any new design and construction technologies; (B) a list of operational and other parameters to be monitored and the location and frequency that we will monitor them; (C) a list of activities we will undertake to ensure to the degree practicable the efficacy of installed design and construction technologies and operational measures and our schedule for implementing them; (D) a schedule and methodology for assessing the efficacy of any installed design and construction technologies and operational measures in meeting applicable performance standards or site-specific requirements, including an "adaptive management plan" for revising design and construction technologies, operational measures, operation and maintenance requirements, and/or monitoring requirements in the event the assessment indicates that applicable performance or site-specific requirements are not being met; and (E) if Cabrillo chooses the compliance alternative in 125.94(a)(4) (wedge-wire screens or a technology approved by the state), documentation that the appropriate site conditions described in 125.99(a) or (b) exist at our facility.

[8] 40 CFR 125.95(b)(4).

Restoration Plan

If Cabrillo determines that restoration measures are the best method to comply with the new rule, in whole or in part, then a Restoration Plan must be submitted in the CDS. This plan must include the information described in 40 CFR 125.95(b)(5). It must include a plan using an adaptive management method for implementing, maintaining, and demonstrating the efficacy of the restoration measures that are selected and for determining the extent to which the restoration measures, or the restoration measures in combination with design and construction technologies and operational measures, have met the applicable performance standards.

Site-Specific Requirements

If Cabrillo determines that site-specific requirements are appropriate because the cost of complying with the Phase II rule will be "significantly greater" than either the cost that EPA considered in its rulemaking or the benefits of complying with the rule, then Cabrillo will have to submit the information described in 40 CFR 125.95(b)(6). This includes a Comprehensive Cost Evaluation Study and, for the cost-benefit analysis, a Benefits Evaluation Study. Cabrillo must also include a Site-Specific Technology Plan describing and justifying the site-specific requirements.

Verification Monitoring Plan

Finally, Cabrillo must prepare a Verification Monitoring Plan as part of a complete CDS.[9] This is a plan to conduct, at a minimum, two years of monitoring to verify the full-scale performance of the proposed or already implemented technologies and/or operational measures.

PIC and CDS Schedule

The first official submittal (besides this request for a schedule) that Cabrillo will make to the Regional Board in compliance with the Phase II 316(b) regulation will be the PIC. For the reasons explained above, Cabrillo proposes to submit a comprehensive PIC for the Regional Board's review and approval by April 1, 2006. Cabrillo asks that the Regional Board either approve the PIC or advise us of any needed changes within 60 days as described in 40 CFR 125.95(a)(1), 125.95(b)(1).

Because Cabrillo plans to collect substantial new information as part of the expected PIC, and since the report presenting the results of the new impingement and entrainment data collected in 2004 and 2005 will not be finalized until the end of 2005, and allowing for the period of time the Regional Board has to review and approve the PIC, it is unlikely that the information needed to commence the majority of the sections of the CDS (including the Design and Construction Technology Plan, the Technology Installation and Operation Plan, the

[9] 40 CFR 125.95(b)(7).

Restoration Plan (if applicable), the Site Specific Requirements (if applicable), and the Verification Monitoring Plan) will be available until mid to late 2006.

Due to the step by step process by which the data must be collected, processed, evaluated, and then turned into a detailed plan of action to achieve the new Phase II 316(b) standards, Cabrillo does not believe a comprehensive CDS can be submitted earlier than January 7, 2008. It is for these important reasons that Cabrillo believes the most expeditious schedule possible for submittal of a comprehensive CDS is by January 7, 2008.

Conclusion

Collecting, generating, compiling, and analyzing the large amount of information required by the Phase II 316(b) rule will require a substantial effort. Cabrillo will have to collect and review the large volumes of already-existing data on the plant and the source waterbody, as well as integrate the substantial new biological information currently being collected.

Because the Phase II rule is new and untried, we foresee the need to coordinate closely with your department as we collect the necessary information, analyze it, and determine what combination of technology, operational measures, or restoration measures will best meet the Phase II rule for EPS. Cabrillo hopes your staff will be available to consult with us throughout this schedule as we complete these efforts.

For the above reasons, we request that we be allowed until January 7, 2008, to submit the information required for a permit application by the Phase II Rule, 40 CFR Part 125 Subpart J.

Sincerely,
Cabrillo Power I LLC
By: Its Authorized Agent,

By: NRG Cabrillo Power Operations Inc.
Gregory J. Hughes
Regional Plant Manager

cc: [redacted]
Sheila Henika (Cabrillo)
John Steinbeck (Tenera)
Pedro Lopez (Cabrillo)
Hashim Navrozali (Regional Board)

Attachment C
Impingement Mortality & Entrainment Characterization Study Sampling Plan

Encina Power Station
4600 Carlsbad Boulevard
Carlsbad, CA 92008-4301

Direct: (760) 268-4000
Fax: (760) 268-4026

NRG CABRILLO POWER OPERATIONS INC.

September 2, 2004

Mr. John R. Phillips, P.E.
Senior Water Resource Control Engineer
San Diego Regional Water Quality Control Board
9174 Sky Park Court, Suite 100
San Diego, CA 92123-4340

Subject: **Cabrillo Power I LLC - Encina Power Station; Phase II 316(b) Entrainment and Impingement Sampling Plan**

Dear Mr. Phillips;

Cabrillo Power I LLC (Cabrillo) is pleased to submit a plan to conduct entrainment and impingement sampling for the Encina Power Station (EPS) to comply with the US EPA's recently published Phase II rule for compliance with Section 316(b) of the Clean Water Act. The approval of the EPS Entrainment & Impingement Sampling Plan (E&I Plan) is one of the early steps in the facility's compliance with the Phase II rule. Cabrillo requests expedited review and approval of this E&I Plan in order to optimize the sampling synergies available by virtue of the data collection efforts already underway on behalf of Poseidon Resources (Poseidon) for their proposed desalination project at EPS.

This sampling plan was prepared by Tenera Environmental (Tenera), which is the same firm that prepared the desalination sampling plan submitted to the San Diego Regional Water Quality Control Board (San Diego RWQCB) on behalf of Poseidon in July 2004. Consistent with that sampling plan, Poseidon has already collected several complete sets of entrainment and source water samples at EPS. The Poseidon study plan and collected data will produce information on the larval fish and target invertebrates contained in Poseidon's source of desalination feedwater (the power plant's cooling water discharge), as well as information on the larval fish and target invertebrates contained in the power plant's source waterbody and intake flows.

Data being collected for Poseidon on the power plant's source population of entrainable larval fish and target invertebrates is identical to the information Cabrillo will be required to collect and analyze for EPS Phase II 316(b) studies. Tenera has prepared this sampling plan to seamlessly and consistently continue the collection of the Poseidon entrainment data. In that way, Cabrillo can continue the sampling effort for compliance with the new Phase II performance standards in an efficient and cost-effective manner.

In the past five years, Tenera has completed 316(b) resource assessments for the Diablo Canyon Nuclear Power Plant, Moss Landing Power Plant, Morro Bay Power Plant and Potrero Plant. Tenera study design and assessment methods are also being employed in the ongoing 316(b) studies for the Huntington Beach Generating Station. Throughout these projects, Tenera has worked closely with State and Federal agencies in the development of their field study, impact assessment, and benefits evaluation methods. Tenera has also just recently completed a 316(b) resource assessment for the South Bay Power Plant that has been presented in final form to the San Diego RWQCB. Cabrillo's proposed E&I Plan has been developed in consideration of, and in keeping with, the 316(b) study rationales, content, sampling methodology, analysis and reporting that were used in the South Bay Power Plant 316(b) Assessment (Duke Energy South Bay, May 2004), as well as all of the power plants listed above.

This submission of the EPS E&I Plan is intended to meet part of the requirements for the Proposal for Information Collection (PIC) section of the Phase II 316(b) regulation, but not to address all of the PIC requirements at this time. All of the sampling plan requirements specified in Section 125.95(b)(1)(iv) are incorporated into the EPS E&I Plan. At a later date, Cabrillo will submit the remainder of the PIC requirements pursuant to Section 125.95(b)(1). Cabrillo requests approval of this E&I Plan specifying how new E&I data will be collected, but acknowledges that the San Diego RWQCB will be able to review the other portions of the PIC once submitted by Cabrillo.

Therefore, in order to provide continuous, efficient and cost-effective sampling at EPS, Cabrillo requests that the San Diego RWQCB expedite review and approval of this E&I Plan. Cabrillo understands that San Diego RWQCB is considering retaining an outside consultant in order to provide timely response to this request. Cabrillo is available and prepared to work with your staff and the consultant to provide any additional clarification necessary to obtain timely approval.

Please contact Tim Hemig directly at 760.268.4037 if there are any questions.

Sincerely,
Cabrillo Power I LLC
By: Its Authorized Agent,

By: NRG Cabrillo Power Operations Inc.
Gregory J. Hughes
Regional Plant Manager

cc: Tim Hemig, Sheila Henika, John Steinbeck (Tenera)

Cabrillo Power I LLC, Encina Power Station

316(b) Cooling Water Intake Effects Entrainment and Impingement Sampling Plan

Submitted to the California Regional Water Quality Control Board – San Diego Region for Compliance with Section 316(b) of the Clean Water Act

September 2, 2004

Prepared by:
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1.0 INTRODUCTION

1.1 Development of the 316(b) Sampling Plan

This document presents a sampling plan for conducting the entrainment and impingement sampling necessary for a cooling water intake assessment required under Section 316(b) of the Federal Clean Water Act (CWA). Our sampling plan is based on a survey and compilation of available background literature, results of completed Encina Power Station (EPS) intake studies, and cooling water system studies at other power plants. The data from this study will form the basis of demonstrating compliance with the new Phase II regulations recently developed by the U.S. Environmental Protection Agency (USEPA).

1.2 Overview of the 316(b) Program

Section 316(b) of the Clean Water Act requires that "the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact" (USEPA 1977). Because no single intake design can be considered to be the best technology available at all sites, compliance with the Act requires a site-specific analysis of intake-related organism losses and a site-specific determination of the best technology available for minimizing those losses. Intake-related losses include losses resulting from entrainment (the drawing of organisms into the cooling water system) and impingement (the retention of organisms on the intake screens).

1.2.1 Target Organisms Selected for Study

The USEPA in its original 316(b) lists several criteria for selecting appropriate target organisms for assessment including the following:

1. representative, in terms of their biological requirements, of a balanced, indigenous community of fish, shellfish, and wildlife;
2. commercially or recreationally valuable (e.g., among the top ten species landed—by dollar value);
3. threatened or endangered;
4. critical to the structure and function of the ecological system (i.e., habitat formers);
5. potentially capable of becoming localized nuisance species;
6. necessary, in the food chain, for the well-being of species determined in 1–4; and
7. meeting criteria 1–6 with potential susceptibility to entrapment/impingement and/or entrainment.

In addition to these USEPA criteria there are certain practical considerations that limit the selection of target organisms such as the following:

- identifiable to the species level;
- collected in sufficient abundance to allow for impact assessment, i.e., allowing the model(s) constraints to be met and confidence intervals to be calculated; and
- having local adult and larval populations (i.e., source not sink species). For example, certain species that may be relatively abundant as entrained larvae may actually occur offshore or in deep water as adults.

These criteria, results from the previous 316(b) studies at EPS completed in 1980, results from a supplemental 316(b) study completed in 1997 (EA Engineering 1997), results from more recent studies on the ecological resources of Aqua Hedionda Lagoon (MEC Analytical Systems 1995), and data collected from studies described in this document will be used to determine the appropriate target organisms that will be evaluated in detail. The final target taxa will include the fishes that are found to be most abundant in the entrainment and impingement samples. In addition to large invertebrates that may be abundant in impingement, megalopal (final) larval stage of all species of cancer crabs (*Cancer* spp., which includes the edible species of rock crabs) and the larval stages of California spiny lobster will be identified and enumerated from all processed entrainment and source water plankton samples.

1.3 Sampling Plan Organization

This sampling plan first describes the EPS environment, design, and operating characteristics. The methods for obtaining updated information on the types and concentrations of planktonic marine organisms entrained by the power plant's CWIS are then discussed. A discussion of the theoretical considerations behind the assessment methods for the entrainment and impingement data is then presented. The final 316(b) report will also include an overview of alternative intake technologies and an analysis of feasible alternatives and their cost-effectiveness to minimize adverse entrainment and impingement effects of the EPS CWIS.

2.0 DESCRIPTION OF THE ENCINA POWER STATION AND CHARACTERISTICS OF THE SOURCE WATER BODY

2.1 Background

The Encina Power Station (EPS) is situated on the southern shore of the outer segment of the Agua Hedionda Lagoon in the city of Carlsbad, California, approximately 193 km (85 miles) south of Los Angeles and 16 km (35 miles) north of San Diego. EPS is a gas- and oil-fueled generating plant with five steam turbine generators (Units 1 through 5), which all use the marine waters of Agua Hedionda Lagoon for once-through cooling, and a small gas turbine generator. EPS began withdrawing cooling water from Agua Hedionda Lagoon in 1954 with the startup of commercial operation of Unit 1. Unit 2 began operation in 1956, Unit 3 in 1958, Unit 4 in 1973, and Unit 5 in 1978. The gas turbine was installed in 1968, which does not use cooling water in its operation. The combined net generation capacity of EPS is 966 megawatts electric (Mwe) (**Table 1**).

2.1.1 Plant Cooling Water System Description and Operation

Cooling water for the five steam electric generating units are supplied by two circulating and one or two service water pumps for each unit. The quantity of cooling water circulated through the plant is dependent upon the number of units in operation. With all units in full operation, the cooling water flow through the plant is 2,253 m^3/min (595,200 gallons per minutes [gpm]) or 3,244,430 m^3/day (857 million gallons per day [mgd]) based on the manufacturer ratings for the cooling water pumps (**Table 1**).

Table 1. Encina Power Station generation capacity and cooling water flow volume.

Unit	Gross Generation (MWe)	Cooling Water Flow m^3/min (gpm)	Daily Flow m^3/day (mgd)
1	107	193 (51,000)	278,000 (73)
2	104	193 (51,000)	278,000 (73)
3	110	204 (54,000)	294,350 (78)
4	300	806 (213,000)	1,161,060 (307)
5	325	856 (226,200)	1,233,010 (326)
Gas Turbine	20		
Total	*966*	**2,252 (595,200)**	**3,244,430 (857)**

Cooling water for all five steam-generating units is supplied through a common intake structure located at the southern end of the outer segment of Aqua Hedionda Lagoon, approximately 854 m (2,800 ft) from the opening of the lagoon to the ocean (**Figure 1**). Cooling water from the system is discharged into a small discharge pond that is located to the west of the intake structure. Water from the discharge pond flows through a culvert under Carlsbad Blvd and through a discharge canal across the beach and out to the ocean.

Seawater entering the cooling water system passes through metal trash racks on the intake structure that are spaced 8.9 cm (3½ in) apart and keep any large debris from entering the system. The trash racks are cleaned periodically. Behind the trash racks the intake tapers into two 3.7 m (12 ft) wide tunnels that further splits into four 1.8 m (6 ft) wide conveyance tunnels (**Figure 2**). Conveyance tunnels 1 and 2 provide cooling water for Units 1, 2 and 3, while conveyance tunnels 3 and 4 supply cooling water to Units 4 and 5, respectively. Vertical traveling screens prevent fish and debris from entering the cooling water system and potentially clogging the condensers. There are two traveling screens for Units 1, 2 and 3, two screens for Unit 4, and three screens for Unit 5. The mesh size on the screens for Units 1 through 4 is 0.95 cm (3/8 in), while the mesh size for Unit 5 is 1.6 cm (5/8 in).

The traveling screens can be operated either manually or automatically when a specified pressure differential is detected across the screens due to the accumulation of debris. When the specified pressure is detected the screens rotate and the material on the screen is lifted out of the cooling water intake. A screen wash system (70-100 psi), located at the head of the screen, washes the debris from each panel into a trough, which empties into collection baskets where it is accumulated until disposal.

The velocity of the water as it approaches the traveling screens has a large effect on impingement and entrainment and varies depending on the number of pumps operating, tidal level, and cleanliness of the screen faces. Approach velocities at high and low tide with all pumps operating were presented in the previous 316(b) study conducted in 1979 and 1980 (**Table 2**).

Table 2. Approach velocities at traveling screens for Encina Power Station with all circulating water and service water pumps in operation.

	Estimated Mean Approach Velocity (fps)	
Unit	**High Tide**	**Low Tide**
1	0.7	1.2
2	0.7	1.2
3	0.7	1.2
4	1.0	1.6
5	0.7	1.1

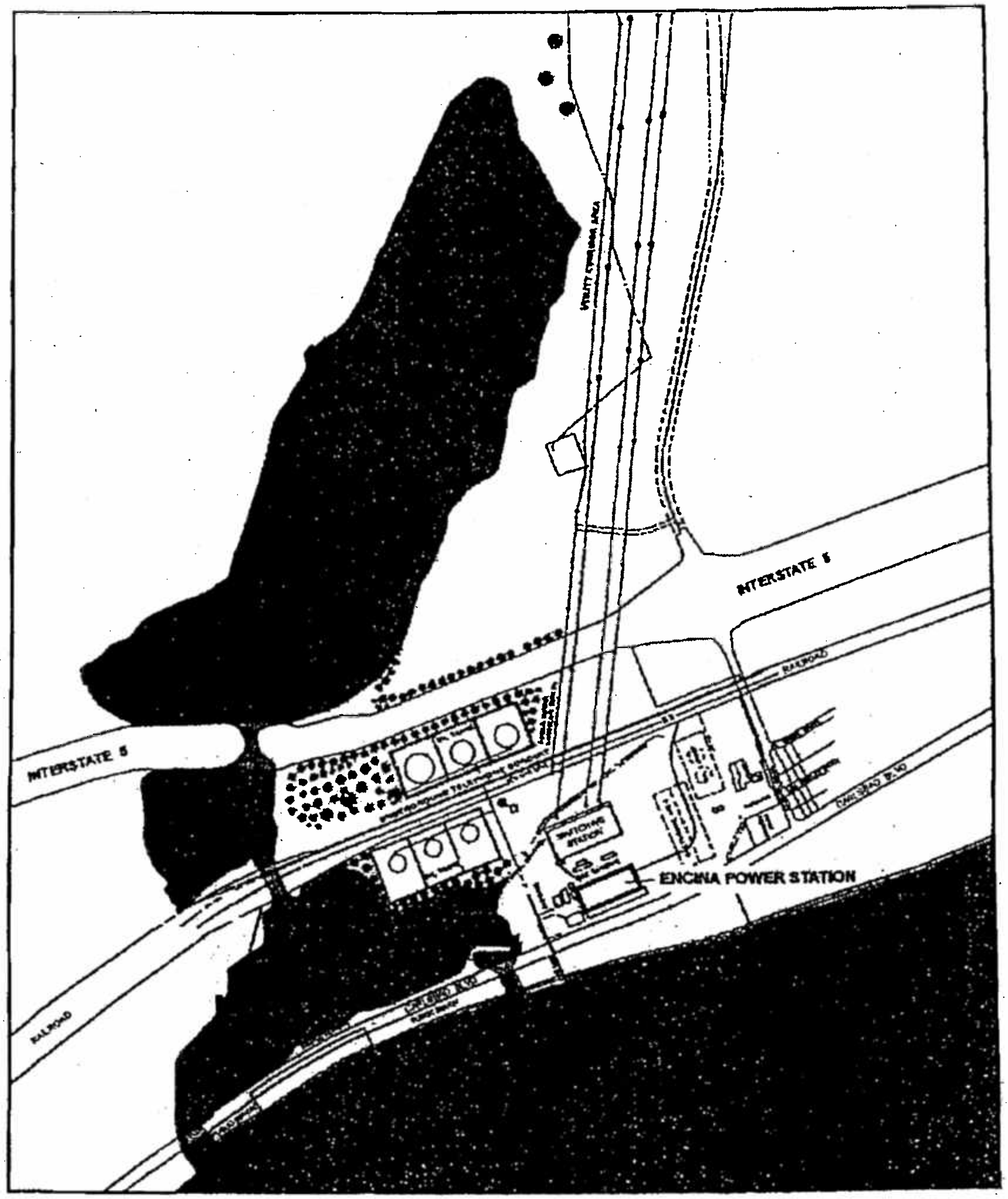

Figure 1. Location of Encina Power Station in Carlsbad, California

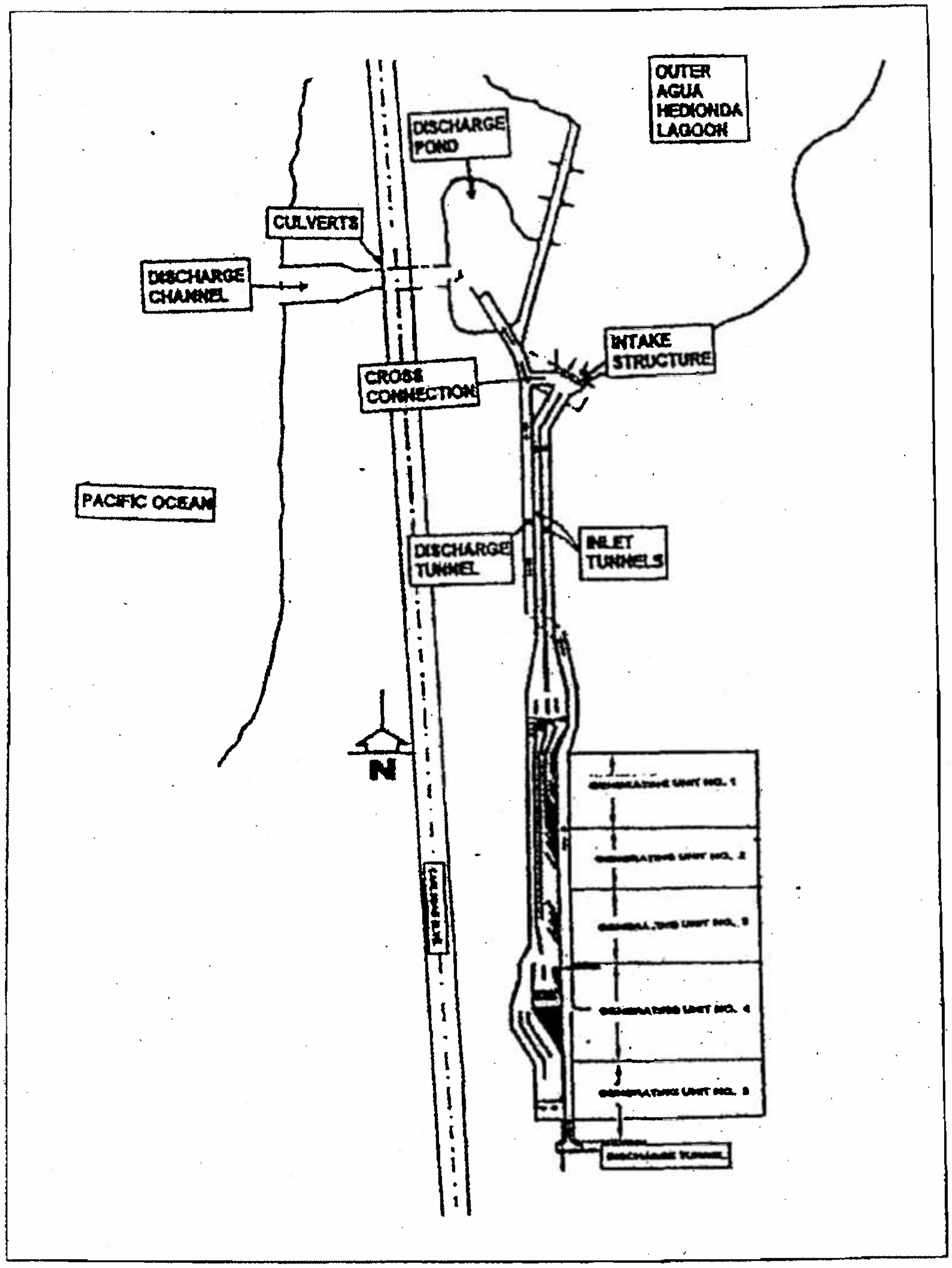

Figure 2. Schematic of Encina Power Station cooling water intake system.

2.2 Aquatic Biological Resources in the Vicinity of EPS

2.2.1 Agua Hedionda Lagoon

The Encina Power Station (EPS) is located on Agua Hedionda Lagoon, which is a man-made coastal lagoon that extends 2.7 km (1.7 miles) inland and is up to 0.8 km (0.5 mi) wide. The lagoon was constructed in 1954 to provide cooling water for the power plant. A railroad trestle and the Interstate Highway 5 bridge separate Agua Hedionda Lagoon into three interconnected segments: an Outer, Middle, and Inner lagoon. The surface areas of the Outer, Middle, and Inner lagoons are 26.7 (66 acres), 9.3 (23 acres), and 79.7 (197 acres) hectares, respectively. The lagoon is separated from the ocean by Carlsbad Boulevard and a narrow inlet 46 m [151 ft] wide and 2.7 m [9 ft] deep at the northwest end of the Outer Lagoon that passes under the highway and allows tidal exchange of water with the ocean.

Circulation and input into Aqua Hedionda Lagoon is dominated by semi-diurnal tides that bring approximately 2.0 million m^3 of seawater through the entrance to the Outer Lagoon on flood tides. Approximately half of this tidal volume flows into the Middle and Inner lagoons. On ebb tides this same tidal volume flows out through the entrance to the ocean. As a result of this tidal flushing the lagoon is largely a marine environment. Although freshwater can enter the lagoon through Buena Creek, which drains a 7,500 hectare (18,500 acres) watershed, for most of the year freshwater flow is minimal. Heavy rainfall in the winter can increase freshwater flows, reducing salinity, especially in the Inner Lagoon.

A study on the ecological resources of Agua Hedionda showed that it has good water quality and supports diverse infaunal, bird, and fish communities (MEC Analytical 1995). Eelgrass was found in all three lagoon segments, but was limited to shallower depths in the Inner Lagoon because water turbidity reduces photosynthetic light penetration in deeper areas. The eelgrass beds provide a valuable habitat for benthic organisms that are fed upon by birds and fishes. Although eelgrass beds were less well developed in areas of the Inner Lagoon, it also provides a wider range of habitats, including mud flats, salt marsh, and seasonal ponds that are not found elsewhere in Aqua Hedionda. As a result bird and fish diversity was highest in the Inner Lagoon.

A total of 35 species of fishes was found during the 1994 and 1995 sampling conducted by MEC (MEC Analytical 1995). The Middle and Inner lagoons had more species and higher abundances than the Outer Lagoon. During the 1995 survey only four species were collected in the Outer Lagoon, compared to 14 to 18 species in the Middle and Inner lagoons. The sampling did not include any surveys of the rocky revetment lining the Outer Lagoon that would increase the abundance and number of species collected. Silversides (Atherinopsidae) and gobies (Gobiidae) were the most abundant fishes collected. Silversides, including jacksmelt and topsmelt, that occur in large schools in shallow waters where water temperatures are warmest were most abundant in the shallower Middle and Inner lagoons. Gobies were most abundant in the Inner Lagoon which has large shallow mudflat areas that are their preferred habitat.

Special Status Species

The recent assessment of the ecological resources of Agua Hedionda did not collect any federally endangered tidewater goby (*Eucyclogobius newberryi*) that was once recorded from the lagoon (MEC Analytical 1995). The record of the occurrence may not be accurate or may predate the construction of the Outer Lagoon that provided a direct connection with the ocean. The current marine environment in the lagoon would not generally support tidewater gobies because they prefer brackish water habitats. No other listed fish species were collected in the study.

2.2.2 Pacific Ocean

Agua Hedionda Lagoon is tidally flushed through the small inlet in the Outer Lagoon by waters from the Pacific Ocean. The physical oceanographic processes of the southern California Bight that influence the lagoon include tides, currents, winds, swell, temperature, dissolved oxygen, salinity and nutrients through the daily tidal exchange of coastal seawater. Near the mouth of the lagoon the mean tide range is 3.7 ft (1.1 m) with a diurnal range of 5.3 ft (1.6 m). Waves breaking on the shore generally range in height from 2 to 4 ft (0.6 to 1.2 m), although larger waves (6 to 10 ft [1.8 to 3.0 m]) are not uncommon. Larger waves exceeding 15 ft (4.6 m) occur infrequently, usually associated with winter storms. Surface water in the local area ranges from a minimum of 57°F (13.9°C) to a maximum 72°F (22.2°C) with an average annual temperature between 63°F (17.2°C) and 66°F (18.9°C).

The outer coast has a diversity of marine habitats and includes zones of intertidal sandy beach, subtidal sandy bottom, rocky shore, subtidal cobblestone, subtidal mudstone and water column. Organisms typical of sandy beaches include polychaetes, sand crabs, isopods, amphipods, and clams. Grunion utilize the beaches around EPS during spawning season from March through August. Numerous infaunal species have been observed in subtidal sandy bottoms. Mollusks, polychaetes, arthropods, and echinoderms comprise the dominant invertebrate fauna. Sand dollars can reach densities of 1,200 per square meter. Typical fishes in the sandy subtidal include queenfish, white croaker, several surfperch species, speckled sanddab, and California halibut. Also, California spiny lobster and *Cancer* spp. crabs forage over the sand. Many of the typically outer coast species can occasionally occur within Agua Hedionda Lagoon, carried by incoming tidal currents.

The rocky habitat at the discharge canal and on offshore reefs supports various kelps and invertebrates including barnacles, snails, sea stars, limpets, sea urchins, sea anemones, and mussels. Giant kelp (*Macrocystis*) forests are an important habitat-forming community in the area offshore from Agua Hedionda. Kelp beds provide habitat for a wide variety of invertebrates and fishes. The water column and kelp beds are known to support many fish species, including northern anchovy, jack smelt, queenfish, white croaker, garibaldi, rockfishes, surfperches, and halibut.

Marine-associated wildlife that occur in the Pacific waters off Agua Hedionda Lagoon are numerous and include brown pelican, surf scoter, cormorants, western grebe, gulls, terns and loons. Marine mammals, including porpoise, sea lions, and migratory gray whales, also frequent the adjacent coastal area.

3.0 Entrainment Study And Assessment Methods

Entrainment studies were previously conducted in 1979 and 1980 at the EPS as part of the plant's initial Section 316(b) Demonstration requirement. The original study was conducted using pump sampling for plankton at the intake structure and net sampling of plankton at three source water stations in the Outer Lagoon (SDG&E 1980). For this study, plankton net sampling at the intake station and at an array of source water stations will be used to collect data for impact models that will be used to update the previous 316(b) Demonstration study. The following questions will be addressed by the entrainment and source water studies:

- What is the baseline entrainment mortality?
- What are the species composition and abundance of larval fishes, cancer crabs, and lobsters entrained by the EPS?
- What are the estimates of local species composition, abundance and distribution of source water stocks of entrainable larval fishes, cancer crabs, and spiny lobsters in Agua Hedionda Lagoon and the nearshore oceanic source waters?

The basis for estimation of entrainment effects is accurate knowledge of the composition and densities of planktonic organisms that are at risk of entrainment through the power plant cooling water system. Recent studies addressing 316(b) issues have focused on larval fishes and commercially important crustacean species (Tenera 2001, 2004). The basic study design involves the collection of plankton samples directly from the intake cooling water flow (entrainment sampling) and comparing the densities of various target species from plankton samples taken concurrently from the source water body (source water sampling). In the case of Encina Power Station (EPS), two areas contribute to the source water body; the lagoon sub-area and the nearshore sub-area, each having a unique contribution to the cooling water flows in terms of species composition and probability of entrainment.

3.1 Entrainment Study

Field data on the composition and abundance of potentially entrained larval fishes, *Cancer* spp. megalopae, and larval spiny lobster *Panulirus interruptus* will provide a basis to estimate the total number and types of these organisms passing through the power plant's cooling water intake system. For the purposes of modeling and calculations, through-plant mortality will be assumed to be 100 percent; unless otherwise determined through a San Diego RWQCB approved entrainment mortality study. Monthly entrainment and source water surveys started in June 2004 will be continued on a monthly basis through May 2005.

3.1.1 Entrainment Sampling Methods

This study was designed to quantify the composition and abundance of entrained larval fishes, *Cancer* spp. megalopae, and spiny lobster larvae. A map of the station locations that were sampled starting in June 2004 is shown in **Figure 3**. These stations will continued to be sampled through May 2005 on a monthly basis.

Sample collection methods are similar to those developed and used by the California Cooperative Oceanic and Fisheries Investigation (CalCOFI) in their larval fish studies (Smith and Richardson 1977) but modified for sampling in the shallow areas of Agua Hedionda Lagoon. Two replicate entrainment samples are collected from a single station (E1) located in front of the EPP intakes by towing plankton nets from a small boat. A net frame is equipped with two 0.71 m (2.33 ft) diameter openings each with a 335 μm (0.013 in) mesh plankton net and codend. The start of each tow begins close to the intake structure, proceeds in a northerly direction against the prevailing intake current, and ends approximately 100 m from the structure. It is assumed that all of the water sampled at the entrainment station would have been drawn through the EPS cooling water system.

The tows are done by first lowering the nets as close to the bottom as practical without contacting the substrate. Once the nets are near the bottom, the boat is moved forward and the nets retrieved at an oblique angle (winch cable at approximately 45° angle) to sample the widest strata of water depths possible. Total time of each tow is approximately two minutes at a speed of 1 kt during which a combined volume of at least 60m^3 (2,119 ft^3) of water is filtered through both nets. In similar studies conducted by Tenera, this volume has been shown to typically provide a reasonable number and diversity of larvae for data modeling. The water volume filtered is measured by calibrated flowmeters (General Oceanics Model 2030R) mounted in the openings of the nets. Accuracy of individual instruments differed by less than 5% between calibrations. The sample volume is checked when the nets reach the surface. If the target volume is not collected, the tow was repeated until the targeted volume is reached. The nets are then retrieved from the water, and all of the collected material rinsed into the codend. The contents of both nets are combined into one sample immediately after collection. The sample is placed into a labeled jar and preserved in 10 percent formalin. Each sample is given a serial number based on the location, date, time, and depth of collection. In addition, the information is logged onto a sequentially numbered data sheet. The sample's serial number is used to track it through laboratory processing, data analyses, and reporting.

Entrainment samples are collected over a 24-hour period, with each period divided into four 6-hour sampling cycles. Larval fishes show day-night differences in abundances related to their vertical migratory behavior and spawning periodicity, and the 24-hr sampling regime allows these differences to be averaged for assessing entrainment abundances. Concurrent surface water temperatures and salinities are measured with a digital probe (YSI Model 30).

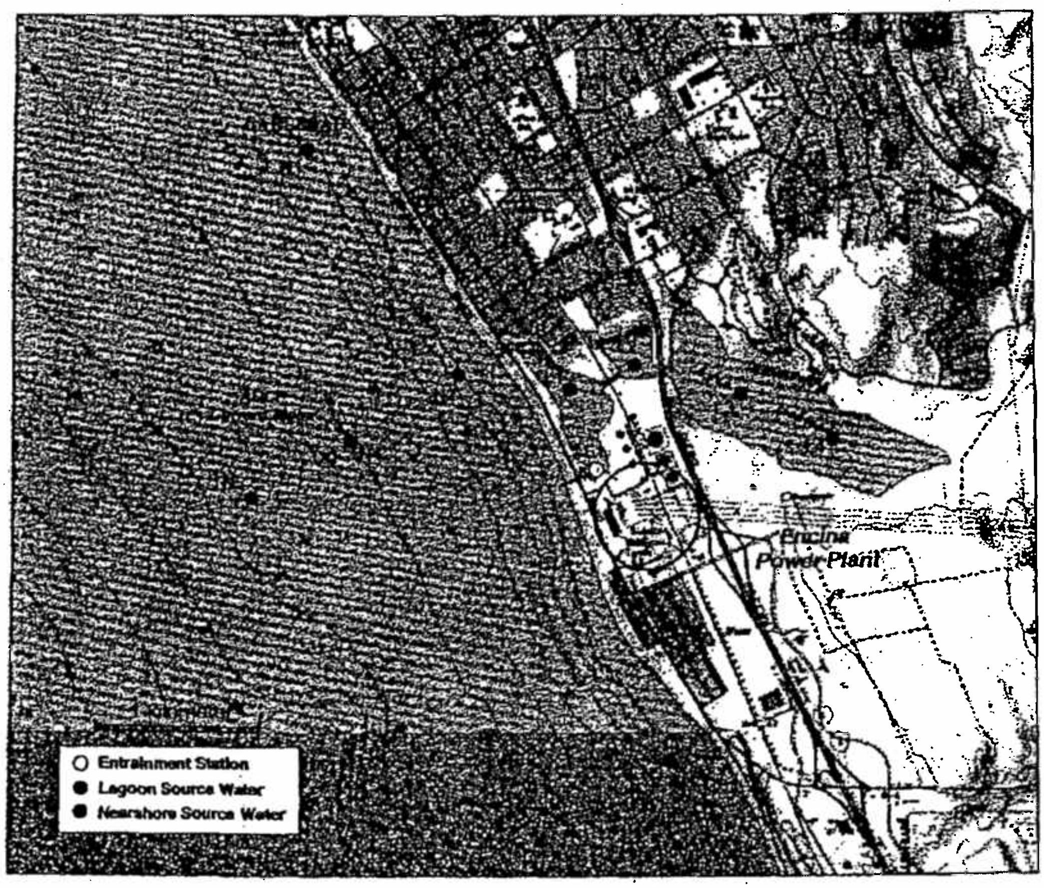

Figure 3. Location of Encina Power Station entrainment (E1) and source water stations (L1 through L4, and N1 through N5).

3.2 Source Water Study

This study was designed to quantify the local source water composition and abundance of larval fishes, *Cancer* spp. megalopae, and larval *Panulirus interruptus* in Agua Hedionda Lagoon and the nearshore source waters. The source water is partitioned into lagoon and nearshore sub-areas for modeling cooling water withdrawal effects (**Figure 3**). Collection methods are identical to the entrainment sample collection, with the exception that a single paired-net sample is collected at each station and the nearshore samples are be collected from a larger vessel capable of navigating open coastal waters in all weather conditions, day or night. The shallow waters in the Middle and Inner lagoons required a different sampling protocol than the oblique tows used at the Outer Lagoon and nearshore stations. The Inner Lagoon is sampled using a single frame plankton net mounted on the bow of a small boat which pushes the net through the water thereby eliminating any obstructions in front of the net during sampling. The net is raised and lowered during sampling to sample the range of depths available in the shallow Inner Lagoon.

The stations are stratified to include four lagoon stations within the inner (2), middle (1), and outer lagoons (1), and five nearshore stations that cover a depth range of 5–30 m (16–98 ft). The array of locations and depths was chosen to assure that all potential source water community types are represented. For example, stations in the inner lagoon will have a greater proportion of larvae from species with demersal eggs, such as gobies, that spawn in quiet water environments, while nearshore stations will have more larvae of species that spawn in open water such as California halibut and white seabass. The study will allow comparison to earlier larval fish studies done for the original EPS 316(b) in 1979-80 (SDG&E 1980).

A current meter is placed in the nearshore between Stations N4 and N5. The data from the meter will be used to characterize currents in the nearshore area that would directly affect the dispersal of planktonic organisms that could be entrained by the power plant. The data will be used to define the size of the nearshore component of the source water by using the current speed and the estimated larval durations of the entrained organisms.

The number of source water stations will be evaluated as data become available to determine if fewer stations can be sampled. For example, a reduction in the number of stations may be recommended if analysis indicates that only one station is necessary to characterize the Inner Lagoon, or the Middle Lagoon is sufficiently similar to the Inner Lagoon that it does not need to be sampled separately. Analysis of current meter data may also indicate that Station N5 does not need to be sampled because the current is predominantly alongshore and can be adequately characterized using the other stations closer to shore.

3.2.1 Source Water Sampling Methods

Sampling is conducted using the same methods and during the same time period described earlier for the entrainment collections (Section 3.1.1) with target volumes for the oblique tows of approximately 60 m^3 (2–3 minute tow at approximately 1 knot).

3.3 Laboratory Processing and Data Management

Laboratory processing will remove all larval fishes, megalopal stages of *Cancer* spp., and larvae of spiny lobster from the samples. Fish eggs will not be sorted from the samples. Although many marine fish eggs are described in the scientific literature, most identifications are difficult and very time consuming, and impact models can be adequately parameterized without egg density data. Larval fishes and all species of cancer crab megalopae will be identified to the lowest taxonomic level possible by Tenera's taxonomists. In addition, the developmental stage of fish larvae (yolk-sac, preflexion, flexion, postflexion, transformation) will be recorded on the data sheet. A laboratory quality control (QC) program for all levels of laboratory sorting and taxonomic identification will be applied to all samples. The QC program will also incorporate the use of outside taxonomic experts to provide taxonomic QC and resolve identification uncertainties.

Many larval fish cannot be identified to the species level; these fish will be identified to the lowest taxonomic classification possible (e.g., genus and species are lower orders of classification than order or family). Myomere and pigmentation patterns are used to identify many species; however, this can be problematic for some species. For example, sympatric members of the family Gobiidae share similar characteristics during early life stages (Moser 1996), making identifications to the species level uncertain. Those gobiids that we are unable to identify to species will be grouped into an "unidentified goby" category.

Laboratory data sheets will be coded with species or taxon codes. These codes will be verified with species/taxon lists and signed off by the data manager. The data will be entered into a computer database for analysis.

Length measurements will be taken on a representative sample of the target larval fish taxa. Approximately 100 fish from each taxon will be measured using a video capture system and Optimus™ image analysis software. The 100 fish from each taxon will be selected from the entrainment station based on the percentage frequency of occurrence of a taxon in each survey. For example, if 20 percent of the California halibut larvae for the entire year-long study were collected from during the June survey then 20 fish will be measured from that survey.

3.4 Assessment Methods

Potential cooling water intake system (CWIS) entrainment effects will be evaluated using a suite of methods, with no single method being superior to any others. The potential entrainment effects of the EPS CWIS, assuming 100 percent through-plant mortality, will be estimated using the site-specific field data collected in this proposed study. The potential for any such CWIS effects to cause long-term population level impacts will be evaluated through the use of three analytical techniques: proportional entrainment (*PE*), adult equivalent loss (*AEL*), and fecundity hindcasting (*FH*). The results of these analytical steps will support assessments with respect to species population demographics (e.g., standing stock, age structure stability, fishery trends, and sustainable harvest management plans).

3.4.1 Demographic Approaches (FH and AEL)

The fecundity hindcasting or *FH* analysis approach (Horst 1975) compares larval entrainment losses with adult fecundity to estimate the amount of adult female reproductive output eliminated by entrainment. It thereby hindcasts the numbers of adult females effectively removed from the reproductively active population. The accuracy of these estimates of effects is dependent upon such factors as accurate estimates of age-specific mortality from the egg and early larval stages to entrainment, and also on age-specific estimates of adult fecundity, spawning periodicity, and reproductive lifespan. If it is assumed that the adult population has been stable at some current level of exploitation and that the male:female ratio is known and constant, then fecundity and mortality are integrated into an estimate of loss by converting entrained larvae back into females (i.e., hindcasting). In making this conversion, the number of eggs, derived from the number of larvae adjusted for egg to larvae mortality, are divided by the average number of eggs produced by each age class (size) of reproductive females in the stable population's ideal age structure. However this degree of information is rarely available for a population. In most cases, a simple range of eggs per females is reported without age-specificity.

An advantage of *FH* is that survivorship need only be estimated for a relatively short period of the larval stage (i.e., egg to larva). This method does not require source water sampling in addition to estimates of larval entrainment concentrations. This method assumes that the loss of a single female's reproductive potential is equivalent to the loss of adults. For the purpose of the resource assessment, if EPS-induced entrainment losses are to be equated to population level units in terms of fractional losses, it is still necessary to estimate the size of the population of interest. To this end, our assessment will employ any available, scientifically acceptable sources of information on fisheries stock or population estimates of unexploited species entrained by the EPS.

The adult equivalent loss or *AEL* approach (Goodyear 1978) uses age-specific estimates of the abundance of entrained or impinged organisms to project the loss of equivalent numbers of adults based on mortality schedules and age at recruitment. The primary advantage of this approach is that it translates power plant-induced, early life-stage mortality into equivalent numbers of adult fishes, the units used by resource managers. Adult equivalent loss does not necessarily require source water estimates of larval abundance in addition to entrainment estimates, as required in *PE*. This latter advantage may be offset by the need to gather age-specific mortality rates to predict adult losses and the need for information on the adult population of interest for estimating population-level effects (i.e., fractional losses). However, the need for age-specific mortality estimates can be reduced by various approximations as shown by Saila et al. (1987), who used six years of entrainment and two years of impingement data for winter flounder *Pleuronectes americanus*, red hake *Urophycis chuss*, and pollock *Pollachius virens* at the Seabrook Station in New Hampshire. Their model assumed an adult population at equilibrium, a stable age distribution, a constant male:female ratio, and an absence of density-dependent (i.e., compensatory) mortality between entrainment and recruitment to the adult or fished stocks. Input data to their model parameters were gathered in field surveys of spawning populations, egg and larval production, and local hydrology.

Declining populations can be accounted for in both the *AEL* and *FH* approaches by using age-specific adult mortality estimates from fishery catch data and by assuming no compensatory mortality. However, we know that this is not an assumption that fits the reality of population dynamics. The removal (mortality) of any life stage will have an effect if it exceeds the number of reproductive adults required to produce that number of larvae. That is, the adult population will decline one for one with every larva lost. This is clearly not the case, nor does every larva survive to become an adult. Although we have essentially no way of estimating the degree to which a population can sustain losses and remain stable, it is an important issue when estimating long-range effects. The effect, known as density-dependence (sometimes called compensation), can affect the vital rates of impacted organisms. Density-dependence is not confined to acting through mortality; growth and fecundity may also be density-dependent. In fisheries management models, which we will take as our working models in forecasting long-term population trends, the level of compensation possible in species can be examined empirically by the response of its population to harvest rates.

Some entrainment studies have assumed that compensation is not acting between entrainment and the time when adult recruitment would have taken place, and further, that this specific assumption resulted in conservative estimates of projected adult losses (Saila et al. 1987). Others, such as Parker and DeMartini (1989), did not include compensatory mortality in estimates of equivalent adult losses because of a lack of consensus on how to include it in the models and, more importantly, uncertainty about how compensation would operate on the populations under study. The uncertainty arises because the effect of compensation on the ultimate number of adults is directly related to which of the vital processes (fecundity, somatic growth, mortality) and which life stages are being affected. In particular, Nisbet et al. (1996) showed that neglecting compensation does not always lead to conservative long-term estimates of equivalent adult losses.

3.4.2 Empirical Transport Model (ETM)

The *PE* approach (Boreman et al. 1978, Boreman et al. 1981) will provide an estimate of incremental (conditional, Ricker 1975) mortality imposed by EPS on local source water larval populations by using empirical data (plankton samples) rather than relying solely on hydrodynamic and demographic calculations. Consequently, *PE* requires an additional level of field sampling to characterize abundance and composition of larvae using results from the larval fish surveys defined in this document (Section 3.2.1). These estimates of species-specific fractional losses (entrainment losses relative to source water abundance) can then be expanded to predict regional effects on appropriate adult populations using an empirical transport model (*ETM*), as described below. Required parameters for the *PE* approach include the rate of cooling water withdrawal, estimates of entrained larval fish concentrations, and estimates of the larval fish concentrations in the source waters.

The use of *PE* as an input to the empirical transport model (*ETM*) has been proposed by the U.S. Fish and Wildlife Service to estimate mortality rates resulting from cooling water withdrawals by power plants (Boreman et al. 1978, and subsequently in Boreman et al. 1981). Variations of this model have been discussed in MacCall et al. (1983) and have been used to assess impacts at a southern California power plant (Parker and DeMartini 1989). The *ETM* has also been used to assess impacts at the Salem Nuclear Generating Station in Delaware Bay, New Jersey (PSE&G 1993) as well as other power stations along the East Coast. Empirical transport modeling permits the estimation of annual conditional mortality due to entrainment while accounting for the spatial and temporal variability in distribution and vulnerability of each life stage to power plant withdrawals. The generalized form of the *ETM* incorporates many time-, space-, and age-specific estimates of mortality as well as information regarding spawning periodicity and duration, many of which are limited or unknown for the marine taxa being investigated at EPS. The applicability of the *ETM* to the present study at EPS will be limited by a lack of either empirically derived or reported demographic parameters needed as input to the model. However, the concept of summarizing *PE* over time that originated with the *ETM* can be used to estimate entrainment effects over appropriate temporal scales either through modeling or by making assumptions about species-specific life histories. We will employ a *PE* approach that is similar to the method described by MacCall et al. (1983) and used by Parker and DeMartini (1989) in their final report to the California Coastal Commission (Murdoch et al. 1989), as an example for the San Onofre Nuclear Generating Station (SONGS). This estimate can then be summarized over appropriate blocks of time in a manner similar to that of the *ETM*.

4.0 IMPINGEMENT EFFECTS

The two primary ways cooling water withdrawal can affect aquatic organisms are through impingement and entrainment. Larger organisms are subjected to impingement on the screening system on the power plant's cooling water intake system (CWIS) that excludes debris from the circulating water pumps. EPS presently has seven sets of vertical traveling screens in three separate areas. Approach velocities vary from approximately 0.7 fps at high tide to 1.6 fps at low tide. Impingement occurs when an organism larger than the traveling screen mesh size is trapped against the screens. These impinged organisms are assumed to undergo 100 percent mortality for the purposes of this study. The following questions will be addressed by the impingement study:

- What is the baseline impingement mortality?
- What are the species composition and abundance of fishes and macroinvertebrates impinged by EPS?

4.1 Review of 1980 Impingement Study

In earlier impingement studies at EPS, fish samples were collected from screen washes during high and low impingement periods for one year (SDG&E 1980). Samples were collected over two-12 hour periods during each day to represent daytime and nighttime impingement. Since samples were collected every day the study provides a direct measure of EPS impingement. During the one-year period during normal plant operations 76 species of fishes and 45 species of macro-invertebrates totaling 85,943 individuals and weighing 1,548 kg (3,414 lb) were impinged. During the seven heat treatments conducted during the sampling period 108,102 fishes weighing 2422 kg (5,341 lb) were collected. The most abundant fishes collected in impingement samples were actively swimming, open-water schooling species such as deepbody and northern anchovy, topsmelt, and California grunion. Other abundant species included queenfish and shiner surfperch. During heat treatments larger fishes were collected that were less common during normal impingement. These larger fishes probably live in the CWIS and are able to avoid impingement during normal plant operation, but succumb to the warmer temperatures during heat treatment. Marine plants, largely eelgrass and giant kelp, made up the largest component of material in impingement samples.

Impingement losses at EPS were much less when compared with impingement at other coastal plant in southern California. Impingement was much greater at the Redondo Beach Generating Station and San Onofre Nuclear Generating Station Unit 1, even though the cooling water flows at those two facilities are less than the flow at EPS (673 and 500 MGD, respectively compared with 828 mgd at EPS). The intake approach velocities at the screenwells at EPS are lower than the velocities at these other facilities allowing most fishes to avoid impingement by continuous or burst swimming. The SDG&E report (SDG&E 1980) and a later evaluation (EA 1997) both concluded that the biological impact of EPS was insignificant in terms of impingement losses.

4.2 Impingement Study Methods

The purpose of the proposed 316(b) impingement study will be to characterize the juvenile and adult fishes and selected macroinvertebrates (e.g., shrimps, crabs, lobsters, squid, and octopus) impinged by the power plant's CWIS. The sampling program is designed to provide current estimates of the abundance, taxonomic composition, diel periodicity, and seasonality of organisms impinged at EPS. In particular, the study will focus on the rates (i.e., number or biomass of organisms per m^3 water flowing per time into the plant) at which various species of fishes and macroinvertebrates are impinged. The impingement rate is subject to tidal and seasonal influences that vary on several temporal scales (e.g., hourly, daily, and monthly) while the rate of cooling water flow varies with power plant operations and can change at any time. A review of the previous impingement study at EPS will provide context for interpreting changes in the magnitude and characteristics of the present day impingement effects. Studies of the Agua Hedionda fish assemblages independent of EPS (e.g., MEC Analytical 1995) will also provide information regarding the marine environment in southern and central Agua Hedionda Lagoon.

In accordance with procedures employed in similar studies, impingement sampling will occur over a 24-hour period one day per week. Before each sampling effort, the trash racks will be cleaned and the traveling screens will be rotated and washed clean of all impinged debris and organisms. The sluiceways and collection baskets will also be cleaned before the start of each sampling effort. The operating status of the circulating water pumps on an hourly basis will be recorded during the collection period. Each 24-hour sampling period at the traveling screens will be divided into six 4-hour cycles. The traveling screens will remain stationary for a period of 3.5 hours then they will be rotated and washed for 30 minutes. The trash racks will be cleaned once every 24 hours. The impinged material from the traveling screens will be rinsed into the collection baskets associated with each set of screens and the impinged material from the trash racks will be collected in the bin on the rake apparatus. The debris and organisms rinsed from each set of traveling screens and the trash racks will be kept separate and processed according to the procedures presented in the following section.

If the traveling screens are operating in the continuous mode, then sampling will be coordinated with the intake crew so samples can be collected safely. A log containing hourly observations of the operating status (on or off) of the circulating water pumps for the entire study period will be obtained from the power plant operation staff. This will provide a record of the amount of cooling water pumped by the plant, which will then be used to calculate impingement rates. The same procedure will be used to coordinate additional sampling efforts at the trash racks in case they need to be cleaned more frequently than once every 24 hours. The sampling at each of the three sets of traveling screens will be offset by one hour to allow screen wash and collection to occur at each set of screens separately.

Impingement sampling will also be conducted during heat treatment "tunnel shock" operations. Procedures for heat treatment will involve clearing and rinsing the traveling screens prior to the start of the heat treatment procedure. At the end of the heat treatment procedure normal pump operation is resumed and the traveling screens rinsed until no more fish are collected on the screens. Processing of the samples will occur using the same procedures used for normal impingement sampling. We anticipate that up to eight heat treatments will occur during the one-year study period.

A quality control (QC) program will be implemented to ensure the correct identification, enumeration, length and weight measurements of the organisms recorded on the data sheet. Random cycles will be chosen for QC re-sorting to verify that all the collected organisms were removed from the impinged material.

Depending on the number of individuals of a given target species present in the sample, one of two specific procedures is used, as described below. Each of these procedures involves the following measurements and observations:

1. The appropriate linear measurement for individual fishes and motile invertebrates is determined and recorded. These measurements are made in millimeters to the nearest 1 mm. The following standard linear measurements are used for the animal groups indicated:

Fishes	Total body length for sharks and rays and standard lengths (fork length) for bony fishes.
Crabs	Maximum carapace width.
Shrimps & Lobsters	Carapace length, measured from the anterior margin of carapace between the eyes to the posterior margin of the carapace.
Gastropod & Pelecypod Molluscs	Maximum shell length or maximum body length.
Octopus	Maximum "arm" spread, measured from the tip of one tentacle to the tip of the opposite tentacle.
Squid	Maximum body length, measured from the tip of one tentacle to the posterior end of the body.

2. The wet body weight of individual animals is determined after shaking loose water from the body. Total weight of all individuals combined is determined in the same manner. All weights are recorded to the nearest 1 g.

3. The qualitative body condition of individual fishes and macroinvertebrates is determined and recorded, using codes for decomposition and physical damage. These codes are shown on the attached form.

4. Other non-target, sessile macroinvertebrates are identified to species and their presence recorded, but they are not measured or weighed. Rare occurrences of other impinged animals, such as dead marine birds, are recorded and their individual weights determined and recorded.

5. The amount and type of debris (e.g., *Mytilus* shell fragments, wood fragments, etc.) and any unusual operating conditions in the screen well system are noted by writing specific comments in the "Notes" section of the data sheet.

The following specific procedures are used for processing fishes and motile invertebrates when the number of individuals per species in the sample or subsample is ≤ 29 :

1. For each individual of a given species the linear measurement, weight, and body condition codes are determined and recorded on separate lines.

The following specific subsampling procedures are used for fishes and motile invertebrates when the number of individuals per species is > 29:

1. The linear measurement, individual weight, and body condition codes for a subsample of 30 individuals are recorded on individual lines of the data sheet. The individuals selected for measurement should selected after spreading out all of the individuals in a sorting container, making sure that they are well mixed and not segregated into size groups. Individuals with missing heads or other major body parts are eliminated from consideration, since linear measurements of them are not representative.

2. The total number and total weight of all the remaining individuals combined are determined and recorded on a separate line.

4.2.1 Sampling Frequency

Results from the previous impingement study indicated that the impingement is much greater during the heat treatment "tunnel shock" events. Almost 60 percent of the total impinged fishes (over 60 percent by weight) were collected during the seven tunnel shock events. Impingement rates during normal operations were much less. Although we have proposed to sample normal impingement weekly, we will evaluate the potential to reduce the sampling frequency to once every two weeks. The analysis will be done using the weekly data collected at EPS during this study and data from other southern California power plants with shoreline intake structures. The reduced sampling frequency may provide an adequate estimate of impingement especially since we will continue to sample impingement during each of the tunnel shock events when impingement is highest.

5.0 Cooling Water System Impact Assessment

The entrainment and impingement effects of the cooling water intake system for the EPS project will be assessed on the basis of historical studies and 12 months of recent plankton and 12 months of impingement survey information. The assessment will consider the effects of entraining larval fishes, crabs and lobsters, and impinging larger fishes and invertebrates in the CWIS. The three methods for assessing CWIS effects are fecundity hindcasting (*FH*), adult equivalent loss (*AEL*) and empirical transport modeling (*ETM*). These methods were explained in Section 3.5—Assessment Methods. The report will contain estimates of *AEL* and *FH* where data are available to parameterize these demographic approaches.

The impacts of impingement and entrainment on source water populations can be evaluated by estimating the fractional losses to the population attributable to the CWIS. Impingement rates and biomass estimates from the study will provide estimates of impingement losses that can then be translated directly to estimate potential impingement effects on local fisheries. Estimated entrainment losses are extrapolated to fishery losses using *FH* and *AEL* estimates. One constraint in the modeling approach is that life history data are available for only a portion of the entrained taxa and commercial fishery statistics will also only be available for a few of the entrained species (e.g., California halibut, northern anchovy, white croaker). Many of the fishes that have historically been entrained in highest numbers are small fishes that are not the focus of any recreational or commercial fishery.

Present-day findings on the EPS CWIS entrainment effects will be reviewed and assessed for the most abundant larval fish taxa, megalopal cancer crabs, and larval spiny lobster. By comparing the number of larvae and megalopae withdrawn by the power plant to the number available (i.e., at risk to entrainment), an estimate of the conditional mortality due to entrainment (*PE*) can be generated for each taxon or species. These estimates of conditional mortality will be combined in the *ETM* model to provide an estimate of the annual probability of mortality due to entrainment (P_m) that can be used for determining CWIS effects and the potential for long-term population declines. Fishery management practices and other forms of stock assessments will provide the context required to interpret P_m. In the case of a harvested species, P_m must be considered in addition to these harvest losses when assessing impacts and any potential for population decline.

5.1 Entrainment Effects Assessment

The assessment will focus on entrainment effects to the most abundant and to commercially or recreationally important fish taxa, cancer crab megalops and lobster larvae. Larval fishes analyzed will tentatively be the Goby complex, three Engraulid species, three Atherinopsid species, California halibut, white croaker, black croaker, spotted sand bass, and barred sand bass. These taxa likely comprise over 90 percent of all the entrained larval fishes based on earlier studies. Other species, which may occur in lower abundances, may also be included in the assessment because they represent species of commercial or recreational importance

5.2 Summary of Entrainment Effects

The length of time that a larval fish is in the plankton and subject to entrainment is a key parameter in *ETM* calculations. Length measurements taken from representative samples of the larval fish taxa presented in Section 4.0 will be used to estimate the number of days that larvae (for a specific taxon) are at risk to entrainment. Reports on larval duration from the scientific literature are likely to overestimate the period of time that larvae are exposed to entrainment. This is because ontogenetic changes during larval development result in increased swimming ability or behavioral changes, such as association with the bottom or other pre-settlement microhabitats. Possible outliers are eliminated by basing the minimum and maximum lengths on the central 98 percent of the length distribution for a taxon and excluding the lengths of the top and bottom percentiles. Estimates of larval growth rates (mm/day) are then used on this range to estimate the number of days the larvae are exposed to entrainment. The estimates of growth rates and their source from the literature will be presented in the impact assessment section for the different taxa. The average duration of entrainment risk for a taxon is calculated from the bottom percentile value to the mean value, while the maximum duration is calculated from the bottom percentile value to the 99 percentile value. Our estimates of the period of entrainment risk for cancer crabs and spiny lobster will be derived from literature values on the average age of the stages for each crustacean species.

5.3 Summary of Impingement Effects

Impingement effects in relation to source water fishery resources and potential ecological effects will be summarized based on data summarized from the earlier impingement study (SDG&E 1980), data on fish populations in Agua Hedionda Lagoon (MEC 1995), and CDF&G catch records for sport and commercial fishery resources.

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NRG CABRILLO POWER OPERATIONS INC.

January 10, 2005

Mr. John Phillips
San Diego Regional Water Quality Control Board
9174 Sky Park Court, Suite 100
San Diego, CA 92123-4340

Subject: Cabrillo Power I LLC Response to Comments from Tetra Tech to San Diego Regional Water Quality Control Board on the Encina *316(b) Cooling Water Intake Effects Entrainment & Impingement Sampling Plan*

Dear Mr. Phillips:

Cabrillo Power I LLC (Cabrillo) appreciates the opportunity to respond to the comments from Tetra Tech on the *316(b) Cooling Water Intake Effects Entrainment and Impingement Sampling Plan* for the Encina Power Station (EPS) submitted to the San Diego Regional Water Quality Control Board (Regional Board) on September 2, 2004. Tenera Environmental prepared the plan for the EPS 316(b) studies, and Cabrillo had them respond to comments from Tetra Tech. The responses from Tenera are incorporated into this letter and identified accordingly.

The Tetra Tech comments generally call for further clarification of the study plan or additions to the plan that will not affect the sampling procedures currently being used. The Tetra Tech comments (numbered the same as on the Tetra Tech memo) with specific questions of Cabrillo have responses that are highlighted in boldface type. Tetra Tech also made several suggestions that we have responded to in the final section of this letter.

TETRA TECH COMMENTS AND CABRILLO RESPONSES:

1) *Page 2:* The authors state that they will use EPA's criteria for selecting appropriate target organisms for assessment, results from previous 316(b) studies, Aqua Hedionda Lagoon ecological surveys, and results from the upcoming study to "determine the appropriate target organisms that will be evaluated in detail." Final selection of target organisms should involve consultation with the appropriate resource agencies. Will the California Regional Water Quality Control Board (and others) be contacted to approve target organism selection before commencement of assessment analyses?

Response: **The final selection of the specific target organisms will be made in collaboration with the Regional Board and other appropriate agencies. The**

sampling and processing is currently focused on fishes and selected macroinvertebrates; the same groups of organisms that were studied in San Diego Bay in 2001–2003 at the Duke Energy South Bay Power Plant in San Diego. The final list of target organisms will be based largely on their abundances in the entrainment and impingement samples. The impact assessment will be restricted to the most abundant taxa to ensure that there is have reasonable confidence in the results.

3) *Page 7*: The MEC Analytical (1995) ecological surveys will be used to provide "data on fish populations in Aqua Hedionda Lagoon" (see page 24) for the evaluation of EPS impingement effects in relation to source water fishery resources. The authors mention that the MEC Analytical sampling "did not include any areas of the rocky revetment lining the Outer Lagoon that would increase the abundance and number of species collected." It appears that the surveys focused on the Middle and Inner Lagoons. Since the MEC Analytical data will be used for impingement effects analyses, the search for and/or collection of supplemental information for Outer Lagoon fishes may be warranted (however, it should be noted that we have not reviewed the contents of the MEC Analytical report).

Response: **The MEC study utilized multiple gear types that effectively sampled most of the habitats in Aqua Hedionda Lagoon. Cabrillo is currently evaluating if supplemental studies of the habitats not sampled in the MEC study are necessary and will propose those to the Regional Board if warranted. These habitats include the shallow mudflats areas that are common in the middle and inner lagoon, the rocky habitat that lines the boundary of the outer lagoon, and the artificial substrates on the piers, docks and floats of the outer lagoon. Gobies that occur in burrows on the mudflats and combtooth blennies, garibaldi and rockfishes that occur on the rocky habitat and artificial substrates in the outer lagoon were not effectively sampled by any of the gear types used in the MEC study. The larvae from these fishes will likely be abundant in the entrainment samples and this study will provide an estimate of their adult source water populations that will be used in the assessment of cooling water intake system (CWIS) effects.**

6) *Page 11*: The authors state that entrainment sampling began in June 2004 and will continue through May 2005. Has this proposed index period changed, or was approval received for sampling commencement prior to the preparation and review of this sampling plan (Plan is dated September 2004)? Did source water sampling also begin before this plan was written?

***Response*: Both entrainment and source water sampling began in June 2004. The sampling started before a sampling plan was submitted to the Regional Board to take advantage of studies of the cooling water system that were being conducted in association with the permitting for the desalination facility being proposed for construction at the plant site by Poseidon Resources. The original proposal for the Poseidon study did not include the more extensive source water sampling in the final study plan. The scope of the study was expanded to conform to other 316(b) demonstration studies Tenera has completed in California including the study recently completed at the Duke Energy South Bay Power Plant in San Diego Bay. This provided Cabrillo the opportunity to continue the sampling in response to EPA's recently published Phase II rule for compliance with Section 316(b) of the Clean Water Act.**

7) *Page 11*: Entrainment samples will be collected from the lagoon, near the intake structure. Is entrainment sampling not possible from a location within the EPS CWIS?

***Response*: Entrainment sampling conducted at ocean and estuarine power plants over the last ten years in California has been done in the source waters as near as possible to the intakes. This sampling location has been used because studies at the Diablo Canyon Power Plant in central California showed that large losses of planktonic organisms such as larval fishes can occur as a result of filtering by biofouling organisms that grow on the surfaces inside the power plant cooling water intake system. Studies have shown reductions in densities of greater than 90 percent between intake and discharge samples that have been attributed to biofouling losses. Although the entrainment sampling proposed for the EPS with plankton nets in the source waters at the power plant intake structure requires the assumption that the densities of organisms in the source waters are representative of the densities of organisms that are entrained, sampling inside the power plant introduces additional assumptions, sampling problems, and the known problem of cropping by biofouling organisms. One of these problems involves obtaining representative, well-mixed samples and sampling in rapidly flowing water. In addition, sampling inside the plant cooling water system usually requires pump sampling methods that are different than the towed net sampling used in the source waters, therefore introducing additional assumptions affecting comparisons between density estimates. All of these issues have resulted in the recommendation that entrainment sampling be done in the lagoon using nets towed as close as practical to the intake structure.**

8) *Page 11*: As part of the description of entrainment sampling methods, the authors mention that the "accuracy of individual instruments differed by less than 5% between calibrations." This is mentioned as a statement. Is it intended to be a quality standard?

Response: **No, it is not intended as a quality standard, it is just a statement that the difference in rotor constants between calibrations was generally less than 5%. In addition to maintaining the flowmeters before and after each survey, they are calibrated every three months to recalculate a new rotor constant, which is used to calculate the flow of water through the net. If the value of a constant changes greater than 10% between calibrations, which is almost never the case, the readings from the field data sheets are reviewed to determine when the change occurred. If the change in the flowmeter can be detected from the data, the values will be adjusted using the average difference between the two flowmeters used on the bongo frame prior to that sample; otherwise the flowmeter reading for the instrument that is within the 10% calibration range will be used to estimate the volume of seawater filtered through both nets on the bongo frame.**

9) *Page 11*: The authors state that if the target volume of water is not filtered during the entrainment tow, the tow will be repeated until the targeted volume is reached. Will the tow distance be extended to accomplish this, or will the tow truly be "repeated?"

Response: **The tow will be continued at the lagoon and entrainment stations by extending the tow, covering the vertical depth of the water column until the target volume is collected. Some of the deeper nearshore samples cannot simply be extended because it would not be possible to collect an unbiased sample that extended across all depths without greatly increasing the sample volume. In these cases, or if flowmeters are fouled with kelp, the samples are discarded and the sampling is repeated at the station.**

10) *Page 12*: The source water sampling methods are said to be "identical to the entrainment sample collection" (with a few noted exceptions). Does that mean that all source water stations will be sampled concurrently with entrainment sampling, and during the same (four) six-hour cycles? Is the source water sampling index period the same as the June 2004-May 2005 entrainment period?

Response: **Yes, all of the stations, source water and entrainment, are sampled during the same four six-hour blocks on the day the survey is conducted. All of the stations are usually sampled within a 2-3 hour period. All of the**

stations have been sampled since June 2004 with a total of eight surveys collected as of December 2004.

11) *Page 13*: The Inner Lagoon will be sampled with a single pushnet. Will the targeted volume of water be the same as the paired net (oblique) samples taken in the Outer Lagoon and nearshore ocean areas?

Response: **Yes. The targeted volume for the lagoon source water and entrainment samples is approximately 50 m^3. The volumes for samples from the nearshore stations may be greater, especially at the deepest stations, N4 and N5, where the minimum sample volume may exceed 50 m^3 because the nets are lowered through the entire water column and then retrieved.**

13) *Page 13*: The authors mention that "the number of source water stations will be evaluated as data become available to determine if fewer stations can be sampled." More information may be warranted to explain this process, and in particular, to explain whether reviewing agencies will be included in the decision process.

Response: **A proposal for this or any other change in the sampling program would first be submitted to the Regional Board for review. Any changes would only be implemented after review and approval by Regional Board and other reviewing agencies.**

14) *Page 14*: The authors state that, "A laboratory quality control (QC) program...will be applied to all samples." Is this a printed and approved QA/QC plan? If so, it should be cited. If not, what are the specific data quality objectives for laboratory processing (e.g., sorting efficiencies, taxonomic agreement, etc.)?

Response: **The laboratory QC program is an internal Tenera document that was not cited in the study plan. The QC program includes a procedure for preserving, transferring, splitting, and sorting plankton samples. There is a separate procedure for identification of the organisms from the samples. The following data quality objectives are used for sorting:**

1. **The first ten samples that are sorted by an individual are completely resorted by a designated QC sorter. A sorter is allowed to miss one target organism when the original sorted count is 1-19. For original counts above 20 a sorter must maintain a sorting accuracy of 90%.**
2. **After the sorter has passed 10 consecutive sorts, the program is switched to a '1 sample in 10' QC program for that sorter. After the sorter has**

completed another 10 samples, one sample is randomly selected by the designated QC sorter for a QC resort.

3. **If the sorter maintains the 90% accuracy sorting rate for this sample, then the sorter continues in the '1 sample in 10' QC mode.**
4. **If a sample does not meet the 90% accuracy rate their subsequent samples will be resorted until 10 consecutive samples meet the criteria.**

A similar QC procedure is used for taxonomic identification except that the taxonomist must maintain an accuracy level of 95% for the identifications.

16) *Page 15*: The FH model requires specific input parameter data (e.g., age-specific mortality) that may not be readily available. The authors state that, "...this degree of information is rarely available for a population." They also mention that "...our assessment will employ any available, scientifically acceptable sources of information on fisheries stock or population estimates of unexploited species entrained by the EPS." Will adequate input parameter data be available, or is it too early in the process to tell?

Response: **The initial review of the data showed that many of the same fish taxa that were analyzed from other studies were also abundant in the EPS samples. Also, similar to other studies, the majority of the fishes were small, forage species that do not have direct commercial/recreational fishery values. Therefore, while it has been possible to parameterize the adult equivalent models (FH and AEL) for many of these species in past studies, estimates of their adult populations that were necessary to interpret the results of the modeling efforts were usually not available. The MEC study on the fishes of Aqua Hedionda Lagoon and results from supplemental studies on adult fishes will help provide some of this information.**

19) *Page 19*: The impingement study methods do not mention an index period. Has impingement sampling begun, and will the sampling period coincide with entrainment sampling (June 2004-May 2005)?

Response: **Yes, impingement sampling began in early July 2004 and will continue through June 2005. Although it does not exactly coincide with entrainment sampling, it is close enough to capture the same seasonal changes in fish and target invertebrate abundance that will be present in the entrainment sampling. The sampling was started in July to take advantage of studies at the plant being conducted in association with the permitting for the desalination facility being proposed for construction at the plant site by Poseidon Resources (See *Tenera Response* to Comment 6).**

20) *Page 20*: The authors mention a quality control (QC) program for impingement sampling. Is this a printed and approved QA/QC plan? If so, it should be cited. If not, what are the "random cycles for re-sorting" and the specific quality objectives (e.g., for sorting efficiency)?

***Response*: Tenera has written procedures for conducting the impingement sampling at EPS that all participating samplers are required to follow. A quality control plan is part of this procedure. Each impingement sampling team is comprised of two qualified biologists familiar with the fish and invertebrate fauna likely to be impinged. The goal of the sampling is to correctly identify, and accurately count and weigh all impinged organisms according to the criteria in the sampling protocol. In addition to ongoing quality control checks by samplers (e.g., consultations among team members, supervisor involvement, preservation of specimens of uncertain identity), Tenera personnel will check the counts and identifications from two cycles of impinged material on a quarterly basis. Unlike the laboratory identification process where a 90% sorting accuracy objective is specified, a specific quantitative objective for the impingement QC program is not feasible because of the variability in the quantity and types of impinged material. The objective is 100% accuracy. Tenera will document the results of the QC checks and implement any corrective actions necessary to ensure compliance with the written procedures.**

21) *Page 22*: The authors state that, "Although we have proposed to sample normal impingement weekly, we will evaluate the potential to reduce the sampling frequency to once every two weeks." More information may be warranted to explain this process, and in particular, to explain whether reviewing agencies will be included in the decision process.

***Response*: See response to Comment 13.**

22) *Page 23*: The authors state that, "Fishery management practices and other forms of stock assessments will provide the context required to interpret [the estimate of the annual probability of mortality due to entrainment]." The data types mentioned may not be available for some of the most frequently entrained fishes (e.g., non-commercial /non-recreational species). Will adequate evaluation data be available, or is it too early in the process to tell?

***Response*: See response to Comment #16. The MEC study on the fishes of Agua Hedionda Lagoon will help provide this information for the small,**

estuarine, forage species that are not targeted by commercial or recreational fisheries.

23) *Page 23 and 24*: Potential target organisms are mentioned. Comment 1 (above) applies here. Will the California Regional Water Quality Control Board (and others) be contacted to approve target organism selection before commencement of assessment analyses?

Response: **See response to Comment 1.**

SUGGESTIONS

- The governing regulatory/resource agencies should be given the opportunity to consider and approve/reject: the selection process for representative species (mentioned in comments 1 and 23, above); the possible reduction in the number of source water sampling stations (comment 13); and the possible reduced impingement sampling frequency.

  Response: **See responses to comments 1, 13, and 23. Proposals for these, or any other, change to the sampling program would first be submitted to the Regional Board for review. Any changes would only be implemented after review and approval by the Regional Board.**

- The temporal aspects of the study questioned in comments 6, 10 and 19 (above) need to explained in more detail.

  Response: **See responses to Comments 6 and 19.**

- The quality control program needs to be described in more detail (see comments 14 and 20), or the QA/QC plan should be cited and/or attached as an appendix.

  Response: **Procedures for the sampling and laboratory processing will be submitted as attachments to the study plan.**

- As mentioned previously, the study plan was obviously developed by qualified and experienced contractors, and we think that their study design is conceptually valid. Most comments listed above represent the need for relatively minor clarifications or additions.

Thank you again for the opportunity to respond to the comments from Tetra Tech. The study being conducted by Tenera Environmental is based on the design used for the entrainment and impingement studies at the Duke Energy South Bay Power Plant in San

Diego Bay. These studies were required for the plant's NPDES permit that was recently approved by the Regional Board. Therefore, we are confident that the study will provide the information necessary for Cabrillo Power I LLC to comply with EPA's recently published Phase II rule for Section 316(b) of the Clean Water Act. We look forward to working with you and the other Regional Board staff on this project and would be available to discuss our responses to these comments at your convenience.

If you have any questions or comments, please contact Mr. Tim Hemig at (760) 268-4037.

Sincerely,
Cabrillo Power I LLC
By: Its Authorized Agent,

By: NRG Cabrillo Power Operations Inc.
Gregory J. Hughes
Regional Plant Manager

cc: Tim Hemig (Cabrillo)
Sheila Henika (Cabrillo)
John Steinbeck (Tenera)
Pedro Lopez (Cabrillo)
Hashim Navrozali (Regional Board)

CARLSBAD SEAWATER DESALINATION PROJECT

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

REGION 9, SAN DIEGO REGION

ORDER NO. R-9-2006-0065

NPDES NO. CA0109223

FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

ATTACHMENT 5 - ESTIMATION OF THE POTENTIAL FOR IMPINGEMENT SHOULD THE CDP OPERATE IN STAND-ALONE MODE

March 27, 2009

ESTIMATION OF THE POTENTIAL FOR IMPINGEMENT SHOULD THE CDP OPERATE IN STAND-ALONE MODE

The San Diego Regional Water Quality Control Board ("Regional Board") will consider the Flow, Entrainment and Impingement Minimization Plan ("the Plan") for the Carlsbad Desalination Project (the "CDP" or "Project") at its April 8, 2009 meeting. The Plan was required as a Special Provision of the Project's NPDES permit[1] in order to assure compliance with the Porter-Cologne Water Quality Control Act, Water Code Section 13142.5(b), which requires that the intake and mortality of marine life be minimized. Relevant to that evaluation is the potential for impingement should the CDP operate in stand-alone mode.

This memorandum evaluates potential approaches that could be used to estimate the potential for impingement when the CDP is operated in stand-alone mode. Based on the relevant facts, data, and literature, this memorandum concludes that a sound and reasonable approach is a flow-proportioned approach. Accordingly, the Regional Board reasonably may rely on this approach in making findings about projected impingement.

I. BACKGROUND

The CDP will be co-located with the Encina Power Station ("EPS"), and will receive its feedstock water from Agua Hedionda Lagoon through the EPS's existing seawater intake system.

From June 2004 to June 2005, Tenera Environmental ("Tenera") conducted a field program during which impingement at the EPS intake structure was measured. Since the Project's feedwater will come from the EPS's intake system, the Project's projected impingement was estimated based on the impingement data collected during this program, in which biological samples were collected one day each week from June 24, 2004 through June 15, 2005. Table 1 presents the results from the weekly sampling events. It reflects the number and weight of marine organisms collected from the intake screens for each 24-hour sampling event along with the corresponding intake flow.

Table 2

Number and weight of fishes (bony fishes, sharks and rays) and invertebrates impinged during normal operations at EPS from June 2004 to June 2005 on the sample days

	Daily Volume (MGD)	Fishes (Bony Fishes & Sharks + Rays)		Invertebrates	
		Number	Weight (g)	Number	Weight (g)
6/24/2004	632	287	4,355.6	7	66.1
6/30/2004	620	419	4,666.3	6	106.4
7/7/2004	671	209	3,590.1	6	54.0
7/14/2004	856	842	12,377.4	4	272.1
7/21/2004	817	263	7,264.0	3	21.1
7/28/2004	751	255	6,479.3	2	32.5
8/4/2004	676	70	3,951.0	2	7.4
8/11/2004	857	679	11,898.7	7	45.1

[1] Order No. R9-2006-0065, NPDES No. CA0109223, § VI.C.2.e.

Table 2

Number and weight of fishes (bony fishes, sharks and rays) and invertebrates impinged during normal operations at EPS from June 2004 to June 2005 on the sample days

	Daily Volume (MGD)	Fishes (Bony Fishes & Sharks + Rays)		Invertebrates	
		Number	Weight (g)	Number	Weight (g)
8/18/2004	857	86	3,999.7	3	24.9
8/25/2004	626	100	3,809.5	5	26.4
9/1/2004	735	34	1,489.8	2	4.7
9/8/2004	857	250	4,010.0	1	2.5
9/15/2004	771	96	1,348.4	8	62.6
9/22/2004	793	167	2,092.4	6	50.1
9/29/2004	840	122	1,581.4	15	115.9
10/6/2004	823	218	2,908.8	28	116.5
10/13/2004	550	17	323.6	21	118.8
10/20/2004	419	258	2,942.3	16	70.2
10/27/2004	477	206	4,724.5	37	254.0
11/3/2004	477	99	488.5	12	100.1
11/10/2004	550	21	129.0	29	196.6
11/17/2004	544	61	965.6	12	117.9
11/22/2004	550	43	1,350.5	37	156.2
12/1/2004	813	1,947	9,782.8	21	142.5
12/8/2004	784	324	2,899.0	22	335.0
12/15/2004	710	207	2,570.5	20	161.3
12/20/2004	710	66	678.9	20	197.7
12/29/2004	710	1,146	10,427.0	45	189.8
1/5/2005	566	528	7,280.2	40	385.6
1/12/2005	560	5,001	109,526.0	95	2,583.5
1/19/2005	599	600	6,914.1	49	444.0
1/26/2005	632	306	8,330.4	39	414.0
2/2/2005	560	246	3,196.5	26	678.4
2/9/2005	632	227	5,696.6	19	133.5
2/16/2005	497	23	1,186.0	714	2,153.6
2/23/2005	307	1,274	29,531.0	42	4,199.8
3/2/2005	497	48	3,638.2	20	424.6
3/9/2005	497	132	6,586.5	74	629.9
3/16/2005	497	30	887.6	16	62.0
3/23/2005	673	282	7,722.8	65	295.8
3/30/2005	674	240	9,163.4	37	162.5
4/6/2005	673	109	7,150.5	49	343.0
4/13/2005	673	220	11,137.4	184	631.4
4/20/2005	745	96	2,734.5	23	288.1
4/27/2005	745	102	3,891.5	8	24.4
5/4/2005	706	280	4,241.8	7	28.6
5/11/2005	576	200	6,343.4	11	328.4
5/18/2005	706	312	7,347.4	20	96.6
5/25/2005	632	195	4,444.6	20	107.0
6/1/2005	700	228	5,925.4	19	52.9
6/8/2005	778	234	4,626.6	5	13.0
6/15/2005	563	37	1,912.7	8	24.5

Table 2
Number and weight of fishes (bony fishes, sharks and rays) and invertebrates impinged during normal operations at EPS from June 2004 to June 2005 on the sample days

	Daily Volume (MGD)	Fishes (Bony Fishes & Sharks + Rays)		Invertebrates	
		Number	Weight (g)	Number	Weight (g)
EPS Totals (52 days)	**34,167**	**19,442**	**372,520**	**1,987**	**17,554**
EPS Daily Averages	**657**	**374**	**7,163.8**	**38**	**337.6**

The EPS has the capacity to withdraw 863.5 million gallons per day ("MGD").[2] During the 2004-2005 sampling period, the EPS's average flow volume was approximately 657 MGD for the 52 sample days. In contrast, the water demand for the Project is 304 MGD. Unlike the EPS, the cooling water requirements of which are driven by variable demand for electricity, the CDP's feedstock demand will remain relatively constant.

II. IMPINGEMENT IS RELATED TO INTAKE VELOCITY, FLOW VOLUME, AND FISH SWIM SPEED

Impingement is defined as the entrapment of all life stages of fish and shellfish on the outer part of an intake structure or against a screening device during periods of intake water withdrawal.[3] It long has been recognized that impingement is related to water velocities in the vicinity of the intake structure[4]. In particular, it is well-established that fish can escape intake structures if their ability to swim away from the structure is not overwhelmed by the velocities at the structure[5]. The fish also must be able to detect the structure, and the flow field at and near the structure must be uniform enough so that the fish's ability to navigate is not compromised. All other things being equal, when intake flow at an intake structure is relatively low compared to the design capacity of the structure, intake velocities correspondingly will be relatively low. Thus, reducing flow at a given intake structure is an effective means by which to reduce velocities and the potential for impingement.

These principles are reported in the scientific literature, and have supported national standards proposed by the United States Environmental Protection Agency ("EPA"). EPA explains that the impingement of organisms is governed by the combination of three primary factors—flow, intake velocity, and fish swim speed.[6] Consistent with EPA's guidance, each of these factors is relevant in estimating the Project's projected impingement. California agencies also recognize the relationship between intake velocity and flow, on the one hand, and the potential for impingement, on the other.

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[2] EPS's NPDES Permit, Order No. R9-2006-0043, NPDES No. CA0001350, at 5.

[3] Criteria and Standards for the National Pollutant Discharge Elimination System, 40 C.F.R. 125(93) (2009).

[4] General Fish Screen Criteria, Interagency Ecological Program's CALFED Fish Facility Technical Team (p. 18).

[5] *Id.*

[6] National Pollutant Discharge Elimination System—Final Regulations to Establish Requirements for Cooling Water Intake Structures at Phase II Existing Facilities; Final Rule, 69 Fed. Reg. 41612 (July 9, 2004) (to be codified at 40 C.F.R. pt. 9, 122 et al).

A. The Scientific Literature Documents the Generally Accepted Relationship Between Velocity and Flow, on the One Hand, and Impingement, on the Other

"Rates of entrainment and impingement of aquatic resources are directly related to intake velocities at and around the intake structure, and also to numerous other physical and biological phenomena."[7] "Naturally, the best technique is to minimize the number of fish which enter the intake area. This can be accomplished by locating the intake in an area of low fish population, reducing the velocity of the intake water, and eliminating areas where fish can be trapped."[8] "'[A]pproach velocity and screen face velocity are the principal design criteria for controlling the impingement of larger organisms, principally fish, on intake screens."[9]

A gross cross-sectional area can be calculated if the width of the intake bay and the depth of the water in that opening are known values. From this gross cross-sectional area, the net open area that flow can pass through is determined by subtracting the area of the rack bars and supports that block the passage of water through the opening. Once the net area has been calculated, the equation Q = AV provides the relationship between flow and velocity (i.e., V =Q/A).[10] Since the area of an existing intake is fixed, velocity is exclusively a function of flow.

Turnpenny (1988) reported that the "three vital elements to fish exclusion" from intake structures are as follows:

> (1) the fish must be able to detect its approach to an intake before it can attempt to escape; (2) the direction of water flow must be horizontal, since fish are ill-equipped to react to vertical flow components; (3) the water velocity must be within the fish's swimming performance range. All three requirements must be met simultaneously; it is futile, for example, to reduce intake current velocities where waters are perpetually turbid, since fish would be unlikely to detect their approach to the intake.[11]

Turnpenny also points out the common sense fact that fish are not influenced by currents when they are very low. "At low current speeds (<1-3 cm s^{-1}), the current has no effect on the direction in which the fish swims."[12] In other words, there is some minimum threshold below which intake velocities and corresponding flows do not place the fish at risk of impingement. He concludes that, "it is possible to predict how fish will respond to man-made

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[7] Boreman, J. 1977. Impacts of power plant intake velocities on fish. Power Plant Team (p. 2), U.S. Fish and Wildlife Service.

[8] *Id*. at 14.

[9] U.S. Nuclear Regulatory Comm'n, Office of Nuclear Regulatory Research, Regulatory Guide 4.7, General Site Suitability Criteria for Nuclear Power Stations, n. 4, at B-3 (April 1998).

[10] Q = the flow in cubic feet per second being provided by the pumps (where 448.8 gallons per minute = 1 cubic foot per second); A = the net area (in square feet) available for flow to pass through the racks; and V= the velocity in feet per second of the water passing through the racks.

[11] Turnpenny, A.W. H. The Behavioral Basis of Fish Exclusion from Coastal Power Station Cooling Water Intakes (p. 1) Central Electricity Generating Board Research Report, RD/L/3301/R88, 1988.

[12] *Id*. at 5.

currents at CW [cooling water] intakes."[13] "The main consideration for fish escape is therefore that the approach velocity at that point," referring to the coarse screens, "is kept within the swimming ranges of the fish…."[14]

B. EPA and California State Regulators Have Recognized the Relationship between Velocity and Flow, on the One Hand, and Impingement, on the Other

1. The Agencies Recognize that Reducing Flow Reduces Impingement

Since the 1970s, EPA has recognized the relationship between flow and impingement.[15] EPA notes that "flow reduction serves the purpose of reducing both impingement and entrainment."[16] According to EPA, this explains why "[e]nvironmental commentators [have] advocated for flow reduction technologies as the most direct means of reducing fish kills from power plant intakes."[17]

In accord with these well-recognized principles, EPA's Phase I, II and III regulations use flow as a criterion when determining which set of rules will apply to a particular intake system. The regulations reflect that the rate of impingement is related to the flow (i.e., volume) of water drawn through an intake structure. As a facility increases its flow by pumping more water from the source water body, the amount of impingement can be expected to increase correspondingly when other factors remain constant. Conversely, as a facility decreases its flow by pumping less water from the source water body, the amount of impingement can be expected to decrease.

For example, in the Preamble to its Phase II regulations, EPA explains that it established 50 MGD as the threshold level for applying its regulations, "because the regulation of existing facilities with flows of 50 MGD or greater in Phase II will address those existing power generating facilities with the greatest potential to cause or contribute to adverse environmental impact."[18]

Similarly, the State Water Resources Control Board ("SWRCB") recognizes the relationship between reduced flow and reduced impingement. In its March 2008 Scoping Document, Water Quality Control Policy on the Use of Coastal and Estuarine Water for Power Plant Cooling, the SWRCB reiterated EPA's conclusion and observed that "[f]low reduction will

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[13] *Id*.

[14] *Id*. at 15.

[15] Development Document for Best Technology Available for the Location, Design, Construction and Capacity of Cooling Water Intake Structures for Minimizing Adverse Environmental Impact. EPA 440/1-76/015-a. USEPA April 1976. Washington, DC.

[16] U.S. Environmental Protection Agency, Phase II, Final Rule Technical Development Document, Chapter 4 (Efficacy of Cooling Water Intake Structure Technologies), at Section 1.5, p. 4-4, *available at* http://www.swrcb.ca.gov/rwqcb3/water_issues/programs/duke_energy/docs/usepa_efficacy_of_intake_technologies.pdf.

[17] 69 Fed. Reg. 41612

[18] *Id*.

reliably reduce both impingement and entrainment impacts of OTC [once through cooling]."[19] The EPS intake structure is an OTC intake, although the structure will be used for feedstock water – not cooling[20] – when the CDP operates in stand-alone mode.

2. The Agencies Recognize that Reducing Velocity Reduces Impingement

When EPA established "best technology available" under Section 316(b) of the federal Clean Water Act for purposes of new facilities utilizing cooling water intake structures (Phase I Rule), the agency determined that a maximum intake velocity of 0.5 fps (feet per second) or less minimizes impingement to acceptable levels.[21]

In developing the Phase I Rule, EPA drew from federal agency reports that recommend a velocity of 0.5 fps to protect fish species from impingement previously.[22] These reports were based in part on a study of fish swimming speeds and endurance performed by Sonnichsen et al. (1973).[23] EPA concluded that "thresholds should be based on the fishes' swimming speeds (which are related to the length of the fish) and endurance (which varies seasonally and is related to water quality)."[24] This analysis demonstrated that "the species and life stages evaluated could endure a velocity of 1.0 ft/s."[25] However, in order to "develop a threshold that could be applied nationally and is effective at preventing impingement of most species of fish at their different life stages, EPA applied a safety factor of two to the 1.0 ft/s threshold to derive a lower threshold of 0.5 ft/s. This safety factor, in part, was meant to ensure protection when screens become partly occluded by debris during operation and velocity increases through portions of the screen that remain open."[26] "EPA compiled the data from three

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[19] SWRCB, Scoping Document: Water Quality Control Policy on the Use of Coastal and Estuarine Waters For Power Plant Cooling (March 2008), at 45, *available at* http://www.energy.ca.gov/2008publications/SWRCB-1000-2008-001/SWRCB-1000-2008-001.PDF.

[20] This is why the CDP's operations will not involve heat treatment.

[21] *See* 66 Fed. Reg. 65274; *see also* 40 C.F.R. 125.84(b)(2), 125.84(c)(1) (*cited in* Comment Letter of January 26, 2009 at Section V, Footnote 49).

[22] 66 Fed. Reg. 65274 (citing Boreman, J. 1977. Impacts of power plant intake velocities on fish. Power Plant Team, U.S. Fish and Wildlife Service; 33 Christianson, A. G., F. H. Rainwater, M.A. Shirazi, and B.A. Tichenor. 1973. Reviewing environmental impact statements: power plant cooling systems, engineering aspects, U.S. Environmental Protection Agency (EPA), Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon, Technical Series Report EPA–660/2–73–016; King, W. Instructional Memorandum RB–44: Review of NPDES (National Pollutant Discharge Elimination System) permit applications processed by the EPA (Environmental Protection Agency) or by the State with EPA oversight.'' In: U.S. Fish and Wildlife Service Navigable Waters Handbook.) (*cited in* Comment Letter of January 26, 2009 at Section V, Footnote 51).

[23] Sonnichsen, J.C., Bentley, G.F. Bailey, and R.E. Nakatani. 1973. A review of thermal power plant intake structure designs and related environmental considerations. Hanford Engineering Development Laboratory, Richland, Washington, HEDL–TME 73– 24, UC–12. (*cited in* Comment Letter of January 26, 2009 at Section V, Footnote 52).

[24] 66 Fed. Reg. 65274 (*cited in* Comment Letter of January 26, 2009 at Section V, Footnote 53).

[25] *Id* (*cited in* Comment Letter of January 26, 2009 at Section V, Footnote 54).

[26] *Id* (*cited in* Comment Letter of January 26, 2009 at Section V, Footnote 55).

studies[27] on fish swim speeds …[which] suggest that a 0.5 ft/s velocity would protect 96 percent of the tested fish[28].”

III. DATA SET INCLUDES TWO EVENTS WHERE FACTORS OTHER THAN FLOW APPEAR TO BE PRIMARY DRIVERS OF IMPINGEMENT

Inspection of the data set indicated that the vast majority of the data clustered around a range of flows and corresponding values of impingement. On two of the 52 sampling days, however, there seemed to be more impingement than could be accounted for on the basis of flow. These two events were given particular consideration as they suggest that, from time to time, the EPS's impingement primarily is influenced by factors other than flow at the intake. In essence, the data set appears to consist of two populations. For the vast majority of the time, perhaps fifty weeks per year, impingement is within a range where flow appears to be a meaningful influence.

Based on the data set, about two weeks out of the year, factors other than flow may be primary. This section focuses on that smaller population. Please note that the analysis presented in this section assumes that each of the two non-flow-related events will occur seven days each year. If in fact these events are associated with storm events, it will be important to examine the nature of these storms in order to get a better picture of the frequency of such events. If it is true that the non-flow-related events correspond to infrequent storm events, it may be warranted to assume that these events will repeat seven times per year. Doing so may be very conservative. Poseidon's experts continue to assess this matter.

1. January 12 and February 23, 2005 Data May be Outliers.

EPA defines the term “outliers” to include “measurements that are extremely large or small relative to the rest of the data set and…suspected of misinterpreting the population from which they were collected.”[29] The impingement totals on January 12 and February 23, 2005 were “extremely large” relative to the mean values of the other collection samples. As such they may qualify as outliers per EPA's definition.

On January 12 and February 23 of 2005, impingement was relatively high. During the 50 more typical sampling events, Tenera collected an average of 263 fish, with a daily biomass of 4.67 kg. Table 2 compares these mean values with the impingement totals collected on January 12 and February 23 and demonstrates the differing nature of these two days. On January 12, Tenera collected 5,001 fish weighing 109,526 grams. The number and weight of

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[27] *Id*. (*citing* University of Washington study [Smith, L.S., L.T. Carpenter. Salmonid Fry Swimming Stamina Data for Diversion Screen Criteria. Prepared by Fisheries Research Institute, University of Washington, Seattle, WA for Washington State Department of Fisheries and Washington State Department of Wildlife, 1987], Turnpenny [Turnpenny, A.W. H. The Behavioral Basis of Fish Exclusion from Coastal Power Station Cooling Water Intakes. Central Electricity Generating Board Research Report, RD/L/3301/R88, 1988], and EPRI [EPRI. Technical Evaluation of the Utility of Intake Approach Velocity as an Indicator of Potential Adverse Environmental Impact Under Clean Water Act Section 316(b). Technical Report. 1000731, 2001]) (*cited in* Comment Letter of January 26, 2009 at Section V, Footnote 56).

[28] 69 Fed. Reg. 41601.

[29] EPA (2006) Qa/G-9S Report Data Quality Assessment: Statistical Methods for Practitioners.

fish collected on that day were, respectively, 19 and 23.5 times greater than the other 50 days. On February 23, Tenera collected 1,274 fish weighing 29,531 grams. The number and weight of fish collected on February 23 were, respectively, 4.8 and 6.3 times greater than the other 50 days.

Table 2: comparison of flow-related and non-flow-related days				
	Number Fishes		**Weight**	
Average for the 50 normal sampling events	263		4.67 kg/day	
January 12, 2005	5,001	19 times greater than the average	109,526 (grams)	23.5 times greater than the average
February 23, 2005	1,274	4.8 times greater than the average	29,531 (grams)	6.3 times greater than the average

2. Non-flow-related Factors Contribute to Impingement.

A number of non-flow-related factors also cause impingement. For instance, water quality, temperature, salinity, urban runoff, herding behavior by predators (e.g., sea lions), attractants like light, and other factors each can affect impingement.[30] In 1977 the U.S. Fish and Wildlife Service reported that, "impingement rates of fishes are strongly influenced by temperature and salinity conditions in the vicinities of estuarine power plant intakes."[31]

An examination of the data for January 12 and February 23 suggests that some combination of these and/or other non-flow-related factors may have contributed to the relatively higher impingement totals observed on these days. On February 23, for instance, the EPS's flow was only 307 million gallons—the lowest flow volume recorded for the entire sampling period. Nevertheless, approximately 30 kg of fish biomass were collected on that day. Similarly, on January 12 the flow volume was 560 million gallons—about 15 percent less than the average 657 MGD amount recorded over the entire sampling period. Despite this below-average flow, Tenera collected nearly 110 kg of fish biomass.

While non-flow-related factors may have contributed significantly to the impingement recorded on January 12 and February 23, the exact nature of these factors is not clear. One theory is that heavy rains preceding the sampling events somehow caused the added

[30] It is unclear whether or to what extent these factors contributed to the two outlier sampling events. However, because only two of the 52 sampling events exhibited relatively high values (i.e., extreme events occurred only 3.85 % of the time of the study – 2/52 = 3.85 %), the analysis of the collected data indicates that a relationship between flow and impingement weight was observed more for more than 96% of the time. Since trends that persist over 95% of the time are usually considered significant, the exclusion of the two outliers establishes a correlation between impingement weight and flow that reflects commonly accepted scientific principles.

[31] Boreman, J. 1977. Impacts of power plant intake velocities on fish. Power Plant Team (p. 5), U.S. Fish and Wildlife Service.

impingement, e.g., by affecting water quality and/or salinity levels at or near the intake. Fish killed by urban runoff from these rains may have drifted to the mouth of the lagoon and eventually settled against the intake screens. This theory is supported by the large number of freshwater fishes that were collected on these two days.[32] For instance, 40 freshwater catfish were collected on these two days (2 on January 12th and 38 on February 23rd) while catfish were never collected on any other day. These catfish and other freshwater fishes[33] may have been flushed from Agua Hedionda Creek into the saltwater lagoon where they may have died before settling against the intake screens.

Given that the data are not available to control for all of the potential non-flow-related variables, we were not able to conduct a statistical analysis to account for these factors. Rather than hypothesizing as to why these events were outside the remainder of the data set, this memorandum identifies and evaluates different approaches that could be used to account for these data.

3. Outliers Are Typically Treated in One of Three Ways.

Outliers may be suspect and warrant careful examination. In the realm of statistical analysis, the appropriateness of their treatment depends on the nature of the observations. First, the outliers may simply be unusual values that have occurred by chance. In this case they should be retained without modifying the model. Second, they may represent erroneous data; if so, the data should be corrected or disregarded. Third, they may signal a violation of model assumptions; if so, another model should be considered.[34]

Three facts weigh against the application of the first option to the EPS data. First, as described above, the impingement values on the outlier days were significantly higher than the number and weight averages for the 50 other days. Second, the number of outlier events (2) was small relative to the number of other events (50)—in other words, only 4% of the samples were outside the remainder of the population. Third, these events followed heavy rains, which may have contributed to the increased impingement. These facts suggest that the outliers are not typical, but also not random, and, consequently, should either be declared erroneous and removed from the data set per the second option or treated specially under a modified model per the third.

IV. APPROACHES TO ESTIMATING THE POTENTIAL FOR IMPINGEMENT DURING STAND-ALONE OPERATIONS

This Section describes five different approaches to estimating the Project's impingement: (1) a correlation approach that excludes non-flow-related events altogether; (2) a correlation that then adds back the non-flow-related events; (3) an equivalence approach that

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[32] See Attachment 3, "IMPINGEMENT RESULTS, G1 - TRAVELING SCREEN AND BAR RACK WEEKLY SURVEYS, G2 - HEAT TREATMENT SURVEYS", pages G1-18, G1-23.

[33] In addition to the catfish that it collected on January 12 and February 23, Tenera also collected the following freshwater species: chubs (95), bluegill (16), green sunfish (15), sunfishes (1), and smallmouth bass (1). *See* Id.

[34] DAVID RAY ANDERSON ET AL., STATISTICS FOR BUSINESS AND ECONOMICS 588 (8th ed. 2002).

includes non-flow-related events; (4) a standard flow-proportioned approach that includes non-flow-related events; and (5) a flow-proportioned approach that adds back non-flow-related events. Each approach is evaluated by considering (a) the manner by which it accounts for the non-flow-related events, and (b) the extent to which it draws upon the well-recognized relationships between flow, velocity, and impingement.

The utility of the first approach, the regression analysis approach, is lessened because it treats the non-flow-related events as outliers without accounting for them. The second approach, the weighted average regression analysis, is deemed reasonable because it accounts for non-flow-related events while also reflecting the well-established relationship between flow and impingement. The utility of the third approach, the equivalence approach, is limited because it treats the data from both the flow-related and the non-flow-related populations the same, and does not account for the reduced flows and velocities relative to the sampling period. The fourth approach, the standard flow-proportioned approach, is deemed reasonable because it accounts for the non-flow-related events, and reflects the relationship between flow and impingement while providing a conservative estimate by not adjusting for the Project's reduced velocities. The fifth approach, the weighted average flow-proportioned approach, is recommended because it (a) accounts for non-flow-related events by treating them as a separate, but relevant and important, population, (b) reflects the relationship between flow and impingement, and (c) provides a conservative estimate by not adjusting for the Project's reduced velocities.

Table 3 summarizes the results of the five impingement estimation approaches. Results are presented in terms of number and weight (in grams) of fish impinged. The table indicates whether the results includes outlier values.

Table 3: estimates of CDP's stand-alone impingement based on five possible approaches

Approaches	**Treatment of Non-Flow-Related Events**	**Number of Fishes**	**Weight (kg/day)**
1. Regression (1-A)	Excluded	N/A	1.57
2. Regression (1-B)	Weighted Average	N/A	4.18
3. Equivalence (2)	Included	374	7.16
4. Proportional (3-A)	Included	188	3.74
5. Proportional (3-B)	Weighted Average	232	4.70

A. Approaches 1-A and 1-B: Regression Analyses

1. Explanation of the Approaches.

Both of the regression approaches employ statistical principles in order to characterize the potential for impingement from the Project's stand-alone operations. Both seek to develop a site-specific relationship between flow volume and impingement by plotting each of the 2004/2005 sampling events on a graph (Figure 1) where the X axis represents the EPS's flow and the Y axis represents the amount of impingement (in terms of kg/day). Each point on this graph represents data obtained from one sampling event—i.e., the total weight of fishes impinged and the total flow drawn through the EPS's intake structure over a 24-hour period. Figure 1 contains 50 plotted points—one for each of the 52 days of the year, excluding two samples considered for this particular analysis to be outliers.

The regression approaches are different to the extent that they treat the outliers differently. Regression Approach 1-A excludes the outliers from the analysis altogether. It operates on the assumption that the outliers represent erroneous data that should be disregarded.

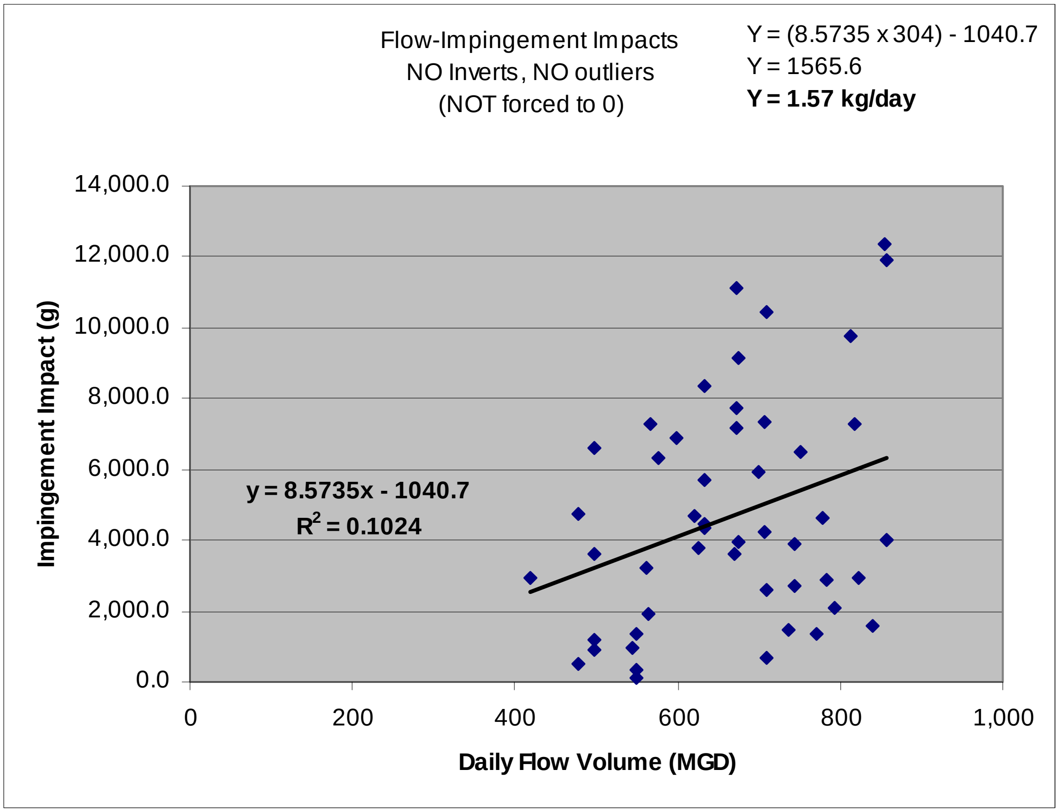
Regression Approach 1-B, on the other hand, accounts for the outliers by treating them as a population separate and distinct from the other 50 events. This approach makes a distinction between flow-related events—i.e., the 50 more typical data points—and non-flow-related events—i.e., the two other days with higher relative impingement. Regression Approach 1-B calculates a weighted average between (a) the regression result for the 50 more typical events and (b) the average of the non-flow-related events as follows:

$$\text{Daily Impingement} = {(\text{regression value for normal events x } 50) + (\text{outlier average x } 2)} \big/ {52}$$

2. <u>Results of the Regression Approaches:</u>

The regression approaches use the least-squares methods to calculate a line through the data points that is described by the following equation: y = (8.5735 x 304) – 1040.7. Based upon the Project's flow of 304 MGD, this approach calculates a straight-line extrapolation value of 1.57 kg/day (i.e., (8.5735 x 304 – 1040.7) x 304/1000).

<u>Figure 1</u>: Regression Analysis



a. Approach 1-A: 1.57 kg/day

b. Approach 1-B: 4.18 kg/day

$$\text{Daily impingement result} = ((1{,}566 \times 50) + (((109{,}526 + 29{,}531)/2) \times 2)) / 52$$

$$(78{,}300 + 69{,}528.5 \times 2) / 52$$

$$(78{,}300 + 139{,}057) / 52$$

$$(217{,}357) / 52$$

$$4{,}180 \text{ grams/day}$$

3. Evaluation of the Approaches. The regression approaches provide methods by which to attempt to account for the generally recognized relationship between flow and impingement. The results of the regression generally are consistent with the proposition that impingement declines as flow decreases, but there are weaknesses in the statistics.

The regression yields a y-intercept that is less than zero.[35] While impingement should be about zero when there are no flows, it will not be less than zero, as the regression suggests. This outcome is not physically possible. In addition, the regression requires an extrapolation beyond the data set, since flows as low as 304 MGD were not observed during the 2004-2005 sampling events.

a. Regression Approach 1-A. By excluding outliers altogether, this approach does not account for the fact that the data show that on certain occasions (i.e., 4% of the time), non-flow-related factors may result in relatively higher impingement. While these data points may reflect errors that occurred in the sampling process and would hence be justifiably excluded, without further information, there is an insufficient basis upon which to draw such a conclusion at this juncture.

b. Regression Approach 1-B. This approach is reasonable to the extent that it accounts for the non-flow-related events and results in a higher impingement estimate in doing so. The weaknesses inherent in the statistics, however, remain present.

B. Approach 2: Equivalence

1. Explanation of the Approach. The equivalence approach assumes that there is no difference between the EPS's impingement and the CDP's projected impingement, even though the CDP will be operating at substantially lower flows than those recorded during the EPS sampling period. For each discrete sampling event that resulted in the collection of a given number and weight of impinged fishes, the approach assumes that the Project's stand-alone impingement would have been the same. For instance, the data show that on June 24, 2004, the EPS withdrew 632 million gallons of seawater, which resulted in the impingement of 287 fish that weighed 0.436 kg in total. The assumed equivalence approach estimates that the Project would impinge the same number and weight of fish (i.e., 287 and 0.436 kg, respectively) as the EPS, notwithstanding its significantly lower flow of 304 MGD.

2. Result of the Approach.

a. 374 fish weighing 7.16 kg/day (including non-flow-related events)

b. 263 fish weighing 4.67 kg/day (excluding non-flow-related events)

[35] The main reason for the deviation from the linear relationship, however is that impingement is reduced abruptly when the screen velocity falls below 0.5 fps, which is the basis upon which EPS established BTA as 0.5 fps. *See e.g.,* 66 Fed. Reg. 65274.

3. Evaluation of the Approach. It may make sense to use the EPS's impingement at higher flow rates to make a first-order assessment as to whether the CDP might bear a minimization obligation with respect to impingement. Based on general principles, it can be reasonably anticipated that impingement during stand-alone operations at 304 MGD will be less than the impingement that actually occurred during the 2004-2005 sampling period at an average of 657 MGD. Thus, if the EPS impingement were such that it required no minimization, or plainly was offset by planned mitigation measures, one could stop there. In the event that the EPS impingement implies a need for minimization or mitigation, one would want to obtain a value of projected impingement for the CDP itself, which this approach does not provide.

The equivalence approach is easy to apply, and incorporates non-flow-related events, but is limited in utility as described above, and uses the impingement from one project, the EPS, to characterize the impingement for another project, the CDP, without taking into account any of the important differences between these two projects. The equivalence approach also suffers from the fact that it fails to make any distinction whatsoever between two populations that plainly are distinct. In so doing, the equivalence approach allows the non-flow-related events to skew the impingement estimate. Finally, the equivalence approach ignores relationships between flow and impingement that are well-recognized in the scientific literature. In addition to not accounting for flow reduction, the equivalence approach does not account for velocity reduction associated with the reduced flows.

Two hypothetical scenarios illustrate the equivalence approach's inherent limitations. In the first scenario, assume that the EPS had withdrawn 1.26 billion gallons of water on June 24, 2004—an amount that (a) is twice the 632 million gallons amount that the facility actually withdrew on that day (b) and approximates the factor by which the EPS's flow will actually exceed the CDP's. The equivalence approach would ignore this extreme flow differential and assume that the EPS's operations would have resulted in the impingement of only 287 fish. In the second scenario, assume that the EPS's steam-generating units had been shut down on June 24, 2004. In the event of an outage, the facility will probably turn off its cooling water pumps but it will continue to pump approximately 60 MGD via its smaller saltwater service pumps.[36] Even if the EPS had withdrawn 60 million gallons on June 24, 2004 instead of its actual flow of 632 million gallons, the equivalence approach would ignore the extreme flow differential and assume that the Project's operations would still have resulted in the impingement of 287 fish.

C. Approaches 3-A and 3-B: Flow-Proportioned Approaches

1. Explanation of the Approaches.

The two flow-proportioned approaches assume that the Project's stand-alone impingement will be related to the EPS's impingement based on its proportional flow. Both approaches estimate the Project's impingement by adjusting the EPS's impingement by its reduced flow percentage. The manner by which they each do so, however, is somewhat different.

[36] Saltwater service pumps (SWSP) supply water for a variety of purposes, e.g., cooling of small capacity heat exchangers, lubrication of rotating equipment, etc.

a. Standard Flow-Proportioned Approach 3-A.

Approach 3-A simply adjusts the EPS's impingement by the Project's reduced flow percentage. For instance, on June 24, 2004, the Project's flow volume would have been 48.1% that of the EPS (304/632). The standard flow-proportioned approach would adjust the impingement resulting from the EPS's operations on that day by 48.1%. This calculation estimates that the Project's stand-alone operations would result in the impingement of 138 fish (48.1% x 287) weighing 0.209 kg (48% of 0.436 kg).

b. Weighted Average Flow-Proportioned Approach 3-B.

Approach 3-B is similar to Regression Analysis Approach 1-B in that both approaches account for the non-flow-related events by treating them as a population distinct from the other 50 events. Approach 3-B makes a distinction between flow-related events—i.e., the 50 data points—and non-flow-related events—i.e., the 2 days with relatively higher impingement. Whereas Regression Approach 1-B calculates a weighted average on the basis of the regression result, however, the flow-proportioned approach prorates the 50 more typical events and uses this value along with the average of the non-flow-related events to estimate a weighted average. The model operates as follows:

$$\text{Daily Impingement} = {(\text{prorated value for normal events x } 50) + (\text{outlier average x } 2)} \big/ {52}$$

$$\text{Daily impingement result} = ((2{,}111 \text{ grams} \times 50 \text{ days}) + (((109{,}526 \text{ grams} + 29{,}531 \text{ grams}) / 2) \times 2)) \big/ 52$$

$$(105{,}550 + 69{,}528.5 \times 2) \big/ 52$$

$$(105{,}550 + 139{,}057) \big/ 52$$

$$(244{,}607) \big/ 52$$

$$4{,}704 \text{ grams/day}$$

$$\text{Daily impingement result} = ((116 \text{ fishes} \times 50 \text{ days}) + (((5{,}001 \text{ fishes} + 1{,}274 \text{ fishes}) / 2) \times 2)) \big/ 52$$

$$(5{,}800 + 3137.5 \times 2) \big/ 52$$

$$(5{,}800 + 6{,}275) \big/ 52$$

$$(12{,}075) \big/ 52$$

$$232 \text{ fishes/day}$$

2. Results of the Approaches.

a. Approach 3-A: 188 fish weighing 3.74 kg/day

b. Approach 3-B: 232 fish weighing 4.70 kg/day

3. Evaluation of the Approaches. The flow-proportioned approaches provide methods by which to account for the relationship between flow and impingement. The approaches show that impingement declines as flow decreases, which appropriately reflects EPA's understanding that impingement is in fact related to flow.

The approaches are conservative and similar to the others to the extent that they include the non-flow-related events, and do not fully account for the impingement reductions that may arise when the Project reduces flow velocities. Since velocity is a function of flow, the fact that the Project will evenly distribute its flow over the longest possible time periods means that the Project will reduce its intake velocity meaningfully below that of the EPS. In addition, by using the EPS's 2004/2005 impingement data—data that reflect the impingement associated with the EPS's variable flow and higher velocities—the flow-proportioned approaches are based on a data set which would appear to be conservative for the purpose of estimating the Project's potential impingement.

a. Standard Flow-Proportioned Approach 3-A.

The standard flow-proportioned approach does not distinguish between the 50 more typical, flow-related events and the two non-flow-related events. Rather, it is used to estimate a daily average based on the inclusion of all of these values. Because it appears that the two non-flow-related events represent days during which various factors other than flow resulted in relatively higher impingement, it may be more reasonable to exclude these values from the overall prorated calculation. In other words, it may not make sense to rely on the flow-impingement relationship for those days when flow was not a principal driver of impingement.

b. Weighted Average Flow-Proportioned Approach 3-B.

The weighted average-flow proportioned approach does not include flow-independent days in the prorated calculation. This modified model responds to the two-population issue by assuming that on 2/50 days—i.e., 4% of the time—factors other than flow will drive impingement, and may result in relatively higher impingement.

The proportional approach is limited somewhat, however, because it assumes that the relationship between flow and impingement is always directly proportional. Even on more typical days, we cannot be certain that a 50% reduction in flow will result in an exactly proportional reduction in impingement. Nevertheless, the weighted average, flow-proportioned approach reasonably approximates the potential for impingement from the Project by accounting for the important relationship between flow and impingement. Its reasonableness is supported by the conservative manner by which it discounts the benefits of reduced flow velocities.

V. CONCLUSION

The relevant facts, data, and scientific principles and literature indicate that the weighted average, flow-proportioned approach provides a reasonable, conservative estimate of the potential for impingement from the Project. By treating the non-flow-related events separately and accounting for the relationship between flow and impingement while discounting the fact that the intake flow velocities during stand-alone operations will be lower than the velocities that occurred during the sampling period, this approach provides a reasonable basis for estimating that impingement during such operations will be approximately 4.70 kg/day of fish biomass. Employing calculations that are consistent with generally accepted scientific principles, this method provides the Regional Board a rational basis upon which to base its Section 13142.5(b) analysis.

CARLSBAD SEAWATER DESALINATION PROJECT

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

REGION 9, SAN DIEGO REGION

ORDER NO. R-9-2006-0065

NPDES NO. CA0109223

FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

ATTACHMENT 6 - CARLSBAD DESALINATION FACILITY – ENCINA POWER STATION, SUMMARY OF FISH AND TARGET SHELLFISH LARVAE COLLECTED FOR ENTRAINMENT AND SOURCE WATER STUDIES IN THE VICINITY OF AGUA HEDIONDA LAGOON FROM JUNE 2004 THROUGH MAY 2005.

March 27, 2009

Carlsbad Desalination Facility
Encina Power Station

Summary of Fish and Target Shellfish Larvae Collected for Entrainment and Source Water Studies in the Vicinity of Agua Hedionda Lagoon from June 2004 through May 2005

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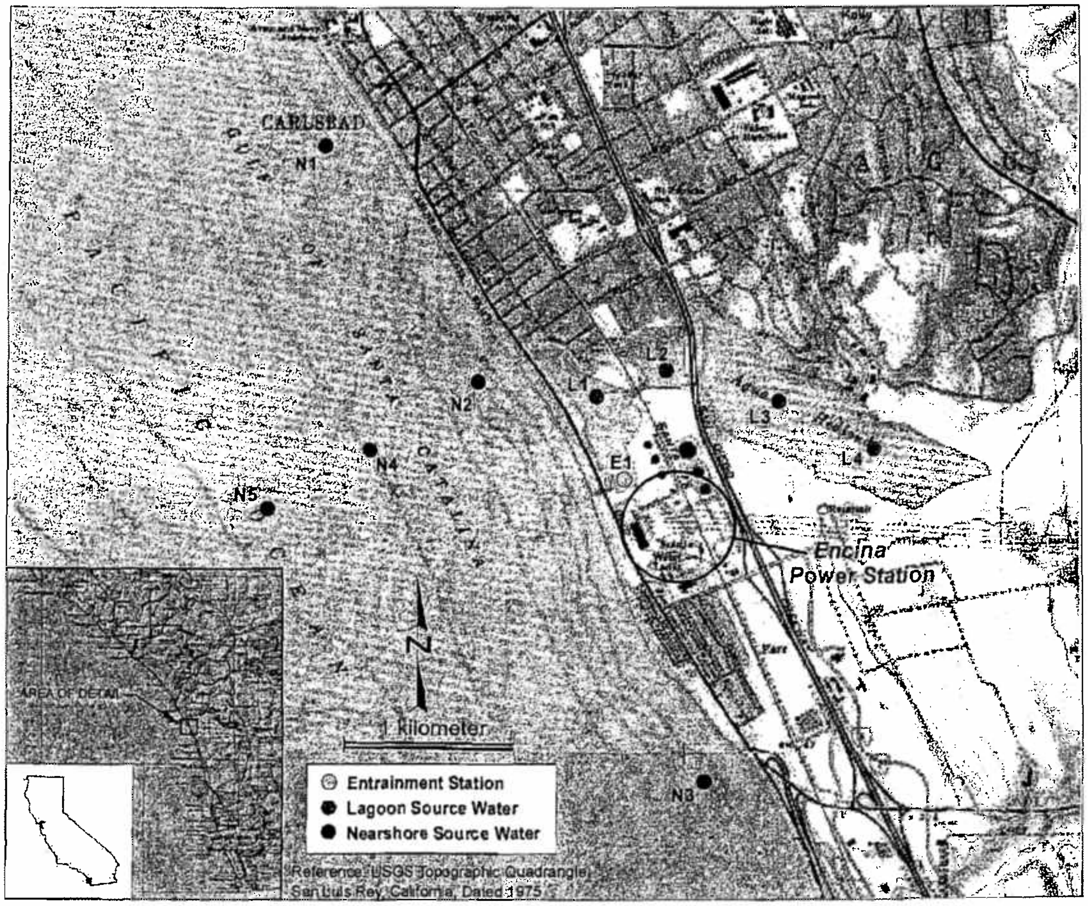


Figure 1. Location of entrainment (E1) and source water (L1–L4; N1–N5) plankton sampling stations.

Table 1. Average concentration and total number collected of larval fishes and target shellfishes in entrainment samples collected in Agua Hedionda Lagoon (Station E1), June 2004–May 2005.

Taxon	Common Name	Average Concentration (# / 1,000 m^3)	Total Count	Percentage of Total	Cumulative Percentage
Gobiidae (CIQ complex)	gobies	2,222.93	12,763	61.95	61.95
Hypsoblennius spp.	blennies	1,107.67	5,838	28.34	90.29
Engraulidae	anchovies	134.29	819	3.98	94.27
Hypsypops rubicundus	garibaldi	40.99	188	0.91	95.18
Typhlogobius californiensis	blind goby	24.65	148	0.72	95.90
Gibbonsia spp.	clinid kelpfishes	22.45	125	0.61	96.51
Labrisomidae.	labrisomid kelpfishes	17.65	81	0.39	96.90
Syngnathidae	pipefishes	16.06	83	0.40	97.30
Acanthogobius flavimanus	yellowfin goby	14.41	87	0.42	97.72
larvae, unid. fish fragment	unid. larval fishes	9.65	56	0.27	98.00
Atherinopsidae	silversides	9.18	54	0.26	98.26
larvae, unid. yolksac	unid. yolksac larvae	8.36	39	0.19	98.45
Roncador stearnsii	spotfin croaker	8.33	42	0.20	98.65
Rimicola spp.	kelp clingfishes	7.92	43	0.21	98.86
Genyonemus lineatus	white croaker	7.04	44	0.21	99.07
Seriphus politus	queenfish	5.50	29	0.14	99.21
Paraclinus integripinnis	reef finspot	4.95	31	0.15	99.36
Paralichthys californicus	California halibut	3.73	21	0.10	99.47
Sardinops sagax	Pacific sardine	2.66	16	0.08	99.54
Citharichthys spp.	sanddabs	2.24	14	0.07	99.61
Gillichthys mirabilis	longjaw mudsucker	2.14	13	0.06	99.67
Sciaenidae	croakers	1.86	11	0.05	99.73
Paralabrax spp.	sea basses	1.86	11	0.05	99.78
Hypsopsetta guttulata	diamond turbot	1.78	10	0.05	99.83
larvae, unid. post-yolksac	larval fishes	1.61	10	0.05	99.88
Pleuronectiformes	flatfishes	0.63	4	0.02	99.90
Heterostichus rostratus	giant kelpfish	0.54	3	0.01	99.91
Clinocottus analis	wooly sculpin	0.51	3	0.01	99.93
Stenobrachius leucopsarus	northern lampfish	0.37	2	0.01	99.94
Cheilotrema saturnum	black croaker	0.35	2	0.01	99.95
Scomber japonicus	Pacific mackerel	0.35	1	<0.01	99.95
Ophidiidae	cusk-eels	0.21	1	<0.01	99.96
Gobiesocidae	clingfishes	0.20	1	<0.01	99.96
Diaphus theta	Calif. headlight fish	0.19	1	<0.01	99.96
Semicossyphus pulcher	California sheephead	0.19	1	<0.01	99.97
Menticirrhus undulatus	California corbina	0.18	1	<0.01	99.97
Haemulidae	grunts	0.18	1	<0.01	99.98
Labridae	wrasses	0.17	1	<0.01	99.98
Myctophidae	lanternfishes	0.16	1	<0.01	99.99
Symbolophorus californiensis	California lanternfish	0.16	1	<0.01	99.99
Oxyjulis californica	señorita	0.14	1	<0.01	100.00
			20,601		
Cancer spp. (megalops)	cancer crabs	0.17	1		0.07

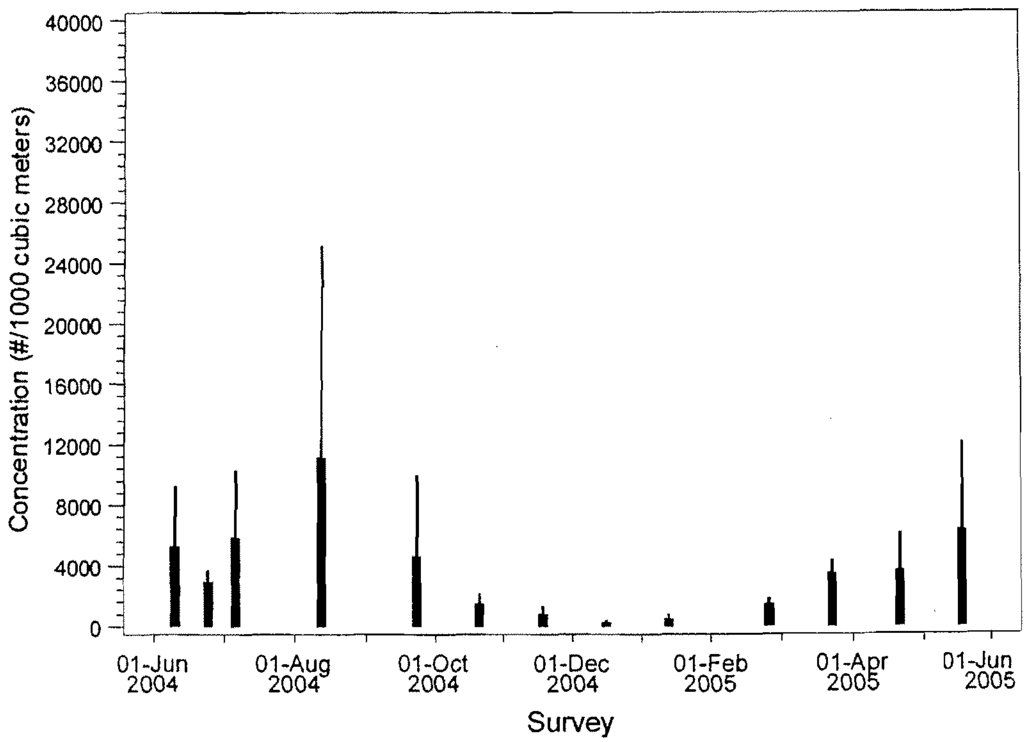


Figure 2. Mean concentration (# / 1,000 m^3 [264,172 gal]) and standard error of all larval fishes collected at entrainment Station E1 during monthly surveys, June 2004–May 2005.

Table 2. Average concentration of larval fishes and target shellfishes in source water samples collected at Agua Hedionda Lagoon and nearshore stations, June 2004–May 2005.

		Nearshore		Lagoon	
Taxon	**Common Name**	**Average Concentration (# / 1,000 m³)**	**Total Count**	**Average Concentration (# / 1,000 m³)**	**Total Count**
Fishes					
Engraulidae	anchovies	525.48	7,631	103.41	1,210
Hypsoblennius spp.	blennies	137.56	1,966	467.32	4,725
Gobiidae (CIQ complex)	gobies	69.12	921	2,718.58	30,270
Genyonemus lineatus	white croaker	64.66	921	4.25	54
larvae, unidentified yolksac	unid. yolksac larvae	45.82	678	3.12	32
Paralichthys californicus	California halibut	42.91	601	1.93	22
Paralabrax spp.	sand basses	24.88	372	0.68	8
Seriphus politus	queenfish	23.79	365	2.40	26
Sciaenidae	croaker	22.55	306	6.56	73
Citharichthys spp.	sanddabs	21.70	334	1.14	15
Roncador stearnsii	spotfin croaker	20.17	286	6.82	74
Gibbonsia spp.	clinid kelpfishes	19.29	277	16.74	182
Labrisomidae	labrisomid kelpfishes	16.36	219	35.30	366
Sardinops sagax	Pacific sardine	13.21	202	0.74	9
larval fish fragment	unid. larval fishes	10.50	145	15.02	174
Haemulidae	grunts	8.80	116	0.17	2
Scomber japonicus	Pacific mackerel	7.07	110	-	-
Hypsypops rubicundus	garibaldi	7.03	110	35.12	352
larval/post-larval fish unid.	larval fishes	6.81	93	1.36	16
Oxyjulis californica	senorita	5.55	79	0.75	8
Paralabrax nebulifer	barred sand bass	5.08	82	-	-
Sphyraena argentea	California barracuda	3.74	59	0.17	2
Xenistius californiensis	salema	3.61	55	0.30	3
Lepidogobius lepidus	bay goby	3.59	56	0.09	1
Stenobrachius leucopsarus	northern lampfish	3.26	51	-	-
Atherinopsidae	silversides	3.09	39	29.73	348
Pleuronichthys verticalis	hornyhead turbot	2.79	43	-	-
Umbrina roncador	yellowfin croaker	2.62	39	0.09	1
Ophidiidae	cusk-eels	2.61	37	0.09	1
Pleuronichthys ritteri	spotted turbot	2.51	34	0.17	2
Pleuronectidae unid.	flounders	2.28	35	0.08	1
Xystreurys liolepis	fantail sole	1.97	27	0.21	2
Hypsopsetta guttulata	diamond turbot	1.97	30	0.55	7
Rimicola spp.	kelp clingfishes	1.79	22	3.28	34
Peprilus simillimus	Pacific butterfish	1.78	28	-	-
Cheilotrema saturnum	black croaker	1.71	24	0.36	4
Semicossyphus pulcher	California sheephead	1.49	21	-	-
Diaphus theta	Calif. headlight fish	1.46	24	-	-
Acanthogobius flavimanus	yellowfin goby	1.46	22	38.98	499
Pleuronectiformes	flatfishes	1.25	21	0.07	1
Menticirrhus undulatus	California corbina	1.21	16	0.47	5
Atractoscion nobilis	white seabass	1.18	18	0.08	1
Sebastes spp.	rockfishes	1.09	18	-	-

(table continued)

Table 2 (continued). Average concentration of larval fishes and target shellfishes in source water samples collected at nearshore stations and Agua Hedionda Lagoon, June 2004-May 2005.

		Nearshore		Lagoon	
Taxon	**Common Name**	**Average Concentration (# / 1,000 m³)**	**Total Count**	**Average Concentration (# / 1,000 m³)**	**Total Count**
Girella nigricans	opaleye	1.06	16	-	-
Syngnathidae	pipefishes	1.02	13	5.31	53
Typhlogobius californiensis	blind goby	0.99	15	9.63	118
Trachurus symmetricus	jack mackerel	0.96	17	-	-
Halichoeres semicinctus	rock wrasse	0.95	15	-	-
Labridae	wrasses	0.83	11	-	-
Paraclinus integripinnis	reef finspot	0.81	14	2.88	31
Symphurus atricaudus	California tonguefish	0.77	11	-	-
Triphoturus mexicanus	Mexican lampfish	0.73	12	0.16	2
Nannobrachium spp.	lanternfishes	0.57	9	-	-
Medialuna californiensis	halfmoon	0.53	7	-	-
Gillichthys mirabilis	longjaw mudsucker	0.51	8	5.17	62
Chilara taylori	spotted cusk-eel	0.50	7	-	-
Heterostichus rostratus	giant kelpfish	0.50	7	-	-
Paralichthyidae	lefteye flounders	0.44	7	-	-
Parophrys vetulus	English sole	0.30	5	-	-
Myctophidae	lanternfishes	0.30	4	-	-
Hippoglossina stomata	bigmouth sole	0.29	5	-	-
Zaniolepis frenata	shortspine combfish	0.25	5	-	-
Ruscarius creaseri	roughcheek sculpin	0.22	3	-	-
Clupeiformes	herrings and anchovies	0.21	3	-	-
Gobiesocidae	clingfishes	0.18	3	0.64	7
Clupeidae	herrings	0.18	3	-	-
Lyopsetta exilis	slender sole	0.16	3	-	-
Pomacentridae	damselfishes	0.14	2	-	-
Rhinogobiops nicholsii	blackeye goby	0.14	2	-	-
Nannobrachium ritteri	broadfin lampfish	0.13	2	-	-
Cyclothone spp.	bristlemouths	0.13	2	-	-
Chromis punctipinnis	blacksmith	0.13	2	-	-
Icelinus spp.	sculpins	0.13	3	-	-
Anisotremus davidsonii	sargo	0.12	2	-	-
Sebastes jordani	shortbelly rockfish	0.10	2	-	-
Blennioidei	blennies	0.08	1	0.36	4
Clinidae	clinid kelpfishes	0.08	1	-	-
Chaenopsidae	tube blennies	0.07	1	-	-
Leptocottus armatus	Pacific staghorn sculpin	0.07	1	0.51	6
Cynoglossidae	tongue soles	0.07	1	-	-
Kyphosidae	sea chubs	0.07	1	-	-
Cyclothone acclinidens	benttooth bristlemouth	0.07	1	-	-
Hexagrammidae	greenlings	0.06	1	-	-
Bathylagus ochotensis	popeye blacksmelt	0.06	1	-	-
Hypsoblennius gentilis	bay blenny	0.05	1	-	-
Rimicola eigenmanni	slender clingfish	-	-	4.13	53
Clinocottus analis	wooly sculpin	-	-	0.31	4
Clinocottus spp.	sculpins	-	-	0.07	1
Semicossyphus pulcher	California sheephead	-	-	0.06	1
			16,763		38,872
Shellfishes					
Cancer spp. (megalops)	cancer crabs	9.29	158	0.17	2
Panulirus interruptus (larval)	California spiny lobster	7.04	98	0.21	2
Cancer gracilis (megalops)	slender crab	2.93	48		

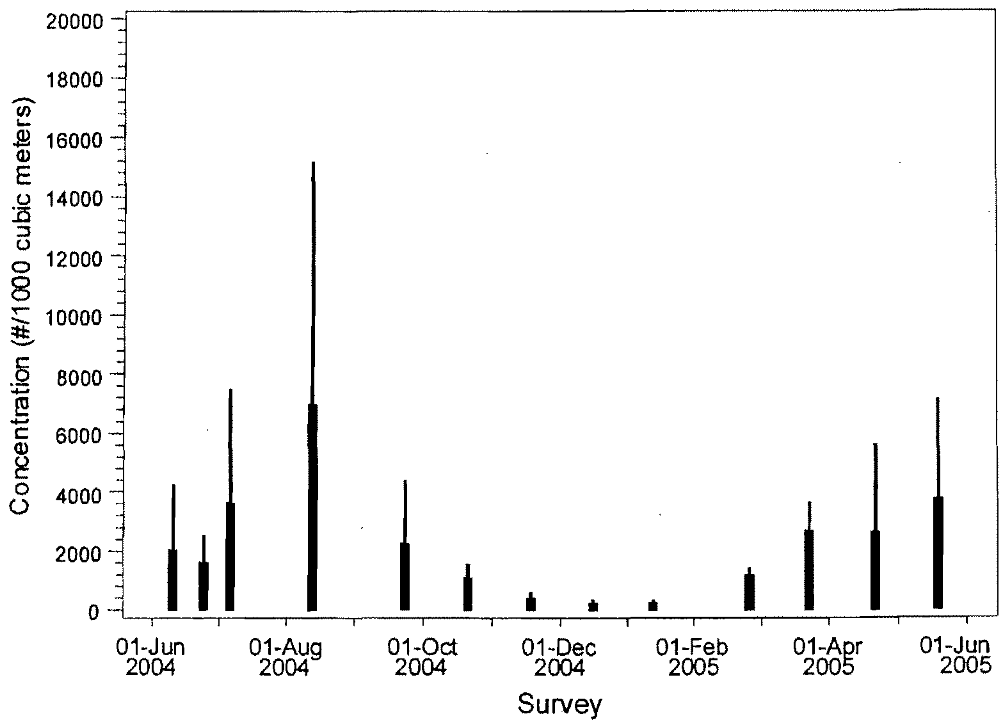


Figure 3. Comparison among surveys of mean concentration (#/1,000 m^3 [264,172 gal]) of CIQ goby complex larvae at entrainment Station E1.

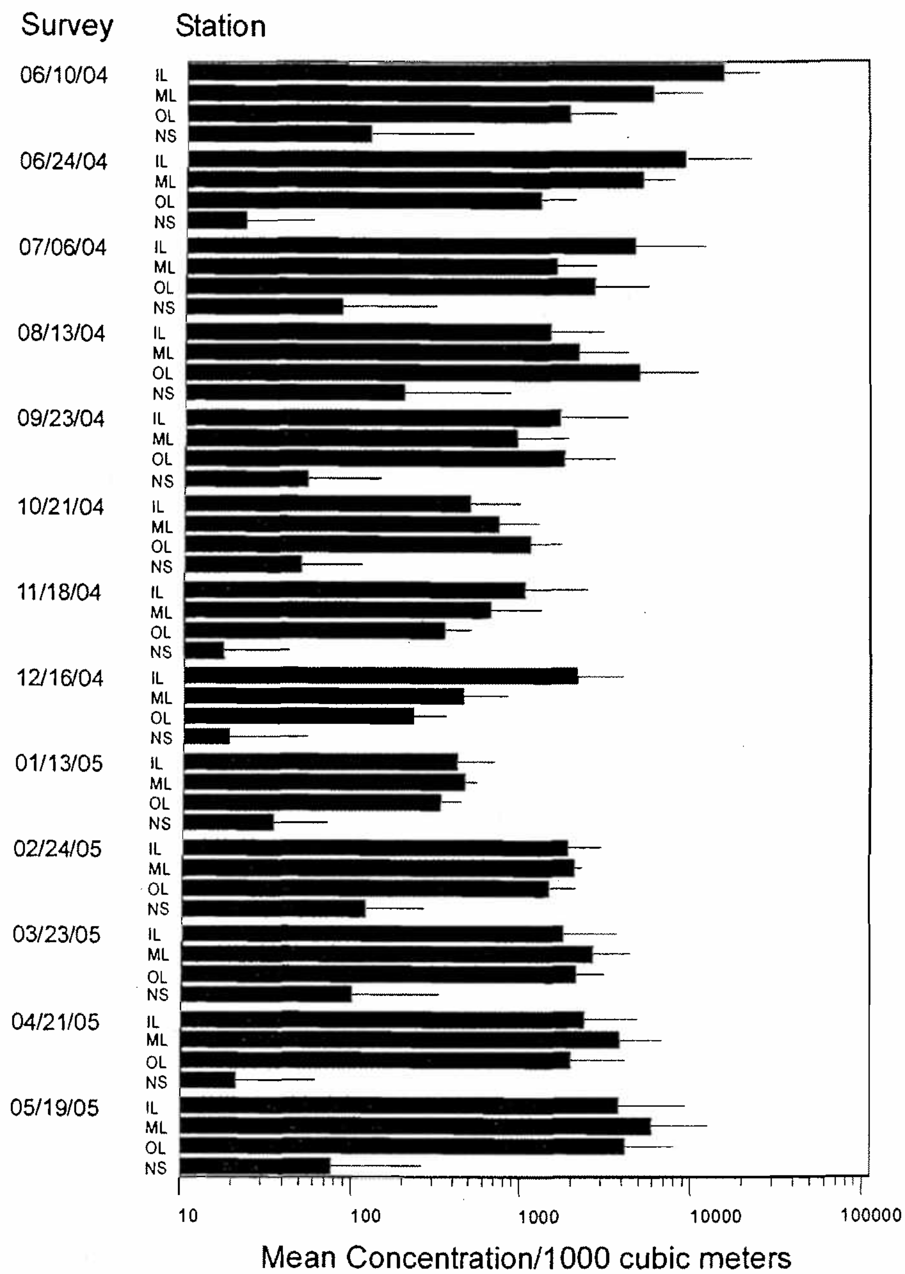


Figure 4. Mean concentration (#/1,000 m^3 [264,172 gal]) and standard error of CIQ goby complex larvae at Agua Hedionda Lagoon (inner, middle, and outer) and nearshore source water stations during the 2004 and 2005 sampling periods. Note logarithmic abundance scale.

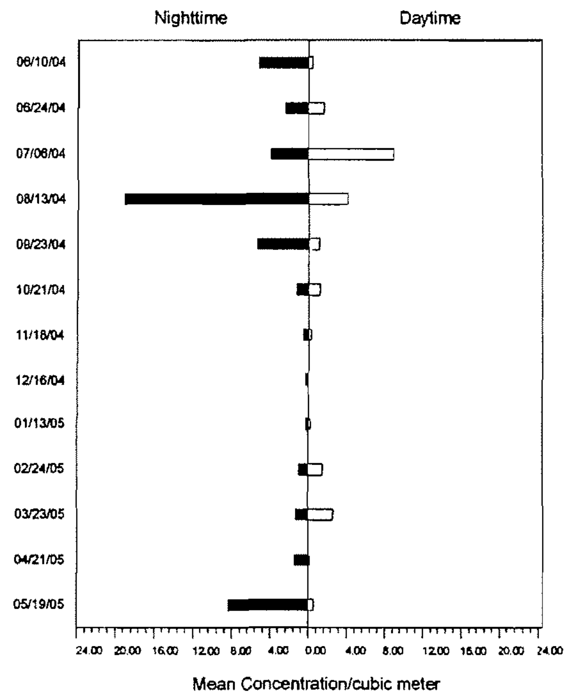


Figure 5. Mean concentration (#/1.0 m^3 [264 gal]) of CIQ goby complex larvae at entrainment Station E1 during night (Cycle 3) and day (Cycle 1) sampling.

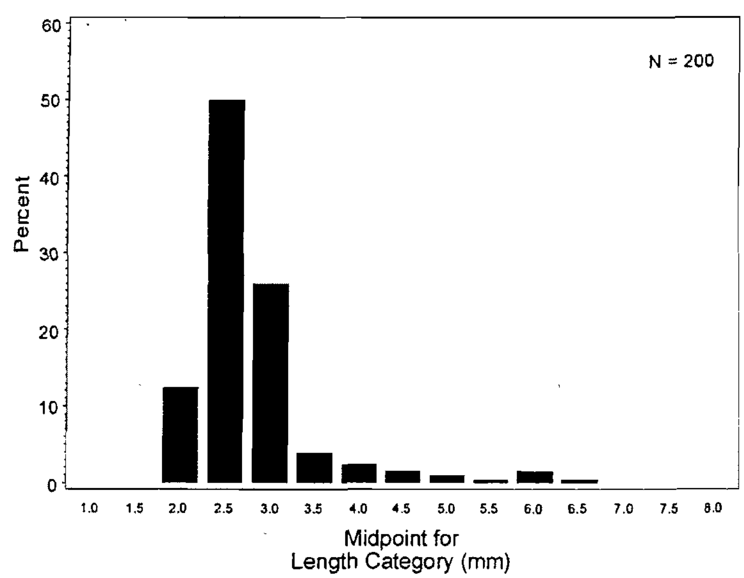


Figure 6. Length frequency of CIQ goby complex larvae at entrainment Station E1. Data from sub-samples of all surveys in 2004–2005.

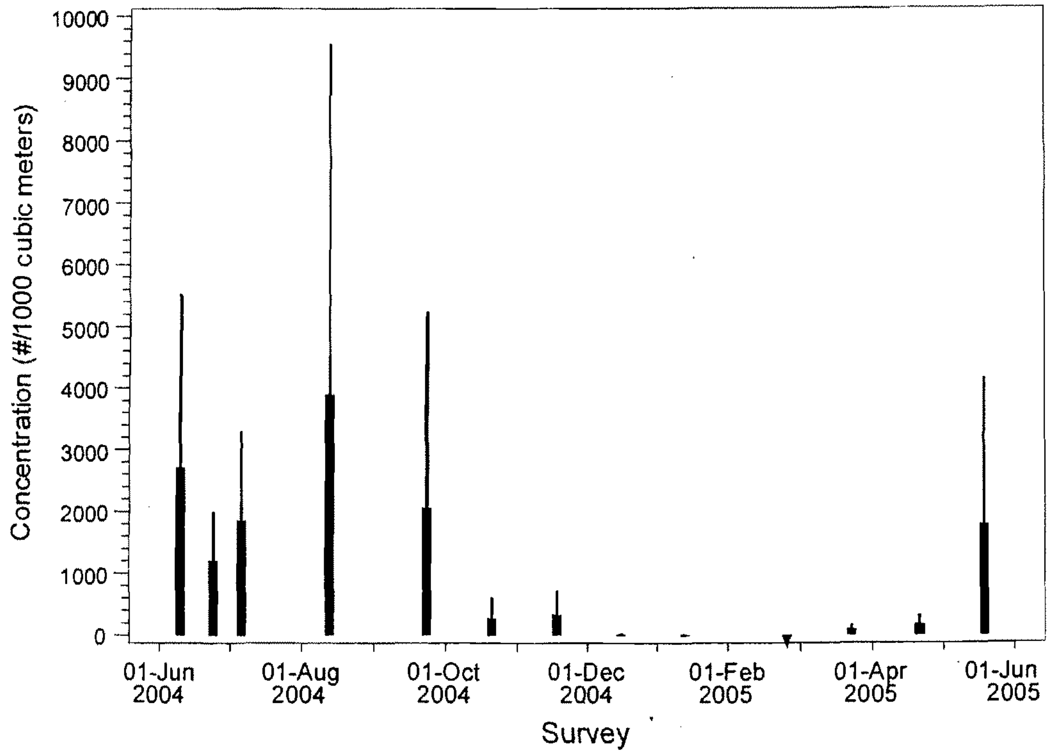
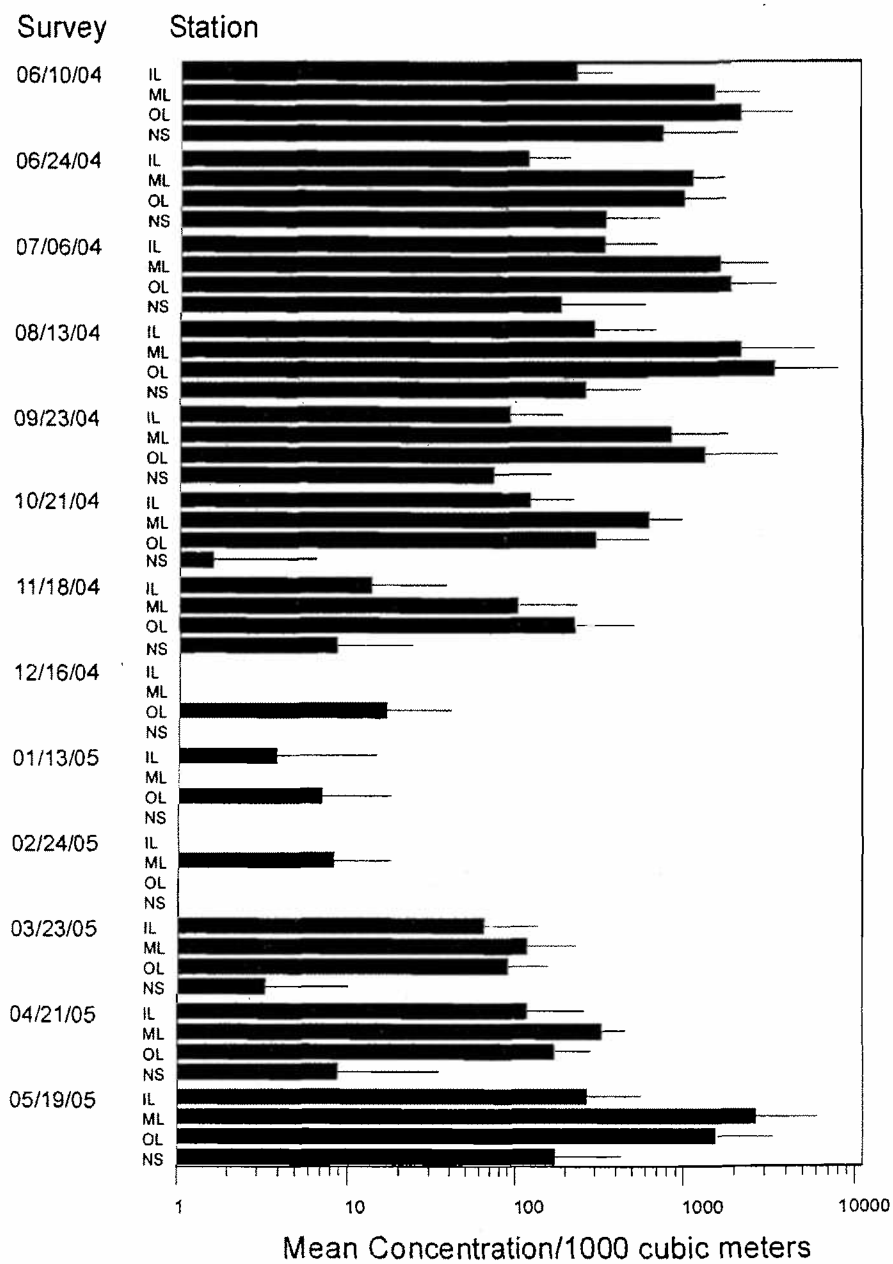


Figure 7. Comparison among surveys of mean concentration (#/1000 m^3 [264,172 gal]) of combtooth blenny larvae at entrainment Station E1. Note: downward pointing triangle indicates survey with no larvae collected.



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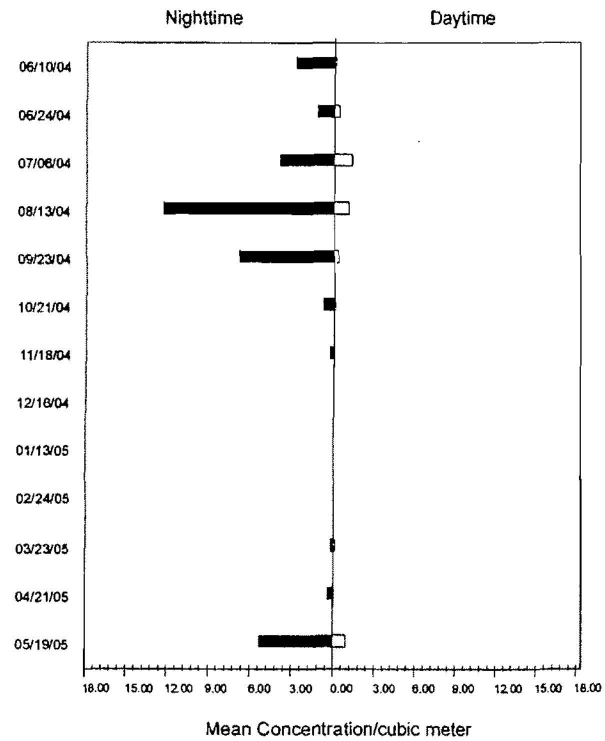

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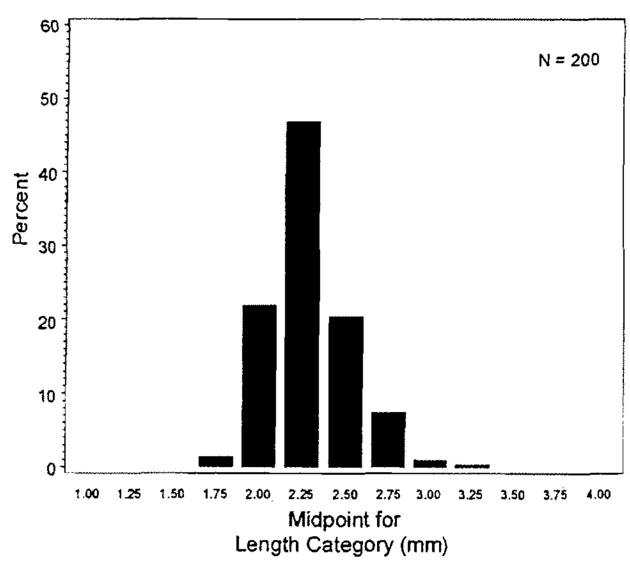
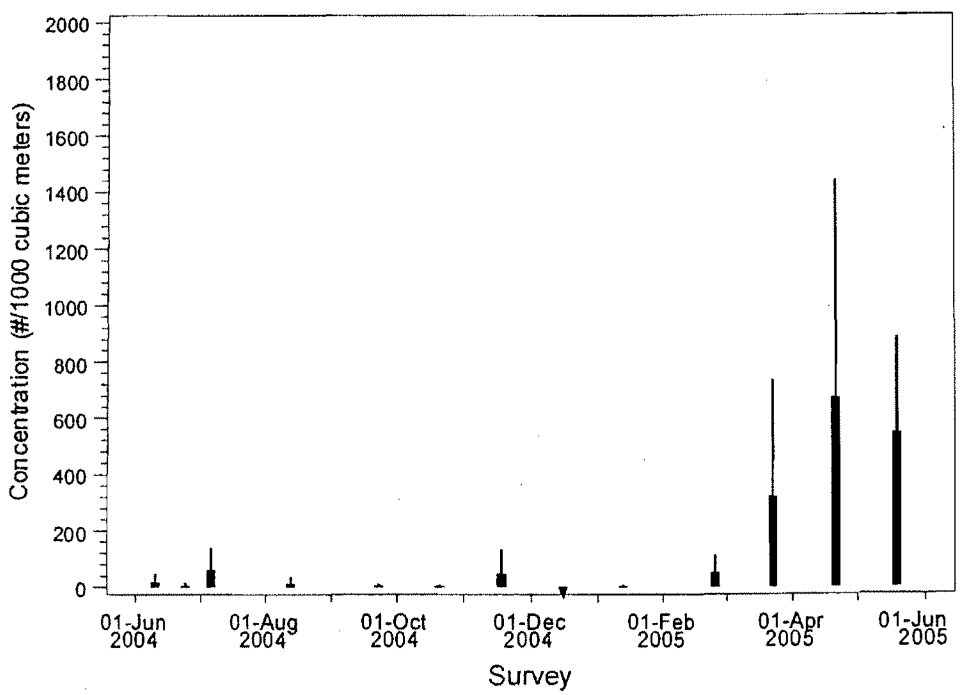


Figure 10. Length frequency of combtooth blenny larvae at entrainment and all source water stations combined. Data from sub-samples of all surveys in 2004–2005.



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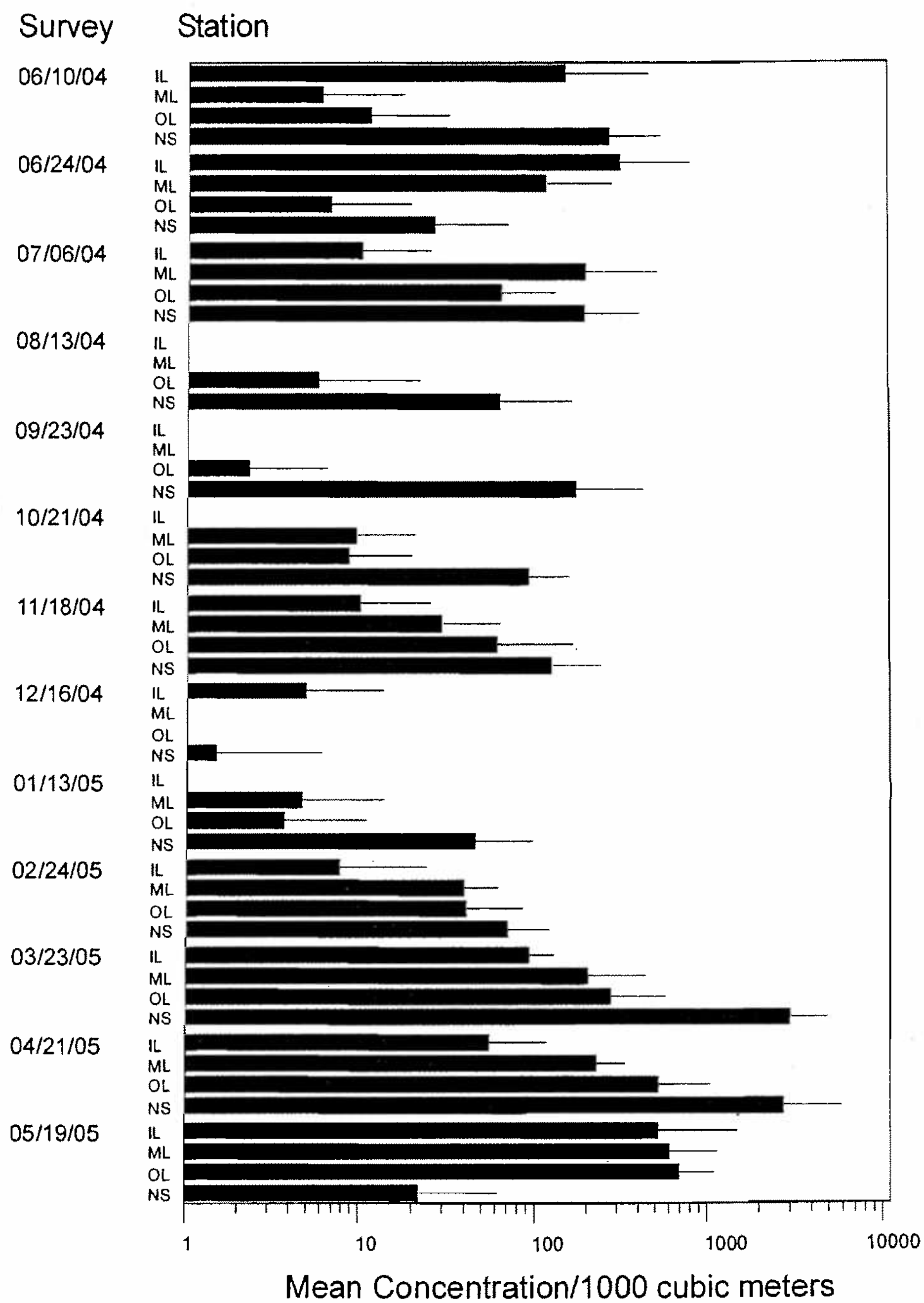

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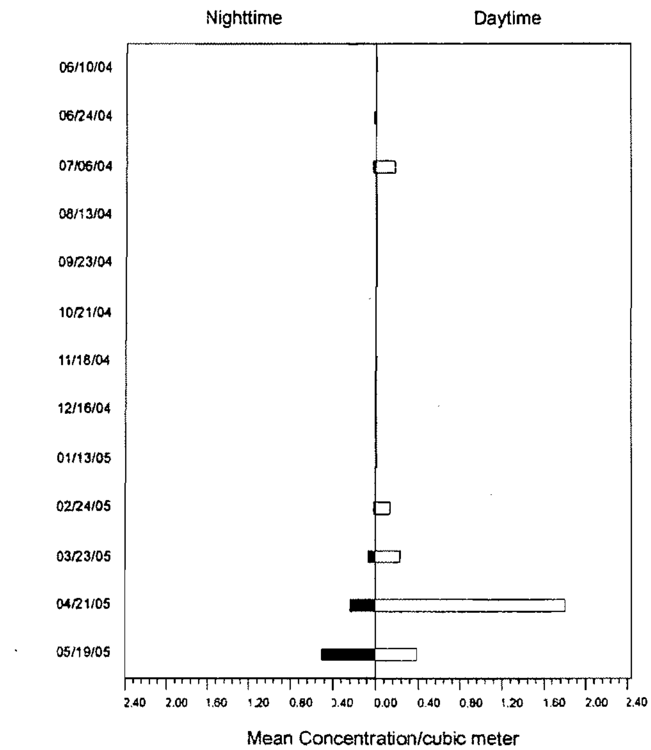

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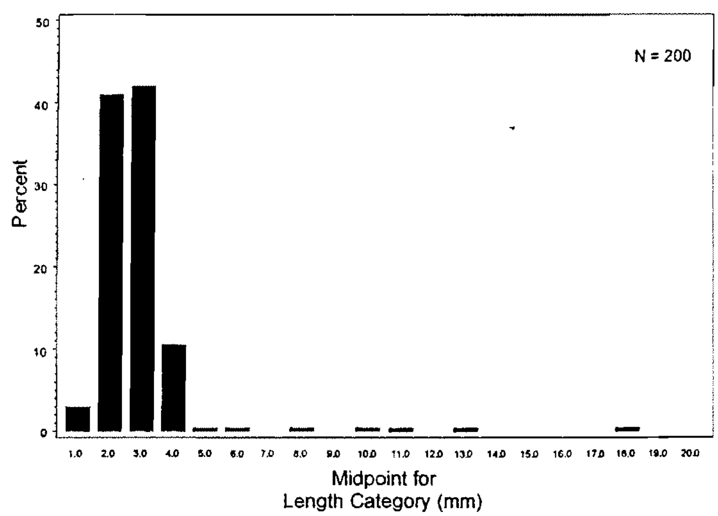

Figure 14. Length frequency of anchovy larvae at entrainment Station E1. Data from sub-samples of all surveys in 2004–2005.

Appendix A

Entrainment and Source Water Sampling Results by Survey

A1 – Entrainment

A2 – Source Water: Agua Hedionda Lagoon

A3 – Source Water: Nearshore

Table A1. Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at entrainment Station E1.

		Survey Number:		1		2	
		Survey Date:		06/10/04		06/24/04	
		Sample Count:		8		8	
	Taxon	Common Name	Total Count	Mean Conc.	Count	Conc.	Count	Conc.

	Taxon	Common Name	Total Count	Mean Conc.	Count (1)	Conc. (1)	Count (2)	Conc. (2)
	Fishes							
1	Gobiidae unid.	gobies	12,762	2,222.69	609	2,059.68	576	1,622.60
2	*Hypsoblennius* spp.	combtooth blennies	5,838	1,107.67	784	2,712.14	438	1,197.26
3	*Engraulis mordax*	northern anchovy	505	84.40	6	17.86	-	-
4	Engraulidae unid.	anchovies	314	49.88	-	-	2	5.15
5	*Hypsypops rubicundus*	garibaldi	188	40.99	79	268.68	8	23.41
6	*Typhlogobius californiensis*	blind goby	148	24.65	2	4.80	-	-
7	*Gibbonsia* spp.	clinid kelpfishes	125	22.45	3	11.11	2	5.24
8	Labrisomidae unid.	labrisomid kelpfishes	81	17.65	26	92.41	10	28.36
9	*Acanthogobius flavimanus*	yellowfin goby	87	14.41	-	-	-	-
10	larval fish fragment	larval fishes	56	9.65	8	25.54	-	-
11	larvae, unidentified yolksac	yolksac larvae	39	8.36	5	16.62	6	18.21
12	*Roncador stearnsi*	spotfin croaker	42	8.33	1	2.40	1	2.57
13	*Syngnathus leptorhynchus*	bay pipefish	36	8.20	7	21.36	8	22.75
14	*Atherinopsis californiensis*	jacksmelt	47	7.99	-	-	-	-
15	*Rimicola* spp.	kelp clingfishes	43	7.92	3	9.95	1	2.49
16	*Syngnathus* spp.	pipefishes	47	7.85	2	6.39	-	-
17	*Genyonemus lineatus*	white croaker	44	7.04	-	-	-	-
18	*Seriphus politus*	queenfish	29	5.50	2	6.65	-	-
19	*Paraclinus integripinnis*	reef finspot	31	4.95	-	-	-	-
20	*Paralichthys californicus*	California halibut	21	3.73	1	2.40	-	-
21	*Sardinops sagax*	Pacific sardine	16	2.66	-	-	-	-
22	*Gillichthys mirabilis*	longjaw mudsucker	13	2.14	-	-	-	-
23	Sciaenidae unid.	croaker	11	1.86	-	-	1	2.49
24	*Hypsopsetta guttulata*	diamond turbot	10	1.78	-	-	-	-
25	larval/post-larval fish unid.	larval fishes	10	1.61	1	2.40	-	-
26	*Citharichthys stigmaeus*	speckled sanddab	8	1.33	-	-	-	-
27	*Paralabrax* spp.	sand bass	7	1.15	-	-	-	-
28	Atherinopsidae unid.	silverside	5	0.82	-	-	-	-
29	*Citharichthys sordidus*	Pacific sanddab	5	0.79	-	-	-	-
30	*Paralabrax clathratus*	kelp bass	4	0.71	-	-	-	-
31	Pleuronectiformes unid.	flatfishes	4	0.63	-	-	-	-
32	*Heterostichus rostratus*	giant kelpfish	3	0.54	1	2.40	-	-
33	*Clinocottus analis*	wooly sculpin	3	0.51	-	-	-	-
34	*Stenobrachius leucopsarus*	northern lampfish	2	0.37	-	-	-	-
35	*Atherinops affinis*	topsmelt	2	0.36	-	-	-	-
36	*Cheilotrema saturnum*	black croaker	2	0.35	-	-	-	-
37	*Scomber japonicus*	Pacific mackerel	1	0.35	1	4.51	-	-
38	*Quietula y-cauda*	shadow goby	1	0.25	-	-	-	-
39	Ophidiidae unid.	cusk-eels	1	0.21	-	-	-	-
40	*Gobiesox* spp.	clingfishes	1	0.20	-	-	1	2.66
41	*Diaphus theta*	California headlight fish	1	0.19	-	-	-	-
42	*Semicossyphus pulcher*	California sheephead	1	0.19	-	-	-	-
43	*Menticirrhus undulatus*	California corbina	1	0.18	-	-	-	-
44	Haemulidae unid.	grunts	1	0.18	-	-	-	-
45	Labridae unid.	wrasses	1	0.17	-	-	-	-
46	Myctophidae unid.	lanternfishes	1	0.16	-	-	-	-
47	*Symbolophorus californiensis*	California lanternfish	1	0.16	-	-	-	-
48	*Oxyjulis californica*	senorita	1	0.14	-	-	-	-
49	*Citharichthys* spp.	sanddabs	1	0.13	-	-	-	-
	Invertebrates							
	Cancer anthonyi (megalops)	yellow crab	1	2.21	-	-	-	-
			20,602		1,541		1,054	

Table A1 (continued). Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at entrainment Station E1.

Survey Number:	3		4		5		6	
Survey Date:	07/06/04		08/13/04		09/23/04		10/21/04	
Sample Count:	8		8		8		8	
Taxon	Count	Conc.	Count	Conc.	Count	Conc.	Count	Conc.
Fishes								
Gobiidae unid.	1,349	3,651.19	3,347	6,989.90	992	2,259.40	454	1,118.40
Hypsoblennius spp.	615	1,857.95	1,843	3,900.14	917	2,056.02	115	275.79
Engraulis mordax	7	19.60	-	-	2	4.55	2	4.43
Engraulidae unid.	17	41.45	6	11.44	-	-	-	-
Hypsypops rubicundus	24	76.54	8	16.58	-	-	-	-
Typhlogobius californiensis	1	3.57	-	-	-	-	-	-
Gibbonsia spp.	-	-	1	1.85	-	-	16	42.17
Labrisomidae unid.	20	52.50	2	4.38	20	45.30	1	2.62
Acanthogobius flavimanus	-	-	-	-	-	-	-	-
larval fish fragment	-	-	3	6.62	4	8.90	8	19.52
larvae, unidentified yolksac	16	46.61	-	-	3	7.57	-	-
Roncador stearnsi	11	34.26	1	2.09	28	67.03	-	-
Syngnathus leptorhynchus	19	57.50	-	-	-	-	1	2.83
Atherinopsis californiensis	-	-	-	-	-	-	-	-
Rimicola spp.	12	29.44	15	31.44	3	6.87	9	22.75
Syngnathus spp.	-	-	32	67.29	13	28.39	-	-
Genyonemus lineatus	-	-	1	1.93	7	16.59	-	-
Seriphus politus	-	-	3	6.38	22	53.74	2	4.77
Paraclinus integripinnis	-	-	31	64.39	-	-	-	-
Paralichthys californicus	-	-	1	2.09	5	13.58	2	5.23
Sardinops sagax	-	-	-	-	-	-	-	-
Gillichthys mirabilis	-	-	-	-	-	-	-	-
Sciaenidae unid.	1	3.20	-	-	3	6.64	1	2.62
Hypsopsetta guttulata	-	-	-	-	3	7.81	-	-
larval/post-larval fish unid.	1	2.39	5	9.76	-	-	-	-
Citharichthys stigmaeus	-	-	-	-	-	-	2	5.54
Paralabrax spp.	-	-	3	5.69	4	9.26	-	-
Atherinopsidae unid.	-	-	-	-	-	-	-	-
Citharichthys sordidus	-	-	-	-	-	-	-	-
Paralabrax clathratus	-	-	-	-	4	9.21	-	-
Pleuronectiformes unid.	-	-	-	-	-	-	-	-
Heterostichus rostratus	-	-	-	-	-	-	-	-
Clinocottus analis	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	-	-	-	-	-	-	-	-
Atherinops affinis	1	2.50	-	-	-	-	-	-
Cheilotrema saturnum	1	2.50	1	2.02	-	-	-	-
Scomber japonicus	-	-	-	-	-	-	-	-
Quietula y-cauda	1	3.20	-	-	-	-	-	-
Ophidiidae unid.	-	-	-	-	-	-	1	2.71
Gobiesox spp.	-	-	-	-	-	-	-	-
Diaphus theta	-	-	-	-	-	-	-	-
Semicossyphus pulcher	-	-	-	-	-	-	-	-
Menticirrhus undulatus	1	2.39	-	-	-	-	-	-
Haemulidae unid.	-	-	-	-	1	2.29	-	-
Labridae unid.	-	-	-	-	1	2.19	-	-
Myctophidae unid.	-	-	-	-	-	-	-	-
Symbolophorus californiensis	-	-	-	-	-	-	-	-
Oxyjulis californica	-	-	-	-	-	-	-	-
Citharichthys spp.	-	-	-	-	-	-	-	-
Invertebrates								
Cancer anthonyi (megalops)	-	-	-	-	-	-	-	-
	2,097		5,303		2,032		614	

Table A1 (continued). Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at entrainment Station E1.

Survey Number:	7		8		9		10	
Survey Date:	11/18/04		12/16/04		01/13/05		02/24/05	
Sample Count:	8		8		8		8	
Taxon	Count	Conc.	Count	Conc.	Count	Conc.	Count	Conc.
Fishes								
Gobiidae unid.	203	411.13	102	233.48	118	263.27	555	1,179.31
Hypsoblennius spp.	151	320.89	5	11.75	4	8.53	-	-
Engraulis mordax	26	48.05	-	-	1	2.22	25	51.06
Engraulidae unid.	-	-	-	-	-	-	-	-
Hypsypops rubicundus	-	-	-	-	-	-	-	-
Typhlogobius californiensis	-	-	-	-	-	-	4	8.61
Gibbonsia spp.	7	13.96	6	13.51	61	141.98	11	22.93
Labrisomidae unid.	1	1.75	-	-	-	-	-	-
Acanthogobius flavimanus	-	-	-	-	19	44.01	63	133.24
larval fish fragment	2	3.95	-	-	1	2.28	4	8.48
larvae, unidentified yolksac	-	-	-	-	-	-	-	-
Roncador stearnsi	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	-	-	-	-	-	-	-	-
Atherinopsis californiensis	-	-	2	4.93	13	29.82	22	47.31
Rimicola spp.	-	-	-	-	-	-	-	-
Syngnathus spp.	-	-	-	-	-	-	-	-
Genyonemus lineatus	4	7.92	1	2.47	3	6.50	13	26.67
Seriphus politus	-	-	-	-	-	-	-	-
Paraclinus integripinnis	-	-	-	-	-	-	-	-
Paralichthys californicus	1	1.75	1	2.22	2	4.40	3	5.75
Sardinops sagax	2	3.49	-	-	-	-	5	10.93
Gillichthys mirabilis	3	7.07	1	2.15	1	2.22	5	10.56
Sciaenidae unid.	1	1.85	-	-	-	-	-	-
Hypsopsetta guttulata	2	4.02	1	1.71	4	9.59	-	-
larval/post-larval fish unid.	-	-	-	-	3	6.33	-	-
Citharichthys stigmaeus	4	7.32	-	-	-	-	-	-
Paralabrax spp.	-	-	-	-	-	-	-	-
Atherinopsidae unid.	-	-	-	-	-	-	2	4.61
Citharichthys sordidus	3	5.24	-	-	-	-	-	-
Paralabrax clathratus	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	3	5.70	-	-	-	-	-	-
Heterostichus rostratus	1	2.18	-	-	-	-	1	2.41
Clinocottus analis	-	-	1	2.20	1	2.28	1	2.15
Stenobrachius leucopsarus	-	-	-	-	2	4.82	-	-
Atherinops affinis	-	-	-	-	-	-	-	-
Cheilotrema saturnum	-	-	-	-	-	-	-	-
Scomber japonicus	-	-	-	-	-	-	-	-
Quietula y-cauda	-	-	-	-	-	-	-	-
Ophidiidae unid.	-	-	-	-	-	-	-	-
Gobiesox spp.	-	-	-	-	-	-	-	-
Diaphus theta	-	-	-	-	-	-	-	-
Semicossyphus pulcher	-	-	-	-	-	-	-	-
Menticirrhus undulatus	-	-	-	-	-	-	-	-
Haemulidae unid.	-	-	-	-	-	-	-	-
Labridae unid.	-	-	-	-	-	-	-	-
Myctophidae unid.	-	-	-	-	-	-	-	-
Symbolophorus californiensis	-	-	-	-	-	-	-	-
Oxyjulis californica	-	-	-	-	-	-	-	-
Citharichthys spp.	-	-	-	-	-	-	-	-
Invertebrates								
Cancer anthonyi (megalops)	-	-	1	2.21	-	-	-	-
	414		121		233		714	

Table A1 (continued). Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at entrainment Station E1

Survey Number:	11		12		13	
Survey Date:	03/23/05		04/21/05		05/19/05	
Sample Count:	8		8		8	
Taxon	**Count**	**Conc.**	**Count**	**Conc.**	**Count**	**Conc.**
Fishes						
Gobiidae unid.	1,357	2,700.63	1,314	2,649.98	1,786	3,755.99
Hypsoblennius spp.	49	99.47	86	174.14	831	1,785.69
Engraulis mordax	89	182.27	284	642.95	63	124.21
Engraulidae unid.	60	140.57	14	28.03	215	421.84
Hypsypops rubicundus	-	-	15	30.54	54	117.11
Typhlogobius californiensis	110	238.12	17	34.38	14	31.01
Gibbonsia spp.	12	26.60	2	3.96	4	8.59
Labrisomidae unid.	-	-	-	-	1	2.13
Acanthogobius flavimanus	5	10.08	-	-	-	-
larval fish fragment	12	24.32	4	8.17	10	17.70
larvae, unidentified yolksac	1	2.43	3	7.12	5	10.12
Roncador stearnsi	-	-	-	-	-	-
Syngnathus leptorhynchus	-	-	-	-	1	2.21
Atherinopsis californiensis	10	21.80	-	-	-	-
Rimicola spp.	-	-	-	-	-	-
Syngnathus spp.	-	-	-	-	-	-
Genyonemus lineatus	5	9.18	10	20.28	-	-
Seriphus politus	-	-	-	-	-	-
Paraclinus integripinnis	-	-	-	-	-	-
Paralichthys californicus	1	1.82	3	7.12	1	2.13
Sardinops sagax	1	1.86	8	18.35	-	-
Gillichthys mirabilis	2	3.89	1	1.88	-	-
Sciaenidae unid.	2	3.67	-	-	2	3.75
Hypsopsetta guttulata	-	-	-	-	-	-
larval/post-larval fish unid.	-	-	-	-	-	-
Citharichthys stigmaeus	-	-	2	4.37	-	-
Paralabrax spp.	-	-	-	-	-	-
Atherinopsidae unid.	-	-	2	3.89	1	2.21
Citharichthys sordidus	-	-	2	4.98	-	-
Paralabrax clathratus	-	-	-	-	-	-
Pleuronectiformes unid.	-	-	1	2.49	-	-
Heterostichus rostratus	-	-	-	-	-	-
Clinocottus analis	-	-	-	-	-	-
Stenobrachius leucopsarus	-	-	-	-	-	-
Atherinops affinis	-	-	-	-	1	2.21
Cheilotrema saturnum	-	-	-	-	-	-
Scomber japonicus	-	-	-	-	-	-
Quietula y-cauda	-	-	-	-	-	-
Ophidiidae unid.	-	-	-	-	-	-
Gobiesox spp.	-	-	-	-	-	-
Diaphus theta	-	-	1	2.49	-	-
Semicossyphus pulcher	-	-	1	2.49	-	-
Menticirrhus undulatus	-	-	-	-	-	-
Haemulidae unid.	-	-	-	-	-	-
Labridae unid.	-	-	-	-	-	-
Myctophidae unid.	-	-	1	2.14	-	-
Symbolophorus californiensis	-	-	1	2.14	-	-
Oxyjulis californica	-	-	-	-	1	1.78
Citharichthys spp.	1	1.72	-	-	-	-
Invertebrates						
Cancer anthonyi (megalops)	-	-	-	-	-	-
	1,717		1,772		2,990	

Table A2. Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at source water Stations L1-L4 in Agua Hedionda Lagoon.

		Survey Number:			1		2	
		Survey Date:			06/10/04		06/24/04	
		Sample Count:			16		16	
	Taxon	Common Name	Total Count	Mean Conc.	Count	Conc.	Count	Conc.
	Fishes							
1	Gobiidae unid.	gobies	30,229	2,714.74	7,936	9,400.29	4,466	5,925.43
2	*Hypsoblennius* spp.	combtooth blennies	4,725	467.32	614	901.83	398	547.24
3	Engraulidae unid.	anchovies	652	57.90	54	72.86	141	182.94
4	*Engraulis mordax*	northern anchovy	558	45.51	2	2.79	1	1.33
5	*Acanthogobius flavimanus*	yellowfin goby	499	38.98	-	-	-	-
6	Labrisomidae unid.	labrisomid kelpfishes	366	35.30	166	220.73	71	93.10
7	*Hypsypops rubicundus*	garibaldi	352	35.12	94	134.38	53	76.48
8	*Atherinopsis californiensis*	jacksmelt	279	23.93	-	-	-	-
9	*Gibbonsia* spp.	clinid kelpfishes	182	16.74	8	11.54	4	5.44
10	larval fish fragment	unid. larval fishes	174	15.02	17	19.27	21	30.99
11	*Typhlogobius californiensis*	blind goby	118	9.63	2	2.79	-	-
12	*Roncador stearnsi*	spotfin croaker	74	6.82	1	1.29	-	-
13	Sciaenidae unid.	croakers	73	6.56	23	29.17	-	-
14	*Gillichthys mirabilis*	longjaw mudsucker	62	5.17	-	-	-	-
15	*Genyonemus lineatus*	white croaker	54	4.25	2	2.14	-	-
16	*Rimicola eigenmanni*	slender clingfish	53	4.13	-	-	-	-
17	Atherinopsidae unid.	silversides	41	3.40	3	3.43	-	-
18	*Rimicola* spp.	kelp clingfishes	34	3.28	-	-	2	2.98
19	*Syngnathus leptorhynchus*	bay pipefish	33	3.19	12	15.60	9	11.57
20	larvae, unidentified yolksac	unid. yolksac larvae	32	3.12	5	8.47	-	-
21	*Paraclinus integripinnis*	reef finspot	31	2.88	-	-	-	-
22	*Seriphus politus*	queenfish	26	2.40	1	1.64	5	5.51
23	*Atherinops affinis*	topsmelt	28	2.40	5	7.00	4	5.54
24	*Quietula y-cauda*	shadow goby	26	2.38	5	5.45	5	6.68
25	*Syngnathus* spp.	pipefishes	19	2.01	-	-	2	2.99
26	*Paralichthys californicus*	California halibut	22	1.93	2	2.63	-	-
27	larval/post-larval fish unid.	larval fishes	16	1.36	-	-	-	-
28	*Ilypnus gilberti*	cheekspot goby	14	1.35	-	-	-	-
29	*Oxyjulis californica*	senorita	8	0.75	2	2.36	-	-
30	*Sardinops sagax*	Pacific sardine	9	0.74	-	-	-	-
31	*Citharichthys stigmaeus*	speckled sanddab	9	0.73	-	-	-	-
32	*Paralabrax* spp.	sand basses	8	0.68	-	-	-	-
33	*Hypsopsetta guttulata*	diamond turbot	7	0.55	-	-	-	-
34	*Leptocottus armatus*	Pacific staghorn sculpin	6	0.51	-	-	-	-
35	*Gobiesox* spp.	clingfishes	5	0.49	-	-	2	3.29
36	*Menticirrhus undulatus*	California corbina	5	0.47	-	-	-	-
37	*Cheilotrema saturnum*	black croaker	4	0.36	-	-	-	-
38	Blennioidei unid.	blennies	4	0.36	1	1.11	1	1.40
39	*Citharichthys sordidus*	Pacific sanddab	5	0.34	-	-	-	-
40	*Clinocottus analis*	wooly sculpin	4	0.31	-	-	-	-
41	*Xenistius californiensis*	salema	3	0.30	-	-	-	-
42	*Xystreurys liolepis*	fantail sole	2	0.21	-	-	-	-
43	*Pleuronichthys ritteri*	spotted turbot	2	0.17	-	-	-	-
44	Haemulidae unid.	grunts	2	0.17	-	-	-	-
45	*Sphyraena argentea*	California barracuda	2	0.17	-	-	-	-
46	*Triphoturus mexicanus*	Mexican lampfish	2	0.16	-	-	-	-
47	Gobiesocidae unid.	clingfishes	2	0.15	-	-	-	-
48	*Clevelandia ios*	arrow goby	1	0.11	-	-	-	-
49	Syngnathidae unid.	pipefishes	1	0.11	-	-	-	-
50	Ophidiidae unid.	cusk-eels	1	0.09	-	-	-	-
51	*Umbrina roncador*	yellowfin croaker	1	0.09	-	-	-	-
52	*Lepidogobius lepidus*	bay goby	1	0.09	-	-	-	-
53	*Pleuronichthys* spp.	turbots	1	0.08	-	-	-	-
54	*Atractoscion nobilis*	white seabass	1	0.08	-	-	-	-
55	Pleuronectiformes unid.	flatfishes	1	0.07	-	-	-	-
56	*Clinocottus* spp.	sculpins	1	0.07	-	-	-	-
57	*Citharichthys* spp.	sanddabs	1	0.06	-	-	-	-
58	*Semicossyphus pulcher*	California sheephead	1	0.06	1	0.78	-	-
	Invertebrates							
	Panulirus interruptus (larvae)	California spiny lobster	2	0.21	-	-	-	-
	Cancer antennarius (megalops)	brown rock crab	1	0.09	-	-	-	-
	Cancer anthonyi (megalops)	yellow crab	1	0.08	-	-	-	-
		Totals:	38,876		8,958		5,185	

Table A2 (continued). Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at source water Stations L1-L4 in Agua Hedionda Lagoon.

Survey Number:	3		4		5		6	
Survey Date:	07/06/04		08/13/04		09/23/04		10/21/04	
Sample Count:	16		16		20		16	
Taxon	**Conc.**	**Count**	**Count**	**Conc.**	**Count**	**Conc.**	**Count**	**Conc.**
Fishes								
Gobiidae unid.	3,034.53	30,229	1,498	1,925.13	1,115	1,272.53	550	690.51
Hypsoblennius spp.	1,053.95	4,725	1,004	1,421.30	360	398.18	245	290.58
Engraulidae unid.	57.39	652	-	-	-	-	-	-
Engraulis mordax	12.07	558	-	-	-	-	4	5.58
Acanthogobius flavimanus	-	499	-	-	-	-	-	-
Labrisomidae unid.	44.54	366	23	29.27	68	70.20	-	-
Hypsypops rubicundus	122.15	352	1	1.38	-	-	-	-
Atherinopsis californiensis	1.15	279	-	-	-	-	-	-
Gibbonsia spp.	4.46	182	1	1.38	3	3.04	12	19.17
larval fish fragment	4.41	174	9	10.98	3	3.48	8	9.95
Typhlogobius californiensis	11.38	118	-	-	-	-	-	-
Roncador stearnsi	34.73	74	-	-	48	51.42	-	-
Sciaenidae unid.	10.27	73	4	4.85	17	17.20	-	-
Gillichthys mirabilis	-	62	-	-	-	-	-	-
Genyonemus lineatus	-	54	4	4.85	6	6.58	1	1.81
Rimicola eigenmanni	-	53	-	-	53	53.73	-	-
Atherinopsidae unid.	1.15	41	-	-	-	-	3	3.66
Rimicola spp.	6.03	34	-	-	9	9.96	10	13.61
Syngnathus leptorhynchus	7.04	33	-	-	5	4.97	1	1.33
larvae, unidentified yolksac	12.08	32	6	7.87	2	2.11	-	-
Paraclinus integripinnis	-	31	31	37.45	-	-	-	-
Seriphus politus	6.58	26	1	1.26	8	8.51	6	7.72
Atherinops affinis	1.15	28	-	-	-	-	-	-
Quietula y-cauda	2.29	26	4	5.80	1	1.01	-	-
Syngnathus spp.	-	19	15	20.83	-	-	1	1.09
Paralichthys californicus	1.63	22	1	1.21	7	7.51	2	3.18
larval/post-larval fish unid.	-	16	2	2.42	3	3.03	-	-
Ilypnus gilberti	-	14	3	4.46	-	-	-	-
Oxyjulis californica	-	8	5	6.24	-	-	-	-
Sardinops sagax	-	9	-	-	-	-	-	-
Citharichthys stigmaeus	1.36	9	1	1.20	2	2.12	-	-
Paralabrax spp.	-	8	3	3.63	5	5.24	-	-
Hypsopsetta guttulata	-	7	-	-	2	2.20	-	-
Leptocottus armatus	-	6	-	-	-	-	-	-
Gobiesox spp.	-	5	-	-	-	-	-	-
Menticirrhus undulatus	1.63	5	1	1.21	3	3.33	-	-
Cheilotrema saturnum	1.32	4	1	1.21	2	2.19	-	-
Blennioidei unid.	-	4	-	-	-	-	-	-
Citharichthys sordidus	-	5	-	-	-	-	-	-
Clinocottus analis	-	4	-	-	-	-	-	-
Xenistius californiensis	-	3	-	-	2	2.03	1	1.81
Xystreurys liolepis	2.77	2	-	-	-	-	-	-
Pleuronichthys ritteri	-	2	-	-	2	2.20	-	-
Haemulidae unid.	-	2	1	1.21	1	0.96	-	-
Sphyraena argentea	-	2	1	1.17	1	0.99	-	-
Triphoturus mexicanus	-	2	-	-	1	1.10	-	-
Gobiesocidae unid.	-	2	-	-	-	-	2	2.01
Clevelandia ios	-	1	1	1.45	-	-	-	-
Syngnathidae unid.	-	1	-	-	-	-	1	1.38
Ophidiidae unid.	-	1	1	1.21	-	-	-	-
Umbrina roncador	-	1	-	-	1	1.21	-	-
Lepidogobius lepidus	-	1	-	-	-	-	-	-
Pleuronichthys spp.	-	1	-	-	1	1.10	-	-
Atractoscion nobilis	-	1	-	-	-	-	-	-
Pleuronectiformes unid.	-	1	-	-	-	-	-	-
Clinocottus spp.	-	1	-	-	-	-	-	-
Citharichthys spp.	-	1	-	-	-	-	-	-
Semicossyphus pulcher	-	1	-	-	-	-	-	-
Invertebrates								
Panulirus interruptus	2.73	2	-	-	-	-	-	-
Cancer antennarius (megalops)	-	1	-	-	-	-	-	-
Cancer anthonyi (megalops)	-	1	-	-	1	1.01	-	-
		38,876	2,622		1,732		847	

Table A2 (continued). Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at source water Stations L1-L4 in Agua Hedionda Lagoon.

Survey Number:	7		8		9		10	
Survey Date:	11/18/04		12/16/04		01/13/05		02/24/05	
Sample Count:	16		16		16		16	
Total								
Taxon	**Count**	**Conc.**	**Count**	**Conc.**	**Count**	**Conc.**	**Count**	**Conc.**
Fishes								
Gobiidae unid.	706	734.73	1,032	1,201.76	368	402.81	1,873	1,867.75
Hypsoblennius spp.	59	61.74	4	5.26	3	3.22	2	2.05
Engraulidae unid.	2	2.12	-	-	2	2.42	-	-
Engraulis mordax	30	28.07	2	2.43	-	-	21	21.19
Acanthogobius flavimanus	-	-	-	-	140	152.20	300	298.81
Labrisomidae unid.	-	-	-	-	-	-	-	-
Hypsypops rubicundus	-	-	-	-	-	-	-	-
Atherinopsis californiensis	5	5.80	16	18.84	52	61.60	167	185.66
Gibbonsia spp.	13	13.30	56	65.83	43	52.02	21	20.79
larval fish fragment	11	11.11	11	12.69	-	-	49	48.54
Typhlogobius californiensis	-	-	2	2.23	-	-	8	8.22
Roncador stearnsi	-	-	-	-	-	-	-	-
Sciaenidae unid.	-	-	-	-	3	3.65	-	-
Gillichthys mirabilis	4	4.25	21	24.94	14	14.54	15	15.16
Genyonemus lineatus	1	0.95	-	-	2	2.27	23	21.56
Rimicola eigenmanni	-	-	-	-	-	-	-	-
Atherinopsidae unid.	4	4.47	-	-	-	-	12	11.64
Rimicola spp.	1	1.14	5	5.82	-	-	-	-
Syngnathus leptorhynchus	-	-	-	-	-	-	1	0.94
larvae, unidentified yolksac	-	-	1	1.31	-	-	-	-
Paraclinus integripinnis	-	-	-	-	-	-	-	-
Seriphus politus	-	-	-	-	-	-	-	-
Atherinops affinis	-	-	-	-	-	-	12	12.21
Quietula y-cauda	2	2.24	4	4.22	-	-	3	3.18
Syngnathus spp.	1	1.28	-	-	-	-	-	-
Paralichthys californicus	2	1.67	-	-	2	2.31	2	1.80
larval/post-larval fish unid.	-	-	-	-	10	11.33	1	0.89
Ilypnus gilberti	1	0.86	5	5.99	5	6.28	-	-
Oxyjulis californica	1	1.12	-	-	-	-	-	-
Sardinops sagax	-	-	-	-	1	1.23	4	4.40
Citharichthys stigmaeus	1	0.81	-	-	-	-	-	-
Paralabrax spp.	-	-	-	-	-	-	-	-
Hypsopsetta guttulata	2	1.68	-	-	1	1.34	1	1.01
Leptocottus armatus	-	-	-	-	5	6.63	-	-
Gobiesox spp.	-	-	-	-	-	-	3	3.04
Menticirrhus undulatus	-	-	-	-	-	-	-	-
Cheilotrema saturnum	-	-	-	-	-	-	-	-
Blennioidei unid.	-	-	1	1.24	-	-	1	0.94
Citharichthys sordidus	4	3.66	-	-	-	-	1	0.77
Clinocottus analis	-	-	2	2.27	-	-	2	1.74
Xenistius californiensis	-	-	-	-	-	-	-	-
Xystreurys liolepis	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	-	-	-	-	-	-	-	-
Haemulidae unid.	-	-	-	-	-	-	-	-
Sphyraena argentea	-	-	-	-	-	-	-	-
Triphoturus mexicanus	1	0.95	-	-	-	-	-	-
Gobiesocidae unid.	-	-	-	-	-	-	-	-
Clevelandia ios	-	-	-	-	-	-	-	-
Syngnathidae unid.	-	-	-	-	-	-	-	-
Ophidiidae unid.	-	-	-	-	-	-	-	-
Umbrina roncador	-	-	-	-	-	-	-	-
Lepidogobius lepidus	-	-	-	-	1	1.18	-	-
Pleuronichthys spp.	-	-	-	-	-	-	-	-
Atractoscion nobilis	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	-	-	-	-	-	-	-	-
Clinocottus spp.	-	-	1	0.93	-	-	-	-
Citharichthys spp.	1	0.81	-	-	-	-	-	-
Semicossyphus pulcher	-	-	-	-	-	-	-	-
Invertebrates								
Panulirus interruptus	-	-	-	-	-	-	-	-
Cancer antennarius (megalops)	-	-	1	1.22	-	-	-	-
Cancer anthonyi (megalops)	-	-	-	-	-	-	-	-
	852		**1,164**		**653**		**2,522**	

Table A2 (continued). Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at source water Stations L1-L4 in Agua Hedionda Lagoon.

Survey Number:	11		12		13	
Survey Date:	03/23/05		04/21/05		05/19/05	
Sample Count:	16		16		16	
Taxon	Count	Conc.	Count	Conc.	Count	Conc.
Fishes						
Gobiidae unid.	1,923	1,908.93	2,314	2,455.55	3,980	4,471.69
Hypsoblennius spp.	81	80.32	175	181.27	1,013	1,128.18
Engraulidae unid.	57	55.27	22	22.80	331	356.88
Engraulis mordax	104	98.45	151	155.03	235	264.72
Acanthogobius flavimanus	54	50.65	3	2.95	2	2.12
Labrisomidae unid.	-	-	-	-	1	1.06
Hypsypops rubicundus	-	-	62	63.71	48	58.49
Atherinopsis californiensis	38	37.99	-	-	-	-
Gibbonsia spp.	4	4.30	4	4.07	10	12.22
larval fish fragment	16	15.83	14	14.73	12	13.31
Typhlogobius californiensis	85	84.34	10	10.82	4	5.36
Roncador stearnsi	-	-	1	1.18	-	-
Sciaenidae unid.	7	6.96	6	5.27	6	6.88
Gillichthys mirabilis	5	5.20	3	3.16	-	-
Genyonemus lineatus	2	1.95	12	12.02	1	1.12
Rimicola eigenmanni	-	-	-	-	-	-
Atherinopsidae unid.	6	7.09	7	7.50	5	5.29
Rimicola spp.	-	-	-	-	3	3.09
Syngnathus leptorhynchus	-	-	-	-	-	-
larvae, unidentified yolksac	5	4.69	-	-	4	4.10
Paraclinus integripinnis	-	-	-	-	-	-
Seriphus politus	-	-	-	-	-	-
Atherinops affinis	1	0.81	2	2.23	2	2.27
Quietula y-cauda	-	-	-	-	-	-
Syngnathus spp.	-	-	-	-	-	-
Paralichthys californicus	2	1.92	1	1.18	-	-
larval/post-larval fish unid.	-	-	-	-	-	-
Ilypnus gilberti	-	-	-	-	-	-
Oxyjulis californica	-	-	-	-	-	-
Sardinops sagax	-	-	4	3.93	-	-
Citharichthys stigmaeus	1	1.05	3	2.97	-	-
Paralabrax spp.	-	-	-	-	-	-
Hypsopsetta guttulata	1	0.89	-	-	-	-
Leptocottus armatus	-	-	-	-	-	-
Gobiesox spp.	-	-	-	-	-	-
Menticirrhus undulatus	-	-	-	-	-	-
Cheilotrema saturnum	-	-	-	-	-	-
Blennioidei unid.	-	-	-	-	-	-
Citharichthys sordidus	-	-	-	-	-	-
Clinocottus analis	-	-	-	-	-	-
Xenistius californiensis	-	-	-	-	-	-
Xystreurys liolepis	-	-	-	-	-	-
Pleuronichthys ritteri	-	-	-	-	-	-
Haemulidae unid.	-	-	-	-	-	-
Sphyraena argentea	-	-	-	-	-	-
Triphoturus mexicanus	-	-	-	-	-	-
Gobiesocidae unid.	-	-	-	-	-	-
Clevelandia ios	-	-	-	-	-	-
Syngnathidae unid.	-	-	-	-	-	-
Ophidiidae unid.	-	-	-	-	-	-
Umbrina roncador	-	-	-	-	-	-
Lepidogobius lepidus	-	-	-	-	-	-
Pleuronichthys spp.	-	-	-	-	-	-
Atractoscion nobilis	-	-	1	0.99	-	-
Pleuronectiformes unid.	-	-	1	0.93	-	-
Clinocottus spp.	-	-	-	-	-	-
Citharichthys spp.	-	-	-	-	-	-
Semicossyphus pulcher	-	-	-	-	-	-
Invertebrates						
Panulirus interruptus	-	-	-	-	-	-
Cancer antennarius (megalops)	-	-	-	-	-	-
Cancer anthonyi (megalops)	-	-	-	-	-	-
	2,392		2,796		5,657	

Table A3. Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at source water Stations N1-N5 in nearshore area.

		Survey Number:			1		2	
		Survey Date:			06/10/04		06/24/04	
		Sample Count:			20		19	
	Taxon	Common Name	Total Count	Mean Conc.	Count	Conc.	Count	Conc.
	Fishes							
1	*Engraulis mordax*	northern anchovy	6,318	423.31	285	211.27	27	24.69
2	*Hypsoblennius* spp.	combtooth blennies	1,959	137.11	936	747.96	325	335.32
3	Engraulidae unid.	anchovies	1,313	102.17	80	54.22	2	1.74
4	Gobiidae unid.	gobies	920	69.06	150	118.83	22	22.51
5	*Genyonemus lineatus*	white croaker	921	64.66	-	-	3	2.82
6	larvae, unidentified yolksac	unid. yolksac larvae	678	45.82	86	68.17	45	40.04
7	*Paralichthys californicus*	California halibut	601	42.91	39	28.28	45	40.90
8	*Seriphus politus*	queenfish	365	23.79	81	59.98	126	109.01
9	Sciaenidae unid.	croaker	306	22.55	52	36.56	17	15.94
10	*Roncador stearnsi*	spotfin croaker	286	20.17	105	84.11	66	63.55
11	*Citharichthys stigmaeus*	speckled sanddab	309	20.01	7	5.17	11	10.03
12	*Gibbonsia* spp.	clinid kelpfishes	277	19.29	36	29.62	5	6.93
13	Labrisomidae unid.	labrisomid kelpfishes	219	16.36	87	73.38	47	48.08
14	*Paralabrax clathratus*	kelp bass	213	14.12	29	20.88	43	36.99
15	*Sardinops sagax*	Pacific sardine	202	13.21	3	1.99	-	-
16	*Paralabrax* spp.	sand bass	159	10.76	12	9.46	8	7.03
17	larval fish fragment	unid. larval fishes	145	10.50	13	9.98	11	9.51
18	Haemulidae unid.	grunts	116	8.80	10	6.71	4	3.34
19	*Scomber japonicus*	Pacific mackerel	110	7.07	32	25.62	9	7.39
20	*Hypsypops rubicundus*	garibaldi	110	7.03	84	66.63	6	5.73
21	larval/post-larval fish unid.	larval fishes	93	6.81	8	5.67	5	4.57
22	*Oxyjulis californica*	senorita	79	5.55	12	8.05	2	1.98
23	*Paralabrax nebulifer*	barred sand bass	82	5.08	-	-	2	1.67
24	*Sphyraena argentea*	California barracuda	59	3.74	8	6.51	8	6.60
25	*Xenistius californiensis*	salema	55	3.61	-	-	31	25.82
26	*Lepidogobius lepidus*	bay goby	56	3.59	-	-	-	-
27	*Stenobrachius leucopsarus*	northern lampfish	51	3.26	-	-	-	-
28	*Pleuronichthys verticalis*	hornyhead turbot	43	2.79	-	-	3	2.56
29	*Atherinopsis californiensis*	jacksmelt	35	2.78	-	-	-	-
30	*Umbrina roncador*	yellowfin croaker	39	2.62	1	0.71	24	21.89
31	*Pleuronichthys ritteri*	spotted turbot	34	2.51	-	-	-	-
32	*Xystreurys liolepis*	fantail sole	27	1.97	-	-	-	-
33	*Hypsopsetta guttulata*	diamond turbot	30	1.97	-	-	-	-
34	*Rimicola* spp.	kelp clingfishes	22	1.79	-	-	-	-
35	*Peprilus simillimus*	Pacific butterfish	28	1.78	-	-	15	12.77
36	*Cheilotrema saturnum*	black croaker	24	1.71	6	4.76	4	3.79
37	*Semicossyphus pulcher*	California sheephead	21	1.49	6	4.23	-	-
38	*Ophidion scrippsae*	basketweave cusk-eel	22	1.48	-	-	-	-
39	*Diaphus theta*	California headlight fish	24	1.46	1	0.76	1	0.83
40	*Acanthogobius flavimanus*	yellowfin goby	22	1.46	-	-	-	-
41	*Pleuronichthys* spp.	turbots	19	1.30	-	-	1	0.83
42	Pleuronectiformes unid.	flatfishes	21	1.25	-	-	-	-
43	*Menticirrhus undulatus*	California corbina	16	1.21	4	3.04	4	4.05
44	*Atractoscion nobilis*	white seabass	18	1.18	2	1.48	9	8.43
45	Ophidiidae unid.	cusk-eels	15	1.14	-	-	-	-
46	*Sebastes* spp.	rockfishes	18	1.09	-	-	-	-
47	*Girella nigricans*	opaleye	16	1.06	2	1.36	1	0.80
48	*Typhlogobius californiensis*	blind goby	15	0.99	4	3.24	1	0.81
49	*Citharichthys sordidus*	Pacific sanddab	16	0.99	-	-	1	0.83
50	Pleuronectidae unid.	flounders	16	0.98	-	-	-	-
51	*Trachurus symmetricus*	jack mackerel	17	0.96	13	9.40	-	-
52	*Halichoeres semicinctus*	rock wrasse	15	0.95	-	-	-	-
53	*Syngnathus* spp.	pipefishes	10	0.84	-	-	1	0.81
54	Labridae	wrasses	11	0.83	-	-	-	-

Table A3 (continued). Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at source water Stations N1-N5 in nearshore area.

			Survey Number:		1		2	
			Survey Date:		06/10/04		06/24/04	
			Sample Count:		20		19	
	Taxon	Common Name	Total Count	Mean Conc.	Count	Conc.	Count	Conc.
	Fishes							
55	*Paraclinus integripinnis*	reef finspot	14	0.81	7	4.25	-	-
56	*Symphurus atricauda*	California tonguefish	11	0.77	-	-	-	-
57	*Triphoturus mexicanus*	Mexican lampfish	12	0.73	-	-	1	0.83
58	*Citharichthys* spp.	sanddabs	9	0.70	-	-	1	0.83
59	*Nannobrachium* spp.	lanternfishes	9	0.57	-	-	-	-
60	*Medialuna californiensis*	halfmoon	7	0.53	2	1.69	-	-
61	*Gillichthys mirabilis*	longjaw mudsucker	8	0.51	-	-	-	-
62	*Chilara taylori*	spotted cusk-eel	7	0.50	-	-	-	-
63	*Heterostichus rostratus*	giant kelpfish	7	0.50	1	1.00	1	1.39
64	*Hypsoblennius jenkinsi*	mussel blenny	7	0.46	-	-	-	-
65	Paralichthyidae unid.	lefteye flounders & sandd	7	0.44	-	-	-	-
66	Atherinopsidae	silverside	4	0.31	-	-	-	-
67	*Parophrys vetulus*	English sole	5	0.30	-	-	-	-
68	Myctophidae unid.	lanternfishes	4	0.30	-	-	-	-
69	*Hippoglossina stomata*	bigmouth sole	5	0.29	-	-	-	-
70	*Zaniolepis frenata*	shortspine combfish	5	0.25	-	-	-	-
71	*Ruscarius creaseri*	rouchcheek sculpin	3	0.22	-	-	-	-
72	Clupeiformes	herrings and anchovies	3	0.21	2	1.92	-	-
73	*Syngnathus leptorhynchus*	bay pipefish	3	0.18	3	2.37	-	-
74	Clupeidae unid.	herrings	3	0.18	-	-	-	-
75	*Lyopsetta exilis*	slender sole	3	0.16	-	-	-	-
76	Pomacentridae	damselfishes	2	0.14	-	-	-	-
77	*Rhinogobiops nicholsi*	blackeye goby	2	0.14	-	-	-	-
78	*Nannobrachium ritteri*	broadfin lampfish	2	0.13	-	-	-	-
79	*Cyclothone* spp.	bristlemouths	2	0.13	-	-	-	-
80	*Chromis punctipinnis*	blacksmith	2	0.13	-	-	-	-
81	*Icelinus* spp.	sculpins	3	0.13	-	-	-	-
82	Gobiesocidae unid.	clingfishes	2	0.12	1	0.88	-	-
83	*Anisotremus davidsonii*	sargo	2	0.12	-	-	-	-
84	*Sebastes jordani*	shortbelly rockfish	2	0.10	-	-	-	-
85	Blennioidei	blennies	1	0.08	-	-	-	-
86	Clinidae unid.	clinid kelpfishes	1	0.08	1	1.00	-	-
87	Chaenopsidae unid.	tube blennies	1	0.07	-	-	-	-
88	*Leptocottus armatus*	Pacific staghorn sculpin	1	0.07	-	-	-	-
89	Cynoglossidae	tongue soles	1	0.07	-	-	-	-
90	Kyphosidae	sea chubs	1	0.07	-	-	-	-
91	*Cyclothone acclinidens*	bent tooth bristlemouth	1	0.07	-	-	-	-
92	*Ilypnus gilberti*	cheekspot goby	1	0.06	-	-	-	-
93	*Gobiesox* spp.	clingfishes	1	0.06	-	-	-	-
94	Hexagrammidae unid.	greenlings	1	0.06	-	-	-	-
95	*Bathylagus ochotensis*	popeye blacksmelt	1	0.06	-	-	-	-
96	*Hypsoblennius gentilis*	bay blenny	1	0.05	1	0.64	-	-
	Invertebrates							
	Panulirus interruptus (larvae)	California spiny lobster	98	7.04	1	0.82	71	64.80
	Cancer anthonyi (megalops)	yellow crab	80	4.74	-	-	2	2.38
	Cancer antennarius (megalops)	brown rock crab	71	4.11	-	-	3	3.15
	Cancer gracilis (megalops)	slender crab	48	2.93	2	1.35	-	-
	Cancer spp. (megalops)	cancer crabs	4	0.23	-	-	-	-
	Cancer productus (megalops)	red rock crab	3	0.22	-	-	-	-
		Totals:	17,067		40,384		39,197	

Table A3 (continued). Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at source water Stations N1-N5 in nearshore area.

	3		4		5		6	
	07/06/04		08/13/04		09/23/04		10/21/04	
	20		20		20		20	
Taxon	**Count**	**Conc.**	**Count**	**Conc.**	**Count**	**Conc.**	**Count**	**Conc.**
Fishes								
Engraulis mordax	214	168.35	73	62.19	204	167.31	94	81.59
Hypsoblennius spp.	183	181.20	234	255.74	64	66.94	1	0.90
Engraulidae unid.	24	19.48	-	-	3	2.95	8	9.23
Gobiidae unid.	86	82.38	154	190.83	48	52.35	44	48.00
Genyonemus lineatus	13	10.58	12	14.77	300	280.83	33	25.28
larvae, unidentified yolksac	347	291.29	72	75.56	60	58.18	16	15.29
Paralichthys californicus	194	173.39	37	38.97	170	171.01	32	30.06
Seriphus politus	50	42.17	8	6.62	97	88.33	2	1.94
Sciaenidae unid.	102	99.70	25	28.73	39	38.37	6	4.90
Roncador stearnsi	52	47.53	10	10.18	53	56.79	-	-
Citharichthys stigmaeus	16	14.03	5	4.29	158	124.03	93	85.55
Gibbonsia spp.	4	4.35	3	3.96	2	2.46	11	11.57
Labrisomidae unid.	46	46.77	22	27.32	15	15.46	1	0.90
Paralabrax clathratus	34	27.63	2	1.75	105	96.31	-	-
Sardinops sagax	9	8.07	5	4.93	25	22.04	3	2.47
Paralabrax spp.	50	40.52	31	29.86	55	50.38	2	1.92
larval fish fragment	41	35.90	16	19.10	29	30.59	6	5.77
Haemulidae unid.	5	4.12	4	2.79	91	95.77	2	1.68
Scomber japonicus	39	30.95	-	-	29	27.04	1	0.89
Hypsypops rubicundus	13	11.43	1	1.32	-	-	-	-
larval/post-larval fish unid.	39	34.86	14	17.27	16	16.26	6	5.81
Oxyjulis californica	17	15.21	16	16.22	17	17.56	9	7.70
Paralabrax nebulifer	-	-	-	-	80	64.38	-	-
Sphyraena argentea	27	20.12	9	8.12	7	7.31	-	-
Xenistius californiensis	-	-	2	1.90	22	19.24	-	-
Lepidogobius lepidus	-	-	1	1.18	3	2.32	-	-
Stenobrachius leucopsarus	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	10	7.29	3	3.18	18	15.33	2	1.69
Atherinopsis californiensis	-	-	-	-	-	-	-	-
Umbrina roncador	14	11.41	-	-	-	-	-	-
Pleuronichthys ritteri	4	3.41	5	5.87	15	14.28	6	5.25
Xystreurys liolepis	12	11.12	1	1.14	9	9.07	3	2.82
Hypsopsetta guttulata	-	-	2	1.93	8	7.31	6	4.26
Rimicola spp.	2	1.96	-	-	12	13.28	3	3.20
Peprilus simillimus	6	4.66	-	-	4	3.42	-	-
Cheilotrema saturnum	10	9.25	1	0.80	3	3.60	-	-
Semicossyphus pulcher	1	1.05	3	2.95	8	8.18	2	2.27
Ophidion scrippsae	-	-	6	6.04	11	8.98	4	3.21
Diaphus theta	1	0.81	-	-	3	2.41	1	0.89
Acanthogobius flavimanus	-	-	-	-	-	-	-	-
Pleuronichthys spp.	1	0.52	1	1.14	11	9.76	3	3.18
Pleuronectiformes unid.	-	-	-	-	1	0.78	5	3.67
Menticirrhus undulatus	-	-	2	2.14	6	6.54	-	-
Atractoscion nobilis	5	3.58	-	-	-	-	-	-
Ophidiidae unid.	-	-	1	0.93	5	5.38	8	7.74
Sebastes spp.	-	-	1	1.14	2	1.85	-	-
Girella nigricans	-	-	-	-	3	2.62	6	5.49
Typhlogobius californiensis	-	-	1	0.60	-	-	-	-
Citharichthys sordidus	-	-	-	-	2	1.53	2	1.89
Pleuronectidae unid.	-	-	-	-	1	0.76	-	-
Trachurus symmetricus	-	-	-	-	-	-	2	1.76
Halichoeres semicinctus	1	0.81	-	-	10	8.07	4	3.52
Syngnathus spp.	-	-	6	7.95	1	0.78	-	-
Labridae	7	6.83	1	1.34	-	-	1	0.68

Table A3 (continued). Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at source water Stations N1-N5 in nearshore area.

	3		4		5		6	
	07/06/04		08/13/04		09/23/04		10/21/04	
	20		20		20		20	
Taxon	**Count**	**Conc.**	**Count**	**Conc.**	**Count**	**Conc.**	**Count**	**Conc.**
Fishes								
Paraclinus integripinnis	-	-	7	6.28	-	-	-	-
Symphurus atricauda	-	-	-	-	10	8.81	1	1.23
Triphoturus mexicanus	-	-	1	0.60	6	5.23	2	1.30
Citharichthys spp.	-	-	1	1.14	-	-	3	3.36
Nannobrachium spp.	-	-	-	-	-	-	-	-
Medialuna californiensis	-	-	4	4.48	-	-	1	0.68
Gillichthys mirabilis	-	-	-	-	-	-	-	-
Chilara taylori	-	-	-	-	-	-	6	5.72
Heterostichus rostratus	-	-	-	-	-	-	-	-
Hypsoblennius jenkinsi	-	-	1	0.70	5	4.55	1	0.68
Paralichthyidae unid.	2	1.04	-	-	1	1.11	-	-
Atherinopsidae	-	-	-	-	-	-	-	-
Parophrys vetulus	-	-	-	-	-	-	-	-
Myctophidae unid.	1	1.21	-	-	1	0.75	-	-
Hippoglossina stomata	-	-	1	0.78	2	1.52	-	-
Zaniolepis frenata	-	-	-	-	-	-	-	-
Ruscarius creaseri	-	-	-	-	-	-	-	-
Clupeiformes	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	-	-	-	-	-	-	-	-
Clupeidae unid.	1	0.71	-	-	-	-	1	0.89
Lyopsetta exilis	-	-	-	-	-	-	-	-
Pomacentridae	-	-	1	0.97	-	-	1	0.90
Rhinogobiops nicholsi	-	-	-	-	1	1.01	-	-
Nannobrachium ritteri	-	-	-	-	-	-	-	-
Cyclothone spp.	-	-	-	-	1	0.77	-	-
Chromis punctipinnis	-	-	-	-	-	-	1	0.83
Icelinus spp.	-	-	-	-	-	-	-	-
Gobiesocidae unid.	-	-	-	-	-	-	-	-
Anisotremus davidsonii	1	0.67	-	-	1	0.90	-	-
Sebastes jordani	-	-	-	-	-	-	-	-
Blennioidei	1	1.05	-	-	-	-	-	-
Clinidae unid.	-	-	-	-	-	-	-	-
Chaenopsidae unid.	-	-	-	-	-	-	-	-
Leptocottus armatus	-	-	-	-	-	-	-	-
Cynoglossidae	-	-	-	-	-	-	1	0.89
Kyphosidae	-	-	-	-	-	-	1	0.89
Cyclothone acclinidens	-	-	-	-	-	-	-	-
Ilypnus gilberti	-	-	-	-	-	-	-	-
Gobiesox spp.	-	-	-	-	-	-	-	-
Hexagrammidae unid.	-	-	-	-	1	0.75	-	-
Bathylagus ochotensis	-	-	-	-	-	-	-	-
Hypsoblennius gentilis	-	-	-	-	-	-	-	-
Invertebrates								
Panulirus interruptus	19	18.79	5	5.56	2	1.49	-	-
Cancer anthonyi (megalops)	29	22.66	17	11.75	16	12.25	1	0.63
Cancer antennarius (megalops)	1	0.67	50	35.14	4	3.35	2	2.08
Cancer gracilis (megalops)	-	-	33	26.49	6	4.92	-	-
Cancer spp. (megalops)	-	-	4	2.93	-	-	-	-
Cancer productus (megalops)	-	-	1	1.32	-	-	-	-
	39,931		39,152	959	40,160		38,757	

Table A3 (continued). Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at source water Stations N1-N5 in nearshore area.

	7		8		9		10	
	11/18/04		12/16/04		01/13/05		02/24/05	
	20		20		20		20	
Taxon	**Count**	**Conc.**	**Count**	**Conc.**	**Count**	**Conc.**	**Count**	**Conc.**
<u>Fishes</u>								
Engraulis mordax	153	122.98	2	1.47	43	35.34	82	68.40
Hypsoblennius spp.	10	8.40	1	0.76	-	-	-	-
Engraulidae unid.	-	-	-	-	11	10.07	2	1.62
Gobiidae unid.	22	17.02	21	17.62	38	33.74	125	118.27
Genyonemus lineatus	78	63.14	8	6.99	46	38.44	143	124.31
larvae, unidentified yolksac	1	0.76	-	-	8	6.08	11	9.22
Paralichthys californicus	11	8.76	3	2.80	5	4.30	20	17.53
Seriphus politus	-	-	-	-	-	-	-	-
Sciaenidae unid.	1	0.67	-	-	6	5.75	3	3.04
Roncador stearnsi	-	-	-	-	-	-	-	-
Citharichthys stigmaeus	12	10.73	2	1.75	-	-	1	0.67
Gibbonsia spp.	6	5.19	40	32.33	61	57.65	52	48.45
Labrisomidae unid.	-	-	-	-	-	-	-	-
Paralabrax clathratus	-	-	-	-	-	-	-	-
Sardinops sagax	5	4.12	-	-	-	-	34	26.67
Paralabrax spp.	-	-	-	-	-	-	-	-
larval fish fragment	7	6.37	1	0.89	2	1.69	4	3.60
Haemulidae unid.	-	-	-	-	-	-	-	-
Scomber japonicus	-	-	-	-	-	-	-	-
Hypsypops rubicundus	-	-	-	-	-	-	-	-
larval/post-larval fish unid.	-	-	-	-	2	1.90	-	-
Oxyjulis californica	-	-	-	-	1	0.81	-	-
Paralabrax nebulifer	-	-	-	-	-	-	-	-
Sphyraena argentea	-	-	-	-	-	-	-	-
Xenistius californiensis	-	-	-	-	-	-	-	-
Lepidogobius lepidus	13	9.84	4	4.20	20	16.88	4	3.75
Stenobrachius leucopsarus	-	-	-	-	41	34.59	-	-
Pleuronichthys verticalis	1	1.08	-	-	-	-	-	-
Atherinopsis californiensis	-	-	3	2.10	10	9.29	7	6.78
Umbrina roncador	-	-	-	-	-	-	-	-
Pleuronichthys ritteri	-	-	-	-	2	1.77	-	-
Xystreurys liolepis	1	0.77	-	-	-	-	-	-
Hypsopsetta guttulata	2	1.51	1	1.05	8	6.75	2	1.60
Rimicola spp.	-	-	1	1.05	3	2.59	1	1.15
Peprilus simillimus	-	-	-	-	-	-	-	-
Cheilotrema saturnum	-	-	-	-	-	-	-	-
Semicossyphus pulcher	-	-	-	-	-	-	-	-
Ophidion scrippsae	1	0.95	-	-	-	-	-	-
Diaphus theta	-	-	-	-	-	-	-	-
Acanthogobius flavimanus	-	-	-	-	11	8.45	8	8.00
Pleuronichthys spp.	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	10	7.45	-	-	-	-	-	-
Menticirrhus undulatus	-	-	-	-	-	-	-	-
Atractoscion nobilis	-	-	-	-	-	-	-	-
Ophidiidae unid.	1	0.76	-	-	-	-	-	-
Sebastes spp.	7	5.29	6	4.35	-	-	-	-
Girella nigricans	4	3.47	-	-	-	-	-	-
Typhlogobius californiensis	-	-	-	-	-	-	2	1.80
Citharichthys sordidus	9	7.31	-	-	-	-	-	-
Pleuronectidae unid.	1	0.88	-	-	-	-	-	-
Trachurus symmetricus	-	-	-	-	-	-	-	-
Halichoeres semicinctus	-	-	-	-	-	-	-	-
Syngnathus spp.	-	-	1	0.74	1	0.66	-	-
Labridae	-	-	-	-	-	-	-	-

Table A3 (continued). Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at source water Stations N1-N5 in nearshore area.

	7		8		9		10	
	11/18/04		12/16/04		01/13/05		02/24/05	
	20		20		20		20	
Taxon	**Count**	**Conc.**	**Count**	**Conc.**	**Count**	**Conc.**	**Count**	**Conc.**
Fishes								
Paraclinus integripinnis	-	-	-	-	-	-	-	-
Symphurus atricauda	-	-	-	-	-	-	-	-
Triphoturus mexicanus	2	1.54	-	-	-	-	-	-
Citharichthys spp.	-	-	1	0.89	2	1.60	-	-
Nannobrachium spp.	1	0.76	1	0.84	4	3.51	1	0.90
Medialuna californiensis	-	-	-	-	-	-	-	-
Gillichthys mirabilis	-	-	1	0.72	4	3.37	3	2.59
Chilara taylori	1	0.81	-	-	-	-	-	-
Heterostichus rostratus	2	1.83	1	0.88	2	1.35	-	-
Hypsoblennius jenkinsi	-	-	-	-	-	-	-	-
Paralichthyidae unid.	2	1.95	-	-	1	1.01	1	0.61
Atherinopsidae	1	0.84	-	-	-	-	-	-
Parophrys vetulus	-	-	-	-	-	-	-	-
Myctophidae unid.	-	-	-	-	1	0.96	-	-
Hippoglossina stomata	2	1.49	-	-	-	-	-	-
Zaniolepis frenata	-	-	1	0.64	2	1.33	1	0.70
Ruscarius creaseri	-	-	-	-	1	0.68	-	-
Clupeiformes	-	-	-	-	-	-	1	0.78
Syngnathus leptorhynchus	-	-	-	-	-	-	-	-
Clupeidae unid.	-	-	-	-	-	-	1	0.67
Lyopsetta exilis	-	-	-	-	-	-	-	-
Pomacentridae	-	-	-	-	-	-	-	-
Rhinogobiops nicholsi	1	0.85	-	-	-	-	-	-
Nannobrachium ritteri	2	1.75	-	-	-	-	-	-
Cyclothone spp.	-	-	-	-	-	-	1	0.90
Chromis punctipinnis	1	0.82	-	-	-	-	-	-
Icelinus spp.	-	-	-	-	-	-	-	-
Gobiesocidae unid.	-	-	1	0.72	-	-	-	-
Anisotremus davidsonii	-	-	-	-	-	-	-	-
Sebastes jordani	-	-	-	-	2	1.33	-	-
Blennioidei	-	-	-	-	-	-	-	-
Clinidae unid.	-	-	-	-	-	-	-	-
Chaenopsidae unid.	-	-	-	-	-	-	1	0.97
Leptocottus armatus	-	-	-	-	-	-	1	0.90
Cynoglossidae	-	-	-	-	-	-	-	-
Kyphosidae	-	-	-	-	-	-	-	-
Cyclothone acclinidens	1	0.85	-	-	-	-	-	-
Ilypnus gilberti	-	-	1	0.84	-	-	-	-
Gobiesox spp.	-	-	-	-	-	-	-	-
Hexagrammidae unid.	-	-	-	-	-	-	-	-
Bathylagus ochotensis	-	-	-	-	-	-	-	-
Hypsoblennius gentilis	-	-	-	-	-	-	-	-
Invertebrates								
Panulirus interruptus	-	-	-	-	-	-	-	-
Cancer anthonyi (megalops)	8	5.93	2	1.26	3	2.96	1	1.01
Cancer antennarius (megalops)	4	2.91	1	1.12	-	-	-	-
Cancer gracilis (megalops)	2	1.44	2	1.73	1	1.05	-	-
Cancer spp. (megalops)	-	-	-	-	-	-	-	-
Cancer productus (megalops)	-	-	-	-	-	-	-	-
	38,722		38,471		38,736		38,950	

Table A3 (continued). Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at source water Stations N1-N5 in nearshore area.

	11		12		13	
	03/23/05		04/21/05		05/19/05	
	15		20		20	
Taxon	**Count**	**Conc.**	**Count**	**Conc.**	**Count**	**Conc.**
Fishes						
Engraulis mordax	1,767	1,805.85	3,356	2,740.48	18	13.11
Hypsoblennius spp.	3	3.31	11	8.69	191	173.15
Engraulidae unid.	1,163	1,211.29	10	8.62	10	8.93
Gobiidae unid.	98	99.04	21	20.98	91	76.18
Genyonemus lineatus	234	235.43	45	33.43	6	4.54
larvae, unidentified yolksac	19	20.47	2	1.58	11	9.07
Paralichthys californicus	28	27.91	11	9.12	6	4.78
Seriphus politus	-	-	1	1.22	-	-
Sciaenidae unid.	38	44.51	6	5.95	11	9.01
Roncador stearnsi	-	-	-	-	-	-
Citharichthys stigmaeus	2	1.93	2	2.00	-	-
Gibbonsia spp.	15	15.39	2	2.29	40	30.54
Labrisomidae unid.	-	-	1	0.74	-	-
Paralabrax clathratus	-	-	-	-	-	-
Sardinops sagax	-	-	118	101.46	-	-
Paralabrax spp.	-	-	1	0.69	-	-
larval fish fragment	5	5.02	8	6.78	2	1.32
Haemulidae unid.	-	-	-	-	-	-
Scomber japonicus	-	-	-	-	-	-
Hypsypops rubicundus	-	-	1	0.94	5	5.36
larval/post-larval fish unid.	-	-	2	1.69	1	0.55
Oxyjulis californica	1	1.20	4	3.35	-	-
Paralabrax nebulifer	-	-	-	-	-	-
Sphyraena argentea	-	-	-	-	-	-
Xenistius californiensis	-	-	-	-	-	-
Lepidogobius lepidus	3	2.73	2	1.99	6	3.84
Stenobrachius leucopsarus	-	-	10	7.78	-	-
Pleuronichthys verticalis	4	3.45	2	1.74	-	-
Atherinopsis californiensis	15	17.97	-	-	-	-
Umbrina roncador	-	-	-	-	-	-
Pleuronichthys ritteri	1	1.34	1	0.74	-	-
Xystreurys liolepis	-	-	-	-	1	0.75
Hypsopsetta guttulata	1	1.20	-	-	-	-
Rimicola spp.	-	-	-	-	-	-
Peprilus simillimus	-	-	3	2.33	-	-
Cheilotrema saturnum	-	-	-	-	-	-
Semicossyphus pulcher	-	-	-	-	1	0.75
Ophidion scrippsae	-	-	-	-	-	-
Diaphus theta	-	-	13	10.38	4	2.94
Acanthogobius flavimanus	3	2.58	-	-	-	-
Pleuronichthys spp.	-	-	1	0.74	1	0.75
Pleuronectiformes unid.	-	-	3	1.94	2	2.42
Menticirrhus undulatus	-	-	-	-	-	-
Atractoscion nobilis	-	-	2	1.91	-	-
Ophidiidae unid.	-	-	-	-	-	-
Sebastes spp.	-	-	1	0.77	1	0.75
Girella nigricans	-	-	-	-	-	-
Typhlogobius californiensis	2	1.94	2	2.17	3	2.30
Citharichthys sordidus	-	-	2	1.29	-	-
Pleuronectidae unid.	1	0.93	13	10.21	-	-
Trachurus symmetricus	-	-	2	1.38	-	-
Halichoeres semicinctus	-	-	-	-	-	-
Syngnathus spp.	-	-	-	-	-	-
Labridae	-	-	2	1.88	-	-

Table A3 (continued). Monthly abundance and mean concentration (#/1,000 m^3) of larval fishes and target invertebrates at source water Stations N1-N5 in nearshore area.

	11		12		13	
	03/23/05		04/21/05		05/19/05	
	15		20		20	
Taxon	**Count**	**Conc.**	**Count**	**Conc.**	**Count**	**Conc.**
Fishes						
Paraclinus integripinnis	-	-	-	-	-	-
Symphurus atricauda	-	-	-	-	-	-
Triphoturus mexicanus	-	-	-	-	-	-
Citharichthys spp.	-	-	-	-	1	1.24
Nannobrachium spp.	-	-	1	0.65	1	0.75
Medialuna californiensis	-	-	-	-	-	-
Gillichthys mirabilis	-	-	-	-	-	-
Chilara taylori	-	-	-	-	-	-
Heterostichus rostratus	-	-	-	-	-	-
Hypsoblennius jenkinsi	-	-	-	-	-	-
Paralichthyidae unid.	-	-	-	-	-	-
Atherinopsidae	3	3.21	-	-	-	-
Parophrys vetulus	-	-	5	3.93	-	-
Myctophidae unid.	-	-	1	0.94	-	-
Hippoglossina stomata	-	-	-	-	-	-
Zaniolepis frenata	-	-	-	-	1	0.55
Ruscarius creaseri	2	2.15	-	-	-	-
Clupeiformes	-	-	-	-	-	-
Syngnathus leptorhynchus	-	-	-	-	-	-
Clupeidae unid.	-	-	-	-	-	-
Lyopsetta exilis	-	-	3	2.04	-	-
Pomacentridae	-	-	-	-	-	-
Rhinogobiops nicholsi	-	-	-	-	-	-
Nannobrachium ritteri	-	-	-	-	-	-
Cyclothone spp.	-	-	-	-	-	-
Chromis punctipinnis	-	-	-	-	-	-
Icelinus spp.	-	-	-	-	3	1.65
Gobiesocidae unid.	-	-	-	-	-	-
Anisotremus davidsonii	-	-	-	-	-	-
Sebastes jordani	-	-	-	-	-	-
Blennioidei	-	-	-	-	-	-
Clinidae unid.	-	-	-	-	-	-
Chaenopsidae unid.	-	-	-	-	-	-
Leptocottus armatus	-	-	-	-	-	-
Cynoglossidae	-	-	-	-	-	-
Kyphosidae	-	-	-	-	-	-
Cyclothone acclinidens	-	-	-	-	-	-
Ilypnus gilberti	-	-	-	-	-	-
Gobiesox spp.	-	-	-	-	1	0.75
Hexagrammidae unid.	-	-	-	-	-	-
Bathylagus ochotensis	-	-	1	0.75	-	-
Hypsoblennius gentilis	-	-	-	-	-	-
Invertebrates						
Panulirus interruptus	-	-	-	-	-	-
Cancer anthonyi (megalops)	-	-	-	-	1	0.77
Cancer antennarius (megalops)	-	-	-	-	6	4.99
Cancer gracilis (megalops)	-	-	-	-	2	1.10
Cancer spp. (megalops)	-	-	-	-	-	-
Cancer productus (megalops)	-	-	-	-	2	1.54
	41,868		**42,167**		**38,953**	

CARLSBAD SEAWATER DESALINATION PROJECT

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

REGION 9, SAN DIEGO REGION

ORDER NO. R-9-2006-0065

NPDES NO. CA0109223

FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

ATTACHMENT 7 - MITIGATION COMPUTATION BASED ON IMPINGEMENT ASSESSMENT - CHRIS NORDBY (March 18, 2009)

March 27, 2009

NORDBY BIOLOGICAL CONSULTING

MITIGATION COMPUTATION BASED ON IMPINGEMENT ASSESSMENT

Chris Nordby - Nordby Biological Consulting

March 18, 2009

My name is Chris Nordby of Nordby Biological Consulting and I am an expert in the field of tidal wetlands restoration. On behalf of Poseidon Resources Corporation, I have prepared this statement to address whether the Marine Life Mitigation Plan will adequately account for the estimated potential impingement of the Carlsbad Desalination Plant ("CDP") should it operate in stand-alone mode. This statement replaced my earlier statement submitted as Attachment 7 to the Minimization Plan on March 9, 2009.

CDP's Estimated Impingement Based on a Flow-Proportioned Calculation and a Weighted Average for Non-Flow-Related Events Is No More Than 4.70 kg/day

The Encina Power Station ("EPS") hired Tenera Environmental to conduct an Impingement Mortality and Entrainment (IM&E) Study to comply with new 316(b) rules that the EPA promulgated in 2004. In 2004-2005, Tenera collected impingement and entrainment data pursuant to the Board-approved IM&E Study.

Since CDP will obtain feedstock water from EPS's existing intake structure, Tenera used the data it collected for the IM&E Study to estimate the potential for impingement from the future operations of the CDP. In order to isolate and account for impacts related to CDP's stand-alone operations, Tenera's data has been pro-rated, i.e., flow-proportioned in accordance with CDP's daily flow needs of 304 MGD. Based on this analysis, which is described in Chapter 5 of CDP's Flow, Entrainment and Impingement Minimization Plan, CDP's projected stand-alone impingement of fishes on some days could be as high as 4.70 kg/day.

I understand the value of 4.70 kg/day likely is very conservative, as it assumes that certain extreme rainfall events that occurred during the sampling period will re-occur every year. The amount of observed impingement during these extreme rainfall events was much higher than that which occurred on the vast majority of the sampling days. Extrapolating this value over the entire year provides an estimate of 1,715.5 kg/year of impingement potentially associated with operation in stand-alone mode. Again, this annual impingement value appears to be very conservative and may not even be seen over the project lifetime.

Poseidon's Mitigation Project Will Offset Fully the CDP's Estimated Stand-Alone Impingement

As is set forth in the MLMP, Poseidon's mitigation project will restore up to 55.4 acres of estuarine wetlands. A primary/express objective of this project is to mitigate for estimated entrainment associated with CDP's stand-alone operations. In addition to mitigating for entrainment, the mitigation project will provide the additional benefit of offsetting CDP's estimated stand-alone impingement. That is, the MLMP accomplishes two objectives: it mitigates fully for all entrainment and mitigates fully for all impingement that may result from CDP's stand-alone operations.

Fish productivity in shallow tidal wetlands is extremely high due to high primary productivity, efficient transfer of energy, and nursery functions that promote rapid growth and provide refugia from predators. The biomass of fishes in estuaries is often among the greatest biomass of higher trophic levels in natural ecosystems in the world (Day et al., 1989).

Allen (1982) conducted a study of fish productivity of the littoral zone of Upper Newport Bay where he calculated fish productivity at 9.35 g DW/m^2/yr. Allen makes several references to the relationship between dry weight (DW) and wet weight (WW) in his manuscript. Those statements indicate that WW is approximately four times greater than DW.[1]

The mudflats and tidal channels that Allen sampled in Upper Newport Bay are analogous to the habitat that would be created by Poseidon as mitigation for impingement and entrainment associated with the CDP. Allen's measurements were conservative in that he did not include mullet, an abundant but difficult-to-sample species, the large size of which would have increased biomass estimates; and he reported very low densities of arrow goby, a small but extremely abundant species in many southern California wetlands.

There are few studies of fish productivity in southern California wetlands that are similar to Allen's study; however, fish density data are available from other southern California systems from the same time period that can be compared to Upper Newport Bay. Nordby and Zedler (1991) sampled fishes at Tijuana Estuary and Los Penasquitos Lagoon from 1986 to 1989 and from 1987 to 1989, respectively. Allen sampled monthly, while Nordby and Zedler sampled quarterly. While there is considerable variability from month to month, and year to year, the densities of the dominant estuarine fishes in Allen's Newport Bay studies are typical of southern California estuaries. Tijuana Estuary consistently had the highest fish densities. Typified by continuous tidal flushing and shallow, dendritic channels, Tijuana Estuary serves as the model estuarine system to be created by Poseidon compared to Upper Newport Bay. Although density is an indirect indicator of productivity, it is reasonable that systems with similar densities of these species would have similar productivities.

Because the density of fishes sampled in Allen's study was typical of the density of fishes in other southern California coastal wetlands, it is reasonable to assume that his conservative productivity measurement for Upper Newport Bay would be applicable to Poseidon's mitigation.

Based on Allen's estimate of 9.35 g DW/m^2/yr and the understanding that wet weight exceeds dry weight by a factor of approximately four, Allen's dry weight value can be converted into a wet weight productivity estimate of approximately 37.4 g WW/m^2/yr. Based on these figures, 37 acres of restored coastal wetland habitat would yield approximately 5,600 kg WW/yr of fish biomass; 55.4 acres would yield approximately 8,385 kg WW/yr fish biomass.[2]

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[1] Allen notes that a biomass density of *Atherinops affinis* of 3.3 g WW/m^2 is about 0.83 g DW/m^2 – a factor of 3.97 (3.3/0.83) (Allen, p. 785). He later explains that the total biomass density of all species by total area was 4.13 g WW/m^2 or about 1.02 g DW/m^2 – a factor of 4.04 (4.13/1.02) (Allen, p. 786). Finally, he says that an average standing stock of 784 kg DW is equivalent to 3,136 kg (wet weight)—a factor of 4 (3136/784) (Allen, 786).

[2] Calculations are based on the following facts:

1. 4,047 square meters in 1 acre;
2. 37.4 grams WW fish biomass produced per square meter (Allen);
3. grams WW fish biomass produced per acre (4047 x 37.4)—151.36 kgWW/acre.

CDP's operations have the potential to result in impingement of no more than 4.70 kg WW of organisms per day or 1,715.5 kg WW per year; its mitigation project, therefore, fully offsets CDP's stand-alone impingement at 11.3 acres. (Design and technology enhancements planned for the intake structure during stand-alone operations further render these estimates conservative. In other words, actual impingement should be reduced from these values by design and technology features. But, it was not possible to quantify such minimization.) Therefore, if all 55.4 acres of mitigation wetlands are constructed, the mitigation project will generate significantly more fish biomass than that potentially be impinged at the CDP.

Mitigation Acreage to Fully Offset Impingement at
Various Impingement Estimates for Stand-Alone Operations

Impingement Estimation Approaches	Treatment of Non-Flow-Related Events	Weight (kg/day)[3]	Mitigation Acreage to Fully Offset
1. Regression	Excluded	1.57	3.8 acres
2. Regression	Weighted Average	4.18	10.1 acres
3. Proportional	Included	3.74	9.0 acres
4. Proportional	Weighted Average	4.70	11.3 acres

Finally, the mitigation wetlands also will provide a habitat for invertebrates, resulting in invertebrate biomass that otherwise would not exist in nature. I was unable to quantify the amount of invertebrate biomass that will be produced at the mitigation sites. But, I can conclude with great confidence that such will occur. The fact that fish biomass production at the mitigation sites alone will offset the potential for combined fish and invertebrate impingement at the CDP introduces a margin of safety into this analysis.

Literature Cited:

1. Larry Glen Allen, *Seasonal Abundance, Composition and Productivity of the Littoral Fish Assemblage in Upper Newport Bay, California*, 80 Fishery Bulletin 4, 769-90 (1982).
2. John W. Day et al., Estuarine Ecology (John Wiley and Sons, Inc.) (1989).
3. C.S. Nordby & J.B. Zedler, *Responses of Fish and Macrobenthic Assemblages to Hydrologic Disturbances in Tijuana Estuary and Los Penasquitos Lagoon, California*, 14 Estuaries 1, 80-93 (1991).

[3] Impingement estimates taken from "Estimation of the Potential for Impingement Should the CDP Operate in Stand-Alone Mode."

SEASONAL ABUNDANCE, COMPOSITION, AND PRODUCTIVITY OF THE LITTORAL FISH ASSEMBLAGE IN UPPER NEWPORT BAY, CALIFORNIA

LARRY G. ALLEN[1]

ABSTRACT

This study was designed to characterize the littoral fish populations by 1) composition and principal species, 2) diversity and seasonal dynamics, 3) productivity, and 4) important environmental factors.

Monthly samples (January 1978 to January 1979) obtained with four quantitative sampling methods at three stations in upper Newport Bay yielded 55,561 fishes from 32 species which weighed 103.5 kg. The top five species made up over 98% of the total number of individuals. One species, *Atherinops affinis*, predominated in numbers (76.7% of all fishes) and biomass (79.8%). This dominance was reflected in the low overall H' diversity values for numbers (H'_N = 0.89) and biomass (H'_B = 0.84). Number of species, number of individuals, and biomass were greatest during the spring and summer.

Quantitative clustering of species based on individual samples revealed five species groups which reflected both microhabitat and seasonal differences in the littoral ichthyofauna. Species Group I was made up of five resident species—*A. affinis*, *Fundulus parvipinnis*, *Clevelandia ios*, *Gillichthys mirabilis*, and *Gambusia affinis*. Species Groups II-VI were composed of summer and winter periodics and rare species.

The mean annual production (9.35 g dry weight m^{-2} determined by the Ricker production model) of the littoral zone fishes was among the highest of reported values for comparable studies. This high annual production was mainly the result of the rapid growth of large numbers of juveniles that utilized the littoral zone as a nursery ground. Young-of-the-year *Atherinops affinis* contributed 85% of this total production.

Canonical correlation analysis indicated that temperature and salinity together may influence littoral fish abundance. These two abiotic factors accounted for 83% of the variation in the abundances of individual species. Emigration from the littoral zone, therefore, seems to be cued by seasonal fluctuations in temperature and salinity. I propose that this offshore movement forms an important energy link between the highly productive littoral zone and local, nearshore marine environment.

Semienclosed bays and estuaries are among the most productive areas on Earth, ranking with oceanic regions of upwelling, African savannas, coral reefs, and kelp beds (Haedrich and Hall 1976) in terms of animal tissue produced per year. Bays and estuaries harbor large stocks of nearshore fishes and are important feeding and nursery grounds for many species of fish, including commercially important ones. However, the high productivity of fishes is accompanied by low diversity (Allen and Horn 1975) which probably reflects the stressful ecological conditions in bays and estuaries and the high physiological cost of adaptation to them (Haedrich and Hall 1976). The few studies that have dealt with productivity in estuarine fishes were summarized by Wiley et al. (1972) and Adams (1976b).

Utilization of temperate embayments by juvenile and adult fishes is markedly seasonal with high abundances corresponding to the warmer, highly productive months of spring through autumn. Seasonal species typically spend one spring-autumn period in the shallows of a bay growing at an accelerated rate in the warm, highly productive waters (Cronin and Mansueti 1971).

Most studies to date dealing with composition and temporal changes of bay-estuarine fish populations have been conducted on the Gulf of Mexico and Atlantic coasts of the United States where estuaries are larger and more numerous than those on the Pacific coast (e.g., Bechtel and Copeland 1970; Dahlberg and Odum 1970; Derickson and Price 1973; McErlean et al. 1973; Oviatt and Nixon 1973; Recksiek and McCleave

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1973; Haedrich and Haedrich 1974; Targett and McCleave 1974; Livingston 1976; Moore 1978; Shenker and Dean 1979; Orth and Heck 1980). Although quantitative in nature, many of these investigations suffer from the inefficient (Kjelson and Johnson 1978) trawl sampling gear used and the high mobility of most fishes. Adams (1976a, b) used dropnet samples to accurately assess the density and productivity of the fishes of two North Carolina eelgrass beds. Weinstein et al. (1980) used a combination of block nets, seines, and rotenone collections to derive accurate quantitative estimates of fishes in shallow marsh habitats in the Cape Fear River Estuary, N.C.

Previous investigations of fishes in Newport Bay have included a species list (Frey et al. 1970), a general species account (Bane 1968), two individual species accounts (Fronk 1969; Bane and Robinson 1970), and two studies on the population ecology of the fauna based on juveniles and adults (Posejpal 1969; Allen 1976). An assessment of the ichthyoplankton and demersal fish populations during 1974-75 (Allen and White in press) is the most comprehensive work to date.

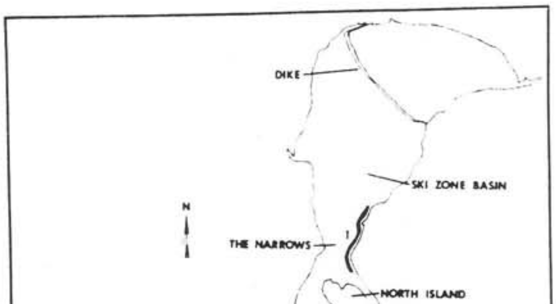

FIGURE 1.—Map of upper Newport Bay, Orange County, Calif., with the locations of the three sampling stations.

Despite these studies, a substantial component of the ichthyofauna, the littoral fishes of the upper bay (0-2 m depth from mean higher high water), had not been adequately sampled. In a study of the demersal ichthyofauna of Newport Bay during 1974-75 (Allen 1976), I found that three—*Atherinops affinis*, *Fundulus parvipinnis*, and *Cymatogaster aggregata*—of the five most numerous species were the ones that occurred in the shallow water over the mudflats which cover about 60-70% of the surface area of the upper bay reserve. Despite their high numerical ranking, the relative abundances of these littoral species were underestimated because sampling was carried out almost exclusively by otter trawls in the deeper channels of the upper bay. The recognition of this gap in our knowledge served as the impetus for the present study.

The main purposes of this study were to characterize the littoral ichthyofauna of upper Newport Bay quantitatively by 1) composition and principal species, 2) diversity and seasonal dynamics, 3) productivity, and 4) key environmental factors that are influencing this fish assemblage.

METHODS AND MATERIALS

Study Area

Newport Bay (lat. 33°37'30"N, long. 117°54'20"W) is located in Orange County, Calif., 56 km southeast of Los Angeles and 140 km north of the Mexican border (Fig. 1). The upper portion is the only large, relatively unaltered bay-estuarine habitat in California south of Morro Bay (lat. 34.5°N). The low to moderately polluted lower portion, commonly called Newport Harbor, has been severely altered by dredging activities, landfills, and bulkheads to accommodate more than 9,000 boats. The study area, the upper two-thirds of the upper bay, is bordered almost completely by marsh vegetation and mudflats. The California Department of Fish and Game purchased and set aside this area as an ecological reserve in 1975.

Three stations, about 0.5 km in length, were spaced evenly along the shore of the upper Newport Bay (Fig. 1). Sampling was stratified based on prior information on the uniqueness of the fish fauna of the three areas (Allen 1976). This design also allowed thorough coverage of the study area. Each station was situated on a littoral (intertidal) mudflat area adjacent to marsh vegetation

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2) A 4.6 m × 1.2 m s
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3) A 2.45 × 2.45 × 1
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4) A small, square e

and was divided into 10 numbered sections of equal size. Selection of the section sampled each month was random in order to satisfy statistical assumptions and minimize the impact of sampling on any particular section from month to month. Each station included a tidal creek or pool (panne) which was sampled on the marsh islands.

Sampling Procedures

Monthly samples were taken at the three stations during the 13-mo period from January 1978 to January 1979 for a total of 39 station samples. Sampling was carried out within ±3 h of daytime neap high tide to minimize tidal level effects. Two days were usually required to sample three stations, stations 1 and 2 the first day and station 3 the second.

Four types of sampling gear were employed at each station as follows:

1) A 15.2 m × 1.8 m bag seine (BS) with 6.4 mm mesh in the wings and 3.2 mm mesh in the 1.8 × 1.8 × 1.8 m bag was used twice at each station. Hauls were made by setting the net parallel to and 15 m off the shore at a depth of 1-2 m. The BS was then hauled to shore using 15 m polypropylene lines attached to 1.8 m brails on each end of the net. Each haul sampled an area of 220 m^2.

2) A 4.6 m × 1.2 m small seine (SS) with 3.2 mm mesh was pulled 10 m along and 2 m from the shore (at a depth to 1 m) and pivoted to shore. Two hauls were made in the inshore area and one haul in the panne at each station. Each haul sampled an area of 62.4 m^2. [One exception to the sampling routine occurred at station 3 panne in April 1978 when no sample was taken due to a dry panne.]

3) A 2.45 × 2.45 × 1.0 m dropnet (DN) with 3.2 mm mesh was used to sample the water column and bottom at 0.5-1.5 m depth. The DN was suspended from a 5.0 × 5.0 × 1.0 m aluminum pipe frame, released by pins at each corner. Two 19 l plastic buckets were attached to each corner of the frame for flotation. The net and frame were maneuvered into position, anchored, and left undisturbed for 10 min. After release the DN was pursed by the chain line and hauled to shore by nylon line. The DN sampled an area of 6.0 m^2.

4) A small, square enclosure (SE) was used in conjunction with an anesthetic (quinaldine mixed 1:5 with isopropyl alcohol) with the intent of sampling small burrow inhabiting fishes, especially gobies. The SE was constructed of heavy duck material mounted on a 1.0 × 1.0 × 1.0 m collapsible frame of 25.0 mm PVC pipe and sampled 1.0 m^2 of bottom. The SE was set at three randomly chosen positions in an undisturbed portion of each station section at a depth of 0.5-1.0 m. The bottom of the SE was forced into the upper few centimeters of substrate and the quinaldine mixture added to the enclosed water column. The enclosed volume and shallow substrate was then thoroughly searched for 10 min using a long-handled dip net of 1.0 mm mesh.

A detailed comparison of the effectiveness of these four methods is the subject of a separate paper (Horn and Allen[2]).

Ten samples were taken at each of the three stations each month (2 BS samples, 3 SS samples, 2 DN samples, 3 SE samples) for a total of 30 samples/mo and 289 samples over the study (minus one SS haul in April 1978 at station 3).

Catches were either frozen on Dry Ice[3] or preserved in 10% buffered Formalin. Specimens >150 mm SL were injected abdominally with 10% buffered Formalin. Subsamples of frozen specimens were oven dried (40°C) for 48-72 h for dry weight determination. Mean dry weights were based on a minimum of 20 individuals/size-class of each common species at each station each month.

Data on six abiotic factors were recorded or determined for each station: temperature, salinity, dissolved oxygen, sediment particle size, depth of capture (by individual samples), and distance into the upper Newport Bay from the Highway 1 bridge (see Fig. 1).

Production Estimation

Production is the total amount of tissue produced during any given time interval including that of individuals which do not survive to the end of that time interval (Ivlev 1966). Productivity is the rate of production of biomass per unit of time (Wiley et al. 1972). Production of a fish stock

[2]Horn, M. H., and L. G. Allen. Comparison of methods for sampling shallow-water estuarine fish populations. Manuscr. in prep. California State University, Fullerton, Fullerton, CA 92634.

[3]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

is the product of the density of fish and the growth of the individuals (Ricker 1946).

An HP9100A program was developed with the aid of Joel Weintraub (California State University, Fullerton) to calculate the production of each recognizable size-class of the common species, those which were collected in at least 2 consecutive months at each station. The model used was that proposed by Ricker (1946) and modified by Allen (1950) and is calculated as follows:

$$P = G\overline{B}$$

where $G = \dfrac{\log_e \overline{w}_2 - \log_e \overline{w}_1}{\Delta t}$ is the instantaneous coefficient of growth;

$\overline{B} = \dfrac{B_1(e^{G-Z}-1)}{G-Z}$ is the average biomass over the time interval;

$Z = \dfrac{-(\log_e N_2 - \log_e N_1)}{\Delta t}$ is the instantaneous coefficient of population change of the immediate sampling area (station) attributable to mortality and migration;

B is the biomass density of fishes at t_1; w_1, w_2 are the mean weights of individuals at time t_1 and t_2; and N_1, N_2 are the numbers of fishes present at t_1 and t_2. $G-Z$ is the net rate of increase in biomass during Δt (1 mo).

The model assumes that production data need not be corrected for immigration and emigration of fishes in and out of the sampling area, provided the density and growth by size-class are estimated frequently enough to accurately assess the abundance and growth of fishes actually in the sampling area (Chapman 1968).

In the present study, growth increments were estimated from length-frequency data for fishes from all three stations each month for each size-class. The length data, therefore, were representative of the entire population of the size-class in the upper Newport Bay and served to minimize the effects which localized movements into and out of a particular station have on monthly growth values. The average weight, $\overline{w}$, of a size-class per month was calculated as follows: 1) Dry weight equivalent for the median length in a size interval (5 mm intervals) was determined using standard length to dry weight curves for each common species; 2) the proportion (range 0-1) of individuals represented in the size interval was multiplied by the dry weight equivalent for the interval; 3) the products were then summed for all size intervals contained within the particular size-class of the species yielding an average weight, $\overline{w}$. This method proved to be more accurate than simply taking the mean length of the entire size-class and determining the dry weight equivalent.

The "best estimate" of biomass density (B) for each discernible size-class was determined in the following manner: 1) The biomass density (wet weight) derived from the method (BS, SS, DN, or SE) shown to be most effective at sampling the particular species was used. Table 1 lists the species with corresponding collecting gear ranked by their effectiveness at capturing the species. This list is based on a comparative study of the sampling methods (Horn and Allen footnote 2); 2) if, as in a few cases, the biomass estimated was inordinately high, due to a large catch in one replicate sample, the estimate defaulted to the next gear type in the rank order; 3) the biomass estimate in wet weight was converted to a dry weight (DW) equivalent by a conversion factor determined for each species and entered into the production model as B_1 (g DW/m^2). Production is the total of all positive values for size-classes during a time period (1 mo in this case) at each station. Negative values were due to sampling error and emigration and were not included in production estimates.

Large individuals (>100 mm SL) of *Mugil cephalus* were not included in production esti-

TABLE 1.—Methods for best estimate of species densities ranked by effectiveness (Horn and Allen text footnote 2). BS = bag seine; SS = small seine; DN = dropnet; SE = square enclosure.

Species	Methods ranked by effectiveness
Atherinops affinis	BS, SS
Fundulus parvipinnis	SS, BS
Clevelandia ios	SE, SS, DN
Anchoa compressa	BS, SS, DN
Gambusia affinis	SS, BS
Cymatogaster aggregata	BS, DN, SS
Gillichthys mirabilis	SS, SE, BS
Anchoa delicatissima	BS, SS
Mugil cephalus	SS, BS
Engraulis mordax	BS, SS
Leuresthes tenuis	BS, SS
Quietula ycauda	DN, SS
Ilypnus gilberti	DN, SS
Syngnathus spp.	SS, DN
Hypsopsetta guttulata	SS, DN
Lepomis macrochirus	BS, SS
Lepomis cyanellus	BS, SS
All other species	BS, SS

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mates because quantitative estimates of densities could not be obtained for the large members of this mobile species.

Data Analysis

Cumulative Species Curve

The cumulative number of species in February (low fish density) and June (high fish density) was plotted against the number of samples taken in order to assess the adequacy of sampling. Two random sequences were used for the arrangement of the 30 samples taken each month by the four methods. Each method sampled a unique subhabitat within the littoral zone. Cumulative species curves (reflecting presence/absence) were based on a combination of methods to insure that all possible species occupying the littoral zone at a particular time were represented.

Diversity

Both the Shannon-Wiener information function (Shannon and Weaver 1949) and species richness were used as measures of diversity for pooled station and upper bay samples. The Shannon-Wiener index reflects both species richness and evenness in a sample.

Cluster Analysis and Canonical Correlation

The Ecological Analysis Package (EAP) developed by R. W. Smith was used at the University of Southern California Computer Center to determine species associations (cluster analysis), species abundance correlations to abiotic factors (multiple regression subprogram), and possible effects of abiotic factors on individual species abundance (canonical correlation).

The cluster analysis utilized the Bray-Curtis index of dissimilarity (Clifford and Stephenson 1975). This index allowed quantitative clustering without assuming normality in the sampled population. A square-root transformation of species counts was done to counter the tendency of this index to overemphasize dominant species.

Canonical correlation analysis was used to determine whether and to what extent abiotic factors interacted with individual species abundances in the 39 station samples over the study period. Two separate canonical correlation analyses were made: The first run included six abiotic factors—temperature (TEMP), salinity (SAL), dissolved oxygen (DO), distance into the upper bay from the Highway 1 bridge (DSTUPB), average particle size of the sediment (APRTSZ), and depth of capture (DPTHCAP); the second included only temperature and salinity to determine the amount of variation these two factors accounted for alone.

RESULTS

Temperature and Salinity Patterns

Water temperatures of the littoral zone at all three stations increased steadily during the period January-June from 14°-15°C to 26°-28°C (Fig. 2). The temperatures remained high (>25°C) throughout the summer months and then declined gradually until November. Between November and December the temperature dropped sharply at each station. Temperatures in the pannes were generally higher than the tempera-

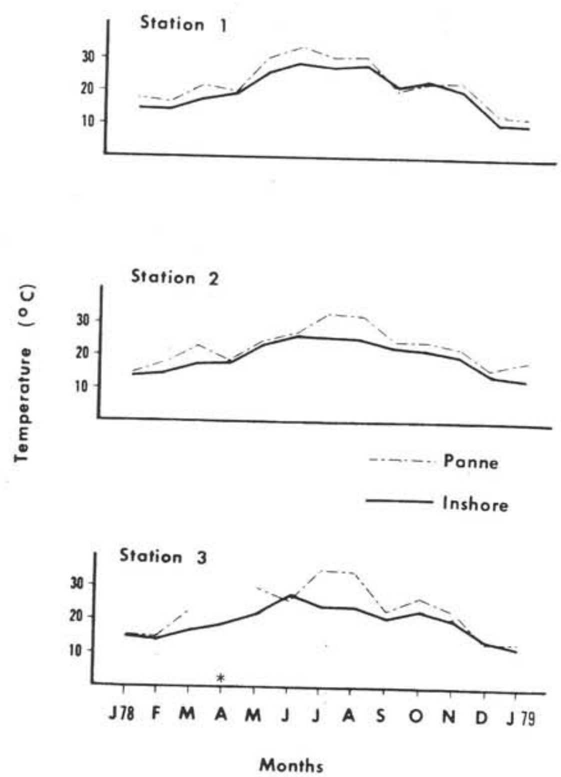

FIGURE 2.—Month-to-month variation (January 1978-January 1979) in water temperature (°C) for the alongshore area and panne at each of the three sampling stations. (* = panne dried-up.)

tures along the shore especially in the summer months (July-September).

Salinity varied more than temperature (Fig. 3) due to rainfall and periodic runoff from surrounding urban areas. In general all stations had low salinities during January through March 1978, a period of heavy rainfall. After May 1978, salinities remained high (between 25 and 32 ppt) with decreases in June 1978 (stations 1 and 3, unknown cause), September 1978 (all stations due to heavy rainfall), and January 1979 (station 3 due to rainfall). Panne salinities at station 1 were consistently low (usually <6 ppt) indicating a constant freshwater input. The pannes at stations 2 and 3, however, usually had salinities equal to or higher than the alongshore area due to evaporation.

Total Catch

Sampling during the 13-mo period yielded 55,561 individuals of 32 species that weighed a total of 103.5 kg (Table 2).

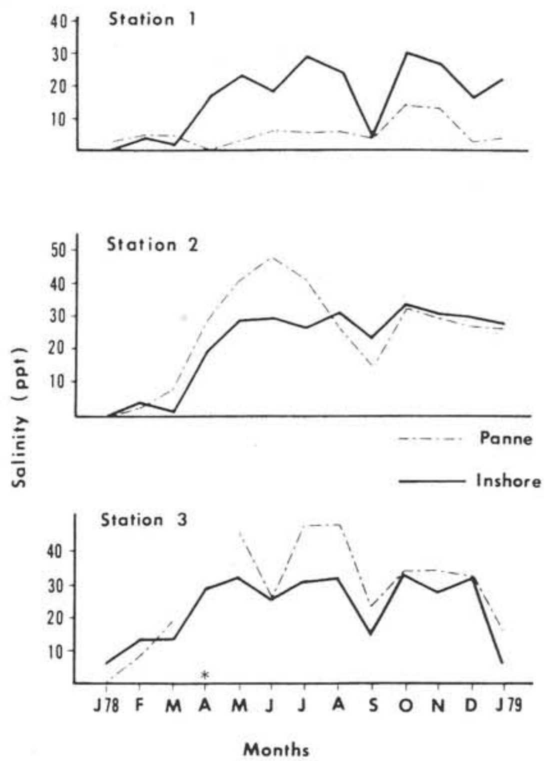

FIGURE 3.—Month-to-month variation (January 1978-January 1979) in salinity (ppt) for the alongshore area and panne at each of the three sampling stations. (* = panne dried-up.)

Atherinops affinis greatly predominated in numbers (76.7%) and biomass (79.9%). *Fundulus parvipinnis* ranked second in both numbers (12.1%) and biomass (7.6%), followed in order by *Gambusia affinis* (5.5% numbers), *Clevelandia ios* (2.4% numbers), and *Anchoa compressa* (1.2% numbers). These five species accounted for 98% of the total number of individuals and 96% of the total biomass (Table 2). The skewed distribution of number of individuals among species was reflected in the relatively low overall H' diversity values of 0.89 for numbers (H'_N) and 0.84 for biomass (H'_B). The vast majority of individuals of most species were either young-of-the-year or juveniles.

Station 1—A total of 13,859 individuals representing 19 species was collected during the year. The catch totaled 22.7 kg. All three of these totals were the lowest of those from the three stations. Overall H' diversity for numbers was 1.17 and for biomass, 0.89. *Atherinops affinis* ranked first in numbers (55.2%) and biomass (76.7%) but was less abundant here than at stations 2 and 3. *Gambusia affinis* (20.6%) and *Fundulus parvipinnis* (19.1%) were common at this station especially in the panne.

Station 2—The greatest number of individuals (24,813) and biomass (42.9 kg) were collected at this site. Although 27 species were captured, over 90% of these individuals were from one species, *Atherinops affinis*. The large number of attached eggs and small (<20 mm) fish caught in July (52% of all *A. affinis*) indicated that this area was a breeding site for *A. affinis*. *Fundulus parvipinnis* (4.4%) was second in numerical rank. H' for numbers (0.49) and biomass (0.70) were low.

Station 3—A total of 16,889 fishes belonging to 23 species were obtained at this station. *Atherinops affinis* made up 74.4% of the individuals and 78.8% of the 37.9 kg total biomass. Other important species in order of decreasing numerical abundance were *Fundulus parvipinnis* (17.6%), *Clevelandia ios* (3.4%), *Cymatogaster aggregata* (1.3%), and *Anchoa compressa* (1.3%). Overall, H'_N and H'_B were 0.87 and 0.85, respectively.

Cumulative Species Curves

Cumulative species curves from February and June (Fig. 4) reached an asymptote before 20 samples (about 66% of total samples), indicating

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TABLE 2.—Monthly abundance and biomass for fish species inhabiting the littoral zone of upper Newport Bay totaled for stations 1-3 (January 1978-January 1979).

Species	January 1978		February		March		April		May		June		July	
	No	Wt (g)	No	Wt (g)	No	Wt (g)	No	Wt (g)	No	Wt (g)	No	Wt (g)	No	Wt (g)
Atherinops affinis	15	70.5	5	158.3	4	92.0	15	59.1	322	1,212.1	6,296	2,377.6	19,817	19,093.3
Fundulus parvipinnis	377	315.7	208	198.3	181	90.4	17	20.7	35	92.2	89	112.3	758	854.8
Gambusia affinis	46	10.3	23	7.1	9	3.2	5	2.8	56	7.1	235	107.4	573	342.9
Clevelandia ios	49	21.4	39	14.3	80	12.9	47	6.1	100	22.4	74	15.8	485	109.0
Anchoa compressa	26	82.9	1	1.2	15	29.4	136	629.3	317	4,393.4	98	1,154.6	77	920.5
Cymatogaster aggregata							11	11.5	141	196.8	4	5.7		
Gillichthys mirabilis	12	2.4	38	5.9	14	3.5	5	10.0	17	39.6	49	127.1	52	141.4
Anchoa delicatissima	10	6.5	1	0.2	28	16.8	47	86.7	17	48.2			1	3.0
Mugil cephalus	41	78.0	11	7.1	1	1.5	1	555.5	1	550.0				
Engraulis mordax													81	89.4
Leuresthes tenuis														
Quietula ycauda	1	1.0							3	1.4	9	3.9	28	14.9
Ilypnus gilberti									3	0.5	10	1.0	24	6.5
Lepomis cyanellus			1	5.2										
Syngnathus auliscus									4	3.6	10	8.7	4	3.3
Hypsopsetta guttulata									10	1.9	4	12.9	2	18.2
Lepomis macrochirus	2	8.1	4	22.2	2	4.1								
Syngnathus leptorhynchus							1	2.1			2	2.6		
Leptocottus armatus					1	1.0			2	4.7	1	1.6		
Acanthogobius flavimanus							2	0.5	1	4.0				
Paralichthys californicus													2	5.4
Pimephales promelas			2	0.2										
Morone saxatilis											1	317.1		
Urolophus halleri														
Mustelus californicus													1	58.0
Seriphus politus														
Cynoscion nobilis													1	6.6
Sphyraena argentea														
Girella nigricans													1	0.4
Symphurus atricauda			1	0.2										
Porichthys myriaster														
Umbrina roncador														
Totals	579	596.8	334	420.2	335	254.8	287	1,384.3	1,029	6,577.9	6,882	4,248.3	21,907	21,667.6
n	10		12		10		11		15		14		16	
H'	1.29	1.46	1.33	1.27	1.37	1.55	1.61	1.22	1.76	1.07	0.44	1.24	0.46	0.56

TABLE 2.—*Continued.*

Species	August No.	August Wt (g)	September No.	September Wt (g)	October No.	October Wt (g)	November No.	November Wt (g)	December No.	December Wt (g)	January 1979 No.	January 1979 Wt (g)	Totals No.	Totals % No.	Totals Wt (g)	Totals % Wt
Atherinops affinis	4,645	13,181.2	4,122	9,606.2	2,902	14,016.0	2,474	12,409.8	1,143	5,738.8	831	4,650.1	42,591	76.67	82,665.0	79.86
Fundulus parvipinnis	312	250.1	1,707	2,323.0	1,023	2,638.8	1,356	738.0	593	259.7	66	26.5	6,722	12.10	7,920.5	7.65
Gambusia affinis	252	42.4	1,029	399.4	680	126.2	149	15.2	20	2.1			3,077	5.54	1,066.1	1.03
Clevelandia ios	68	16.4	151	41.8	66	16.3	142	31.3	28	3.9	5	1.1	1,334	2.40	312.7	0.30
Anchoa compressa	7	104.9	3	53.1	4	104.8							684	1.23	7,474.1	7.22
Cymatogaster aggregata	61	390.9	2	16.6			2	34.1	1	22.6	1	12.4	223	0.40	690.6	0.67
Gillichthys mirabilis	4	27.0	1	20.0	4	37.1	1	12.0			6	0.3	203	0.37	426.3	0.41
Anchoa delicatissima	64	234.4	26	71.7	1	3.5							195	0.35	471.0	0.46
Mugil cephalus									68	13.3	9	1.5	132	0.24	1,206.9	1.17
Engraulis mordax			29	58.6	2	7.2					1	—	113	0.20	155.2	0.15
Leuresthes tenuis	85	57.8	3	2.3									88	0.16	60.1	0.06
Quietula ycauda	5	1.9	4	1.5	2	0.4	1	0.1					53	0.10	25.1	0.02
Ilypnus gilberti							1	0.1					38	0.07	8.1	0.01
Lepomis cyanellus			31	49.3									32	0.06	54.5	0.05
Syngnathus auliscus	1	0.4			1	0.1							20	0.04	16.1	0.02
Hypsopsetta guttulata							1	2.9			2	0.2	19	0.03	36.1	0.03
Lepomis macrochirus													8	0.01	34.4	0.03
Syngnathus leptorhynchus	1	2.8	3	5.2							1	0.3	8	0.01	13.0	0.01
Leptocottus armatus													4	0.01	7.3	0.01
Acanthogobius flavimanus													3	0.01	4.5	<0.01
Paralichthys californicus													2	<0.01	5.4	0.01
Pimephales promelas													2	<0.01	0.2	<0.01
Morone saxatilis													1	<0.01	317.1	0.31
Urolophus halleri	1	430.0											1	<0.01	430.0	0.42
Mustelus californicus													1	<0.01	58.0	0.06
Seriphus politus					1	0.3							1	<0.01	0.3	<0.01
Cynoscion nobilis													1	<0.01	6.6	0.01
Sphyraena argentea							1	4.2					1	<0.01	4.2	<0.01
Girella nigricans													1	<0.01	0.4	<0.01
Symphurus atricauda													1	<0.01	0.2	<0.01
Porichthys myriaster							1	0.1					1	<0.01	0.1	<0.01
Umbrina roncador	1	44.2											1	<0.01	44.2	0.04
Totals	5,507	14,784.4	7,111	12,648.7	4,686	16,950.7	4,129	13,247.8	1,853	6,040.4	922	4,692.4	55,561		103,514.3	
n	14		13		11		11		6		9		32			
H'	0.69	0.55	1.10	0.77	0.99	0.54	0.92	0.27	0.90	0.23	0.42	0.06	0.89		0.84	

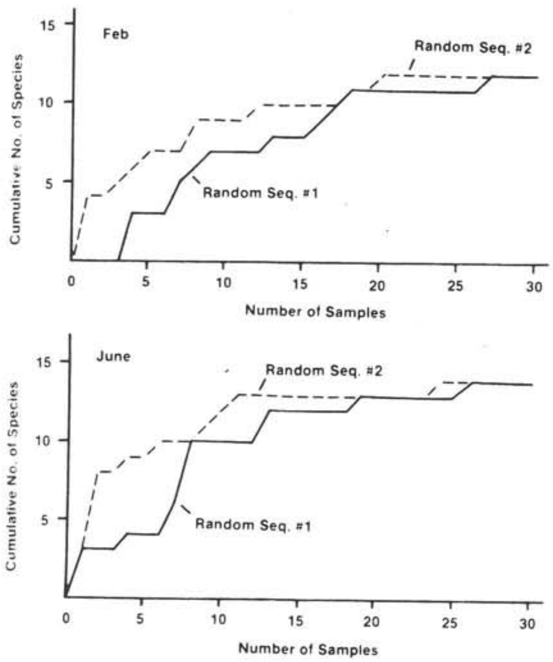

FIGURE 4.—Cumulative number of species as a function of the number of samples of all methods at stations 1-3 combined in upper Newport Bay for two different months (February and June 1978) during the study period. Curves were generated by two random sequences for each month.

that the range of fish species in the area had been adequately sampled by the four methods. Accumulation of species in June, however, was generally more rapid than in February.

Seasonal Abundance and Diversity

Fish abundance and diversity fluctuated markedly during the 13 mo of the study (Fig. 5). As a whole, the ichthyofauna of the littoral zone showed increased species richness from 10 species in January to 16 species in July 1978. The number of species was elevated (>14) for the entire spring-summer period from May to August 1978. Richness then decreased through the fall, reaching its lowest point of six species in December 1978. Diversity H' values fluctuated in a pattern opposite to that of species richness. H'_N decreased during the summer from a high in May of 1.76 to a low in June of 0.44. H'_B also decreased sharply in summer but unlike H'_N continued to decline for the remainder of the study. Both the number of individuals and biomass began to increase dramatically during May 1978 and reached peaks of 21,907 individuals and 21.7 kg in June. Both numbers and biomass decreased in August with number of individuals increasing again in September. Biomass declined once again in September during a period of rainfall and then increased in October. In the months from October 1978 to January 1979 a rapid decline in both numbers and biomass was evident and was especially pronounced from November to December. A greater number of individuals (992-579) and much greater biomass (4,692-597 g) was obtained in January 1979 than in January 1978.

Species Associations

Cluster analysis based on individual samples yielded five species groups which, upon further

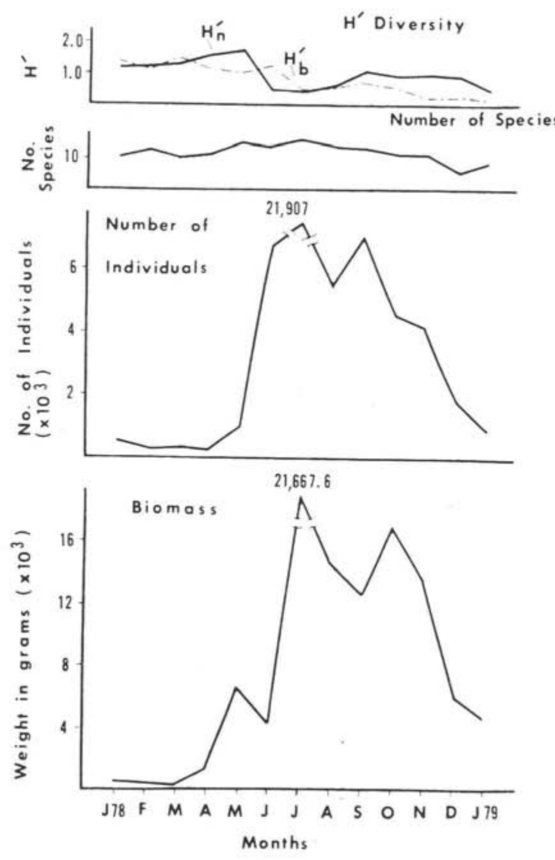

FIGURE 5.—Monthly variation (January 1978-January 1979) in total number of species, diversity H' (for numbers, H'_N, and biomass, H'_B), number of individuals and biomass (g) for fishes collected by all methods at stations 1-3 combined in the littoral zone of upper Newport Bay.

examination, reflected both spatial (microhabitat) and seasonal differences in the littoral ichthyofauna (Fig. 6).

Group I was a loosely associated group of the five resident species (maintain populations year round in littoral zone) which could be further divided into three subgroups. Subgroup A had only one member, *Atherinops affinis*, an abundant schooling species. *Clevelandia ios* and *Gillichthys mirabilis* which comprised subgroup B are burrow-inhabiting gobiids of the shallows and pannes. Subgroup C included two species, *Fundulus parvipinnis* and *Gambusia affinis*, which inhabited pannes and other high intertidal areas. *Clevelandia ios*, *G. mirabilis*, and *F. parvipinnis* are residents of salt marshes in California and other west coast estuaries and are probably the species most threatened by alterations of these habitats.

Group II consisted of three midwater schooling species—*Anchoa compressa*, *A. delicatissima*, and *Cymatogaster aggregata*—most of which were caught mainly from January to August.

Group III was made up of three distinctly seasonal, benthic species: Two gobiids, *Quietula ycauda* and *Ilypnus gilberti*, and a cottid, *Leptocottus armatus*, which was relatively rare during 1978 compared with previous years (pers. obs.).

Group IV included an engraulid, *Engraulis mordax*; syngnathids, Syngnathus spp. (including *S. auliscus* and *S. leptorhynchus*); and the pleuronectid, *Hypsopsetta guttulata*. These species were seasonally present in mid- to late summer. Members of this group were only loosely associated (> 80% distance).

Group V was composed of four species which were collected at times of low salinities. *Lepomis macrochirus* and juveniles of *Mugil cephalus* were sampled together early in the year (January-March 1978). *Lepomis cyanellus* and *Leuresthes tenuis* were found together only in September.

Group VI included 12 rare species, most of which could be considered summer periodics in the littoral zone in 1978. These were *Umbrina roncador*, *Urolophus halleri*, *Paralichthys californicus*, *Mustelus californicus*, *Cynoscion nobilis*, *Acanthogobius flavimanus*, *Sphyraena argentea*, *Girella nigricans*, *Symphurus atricauda*, *Porichthys myriaster*, *Morone saxatilis*, and *Seriphus politus*.

Members of the species groups identified in the dendrogram (Fig. 6) are illustrated in dia

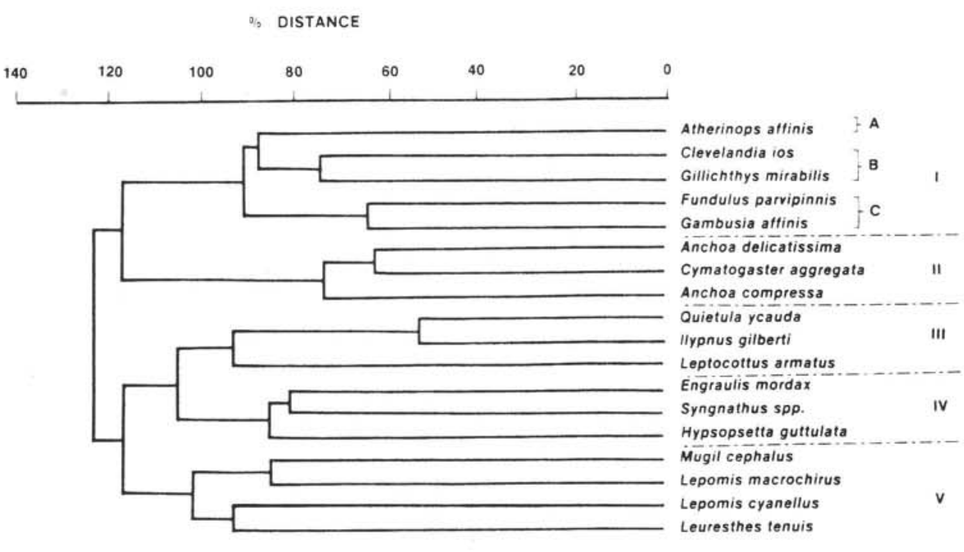

FIGURE 6.—Dendrogram of the clustering of littoral fish species by individual samples taken at stations 1-3 in upper Newport Bay. five species groups (Roman numerals) are recognized according to the Bray-Curtis index of dissimilarity (% distance). A, B, and C are subgroups of species Group I.

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grams (Figs. 7-9), depicting occurrences in the alongshore area or panne during three different time periods (January-March 1978, April-September 1978, and October 1978-January 1979). Only species with ≥5 individuals during each time segment were included in the diagrams. These diagrams illustrate the high degree of seasonality within this fish assemblage.

During the January-March 1978 period of heavy rainfall, members of three species groups (I, II, and V) were present in relatively low abundances (Fig. 7). A halocline existed at station 3 during this period, and *Atherinops affinis* was collected only seaward of the halocline at this station. Representatives of group V, *Mugil cephalus* juveniles and *Lepomis macrochirus*, were found associated with very low salinities. Large *M. cephalus* were observed in both the channel and littoral areas during most of the year.

The spring-summer period of April-September 1978 was characterized by increased water temperatures and salinities, accompanied by increased numbers of species and individual fishes (Fig. 8). Green algal beds, composed primarily of *Enteromorpha* sp., *Chaetomorpha linum*, and *Ulva lobata*, developed along the shore of the entire upper bay, and served as a nursery area for large numbers of juvenile fishes. All species groups, except V, were represented during this time. Juveniles of *Atherinops affinis* occurred in large numbers in the shallows with juvenile *Cymatogaster aggregata* also being abundant at station 3. Young-of-the-year *F. parvipinnis* were very abundant in the pannes, especially at stations 1 and 3.

By October the extensive algal beds had disappeared. The October 1978-January 1979 period was marked by decreased number of species and abundance (Fig. 9). The only common species were members of group I (residents) with a few juvenile *M. cephalus* representing group V.

Productivity

Annual production (mean of three stations by month) of the entire upper Newport Bay was 9.35 g DW/m^2 per year (Table 3). Young-of-the-year *Atherinops affinis* contributed 85.1% to total production followed by *Anchoa compressa* (4.9%) and *Fundulus parvipinnis* (4.2%).

Productivity was highly seasonal with the spring-summer period (April-September) accounting for 75.9% of the total annual production (Table 3, Fig. 10). Productivity, which was very

TABLE 3.—Monthly mean production (g DW/m^2) for individual species inhabiting the littoral zone (excluding panne) of upper Newport Bay (February 1978-January 1979).

Species	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Total annual	% total production
Atherinops affinis (adult)				0.0280	0.1049								0.1329	1.42
A. affinis (78 class)					0.0800	0.6764	5.1397		1.2942	0.6428		0.1307	7.9638	85.15
Fundulus parvipinnis	0.0005		0.0007	0.0240	0.0167	0.1323	0.0352	0.0826	0.1033				0.3953	4.23
Clevelandia ios	0.0003			0.0027	0.0051	0.0093	0.0068		0.0431			0.0145	0.0818	0.87
Anchoa compressa	0.0142		0.0045	0.1127	0.2524	0.0485	0.0154		0.0075				0.4552	4.87
Gillichthys mirabilis		0.0001	0.0014		0.0889	0.0361	0.0102	0.0020					0.1387	1.48
Hypsopsetta guttulata					0.0082	0.0020							0.0102	0.11
Mugil cephalus	0.0006	0.0004										0.0003	0.0013	0.01
Anchoa delicatissima	0.0030	0.0002	0.0039	0.0084	0.0013		0.0001	0.0017					0.0186	0.20
Quietula ycauda						0.0011							0.0011	0.01
Engraulis mordax							0.0046	0.0003					0.0049	0.05
Cymatogaster aggregata				0.0074	0.0072	0.0023		0.0101	0.0009				0.0279	0.30
Ilypnus gilberti						0.1197							0.1197	1.28
Lepomis macrochirus	0.0008												0.0008	0.01
Monthly total	0.0194	0.0007	0.0105	0.1832	0.5647	1.0277	5.2120	0.0967	1.4490	0.6428	0	0.1455	9.3522 g DW/m^2/yr	
													April-September 7.0948-75.86%	

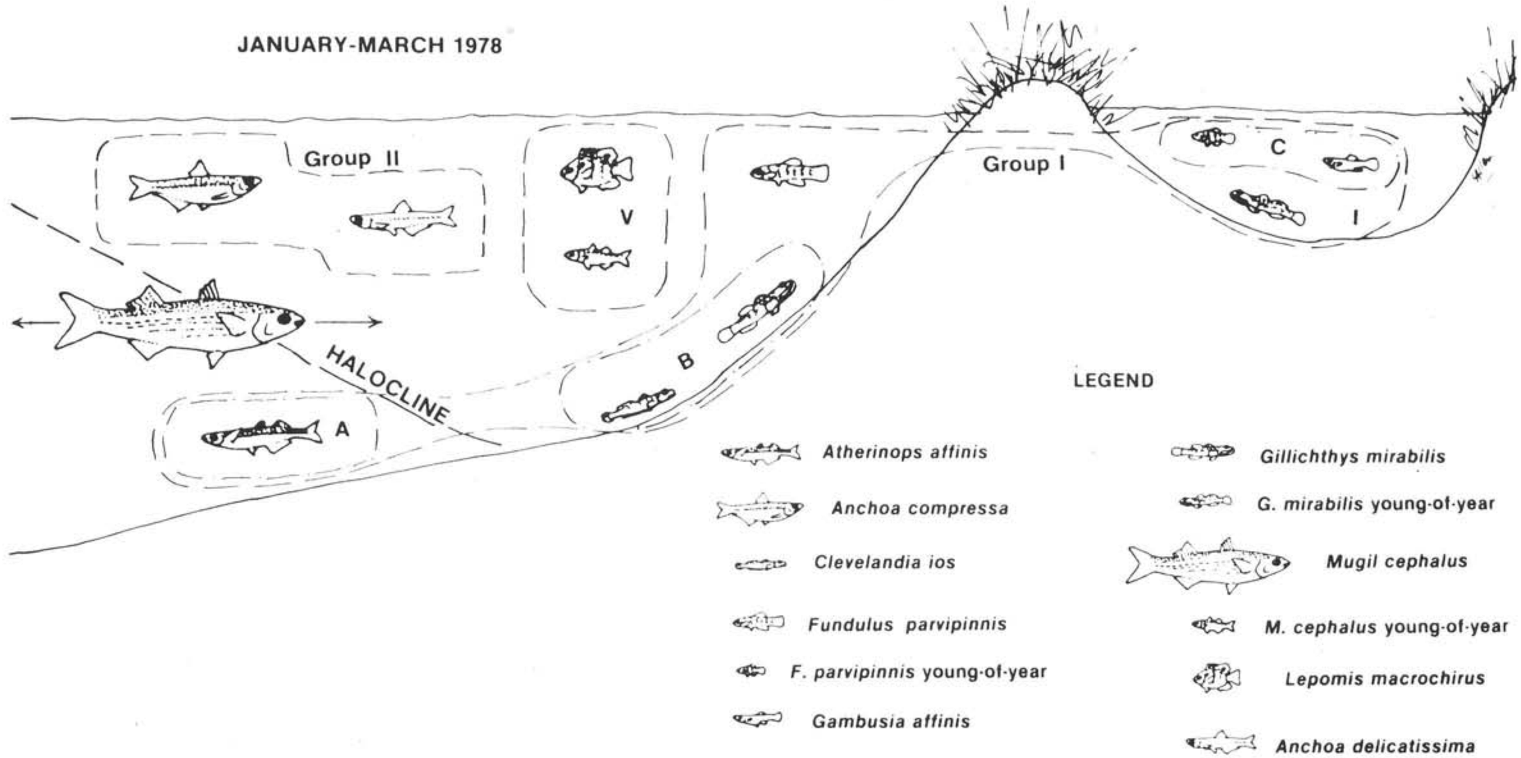

FIGURE 7.— Diagrammatic representation of the principal species inhabiting the littoral zone (alongshore and panne) of upper Newport Bay during January-March 1978. Inclusion level for species was ≥5 individuals in the samples during the period. Dashed lines enclose species from groups derived in the dendrogram of Figure 6. Arrows indicate inshore-offshore occurrence.

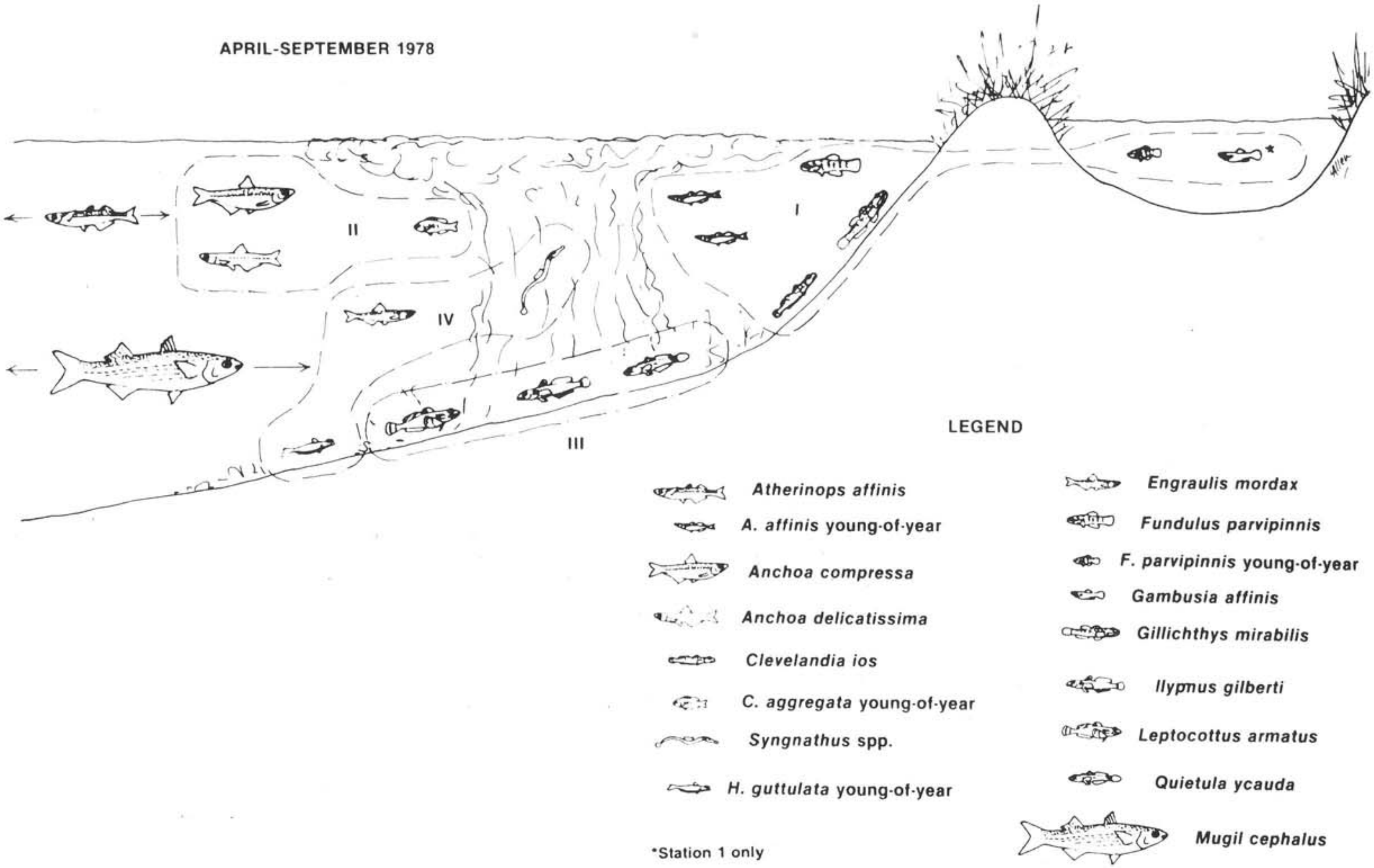

FIGURE 8.—Diagrammatic representation of the principal species inhabiting the littoral zone of upper Newport Bay during April-September 1978. Wavy vertical lines represent the large algal beds present during this period. Other information is the same as in Figure 7. (*Syngnathus* spp. includes *S. leptorhynchus* and *S. auliscus*.)

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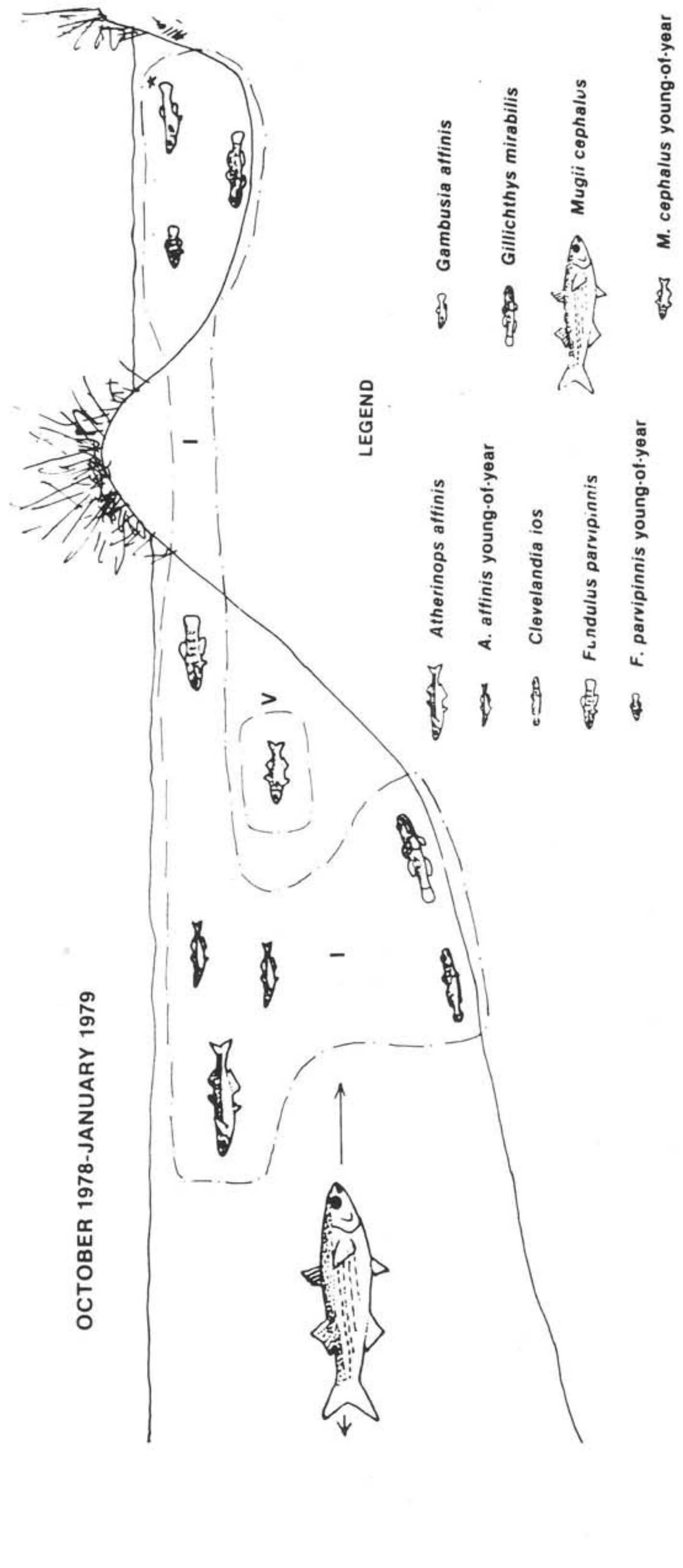

FIGURE 9.—Diagrammatic representation of the principal species inhabiting the littoral zone of upper Newport Bay during October 1978-January 1979. Other information as in Figure 7.

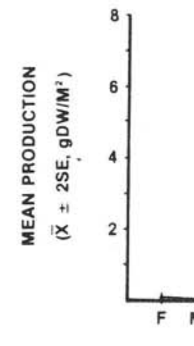

FIGURE 10.—Month...
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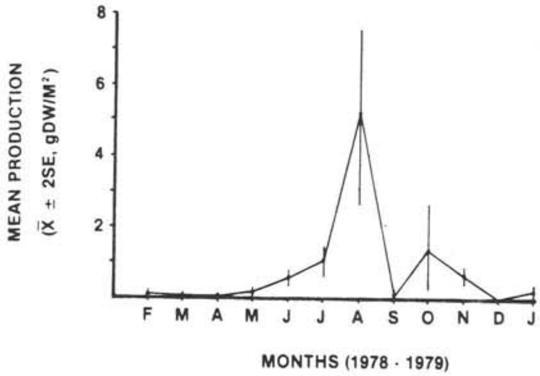

FIGURE 10.—Monthly variation in mean production ($\bar{x} \pm 2$ SE, g DW/m²) of the littoral fishes from three stations in upper Newport Bay (February 1978-January 1979).

low from February to May 1978, increased rapidly from June to a peak in August (5.2 g DW/m²). Monthly production then declined drastically in September, a period of heavy rainfall during which many of the larger young-of-the-year *Atherinops affinis* emigrated from the study area. Production increased in October but then showed a steady decline to zero in December, a time of a sharp decrease in mean water temperature in the upper bay.

Relationship of Abiotic Factors to Fish Abundance and Distribution

Temperature was found to have a significant, positive correlation ($P<0.01$, df = 37) with number of species ($r = 0.42$), number of individuals ($r = 0.48$), and biomass ($r = 0.54$) when station totals were considered. Similarly, salinity was significantly correlated with number of individuals ($r = 0.36$) and biomass ($r = 0.64$) (Table 4).

Temperature was the factor which yielded the highest number of significant correlations (6) with individual species, followed by salinity, dissolved oxygen, distance into the upper bay, and depth of capture, each with four (Table 4).

An analysis of intercorrelations among abiotic factors yielded three significant ($P<0.05$, df = 37) positive relationships: 1) Temperature and salinity ($r = 0.48$); 2) temperature and dissolved oxygen ($r = 0.53$); and 3) dissolved oxygen and distance into the upper bay ($r = 0.32$).

According to canonical correlation analysis, the six abiotic variables accounted for 93% of the variation in individual species abundances along the first canonical axis (Table 5). A second run indicated that 83% of the variation in species abundances could be accounted for by temperature and salinity alone. This finding strongly implies that interactive effects of temperature

TABLE 4.—Correlation coefficients (r) of individual species numbers and of total number of species, number of individuals, and biomass with six environmental factors. TEMP = temperature, SAL = salinity, DO = dissolved oxygen, DSTUPB = distance into upper Newport Bay from Highway 1 bridge, APRTSZ = average particle size of sediments, DPTHCAP = depth of capture.

Species	Abiotic factors					
	TEMP	SAL	DO	DSTUPB	APRTSZ	DPTHCAP
Atherinops affinis	0.55**	0.57**	0.21	0.00	−0.12	0.23
Fundulus parvipinnis	0.18	0.15	−0.31*	0.00	−0.06	0.03
Anchoa compressa	0.38*	0.21	0.35*	−0.01	0.05	0.24
Clevelandia ios	0.43**	0.22	0.08	−0.09	−0.16	0.23
Mugil cephalus	−0.62**	−0.29	−0.10	0.11	0.26	0.02
Gillichthys mirabilis	0.25	−0.22	0.44**	0.31*	0.01	0.00
Anchoa delicatissima	0.10	0.08	−0.22	−0.22	0.05	−0.02
Gambusia affinis	0.21	−0.25	0.16	0.58**	−0.07	−0.02
Hypsopsetta guttulata	0.30	0.21	0.43**	0.26	−0.10	0.28
Cymatogaster aggregata	0.14	0.28	−0.01	−0.34*	0.01	0.14
Quietula ycauda	0.46**	0.35*	0.19	−0.16	0.01	0.35*
Ilypnus gilberti	0.39*	0.31*	0.23	−0.10	0.11	0.33*
Lepomis macrochirus	−0.29	−0.44*	−0.23	0.10	0.09	0.04
Lepomis cyanellus	0.06	−0.27	−0.29	0.16	−0.20	0.05
Engraulis mordax	0.22	0.16	0.00	0.13	−0.07	0.33*
Leuresthes tenuis	0.16	0.14	−0.09	−0.15	0.10	−0.01
Leptocottus armatus	0.29	0.13	0.38	−0.09	−0.01	0.05
Syngnathus spp.	0.53	0.23	0.35	0.08	−0.07	0.33*
Species totals (by station)						
No. of species	0.42**	0.05	—	—	—	—
No. of individuals	0.48**	0.36*	—	—	—	—
Biomass	0.54**	0.64**	—	—	—	—

* = significant at 0.05 level
** = significant at 0.01 level

TABLE 5.—Summary of two canonical correlation runs of individual species abundances against environmental variables.

Axis	R^2	R	X^2	df
Run No. 1 (6 environmental; 18 species)				
1	0.93	0.96	212.9*	126
2	0.84	0.92	144.1*	102
3	0.73	0.85	96.3	80
Run No. 2 (temperature, salinity only, 18 species)				
1	0.83	0.91	77.8*	36
2	0.61	0.78	26.5	17

* = significant at 0.01.

and salinity were important in influencing species abundance.

The 18 most common species were ordinated along temperature and salinity axes using simple correlation values (r) as an index of relative influence of these two factors (Fig. 11). Thirteen of the 18 species were positioned in the upper right quadrant indicating that they were all positively correlated with temperature and salinity. Three species, *Gambusia affinis*, *Gillichthys mirabilis*, and *Lepomis cyanellus*, located in the upper left quadrant correlated positively

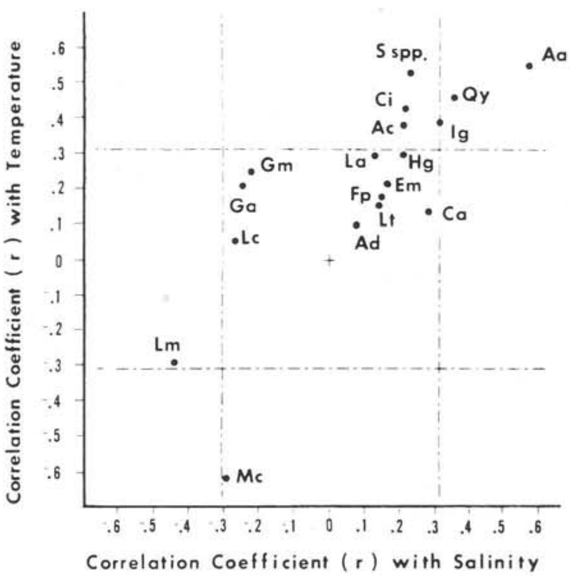

FIGURE 11.—Ordination of 18 common species of the littoral zone of upper Newport Bay on correlation coefficients (r) for temperature (y-axis) and salinity (x-axis). Dashed lines indicate 0.05 significance levels. Aa-*Atherinops affinis*, Ac-*Anchoa compressa*, Ad-*Anchoa delicatissima*, Ca-*Cymatogaster aggregata*, Ci-*Clevelandia ios*, Em-*Engraulis mordax*, Fp-*Fundulus parvipinnis*, Ga-*Gambusia affinis*, Gm-*Gillichthys mirabilis*, Hg-*Hypsopsetta guttulata*, Ig-*Ilypnus gilberti*, La-*Leptocottus armatus*, Lm-*Lepomis macrochirus*, Lt-*Leuresthes tenuis*, Mc-*Mugil cephalus*, Qy-*Quietula ycauda*, Sspp-*Syngnathus* spp.

with temperature, but negatively with salinity. The lower left quadrant includes two species, *Lepomis macrochirus* and *Mugil cephalus*, with negative temperature and salinity influences. No species were positioned in the negative temperature, positive salinity quadrant probably because this situation rarely occurred in the littoral zone in 1978.

DISCUSSION

Composition, Diversity, and Seasonal Dynamics

The ichthyofauna of the littoral zone in upper Newport Bay was numerically dominated by a few, low trophic-level species (five species accounted for >98% of all specimens collected), a situation similar to that found in many estuarine fish populations (Allen and Horn 1975). *Atherinops affinis* is an opportunistic feeder and has been characterized as both a herbivore/detritivore (Allen 1980) in upper Newport Bay and a low-level carnivore (Fronk 1969; Quast 1968). The second most abundant fish, *Fundulus parvipinnis*, is a low-level carnivore that feeds on small crustaceans and insects (Allen 1980; Fritz 1975). *Gambusia affinis*, *Clevelandia ios*, and *Anchoa compressa* are, likewise, low-level carnivores, feeding mainly on insects, benthic microinvertebrates, and zooplankton (Allen 1980).

Large individuals of *Mugil cephalus* were not sampled effectively, but probably constituted a significant proportion of biomass within these fish assemblages. Adult *M. cephalus* fed mainly on detritus and pennate diatoms (Allen 1980). This essentially herbivorous diet closely matches that described by Odum (1970) for *M. cephalus*.

The overall H' diversity values (H'_N range 0.42-1.76; overall 0.89) for the littoral zone were comparable to values derived from other studies of bay-estuarine fish faunas and to other studies in Newport Bay. Haedrich and Haedrich (1974) derived values of 0.33-1.03 for Mystic River Estuary, Mass.; Stephens et al. (1974) presented indices of 0.65-2.08 for Los Angeles Harbor, Calif.; Allen and Horn (1975) published values of 0.03-1.11 for Colorado Lagoon, Alamitos Bay, Calif.; and Quinn (1980) calculated values of 0.21-2.59 (overall 1.9) for Serpentine Creek in subtropical Queensland. Using otter trawl data, I calculated H'_N values of 0.20-1.96 (overall 0.98) for the upper Newport Bay in 1974-75 (Allen 1976). The concurrent bimonthly portion of this study (Horn

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and Allen 1981) obtained a bimonthly range for numbers of 0.48-2.17 (overall 1.05) when the deeper channel areas were also sampled. The relatively wide range of H'_N values in all of the above studies reflects the differential utilization of these embayments by fishes on a seasonal basis. At the same time, the low overall diversity reflects dominance both in numbers and biomass by a few species. The seasonal usage has the effect of increasing annual diversity, although only one or two species dominate numerically at any one time. The H' values for biomass (H'_B range 0.23-1.55; overall 0.84) were fairly close to those for numbers and, again, mainly reflected the dominance of *A. affinis* (~80%). In all, 26 of the 32 reported species had young-of-the-year fishes, making up a significant portion of their populations. Fluctuations in juvenile population levels had a substantial effect on the littoral fish populations. Juvenile recruitment plus the immigration of adult fishes presumably for reproduction or for exploitation of high productivity in warmer months were the principal causes for seasonal changes in the ichthyofauna. These activities reflect the widely recognized function of bay-estuarine environments as spawning and nursery grounds (Haedrich and Hall 1976).

The general pattern of increased number of species and numbers of individuals during the late spring through fall period in upper Newport Bay has been observed in many other studies of temperate bay-estuarine fishes (e.g., Pearcy and Richards 1962; Dahlberg and Odum 1970; Allen and Horn 1975; Adams 1976a). Several studies of estuarine fish populations have, in addition, detected summer depressions in abundance between peaks in spring and fall in other estuaries (Livingston 1976; Horn 1980) and in lower Newport Bay (Allen 1976).

Studies of subtropical estuarine fish populations have shown a trend in seasonal abundances that is 6 mo out of phase with the above observations. Fish abundances were highest during the winter months (November-March) in the Huizache-Caimanero Lagoon of Mexico due to increases in members of both demersal and pelagic fishes (Amezcua-Linares 1977; Warburton 1978). This coastal lagoon system is subject to a narrower range of temperatures over the year (18.3°-27.9°C) than most temperate systems. However, the Mexican system undergoes wide variation in salinity, especially during the rainy season from July to October (see section Influence of Abiotic Factors).

Species Associations

Species groupings were subject to strong seasonal influence and bore a striking resemblance to the classification scheme of Atlantic nearshore fish communities proposed by Tyler (1971). According to Tyler's classification the Atlantic nearshore fish communities can be divided into regular and periodic components. Periodic components can be winter seasonals, summer seasonals, or occasionals. The upper Newport Bay fish assemblage had regulars (group I) and periodics (groups II-V). The "anchovy" group (II), the "goby" group (III), and the "*Engraulis-Hypsopsetta*" group (IV) were all summer seasonals. Group V had both winter seasonals in *Mugil cephalus* and *Lepomis macrochirus* and summer seasonals in *Lepomis cyanellus* and *Leuresthes tenuis*. The latter group, however, could best be characterized by the affinity of its components to lower salinities rather than to a particular time of year. The occasional component was represented by the 12 species of group VI which also occurred in the summer. Thus Tyler's classification may have a broader application than he originally proposed, and perhaps holds true for many estuarine ichthyofaunas.

Species Densities and Productivity

Density estimates for some species of littoral fishes are particularly difficult to obtain. Such species include small, burrow-inhabiting fishes of the family Gobiidae and other small benthic fishes such as killifishes, flatfishes, and sculpins which escape under a seine or through the mesh of various nets. This study attempted to obtain density values for all littoral fishes, especially for the elusive species listed above. By setting up the procedure for choosing the "best estimate" of density from among four different sampling methods, actual densities of the species have been more closely approximated.

If the biomass density of *Atherinops affinis* for the entire study is calculated by dividing its total biomass by the total area of coverage by all four sampling gears, a biomass density of 3.3 g/m^2 (or about 0.83 g DW/m^2) is obtained. This density value is lower than the estimate of 1.16 g DW/m^2 derived through the best estimate process (Table 6). In this particular case, most densities were mean values of six bag seines which were very effective (99%) at capturing *A. affinis* (Horn and Allen footnote 2). Biomass density for the gobiid,

TABLE 6.—Grand mean estimate of biomass density (g DW/m²) for common species in the littoral zone (excluding panne) over the 13-mo period (January 1978-January 1979) from the best estimate criteria.

Species	$\bar{X}$ g DW/m² ±1 SE
Atherinops affinis (adult)	0.1043±0.0602
A. affinis	1.1590±0.2573
Fundulus parvipinnis	0.1064±0.0223
Gambusia affinis	0.0015±0.0028
Clevelandia ios	0.0261±0.0117
Anchoa compressa	0.1195±0.0493
Cymatogaster aggregata	0.0167±0.0158
Gillichthys mirabilis	0.0131±0.0035
Anchoa delicatissima	0.0077±0.0053
Mugil cephalus	0.0024±0.0018
Quietula ycauda	0.0029±0.0025
Ilypnus gilberti	0.0021±0.0021
Hypsopsetta guttulata	0.0043±0.0035
Engraulis mordax	0.0019±0.0018
Lepomis macrochirus	0.0006±0.0005
Lepomis cyanellus	0.0003±0.0001
	1.5688 g DW/m²

Clevelandia ios, determined by total area coverage was 0.013 g/m² (about 0.003 g DW/m²). The value based on best estimate (using square enclosures and small seine estimates) was about 10 times higher at 0.03 g DW/m². This large discrepancy is due to the low efficiency of the bag seine for capturing this species. Since the bag seine covered the largest area of any of the sampling gears (220 m²), its addition to the density determination for *C. ios* led to the large underestimate. The total biomass density of all species by total area was 4.13 g/m² (or about 1.02 g DW/m²) which again was lower than the best estimate grand mean density of 1.57 g DW/m².

Average standing stock for the upper bay species during 1978 was 784 kg DW, based on an estimate of 50 ha of habitable littoral zone in upper Newport Bay. This is equivalent to 3,136 kg (wet weight) or 6,899 lb of fish. By the same procedure, the average standing stock of *A. affinis* was 631.6 kg DW and that of *C. ios*, 13.1 kg DW.

The annual production of 9.35 g DW/m² for the upper Newport Bay littoral zone in 1978 ranked among the highest values recorded for studies with comparable production determinations of production models (Table 7).

The Newport Bay production estimate in 1978 was surpassed only by the estimate for *Fundulus heteroclitus* (Meredith and Lotrich 1979), an estuarine species of the east coast of the United States. *Fundulus heteroclitus* represented a very efficient energy link between the marsh and the littoral zone in their study. However, as Meredith and Lotrich pointed out, the production value may be an overestimation due to the underestimation of the area of marsh utilized by the fish. The value 4.6 g DW/m² obtained by Adams (1976b) for fishes inhabiting east coast eelgrass beds, which are acknowledged as highly productive areas, is half the estimate for the littoral zone of upper Newport Bay.

Short food chains have been implicated as the primary reason for high production in estuarine fish communities (Adams 1976b), a contention which is supported by the findings of this study. Young-of-the-year *Atherinops affinis* accounted for 85% of the annual production and formed a direct link through their herbivorous/detritivorous diet to the high primary productivity of this estuarine system. The remaining, numerically important species of the littoral zone were low-level carnivores. There is little doubt that this assemblage represents an example of "food chain telescoping" as described by Odum (1970).

Even though the fish production in the littoral zone of upper Newport Bay was high compared with most comparable studies, the value presented here is undoubtedly an underestimate. The largest species of the system, adult *Mugil cephalus*, was not represented in the production estimates due to inadequate sampling. Inclusion of this species would have substantially increased the production value. It is unlikely, however, that productivity of adult *M. cephalus* could approach that of juvenile *Atherinops affinis* which were responsible for 85% of the annual fish production.

Influence of Abiotic Factors

The positive correlations between temperature and total abundance, biomass and number of species, and between salinity and total abundance and biomass indicate the general impor-

TABLE 7.—Comparison of annual fish production (P) for marine or estuarine studies with comparable production determinations. Wet weights were converted by multiplying by 0.25. Values are for all species except where noted.

Locale and habitat	Study	Estimated annual P (g DW/m²)
Delaware salt marsh creek (*Fundulus heteroclitus*)	Meredith and Lotrich (1979)	10.2
Newport Bay littoral zone	present study	9.4
Mexican coastal lagoon	Warburton (1979)	8.6
Cuban freshwater lagoons	Holčík (1970)	6.2
No. Carolina eelgrass beds	Adams (1976b)	4.6
Bermuda Coral Reef	Bardach (1959)	4.3
Texas lagoon (Laguna Madre)	Hellier (1962)	3.8
English Channel pelagic and demersal fishes	Harvey (1951)	1.0
Georges Bank commercial fishes	Clarke (1946)	0.4

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tance of these factors to this assemblage. Individual correlations between abiotic factors and species abundances likewise emphasized the importance of temperature and salinity. The correlations between individual species abundances and dissolved oxygen as well as distance into the upper Newport Bay could be due to the intercorrelations of both dissolved oxygen and distance with temperature.

Intercorrelations among factors can confound the interpretation of relationships and introduce redundancy in multivariate analyses. The relationship between dissolved oxygen and distance into the upper Newport Bay is intuitive considering its shallow depths. The positive relationship between temperature and dissolved oxygen was probably due to photosynthesis by green algae during the summer. Winter rainfall in the basically Mediterranean climate of southern California was responsible for the positive correlation between temperature and salinity found in Newport Bay. This relationship is by no means absolute, as evidenced by the low salinities encountered during the tropical rains of September 1978 when temperatures were high.

The results of the second canonical correlation analysis indicate that interaction between temperature and salinity explained most of the variability in species abundance in this system. The correlation between these two abiotic factors probably inflated the R^2 value slightly, but does not negate the overall findings. Ordination of individual species by correlation coefficients with temperature and salinity underscores the influences of these factors on individual species. Furthermore, the substantial decrease in numbers of *A. affinis* at station 1 and the somewhat smaller decrease at station 3 during September rains (low salinity) and relatively high temperatures also illustrate this temperature-salinity interaction.

I propose that an important consequence of temperature-salinity influence found in the present study is the transfer of biomass and, therefore, energy from the littoral zone to the adjacent channel and ultimately to local offshore areas via migration of fishes. This mechanism for energy transfer was best illustrated by the apparent emigration of a large portion of the 0-age class *A. affinis* from the littoral zone from September to December 1978. The transfer also included the biomass produced by essentially all of the periodic species. Weinstein et al. (1980) reached a similar conclusion in their study of the fishes in shallow marsh habitat of a North Carolina estuary. An extensive mark and recapture study should be planned to test this hypothesis in the future.

Seasonal fluctuations of temperate bay-estuarine fish populations may have several causes, but temperature and salinity seem frequently to be the underlying factors. The pattern of increased number of species and individuals with increased temperature in temperate bays and estuaries has been reviewed by Allen and Horn (1975). Recently the large-scale influence of salinity on bay-estuarine fish populations has been demonstrated by Weinstein et al. (1980) for Cape Fear River Estuary, N.C. Unfortunately, any salinity interaction with temperature was not investigated or discussed in the above study.

Studies of subtropical estuaries (Amezcua-Linares 1977; Warburton 1978; Quinn 1980) indicate that salinity may have greater influence on fish populations, since annual temperature ranges are narrower than in temperate bays and estuaries. In each of the above studies on subtropical estuaries, increased abundances corresponded to the season of low rainfall and therefore high salinity. Blaber and Blaber (1981) concluded that turbidity and not temperature and salinity was the single most important factor to the distribution of juvenile fishes in subtropical Moreton Bay, Queensland. However, Blaber and Blaber (1981) did not present statistical evidence to support this contention. The most important environmental factors influencing tropical estuarine (eelgrass) ichthyofaunas are more difficult to identify (Weinstein and Heck 1979; Robertson 1980) and probably include biotic factors such as prey availability, competitors, predators, as well as abiotic factors. Biotic interactions are undoubtedly important in temperate estuarine systems including upper Newport Bay. However, their overall influence on the system is probably swamped by large fluctuations in the physical environment.

Fluctuations in rainfall and temperature regimes during a year and from year to year can have marked effects on the ichthyofauna of estuaries. Moore (1978) has identified long-term (1966-73) fluctuations in summer fish populations in Aransas Bay, Tex. He found that diversity values (H' range of 1.38-2.13) were quite variable from year to year probably as a result of major climatological changes (an unusually wet year; a drought and two hurricanes). These changes in diversity values were probably caused by changes in abundance within a set of resident estuarine species and of periodic species.

In 1978 the ichthyofauna of upper Newport Bay was subjected to rainfall twice that of a "normal" year (70.9 cm for 1978; mean 28.1 cm). The specific effects of this increased precipitation are difficult to assess due to a lack of data from previous years but some guarded comparisons can be made. Population densities of *Atherinops affinis* were lower in 1974-75 than those encountered during 1978 (Allen 1976). Also *Cymatogaster aggregata*, *Clevelandia ios*, and *Leptocottus armatus* occurred in lower numbers in 1978 than in previous years (Horn and Allen 1981). These discrepancies point out the strong year-to-year fluctuations that occur in the fish populations of upper Newport Bay. This conclusion is in complete agreement with the findings of Moore (1978) and sheds doubt on the possibility of completely characterizing a "normal" year in many estuaries because of unpredictable annual variations in climate.

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Responses of Fish and Macrobenthic Assemblages to Hydrologic Disturbances in Tijuana Estuary and Los Peñasquitos Lagoon, California

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ABSTRACT: Changes in the assemblages of fishes and benthic macro-invertebrates were evaluated in relation to wastewater inflows at Tijuana Estuary and impounded streamflows and mouth closure at Los Peñasquitos Lagoon. Freshwater from sewage spills or winter rains lowered water salinities and had major impacts on the channel organisms of both southern California coastal wetlands. Benthic infaunal assemblages responded more rapidly to reduced salinity than did fishes, with continued salinity reduction leading to the extirpation of most species. Both the fish and benthic invertebrate assemblages became dominated by species with early ages of maturity and protracted spawning seasons. Between-system comparisons showed that good tidal flushing reduced negative impacts on both the fish and benthic assemblages.

Introduction

Southern California estuaries and lagoons are subject to interannual variability in rainfall, streamflow, and disturbances such as sedimentation, dredging, and wastewater inflows. Two San Diego County wetlands, Tijuana Estuary (TJE; 32°34′N, 117°7′W) and Los Peñasquitos Lagoon (LPL; 32°56′N, 117°15′W) differ in many respects, including size and watershed, but especially in disturbance and tidal histories.

TJE has been open to tidal flushing except for periodic closures in the early 1960s and prolonged closure in 1984 (Zedler and Nordby 1986). LPL has been primarily closed to tidal flushing for most of this century (Bradshaw, unpublished report). A comparison of primary productivity of the two systems (Zedler et al. 1980) demonstrated higher accumulation of biomass of vascular plants at LPL, possibly due to impoundment of freshwater during the growing season. TJE and LPL represent extremes in southern California coastal wetlands (e.g., mouth usually open vs. usually closed) and the differences between the two systems could be explained in terms of the reliability of communication with the Pacific Ocean. In the last decade, human disturbance of these systems has intensified. A comparison of the channel communities of these two wetlands was undertaken to understand the responses to the wider range and increased severity of stresses resulting from these multiple disturbances.

Study Sites

TIJUANA ESTUARY

Tijuana Estuary is located in the southwestern corner of the continental U.S. (Fig. 1) and is included in the Tijuana River National Estuarine Research Reserve, administered by the National Oceanic and Atmospheric Administration (NOAA). The reserve includes approximately 1,012 ha (2,500 acres), 60 ha of which are tidal channels. The Tijuana River, with a watershed of 1,731 km^2, bisects the estuary into a northern and southern portion and rarely provides much freshwater input except in years with sewage-augmented flows.

In recent years, several disturbances at Tijuana Estuary have changed the salt marsh and channel communities dramatically (Zedler and Beare 1986; Zedler and Nordby 1986; Nordby 1987, 1988). Coastal dune sands were destabilized by trampling, and high tides coupled with sea storms washed large volumes of sand into the main channels of the estuary in 1983 (Zedler and Nordby 1986). The sedimentation events immediately affected channel biota through burial and increased turbidity (Nordby 1987). Later, the reduced tidal prism allowed sand to accumulate, and the tidal inlet closed in April 1984. Dredging to reopen the inlet (in December 1984) removed large numbers of channel organisms, and affected others by suspending sediments. During the eight-month closure of the estuary, hy-

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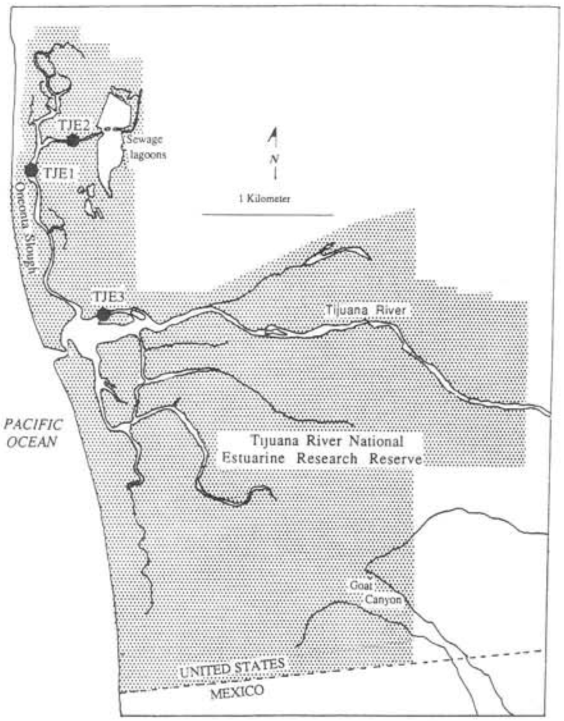

Fig. 1. Fish and invertebrate sampling stations at Tijuana Estuary (TJE). Stippled area represents the boundaries of the Tijuana River National Estuarine Research Reserve.

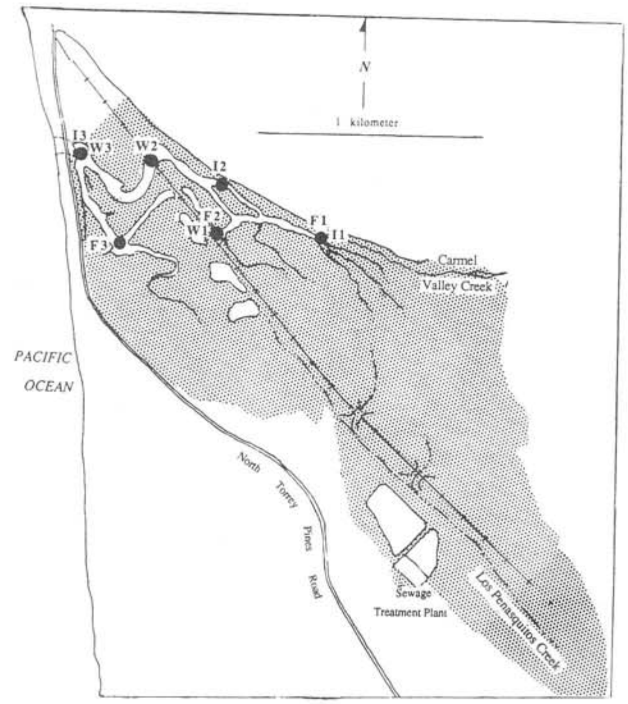

Fig. 2. Fish, invertebrate, and water quality sampling stations at Los Peñasquitos Lagoon (LPL). F = Fish site. I = Invertebrate site. W = Water quality site. Stippled area represents the approximate extent of coastal wetland habitat.

persaline conditions (60‰ in channels) developed through the long dry season, roughly May through November. Three fish species *Gillichthys mirabilis* (longjaw mudsucker), *Paralichthys californicus* (California halibut), and *Hypsopsetta guttulata* (diamond turbot) declined in abundance, and the dominant bivalve species *Nutallia nuttallii* (purple clam) became extinct at Tijuana Estuary (Nordby 1987).

The Tijuana River usually has very little or no flow in summer months when rainfall is low and evaporation rates are high (Zedler et al. 1984). For over 50 years, the river has received raw sewage flows from the City of Tijuana, Mexico (City of San Diego 1988), increasing in volume to an estimated average of 10–12 million gallons per day (MGD) in recent years (Seamans 1988). It has been estimated that a prolonged input of 12.5 MGD of raw or treated sewage would negatively impact the channel biota of the system (Zedler et al. 1984). Renegade flows were estimated at 22 MGD in 1987–1988 (Seamans 1988). Intermittent sewage flows also enter the estuary from Goat Canyon and Smuggler's Gulch. The latter conveyed 4–5 MGD of sewage to the estuary in recent years (City of San Diego 1988). In 1988 the International Boundary and Water Commission built an interceptor to collect and return those flows to the Tijuana treatment system. No interceptor was built at Goat Canyon, which carries intermittent sewage spills to the southern arm of Tijuana Estuary (Fig. 1).

Los Peñasquitos Lagoon

Los Peñasquitos Lagoon is a small coastal wetland of approximately 142 ha, 12 ha of which are channel habitat. The lagoon is the terminus of a small watershed (246 km^2) and is fed by two creeks: Carmel Valley Creek to the east and Los Peñasquitos Creek to the southeast (Fig. 2). Historically, both streams were seasonal, with little or no flow during summer and autumn. Recently, agricultural and residential run-off have increased flows of Carmel Valley Creek to year-round so that brackish marsh has encroached into the salt marsh.

In recent decades, LPL has evolved from a tidal estuary to a lagoon that is usually closed to tidal flushing. Construction of a railroad embankment across the center of the lagoon in 1925 isolated channels and thereby greatly reduced tidal volume and circulation. In 1932–1933, construction of a highway along the barrier beach resulted in more fill and constriction at the mouth. The tidal prism of the lagoon is no longer large enough to maintain an opening to the ocean. Consequently, mechanical removal of the sand and cobble sill at the mouth is necessary to provide occasional tidal circulation. The lagoon is nearly always nontidal in summer, and impounded seawater increases in salinity through the summer and autumn due to evaporation. In the cool wet season, storm run-off flows into the lagoon and decreases water salinity. Only major rainfalls raise the lagoon water level high enough to break through the sand berm at the mouth. The extremes in salinity cause conditions that are stressful to channel organisms (Bradshaw, unpublished report).

Wastewater flows also affect this lagoon. From 1962 to 1972 a sewage treatment facility discharged 0.5–1.0 MGD of treated effluent into the lagoon, increasing nitrate and phosphate loads and reducing water salinity. While the wastewater line was connected to the metropolitan sewer system in 1972, the pumps transporting the sewage to the treatment facility on Pt. Loma have failed repeatedly. A raw sewage spill of about 20 MGD occurred in March 1987. There were flood events during the wet seasons of 1986, 1987, and 1988. Organic matter from sewage spills, tidal closure, and floods probably interact to cause both salinity and oxygen stress to organisms. Persistence of these conditions for 2 to 3 d can eliminate most of the channel fauna. Only species that survive rapid reduction in salinity and dissolved oxygen or reinvade from the nearshore habitat via extreme high tides, storm waves, or brief tidal openings, persist from year to year.

Sampling Stations and Methods

Tijuana Estuary Stations

This study was conducted primarily in the northern arm of the estuary known as Oneonta Slough (Fig. 1). Sampling stations were chosen to reflect differences in channel morphometry (width, depth, and substrate type) and distance from the mouth. During the study, chronic wastewater inflows entered the system via the Tijuana River, while sewage spills from broken pipelines intermittently flowed across the southern portion of the marsh to the mouth. Areas near the mouth received more sewage than did areas further from the mouth.

Station TJE1 was 15 m wide, usually less than 1 m deep during sampling and had a sand substrate. This site was located about 900 m from the mouth. At station TJE1, extremely high tides (2.38 m MLLW) and coincident storm-induced waves washed dune sand into the channel on two occasions during the study period: December 31, 1986, and December 31, 1987. Several centimeters of dune sand were deposited at this sampling site on those dates. In April 1987, the north arm of the estuary was dredged to restore the tidal prism lost from sediment deposited that winter. Dredging was performed by drag line from the western bank of the channel beginning approximately 0.25 km north of TJE1 and ending roughly adjacent to TJE3 (Fig. 1). Following the dune wash-over of 1987, a shorter length of the southern main channel was bulldozed to remove sediment.

Station TJE2 was located in a man-made channel that was excavated in the early 1900s to link the former sewage lagoons with the main channels (Fig. 1). This was the deepest site (usually about 1 m), with eroding banks. The channel was 10 to 11 m wide at this site with a substrate that was composed of a clay/mud mixture with broken shell fragments in the upper 10 to 15 cm over a bed of coarse sand/gravel. TJE2 was located approximately 1,800 m from the mouth.

Site TJE3 was situated in the mouth region on a side channel paralleling the Tijuana River. This was the shallowest site (<0.5 m) and had sloping banks. The channel was 6 to 7 m wide with a sand substrate. TJE3 received sewage flows directly from the Tijuana River.

Los Peñasquitos Lagoon Stations

Sampling stations at LPL were chosen to represent a spatial continuum from the mouth to the terminal tidal creeks in the eastern end of the lagoon (Fig. 2). Station LPL1 was located in the extreme eastern end of the lagoon. The channel at this site was 5 to 7 m wide, 40 to 90 cm in depth depending upon season, with a clay substrate. Station LPL2 was located in a blind diverticulum which resulted from the construction of the railroad berm. This site was approximately half-way between the mouth and LPL1. The channel was 8 m wide and 30 to 90 cm deep with a clay/mud substrate. Station LPL3 was the widest site (>40 m), 30 to 100 cm deep with a mud substrate and was located in the mouth region.

Sampling Protocol

Fishes and benthic invertebrates were collected quarterly from each wetland. All samples were collected during daylight hours on moderate to low tides. Each system was sampled within the same 1-wk period. TJE has been sampled for 3 yr, from June 1986 to March 1989, while LPL has been sampled for 2 yr, from June 1987 to March 1989. However, due to different start-up times for various stages of invertebrate sampling, and due to a lag in the analysis of some benthic invertebrate samples, the numbers of samples are not identical (Table 1).

At each site, two "blocking nets" (13.7 m long, 1.8 m deep, 3-mm mesh) were used to confine all fishes within a section of the channel. A beach seine (3.7 m long, 1.8 m deep, with a 2 × 2 m bag, 3-mm mesh) was then drawn in a circular manner

TABLE 1. Sampling schedule for the collection of fishes and benthic invertebrates at Tijuana Estuary (TJE) and Los Peñasquitos Lagoon (LPL).

	TJE	LPL
Fishes	12 quarterly samples June 1986–March 1989	8 quarterly samples June 1987–March 1989
Bivalves	10 quarterly samples September 1986–December 1989	7 quarterly samples June 1987–December 1988
Polychaetes and other benthic forms	7 quarterly samples June 1987–December 1988	7 quarterly samples June 1987–December 1988

within the two blocking nets and pulled to shore. Hauls were repeated until the number of fish captured declined to near zero, usually 4–5 hauls. The blocking nets were then drawn together in a semicircle to catch any fishes that were hiding in the blocking nets.

The areas sampled differed both within each wetland and between the two systems. The earliest samples at TJE were taken from relatively large areas. For example, June 1986 samples at TJE1, TJE2, and TJE3 were taken from areas of 520 m^2, 300 m^2, and 150 m^2, respectively. These areas were reduced to a standard area of 110 m^2, 110 m^2, and 70 m^2 for TJE1, TJE2, and TJE3, respectively, after preliminary analysis demonstrated that the number of species collected was not affected and densities were not significantly reduced.

The areas sampled at LPL were modeled after those at TJE. Thus, stations LPL1–LPL3 included areas of 70 m^2, 70 m^2, and 110 m^2, respectively. The numbers of fishes collected are expressed as densities (number m^{-2}) for comparative purposes.

To test the effectiveness of the fish sampling method and to demonstrate the catchability of individual species, the numbers of fish captured per haul were compared. A test of the number of hauls required to provide an adequate sample was also performed by plotting the number of fish caught against the prior cumulative catch. These tests were performed in March 1987.

Benthic invertebrates were collected using a 15-cm diameter (177 cm^2) coring device pressed into the sediment to a depth of 20 cm. The core was then sieved through a 1-mm mesh screen, with large organisms tallied in the field and the remaining specimens fixed in 3% formalin and transported to the laboratory for identification. Three replicate samples consisting of three pooled cores each were taken per site for a total of nine cores (0.16 m^2) per station. Sampling sites corresponded to fish sampling stations at TJE. At LPL, three stations within the main channel were sampled (Fig. 2).

Water quality was monitored approximately biweekly at LPL and quarterly at TJE. Sampling sites at TJE were the same as benthic invertebrate and fish sampling sites. Sampling stations at LPL were chosen to reflect extremes in water quality. These extremes represent a spatial continuum from the mouth of the lagoon to the terminal creeks (Fig. 2). Station LPL1 was nearest the freshwater inflows from Carmel Valley Creek, while station LPL3 was nearest the mouth and was the most affected by seawater when the mouth was open.

Water temperature and dissolved oxygen were measured using a Yellow Springs Instrument Model 51B DO/temperature meter. Salinity was measured to the nearest part per thousand using an American Optical salinity refractometer.

Sediments were analyzed for grain size using the Emery Settling Tube (Emery 1938), a 164-cm long water-filled glass tube that allows differential settling and separation of particles into size classes. This analysis was employed at TJE1 and TJE2 only.

Statistical tests of patterns of fish and benthic invertebrate distributions and abundances were conducted for each wetland. To test for differences in the number of fish species collected at each sampling station, a two-way ANOVA without replication was performed with stations and surveys as treatments. Because the assumption of no interaction may not have been met, these results are presented as an index of species distributions rather than a strict test of the null hypothesis. A one-way ANOVA was employed to test for differences in the sizes of *Atherinops affinis* (topsmelt) present each June at TJE1. A two-way ANOVA was performed on the square roots of bivalve densities using stations and surveys as treatments. Density data for bivalve assemblages were transformed to make the variances equal and distributions normal ($n = 3$ pooled cores).

Results

Environmental Conditions

The streamflow of the Tijuana River is characterized by high variability in both mean annual and monthly flows. Streamflow records from 1937 to 1977 document a mean annual discharge of 5,500 MGD with a coefficient of variability of 325% (Zedler and Beare 1986). Due to high variability in both

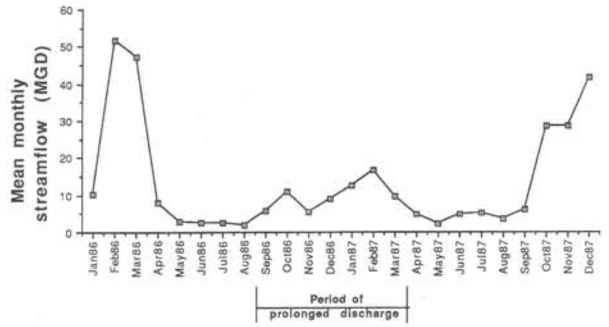

Fig. 3. Mean monthly streamflow for the Tijuana River 1986–1987. Data from the International Water and Boundary Commission (IBWC).

streamflow and rainfall, there is no means of separating "normal" streamflow from wastewater flows. For this study, we will refer to all flows as wastewater flows, realizing that considerable amounts of freshwater may enter the system following winter rainfall events.

The volume of wastewater entering the United States via the Tijuana River varied widely from 1986 through 1987 (Fig. 3). A peak discharge in winter 1986 was followed by about 6 months of low flow. Flow volumes were on the order of 5 to 20 MGD in late 1986 and early 1987 but increased again in late 1987.

At LPL, water salinity and dissolved oxygen levels fluctuated widely when the mouth was closed (Fig. 4). During this study period rapid reductions in salinity and dissolved oxygen occurred during October 1987 and December 1988.

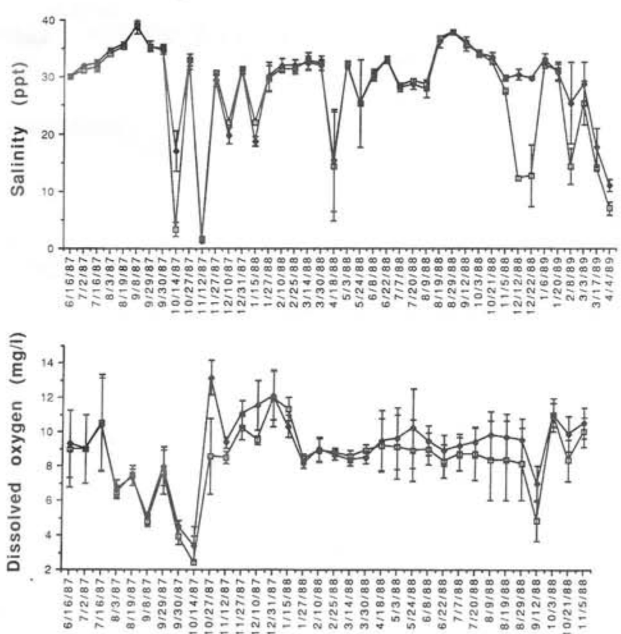

Fig. 4. Mean water salinity and dissolved oxygen at three sampling sites at Los Peñasquitos Lagoon (LPL). Error bars = ± one standard error.

TABLE 2. Fish species collected at Tijuana Estuary (TJE) and Los Peñasquitos Lagoon (LPL).

Taxon	Common Name	TJE 1986–1988	LPL 1987–1988
Atherinidae			
Atherinops affinis	topsmelt	15,437	1,875
Blennidae			
Hypsoblennius gentilis	bay blenny	4	0
Hypsoblennius gilberti	rockpool blenny	1	0
Hypsoblennius jenkinsi	mussel blenny	1	0
Bothidae			
Paralichthys californicus	California halibut	283	12
Cottidae			
Leptocottus armatus	staghorn sculpin	1,431	346
Artedius sp.	sculpin	2	0
Cyprinodontidae			
Fundulus parvipinnis	California killifish	2,367	107
Engraulidae			
Anchoa compressa	deepbody anchovy	11	67
Girellidae			
Girella nigricans	opaleye	82	0
Gobiidae			
Clevelandia ios	arrow goby	60,097	816
Gillichthys mirabilis	longjaw mudsucker	275	877
Ilypnus gilberti	cheekspot goby	50	22
Lepidogobius lepidus	bay goby	0	9
Quietula y-cauda	shadow goby	3	0
Mugilidae			
Mugil cephalus	striped mullet	5	3
Pleuronectidae			
Hypsopsetta guttulata	diamond turbot	83	14
Pleuronichthys ritteri	spotted turbot	4	0
Poeciliidae			
Gambusia affinis	mosquitofish	0	937
Rhinobatidae			
Rhinobatos productus	shovelnose guitarfish	2	0
Serranidae			
Paralabrax clathratus	kelp bass	12	0
Sciaenidae			
Seriphus politus	queenfish	1	0
Syngnathidae			
Syngnathus leptorhynchus	bay pipefish	14	2
Total fishes collected		80,165	5,087
Total species encountered		21	13
Total sampling effort (cumulative area in m²)		4,795	1,985
Number of quarterly samples		12	8

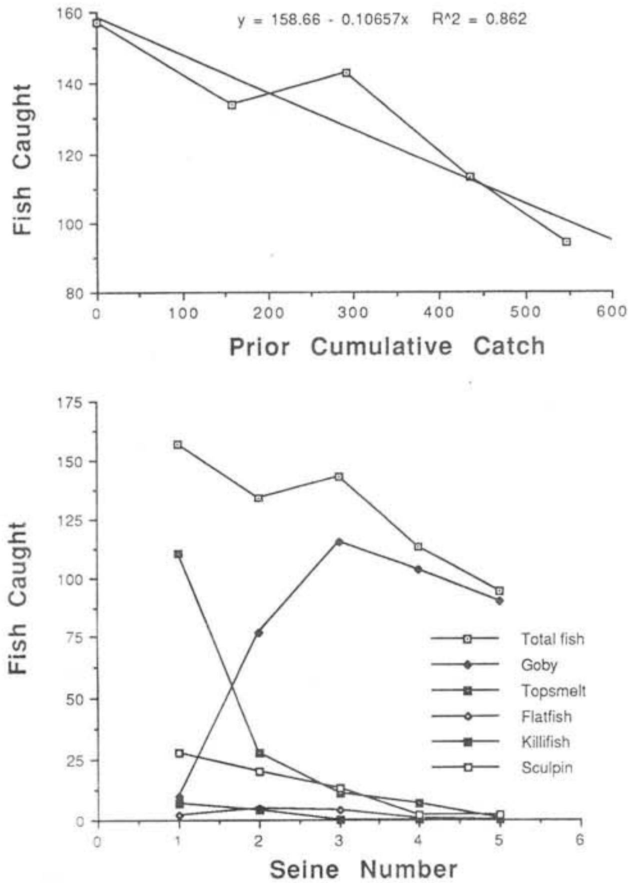

Fig. 5. Tests of the sampling efficiency of the method of collecting fish used in this study. Top: repeated seining of a blocked channel plotted against prior cumulative catch. Bottom: species composition of repeated seinings.

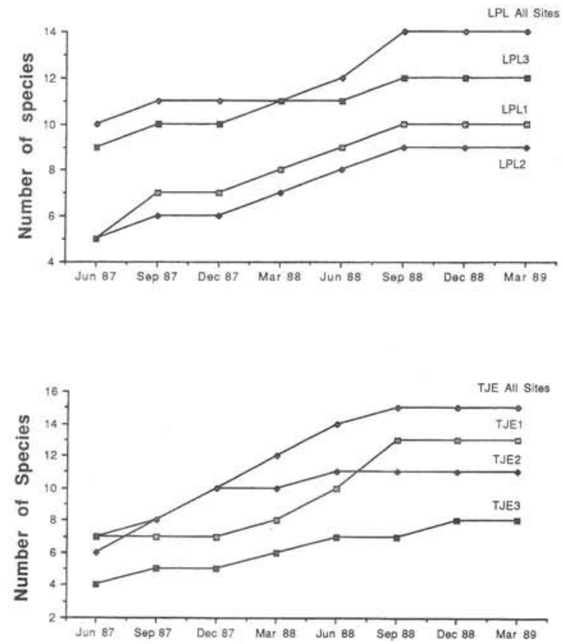

Fig. 6. Cumulative species curves for fishes collected at Tijuana Estuary (TJE) and Los Peñasquitos Lagoon (LPL) from June 1987 to March 1989.

Fishes

The two wetlands exhibited obvious differences in fish assemblages (Table 2) in terms of dominants (total individuals collected) and species richness (number of species). At TJE, 21 species of fish representing 14 families were collected over the 3-yr period. Three species dominated the samples: 75% were *Clevelandia ios* (arrow goby), 19% *Atherinops affinis,* and 3% *Fundulus parvipinnis* (California killifish). The remaining 18 species comprised only 3% of the total combined. In contrast, 13 species from 10 families were collected at LPL. Dominants included four species: 36% were *Atherinops affinis,* 18% *Gambusia affinis* (mosquitofish), 17% *Gillichthys mirabilis,* and 16% *Clevelandia ios.*

A test of the sampling procedure used in this study illustrates its effectiveness in capturing the majority of the fishes contained within the two blocking nets (Fig. 5). Repeated seining was especially needed to sample the small, numerically dominant *Clevelandia ios.* The number of *C. ios* captured per seine increased on the second and third sweeps and remained high throughout the fourth and fifth efforts. Conversely, *Atherinops affinis* densities declined dramatically after the first seine, illustrating the relative ease with which this pelagic species was captured.

The differences in the number of species encountered in each wetland are partially due to a greater sampling effort at TJE. Many of the species taken at TJE were collected in 1986, a year before sampling began at LPL. There was also some disparity in areas sampled, with the total area at LPL somewhat smaller than at TJE. When the 1986 data from TJE are omitted from comparisons, the cumulative species curves for each wetland are similar with curves leveling after the sixth quarterly sample (Fig. 6), suggesting that both wetlands were adequately assessed for species richness.

A comparison of absolute and relative abundances demonstrated system-wide changes at TJE during the study (Table 3). The fish assemblage shifted from one codominated by *Atherinops affinis* and *Clevelandia ios* in 1986 to one in which *Clevelandia ios* was by far the numerical dominant. The relative abundance of *Atherinops affinis* remained fairly constant in LPL (Table 3). While *Clevelandia ios* dominated TJE, it was a relatively minor species at LPL. Conversely, *Gillichthys mirabilis* was important at LPL but rare at TJE. *Atherinops affinis* was common in both wetlands but declined throughout

TABLE 3. Annual relative abundance (% of total) of the dominant channel organisms collected at Tijuana Estuary (TJE) and Los Peñasquitos Lagoon (LPL). X = no data.

Species	TJE 1986–1987	TJE 1987–1988	TJE 1988–1989	LPL 1987–1988	LPL 1988–1989
Fishes					
Atherinops affinis	52%	14%	7%	38%	36%
Clevelandia ios	41%	58%	90%	22%	14%
Fundulus parvipinnis	4%	19%	1%	4%	2%
Gillichthys mirabilis	0%	<1%	<1%	28%	14%
Gambusia affinis	0%	0%	0%	<1%	24%
Total fishes collected	20,888	4,976	54,301	1,253	3,834
Bivalves					
Tagelus californianus	73%	33%	27%	35%	50%
Protothaca staminea	19%	34%	42%	2%	8%
Macoma nasuta	2%	17%	19%	7%	5%
Cryptomya californica	0%	6%	4%	0%	8%
Total bivalves collected	658	490	651	55	40
Polychaetes					
Capitellidae	X	33%	50%	22%	36%
Spionidae					
Boccardia spp.	X	<1%	5%	19%	7%
Polydora spp.	X	18%	20%	28%	21%
Nephtys spp.	X	16%	1%	0%	0%
Pseudopolydora spp.	X	0%	0%	5%	3%
Spiophanes missionensis	X	0%	8%	0%	0%
Opheliidae					
Armandia brevis	X	<1%	5%	<1%	<1%
Euzonus mucronata	X	0%	0%	<1%	25%
Unidentified taxa	X	3%	0%	4%	0%
Total polychaetes collected		276	1,422	709	659

the study period at TJE. *Gambusia affinis* was common at LPL but absent from TJE.

The total numbers of fish species have also changed. At TJE, species richness fell from a high of 14 in September 1986 to a low of 6 in December 1988 and March 1989 (Fig. 7). The most dramatic change in species richness occurred between September 1986 and June 1987, a time of prolonged sewage discharge. Each quarterly sampling period in 1986–1987 yielded more species than the corresponding sampling period in 1987–1988. The number of fish species differed significantly with sampling station ($p < 0.05$; Fig. 8).

At LPL, species richness was highest in June and September and lowest in December (Fig. 7). There were no significant differences among stations ($p > 0.05$). A maximum of 10 species was collected from LPL during any single sampling period.

Fishes also declined in density and size. At TJE,

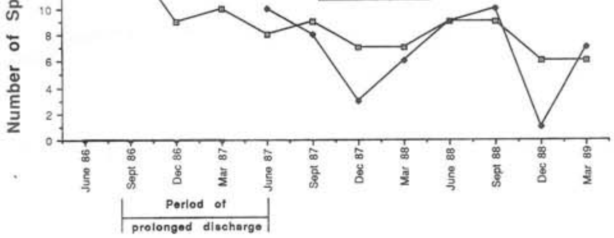

Fig. 7. Total number of fish species collected from each of three sampling sites at Tijuana Estuary (TJE) and Los Peñasquitos Lagoon (LPL).

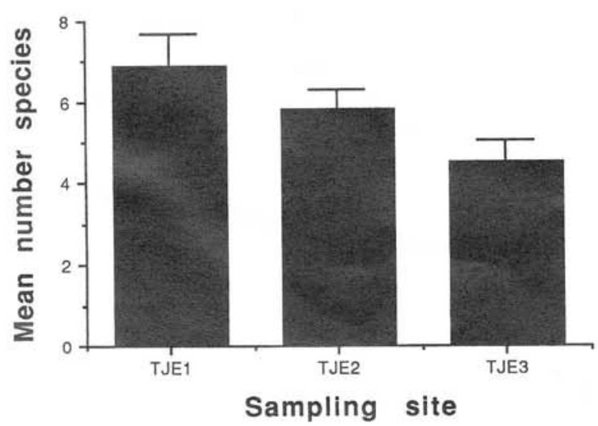

Fig. 8. Mean number fish species (n = 12) collected at three sampling sites at Tijuana Estuary (TJE). Error bars = ± one standard error.

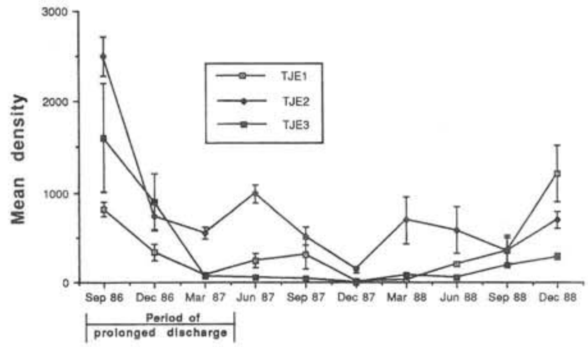

Fig. 10. Mean densities (no. m^{-2}) of all bivalves collected from each of three sampling sites at Tijuana Estuary (TJE). Error bars = ± one standard error.

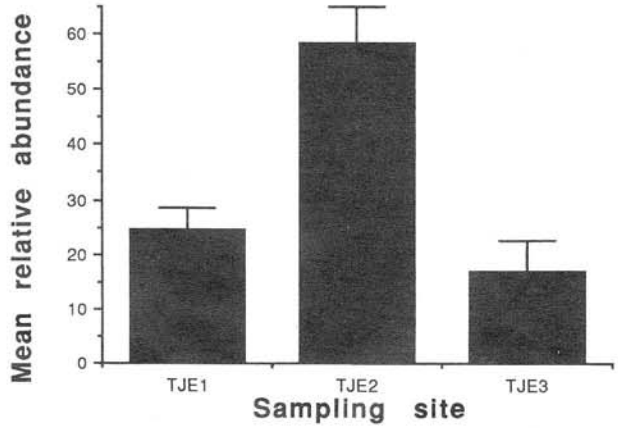

Fig. 12. Mean number of bivalve species collected from each of three sampling sites at Tijuana Estuary (TJE). Data are means for 10 sampling dates. Error bars = ± one standard error.

(two-way ANOVA, $p < 0.01$); the interaction was also significant ($p < 0.01$), primarily because there were zero bivalves collected on some dates at some stations.

Two of the three dominant bivalve species were found in highest densities at station TJE2 compared to TJE1 and TJE3 (Fig. 11). Both *Protothaca staminea* and *Macoma nasuta* showed a strong site preference for TJE2. *Tagelus californianus* did not demonstrate a clear site preference but occurred at all sampling stations. TJE2 also supported higher mean relative abundances of bivalves than did stations TJE1 and TJE3 (Fig. 12).

Sediments analyzed at TJE2 had ϕ values (Table 6) that indicated a very coarse grain size and a high degree of variation about the mean grain size (sorting and skewness). Sediments from station TJE1 were coarse and well sorted. This site was buried with several centimeters of dune sand on two occasions during the study and was dredged once to remove sediments.

As with the fish assemblage, benthic invertebrates at TJE showed a shift in dominance and an overall decline in total number of individuals collected (Table 3). In 1986, *Tagelus californianus* dominated the collections while *Cryptomya californica* was absent. *Callianassa californiensis*, a commensal of *Cryptomya*, was collected in low densities in 1986. By 1987, *T. californianus* had declined

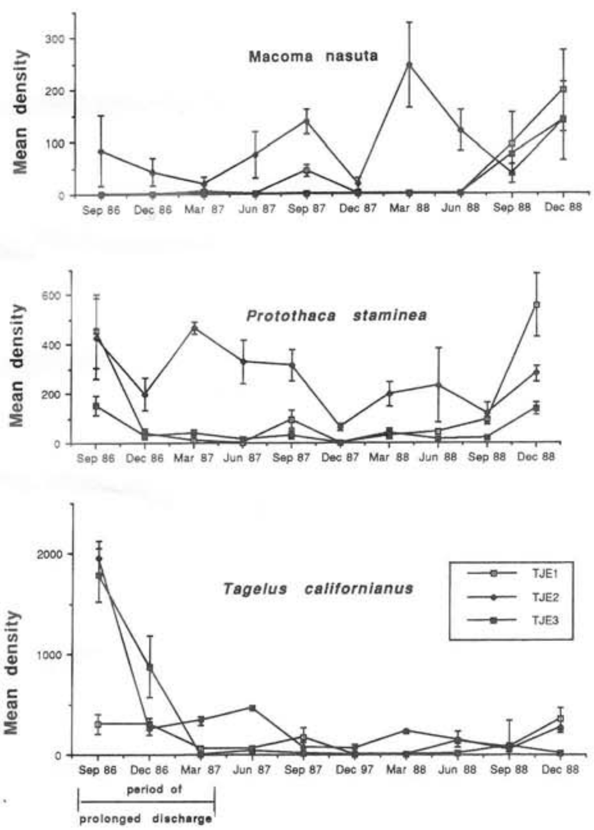

Fig. 11. Mean densities (no. m^{-2}) of the dominant bivalve species collected at each of three sampling sites at Tijuana Estuary (TJE). Error bars = ± one standard error. Note different vertical scales.

TABLE 6. Phi values determined from sediment analysis for Tijuana Estuary site TJE1 (from Duggan 1989).

Station	Date	Mean Grain Size[a] (mm)	Sorting[b]	Skewness[c]
TJE1	Sept. 1986	2.22	0.65	−0.11
TJE1	Jan. 1987	1.90	0.81	0.05
TJE2	May 1987	1.04	1.65	0.09
TJE2	Sept. 1987	0.75	1.81	−0.41

[a] 2 mm to 1 mm indicates very coarse grain size, 0.5 to 1.00 indicates coarse sand (from Krumbein and Pettijohn 1938).

[b] 0.5 to 1.0 indicates moderately well to moderately sorted; 1.0 to 2.0 indicates poorly sorted, with sorting a measure of dispersion of grain size around the mean grain size of that sample (from Folk and Ward 1957).

[c] −0.10 to +0.10 indicates nearly symmetrical distribution of grain size around the mean; −1.0 to −0.3 indicates negatively skewed (from Folk and Ward 1957).

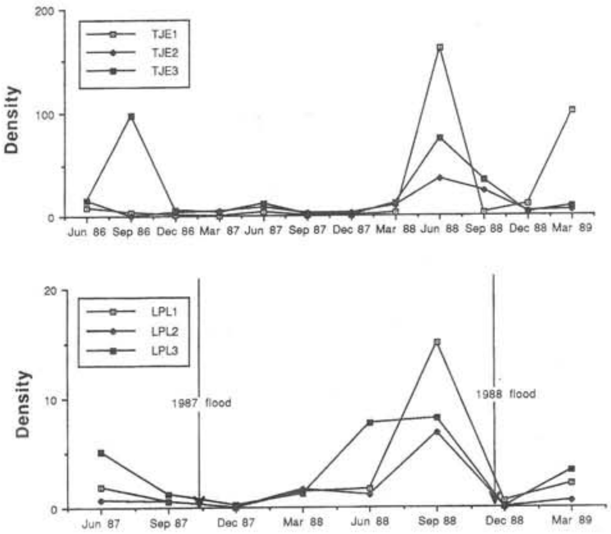

Fig. 9. Mean densities (no. m^{-2}) of all fishes collected at each of three sampling sites at Tijuana Estuary (TJE) and three sites at Los Peñasquitos Lagoon (LPL). Note different vertical scales.

the density of fishes collected decreased from a peak in September 1986 to relatively low values throughout 1987 before rising dramatically in March and June 1988 (Fig. 9). Mean density of fishes at LPL declined after a June peak to levels near zero in December, following the 1987 flood, and peaked again in September 1988, before crashing as a result of the 1988 flood (Fig. 9).

The maximum and mean sizes of *Atherinops affinis* captured at station TJE1 in June of each year declined dramatically (Table 4). There were significant differences in sizes present each June ($p < 0.001$). Station TJE1 was chosen for this example because it typically yielded the highest numbers of this species.

Benthic Invertebrates

Fifty-eight taxa of benthic invertebrates were collected from TJE from September 1986 to June 1988 (Table 5). The collections were nearly equally represented by polychaetes and bivalves. The dominant bivalve species included *Tagelus californianus*, *Protothaca staminea*, and *Macoma nasuta*, while capitellids and spionids dominated the polychaete fraction. The decapod crustacean *Callianassa californiensis* was also abundant.

TABLE 4. Sizes of *Atherinops affinis* (fork length in mm) collected at station TJE1 during June of three consecutive years. SE = ± one standard error.

Year	Maximum Size	Mean Size	SE	n
1986	188	110.3	±1.2	292
1987	121	91.6	±2.8	109
1988	68	47.2	±0.6	124

TABLE 5. Numbers of individuals of benthic invertebrates collected at Tijuana Estuary (TJE) and Los Peñasquitos Lagoon (LPL). Taxa comprising less than 5% are presented as "others."

Taxon	TJE 1986–1988	LPL 1987–1988
Sipunculid worms		
Themiste sp.	17	0
Echinoid echinoderms		
Dendraster excentricus	6	3
Nemertean worms	93	3
Polychaete worms		
Capitellidae	814	399
Spionidae		
Boccardia spp.	68 (5 spp)	183 (4 spp)
Polydora cornuta	124	18
Polydora ligni	143	92
Polydora spp.	63 (2 spp)	210 (2 spp)
Spiophanes missionensis	117	0
Opheliidae		
Euzonus mucronata	0	162
Other taxa combined	437	161
Total polychaetes collected	1,698	1,207
Total families collected	13	11
Total species collected	35	20
Bivalve molluscs		
Tagelus californianus	797	40
Protothaca staminea	554	4
Macoma nasuta	221	6
Laevicardium substriatum	30	8
Spisula sp.	0	17
Other species combined	227	17
Total bivalves collected	1,799	92
Total species collected	18	12
Decapod crustaceans		
Callianassa californiensis	234	3
Phoronida		
Phoronis sp.	1	114
Total sampling area (cumulative area in m^2)	5.25 m^2	3.82 m^2
Total number quarterly samples	11	8

By comparison, 37 taxa of benthic invertebrates were collected from LPL (Table 5). There, the benthic assemblage was dominated by three taxa of polychaetes and had relatively few bivalves. Polychaetes were dominated by capitellids, spionids, and the opheliid, *Euzonus mucronata*. Only 95 individual bivalves representing 12 species were collected from LPL.

Bivalves

At TJE, bivalve densities were greatest in September 1986 when as many as 2,500 m^{-2} were collected at station TJE2 (Fig. 10). Densities declined during the prolonged period of wastewater discharge. There were significant differences in bivalve densities among stations and on different dates

TABLE 7. Mean length (in mm) of the dominant bivalves collected from Tijuana Estuary November 23, 1986, and January 24, 1987. SE equals one standard error (from R. Duggan 1989).

Species	11/23/86			1/24/87		
	Mean	SE	n	Mean	SE	n
Tagelus californianus	40.3	2.2	302	38.4	0.4	164
Protothaca staminea	11.2	0.3	126	10.8	0.6	90

while *Protothaca staminea, Cryptomya,* and *Callianassa* had increased. In the three quarterly samples analyzed for 1988, *T. californianus* continued to decline and *P. staminea* continued to increase. *Cryptomya californica* and *Macoma nasuta* remained near 1987–1988 levels (Table 3).

A comparison of the mean sizes of the two dominant bivalve species (Table 7) suggests that the majority of the individuals encountered in this study were 0 to 1 year old with a few specimens slightly older (Shaw 1986; R. Duggan, SDSU, personal communication). Thus, newly recruited individuals comprised the majority of those collected.

Polychaetes

The abundance of polychaetes collected at TJE increased from 1987 to 1988, especially at station TJE3, nearest the Tijuana River (Fig. 13). The dominant taxa during this peak were capitellids and spionids, primarily *Polydora nuchalis* and *P. cornuta.*

At LPL, polychaetes were the dominant benthic form during the 2-yr study period. Capitellids, spionids (*Polydora* spp.) and the opheliid, *Euzonus mucronata,* dominated. Prior to the October 1987 flood, mean polychaete densities were highest near the mouth (station LPL3, Fig. 14). After flooding, mean densities fell to levels near zero at all sites. By September 1988, peak densities were encountered with the greatest values again at station LPL3.

A comparison of the annual relative abundances demonstrates the instability of both systems (Table 3). The relative abundance of each of the dominant taxa at TJE changed substantially, especially among the spionids where *Nephtys* spp. decreased and *Boccardia* spp. and *Spiophanes missionensis* increased from the previous year. The changes at LPL were less dramatic but included the decrease of *Boccardia* spp. and the sudden increase of *Euzonus mucronata.*

Discussion

Three lines of reasoning lead us to conclude that hydrologic disturbances, especially reduced salinity, are responsible for the patterns that have been found at both Tijuana Estuary (TJE) and Los Peñasquitos Lagoon (LPL). The trends over the course of the study are reduced species richness and abundances, population structures skewed toward young animals, and dominance by species with early reproductive maturity and prolonged spawning periods. First, an examination of historic data in southern California coastal wetlands, including TJE, shows that summer streamflows were rare or absent prior to the late 1970s. At that time, a very different benthic assemblage was present at TJE consisting of larger, and presumably older, bivalves (Hosmer 1977). Second, comparison of sampling sites within TJE indicates that the least-disturbed station (farthest from wastewater and not dredged) serves as a refuge for species that have been eliminated elsewhere. Finally, comparison of TJE with LPL, where reduced salinity is more severe due to annual impoundment of flood waters, shows that the fauna is most depleted where the hydrologic disturbances have been greatest. The history of impacts leads to concern regarding future planned modifications to regional streamflows.

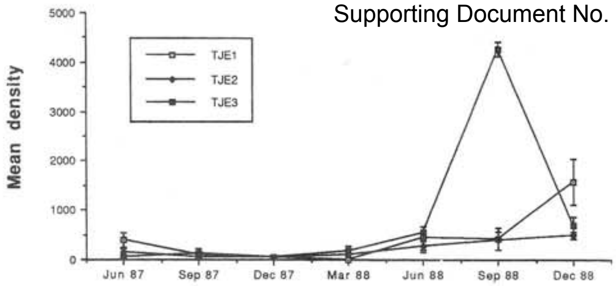

Fig. 13. Mean densities (no. m^{-2}) of polychaetes collected from each of three sampling sites at Tijuana Estuary (TJE). Error bars = ± one standard error.

Historic Comparison

Weather and streamflow records for the San Diego area (Zedler et al. 1984) show that there were no major flood years between 1944 and 1978. Streamflow in the lower Tijuana River was minimal, even in winter, with many years of no measurable flow entering Tijuana Estuary. It is reasonable to assume that the channels were essentially

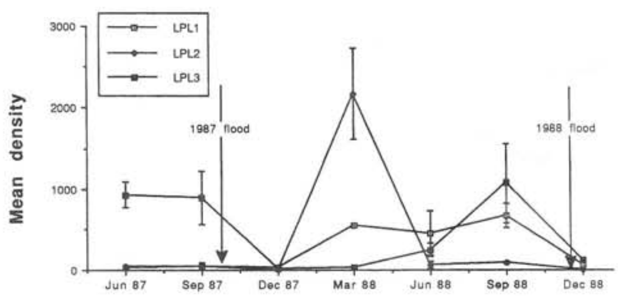

Fig. 14. Mean densities (no. m^{-2}) of polychaetes collected from each of three sites at Los Peñasquitos Lagoon (LPL). Error bars = ± one standard error.

marine at this time. The only historic salinity measurements were made by Purer (1942) in 1939 during a year of average (approx. 25 cm) rainfall and near-average streamflow. The lowest salinity she found at Tijuana Estuary in monthly sampling of three stations was 24‰ in March 1939. Even in a month with 10 cm of rainfall (March 1940), salinities were above 30‰.

The responses of the macrobenthic invertebrates of coastal wetlands to salinity reductions are more apparent than those of the fish assemblages, largely because of their inability to avoid exposure to unfavorable conditions. For this reason, we have concentrated our discussion of the historic comparison on the these assemblages. As previously mentioned, there was some disparity in sampling area with TJE1 and TJE2 equal at 110 m^2 and TJE3 at 70 m^2. While such disparity might have influenced fish distribution and abundance, it would not have affected benthic assemblages that were collected from equal areas and equal effort at all stations at all times. Thus, the strong intra-wetland patterns in the benthos at TJE are not artifacts of sampling design.

The benthos of Tijuana Estuary and Mugu Lagoon (34°N, 119°W) were sampled in the 1970s by Peterson (1972, 1975). His data for live bivalves characterize the low-disturbance assemblage in saline habitats. *Nuttallia (Sanguinolaria) nuttallii* and *Protothaca staminea* were the most abundant bivalves at both study sites. *Tagelus californianus*, *Cryptomya californica*, *Macoma nasuta*, and *Laevicardium substriatum* were also present but in lower numbers. Samples from Mugu Lagoon taken before and after the 1969 flood suggested that the population of *Tagelus californianus* was reduced by freshwater inflows (Peterson 1972). To test the tolerance of different bivalves to reduced salinity, Peterson simulated flood conditions in the laboratory (6-h periods with seawater diluted to increasing degrees). He found that *Tagelus californianus* and *Laevicardium substriatum* were intolerant of the lowest salinities (3–10‰) while *Protothaca staminea* and *Macoma nasuta* survived 0‰.

Our findings for Tijuana Estuary under continuous wastewater inflows are consistent with Peterson's conclusion that bivalve communities are strongly affected by lowered salinity. The species that are now dominant, *T. californianus*, *P. staminea*, and *M. nasuta*, were least abundant at TJE3, the site nearest the source of wastewater inflow (Fig. 11).

Hosmer (1977) examined bivalve composition and size structure at Tijuana Estuary before wastewater flows were a consistent problem. Large individuals were abundant. The mean sizes for the dominant bivalves were 71 mm for *Nuttallia nuttallii*, 22 mm for *Protothaca staminea*, and 27 mm for *Tagelus californianus*. His results contrast strongly with those of the present study. *Nuttallia nuttallii* no longer exists at Tijuana Estuary, and *P. staminea* is, on the average, half as large (Table 7). The mean size of *Tagelus californianus* in 1986–1987 was larger than that reported by Hosmer (1977), but he had problems in sampling this species and suggested that larger specimens may have eluded him.

While predisturbance data on fishes at TJE are lacking, the effects of a major winter storm on the fishes of Mugu Lagoon have been documented (Onuf and Quammen 1983). They found that *Atherinops affinis* and *Cymatogaster aggregatus* (shiner surfperch), the two dominant preflood fishes, suffered heavier reduction in numbers than did other species. They concluded that fishes that spend the majority of their time in the water column were more affected than were benthic fishes, and attributed this to the reduction of low tide volume within the lagoon as a result of flood-induced sedimentation. The sewage flows at TJE have not resulted in a noticeable decrease in tidal prism. The decline in *A. affinis*, the formerly dominant pelagic species, thus appears to be the result of salinity rather than loss of open water habitat.

Comparison of Stations Within Tijuana Estuary

At TJE, continual wastewater inflows pose a threat to the channel biota. However, the influx of nonsaline water to this tidal wetland had less drastic impacts than the flooding at LPL when it is nontidal.

The importance of salinity reduction is suggested by comparisons of the sampling stations near to and far from the freshwater inflows. At the mouth station (TJE3), channel organisms declined throughout the study period but increased in late 1988. Bivalve densities declined drastically from highs of more than 2,500 m^{-2}, mostly *Tagelus californianus*, in September 1986 to much lower densities for the remainder of the study (Fig. 10). Bivalves at the other two stations did not show similar responses. Polychaete densities were low until September 1988, when mean densities greater than 4,000 m^{-2} were encountered (Fig. 13). Fishes likewise declined at TJE3 throughout the study until June 1988, with the assemblage shifting from one co-dominated by *Atherinops affinis* and *Clevelandia ios* to one in which *Clevelandia ios* was the sole dominant. The highest densities of fish encountered in the study occurred in June 1988 (Fig. 9). This increase may have been a response to the elimination of wastewater flows in Smuggler's Gulch. The Smuggler's Gulch sewage interceptor was completed in April 1988 and operated throughout the 1988 summer; however, it failed to return flows on several occasions in fall 1988.

Station TJE1, which was disturbed by dredging, also demonstrated a general decline in channel organisms. Overall bivalve density declined from peaks in 1986, with little recovery until December 1988. Polychaete densities rose in 1988 to a peak mean density greater than 1,500 m^{-2}. Fish densities declined from 1986 until spawning peaks in June and December 1988.

Analyses of sediments before and after the 1988 dune washover (Table 6) showed that the substrate at TJE1 changed little, possibly because sedimentation events have long recurred at this site. Any impacts to the channel organisms at TJE1 were probably due to conditions other than sediment type, such as changes in water quality or direct disturbance due to dredging.

Station TJE2 acted as a refuge for two of the three important bivalves, *Protothaca staminea* and *Macoma nasuta.* Although the channel was not formed naturally (it was dredged in the early 1900s to connect the former sewage lagoons to the main channel and, ultimately, the ocean), it has had several decades to develop a rich fauna. The strong site preference of *M. nasuta* and *P. staminea* for station TJE2 is not explained by sediment type, since all three species inhabit a wide range of sediment types at TJE (Hosmer 1977), and each of the sampling stations contained sediments suitable for all three species. The high bivalve abundances at TJE2 are more likely due to isolation from wastewater and dredging disturbances. Mean polychaete densities were lowest at TJE2, a pattern that may be explained by their preference for finer sediments.

Station TJE3, at the mouth of the estuary, was directly in the path of the wastewater conveyed by the Tijuana River. This site supported the lowest mean density of bivalves and, at least in September 1989, very high densities of opportunistic polychaetes. In addition, the fewest fish species were collected here.

Populations of southern California coastal wetland fishes have marked seasonality, with highest densities in summer and low densities in winter; however, there are inconsistencies in TJE populations that suggest that this system did not display typical seasonality. These include the low densities encountered in June 1986 and June 1987 (Fig. 8) and the low species richness in June 1987 and March 1989 (Fig. 7). We suggest that this departure from typical seasonal patterns can be attributed to the impacts of modified hydrology.

The shift in the structure of the fish assemblage at TJE to one dominated by *Clevelandia ios* may be due partly from reduced predation pressure. *Clevelandia ios* is preyed upon by a number of estuarine species including *Paralichthys californicus, Hypsopsetta guttulata, Leptocottus armatus* (Pacific staghorn sculpin), and *Fundulus parvipinnis,* according to MacDonald (1975). Although not reported as a predator of *Clevelandia ios, Gillichthys mirabilis* has been observed to be an aggressive predator and cannibal. All of these potential predators have declined in density following mouth closure in 1984 (Nordby 1987) and the multiple disturbances discussed herein. An additional factor that may allow *Clevelandia ios* to dominate disturbed areas is its life history strategy. *Clevelandia ios* matures within one year (Brothers 1975) and spawns from September through June. In 1981, peak spawning at TJE occurred in March, April, and May, with lesser peaks in September and January (Nordby 1982). Larvae were collected in densities greater than 60 m^{-3} in April 1981.

Other components of the channel assemblage are also quick to mature. The dominant polychaetes at both LPL and TJE were species that reach sexual maturity rapidly. Some capitellid species mature sexually in as little as one month and may reproduce year-round (Grassle and Grassle 1976).

High densities of capitellids and *Polydora* spp. may have been encouraged by sewage spills. Both taxa are associated with pollution. Capitellids are considered enrichment opportunists (Pearson and Rosenberg 1978) while *Polydora cornuta* has been reported from areas of high organic matter (Pearson 1975).

In Los Angeles Harbor, Crippen and Reisch (1969) found that *Capitella* sp. and *Polydora cornuta* were most abundant in polluted to very polluted areas. Capitellids have also been shown to increase in density when the source of disturbance ceases, for example, abatement of a pollution source (Rosenberg 1976; Sanders et al. 1980). Thus, the reason for their sudden increase at TJE3 in September 1988 does not necessarily indicate increased wastewater flows.

Tijuana Estuary-Los Peñasquitos Lagoon Comparison

Hydrologic disturbances had a greater impact on the channel assemblage at LPL than TJE. During nontidal conditions at LPL, both fish and benthic invertebrate assemblages experienced seasonal storms and changes in water quality. Populations plummeted following flooding in fall 1987. In spring and summer 1988, the channel organisms recovered, until the December storm event in 1988, which again decimated populations.

There were few spatial patterns in fish and benthic invertebrate distributions within LPL despite stations specifically chosen near the mouth and near freshwater inflows. The small size of the lagoon and its usual closure made its waters relatively homogeneous. Polychaetes were generally more dense at the mouth (LPL3) but were also found in high densities at the other stations at some times of the year. *Gambusia affinis* was found in highest densities at the station most affected by freshwater (LPL1).

Freshwater input to LPL is increasing as the watershed is developed. Flows from Carmel Valley Creek continued throughout the summer and autumn of 1988, a period that is usually dry. This flow has resulted in the encroachment of brackish marsh into the salt marsh and introduced high numbers of *Gambusia affinis* to the landward edges of the lagoon. A long-term increase in freshwater input into the lagoon may jeopardize this coastal wetland.

Future Hydrologic Disturbances

Several municipalities and water utility districts in San Diego County are proposing to discharge treated wastewater into coastal streams, since the ocean outfalls are now at capacity. The California Regional Water Quality Control Board, San Diego Region (1988) projects releases of 10 to 30 MGD by the year 2015 for 10 county streams. All of these streams have natural flow peaks in the winter and many have little or no flow in summer. While plans call for the reuse of treated wastewater for irrigation, streamflows would still be augmented in winter, and the period of heavy flow would no doubt be extended. Shifts in wetland vegetation from dominance by salt marsh halophytes to brackish marsh species (*Typha* and *Scirpus* spp.) have been predicted previously (Zedler et al. 1984). Based on our analyses of channel assemblage responses to hydrologic disturbances, we now predict major impacts to fishes and macroinvertebrates. Discharge of treated wastewater to small coastal wetlands such as LPL, which are frequently closed to tidal flushing, will likely result in the extermination of most or all of the channel biota or replacement with fresh/brackish water species. In many cases these include exotic fish species such as *Acanthogobius flavimanus* (yellowfin goby) and *Gambusia affinis* and invertebrates such as the Asian bivalves *Corbicula fluminea* and *Musculista senhousia*.

Conclusion

The two coastal wetlands compared in this study differ in types and degrees of disturbance. Tijuana Estuary (TJE) has been subjected to continuous, long-term wastewater inflows while Los Peñasquitos Lagoon (LPL) has had flooding once in 1987 and once in 1988. The channel biota of each system were altered by these events, but short-term recovery appears to be greater at TJE, where tidal flushing is now continuous.

At TJE, the structure of the fish assemblage has shifted toward dominance by species with an extended spawning season and rapid maturity. Bivalve populations are composed of young individuals as the result of disturbance events. Polychaete populations are dominated by taxa associated with pollution and that have prolonged spawning seasons and mature rapidly. The sampling station farthest from the wastewater inflows harbored significantly higher densities of bivalves than did the other sites. The sampling station nearest the source of wastewater supported the fewest fish species.

At LPL, the channel assemblage is dominated by species that can survive salinity shock and very low levels of dissolved oxygen, are easily reintroduced during brief periods of mouth opening, or are introduced from freshwater inflows. Density and diversity of all species mirrors the changes in water chemistry; both decrease as water quality deteriorates and increase after water quality improves.

Neither of these coastal wetlands has a channel assemblage that is characteristic of pristine tidal ecosystems. Long histories of disturbance have shifted their composition to a small group of species that is tolerant of reduced salinity. Resilience in the short term is conferred by opportunistic life histories and quick reestablishment following the return of tidal influence. Recovery in the long term would require elimination of the hydrologic disturbances and time for native species to reinvade from refuges within the region's coastal water bodies.

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This manuscript is dedicated to Jordan Dale Covin, friend and colleague, who passed away during its preparation.

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REGION 9, SAN DIEGO REGION

ORDER NO. R-9-2006-0065

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FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

ATTACHMENT 8 - NUMBERS AND BIOMASS OF SPECIES COLLECTED DURING 2004/2005 SAMPLING PERIOD

March 27, 2009

EPS Impingement Summary:

Numbers and Biomass of Species Collected During 2004/2005 Sampling Period

Table A.

Numbers and weights of fishes, sharks and rays impinged during 52 normal operations surveys at EPS from June 2004 to June 2005, sorted by taxa abundance. Traveling screen data and bar rack data presented separately. Some sample weights were extrapolated based on a subset of collected fishes.

Taxon	Common Name	Sample Count	Sample Weight (g)	Bar Rack Count	Bar Rack Weight (g)
Atherinops affinis	topsmelt	5,242	42,298.7	10	261.5
Cymatogaster aggregata	shiner surfperch	2,827	28,374.4	–	–
Anchoa compressa	deepbody anchovy	2,079	11,605.9	2	21.0
Seriphus politus	queenfish	1,304	7,498.8	2	16.5
Xenistius californiensis	salema	1,061	2,389.8	–	–
Anchoa delicatissima	slough anchovy	1,056	3,143.5	–	–
Atherinopsidae	silverside	999	4,453.9	–	–
Hyperprosopon argenteum	walleye surfperch	605	23,961.8	1	21.0
Engraulis mordax	northern anchovy	537	786.3	–	–
Leuresthes tenuis	California grunion	489	2,280.3	–	–
Heterostichus rostratus	giant kelpfish	344	2,612.3	–	–
Paralabrax maculatofasciatus	spotted sand bass	303	4,603.6	–	–
Sardinops sagax	Pacific sardine	268	1,479.7	–	–
Roncador stearnsi	spotfin croaker	182	8,353.6	2	3,000.0
Paralabrax nebulifer	barred sand bass	151	1,540.8	–	–
Gymnura marmorata	California butterfly ray	146	60,628.5	1	390.0
Phanerodon furcatus	white surfperch	144	4,685.6	–	–
Strongylura exilis	California needlefish	135	6,025.0	–	–
Paralabrax clathratus	kelp bass	111	679.8	–	–
Porichthys myriaster	specklefin midshipman	103	28,189.3	–	–
unidentified chub	unidentified chub	96	877.3	–	–
Paralichthys californicus	California halibut	95	1,728.9	–	–
Anisotremus davidsoni	sargo	94	1,662.3	–	–
Urolophus halleri	round stingray	79	20,588.6	–	–
Atractoscion nobilis (Sciaenidae)	white seabass	70	11,294.8	6	872.1
Hypsopsetta guttulata	diamond turbot	66	10,679.2	1	85.0
Micrometrus minimus	dwarf surfperch	57	562.2	–	–
Syngnathus spp.	pipefishes	55	160.7	–	–
Atherinopsis californiensis	jacksmelt	54	1,152.0	–	–
Myliobatis californica	bat ray	50	19,899.1	4	5,965.0
Menticirrhus undulatus	California corbina	43	1,906.1	–	–
Amphistichus argenteus	barred surfperch	43	1,306.4	–	–
Fundulus parvipinnis	California killifish	43	299.0	–	–
unidentified fish, damaged	unidentified damaged fish	36	1,060.2	1	70.0
Ictaluridae	catfish unid.	35	4,278.5	–	–
Leptocottus armatus	Pacific staghorn sculpin	32	280.2	–	–
Lepomis cyanellus	green sunfish	29	1,169.6	–	–

Sphyraena argentea	California barracuda	29	397.2	–	–
Umbrina roncador	yellowfin croaker	28	572.5	–	–
Lepomis macrochirus	bluegill	20	670.0	–	–
Ophichthus zophochir	yellow snake eel	18	5,348.6	–	–
Citharichthys stigmaeus	speckled sanddab	17	61.6	–	–
Brachyistius frenatus	kelp surfperch	16	181.5	–	–
Cheilotrema saturnum	black croaker	15	103.4	–	–
Embiotoca jacksoni	black surfperch	14	1,240.3	–	–
Genyonemus lineatus	white croaker	12	170.7	–	–
Platyrhinoidis triseriata	thornback	11	4,730.9	1	1,500.0
unidentified fish	unidentified fish	10	811.0	–	–
Chromis punctipinnis	blacksmith	10	395.9	–	–
Porichthys notatus	plainfin midshipman	9	1,791.8	–	–
Hermosilla azurea	zebra perch	9	1,097.2	–	–
Micropterus salmoides	large mouth bass	9	27.0	–	–
Heterostichus spp.	kelpfish	7	47.8	–	–
Hypsoblennius gentilis	bay blenny	7	36.5	–	–
Trachurus symmetricus	jack mackerel	7	7.2	–	–
Anchoa spp.	anchovy	6	27.0	–	–
Engraulidae	anchovies	6	2.8	–	–
Peprilus simillimus	Pacific butterfish	5	91.3	–	–
Rhacochilus vacca	pile surfperch	4	915.1	–	–
Pylodictis olivaris	flathead catfish	4	480.0	–	–
Pleuronichthys verticalis	hornyhead turbot	4	189.6	–	–
Pleuronectiformes unid.	flatfishes	4	62.1	–	–
Sebastes atrovirens	kelp rockfish	4	39.8	–	–
Mustelus californicus	gray smoothhound	3	1,850.0	–	–
Cheilopogon pinnatibarbatus	spotted flyingfish	3	604.0	–	–
Ameiurus natalis	yellow bullhead	3	220.0	–	–
Lepomis spp.	sunfishes	3	195.5	–	–
Hypsoblennius gilberti	rockpool blenny	3	15.6	–	–
Syngnathus leptorhynchus	bay pipefish	3	8.8	–	–
Albula vulpes	bonefish	2	1,192.0	–	–
Sarda chiliensis	Pacific bonito	2	1,010.0	–	–
Rhinobatos productus	shovelnose guitarfish	2	460.8	2	6,200.0
Girella nigricans	opaleye	2	346.1	–	–
Scorpaena guttata	California scorpionfish	2	76.0	–	–
Acanthogobius flavimanus	yellowfin goby	2	55.2	–	–
Hyporhamphus rosae	California halfbeak	2	22.6	–	–
Hypsoblennius jenkinsi	mussel blenny	2	17.3	–	–
Symphurus atricauda	California tonguefish	2	15.4	–	–
Hypsoblennius spp.	blennies	2	10.5	–	–
Scomber japonicus	Pacific mackerel	2	10.0	–	–
Tilapia spp.	African mouth brooders	2	6.6	–	–
Sciaenidae unid.	croaker	2	2.8	–	–
Paralabrax spp.	sand bass	2	2.0	–	–
Cynoscion parvipinnis	shortfin corvina	1	900.0	–	–
Porichthys spp.	midshipman	1	200.0	–	–
Micropterus dolomieu	smallmouth bass	1	150.0	–	–
Hyperprosopon spp.	surfperch	1	115.0	–	–

Ameiurus nebulosus	brown bullhead	1	100.0	–	–
Gillichthys mirabilis	longjaw mudsucker	1	34.4	–	–
Lyopsetta exilis	slender sole	1	25.9	–	–
Gibbonsia montereyensis	crevice kelpfish	1	8.3	–	–
Pleuronichthys ritteri	spotted turbot	1	6.5	–	–
Oxylebius pictus	painted greenling	1	4.8	–	–
Paraclinus integripinnis	reef finspot	1	3.7	–	–
Dorosoma petenense	threadfin shad	1	3.4	–	–
Mugil cephalus	striped mullet	1	3.4	–	–
Citharichthys sordidus	Pacific sanddab	1	0.5	–	–
Torpedo californica	Pacific electric ray	–	–	1	3,750.0
		19,408	**351,672.4**	**34**	**22,152.1**

Table B.

Numbers and weights of shellfish invertebrates impinged during 52 normal operations surveys at EPS from June 2004 to June 2005, sorted by taxa abundance. Traveling screen data and bar rack data presented separately.

Taxon	Common Name	Sample Count	Sample Weight (g)	Bar Rack Count	Bar Rack Weight (g)
Portunus xantusii	Xantus' swimming crab	699	4,423.4	–	–
Pachygrapsus crassipes	striped shore crab	655	2,786.3	–	–
Pachygrapsus spp.	shore crab	418	821.9	–	–
Octopus spp.	octopus	36	6,909.4	–	–
Cancer productus	red rock crab	26	222.0	–	–
Loligo opalescens	market squid	24	263.7	–	–
Pugettia spp.	kelp crabs	24	53.3	–	–
Cancer spp.	cancer crabs	23	57.3	–	–
Pugettia producta	northern kelp crab	11	20.4	–	–
Pyromaia tuberculata	tuberculate pea crab	11	17.7	–	–
Octopus bimaculatus	California two-spot octopus	8	1,108.1	–	–
Taliepus nuttallii	globose kelp crab	6	2.9	–	–
Brachyuran unid.	unidentified crab	4	270.9	–	–
Cancer antennarius	brown rock crab	4	11.4	–	–
Loxorhynchus crispatus	moss crab	4	2.4	–	–
Cancer jordani	hairy rock crab	3	15.6	–	–
Hemigrapsus oregonensis	yellow shore crab	3	6.2	–	–
Panulirus interruptus	California spiny lobster	2	96.0	–	–
Caridean unid.	unidentified shrimp	2	35.0	–	–
Pugettia richii	cryptic kelp crab	2	12.3	–	–
Blepharipoda occidentalis	spiny mole crab	2	12.0	–	–
Lophopanopeus spp.	black-clawed crabs	2	9.3	–	–
Callianassa californiensis	ghost shrimp	2	2.9	–	–
Lophopanopeus frontalis	molarless crestleg crab	2	0.8	–	–
Crangon spp.	bay shrimp	1	20.9	–	–
Rhithropanopeus harrisii	Harris mud crab	1	18.0	–	–
Sicyonia ingentis	Ridgeback rock shrimp	1	16.0	–	–
Callinectes spp.	crab	1	13.8	–	–
Podochela hemphilli	Hemphill's kelp crab	1	3.0	–	–
Cycloxanthops novemdentatus	ninetooth pebble crab	1	2.6	–	–
Pelia tumida	dwarf teardrop crab	1	1.9	–	–
Pandalus platyceros	spot shrimp	1	1.8	–	–
Majidae	spider crabs	1	1.8	–	–
Loxorhynchus spp.	spider crabs	1	0.1	1	0.5
Hippolytidae unid.	hippolytid shrimps	1	0.0	–	–
Cancer magister	dungeness crab	1	0.0	–	–
Dosidicus gigas	jumbo squid	–	–	1	500.0
		1,985	**17,241.2**	**2**	**500.5**

CARLSBAD SEAWATER DESALINATION PROJECT

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

REGION 9, SAN DIEGO REGION

ORDER NO. R-9-2006-0065

NPDES NO. CA0109223

FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

ATTACHMENT 9 - IMPINGEMENT ESTIMATION ANALYSIS BASED ON DRS. CHANG'S AND JENKINS'S STATEMENTS REGARDING OUTLIERS IN 2004-2005 EPS SAMPLING DATA

March 27, 2009

IMPINGEMENT ESTIMATION ANALYSIS BASED ON DRS. CHANG'S AND JENKINS'S STATEMENTS REGARDING OUTLIERS IN 2004-2005 EPS SAMPLING DATA

(March 26, 2009)

I. INTRODUCTION AND SUMMARY

This analysis complements Attachment 5 to the Flow, Entrainment and Impingement Minimization Plan, which analyzes various approaches to estimating the impingement should the CDP operate in stand-alone mode. Attachment 5 indicates that the CDP's projected impingement when operating in stand-alone mode ranges from 1.57 to 7.1 kilograms per day ("kg/day") based on the 2004-2005 sampling data for the EPS intake system.

The highest of these values assumes that impingement associated with the CDP's stand-alone operations will be identical to impingement observed at the EPS intake over the 2004-2005 sampling period, even though the CDP will require substantially less seawater than was withdrawn for cooling purposes during the sampling period. The other values adjust the 2004-2005 data in various ways to account for the reduced flow volume of the CDP relative to historical EPS cooling water withdrawals. These values are not adjusted to account for other technological or design measures that may be implemented if the CDP operates in stand-alone mode, which measures would be expected to further reduce impingement.

The 2004-2005 EPS sampling data includes 52 samples events. During two of the sample events, January 12 and February 23, the recorded impingement was observed to be relatively higher than on the other fifty days. Importantly, these two sample days immediately follow storm events. Subsequent analysis completed by experts for Poseidon since Attachment 5 was submitted indicates that the storm events preceding the January 12 and February 23 samples have a low probability of recurrence, each likely to occur no more than once every quarter century. The likelihood that *both* such events will occur in any given year, as they did during the 2004-2005 sample year, is even more remote.

These findings indicate that several of the impingement estimates presented in Attachment 5 ascribe too much weight to the two outlier sample days and overstate the impingement likely to be associated with the CDP's stand-alone operations. For project planning purposes, the impingement values at the lower end of the range from 1.57 to 7.1 are the most relevant, as the lower values reflect estimated impingement based on conditions that are expected to prevail over the project lifetime, whereas the relevance of the impingement values at the higher end is suspect as they presume annual recurrence of rare storm events.

II. THE STORMS PRECEDING THE JANUARY 12 AND FEBRUARY 23 SAMPLING EVENTS WERE VERY RARE

Drs. Jenkins[1] and Chang[2] presented the results of their hydrologic analyses in two short

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[1] *See* "Statement Addressing Regional Board Staff Concerns regarding the Biological Data," Dr.

reports submitted to the Regional Board on March 19, 2009 and included as part of this attachment. Dr. Jenkins explains that the impingement samples taken on January 12 and February 23, 2005 were preceded by at least five days of rainfall totaling 4.01 inches and 3.24 inches, respectively. These rainfall amounts correspond to periods of extreme rain that rank among the highest on record. According to Dr. Jenkins, both storms set rainfall records: precipitation preceding the January 12 sample constituted the highest 5-day rain total in the period of record of the Agua Hedionda Creek watershed, while the storm preceding the February 23 sample was the eighth wettest on record.[3]

Doctors Chang and Jenkins each used a different method to calculate the occurrence probabilities of storms of comparable magnitudes. Dr. Jenkins compared rainfall totals with four decades of rainfall data.[4] He noted the frequency with which storms of equal or greater magnitude to the January 12 or February 23 occurred in the database. He plotted the two storms on a log-scale and determined that the January 12 and February 23 storms have probabilities of occurrence of 0.025% and 0.17%, respectively.[5]

Dr. Chang created a hydrological simulation to generate stream flow estimates at selected points of concentration along the Agua Hedionda Creek. His simulation incorporated rainfall data obtained from the County of San Diego and drainage basin characteristics of the Agua Hedionda Creek watershed.[6] Applying the stream flow hydrological model, Dr. Chang estimated that the storms preceding the January 12 and February 23 collections produced stream flow discharges just before the Calavera Creek confluence of 2,715 and 3,609 cfs, respectively.[7] When compared with peak discharge volume and frequency data for Agua Hedionda Creek that are used by the Federal Emergency Management Agency (FEMA) to evaluate flood hazards in a community, these values represent rare events.[8] Specifically, Dr. Chang concluded that, in any given year, there is only a 4.2% chance that stream flows will occur that are large enough to produce discharge volumes equal to or greater than those resulting from the storms that preceded the January 12 sampling event.[9] Based on this observation, he concluded that the probability that a storm will occur in a year that equals or exceeds that which preceded the January 12 and

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Scott Jenkins, March 19, 2004 (Attachment 9-B, page 4).

[2] *See* “Frequencies for Storm Events of January and February 2005,” Dr. Howard Chang, March 19, 2009 (Attachment 9-A, page 2).

[3] *Id*.

[4] Daily rainfall measured by NOAA/NCDC rain gage #03177 at Carlsbad Airport (cf. NWS, 2009) at Carlsbad Airport (cf. NWS, 2009). *Id*. at 3.

[5] *Id*. at 4.

[6] *Id*.

[7] *Id*. at 4.

[8] *Id*. at 5.

[9] *Id*.

February 23 sampling events is only 4.8% and 2.8% respectively.[10] For every 100 years, in other words, Dr. Chang concludes that these storms will occur approximately 4 and 3 times, respectively. That is, they were about 25- and 35-year storms .[11] The likelihood that *both* such storms will occur in the same year again is 0.12% (4.2% x 2.8%). Therefore, such an event would be expected to occur approximately once in a 1,000 years.[12]

III. RELATIVELY HIGHER IMPINGEMENT WAS ASSOCIATED WITH THE JANUARY 12 AND FEBRUARY 23 STORMS

The samples collected after the extraordinary rain events consisted of relatively higher impingement than that observed on the other sampling days. The impingement on the January 12 sampling day was 23.5 times greater than the impingement on the 50 normal sampling days, and the impingement on the February 23 sampling day was 6.3 times greater. The following table shows the extent to which impingement following the record storms exceeded average impingement totals for the rest of the year.

Table 2: outliers compared with typical events

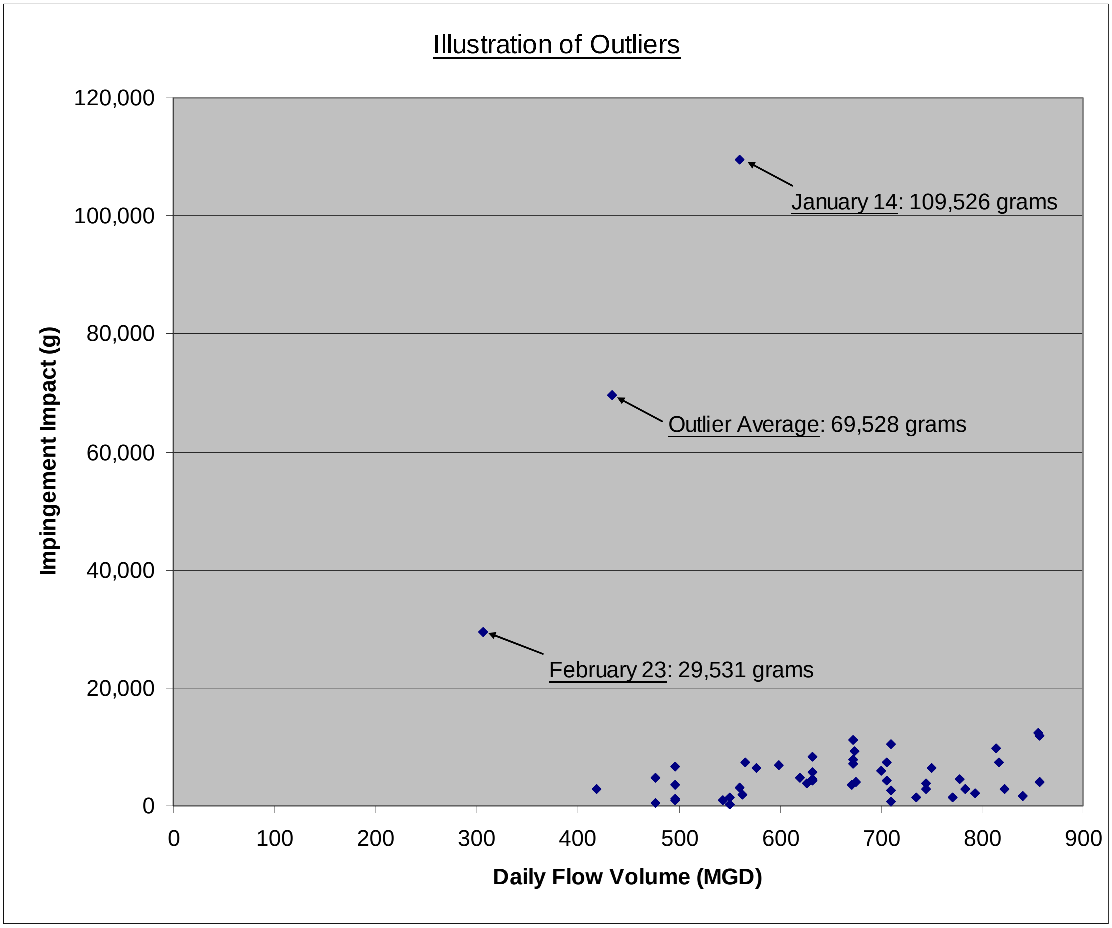
	Number of Fishes		**Weight of Impinged Fish**	
Average for the 50 typical sampling events	263		4.67 kg/day	
January 12, 2005	5,001	19 times greater than the average of the 50 normal events	109,526 (grams)	23.5 times greater than the average
February 23, 2005	1,274	4.8 times greater than the average of the 50 normal events	29,531 (grams)	6.3 times greater than the average
Average for the 2 outlier sampling events	3,138	11.9 times greater than the average of the 50 normal events	69,528 (grams)	15 times greater than the average

The following figure illustrates the same point graphically.

[10] *Id.*

[11] Dr. Chang explains "that the storm events preceding January 12, 2005 have been determined to have the return period of 23.8 years, the storm events preceding February 23, 2005 have been determined to have the return period of 35.7 years." (*Id.*)

[12] *Id.*



Note that the EPS flows for these days were significantly below the sampling period average of 657 MGD. In fact, the 307 MG flow value on February 23 represents the lowest volume recorded during the entire 52-week survey. Attachment 5 describes how these facts indicate that, at least for these two days, impingement was most likely the product of non-flow-related factors.

IV. RECORD RAINFALL PRECEDING JANUARY 12 AND FEBRUARY 23 APPEARS TO BE AN IMPORTANT FACTOR RELATED TO THE RELATIVELY HIGHER IMPINGEMENT ON THOSE DAYS

The association between (a) the extreme rainfall preceding the January 12 and February 23 sampling events, and (b) the atypical impingement values recorded on those days suggests that the increased impingement is related to the heavy rains. This apparent relationship is supported by the fact that a number of freshwater fishes were collected on those days—and on those days only. Freshwater runoff from Agua Hedionda Creek may have transported these freshwater fish into the lagoon, where they may have become susceptible to impingement, possibly because of pre-impingement mortality.

The precise extent and nature of this relationship between record rainfall and atypical impingement remains unclear. The heavy rains may have increased impingement in several different ways. For instance, the rains may have affected water quality and/or salinity levels at or near the intake. They may have washed pollutants into the lagoon in the form of urban runoff. And/or they may have flushed freshwater species into the saltwater lagoon. There is insufficient scientific evidence upon which to draw any definitive conclusions with respect to the exact nature of the relationship.

V. ASSUMING THAT THE EXTRAORDINARY RAIN EVENTS WILL RECUR EVERY YEAR OVERESTATES THE POTENTIAL FOR IMPINGEMENT

A. Four of the Previously Submitted Impingement Estimates Assume that the Outlier Events Will Occur 14 Days Per Year, Every Year

Attachment 5 introduces five estimation approaches, all except one of which (i.e., Regression Approach 1-A) include the outlier data. The following table shows algebraically how these approaches treat the outliers to calculate the CDP's daily impingement estimates.

Approaches	**Expression**: CDP's Daily Impingement = …
Regression (1-A)	*Regression value for typical events* **[excludes outliers]**
Regression (1-B)	*((regression value for typical events x 50) + (average for outliers x 2))/52*
Equivalence (2)	*((average for typical events x 50) + (average for outliers x 2))/52*
Proportional (3-A)	*((flow-proportioned average for typical events x 50) + (flow-proportioned average for outliers x 2))/52)*
Proportional (3-B)	*((flow-proportioned average for typical events x 50) + (average for outliers x 2))/52)*

Thus, the four approaches that account for outliers each assumes that that the 2004/2005 sample properly represents the incidence and extent of the non-flow-related events. Except for Regression Approach 1-A, all approaches assume that there is a 100% probability that every year will include fourteen days (i.e., 2/52 x 365) when impingement will equal the average of the impingement values recorded on the two outlier days (i.e., 69 kg/day).[13] The following table identifies the probability assumption for each of the four approaches:

Approaches	**Expression**: CDP's Daily Impingement = …
Regression (1-B)	*((regression value for normal events)* x *(52 – 2* x $P_{outliers}$*) + ((average for outliers)* x *(2* x $P_{outliers}$*)))/52*
Equivalence (2)	*((average for normal events)* x *(52 – 2* x $P_{outliers}$*) + ((average for outliers)* x *(2* x $P_{outliers}$*)))/52*
Proportional (3-A)	*((flow-proportioned average for normal events)* x *(52 – 2* x $P_{outliers}$*) + ((flow-proportioned average for outliers)* x *(2* x $P_{outliers}$*)))/52*

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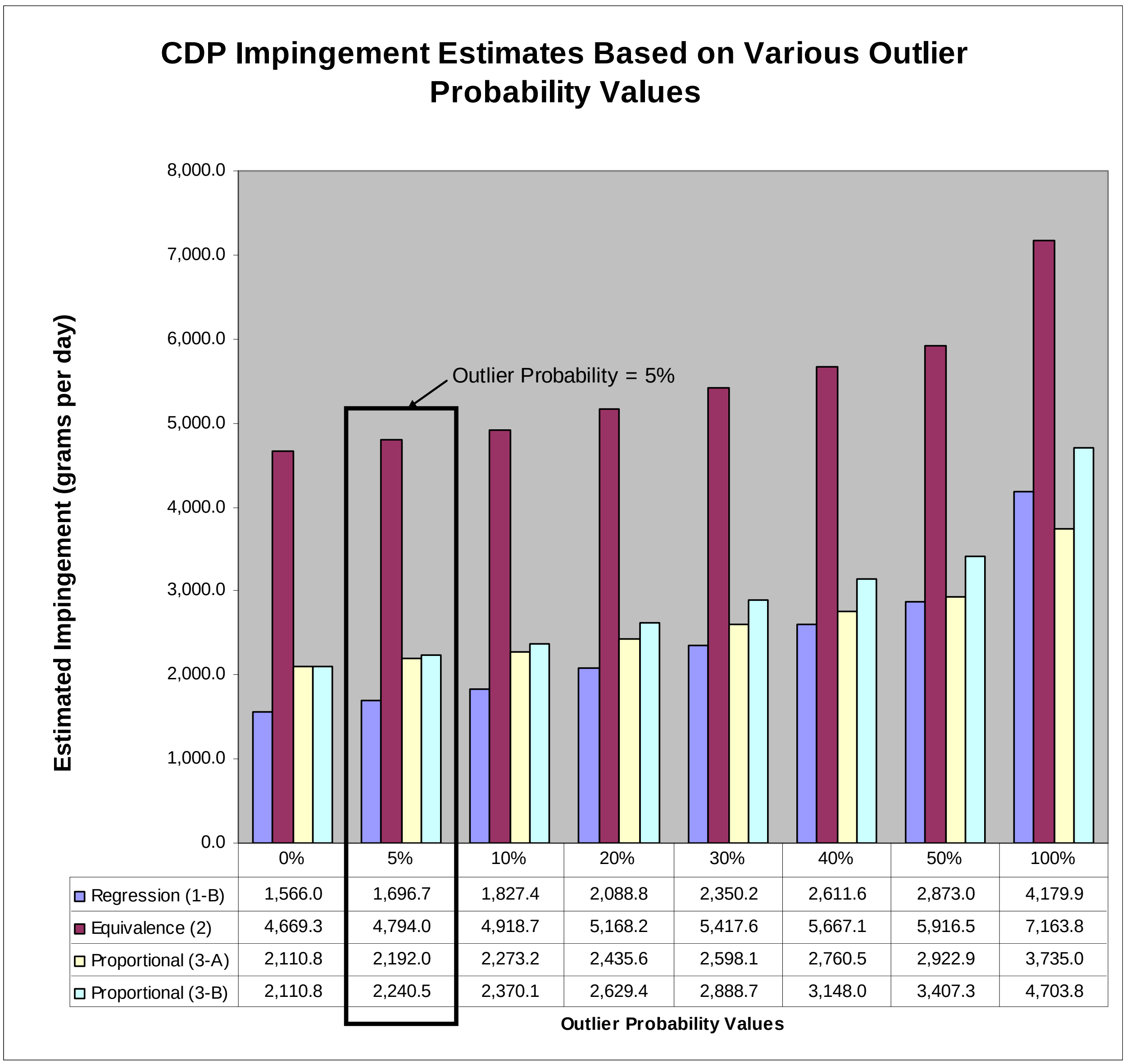
[13] Proportional Approach 3-A would discount this value by the CDP's reduced flow volume.

Proportional (3-B)	*((flow-proportioned average for normal events)* x *(52 – 2* x $P_{outliers}$*)* + *((average for outliers)* x *(2* x $P_{outliers}$*)))/52*

B. <u>It Would Be Reasonable for Each of the Four Approaches to Discount the Outlier Events in Accordance with Their Likelihood of Recurrence</u>

A reasonable estimate of the CDP's stand-alone impingement would discount the non-flow-related events by their probability of occurrence ($P_{outliers}$). Theoretically, the outlier probability value could range from between 0% and 100%. Depending on the value that is assigned to $P_{outliers}$, the various approaches produce the following grams per day estimation ranges for impingement:



	0%	5%	10%	20%	30%	40%	50%	100%
Regression (1-B)	1,566.0	1,696.7	1,827.4	2,088.8	2,350.2	2,611.6	2,873.0	4,179.9
Equivalence (2)	4,669.3	4,794.0	4,918.7	5,168.2	5,417.6	5,667.1	5,916.5	7,163.8
Proportional (3-A)	2,110.8	2,192.0	2,273.2	2,435.6	2,598.1	2,760.5	2,922.9	3,735.0
Proportional (3-B)	2,110.8	2,240.5	2,370.1	2,629.4	2,888.7	3,148.0	3,407.3	4,703.8

In the graph and table above, the overall impingement estimate contained in the March 9 submittal is equivalent to the far-right column, in which it is assumed that the outliers have a probability of recurrence of 100%. In other words, the outlier events were treated as having the same probability of recurrence as typical, routine events, which in fact are highly likely to recur annually. This approach fails to reflect that the sampling data set consists of two subpopulations of events – the rare events corresponding to January 12 and February 23, and the other 50 events.

The graph and table above demonstrate how the impingement estimates are a strong function of how the outlier events are treated. The estimated range of impingement is 3.7 to 7.2 kg/day when the outliers are treated like typical events, and 1.6 to 4.7 kg/day if the outliers are ignored altogether. Note how the outlier events contribute very little to long-term, projected impingement if their probability of recurrence is in the 5% to 10% range. This is because, under such scenarios, their influence in essence is spread over many years. This may be a sound approach for project planning purposes, as it enables unusual events to be taken into account when assessing project mitigation, but not allowing an overstatement of rare events to disproportionately influence mitigation obligations.

C. It Is Reasonable to Assume that the Outlier Probability Is Less than 5%

The analyses of Drs. Chang and Jenkins suggest that the various estimation approaches overstate the influence of the outlier events by assuming that similar rain events will occur every year (i.e., $P_{outliers}$ = 100%). The obvious problem with this assumption is that twenty-five and thirty-five year storms do not occur every year.

Given that: (a) the survey outliers were apparently influenced by the extreme storms, and (b) the likelihood of comparable storms occurring in any given year is less than 5% according to experts Dr. Chang and Dr. Jenkins, it is reasonable to assume that the outlier probability value is less than 5%. If we assume that the outlier impingement values were associated with the record rainfall and that said rainfall has a probability of occurrence of no more than 5% (i.e., occurs less than once every 20 years), the outlier average should be discounted by its probability. This results in the following stand-alone, upper bound impingement estimates:

Approaches	$P_{outliers}$ = 5%
Regression (1-B)	Less than 1.70 kg/day
Equivalence (2)	Less than 4.80 kg/day
Proportional (3-A)	Less than 2.20 kg/day
Proportional (3-B)	Less than 2.24 kg/day

VI. CONCLUSION

Attachment 5 concluded that the weighted-average flow-proportioned approach (i.e., Proportional (3-B)) provides a reasonable basis for estimating the CDP's stand-alone impingement because it (a) treats the flow-independent outliers separately, (b) accounts for the relationship between flow and impingement, and (c) discounts for the fact that the intake flow velocities during stand-alone operations will be lower than the velocities that occurred during the sampling period. For these reasons, the data and analyses of Drs. Chang and Jenkins support Proportional Approach 3-B as an appropriate estimation model.

The hydrologic research of Drs. Chang and Jenkins add depth to the prior analysis by placing the outlier events in context. They establish that the extreme storms that preceded the January 12 and February 23 samples were very rare.

These conclusions inform the estimation models. Because the rains preceding the two outlier collection events can be expected to occur less than once every 20 years (i.e., less than 5%), the weight of the outliers should be discounted accordingly. When the weighted-average flow-proportioned approach (3-B) incorporates an outlier probability value of less than 5%, the approach calculates an impingement estimate of less than 2.24 kg/day, with 2.24 providing a reasonable upper bound. This value provides a reasonable approximation of the CDP's potential impingement.

CARLSBAD SEAWATER DESALINATION PROJECT

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

REGION 9, SAN DIEGO REGION

ORDER NO. R-9-2006-0065

NPDES NO. CA0109223

FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

ATTACHMENT 9-A - FREQUENCIES FOR STORM EVENTS OF JANUARY AND FEBRUARY 2005, submitted by Dr. Howard H. Chang, Ph.D., P.E.

(March 19, 2009)

March 27, 2009

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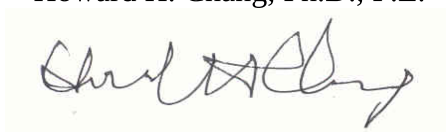
FREQUENCIES FOR STORM EVENTS OF JANUARY AND FEBRUARY 2005

Prepared for Poseidon

Prepared by
Howard H. Chang, Ph.D., P.E.



March 19, 2009

EXECUTIVE SUMMARY

A hydrology study has been made to determine the discharges of Agua Hedionda Creek on January 12 and February 23, 2005. The discharges were determined by hydrologic simulation of stream flows using rainfall data and the Agua Hedionda Creek watershed model. The January 12th stream flow has been determined to have a return period of 25.8 years; and the February 23rd flow has a return period of 35.7 years. Such stream flows with long recurrence intervals are very rare events. Two such rare events occurred in early 2005. The probability of surpassing two such large events in any particular year is only 0.12%, or 1.2 times in 1,000 years. It was an extremely rare combination of stream flows.

Total rainfall for 2004-5 was about 26 inches for the area, far exceeding the long-term average of about 13 inches. The stream flows on January 12 and February 23 are far outliers. After discarding the two outliers, the weekly impingement sampling events captured a sufficient number of storm runoff events to reflect typical wet weather conditions for the watershed. Since the remaining rainfall amount still far exceeds the annual average, there was a sufficient number of storms to be representative of a typical, twelve-month period.

QUALIFICATIONS

I am a registered civil engineer with a specialty in hydrology. I have practiced hydrology in this region for over 40 years. I prepared the hydrology study covering northeastern Carlsbad in 1989 (Chang, 1989). This study has since been used by the City as the standard for stream flows of Agua Hedionda Creek and Calavera Creek. My curriculum vitae is attached.

INTRODUCTION

Certain questions have been raised by the staff of the Regional Water Quality Control Board regarding the data used to support Poseidon's Impingement and Entrainment Assessment for the Agua Hedionda Lagoon. The staff questioned whether the sampling set is skewed because the data were collected during a year that was atypical with regard to rainfall.

The purpose of this study is to determine the frequencies of two unusually large storm events that occurred prior to January 12 and February 23 of 2005. Relatively higher impingement on these two dates may have been related to the fresh water flow in Agua Hedionda Lagoon, which recevives freshwater inflows primarily from Agua Hedionda Creek and Calavera Creek.

METHOD OF STUDY

In a natural stream without stream gages, hydrological simulation is the standard, and generally accepted, method for determining the stream flow. Hydrologic simulation uses the rainfall data and the drainage basin characteristics to generate the stream flow at selected points of concentration. More details of using this method as applied to the Agua Hedionda Creek basin are described below:

Rainfall Records of 2005 - I contacted the County of San Diego for the 2005 rainfall data. For the Agua Hedionda watershed, rainfall data for the periods of January and February 2005 were obtained from the following gaging stations:

- Oceanside Pumping Plant, Thomas Guide p.1086, D5, corner of Jones Rd and San Luis Rey Rd.
- Agua Hedionda, Thomas Guide p.1107, B7, SW corner of El Camino Real and Cannon Rd. Station installed Feb 4, 2005
- Carlsbad AP, Thomas Guide p.1127, D2, central N side of McClellan Palomar AP
- Deer Springs, Thomas Guide p.1089, C7, Mesa Rock Rd at the Deer Springs Fire Station

These are the County stations that are inside and immediately surrounding the Agua Hedionda watershed. The records in the attached spreadsheet represent individual bucket tips (0.04" resolution) that were received by a radio at the County office. The rainfall data have been analyzed to determine the 24-hr total rainfall for the time period immediately before January 12 and February 23. The results for these two dates are tabulated in Tables 1 and 2. The rainfall collected at the reference stations for the period beginning July 1, 2004 and ending June 30, 2005 is tabulated in Table 3. As noted in Table 3, total rainfall for 2004-5 was about 26 inches for the area, far exceeding the long-term average for the Agua Hedionda watershed of about 13 inches.

Table 1. 24-hr Rainfall Immediately Before January 12, 2005

Gaging station	Rainfall depths, inches
Agua Hedionda	---
Carlsbad AP	1.12
Deer Springs	2.20
Oceanside Pumping Station	1.40
Average of three readings	1.57

Table 2. 24-hr Rainfall Immediately Before February 23, 2005

Gaging station	Rainfall depths, inches
Agua Hedionda	2.12
Carlsbad AP	2.08
Deer Springs	2.04
Oceanside Pumping Station	2.00
Average of four readings	2.06

Table 3. Total Rainfall 2004-2005[1]

Gaging station	Rainfall depths, inches
Agua Hedionda	---
Carlsbad AP	24.95
Deer Springs	27.81
Oceanside Pumping Station	26.39
Average of three readings	26.39

Antecedent Moisture Conditions (AMC) – The stream flows of January 12 and February 23 were both preceded by at least five days of heavy rainfall. It is easy to see from the rainfall tabulations that unusual amounts of rainfall occurred preceding these two dates. For this reason, we had very wet antecedent moisture conditions, for which the AMC number is 3.

Hydrological Simulation - This hydrology study is guided by, and consistent with, the Hydrology Manual of the County of San Diego. As specified in the manual, the SCS method for hydrology is applied to drainage basin that is larger than 0.5 square miles in surface area. For this study, the HEC-1 computer model developed by the U. S. Army Corps of Engineers that applies the SCS method was used.

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1 The rainfall collected at the Agua Hedionda and Oceanside stations is for the period beginning July 1, 2004 and ending June 30, 2005; data for the Deer Springs Station is for the period beginning November 1, 2004 and ending June 30, 2005.

Hydrological simulation for the storm events that preceded the January 12 and February 23 sampling events have been made using the HEC-1 model.2 This model is used extensively by engineers for hydrologic simulation of watersheds, and is a generally accepted method for this purpose. This model was used in the 1989 Chang study for northeastern Carlsbad, and is considered to provide an appropriate means by which to simulate rainfall/runoff in the subject watershed.

The hydrologic simulation is based on the rainfall, delineation of the drainage basin and hydrologic parameters for the selected subbasins. For the purpose of hydrological computation, certain basin characteristics are required. Such characteristics include the basin and subbasin areas, precipitation zone number (PZN), antecedent moisture condition (AMC), precipitation amounts for the 24-hr. storms, SCS curve number (CN), lag time, etc. Since the drainage basin of the Agua Hedionda Creek is large, the 24-hour storm produces greater flows than the 6-hour storm. For this study, we used the same hydrologic parameters that were used in the 1989 hydrology study for Agua Hedionda Creek. The rainfall depths and AMC values were changed according to the 2005 storm conditions.

Summary of Results – The peak discharges for Agua Hedionda Creek just before the Calavera Creek confluence have been obtained to be 2,715 cfs for the storm events leading up to January 12, and 3,609 cfs for the storm events leading up to February 23. At this point of concentration, the drainage basin area for Agua Hedionda Creek is 17.3 square miles. Input/output listings for the HEC-1 runs are attached to this report.

In order to determine the occurrence frequency of these two storm events, their peak discharges were compared with the FEMA-adopted peak discharges for Agua Hedionda Creek taken from the FEMA publication “Flood Insurance Study”, 1999. Table 4 lists the FEMA-adopted discharges at two points of concentration along Agua Hedionda Creek. The FEMA-adopted discharges are for the developed, or ultimate, conditions of the watershed. The table also has the discharge for the current (existing) conditions of the watershed.

Table 4. FEMA-Adopted Peak Discharges along Agua Hedionda Creek

Point of Concentration	Basin Area	Peak Discharge in cfs		
		10-yr	50-yr	100-yr
At confluence with Buena Creek (ultimate)	6.3	1,600	4,800	7,000
Upstream of Calavera Creek (ultimate)	17.3	---	---	8,080
Upstream of Calavera Creek (existing)	17.3			6,366

From this study, the stream flow resulting from the storm events prior to January 12th has the peak discharge of 2,715 cfs. The peak discharge for the stream flow from the storm events prior to February 23 has the value of 3,609 cfs. The return periods of these events may be determined from the log-probability paper shown in Fig. 1. The peak discharge versus frequency relation for stream flows in this region follows the long-normal distribution. The return period is

2 *See* http://www.hec.usace.army.mil/software/legacysoftware/hec1/hec1.htm for documentation and software.

the reciprocal of the frequency. The storm return period is plotted against the peak discharge as a straight line on the log-probability paper. Fig. 1 shows one straight line for the concentration point at the confluence with Buena Creek and two straight lines for the concentration point just upstream of Calavera Creek.

The discharges of the stream flows from the storm events preceding January 12 and February 23 are plotted on line 3 in Fig. 1 as Point A and Point B, respectively. Point A has the frequency of 4.2. In other words, the January 12th flow occurs 4.2 times in 100 years. The return period, as the reciprocal of the frequency, is therefore 23.8 years. Point B for the February 23rd flow has the frequency 2.8, for which the return period is 35.7 years.

In summary, the probability to have a storm with the peak discharge greater than 2,715 cfs in a year is 4.2 %. The probability that a storm discharge of 3,607 cfs would be exceeded in any given year is 2.8%. Both events have low probabilities of occurrence; they are rare events. Two such rare events occurred in early 2005. The probability for two events to be exceeded in a year is the product of the two probabilities. In this case, the probability of having two such events in any given year = 0.042 x 0.028 = 0.0012, or 0.12 %

In conclusion, the storm events preceding January 12, 2005 have been determined to have the return period of 23.8 years, the storm events preceding February 23, 2005 have been determined to have the return period of 35.7 years. Such storms are very rare events. The probability of surpassing two such large events in year is only 0.12%, or 1.2 times in 1,000 years.

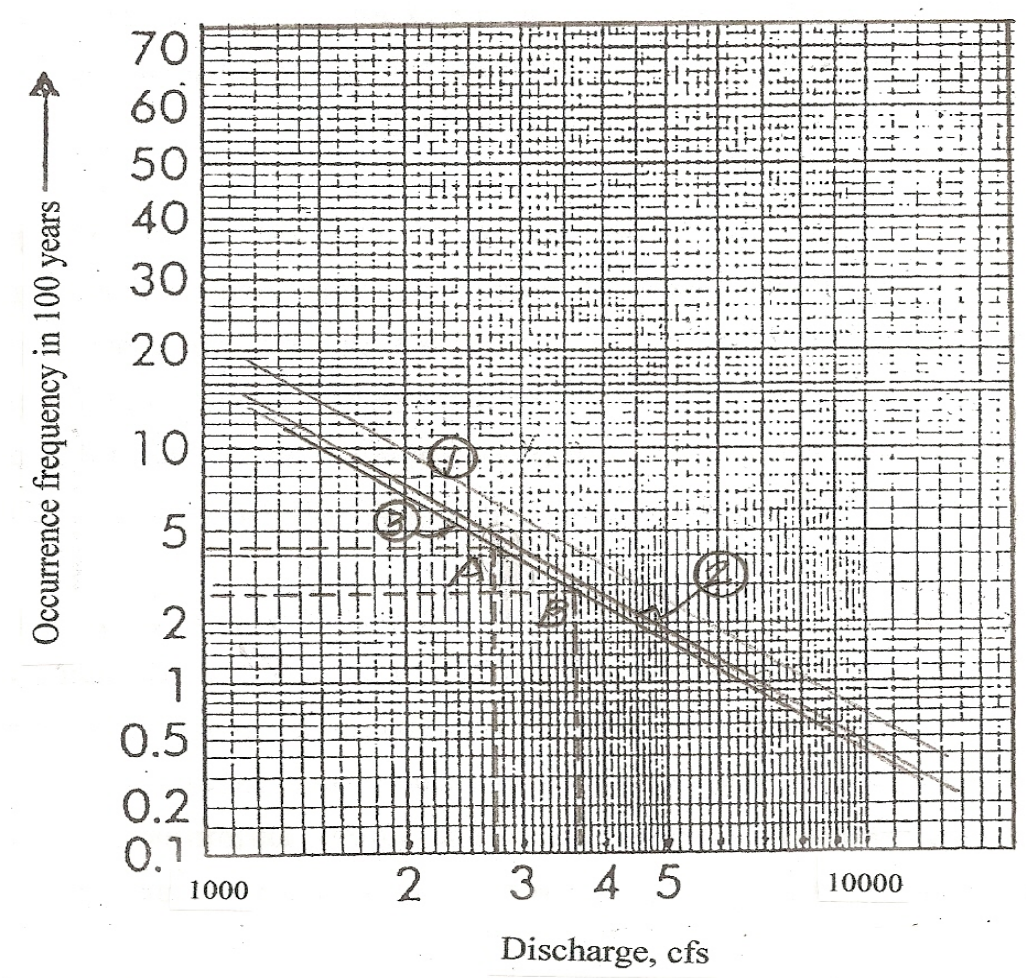

Fig. 1. Log-probability relations of frequency-discharge for Agua Hedionda Creek
Line 1: At confluence with Buena Creek (ultimate)
Line 2: Upstream of Calavera Creek (ultimate)
Line 3: Upstream of Calavera Creek (existing)
Point A: Storm of January 12, 2005
Point B: Storm of February 23, 2005

The distribution of mean annual rainfall in San Diego County is shown in Fig. 2. The mean annual rainfall for the Agua Hedionda Creek watershed varies from 11.5 inched at the coast to 15 inches at the eastern boundary. The total rainfall for 2004-5 was about 26 inches for the area, far exceeding the long-term average of about 13 inches. The storms of January 12 and February 23 are far outliers. After discarding the two outliers, the weekly impingement sampling events captured a sufficient number of storm runoff events to reflect typical wet weather conditions for the watershed. Since the remaining rainfall amount still far exceeds the annual average, there was sufficient number of storms to be representative of a normal twelve month period.

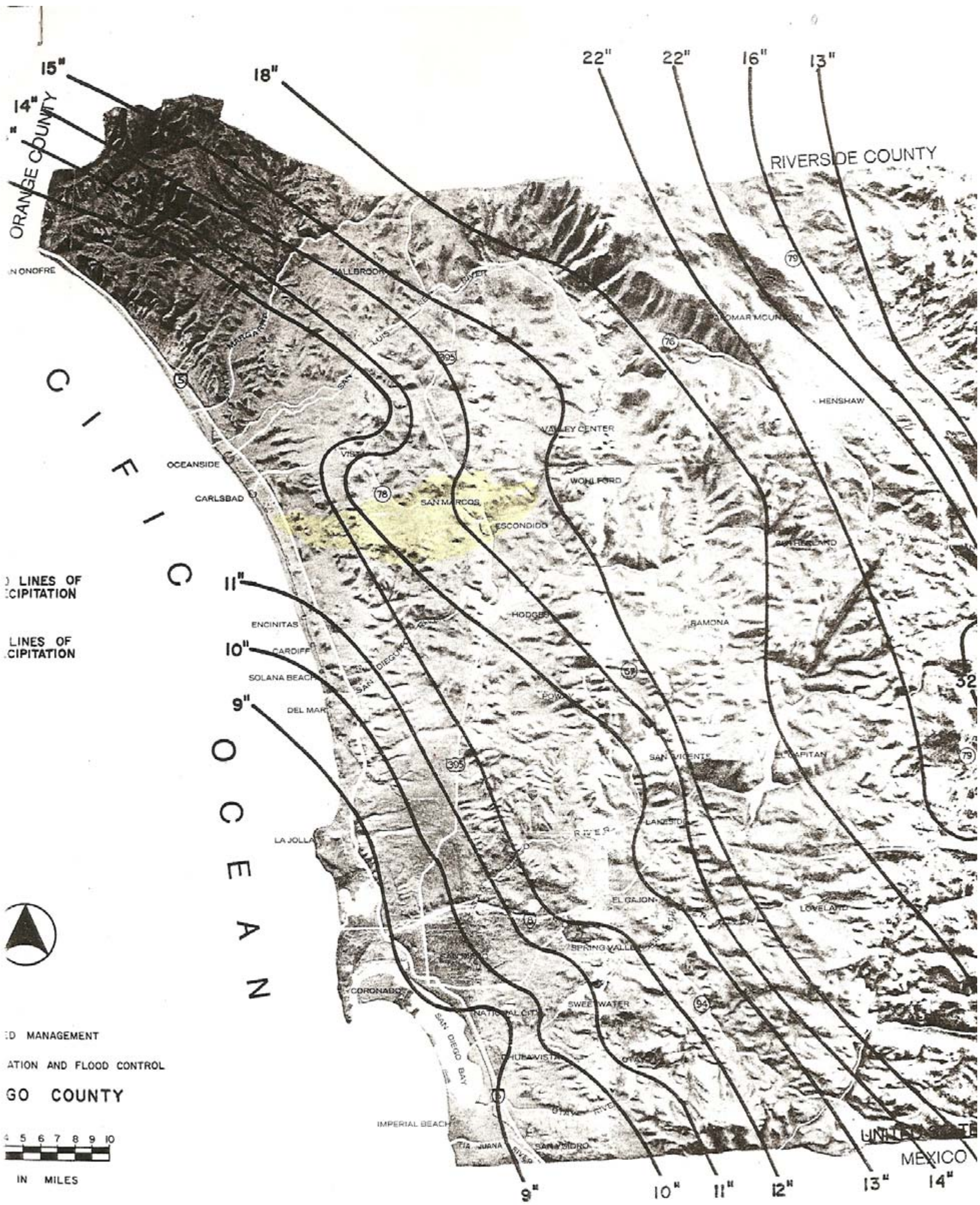

Fig. 2. Mean annual rainfall in San Diego County according to the County Hydrology Manual. The approximate location of the Agua Hedionda Creek watershed is marked in yellow.

REFERENCES

Chang, Howard H., "Hydrological Study for Northeastern Carlsbad – Basins of Calavera Lake Creek and Agua Hedionda Creek", July 1989.

FEMA, "Flood Insurance Study – San Diego County", Volume 1 of 7, 1999.

ATTACHMENTS

This report has the following attachments:

JAN12.OUT: Hydrologic simulation for the Agua Hedionda watershed model based on the January 12, 2005 storm
FEB23.OUT: Hydrologic simulation for the Agua Hedionda watershed model based on the February 23, 2005 storm

2005 RAINFALL DATA

CHANGCV.DOC: Curriculum vitae of Howard H. Chang

CARLSBAD SEAWATER DESALINATION PROJECT

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

REGION 9, SAN DIEGO REGION

ORDER NO. R-9-2006-0065

NPDES NO. CA0109223

FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

ATTACHMENT 9-B - STATEMENT ADDRESSING REGIONAL BOARD STAFF CONCERNS REGARDING THE BIOLOGICAL DATA USED TO SUPPORT POSEIDON'S IMPINGEMENT AND ENTRAINMENT ASSESSMENT, submitted by Dr. Scott A. Jenkins, Ph.D. (March 19, 2009)

March 27, 2009

Statement Addressing Regional Board Staff Concerns regarding the Biological Data Used to Support Poseidon's Impingement and Entrainment Assessment

Prepared by Scott A. Jenkins, Ph.D.

3/19/09

PURPOSE OF STATEMENT

Poseidon asked me to address certain questions raised by staff in staff's April 4, 2008 technical report. Specifically, staff state therein:

"This sampling set is likely to be skewed because it does not account for annual variability and the data were collected during a year that was atypical with regards to rainfall."

I examined these concerns prior to my testimony before the Board at the April 9, 2008 meeting. I submitted a written statement to the Board on 26 January 2009 that memorializes that testimony. Since that time, new information has come to my attention that allows me to perform a more in-depth analysis of these concerns. The statement below presents that new analysis and elaborates on relevant sections of my 26 January 2009 statement.

QUALIFICATIONS

I earned a B.S. in Chemistry at Yale University and a Ph.D. in Physical Oceanography at University of California, Scripps Institution of Oceanography. I am presently a Principal Engineer at the Scripps Institution of Oceanography where I have been employed since the age 16. I have 30 years experience in coastal process and have published research in the Journal of Geology that is specifically relevant to this statement (see, Inman, D. L. & S. A. Jenkins, 1999, "Climate change and the episodicity of sediment flux of small California rivers," *Jour. Geology*, v. 107, p. 251–270). That research discovered a relation between climate cycles and rainfall, stream flow and sediment flux of small California rivers. In addition, I have provided consulting services in wetlands tidal hydraulics and restoration, beach erosion, as well as more generally hydrodynamics, aerodynamics and pollution dispersion in nearshore waters, harbors and estuaries (services include field measurements and numerical modeling). I have authored 23 peer reviewed publications, 47 conference proceedings and technical publications and 60 technical reports. A true and correct copy of my Curriculum Vitae is attached. The opinions expressed here are based on my education and experience including 29 years of studying tidal exchange and sediment transport in the Agua Hedionda Lagoon.

ROLE ON THIS PROJECT

I performed hydrodynamic modeling for Poseidon Resources of the brine dispersion and dilution from the Carlsbad Desalination Plant and tidal transport analysis of the effect the

CDP might have on Agua Hedionda Lagoon water quality, sand influx into the Lagoon and historic variations of water levels in the Lagoon over multi-decadal climate cycles.

SUMMARY STATEMENT

Staff is correct that the year in which the Impingement & Entrainment data were collected was an above-average year for rainfall in the relevant vicinity. This turns out to be a benefit of the field program – not a problem. The field program captured not only typical lagoon conditions and variability, but also two events that were atypical and which have a very low probability of occurring in any given year. This enabled me to examine whether such events skewed the results of the overall program. Such was not the case. The lagoon rebounds quickly from depressed salinities associated with extreme events. Lagoon salinity does not appear to have been depressed on a persistent basis by these extreme events. While infrequent extreme events depress salinity more than typical rainfall-runoff conditions, the effect is transient.

I have examined the relevant characteristics of rainfall-runoff affecting Agua Hedionda Lagoon during the period of the field studies, June 2004-May 2005. The timing of this study was ideal (even fortuitous) because it spanned the full range of natural hydrologic variability, and yet average, long-term water quality properties in the lagoon remained normal during the June 2004-May 2005 study period. The lagoon recovers rapidly from extreme hydrologic impacts associated with rainfall and runoff because it holds a large volume of seawater to dilute the storm water, and, has excellent tidal flushing that limits the residence time of storm water. Over the year-long period of sampling, the rainfall and runoff were neither intense enough nor persistent enough to alter the predominately salt water environment of Agua Hedionda Lagoon on other than a transient and short-term basis. I have concluded that the rainfall-runoff did not skew the results as staff were concerned, but rather provided a comprehensive data base that captured a range of conditions, including some that are not likely to re-occur in most years.

DISCUSSION

The sampling set used for Poseidon's Impingement and Entrainment Assessment is not likely to be skewed because the data were collected during a year that was atypical with regards to rainfall. While two extreme events appear to present a different condition than typically occurs in the lagoon, the effects are isolated to those events, and do not affect the utility of the remaining data set for long-range planning, and characterization of typical conditions. As discussed more fully below, the 2004-2005 rainy season provided a robust picture of impacts arising from hydrologic variability without upsetting the predominately salt water environment of Agua Hedionda Lagoon that is representative of its long-term state. The Regional Board can be confident that the sample set was robust and comprehensive and included extreme hydrologic events.

1. The physical data indicate that the 2005 rainy season altered the predominantly salt water environment of Agua Hedionda Lagoon only on a transient basis. Ninety-

five percent of the time during this period, lagoon salinity exceeded 32 parts per thousand (ppt), whereas average ocean salinity is 33.5 ppt.

Agua Hedionda Lagoon is a salt water environment populated by salt water tolerant species. The watershed draining to Agua Hedionda Lagoon consists of 18,800 acres upstream from the lagoon, which drains to the lagoon principally via the Agua Hedionda Creek. (See Figure 1). The physical data show that this watershed is too small for runoff from it to persistently alter the predominantly salt water environment of Agua Hedionda Lagoon, even in a relatively wet year such as the period from June 2004 to June 2005 when the sampling for the impingement and entrainment study was done. (See Figure 2). As a point of reference, annual rainfall totals in the Agua Hedionda Creek watershed (as measured by the NOAA/NCDC rain gage #03177 at Carlsbad Airport) average 9.05 inches. In contrast, 19.19 inches of rain fell during the Impingement & Entrainment Study according to the same gage.[1]

Tetra Tech (2007) prepared a comprehensive report on the Agua Hedionda Watershed water quality for the City of Vista, and Table 3 and Figure 7 of that report provide flow rate measurements for Agua Hedionda Creek for 2005-2007. Unfortunately, Tetra Tech (2007) provides no flow rate data during the first half of the impingement and entrainment study in 2004, and there were some heavy rainfall events occurring in October 2004. (See Figure 2). The missing flow rate data can be estimated from rainfall data by establishing a quantitative relationship (hydrographic rating function) between rainfall and creek discharge using the body of data that does exist for 2005-2007. Figure 3a compares the Tetra Tech (2007) daily discharge rates for Agua Hedionda Creek (shown as black crosses) against the daily rainfall (red bars) measured by NOAA/NCDC rain gage #03177 at Carlsbad Airport (cf. NWS, 2009). Note each rainfall event produces a corresponding peak discharge event in the creek, except during a portion of the winter of 2006 when no flow data was collected. Figure 3b indicates that the relation between rainfall and creek discharge rate can be expressed as a second order polynomial (hydrographic rating curve) having a coefficient of determination, R-squared = 0.80, (indicating a reasonably good fit). The polynomial can then be applied to the rainfall during the first half of the impingement/entrainment to fill in the missing creek discharge data, as shown in Figure 4. Here, the creek discharge calculated from the hydrographic rating curve (red) tends to over estimate measured creek discharge rates (black), and consequently errs on the side of caution with respect to not underestimating storm water impacts on the lagoon water quality.

Now, consider how the storm water discharge from Figure 4 is diluted in the volume of sea water in the lagoon. On average, the lagoon exchanges 1,700 acre ft. of seawater with the ocean each day through tidal flushing, and stores an average of 3,450 acre ft. of seawater. (Elwany, 2005; Jenkins and Wasyl, 2006.) Because of tidal flushing, storm water would remain in the lagoon for only 2.6 days, based on the residence time of the lagoon water mass as determined by Elwany, (2005) and Jenkins and Wasyl, (2006) using two independent methods. Applying these dilution volumes and residence times to

[1] The NOAA/NCDC rain gage #03177 at the Carlsbad Airport is the closest gage to the project site that is located inside Agua Hedionda Creek watershed.

the creek discharges in Figure 4 (using the tidal hydraulics model detailed in Jenkins and Wasyl, 2006), produces the time series of lagoon salinity throughout the impingement and entrainment study shown by the green/red/cyan trace in Figure 5. Although the dilution analysis in Figure 5 is based on the assumption of a well mixed lagoon, the predicted lagoon salinity in green/red/cyan compares closely with unpublished near-surface salinity measurements (Tenera Environmental, 2009) shown as blue triangles. The lowest predicted salinity (red) in Figure 5 is 20.4 ppt and the lowest measured salinity (blue) is 20.1 ppt. However the green portions of the curve predict a number of other events of salinity depression in the lagoon when salinity measurements were not taken. Regardless, a histogram analysis in Figure 6 of the salinity variation in Figure 5 indicates that 95 % of the time, lagoon salinity exceeded 32 ppt throughout the year-long impingement and entrainment study, while average ocean salinity is 33.52 ppt (Jenkins and Wasyl, 2001, 2006). From this, I conclude that rainfall events during 2004-2005 were neither intense enough nor persistent enough to significantly alter the predominantly salt water environment of Agua Hedionda Lagoon.

2. The June 2004-May 2005 impingement study data include two extremely high weekly samples that contained some fresh water species. These samples are statistically anomalous because they were immediately preceded by extreme storms producing 5-day rain totals among the highest found anywhere in the period of record of the Agua Hedionda Creek watershed, with a probability of occurrence of 0.025% to 0.17%. This range compares to a probability of occurrence of 0.12% for these storms that was calculated by Dr. Howard Chang using HEC-1 hydrographic modeling of the Agua Hedionda Cr. watershed.

The two anomalous weekly impingement samples were taken on 12 January 2005 and 23 February 2005. One sample contained 109.5 kg and the other contained 29.5 kg. In comparison, the average impingement excluding these outliers was only 4.7 kg. Among the fish collected on these dates were catfish and possibly other fresh water species. Both samples were preceded by extreme event storms, each producing five continuous days of rainfall shown as cyan bars in Figure 2. The five-day rain totals preceding the 12 January 2005 samples were the highest 5-day rain totals found anywhere in the period of record of the Agua Hedionda Creek watershed, totaling 4.01 inches with a probability of occurrence of 0.025%. The 23 February 2005 samples were preceded by 5-day rainfall totals that are the eighth highest in the period of record, 3.24 inches with a probability of occurrence of 0.17%. So rare were these two events that a four-decade log-scale was required to render them visible in the histogram of the period of record of the NOAA/NCDC rain gage #03177 at Carlsbad Airport in Figure 7.

The salinity depression in the lagoon caused by these two 5-day storms is shown in cyan in Figure 6. Although these two storms produced the lowest salinity observed during the impingement and entrainment study, these salinity depressions were short-lived. This affirms the value of using the impingement and entrainment study database to identify and quantify both the magnitude and duration of the reaction of the lagoon habitat to the full range of natural hydrologic variability, while still providing a long-term baseline in response to the average hydrologic state.

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Elwany, M. H. S., R. E. Flick, M. White, and K. Goodell, 2005, "Agua Hedionda Lagoon Hydrodynamic Studies," prepared for Tenera Environmental, 39 pp. + appens.

Jenkins, S. A**.** and J. Wasyl, 2006, "Coastal Processes Effects of Reduced Intake Flows at Agua Hedionda Lagoon," submitted to Poseidon Resources, 34pp.

Jenkins, S. A. and J. Wasyl, 2006, "Coastal Processes Effects of Reduced Intake Flows at Agua Hedionda Lagoon," submitted to Poseidon Resources, 34pp.

Jenkins, S. A**.** and J. Wasyl, 2001, "Hydrodynamic modeling of dispersion and dilution of concentrated seawater produced by the Ocean Desalination Project at the Encina Power Plant, Carlsbad, CA," submitted to Poseidon Resources, 186 pp.

NWS, 2009, "National Weather Service Daily Climate Reports," http://www.wrh.noaa.gov/sgx/obs/rtp/carlsbad.html

Tenera Environmental, 2009, "EPS Field Data.xls" un-published salinity data during the Impingement and Entrainment Assessment

Tetra Tech, 2007, "Agua Hedionda Watershed Water Quality Analysis and Recommendations Report", submitted to City of Vista, CA, 91 pp.

Daily Discharge (cfs) Summary Statistics at Agua Hedionda Creek and El Camino Real, from Tetra Tech (2007).

Year	Number measurements	Mean cfs	Median cfs	Minimum cfs	Maximum cfs	10th percentile	90th percentile
2005	306	7.08	3.54	0.91	143.91	1.65	13.8
2006	256	8.03	3.56	1.04	204.6	1.97	9.83
2007	120	11.2	3.62	0.07	314.21	0.1	23.67
Total	682	8.17	3.56	0.07	314.21	1.43	13.28

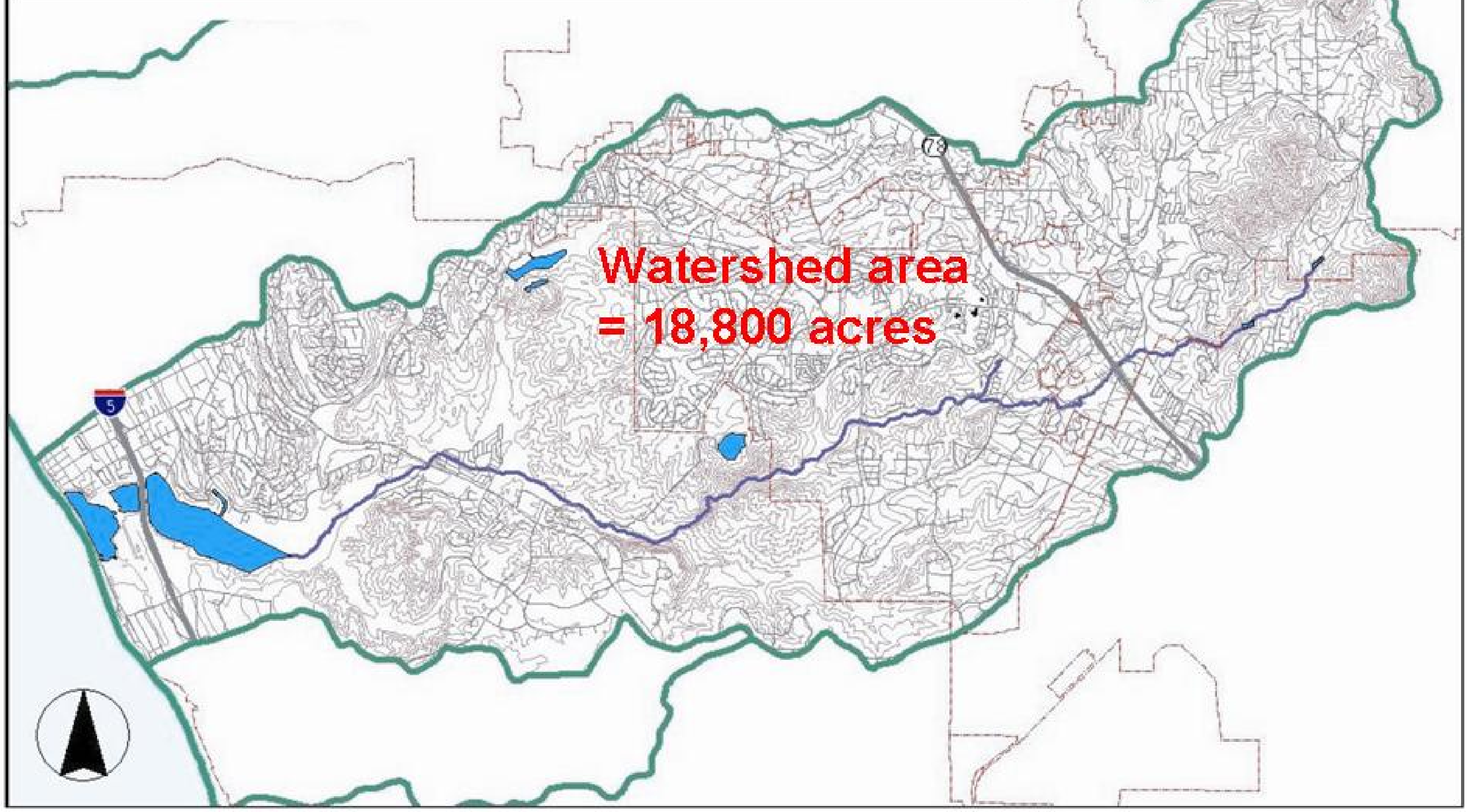

Figure 1. Flow Statistics of Agua Hedionda Creek Watershed, 2005-2007.

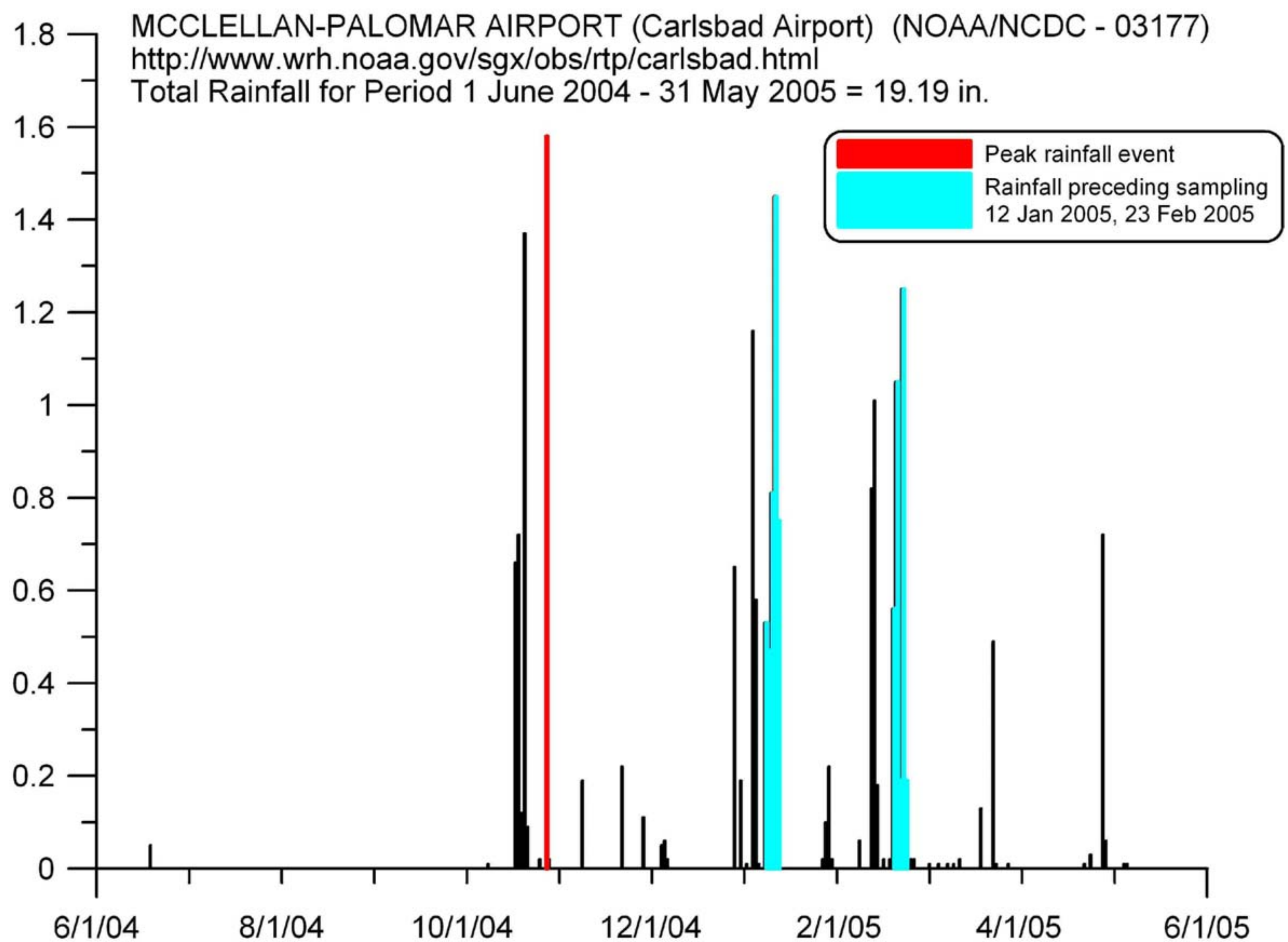

Figure 2. Rainfall history during entrainment / impingement study: 1 June 2004 - 31 May 2005. NOAA/NCDC rain gauge #03177, Carlsbad Airport, CA.

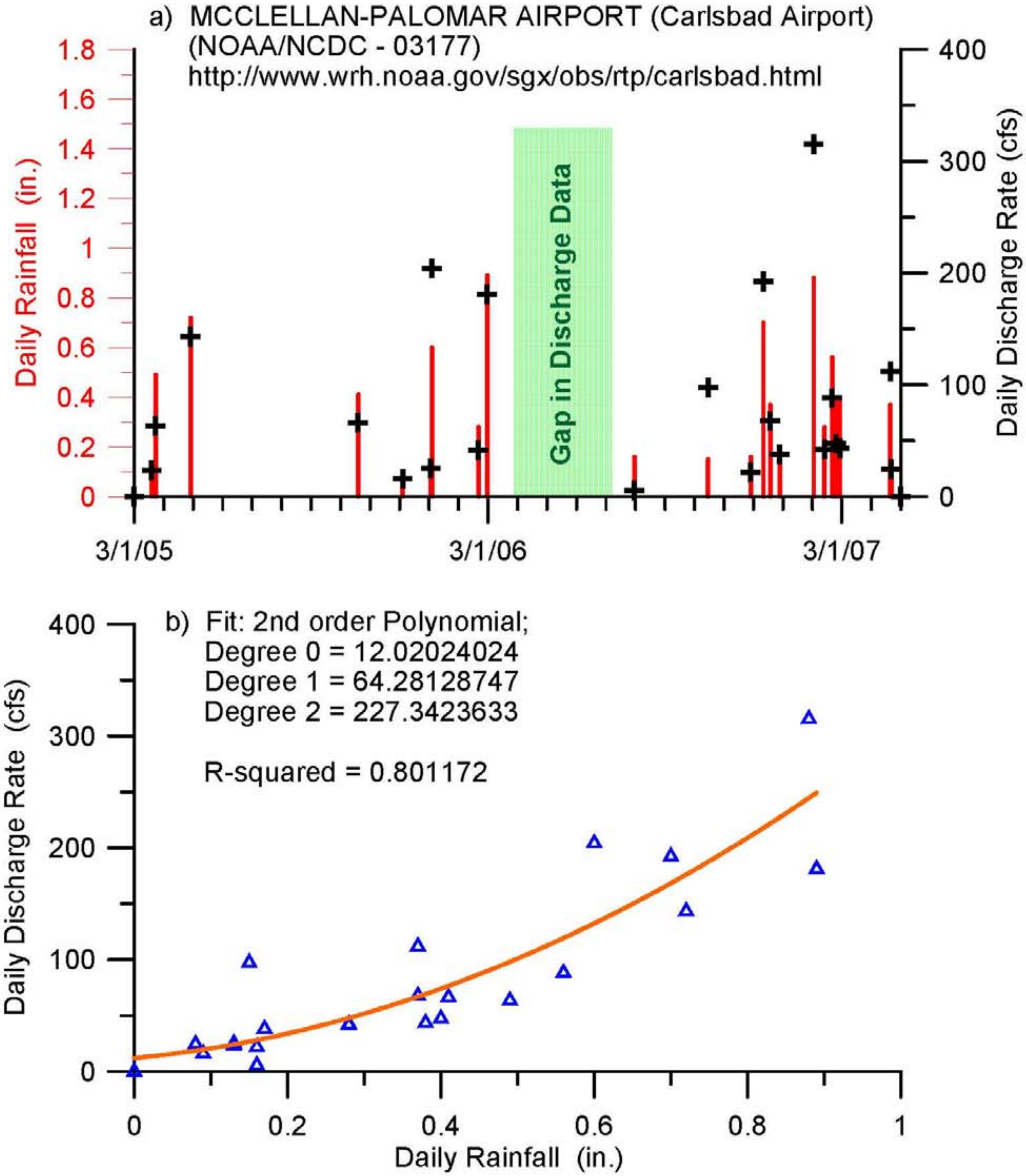

Figure 3. Relation between rainfall and discharge rate of Agua Hedionda Creek: a) Rainfall (red bars) & daily discharge Agua Hedionda Cr. (black crosses from Tetra Tech, 2007). b) Hydrographic rating curve (red) from 2nd order polynomial fit to flow rate vs rainfall data (blue diamonds).

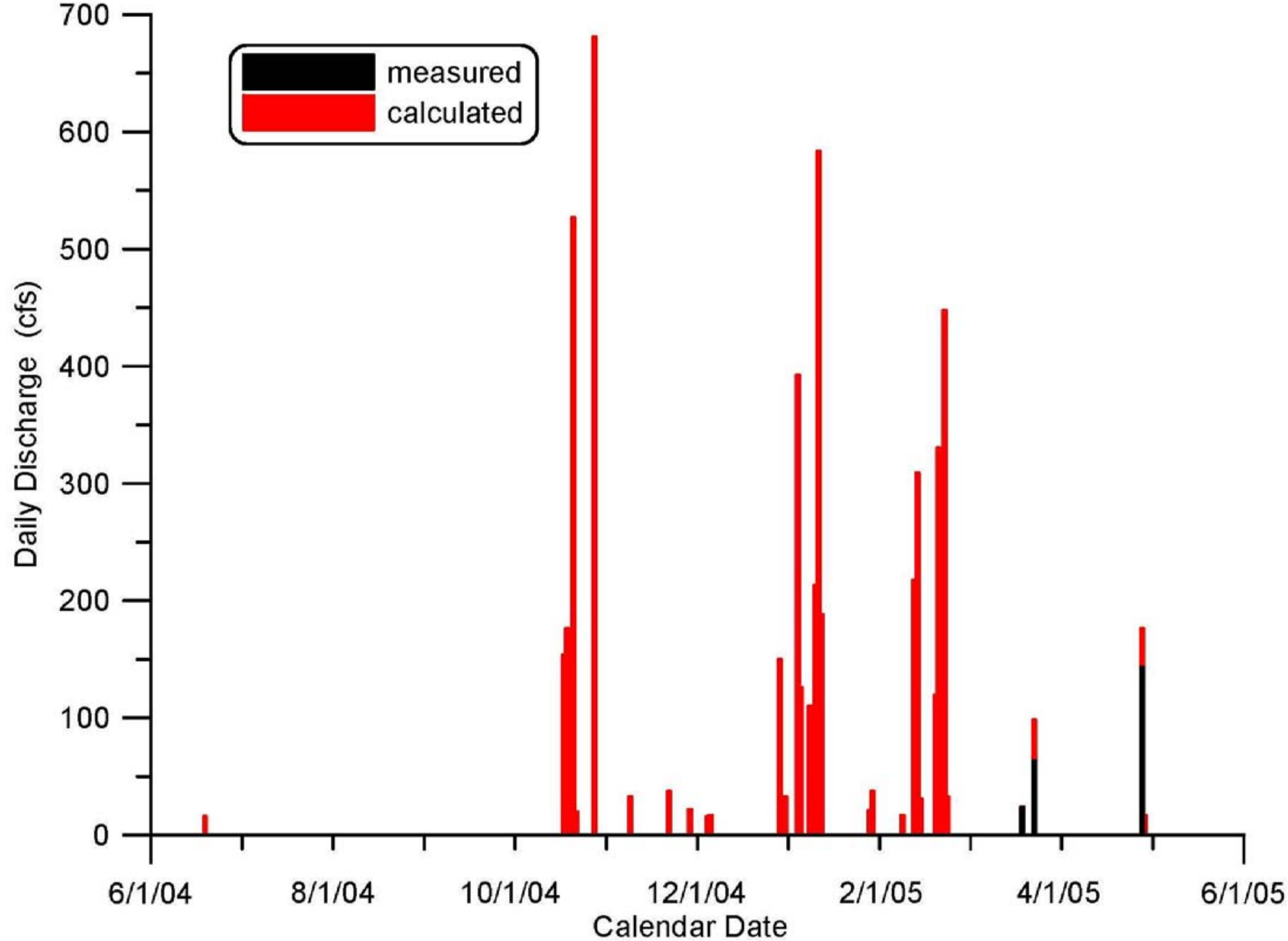

Figure 4. Daily discharge flow rates from Agua Hedionda Creek during the entrainment/impingement study: 1 June 04 - 1 June 05; measured data (black), from Tetra Tech, (2007), values calculated from hydrographic rating curve (red) .

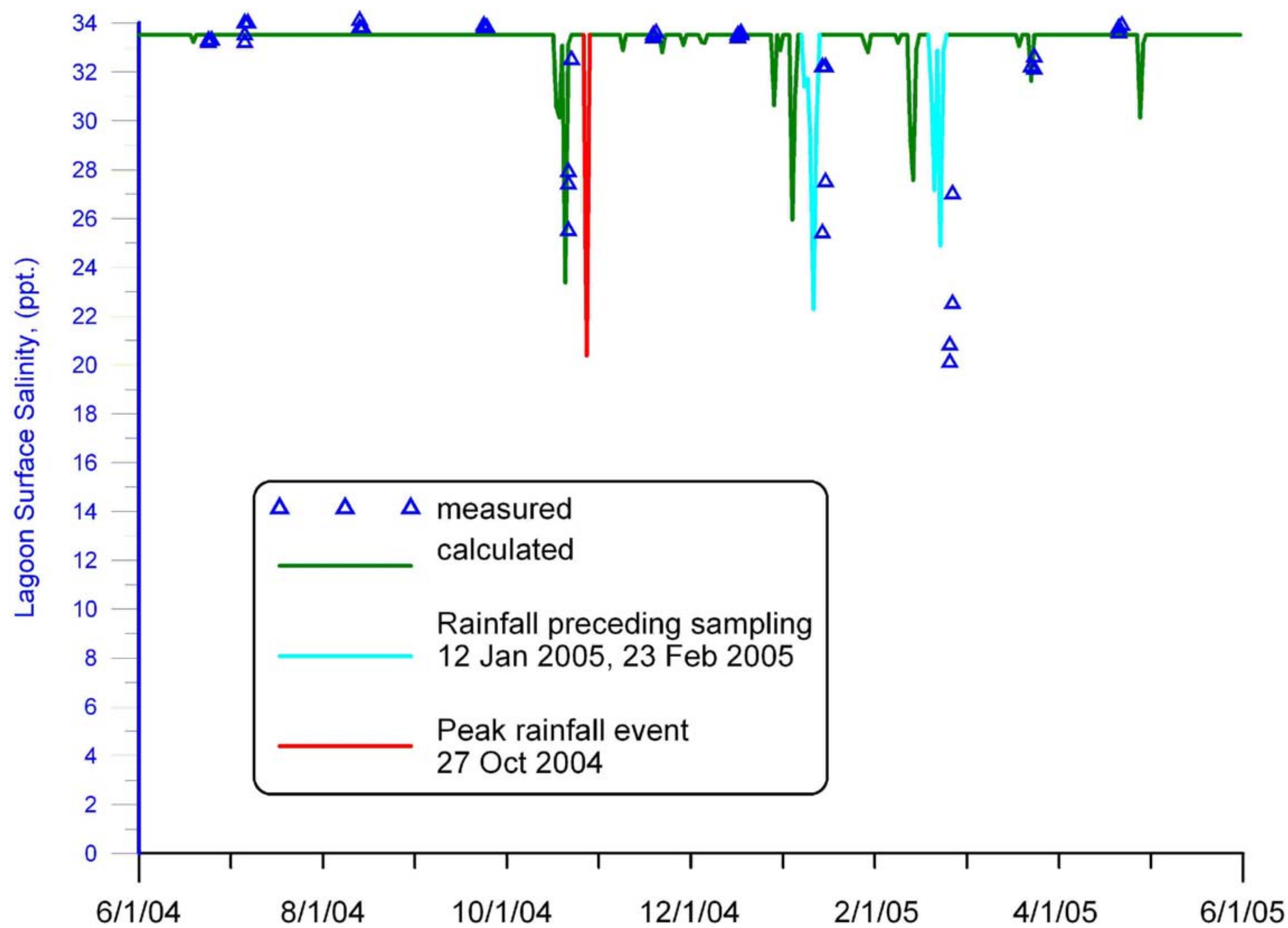

Figure 5. Salinity in Agua Hedionda Lagoon during entrainment/impingement study: 1 June 04 - 1 June 05. Measured values (blue diamonds), from unpublished data due to Tenera Environmental vs. calculated salinity (green, red, cyan) from hydrographic rating curve applied to measurements of tidal prism and storage volume after Elwany et al., [2005], and Jenkins and Wasyl [2006].

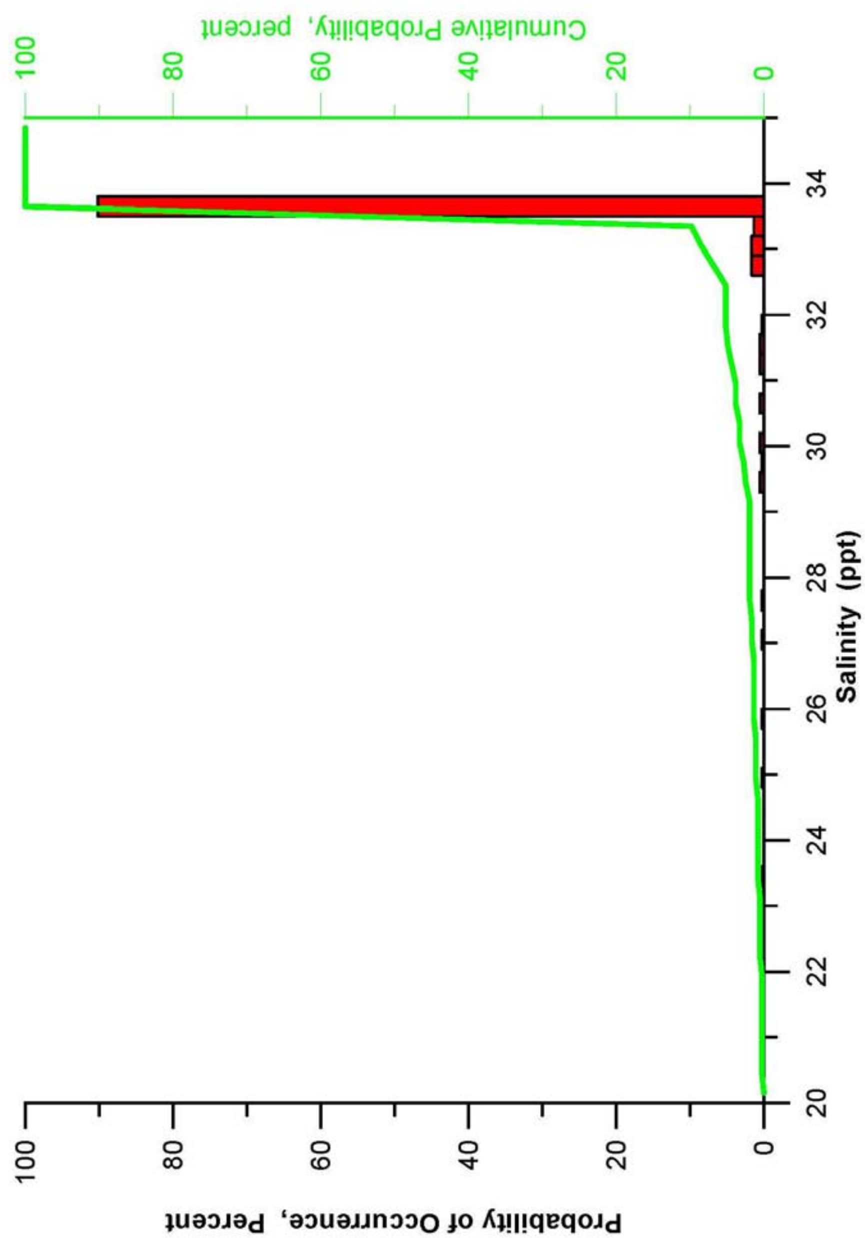

Figure 6. Histogram of salinity in Agua Hedionda Lagoon during the entrainment impingement study, 1 June 2004 - 31 May 2005. Probabilities of occurrence based on the red curve in Figure 5.

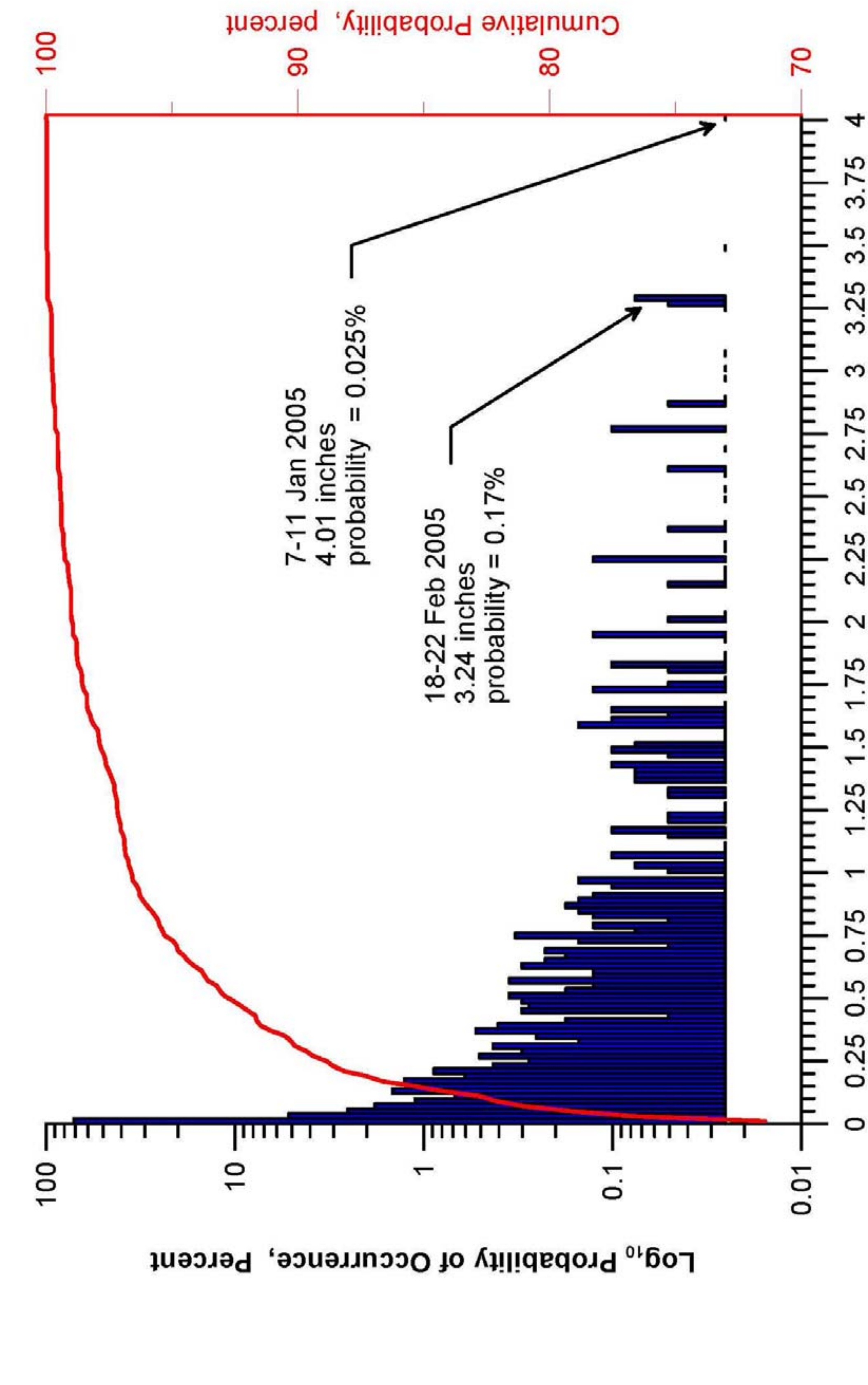

Figure 7. Histogram of 5-day rainfall totals measured in Agua Hedionda Cr. watershed during the period of record, 23 May 1998 - 8 Mar 2009. http://www.wrh.noaa.gov/sgx/obs/rtp/carlsbad.html

CARLSBAD SEAWATER DESALINATION PROJECT

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

REGION 9, SAN DIEGO REGION

ORDER NO. R-9-2006-0065

NPDES NO. CA0109223

FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

ATTACHMENT 10 – EXPLANATION OF MODIFICATION TO ENTRAINMENT MINIMIZATION TECHNOLOGY MEASURES

March 27, 2009

EXPLANATION OF MODIFICATION TO ENTRAINMENT MINIMIZATION TECHNOLOGY MEASURES

The San Diego Regional Water Quality Control Board ("Regional Board") will consider the Flow, Entrainment and Impingement Minimization Plan ("Plan") for the Carlsbad desalination Project ("CDP" or "Project") at its April 8, 2009 meeting. The Plan was required as a Special Provision of the Project's NPDES permit in order to assure compliance with the Porter-Cologne Water Quality Control Act, Water Code Section 13142.5(b), which requires industrial facilities using seawater for processing to use the best available site, design, technology, and mitigation feasible to minimize impacts and mortality to marine life.

This memorandum explains the reasoning for the modification to the entrainment minimization technology measures as reflected in Chapter 4, Technology, of the Plan. Based on updated research and input from the California Coastal Commission and the Commission's Scientific Advisory Panel ("SAP") [1], Poseidon has discovered that the installation of micro screens ahead of seawater pretreatment facilities and the use of a low pressure membrane pretreatment system would not be effective in returning viable organisms to the ocean, and would not result in any minimization or reduction of entrainment. Accordingly, the Plan was modified to remove these technology measures from the Plan.

I. POSEIDON ELIMINATED TECHNOLOGY MEASURES FOLLOWING FINDING BY THE COASTAL COMMISSION THAT SUCH MEASURES WOULD BE INEFFECTIVE IN REDUCING ENTRAINMENT AND IMPINGEMENT IMPACTS

In the April 2008 version of the Plan previously submitted to the Regional Board, Poseidon proposed the installation of micro screens and the use of a low pressure membrane pretreatment system to increase the potential to capture marine organisms and to successfully return them to the ocean.[2] Based upon the use of these proposed technology measures, Poseidon initially considered the mortality rate of the entrained marine organisms to be less than 100%.

Subsequent to that proposal, however, Poseidon, with the assistance of the Coastal Commission and the SAP, discovered that these technology measures would not be effective in returning viable organisms to the ocean, and would not result in any minimization or reduction of entrainment. The SAP observed that the protocols used in the Project's entrainment studies

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[1] **SAP** is a team of independent scientists that provides guidance and oversight to the Commission on ecological issues associated with the San Dieguito Restoration Project. That Project is being implemented by Southern California Edison pursuant to requirements of coastal development permits issued by the Commission and is meant to mitigate for marine resources losses caused by the San Onofre Nuclear Generating Station (SONGS). The Marine Review Committee **SAP currently** consists of ***Dr. Richard Ambrose***, Professor and Director of Environmental Science & Engineering Program, Department of Environmental Health Sciences, University of California Los Angeles; ***Dr. John Dixon***, Senior Ecologist, California Coastal Commission; ***Dr. Mark Page***, Marine Science Institute, University of California at Santa Barbara; ***Dr. Pete Raimondi***, Professor and Chair of Ecology and Evolutionary Biology, University of California at Santa Cruz; ***Dr. Dan Reed***, Marine Science Institute, University of California at Santa Barbara; ***Dr. Steve Schroeter***, Marine Science Institute, University of California at Santa Barbara; and, ***Dr. Russ Schmitt***, Director of Coastal Research Center, University of California at Santa Barbara.

[2] Set forth in Exhibit A is the description of these technology measures which was removed from the Plan.

included an assumption of 100% mortality based on guidance from the U.S. EPA and reflecting the practice of California's State and Regional Water Boards, the California Energy Commission, and the Coastal Commission in conducting and evaluating these studies.[3] The Commission applied this assumption to the Project after consideration of the micro screen and pretreatment system technology measures proposed in the April 2008 version of the Plan. The basis for the Commission's decision not to grant any mitigation credit for these technology measures was the lack of peer-reviewed scientific studies that support using a lower mortality rate for different types of desalination systems that cause entrainment.[4]

In the case of Poseidon's proposed screening and pretreatment technology measures, the Commission found that the entrained organisms will be subject to a number of stressors – including high pressures, significant changes in salinity, possible high temperature differences if the power plant is operating, etc. – and they will then be discharged to a different environment than is found in Agua Hedionda.[5] From this, the Commission concluded that any one or a combination of these stressors could result in mortality of the marine organisms prior to the return to the ocean.[6]

In addition, the long-term survival of marine organisms once they have been returned to the ocean is also uncertain. Researchers have observed that predators will often wait at the area where the marine organisms are returned, having associated it with the regular release of "dazed fish that make for an easy meal."[7] Thus, it is uncertain whether the returned marine organisms survive past the initial release into the ocean or thereafter contribute reproductively to the population.[8]

Therefore, Poseidon determined that these technology measures would not be effective in the minimization or reduction of entrainment, and the decision was made to remove these technology measures from the Plan.

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[3] California Coastal Commission. *Recommended Revised Condition Compliance Findings, Marine Life Mitigation Plan for Coastal Development Permit E-06-013, Poseidon Resources Carlsbad Desalination Project*, November 21, 2008, at 13. Available at http://documents.coastal.ca.gov/reports/2008/12/W16a-12-2008.pdf;
[4] *Id.*
[5] *Id.*
[6] *Id.*
[7] Ferry-Graham, Dorin, and Lin, *Understanding Entrainment at Coastal Power Plants: Informing a Program to Study Impacts and Their Reduction*, CEC-500-2007-120 at 36 (March 2008).
[8] *Id.*

EXHIBIT A
ELIMINATED DESCRIPTION OF REMOVED TECHNOLOGY MEASURES

4.4.2 Installation of Micro-screens Ahead of Seawater Pretreatment Facilities

A very fine screen (120 micron/0.12 mm) or also known as micro-screen filtration technology is planned to be installed to filter out most of the marine organisms entrained by the desalination plant intake pumps. The micro-screens are equipped with polypropylene discs, which are diagonally grooved on both sides to a specific micron size. A series of these discs are stacked and compressed on a specially designed spine. The groove on the top of the disks runs opposite to the groove below, creating a filtration element with series of valleys and traps for marine particulates. The stack is enclosed in corrosion and pressure resistant housing. Filtration occurs while water is percolating from the peripheral end to the core of the element (Figure 4-8).

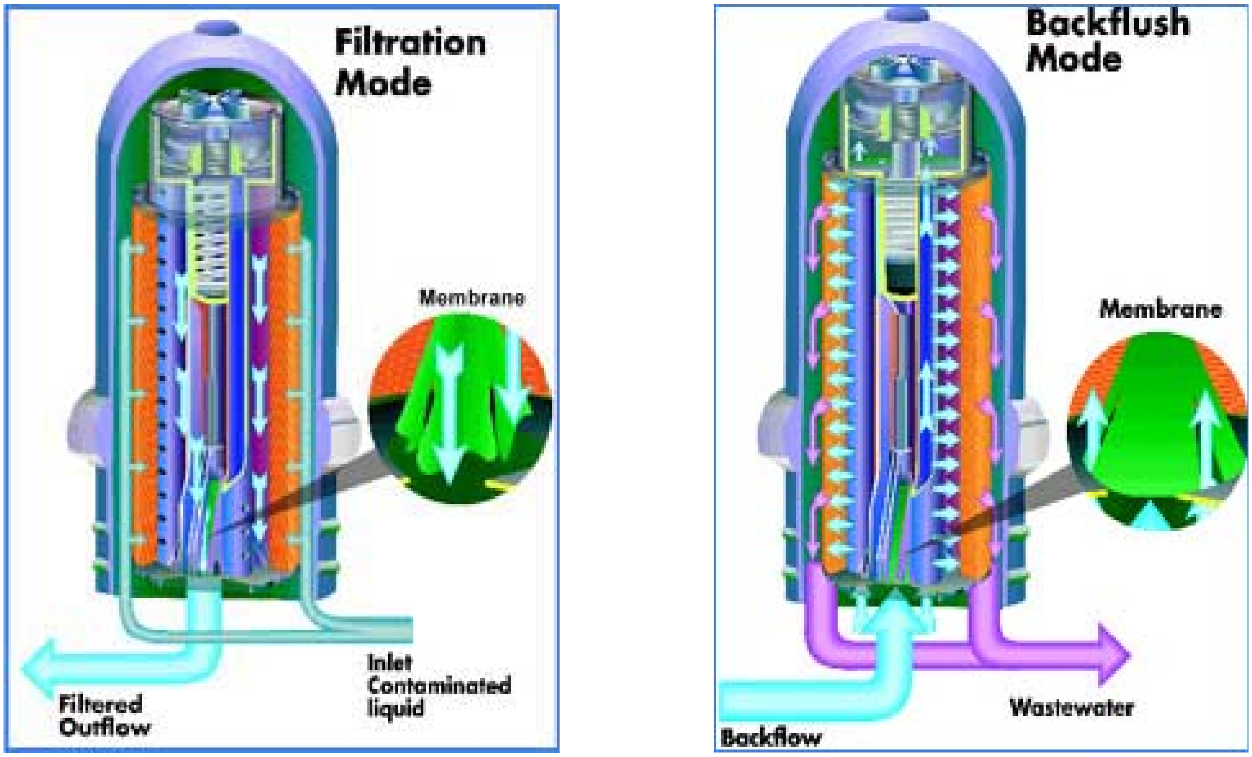

Figure 4-8. Microscreens in filtration and backwash flow modes

Since the intake seawater is already pre-screened by the 3/8 to 5/8- inch power plant intake screens, the seawater directed to the disk filters will contain debris and marine organisms smaller than 3/8-inch (9500 microns) (5/8-inch = 15.8 mm = 15,800 microns). During the filtration mode, seawater debris and marine organisms larger than 15,800 microns but smaller than 120 microns will be retained and accumulated in the cavity between the filter disks and the outer shell of the filters, thereby increasing the head loss through the filters. Once the filter head loss reaches a preset level (typically 5 psi or less) the filters enter backwash mode. All debris and marine organisms retained on the outer side of the filters are then flushed by tangential water jets of filtered seawater flow under 2 to 3 psi of pressure and the flush water is directed to a pipe, which returns the debris and marine organisms retained on the filters back to the ocean.

Because of the small size and relatively low differential pressure, these filters are likely to minimize entrainment and impingement mortality of the marine organisms in the source seawater. Since the disk filtration system is equipped with a wash water/organism return pipe, the impinged marine organisms are returned back to the ocean, thereby increasing their chance of survival. Based on US EPA source (US EPA, 2002, Technical Development Document for the Proposed Section 316 (b) Phase II Existing Facilities Rule, EPA 821-R-02003) fine mesh screens show promise for both impingement and entrainment control and "can reduce entrainment by 80 % or more". According to this source, the use of 0.5 mm (500 µ) screen at the Big Bend Power Plant in Tampa Bay area, "the system efficiency in screening fish eggs (primarily drums and bay anchovy) exceeded 95 % with 80 % latent survival for drum and 93 % efficiency for bay anchovy. For larvae (primarily drums, bay anchovies, blennies, and gobies), screening efficiency was 86 % with 65 % latent survival for drum and 66 % for bay anchovy. (Note that latent survival in control samples was also approximately 60 %). According to the same source, a full-scale test by the Tennessee Valley Authority at the John Sevier Plant showed less than half as many larvae entrained with a 0.5-mm (500 µ) screen than 1.0 mm (1,000 µ) and 2.0 mm (2,000 µ) screens combined. These data are indicative of the fact that most likely using finer screens would result in lower entrainment effect. Since the micro-screens proposed for the Carlsbad project have 120 µ openings which are smaller than the smallest fine screens used elsewhere (i.e., 500 µ), the entrainment reduction capability of these micro-screens is expected to be comparable to the fine screens tested at the full scale installations referenced above.

1.2.1 Use of Low Pressure Membrane Pretreatment System

After the source seawater is screened by the 120-µ micro-screens, this water would be conveyed to a membrane pretreatment system in order to remove practically all remaining suspended solids and particulates. The filtered water will then be pumped to the seawater reverse osmosis system for salt separation.

The pretreatment system planned to be used for the Carlsbad seawater desalination project will consist of submerged ultrafiltration (UF) hollow-fiber membranes bundled in cassettes and operated under slight vacuum – typically in a range of 2.5 to 6 psi (see Figure 4-9). The nominal fiber pore size of the UF membranes is 0.02 µ. Practically all marine organisms that were not removed by the 120-µ micro-screens (mostly algae and other phyto- and zooplankton) would be retained by the UF membranes and would periodically be returned back to the ocean during the backwash cycle of these membranes. Membrane backwash would typically be completed with air and water once every 20 to 40 minutes. No chemicals are planned to be applied for seawater conditioning prior to filtration.

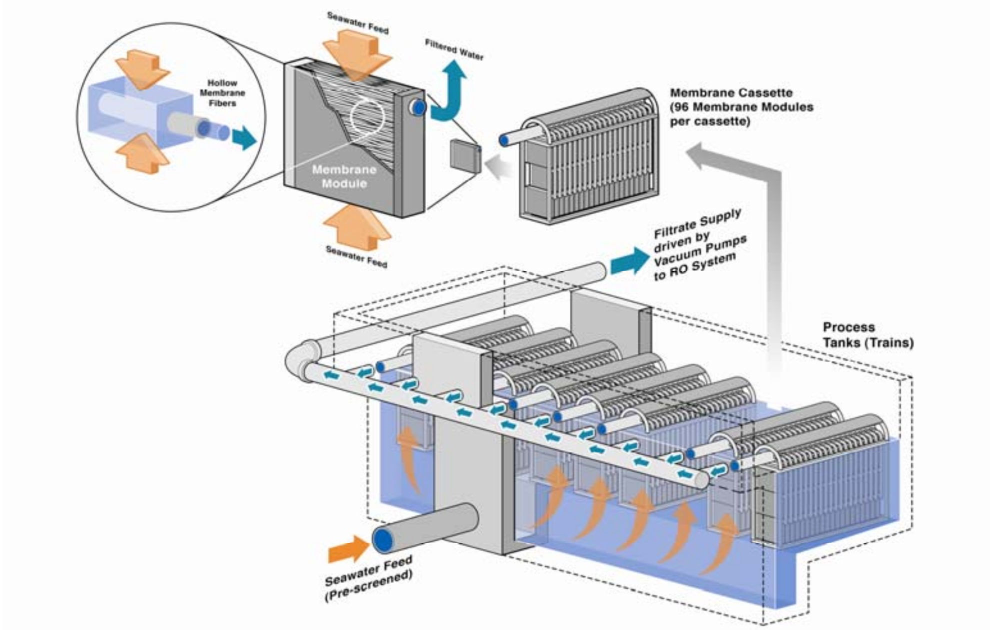

Figure 4-9 – Ultrafiltration Pretreatment System

Evaluation of the same UF pretreatment technology at the Carlsbad seawater desalination pilot plant indicates that the UF system retains all plankton and has potential to be effective entrainment reduction measure. Initial microscopic analysis of the phytoplankton in the UF system backwash completed by M-REP Consulting shows that over 70 % of algal cells maintain their integrity after passing through the micro-screens and the ultrafiltration process (see Figure 4-10).[9]

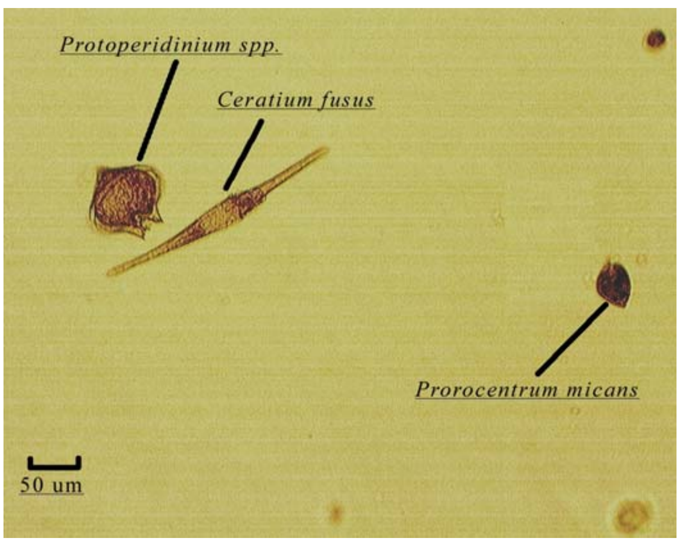

Figure 4-10 – Algae Removed by the UF Pretreatment System

[9] M-Rep Consulting, Update on the preliminary results of the Carlsbad Pilot Algal Study, February 27, 2008.