ATTACHMENT 7

ENVIRONMENTAL ENGINEERING LABORATORY, INC.

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December 6, 1968

San Diego Gas & Electric Company
101 Ash Street
San Diego, California

Attention: Mr. J. E. Thomas

Gentlemen:

In accordance with the terms of Purchase Order No. C-188, we are herewith submitting our report entitled "Marine organisms of South San Diego Bay and the ecological effects of power station cooling water discharge".

The report deals with the marine organisms characteristic of South San Diego Bay, their natural environmental conditions, and the effects on them of power station cooling water discharge during July and August 1968.

We wish to express our appreciation of this opportunity to serve the San Diego Gas & Electric Company in the study of this important area of inquiry.

Respectfully submitted by,

San Diego State College

Dr. Richard F. Ford
Principal Investigator

Environmental Engineering Laboratory

Robert L. Chambers
Project Director

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THE BIOLOGICAL CHARACTERISTICS OF SOUTH SAN DIEGO BAY

One of the major purposes of this study was to establish the species composition, distribution, abundance, and feeding relationships of marine organisms in the South Bay as a baseline for assessing present conditions and possible future ecological changes. The data which form the basis for this discussion are given in detailed form in tables 7 - 9 and 14 - 24. In the case of benthic diatoms, invertebrates, and fishes, these data are summarized in Tables 10 - 13, and for all species in Figures 6 - 8.

South San Diego Bay supports assemblages of marine organisms that are characteristic of the inner portions of relatively undisturbed bays and estuaries in California and Baja California. Ecologically similar forms inhabit bays and estuaries in other temperate areas of the world (Hedgpeth, 1957). In general, the forms found in the South Bay are tolerant of moderately wide ranges of temperature, salinity, and dissolved oxygen content and thus are able to survive seasonal and short term changes in these factors that occur there.

Major Organisms and Feeding Relationships

The dominant or characteristic marine organisms inhabiting South San Diego Bay are considered in the following sections. The scientific and common names of all species considered in the study, and the major groups to which they belong, are given in Tables 7 - 9, 14, and 22 - 24 for reference.

In order to understand the biological, as opposed to physical, environmental relationships of organisms in the South Bay ecosystem, it is also important to consider the trophic or feeding relationships of the major groups or species present. This was accomplished by qualitatively examining the digestive tract contents of larger animals (primarily fishes) and utilizing published information on the food habits of the remaining species. The results of this synthesis are summarized in a three-part food web diagram shown in Figures 6 - 8. The separate sections of such a diagram are generally designated as sub food webs.

The primary purpose of the diagram is to show the general food habits and specific pathways of food and energy transfer among major groups or species in the ecosystem. The complexity of pathways is an indication of the degree of stability exhibited by the association or community of animals and plants in the ecosystem. Because of the diverse diet and seasonal shift in food habits among many fishes, birds, and other forms, the diagram must be considered as a generalized food web which is most directly applicable to the summer months. Primary producers and species or groups that are used as food by man are indicated in the diagram. Pertinent features of this food web are considered in the following sections.

Benthic Plants

The soft sediment bottom throughout most of the South Bay is overlain by extensive mats of living plant material which are interspersed with areas of exposed sediment (Table 15). The dense heavily branched red alga *Gracilaria verrucosa* forms the bulk of this mat throughout most of the outer (higher number) D station area, as well as at O and I stations close to this region. In some areas, notably D-6 and D-7, the mat is 1 - 2 feet thick. Other much less common species, including particularly the red algae *Hypnea valentiae* and *Griffithsia* sp., form part of the mat at some locations. Two apparently undescribed species of the filamentous green alga Chaetomorpha spp. form dense but generally thinner mats in the inner D and more northerly O and I station regions.

Direct observations underwater indicated that these algal mats are an important microhabitat feature, because they provide cover and refuge from predators for many species of fishes and invertebrates, much as marsh vegetation does for ducks and other aquatic birds. The algae also serve as a major, primary food source for many animals, including the California killifish, crabs, isopods, gastropod molluscs, and some aquatic birds (Figures 6-8). The distribution of these algal mat species in relation to the thermal discharge pattern is considered in a later section of this report.

Periphytic diatoms, minute single celled plants that are attached to the surface of the sediment, probably are another significant primary food source for the striped mullet and a variety of small invertebrates (Figures 6 & 7). These animals feed by injesting sediment or selectively removing the diatoms from its surface. The periphytic diatoms and their relationships to the Thermal discharge are considered in detail in a later section.

Benthic Invertebrate Animals

The invertebrate fauna living on and in the bottom sediment is dominated in terms of species composition, abundance, and biomass by molluscs and polychaete worms (Tables 7 & 15), as it is in San Diego Bay as a whole (Marine Advisers, 1958). Several species of the common bivalve molluscs are used as food by man. These are the banded, smooth, and wavy cockles (Chione spp.) and the bent-nosed clam, Macoma nasuta. Unfortunately, the size of most individuals is quite small compared with those in nearby areas, such as the TiaJuana Slough, at least during the summer months (Table 15). The jack-knife clam, Tagelus californianus, and other small bivalves are used commonly as bait for hook and line fishing.

While none of the other invertebrates are of direct value to man, they are extremely important to the biological economy of the area, a fact that is evident from examining Figures 6 & 7 in detail. The feeding of nematode and polychaete worms, gastropod molluscs, brittlestars, crabs, isopods, and a wide variety of smaller crustaceans serves to transform detritus and other organic material into usable food for larger invertebrates and fishes; the latter, in turn, are eaten by other large fishes and aquatic birds, most of which are of esthetic or direct food value to man. Bivalve molluscs and other suspension feeders serve a similar function in transforming plankton and suspended detrital material into usable food for fishes and birds.

An unusual bryozoan animal, Zoobotryon verticillatum is present in some parts of the study area, where it forms large, flexible, tree-like masses. Some clumps appear to be attached to shell material embedded in the sediment or to algae, while much of this material is moved around freely on the bottom. It is very abundant on pier pilings at the G Street boat launching ramp, Chula Vista, and the riprap and other hard substrates in the South Bay Power Plant area. This undoubtedly is the animal that was incorrectly designated as a hydroid in a recent report (A. W. DeWeese, South Bay Temperature Survey, June 9, 1965, SDG&E File No. EPG 420). As indicated in this report, the bryozoan masses became abundant during the Fall of 1964 and are a continuing problem because they clog the intake screens. There appears to be no obvious, practical solution to this problem, short of placing additional screening across the inner part of the intake channel. Biological control of the bryozoan itself would be impractical because of its wide distribution in the South Bay and probable continuous introduction from the adjacent areas to the north. Zoobotryon probably is of moderate biological importance as food for a variety of invertebrates and as a refuge for both invertebrates and small fishes. Another unusual inhabitant is the large "wandering sponge", Tettila mutabilis, which is very common at the outer D and adjacent O and I stations (Tables 15 & 17). It is a large filter feeder that attaches loosely to the sediment. In some areas it is the major component of benthic biomass; but probably of little importance as a food organism.

Benthic and Pelagic Fishes

The study area supports at least 21 species of bottom living and open water fishes during the summer months, of which six are importatnt to man for recreational fishing and food, and are relatively abundant (Tables 8 & 17-19). The latter are the black croaker, California halibut, diamond turbot, two species of sand bass, and striped mullet. The mullet appears to be quite abundant throughout most of the South Bay and particularly so in the vicinity of the thermal discharge pattern. Unfortunately, mullet are difficult to catch with conventional fishing gear; in the present study they were taken only in traps (Table 19). Fishermen in the area who were questioned about their catch indicated that all of these food fishes except mullet are taken fairly commonly in the South Bay and that fishing conditions there are good, despite the small number of suitable species available.

As in the case of the invertebrate fauna, fish species "unimportant" to man in fact are vital to the biological economy of the ecosystem (Figure 7). Only the striped mullet and topsmelt utilize detritus and lower organisms directly by injesting sedimnet. All others feed primarily on other smaller fishes and benthic or pelagic invertebrates. The three most common small fishes living near the bottom, the California killifish, shadow goby, and barred pipefish, as well as the larger and very abundant round stingray, all prey upon a wide variety of small invertebrates. The slough anchovy is a filter feeder on small plankton. Larger species, such as the black croaker and sand basses, feed primarily on fishes, large crustaceans, and molluscs, while the diet of the California halibut is almost exclusively smaller benthic and pelagic fishes. The smaller fishes generally live in holes or within the algal and bryozoan mats on the bottom and have similar protective pattern and coloration to avoid these predators.

Some larger fishes, particularly guitarfishes and rays, may occur in the study area and have been ineffectively sampled by the techniques used. It also seems likely that the fish fauna may change seasonally, possibly as the result of migration into the area by species that are intolerant of warm water conditions that exist during the summer months. Unfortunately, there are no historical survey data or systematic fishing records for other periods of the year.

Shore Birds

The dikes, mudflats, salt marsh areas, and sandy beaches in South San Diego Bay are an important refuge and feeding area for a large variety of resident and migratory shore birds and other aquatic birds species. Because they are generally isolated from public access, the shoreline and dikes of the South Bay Power Plant are particularly important in this regard. On the basis of large and small segment surveys of the area (Figure 5, Tables 20 & 21) the most common shorebirds in the South Bay during August 13 - 25, 1968 were:

- Brown pelican
- Double-crested cormorant
- Unidentified ducks
- Snowy plover
- Black-bellied plover
- Ruddy turnstone
- Willet
- Least sandpiper
- Western sandpiper
- Short-billed dowitcher
- Marbled godwit
- Black-necked stilt
- Western gull
- Forster's tern
- Caspian tern
- Savannah sparrow

These surveys did not include most of the salt pond property at the extreme southern end of the bay. It should be emphasized that the species composition will vary daily, particularly for less abundant birds, as well as seasonally. Thus the species for which population census data were obtained (Tables 9, 20 & 21) are not the only ones inhabiting the area during the summer months. Another complicating factor is that, because individuals move about in the bay and adjacent ocean areas a great deal, the censuses at any given time may include as few as 50% of the birds actually present. However, the counts obtained probably are a reasonably good indication of relative abundance.

The gulls, brown pelican, and royal and elegant terns utilize the dikes of the South Bay Power Plant and those adjacent to it as roosting areas. They return to the dikes in the evening after feeding at sea. These species normally are ocean feeders, but also feed to some extent in the study area. Thus they probably would be affected primarily by environmental changes that altered the roosting areas themselves.

The shore birds recorded, with the exception of two resident species, the snowy plover and black-necked stilt, are birds on fall migration from northern breeding grounds which commences in mid-July. Some of the individuals move farther south in the fall months, while others winter in the South Bay (see Table 9 for residency status). In general, some indivuduals of nearly all species censused winter in this area. Many additional migratory species appear in great numbers during the fall months, including the dunlin (Erolia alpina), which is very abundant after September. Thus shore birds are most abundant and diverse in species composition during the winter. Most leave on spring migration in May, and in the early to mid-summer only remnant populations of non-breeding migratory birds remain in the South Bay. As a result of southward fall migration, shore birds become fairly common during August, the period considered in the present study. Adult birds generally precede the young in migrating south. By November a fairly stable and abundant group of winter populations again is established in the South Bay.

Brown pelicans, cormorants, western gulls, some snowy egrets, and black-crowned night herons are permanent residents in the South Bay. This also is true of the Savannah sparrow, which inhabits salt marsh vegitation at the shoreward margin of the mudflats.

Heerman's gull and the elegant tern, are present during late summer, fall, and winter, while the least tern is a summer resident only. The common tern is a spring and fall migrant. Forster's terns are present all year, but decrease in abundance in summer.

A variety of gulls inhabit the study area during the winter months. Ducks which winter in large numbers on San Diego Bay do not arrive until November. For example, the winter population of surf scoters in the San Diego Bay area may exceed 30,000 individuals. Those noted in the August censuses (Tables 20 & 21) probably were non-breeding birds that failed to leave on Spring migration. All of these individuals were in poor molting condition and unable to fly.

The birds present in summer are important predators on a variety of benthic invertebrates and small to medium sized fishes. The food relationships of major species are summarized in Figure 8; they are considered in detail by Bent (1921; 1922), Poygh (1951), Kortright (1962), and other authors cited by them. The brown pelican and double-crested cormorant feed almost exclusively on fishes by diving while others utilize small fishes, crustaceans, molluscs and polychaetes to varying degrees. Some birds, such as the herons, also feed on small terrestrial mammals and repitles; many species also feed heavily on insects. In general, most sandpipers feed on the exposed mudflats by probing a few millimeters into the sediment for polychaetes, small molluscs, and limited amounts of plant material. Plovers and some sandpipers feed by picking similar food from the sediment surface. Gulls are scavengers that eat practically all aquatic life and associated organic detritus. They serve an important biological function in cleaning up detritus and carrion from the exposed shore line in the South Bay.

Other Seasonal Residents

A small group of sea turtles have been observed in the warm water areas off the South Bay Power Plant during most of the year, except the warmest summer water temperature period. In 1968, a group of about three individuals were observed regularly in the cooling channel, at times in the outlet bridge area itself. None were observed anywhere in the study area during late July and August, 1968. This seasonal resident probably is the Pacific green turtle (*Chelonia mydas agassizii*) or the Pacific loggerhead turtle (*Caretta caretta gigas*). It is a spectacular, if minor, component of the South Bay marine community, and seems to be an example of the attractive influence of the thermal discharge during periods of lower ambient water temperatures. It probably feeds on a variety of fishes and larger invertebrates in the study area.

Employees at the South Bay Power Plant also have observed a moderately large, unidentified shrimp in the inner portion of of the inlet channel during periods of cooler water temperature. None were observed during the course of the present study. It is possible, but unlikely, that these could have been mantis shrimp (*Squilla polita*) which were present in August at Station 0-5.

Plankton and Nekton

The phytoplankton and zooplankton found in South San Diego Bay (Tables 22-24) appear to be similar to those of other bays and estuaries (Riley, 1967) in that individuals are volumetrically quite abundant, but the associations are relatively limited in regard to species composition. This is evident from previous qualitative and statistical comparisons of plankton samples obtained on the same day in outer and inner San Diego Bay (unpublished data, San Diego State College). The abundances of most species and the variety of species present both generally are lower in the study area than in the outer bay.

The dominant species of plant plankton are pennate and chain-forming diatoms, which serve as food for a variety of filter feeding bivalve molluscs and other benthic invertebrates, the slough anchovy, and zooplankton (Table 22; unpublished data, San Diego State College). In shallow marine waters such as the South Bay, the benthic animals and zooplankton utilize many of the same food resources, of which phytoplankton is a major component, to a much greater degree than in deeper water (Riley, 1967). Both dead phytoplankton and zooplankton also undoubtedly contribute significantly to the organic detritus in and on the sediment. Major phytoplankton blooms occur in the study area and elsewhere in the bay. The dynamics and environmental relationships of one such bloom have been reported by Marine Advisers (1962).

The major zooplankters (Table 23) include species of calanoid copepods, of which _Acartia_ spp. are the dominant forms. A large variety of harpacticoid copepods also are present in lower abundance. Most of the copepods feed on phytoplankton, while others rely to varying degrees on suspended detritus. Another presumed detrital feeder, the hypoplanktonic mysid crustaceans, _Metamysidopsis californica_, was judged to be fairly common at most stations surveyed by diving, but was not effectively sampled by nets because it lives within a few feet of the bottom. The "temporary plankton" represent the most diverse zooplankton component in the study area. These are larval and post-larval stages of benthic polychaetes, molluscs, crustaceans, and other groups whose adult stages inhabit the bay floor (Tables 23 & 24). In addition, many of the "temporary plankton" may be forms that are brought into the bay by tidal action, but do not successfully settle there. All of the species described above are important as food of larger benthic and pelagic animals (Figures 6 & 7).

A variety of medusae are common in the South Bay, at least during the summer and fall months. During July - September, 1968, these included two unidentified species of moderately large rhizostome jellyfish. The larger of these, which was yellowish-orange and cream colored, first became evident when small individuals (3 - 5 cm diameter) were carried into the study area in early August. These individuals remained in the South Bay, possibly trapped beacuse of low tidal interchange, and by late September had attained diameter of 50 - 75 cm. These and other smaller forms feed primarily on zooplankton and larval fishes.

Both the abundance and variety of fish eggs and larvae were surprisingly low during the period when they were sampled. These appeared to be primarily the larval forms of local bottom fishes (gobies and sandbass) and the anchovy (Table 24). These and other nektonic species, such as crab and mantis shrimp larvae, feed extensively on phytoplankton, zooplankton and suspended detritus (Figures 6 & 7).

Present and Past Biological Conditions

As in nearly all other areas, there are few specific historical records of past biological conditions in South San Diego Bay that can be used to determine what the area was like under natural conditions and to assess ecological changes. Prior to the summer of 1963, when sewage disposal into the bay was terminated, the present study area was heavily polluted by the effluents from two treatment plants. The Chula Vista Sewage Plant outfall was located just north of the South Bay Power Plant, in the area represented by inner I stations in the present study. Marine Advisers (1958) described conditions in this area during 1958. Although the biological data for their South Bay stations (Nos. 53-62) are qualitative, comparison of these with information obtained in the present study indicates that very striking changes have occurred following pollution abatement.

While the basic sediment types have not changed, extensive sewage sludge noted in 1958 no longer exists in the study area. Based on a limited number of comparisons, organic carbon concentrations in the sediment also appear to be comparable, but probably were somewhat higher in 1958 than at present. The most evident difference is tha major increase in variety and biomass of benthic faunal components at these stations were "small worms" presumably polychaetes, and very few small bivalve molluscs, Chione, Macoma, and Solen, which occur there today. These records, when compared with data for I and easterly O stations, show the marked increase that has occurred in the diversity of polychaete and mollusc species as well as variety of other invertebrate groups now present that did not exist there in 1958. Fishes presumably showed a similar trend. Although the values given in the two studies are not directly comparable, it is obvious that animal biomass also has increased markedly in the area. It seems likely that these basic changes are primarily the result of pollution abatement, but that his effect may have been modified by the presence of the thermal discharge. This conclusion is based on the fact that the stations within the influence of the discharge pattern and those outside its influence are similar in their basic fauna and flora, but show specific differences which are discussed in a later section.