The Biological Resources of South San Diego Bay and the Effect of Thermal Effluent from the South Bay Power Plant

Prepared for:

Earth Tech
9675 Businesspark Avenue
San Diego, CA 92131

Prepared by:

Tierra Environmental Services
9903-E Businesspark Avenue
San Diego, CA 92131

January 2, 2001

TABLE OF CONTENTS

LIST OF FIGURES

1.0 Introduction

Duke Energy South Bay, LLC is currently renewing its National Pollutant Discharge Elimination System (NPDES) permit with the Regional Water Quality Control Board (RWQCB) for operation of the South Bay Power Plant in south San Diego County. Since the plant began operating in 1960, an issue of primary concern has been the effect of discharged thermal effluent on the flora and fauna of San Diego Bay. The plant draws marine water from the bay to be used as cooling water then returns the thermal effluent to the bay. This report presents a discussion of the biological resources of South San Diego Bay in the general vicinity of the power plant, addresses the adequacy of the existing information pertaining to those resources, and summarizes the potential effects of operating the plant on those resources.

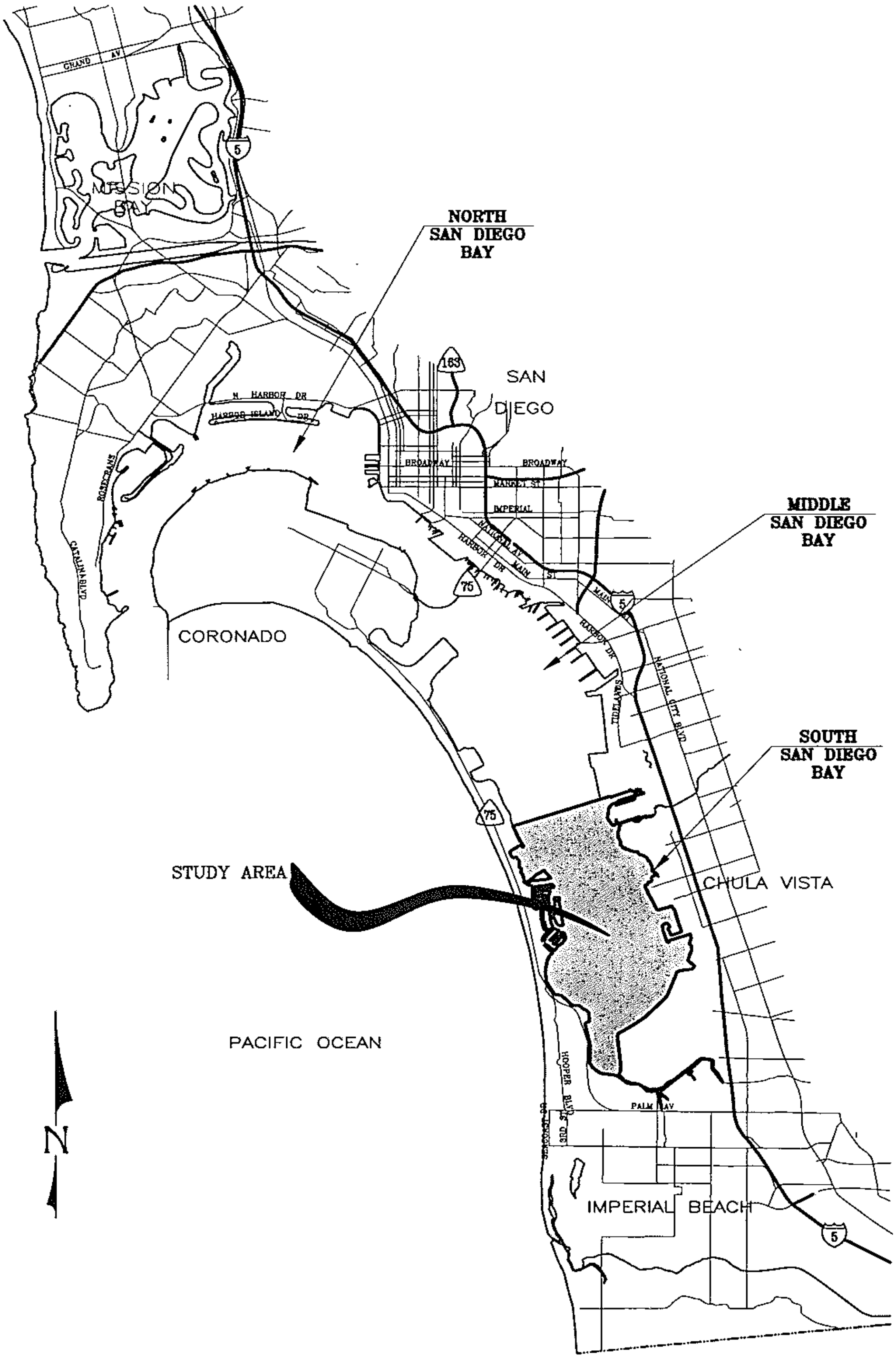
2.0 Project Setting

San Diego Bay is a crescent-shaped, semi-enclosed marine embayment located approximately 5 miles north of the U.S./Mexico Boundary in San Diego County (Figure 1). It is approximately 14 miles long and 2 ½ miles wide at its widest point. Its watershed is approximately 415 square miles. Historically, San Diego Bay has been an important spawning area for ocean and bay fishes and continues to be a significant stopover for migratory birds using the Pacific flyway. In addition, it is an important home to non-migratory bird species.

When discussing its biological resources, San Diego Bay may be described in three sections (Figure 1). North San Diego Bay includes the portion of the bay from its connection with the Pacific Ocean to approximately the Coronado Bridge (Figure 1). North San Diego Bay is subject to regular diurnal tidal flushing and, as a result, is essentially an extension of the Pacific Ocean in terms of water temperature, dissolved oxygen and salinity. The aquatic organisms that inhabit North San Diego Bay are marine organisms that enter and exit the bay, often with the prevailing tide.

Central San Diego Bay may be defined as that portion of the bay between the Coronado Bridge and the Sweetwater River. This portion of the bay receives seasonal freshwater input and is located farther from the mouth of the bay. Consequently, water chemistry may differ from oceanic conditions found in the northern portion of the bay. Water temperatures are usually higher and dissolved oxygen and salinity are somewhat reduced.

South San Diego Bay is less developed than the north or central bay and, according to Macdonald et al. (1990), includes over 4,700 acres including more than 2,500 acres of shallow bay waters, approximately 600 acres of intertidal mudflats, roughly 200 acres of salt marsh, and over 1,250 acres of salt ponds associated with the Western Salt saltworks. It should be noted that other authors have noted acreages that differ from that reported by Macdonald et al. (1990). For example, in an inventory of San Diego County wetlands conducted in 1985 (Los Peñasquitos Lagoon Foundation 1985) it was estimated that there were 359 acres of salt marsh and 1,400 acres of salt ponds in South San Diego Bay. The U.S. Fish and Wildlife Service (1999) estimated 1,175 acres of tidal salt ponds and 95 acres of non-tidal for a total of 1,270 acres.



LOCATION MAP

SUB-DIR:- W:\PROJECTS\43031_KH\Deliv\Dwgs\GIS\CADD

CAD FILE:- sdc-lmap

EARTH TECH

A tyco INTERNATIONAL LTD. COMPANY

Biological Resources of South San Diego Bay

REGIONAL LOCATION MAP

PROJECT: 43031

FEBRUARY 2001

FIGURE 1

Due to its extreme southern position, tidal flushing in South San Diego Bay is reduced. The turnover rate for this area of the Bay has been estimated to range from 10 to 30 days (Merkel & Associates 2000a). This muted tidal flushing combined with the shallow nature of South San Diego Bay (0 to 8 feet), results in an area of the bay that has elevated temperatures, reduced dissolved oxygen levels, and high salinity. These physical/chemical factors influence the assemblages of plant and animals that inhabit the south bay.

The South Bay Power Plant is located southeast of J Street and Bay Boulevard in the City of Chula Vista, California (Figure 1). The plant occupies approximately 150 acres of land owned by the San Diego Unified Port District (SDUPD) and leased to Duke Energy of North America. It has been postulated that the operation of the South Bay Power Plant has exacerbated the physical and chemical conditions presented above, contributing to elevated temperatures and lowered dissolved oxygen levels. The plant can circulate as much as 601 million gallons per day (MGD) through its condensers with an average annual flow rate of about 400 MGD. Findings from several studies that have addressed the impact of the South Bay Power Plant on the marine resources of South San Diego Bay are presented in this review.

The power plant is located immediately north of the salt evaporation ponds, recently owned and operated by Western Salt. This site has recently been designated a U. S. Fish and Wildlife Service National Wildlife Refuge. The South San Diego Bay Unit of the San Diego National Wildlife refuge was designated in 1999. The salt works provide breeding, roosting and feeding habitat to at least 94 bird species, several of which are threatened and endangered (Stadtlander and Konecny 1994). The location of the South Bay Power Plant relative to this important wildlife sanctuary is an important issue addressed in this report.

The marine habitats, and associated species, of South San Diego Bay are the most likely to be affected by discharge of thermal effluent associated with power plant operation. In the vicinity of the power plant, the primary natural marine habitats are: intertidal salt marshes; intertidal mudflats; shallow subtidal bottom habitat; eelgrass beds; and open water. The impacts of plant operation on these habitats is examined in detail in later sections of this document.

3.0 Historic Conditons

The history of San Diego Bay prior to the 1950's is not well documented. However, Macdonald et al. (1990) envisioned a pristine bay that supported extensive mudflats and salt marshes before the Spanish established the first permanent settlement on northern San Diego Bay in 1769. Under such conditions, the bay undoubtedly supported a diverse and abundant invertebrate and fish populations. During the century that followed that first settlement, human population increased along the shoreline of the outer bay. The bay became an important harbor for Spanish trade and, in the 1800's, it became a processing and shipping center for the whaling industry. The population of San Diego in 1846, the year it became part of the United States, was about 500. Although unprocessed waste was undoubtedly discharged to the bay, this small population had little effect on its biological resources.

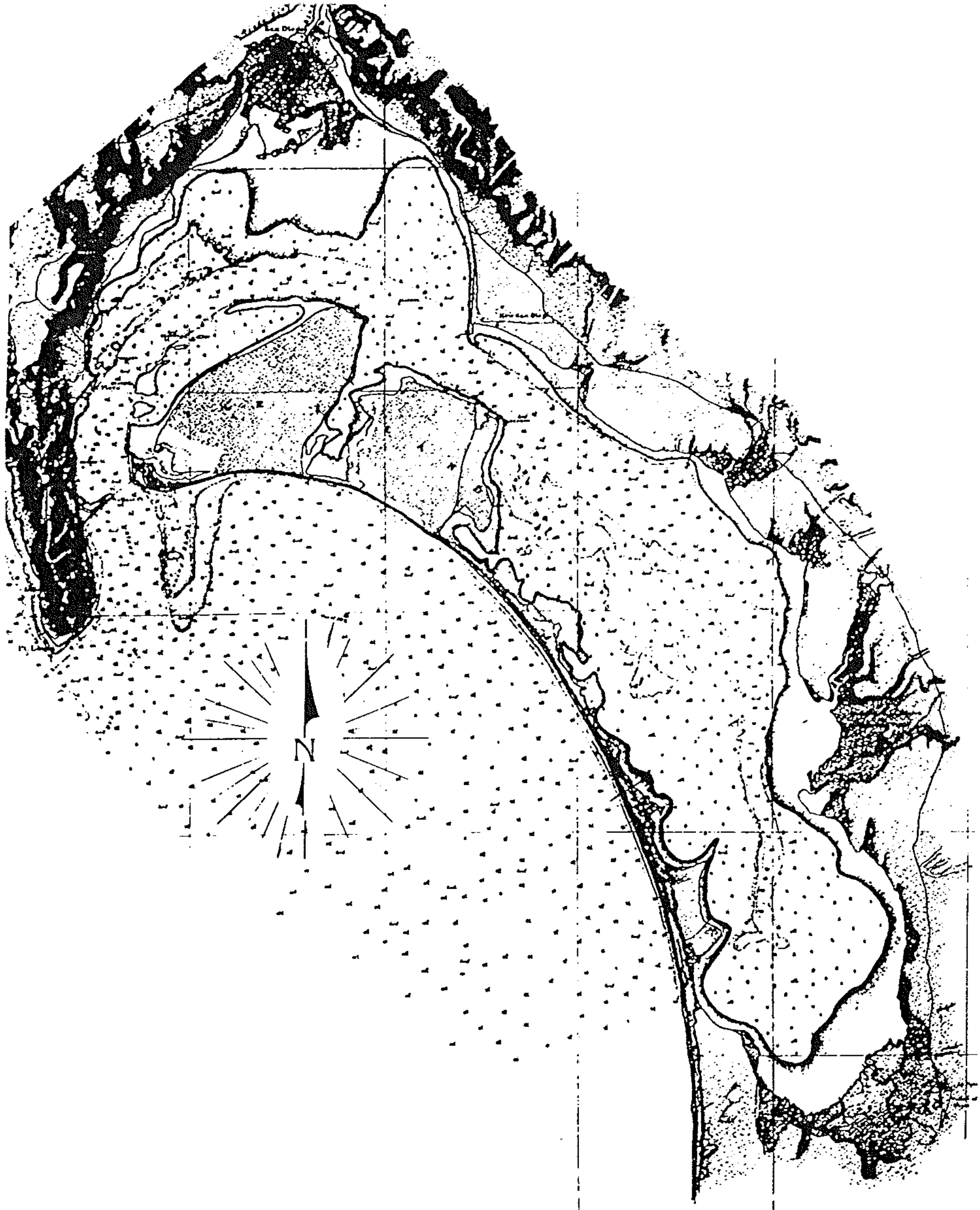
In 1856, U.S. Coast and Geodetic Survey maps show that San Diego Bay supported approximately 2,674 acres of intertidal salt marsh and 4,057 acres of intertidal mudflats (Figure 2; Macdonald et al. 1990). The natural habitats of South San Diego Bay remained essentially undisturbed at this time, with initial development occurring in the central and northern potions of the bay. Important developments included the construction of wharves in the vicinity of Pacific Highway and Market Street, the diversion of the San Diego River to Mission Bay, and discharge of domestic waste into the bay in 1887. The effects of these events on the biological resources of the bay were not documented.

During the late 1880's, 56 species of fish were reported from San Diego Bay (Eigenmann 1892a,b; Eigenmann and Eigenmann 1890, 1892. in Macdonald et al. 1990). By comparison, in 1990, 80-90 species of fish were reported with 67 species found in South San Diego Bay (Macdonald et al. 1990) and in 1999, 78 species of fish were reported (Allen 1999) It is interesting to note that newspaper articles in the late 1800's and early 1900's report capture of sea turtles and octopus in the South Bay area.

By 1902, a revised U.S. Coast and Geodetic Survey map revealed significant development in the central and northern portions of the bay (Figure 3). A comparison of the 1856 and 1902 maps indicates that salt marsh habitat had declined by about 100 acres, mudflats had declined by approximately 545 acres, and construction of the salt works had begun in South Bay.

Between 1900 and 1963, San Diego's population increased rapidly. Commercial, industrial and military installations were developed in the northern and central portions of San Diego Bay and resulted in the loss of natural resources in these areas. In the 1930's and 1940's, extensive dredging and filling resulted in a decrease in the tidal prism of the bay and an increase in subtidal water volume. These changes caused a marked reduction in the rate of water circulation and tidal exchange within the bay. Reduced tidal exchange continues to be an important physical feature in the South Bay area.

As the population of San Diego grew, discharge of domestic and commercial waste to the bay reached critical levels. By 1955, the State Board of Health and the San Diego County Department of Public Health declared most of the bay contaminated and posted quarantine and warning signs along the Coronado shoreline. By 1956, algal blooms had become persistent, sometimes turning the water of the entire bay red. Emergency chlorination programs were instituted but water quality continued to deteriorate until all water contact was prohibited in 1960. By 1963, 56 MGD of domestic waste was being discharged to the bay. Dissolved oxygen levels, critical to healthy marine life, plunged to below 4 milligrams/liter, a lethal threshold for most organisms. As a result, bait and game fish virtually disappeared from the bay. California Department of Fish and Game personnel declared much of the bay a "marine desert". Sewage sludge beds along the eastern shore of the bay were estimated to be nearly 27,000 feet in length, 600 feet in width and 7.5 feet in depth.



Source: Macdonald, et. al. (1990)

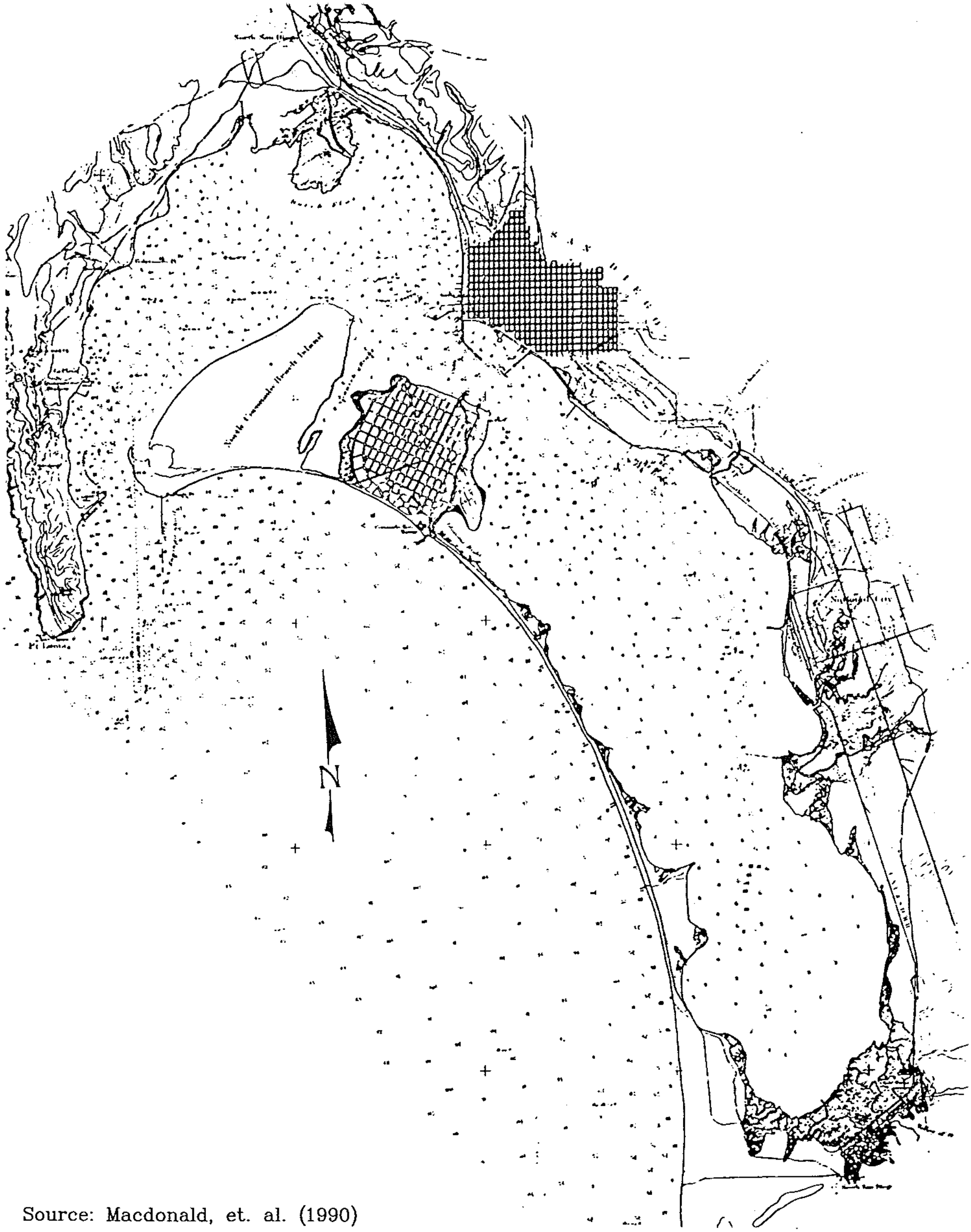
SUB-DIR:- W:\PROJECTS\43031_KH\Deliv\Dwgs\GIS\CADD
CAD FILE:- FIG-2

EARTH TECH
A tyco INTERNATIONAL LTD. COMPANY

Biological Resources of
South San Diego Bay
U.S. COAST AND GEODETIC
SURVEY CHART 1859

PROJECT: 4303
FEBRUARY 200

FIGURE
2



Source: Macdonald, et. al. (1990)

EARTH TECH
A tyco INTERNATIONAL LTD. COMPANY

Biological Resources of South San Diego Bay

U.S. COAST AND GEODETIC SURVEY CHART 1902

PROJECT: 43031
FEBRUARY 2001

FIGURE 3

SUB-DIR:- W:\PROJECTS\43031_KH\Deliv\Dwgs\GIS\CADD
CAD FILE:- FIG-3

In August 1963, the San Diego Metropolitan Sewage System and its ocean outfall began operation. By February 1964, all domestic sewage had been routed through the new system. The bay began to recover following the removal of the pollution source. Dissolved oxygen levels increased, bacterialcounts decreased, and fishes and other marine organisms began to repopulate the bay. Water quality in San Diego Bay has continued to improve since 1963 with reductions in discharge activity from industrial and vessel sources. The last of the major industrial discharges was diverted to the Metropolitan Sewage System in 1969. By 1973, the only authorized discharges to the bay were storm water, brine from Western Salt Western Magnesium and Rayne Soft Water Company, and thermal effluent from the South Bay Power Plant.

South Bay Salt Works. The existing salt works, recently renamed the South Bay Salt Works, are an important component of South San Diego Bay. The salt works operate by extracting salt that is produced via evaporation from bay water confined by dikes and berms into a series of evaporation ponds (Figure 4). The operation began prior to 1900 with the conversion of marsh and upland areas into evaporation ponds. Operations were halted temporarily in 1916, when the Otay Dam broke, flooding and filling the existing ponds (Terp and Pavelka 1999). Reconstruction in 1918 continued into the 1950s and resulted in the current configuration of 36 ponds and dikes that cover just under 1,300 acres (526 ha; Terp and Pavelka 1999). The salt is sold primarily as water softener. The operation also supports brine shrimp harvesting. The ponds vary in salinity from that of bay water (approximately 32 parts per thousand; ppt) to well over 320 ppt. Ponds of intermediate, yet high salt content relative to the bay, support dense populations of brine shrimp and brine flies. These invertebrate food items support a vast array of water-associated birds, as will be made evident in future sections of this review. As previously presented, the salt works have been designated a wildlife refuge by the USFWS. The refuge is still in the planning stages; however, the salt works will continue to produce salt for at least 5 years under the current operating agreement.

4.0 Current Conditions

4.1 Physiography and Bathymetry

As previously presented, San Diego Bay is a natural, crescent-shaped embayment that has been extensively modified by dredging and filling. The bay is bounded by the cities of San Diego, National City, Chula Vista, Imperial Beach and Coronado and is approximately 14 miles long and 2 ½ miles wide at its widest point.

The floor of the bay is characterized as sand, silt, clay and mud or mudstone, depending upon location within the bay. Sands are more common near the entrance and along western margins while silts and muds are more typical of the southern and eastern areas of the bay. Muds of the bay floor average between 5 and 20 feet in depth. Water depths in the South Bay are shallow, ranging from 0 to 8 feet, except in the dredged channels, with an average depth of 3 to 4 feet.

South San Diego Bay supports communities of benthic and marine organisms that are characteristic of other bays and estuaries in California and Baja California, Mexico. There have been many studies conducted of the plants and animals that inhabit the bay, many of them associated with the operation of the South Bay Power Plant. Extensive lists of organisms are presented in Macdonald et al. (1990).

The reader is referred to this document for detailed discussions of the bay's biological resources. This section summarizes the general biological communities of the bay, including South San Diego Bay. Following sections present some recent studies conducted specifically to address potential impacts to marine resources from the discharge of cooling effluent from the power plant.

4.2 Salt Marshes

Coastal salt marshes of South San Diego Bay occur in the upper intertidal zone and support an assemblage of salt tolerant plants known as halophytes. Lower marsh elevations are dominated by Pacific cordgrass (*Spartina foliosa*) which can tolerate long periods of inundation. Middle elevations support a mosaic of species, often succulents, that include common pickleweed (*Salicornia virginica*), annual pickleweed (*S. bigelovii*), sea-blite (*Suaeda esteroa*), saltwort (*Batis maritima*) and arrowgrass (*Triglochin maritima*). Upper marsh species include shoregrass (*Monanthochloe littoralis*), saltgrass (*Distichlis spicata*), glasswort (*Salicornia subterminalis*), alkali heath (*Frankenia salina*), and sea lavender (*Limonium californicum*). Two species of special interest are found in the highest elevations of South San Diego Bay salt marshes: salt marsh bird's beak (*Cordylanthus maritimus* ssp. *maritimus*) and Palmer's frankenia (*Frankenia palmeri*). Salt marsh bird's beak is a federally listed endangered species while Palmer's frankenia occurs only at two known locations in the United States, one at South San Diego Bay.

Historic maps of South San Diego Bay document an 87% decline in salt marsh habitat from approximately 1,613 acres in 1856 to only 203 acres in 1984 (Macdonald et al. 1990). South San Diego bay formerly supported eight major salt marsh areas. These included Paradise Creek Marsh, Sweetwater River Marsh, E Street Marsh, F Street Marsh, J Street Marsh, Otay River Marsh, Naval Radio Station Marsh, and Coronado Cays Marsh.

Paradise Creek Marsh represents a small remnant of a formerly larger system. By 1970, only 26 acres remained. In 1984, construction of the Sweetwater River Flood Control Channel, straightening of Interstate 5, and the construction of the Interstate 5/State Route 54 intersection resulted in direct impacts to Paradise Creek Marsh. Mitigation included creation of the Connector Marsh, an approximately 12-acre hydrologic connection between Paradise Creek Marsh and creation of the 17-acre Marisma de Nacional Marsh from former upland on the D Street fill.

Sweetwater Marsh is the largest remaining marsh in South San Diego Bay. Williams and Zedler (1999) list its acreage as 316 acres of wetland and disturbed upland. Despite its fragmented condition, Sweetwater Marsh supports a diverse assemblage of plants and animals. Zedler (1982) ranks Sweetwater Marsh and Tijuana Estuary as having the highest diversity of salt marsh vascular plant species with 18 species each. Three endangered bird species utilize Sweetwater Marsh: the light-footed clapper rail (*Rallus longirostris levipes*), the California least tern (*Sterna antillarum browni*), and the California brown pelican (*Pelicanus occidentalis californicus*). The endangered salt marsh bird's beak has been successfully established in high marsh areas. The salt marshes at E, F and J street represent remnant, isolated marshes that were once a part of a larger marsh that surrounded San Diego Bay. Today they range in size from approximately 15 to 30 acres and are dominated by common pickleweed.

The Otay River Marsh once included 52 acres of salt marsh that consisted of fragmented marsh areas that expanded into a large mudflat (192 acres) to the north of the salt works. Today, the Otay River Marsh is confined to the channelized Otay River located immediately east and southeast of the salt works. The area of former mudfalt to the north of the salt works supports the South Bay Power Plant (Figure 4).

The Naval Radio Station Marsh is a remnant salt marsh located on the western shore of South San Diego Bay. This marsh has been heavily disturbed by foot traffic. The remnant Coronado Cays Marsh was reported to consist of 8 acres of pickleweed and some cordgrass along a tidal creek (Macdonald et al. 1990).

4.3 Intertidal Mudflats and Shallow Subtidal Habitats

Intertidal mudflats and shallow subtidal mud bottom habitats are combined for purposes of this discussion due to the shallow nature of the South Bay. Many of the organisms that occur on the intertidal mudflats occur subtidally as well. Mudflats are extremely important foraging habitat for shorebirds. As previously presented, San Diego Bay is a crucial link in the Pacific Flyway and the mudflats of South San Diego Bay are, together with open water, the primary habitats utilized by migrating birds. The birds of South San Diego Bay are presented in a separate section of this report and are not discussed here.

The invertebrate populations of the subtidal mud bottom are important in the bay's food web. Feeding activities of polychaete and nematode worms, gastropods, crabs, isopods and other groups convert detritus and other organic matter into usable food for larger invertebrates and fishes. These in turn are eaten by yet larger fishes and birds.

There have been two main studies of the intertidal and subtidal benthic invertebrates of South Bay: Ford and Chambers (1973) and Macdonald et al. (1990). The results of these two surveys are summarized below.

The invertebrate fauna living on and in the bottom sediment of South San Diego Bay is dominated, in terms of numbers of species, abundance, and biomass, by polychaete worms, crustaceans and molluscs. Of the more than 292 invertebrate species encountered, approximately 118 (40%) were polychaetes, 85 (29%) were crustaceans, and 53 (18%) were bivalve and gastropod molluscs. Among the crustacean assemblage, amphipods were represented by 32 species (11%), decapods by 15 species (5%) and ostracods by 10 species (3%). Among the molluscs, bivalves were represented by 25 species (8.5%) and gastropods by 28 species (9.5%).

Plants associated with the soft bottom habitats of South San Diego Bay include extensive mats or masses of living plant material that are interspersed with areas of barren substrate. Many of these species drift along the surface of the substrate or are loosely attached to it. More than 19 species of multicellular algae combined with detritus from eelgrass (*Zostera marina*), form these mats. Almost all of these species occur to some extent in the intertidal zone as well as in the subtidal zone. These masses provide cover and refuge for many species of fishes and invertebrates and serves as a primary food source for many animals.

4.4 Created Lands

In addition to natural lands such as salt marsh, several areas of "created lands" that have been created from fill also occur around the bay. These include the D Street Fill, Marisma de Nacional, and the Chula Vista Wildlife Reserve.

The D Street Fill was created from dredge spoil as part of a shoreline development that was never completed. The majority of the site is now a part of the Sweetwater Marsh National Wildlife Refuge (Figure 4). The remainder is owned by the San Diego Unified Port District. The USFWS and the Port work cooperatively to manage nesting colonies of California least tern and western snowy plover.

In 1990, a 17-acre salt marsh known as Marisma de Nacional, was created at D Street Fill. This marsh was created as partial mitigation for impacts associated with the construction of the Sweetwater River Flood Control Channel, the realignment of Interstate 5, and the construction of the Interstate 5/State Route 54 intersection. The development of this created salt marsh has been closely monitored by scientists from the Pacific Estuarine Research Laboratory at San Diego State University.

The Chula Vista Wildlife Reserve was created from dredge spoil in 1980 as mitigation for the Chula Vista Boat Basin. Approximately 35 acres in size, the reserve includes mudflat, salt marsh and upland areas intended as a least tern nesting site. While the area is consistently utilized as a feeding and resting area for seabirds, migrating shorebirds and wintering waterfowl, nesting by least terns has failed in some years due to nest predation. Though limited, some nesting success has been observed (USFWS 1999).

4.5 Eelgrass Beds

San Diego Bay supports more eelgrass habitat than any other California bay or estuary (Merkel & Associates 2000a). In 1993, approximately 1,248 acres of eelgrass occurred within the bay. Of this total, approximately 848 acres occurred in South San Diego Bay.

In addition to the masses of algae and plant detritus discussed above, eelgrass forms dense beds in the lower intertidal and shallow subtidal areas of South San Diego Bay. Its distribution is limited by light penetration, which is reduced with increasing depth and turbidity. Turbidity is associated with wind action and suspension of sediments in the water column.

Because light penetration is influenced by abiotic factors such as turbidity, sediment grain size and sediment chemistry, it is difficult to place a lower depth limit on eelgrass beds in South San Diego Bay. However, as a rule of thumb for this report, the lower depth of dense eelgrass beds in South San Diego Bay is presented as -3.0 meter below MLLW and the upper limit is designated as approximately + 0.3 meters MLLW with the majority of eelgrass occuring above -1.2 meter MLLW.. Eelgrass beds are considered ecologically valuable habitats due to their high productivity, diverse microhabitat features, and cover they provide for fishes and invertebrates. The fishes that inhabit eelgrass beds are considered in Section 4.7 of this review. Furthermore, black brant feed almost exclusively on eelgrass, when available. Eelgrass is also important in the diet of sea turtles, as presented in later sections of this report.

As part of the NPDES renewal process in 1996, San Diego Gas and Electric Company (SDG&E) authorized an extensive study of the potential effects of operation of the South Bay Power Plant on eelgrass distribution in South San Diego Bay. The results of that study are presented in Section 5.0.

4.6 Plankton and Nekton

The phytoplankton and zooplankton of South San Diego Bay were examined by Ford (1968) and by SDG&E (1980) in relationship to the South Bay Power Plant These studies determined that the plankton of the bay was similar to those of other bays and estuaries in that individuals are abundant but the assemblages are limited in terms of species diversity. The dominant phytoplankton species were pennate and chain-forming diatoms. These are important food items for filter feeding invertebrates and for fishes such as slough anchovy (*Anchoa delicatissima*) and for zooplankton.

The major zooplankton species were calanoid copepods dominated by *Acartia* species. Most copepods feed on phytoplankton and others on suspended detritus. Planktonic larvae and post-larvae of polychaetes, molluscs, crustaceans, and fish eggs and larvae represented the most diverse component of the zooplankton.

4.7 Demersal and Open Water Fishes

Numerous studies have been conducted of the fishes of South San Diego Bay. Sixty-seven species of demersal (bottom living) and open water fishes were reported prior to 1990 (Macdonald et al. 1990). More recently, Allen (1999) conducted a five-year assessment of the fishes of San Diego Bay, including one station in the South Bay near the South Bay Power Plant. That study revealed 78 species of demersal and open water fishes.

The fish assemblage of South San Diego Bay is similar to that found in other regional bays and estuaries. According to Macdonald et al. (1990), the dominant species, in terms of abundance and biomass, is the round stingray (*Urolophus halleri*). Subdominants include the horned shark (*Heterodontus francisci*), grey smoothhound shark (*Mustelus californicus*), leopard shark (*Triakus semifasciata*), deepbody anchovy (*Anchoa compressa*), slough anchovy, specklefin midshipman (*Procithys myriaster*), California needlefish (*Strongyura exilis*), California killifish (*Fundulus parvipinnis*), topsmelt (*Athernipos affinis*), jacksmelt (*A. californicusis*), pipefishes (*Syngnathus* spp.), staghorn sculpin (*Leptocottus armatus*), spotted sandbass (*Peralabrax maculatofasciatus*), barred sandbass (*P. nebulifer*), queenfish (*Seriphus politus*), yellowfin croaker (*Umbrina roncador*), black croaker (*Cheilotrema saturnum*), shiner surfperch (*Cymatogaster aggregata*), striped mullet (*Mugil cephalus*), bay blenny (*Hypsoblennius gentilis*) and seven species of goby. Common flat fishes included diamond turbot (*Hypsopsetta guttulata*), spotted turbot (*Pleuronichthys ritteri*) and California halibut (*Paralichthys californicus*). Nine of these species also occur in the tidal creeks of the Sweetwater River and Paradise Creek marshes. These include California killifish, topsmelt, staghorn sculpin, striped mullet, longjaw mudsucker, cheekspot goby, shadow goby, California halibut, and diamond turbot.

In addition to the species listed above, which were collected using trawls and seines, several species of fish not caught using these methods were observed in samples taken from the intake screens of the South Bay Power Plant. These included six marine species and three freshwater species. Marine species included blue shark (*Prionace glauca*), California flying fish (*Cypselurus heterurus*), kelp pipefish (*Sygnathus calforniensis*), spotted scorpionfish (*Scorpaena gutatta*), mojarra (*Eucinostomus* sp.) and halfmoon (*Medialuna californicusis*). Freshwater species impinged on the intake screens included carp (*Cyprinus carpio*), golden shiner (*Notemigonus crysoleucas*) and an unidentified sunfish (*Lepomis* sp). As very few individuals of each marine species were collected, these were considered to be infrequent visitors to the bay from their outer bay or offshore habitats. The freshwater species were believed to have been carried into South Bay from the adjacent Otay River and/or Sweetwater River. As such, these species were not included in the 67 species of "resident" species reported by Macdonald et al. (1990).

South San Diego Bay, like other southern California bays and estuaries, functions as an important nursery area for juvenile California halibut and spotted and barred sandbass and other species. Young halibut feed on goby species that are very abundant in these protected waters.

The Pacific seahorse (*Hippocampus ingens*)was reported by Macdonald et al. (1990) as an unusual inhabitant of the South Bay. It is occurrence is hypothesized to be the result of warmer water associated with El Niño events. It appears that this species was able to migrate northward with El Niño-influenced waters and has become established in the warmer areas of South San Diego Bay.

Allen (1999) conducted a more recent five-year assessment of the fisheries of San Diego Bay. The bay was divided into four subareas for this study including the northern, north central, south central, and southern sampling subareas. Three separate habitats were sampled in each subarea: a channel sampling area, an unvegetated bottom sampling area and a vegetated bottom sampling area. In the southern sampling subarea, the unvegetated sampling area was located immediately adjacent to the

South Bay Power Plant cooling channel while the channel and vegetated bottom sampling areas were located to the north and west, respectively. Sampling was conducted quarterly using a large beach seine, small beach seine, square enclosure, beam trawl, purse seine and otter trawl. Three replicate collections were made at each sampling area for each type of gear.

Over the five-year period, a total of 497,344 fishes belonging to 78 species, and weighing 2,755 kg, were captured in 20 sampling dates. Northern anchovy was the most common species comprising 43% of the total, followed by topsmelt (23%), slough anchovy (19%), Pacific sardine (3%) and shiner surfperch (2%). As in earlier studies, round stingray dominated in terms of weight, comprising approximately 25% of the total biomass collected, followed by spotted sand bass at about 14%, northern anchovy (9%), bat ray (9%), topsmelt (9%), and slough anchovy (7%).

The South Bay was dominated in terms of individuals by slough anchovy, topsmelt, arrow goby, round stingray, shiner surf perch and bay pipefish. In terms of biomass, the South Bay was dominated by round stingray, spotted and bass, barred sand bass, and bat rays.

Hoffman (1986) conducted a comparative study of fishes utilizing eelgrass beds in South San Diego Bay and those occurring in adjacent non-vegetated areas of bottom habitat. He captured 36 species of fish using replicate seine hauls. Topsmelt, shiner surfperch, and arrow goby (*Clevelandia ios*), bay goby (*Lepidogobius lepidus*), cheekspot goby (*Ilypnus gilberti*) and shadow goby (*Quietula y-cauda*) made up 93% of the individuals collected. Based on biomass, topsmelt, shiner surfperch, spotted sandbass , staghorn sculpin, round stingray and California halibut composed more than 87% of the total fish biomass collected. Hoffman (1986) concluded that more than twice as many individuals were collected in seine hauls through eelgrass beds than through comparative hauls through non-vegetated areas. These data indicate the importance of eelgrass beds as a protective habitat for fishes and invertebrates in the South Bay.

4.8 Sea Turtles

The first modern day report of sea turtles in the South Bay is presented in Ford (1968) wherein a group of sea turtles was observed adjacent to the South Bay Power Plant. These were originally identified as the endangered Pacific green sea turtle (*Chelonia mydas agassizii*). A group of these turtles appear to inhabit the inner bay during much of the year, except during the warmest summer water temperatures (Ford and Chambers 1973). The taxonomic status of these turtles has been the subject of some debate with some referring to them as black sea turtles (*Chelonia agassizzi*). McDonald et al. (1994) conducted a review of the sea turtle population in South San Diego Bay and determined that they are indeed green sea turtles (*Chelonia mydas*). Based on genetic studies, it was determined that black sea turtles are a subpopulation of *C. mydas*. The green sea turtle is considered endangered throughout most of its range, including nesting beaches in Mexico. The study did not speculate on the potential effects of changing the operations of the power plant or reducing or increasing the thermal effluent.

Green sea turtles are poikilothermic (have a variable body temperature usually slightly higher than the surrounding sea water) and can inhabit a wide range of water temperatures. When water temperatures become too low, they burrow into the seas and become "dormant". They have difficulty swimming and diving in waters below 10° C. Populations along the California coast are rare.

Green sea turtles are not considered to be native to San Diego Bay. Their presence in the bay may be attributed to individuals that escaped from commercial holding pens. In 1857, green sea turtles were stored in temporary pens in the bay before shipment for sale in San Francisco (Macdonald et al. 1990). The escaped individuals have continued to inhabit the bay.

In the mid 1960's, SDG&E built the water-cooled South Bay Power Plant which produced a warm water discharge in the southernmost area of South San Diego Bay. Once the plant became operational, the sea turtles were largely restricted to this artificially created warm water habitat. The South Bay Power Plant is the only known location on the west coast of the U.S. where sea turtles congregate (McDonald et al. 1994), although they have been sighted at other west coast locations. Stinson (1984) reported that the green sea turtle is a seasonal visitor to San Diego Bay appearing in November and leaving in April. Individuals that have been radio-tracked spend most of their time in the deeper portions of the South Bay Power Plant discharge channel. At night, they have been observed foraging on the eelgrass beds that exist along the southern shore of the bay.

It is not known how the sea turtles find San Diego Bay or when turtles first arrived. Juveniles could enter and leave the bay with incursions of warm equatorial water during El Niño events. McDonald et al. (1994) captured 18 turtles in the thermal discharge channel of the South Bay Power Plant. These included three mature males, five mature or subadult females, and 10 juveniles. However, despite the presence of juveniles, there is no indication that breeding or nesting occur in San Diego Bay. It is not known whether turtles in San Diego Bay have wandered into the bay and remain as year-round residents, or leave periodically and then return. At least some turtles remain in San Diego Bay year-round as McDonald et al. (1994) failed to see the spring emigration from the bay, as described by Stinson (1984). The turtle's expansion out of the effluent channel into the warmer areas of the South Bay may have been previously misinterpreted as an annual summer emigration from the bay.

4.9 Birds

As previously stated, San Diego Bay is an important component of the Pacific flyway, supporting thousands of waterfowl and shorebirds during seasonal migrations. It also supports a diverse assemblage of year-round resident species. The South Bay is recognized as an important wintering area for waterfowl such as surf scoter, scaup, brant and bufflehead. In a 1994 study by the U.S. Fish and Wildlife Service, the central and southern portions of San Diego Bay supported 44% of the south coast region midwinter scaup population, 15% of the entire state midwinter population of surf scoter, and 31% of the state's midwinter brant population. Waterfowl congregate into rafts of hundreds, and sometimes thousands, of individuals in the shallow South Bay waters.

Several recent studies of bird use of the Western Salt salt works have been undertaken by the U.S.

Fish and Wildlife Service. These and earlier bird studies are summarized in the following section.

Early Bird Surveys Associated with the South Bay Power Plant. Bird surveys of the South Bay were conducted as part of the initial ecological study of the effects of the thermal discharge from the South Bay Power Plant (Ford 1968). The surveys were conducted near the intake of the cooling system, at the thermal discharge cooling channel, and at a control site in the South Bay. Birds were censused from August 15-20, 1968, and thus represent only a snapshot of late summer utilization.

Species composition was similar at the intake and at the discharge channel with 38 and 32 species, respectively. By comparison, 23 species ere observed at the control site, located just north of the power plant. Dominant species included black-bellied plover, marbled godwit, willet, short-billed dowitcher, western sandpiper, and least sandpiper. The total number of individuals observed at each station were 2,739 at the intake site, 1,037 at the discharge site, and 1,297 at the control site.

Early Surveys Conducted at Salt Works. Shorebird use of the South San Diego Bay salt evaporation ponds was examined in an larger effort called the "California Shorebird Study" (Jurek 1973). These surveys were conducted approximately bi-weekly for two years (October 19, 1969-October 20, 1970; August 8, 1971-June 11, 1972). During the 1969-1970 study, counts were conducted at the South San Diego Bay salt ponds, which included two ponds (#3 and #20; 74.5 acres) separated by the Otay River. These counts were timed to correspond with high tide when many shorebird species roosted or fed in the salt ponds. The 1971-1972 studies were conducted at the "Imperial Salt Ponds", which included three salt ponds of 272 acres. These surveys were not timed to correspond with any particular cycle of the tide.

Twenty-two species of shorebirds were observed during the study. Dominant species included western sandpiper, willet, dunlin, marbled godwit, American avocet, black-necked stilt, northern phalarope, and black-bellied plover. A total of 3,999 individual shorebirds were observed at South San Diego Bay Salt Ponds. 2,540 total individuals were observed at the Imperial Salt Ponds. Seasonal peaks for several dominant species occurred in October with secondary peaks in March and April, roughly corresponding with seasonal migrations. Exceptions included the northern phalarope, which showed peak numbers in July and August.

On April 22, 1989, a group of 69 observers conducted a comprehensive survey of San Diego County shorebirds as part of the Point Reyes Bird Observatory Pacific Flyway Project (Macdonald et al. 1990). That group counted shorebirds at 12 San Diego County bays and lagoons including the salt evaporation ponds in South San Diego Bay. Eighteen species were observed at the salt ponds. Dominant species included a combined western/least sandpiper category (4,034 individuals observed), western sandpiper (3,735 individuals), red knot (409 individuals), marbled godwit (266 individuals), dowitcher species (293 individuals), black-necked stilt (158 individuals) and dunlin (116 individuals). These numbers were by far the highest of any San Diego County wetland with only the mudflats of the San Diego River Flood Control Channel supporting similar numbers. At that site, most of the shorebird sightings were western sandpiper (2,422 individuals) or in the combined western/least sandpiper category (2,699 individuals). In comparison, this one-time survey delineated 19 species and 525 individuals at Tijuana Estuary, 20 species and 3,631 individuals at the San Diego River Flood Control Channel, and 19 species and 579 individuals at Mission Bay. That day, fewer than 400 individual shorebirds were observed at the remaining six wetlands in San Diego County.

Macdonald et al. 1990 conducted bird surveys as part of their characterization of the South Bay. Two surveys were conducted of the intertidal mudflats that occur at low tide in front of the salt ponds: one on November 22, 1988 and another on April 14, 1989. Counts were taken every hour throughout a full tidal cycle. The list of dominant species for both surveys was very similar to lists gathered in the surveys presented above. In November, black-bellied plover, marbled godwit, western sandpiper and least sandpiper were the dominant species with surf scoter, bufflehead, long-billed curlew and western gull also abundant. Numbers of individuals were much higher in April. At that time, dominant species included western sandpiper, dunlin, short-billed dowitcher, marbled godwit, willet, and black-bellied plover and subdominant species included California gull, western gull, elegant tern and Forster's tern.

Several focused surveys of the South Bay Salt Works were conducted by the U.S Fish and Wildlife Service (USFWS) in the 1990's. These included the Avifuana of South San Diego Bay: the Western Salt Works 1993-1994 (Stadtlander and Konecny 1994) and, a Summary of Colonial Seabird Nesting at Western Salt Company, San Diego Bay, California, 1998 Season (Terp and Pavelka 1999).

In the 1993-1994 study, a total of 52 surveys weekly were conducted every Wednesday between 0700 and 1100. Over the course of the study, 94 species were identified and a total of 522,553 individuals enumerated. 10,049 birds/day on average were observed. For summary purposes, species were lumped into generalized groups or guilds based on morphological or behavioral similarities. Shorebirds and waterfowl were the dominant guilds in terms of numbers of species with 27 and 22 species, respectively. The gull/tern guild was third most abundant with 18 species and grebes/loons were fourth with 7 species. In terms of numbers, 366,596 individual shorebirds were observed, followed by 50,890 gulls/terns, 43,126 waterfowl, and 42,975 grebes/loons.

Although there was considerable variation in total numbers of individuals counted per survey, counts were generally at or above 10,000 individuals per survey except for the period between mid-April through mid-July. During that time, counts were often below 4,000 individuals per day. In contrast, total numbers of individuals counted peaked in mid-August and again in early December, when nearly 19,000 individuals were observed per survey. Both peaks were attributed to an influx of shorebirds, most notably red phalarope and western sandpiper. Although fewer individuals were observed between late fall through mid-summer, the area remained an important breeding ground for terns and several shorebird species.

The study of breeding colonial seabirds focused on six species of terns, the black skimmer and western snowy plover. Monitoring for nesting pairs of these species was begun on April 3, 1998 and continued every 3-4 days until September 11, 1998. Each nest was marked in the field and followed for the duration of the study.

During the 1998 nesting season, there were 198 nesting pairs of Caspian terns at the salt ponds. Caspian terns nested on dikes that were located on the bayside perimeter of the salt works. A total of 600 eggs were laid, with an overall hatching success of 58%.

The maximum number of elegant tern nests present during the study was 104 on May 12, 1998 with about 100 pairs estimated to be present. All but two nests were single-egg nests, i.e., there about 104+ eggs laid during the nesting season. Predation on these eggs was heavy and a maximum of 11 chicks were sighted during surveys in mid-June. Elegant terns nested primarily in one location, near the bay side of the salt pond network.

Black skimmer nesting at the salt ponds in 1998 was represented by approximately 280 pairs. Nests were distributed over 13 different areas of the salt works. A total of 472 nests were constructed with a mean clutch size of 2.66 $\pm$ 1.0 SD. Egg hatching was estimated at 42.2%.

Gull-billed tern nesting occurred on two areas: on a dike near the middle of the complex and in the southern area on the landside, as opposed to the bayside, of the salt works. An estimated 8-10 pairs were present. These pairs initiated 14 nests and laid a total of 36 eggs. Egg hatching was estimated at a 30.6% success rate and 57.1 of the nests hatched at least one chick.

California least terns nested at five areas within the salt works, all near the center of the pond complex. A total of 42 nests were initiated and 77 eggs were laid with a mean clutch size of 1.83 $\pm$ 0.44 SD. Twenty-one of the 77 eggs hatched (27%).

A maximum of 225 Forster's tern nests were observed during this study. The nests occurred in eight areas within the salt works, with the majority of nests (74) occurring on the perimeter road on the last bayside dike of the complex. No nesting by royal terns was observed in 1998 and only a few individuals were seen during the season. Ten pairs were observed in 1993, none in 1994, and 2 in 1997.

In summary, the Western Salt facility is a known nesting ground for a number of water-associated avian species including several threatened and endangered species For this reason, the Western Salt property has been acquired by the U. S, Fish and Wildlife Service as the South San Diego Bay Unit of the San Diego National Wildlife Refuge. Sensitive bird species that occur at the salt works, as well as in other parts of South San Diego Bay, are presented below.

Sensitive Species

Sensitive species are those that have been designated as endangered or threatened by the state or federal government, are candidates for endangered or threatened status, or are considered rare. Information regarding these species is reported in the California Natural Diversity Data Base (CNDDB). For the purposes of this report, species with state or federal status are given primary consideration. Sensitive species potentially occurring in the project vicinity include: light-footed clapper rail, California least tern, western snowy plover, Belding's savannah sparrow, Peregrine falcon, and brown pelican.

Light-footed clapper rail (*Rallus longirostris levipes*)

Status: federally endangered, state endangered
Habitat: Nests in lower salt marsh, particularly cordgrass. May nest in fresh/brackish marshes. Forages along intertidal channels. Requires higher marsh for refuge from high tides.

Description: Light-footed clapper rail populations in South San Diego Bay were first described by Wilbur et al. in 1979. Five individuals were reported by those authors from surveys conducted in late 1977. Annual surveys have been conducted since that time. In 1981, a census of the South Bay area revealed 17 pairs of clapper rails at seven locations: South Bay Marine Reserve (4 pairs), Otay River mouth (3 pairs), E Street Marsh (1 pair), F Street Marsh (1 pair), J Street Marsh (1 pair), Sweetwater River Marsh (5 pairs) and Paradise Creek Marsh (2 pairs). By 1984, there were 10 pairs observed at the seven South Bay locations. From 1984 to 1985, the population plummeted from 554 pairs state-wide to 143 pairs. Data from surveys conducted between 1990-1994 varied from 5 to 8 pairs. Rails were not observed at the F and J Street marshes or the Otay River Marsh during this period. In addition, the population at the South Bay reserve declined from 5 pairs in 1990 to 0 pairs in 1994 (USFWS unpublished data).

California least tern (*Sterna antillarum browni*)

Status: federally endangered, state endangered
Habitat: Barrier dunes and mudflats, tidal channels, lagoons, and nearshore waters.

Description: Surveys of the California least tern in South San Diego Bay were conducted sporadically between 1970 and 1975 and on an annual basis thereafter. There are eight nesting colonies in San Diego Bay including those at Lindbergh Field, the former Naval Training Center, North Island Naval Air Station, Delta Beach, Chula Vista Wildlife Reserve, D Street Fill, Coronado Cays, and the South Bay Salt Works. Least terns have been monitored at the Western Salt facility for several years (1993 to present). Breeding popoulations at the salt works have ranged from a high of 62 pairs in 1993 to 2 pairs in 1970, with no known nesting during the 1982 and 1983 seasons (Terp and Pavelka 1999).

Western snowy plover (*Charadrinus alexandrius nivosus*)

Status: federally threatened, state species of special concern
Habitat: Nest in beach dunes; sandy ocean beaches, margins of lagoons, tidal mudflats. dried mudflats and bare dirt dikes or fills (Unitt 1984).

Description: In 1978, 16 pairs of snowy plover nested at the salt works. In 1993, seven breeding pairs were estimated. Another evaluation of the species' status at the salt works in 1994 reported 76 birds utilizing the site as roosting and foraging habitat (Stadtlander and Konecny 1994); however, one nest was located. In 1997, five nesting attempts were recorded (Terp and Pavelka 1999).

Belding's Savannah sparrow (*Ammodramus sandwichensis beldingi*)

Status: no federal status; state endangered
Habitat: Nest in mid-marsh, in low, pickleweed-dominated vegetation, forage in peripheral areas.

Description: San Diego Bay Belding's savannah sparrow populations have been censused on an irregular basis since the early 1970s. In 1977, 174 pairs were found in San Diego Bay at the following locations: Paradise Creek Marsh (16 pairs); Sweetwater River Marsh (40 pairs); E Street Marsh (18 pairs); and Western Salt Company Salt Works (100 pairs). In addition, six pairs of nesting Belding's savannah sparrow were observed along the Otay River in 1996 (USFWS 1998).

Peregrine falcon (*Falco peregrinus*)

Status: federally endangered, state endangered
Habitat: Coast, mountains, woodlands.

Description. Peregrine falcons are rare to casual visitors to the San Diego area (Unitt 1984). They were formerly a rare breeding resident, but as of 1984 their local breeding population had been extirpated. They are most frequently observed along or near the coast, especially around mudflats, shores or ponds where large numbers of water birds congregate. Peregrine falcons have been observed at the South Bay salt works, Sweetwater River Marsh, Point Loma, and Tijuana Estuary.

California brown pelican (*Pelecanus occidentalis californicus*)

Status: federally endangered, state endangered
Habitat: Open coast, bays, large channels.

Description: Brown pelicans are common throughout San Diego Bay including the South Bay region. They are frequently observed feeding within the cooling channel of the South Bay Power Plant, where they feed primarily on slough anchovy (Merkel & Associates 2000b). During surveys conducted by Macdonald et al.(1990) this species was observed in all but two stations and in all seasons. Pelicans are known to roost in large numbers on the levees salt works.

5.0 South Bay Power Plant

Much of what is known about the biological resources of South San Diego Bay is the direct result of studies conducted to assess the effects of the South Bay Power Plant on the inner bay. A number of studies were undertaken to address three primary factors: 1) the potential adverse effects of discharging thermal effluent on the adjacent habitats and associated biota; 2) potential mortality due to the impingement and trapping of fishes and larger invertebrates at the intake screens of the cooling system; and 3) potential mortality due to entrainment of ichthyoplantkon and invertebrate plankton in the cooling system water.

SDG&E began operation of the South Bay Power Plant in the summer of 1960. At that time, the plant consisted of a single generating unit. A second unit was added in the summer of 1962 and a third in the summer of 1964. The plant is cooled by drawing bay water from an intake channel, circulating that water through the plant, and discharging the thermal effluent to a discharge or cooling channel. The cooling channel is separated from the bay by an earthen dike and the discharge enters the bay at a point approximately 2,000 yards from the plant. With the three original units in operation, the maximum extent of the thermal discharge was confined to radius of approximately 1,500- 2,000 yards from the outer end of the cooling channel, varying considerably with season and tidal cycle (Macdonald et al. 1990).

SDG&E added a fourth generating plant in August 1971. With all four units operating, the maximum extent of the thermal plume was approximately 3,000 yards from the outer end of the cooling channel. In 1989, the maximum intake of the power plant was 600 million gallons per day (MGD) of cooling water. It is assumed that this represents the current capacity of the plant. A description of the cooling process that is utilized in the operation of the South Bay Power Plant is provided below as an introduction to the numerous studies that have been conducted to assess its effects on biological resources.

Each unit is equipped with two once-through cooling water pumps. While the amount of cooling water required depends on the number of units in operation, the approximate combined capacity of the water pumps for all four units is 417,000 gpm (gallons per minute; 601 MGD). Thus, with all pumps operating, this is the maximum amount of cooling water circulating through the plant at one time.

Cooling water is withdrawn from San Diego Bay through a dredged intake channel. The water then passes a series of skimming booms that remove floating material from the flow. Subsequently, cooling water enters one of three intake structures that are located approximately 200 feet from the power plant, on the southeastern edge of San Diego Bay, north of the intake basin.

Units 1 and 2 are served by a common intake structure; units 3 and 4 are served by separate intake structures. Before entering the intake structures, water passes through trash racks and traveling screens and then is pumped through condensers. Debris is periodically removed from the trash racks and sent to a land disposal site. Debris removed from periodic cleaning of traveling screens is washed into a trough that ultimately empties into the discharge basin.

A jetty constructed by SDG&E extends from the northern side of the discharge basin into San Diego Bay (Figure 4). This jetty was constructed to prevent discharged cooling water from being drawn directly back into the intake structures.

The discharge channel consists of the waters bounded by the jetty, a line extending from the southwesternmost end of the jetty to the eastern side of the mouth of the Otay River, the southern shoreline of San Diego Bay, and the shoreline of the discharge basin. It is part of San Diego Bay and is considered waters of the U. S.

Water in the cooling system is chlorinated with sodium hypochlorite in order to control the formation of algae and slime in the condenser tubes. This is accomplished through the injection of sodium hypochlorite solution into the cooling water immediately upstream of the water pumps for each operating unit. Sodium hypochlorite is currently injected at each cooling water pump for 20 minutes at 4-hour intervals. However, this schedule may be adjusted to other duration/frequency combinations to obtain the most effective results from the chlorination. Furthermore, each injection point can be controlled separately. The quantity of sodium hypochlorite injection is determined by the rate of slime and algae formation. Thus, daily chlorination is typically greater in the summer than in the winter.

In 1972-1973, SDG&E conducted a thermal effects study for the South Bay Power Plant as required by the Thermal Plan. In this study, SDG&E concluded that the existing elevated temperature wastes discharge from the South Bay Power Plant had caused no appreciable harm to the aquatic community of San Diego Bay and, therefore, had no significant adverse effects on the beneficial uses of the waters of San Diego Bay.

However, the conclusions of the thermal effects study were made under the premise that the discharge channel was part of the power plant facilities rather than part of San Diego Bay. Thus, the biological impact of physical changes resulting from power plant operation was not considered. From an ecological perspective, the study concluded that in the late summer-fall, high temperatures caused by the elevated temperature of discharged waste had adverse effects on benthic life within the discharge channel in comparison to other parts of San Diego Bay.

Subsequently, a U. S. Environmental Protection Agency (USEPA) review of 18 years (1977-94) of annual summer benthic studies concluded that although the benthic community in the discharge channel typically contained somewhat reduced diversity and abundance of species, the present community was similarly represented at sampling stations outside of the discharge channel. This review determined that elevated water temperatures associated with power plant waste have not resulted in appreciable long-term upward or downward trends in species diversity or abundance. A discussion of the most relevant studies of the effects of thermal discharge on benthic communities is presented below.

Early Studies of the South Bay Power Plant. Initial studies of the effects of the thermal effluent discharge began in 1968 when SDG&E began a large-scale pilot study of the bay habitats adjacent to the South Bay Power Plant (Ford 1968). The primary purpose of the pilot study was to develop information about the South Bay ecosystem and the ecological effects of thermal effluent during the summer months. Specifically, the study attempted to: 1) determine and evaluate the relevant physical conditions of the inner bay; 2) characterize the ecology of the resident bay organisms; 3) assess the biological impacts of thermal effluent on indicator organisms; 4) assess the effects of the thermal effluent on fishes and other bay organisms that might be of aesthetic recreational or commercial value to man; and, 5) predict the future impacts to biological resources of the inner bay from the addition of the fourth generating unit. Standard quantitative methods were used by Ford (1968) to sample for invertebrates and plants associated with bottom sediments in shallow and deeper subtidal habitats (replicate grabs, diver transect counts and quadrat counts); fishes associated with these same habitats (beam trawls, diver transects counts and traps); fishes associated with intertidal habitats (seines); and phytoplankton and zooplankton (Van Dorn bottle and Plankton net samples). Bird surveys were also conducted, as described in Section 4.9.

Ford subsequently conducted two additional studies using the same methods to sample benthic invertebrates, fishes and plants at 11 of the 18 stations surveyed in 1968. These were performed in August 1970 (plants and invertebrates) and in February-March 1971 (plants, invertebrates and fishes; Ford et al. 1970; 1971).

The results of these three studies indicated that, in late summer, thermal effluent discharged from generating units 1-3 had adverse effects on the marine organisms that inhabited the cooling channel, particularly within about 1,000 yards of the point of discharge. However, no significant effects were evident beyond the end of the cooling channel in the outer part of the thermal plume. These impacts appeared to be most severe during the high ambient water temperature conditions of the late summer months and diminished markedly during winter and early spring.

A fourth monitoring study was conducted beginning August 1971, immediately following the addition of the fourth generating unit (Ford at al. 1972). The results of that study indicated that the ecological effects of the expanded operations were essentially the same as those observed during the late summer periods of 1968 and 1970 (Macdonald et al. 1990).

In 1972-1973, a study was undertaken to assess the effects of thermal effluent from the South Bay Power Plant on: 1) the physical and chemical environment of the bay and 2) benthic, marine plants and invertebrates that inhabit intertidal mudflats and subtidal mud bottom habitats of the South Bay (Ford and Chambers 1973, 1974; Chambers and Chambers 1973). Standardized quantitative

methods developed in earlier studies to assess biological, physical and chemical constituents were employed at 18 subtidal and seven intertidal stations. Sampling was conducted quarterly. Evidence regarding the effects of thermal discharge were assessed on the basis of: 1) differences in species composition; 2) number and diversity of species; 3) distribution, abundance and biomass of species and major taxonomic groups; 4) size of individuals, and 5) the quantitative relationships of these to temperature and other environmental factors.
Similar to the earlier studies of the thermal discharge, evidence from both intertidal and subtidal sampling suggested that elevated water temperatures caused by the thermal discharge had adverse impacts to bay organisms that inhabited the cooling channel, particularly in late summer and early autumn. These effects were much reduced during the winter and spring periods when ambient water temperature dropped and the temperature of the thermal plume lower. During all seasons however, the adverse effects appeared to be confined primarily to the inner portions of the cooling channel. The overall conclusion by Ford and Chambers (1974) was that the thermal effluent from the South Bay Power Plant had no major adverse effects on the benthic communities beyond the end of the cooling channel and that operation of the plant was not a detriment to these communities during the 1968-1973 period.

NPDES Monitoring of the South Bay Power Plant. In 1977, annual monitoring of the effects of the thermal effluent plume from the South Bay Power Plant was resumed in order to comply with NPDES permit requirements. This monitoring focused on benthic infauna based on the results of earlier studies which showed that sedentary benthic organisms, as opposed to more motile forms such as fishes, were the best indicators of environmental change through time and could be easily studied. Consequently, 11 of the benthic invertebrate stations sampled by Ford and Chambers (1973, 1974) were sampled each August. These NPDES studies employed essentially the same methods as Ford and Chambers (1974) for collecting biological, physical and chemical data.

NPDES monitoring was performed by Lockheed Center for Marine Research from 1977 to 1981. A variety of consultants conducted the sampling from 1982 through 1988, the last year of data presented in Macdonald et al. (1990). Detailed analysis by Lockheed of all of the monitoring data collected between 1977 and 1980 revealed that there were no significant adverse ecological effects caused by the operation of the South Bay Power Plant at any locations outside of the cooling water channel. Sampling stations located immediately within the main flow of the thermal effluent within the cooling channel and nearest to the point of discharge had considerably different chemical, physical and biological characteristics than did those of all other stations. Lockheed concluded that these differences could be attributed to variations in both temperature and sediment grain size. Some of the variation in sediment grains may be explained by high thermal effluent flow rates in the cooling channel.

Following the Lockheed studies, NPDES monitoring was conducted by Woodward-Clyde Consultants (1982-1983), Westec Services (1984), CH_2M Hill and Marine Ecological Consultants (1985), and Kinnetic Laboratories (1986-1989) These consulting firms reached the same conclusions, i.e. that the operation of the South Bay Power Plant has had not significant adverse ecological effects on the benthic invertebrate fauna of South San Diego Bay.

In 1979-1980, SDG&E conducted a large-scale demonstration study of the cooling water intake system of the South Bay Power Plant. This demonstration was done in order to meet the requirements of Section 301(b) of the Federal Water Pollution Act Amendments of 1972. The project focused on the hydrographic characteristics, bathymetry and current patterns. The probabilities of entrainment of plankton by the cooling water system were estimated, based on dye marker studies.

Entrainment of invertebrate zooplankton and ichthyoplankton were evaluated for different periods of the 24-hour cycle. Impingement and trapping of fishes and larger invertebrates within the intake structure of the power plant was also evaluated. Both entrainment and impingement were evaluated in relation to tidal cycle and season.

The basic conclusion of the study was that the impacts of both entrainment and impingement by the cooling system of the South Bay Power Plant had no significant ecological effects on the plankton and adult fishes of South San Diego Bay.

As part of the NPDES renewal process in 1996, Merkel & Associates (2000b) conducted a characterization of the fish community of the cooling water discharge channel at the South Bay Power Plant. The study was designed to complement the 1994-1999 study of the fishes of San Diego Bay (Allen 1999). Accordingly, similar methods were utilized including quarterly collection of fishes using a large beach seine, small beach seine, square enclosure, beam trawl, purse seine and otter trawl. Three replicate collected were made at each sampling area for each type of gear. Quarterly sampling was conducted from April 1997 through January 2000. (Effective April 23, 1999, the South Bay Power Plant was sold to the San Diego Unified Port District, and Duke Energy South Bay LLC became the plant operator.)

A total of 176,414 fish representing 38 species were collected during the three year study with samples dominated numerically by slough anchovy. Slough anchovy represented between 14.4% and 99.4% of the total individuals collected each quarter. Overall, this species accounted for 91.4% of all fish captured during the three year period. Deepbody anchovy was second in terms of individuals, comprising 1.4% of the total individuals collected during the study. Round stingray comprised 1.1% of the total individuals collected. Topsmelt comprised 1% of the total catch.

While anchovy dominated the numbers of fish captured, sharks and rays accounted for more than 76% of the total weight of fish captured. The majority of this weight was attributed to the round stingray. Slough anchovy accounted for only 10% of the total weight of fish collected.

The mean biomass of fishes collected for the three-year study was calculated to be $5.48 g/m^2$. Biomass was calculated as the total weight of fish captured per unit area sampled. By comparison, the mean biomass calculated by Allen (1999) for the entire bay was $2.03 g/m^2$.

Merkel & Associates concluded that the cooling channel supports a diverse fish community that is highly productive in terms of fish biomass. The discharge channel provides a year-round foraging base for picivorous birds, including California least tern and California brown pelican. Based on the results of this study, slough anchovy comprise the primary prey of these and other bird species. The authors argue that the 38 species collected during this study could not be directly compared to the 78 species collected by Allen (1999). Furthermore, the authors propose that the unique thermal environment of the discharge channel may provide a warm water refuge for some bay species during the winter but may preclude other species from using the area during the warmest summer months.

Merkel & Associates (2000a) also conducted a two-year assessment of the effects of discharged thermal effluent on eelgrass distribution in the area of the South Bay Power Plant. Like the assessment of fish populations, this study was conducted as part of the NPDES renewal in 1996. It was initiated by the apparent correlation of the lack of eelgrass beds in the vicinity of the power plant and the thermal discharge from the plant.

The study documented physical environmental factors within and outside of existing eelgrass communities. Paired monitoring stations were established so that data on temperature, turbidity, light, salinity and dissolved oxygen could be collected simultaneously and statistical comparisons could be made. During the course of the study, a strong El Niño event occurred that may have confounded some of the results. Eelgrass disappeared over much of the study site during this period only to reestablish later in the study.

Merkel & Associates (2000a) concluded that there were significant and persistent differences between light environments found within eelgrass habitats and outside eelgrass habitats. Greater amounts of usable daily photosynthetically active radiation (PAR) occurred within eelgrass beds than outside of them. These differences persisted even when eelgrass had disappeared from a station where it had occurred previously. This finding suggested that the differences in light environment was intrinsic to the physical environment, not the result of environmental modification by eelgrass occurrence. Temperature was not found to be a determining factor in eelgrass occurrence. The highest temperatures recorded during the survey were those taken within eelgrass beds compared to temperatures taken outside of the eelgrass beds. In addition, the mean temperature for all sampling stations combined was also relatively high within eelgrass areas. The authors further concluded that the thermal discharge from the South Bay Power Plant does not have a significant effect on eelgrass distribution within the South Bay. As discussed previously, light environments appear to control eelgrass distribution; however, many of the specific factors dictating light environment are not fully quantifiable and also may interact with each other.

The El Niño event was determined to have suppressed light levels within the South Bay as a direct result of sea level rise. At the peak of the El Niño event, sea level rose by as much as 1.25 feet beginning in September 1997. This rise in sea level was paralleled by a decline in light levels measured at all stations for this study.

McDonald et al. (1994) conducted a focused survey of the sea turtles potentially affected by thermal effluent discharge of the South Bay Power Plant. The results of this study have been included in the general discussion of sea turtles, presented earlier. That study did not specifically address the effects of the thermal discharge on the turtles nor the implications of increasing, decreasing, or interrupting the discharge of thermal effluent.

6.0 Conclusions

As has been demonstrated above, numerous studies have been conducted of the effects of discharging thermal effluent to the receiving waters of the South Bay. There do not appear to be data gaps regarding this issue. These studies have all concluded that any adverse effects of the thermal discharge have been confined to the cooling channel. During summer and early autumn, these adverse effects extend to the outer limits of the cooling channel. Thermal effects are much reduced during winter and spring when they are confined to the inner reaches of the cooling channel. The Regional Water Quality Control Board historically accepted the cooling channel as part of the plant, not the greater bay, and therefore, has permitted these activities in the past. No modifications to the plant operation and thermal discharge are proposed under the current NPDES renewal. Thus, no adverse effects, beyond those identified within the plant's cooling channel, are expected from continuing the operation of the plant.

Some questions remain regarding the direct and indirect impact of the plant on the new South Bay Unit of the San Diego National Wildlife Refuge. While the power plant and the salt ponds have co-existed since 1960, planning for the new refuge has yet to be completed. Such planning may include restoration options that would place the power plant and the refuge in conflicting positions. For example, restoration that includes breaching of salt ponds near the cooling channel may impact both the temperature of the water within the newly breached pond and the recirculation of water warmed by the thermal discharge. In addition, if the plant is modified, the fate of the green sea turtle population is unknown. Careful coordination between USFWS Refuges and the power plant operators is essential in avoiding or minimizing these potential impacts.

7.0 Literature Cited

Allen, L. 1999. Fisheries Inventory and Utilization of San Diego Bay, San Diego, California. Final Report. Sampling Periods July 1994 to April 1999. Nearshore Marine Fish Research Program, Department of Biology, California State University, Northridge. September.

Chambers, R. W., and Chambers, R. I. 1973. Thermal distribution and biological studies for the South Bay Power Plant. Final Report. Thermal Measurements. Environmental Engineering Laboratory Technical Report on Contract P-25072. Vols. 4A & 4B.

Eigenmann, C. H. 1892a. The fishes of San Diego, California. Proceedings of the U. S. National Museum 15:123-178.

Eigenmann, C. H. 1892b. Viviparous fishes of the Pacific Coast of North America. Bull. U. S. Fish Com. 12:381-478.

Eigenmann, C. H., and Eigenmann, R. S. 1890. Additions to the fauna of San Diego. Proceedings of the California Academy of Sciences 2nd Ser. 3:1-24.

Eigenmann, C. H., and Eigenmann, R. S. 1892. A catalog of the fishes of the Pacific Coast of North America, north of Cerros Island. Annuals of the New York Academy of Sciences 6:349-358.

Ford, R. F. 1968. Marine organisms of South San Diego Bay and the ecological effects of power station cooling water. A pilot study conducted for the San Diego Gas & Electric Co., San Diego. Environmental Engineering Laboratory Tech. Rept. on Contract C-188. 278 pp.

Ford, R. F., R. L. Chambers, and Merino, J. M. 1970. Ecological effects of power station cooling water in South San Diego Bay during August 1970. Prepared for the San Diego Gas & Electric Co., San Diego. Environmental Engineering Laboratory Tech. Rept. on Contract C-821. 52 pp.

Ford, R. F., R. L. Chambers, and Merino, J. M. 1971. Ecological effects of power station cooling water in South San Diego Bay during February-March 1971. Prepared for the San Diego Gas & Electric Co., San Diego. Environmental Engineering Laboratory Tech. Rept. on Contract C-821. 92 pp.

Ford, R. F., R. L. Chambers, and Merino, J. M. 1972. Ecological effects of power station cooling water in South San Diego Bay during August 1972. Prepared for the San Diego Gas & Electric Co., San Diego. Environmental Engineering Laboratory Tech. Rept. on Contract C-821. 50 pp.

Ford, R. F., and Chambers, R. L. 1973. Thermal distribution and biological studies of the South Bay Power Plant. Vols. 5A & 5B. Biological Measurements. Prepared for the San Diego Gas & Electric Co., San Diego. Environmental Engineering Laboratory Tech. Rept. on Contract P-25072. 509 pp.

Ford, R. F., and Chambers, R. L. 1974. Thermal distribution and biological studies for the South Bay Power Plant. Vol. 5C. Biological Studies. Final Report. Prepared for the San Diego Gas & Electric Co., San Diego. Environmental Engineering Laboratory Tech. Rept. on Contract P-25072. 180 pp.

Hoffman, R. S. 1986. Fishery utilization of eelgrass (Zostera marina) beds and non-vegetated shallow water areas in San Diego Bay. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Region, Administrative Report SWR 86-4. 29 pp.

Jurek, R. M. 1973. California shorebird study: accelerated research program for shore and upland migratory game birds. State of California Department of Fish and Game. South San Diego Bay salt ponds. 233 pp. plus appendix.

Macdonald, K. B., R. F. Ford, E. B. Copper, P. Unitt and J. P. Haltiner. 1990. South San Diego Bay Enhancement Plan. Volumes 1-4. Prepared for the San Diego Unified Port District and the California State Coastal Conservancy. Michael Brandman Associates, Inc. March.

McDonald, D., P. Dutton, D. Mayer and K. Merkel. 1994. Review of the green turtles of South San Diego Bay in relation to the operations of the SDG&E South Bay Power Plant. Doc. 94-045-01. Prepared for San Diego Gas & Electric Co., C941210311. San Diego, CA.

Merkel & Associates. 2000a. Environmental Controls on the Distribution of Eelgrass (*Zostera marina* L.) in South San Diego Bay: An Assessment of the Relative Roles of Light, Temperature, and Turbidity in Dictating the Development and Persistence of Seagrass in a Shallow Back-bay Environment. January.

Merkel & Associates. 2000b. South Bay Power Plant Cooling Water Discharge Channel Fish Community Characterization Study, April 1997 through January 2000, Final Report. June.

Los Peñasquitos Lagoon Foundation. 1985. Los Peñasquitos Lagoon Enhancement Plan and Program. 119 pp.

San Diego Gas and Electric (SDG&E). 1980. South Bay Power Plant cooling water intake system demonstration (in accordance with Section 316(b), Federal Water Pollution Control Act Amendment of 1972). Prepared by San Diego Gas & Electric Co. and the Lockheed Center for Marine Research, San Diego, for the San Diego Regional Water Quality Control Board.

Stadtlander, D., and Konecny, J. 1994. Avifauna of South San Diego Bay: the Western Salt Works 1993-1994.

Terp, J. M., and Pavelka, M. 1999. Summary of Colonial Seabird Nesting at Western Salt Company, San Diego Bay, California, 1998 Season. U. S. Fish and Wildlife Service.

Stinson, M. L. 1984. Biology of sea turtles in San Diego Bay and in the northeastern Pacific Ocean. M. S. Thesis. San Diego State University. San Diego, CA.

Unitt, P. 1984. The Birds of San Diego County. Memoir 13. San Diego Society of Natural History.

U. S. Fish and Wildlife Service (USFWS). 1999. Environmental Assessment and Land Protection Plan South San Diego Bay Unit and Stewardship Project, San Diego National Wildlife Refuge, San Diego County, California. March.

Williams, G. D., and Zedler, J. B. 1999. Fish Assemblage Composition in Constructed and Natural Tidal Marshes of San Diego Bay: Relative Influence of Channel Morphology and Restoration History. Estuaries Vol. 22, No. 3A, p. 702-716. September.

Zedler, J. B. 1982. The ecology of southern California coastal salt marshes: a community profile. U. S. Fish and Wildlife Services Program, Washington, D. C. FWS/OBS-81-54. 110 pp.