6.6A MARINE BIOLOGICAL RESOURCES

This section evaluates the marine biological resources at and in the vicinity of the Morro Bay Power Plant (MBPP) and the effects of the Project on those resources. This evaluation addresses requirements of many federal and state laws, ordinances, and standards. Findings from current intake and discharge studies will form the basis for renewal of the plant's National Pollutant Discharge Elimination System (NPDES) permit issued by the Regional Water Quality Control Board (RWQCB). Terrestrial tropical resources are evaluated in Section 6.6B of this Application for Certification (AFC).

The section also provides current information on the existing habitats gathered from studies conducted in the vicinity of the MBPP as required by the California Energy Commission's (Commission) AFC process and discusses the potential effects of the modernization Project on the biological resources.

The MBPP is an existing power production facility that has been in operation since the early 1950s. During its 50-year operation, extensive environmental monitoring has occurred, and no significant impacts to biological resources or to beneficial uses have been reported from operation of the plant. The RWQCB permitted and continuously reviewed (every 5 years) the existing facility's cooling water system intake and discharge by issuance of a NPDES permit. Results of these 5-year reviews by the RWQCB have repeatedly found that the cooling water intake system (CWIS) represents best technology available and that the discharge protects the receiving water's beneficial uses. As required by the RWQCB, the applicant has repeated a number of previous studies relevant to the issuance of a new NPDES permit. These contemporary studies are focused on issues of potential discharge effects in Estero Bay and the impingement and entrainment of Morro Bay marine at the facility's intake. The year-long impingement study has been completed as well as 9 months of the planned 12-month entrainment study. Results from all of these recent studies have been incorporated in this sections impact assessment of the project's reduced intake and discharge volumes.

The evaluation presented in this section responds to requirements of the Federal Clean Water Act Sections 316(a)[(1)(2)] and (b),[(3)] the State Thermal Plan,[(4)] the Ocean Plan,[(5)] the Endangered Species

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(1) Section 316(a); 33 United States Code (USC) §1326 - Thermal Discharges. The administering agency for the above authority is the Central Coast RWQCB with oversight provided by U.S. Environmental Protection Agency (EPA) Region IX.

(2) Section 402; 33 USC §1326; 40 Code of Federal Regulations (CFR) Part 316(a). This federal permit requirement is administered by the Central Coast RWQCB, with oversight provided by EPA Region IX.

(3) Section 316(b); 33 USC §1326 – Cooling Intake Structures. The administering agency for the above authority is the Central Coast RWQCB with oversight provided by EPA Region IX.

(4) Water Quality Control Plan for Control of Temperature in Coastal and Interstate Waters and Enclosed Bays and Estuaries of California (Thermal Plan), Appendix A-3. The plan was established in conjunction with 40 CFR 316(a) for thermal discharges. It is administered by the Central Coast RWQCB.

Act,[6][7] the Migratory Bird Treaty,[8] the Coastal Zone Act,[9] and other laws,[10][11] regulations, ordinances, and standards (LORS).

Biological Benefits of the Modernization Project

Use of the existing MBPP as the site for the Project presents significant opportunities to avoid impacts to biological resources normally associated with use of a greenfield location. This is because MBPP is an existing active industrial site, onsite habitats are highly disturbed, and onsite biological resources are minimal. In addition, this analysis reflects the results of studies of impacts on marine resources from ongoing operations that would be impossible to provide for a greenfield site. The power plant's existing discharge thermal plume has been extensively studied at peak power plant loads and varying receiving water conditions. Contemporary plume monitoring data (Section 6.5) and biological studies are used to verify the past studies and to project the benefits of the Project's reduced discharge on the distribution and dispersion of the discharge plume and associated thermal effects. Several key aspects discussed in this section demonstrate the benefits of the MBPP Project from the perspective of avoiding impacts to biological resources and include:

- An approximately 29 percent reduction in intake pump capacity directly reduces the entrainment effects of present operations. With its smaller volume, the modernized facility's discharge plume will mix more rapidly, become buoyant and separate from the ocean bottom in a shorter distance from the point of discharge. As a result of its smaller size, the modernized facility's thermal plume will contact less linear distance of shoreline than the historical plume present when past biological impact assessments were conducted.
- The Project's slower intake velocities will reduce the risk of impinging organisms on the intake screens.

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(5) California Water Code §13269; 23 California Code of Regulations (CCR) Chapter 9. Clean Water Act §402(p) and implementing regulations at 40 CFR Parts 122 seq., as administered by the Central Coast RWQCB. The administering agency for the above authority is the Central Coast RWQCB.

(6) Endangered Species Act of 1973; 16 USC §1531 et seq.; 50 CFR Parts 17 and 222. The administering agency for the above authority for terrestrial and avian species is the United States Fish and Wildlife Service (USFWS).

(7) California Endangered Species Act of 1984; California Fish and Game Code §2050-2098. Animals of California declared to be endangered or threatened are listed at 14 CCR §670.5. The administering agency for the above authority is the California Department of Fish and Game (CDFG).

(8) Migratory Bird Treaty Act; 16 USC §703-711; 50 CFR Subchapter B. The administering agency for the above authority is the USFWS.

(9) California Coastal Act of 1976. The administering agency is the California Coastal Commission.

(10) California Porter-Cologne Water Quality Control Act 1972; California Water Code §13000-14957; Division 7, Water Quality. The Project will comply with the regulations set forth in this act. The administering agency for the above authority is the Central Coast RWQCB.

(11) California PRC §25523(a); 20 CCR §1752, 1752.5, 2300-2309, and Chapter 2, Subchapter 5, Article 1, Appendix B, Part (I). The administering agency for the above authority is the Commission, with comment provided by CDFG.

- The Project's smaller discharge will further reduce the potential risk of the discharge coming back onshore south of Morro Rock and entering Morro Bay. The results of past MBPP thermal plume studies demonstrate the absence of any possible thermal effects on Morro Bay habitats. Current thermal plume dispersion studies temperature monitoring data verify these past findings.
- The Project's smaller discharge will further reduce the potential risk of temperature effects from the discharge on the area's subtidal habitats (benthos). Because the Units 1 through 4 thermal plume is primarily a surface phenomena, benthic habitat deeper than 5 meters (16 feet) is not contacted beyond the discharge area. Moreover, prior studies of the benthos found no significant impact on this habitat under similar plume conditions to that projected for the Project. These earlier findings are being updated by a contemporary (September 2000) resurvey of the sites.
- The Project's existing NPDES intake finding of Best Technology based on previous impingement studies is confirmed by the results of the completed 1999-2000 impingement studies. Few differences were found between the species composition of impinged fishes collected in the late 1970s and today, based on the results of recent 1999-2000 surveys. Results of contemporary surveys of the facility's CWIS impingement are used in comparison to these past surveys and used to project impacts of the modernized facility's CWIS.
- Use of the existing once-through cooling water intake and discharge structures at MBPP avoids new construction-related impacts to aquatic resources. The facility's once-through cooling water system also returns organisms that are entrained and impinged to the receiving water. The entrainment study (316(b) Resource Assessment Study) is designed to evaluate potential effects of the CWIS on populations as a part of the NPDES permit.
- Use of state-of-the-art combined-cycle technology for the Project reduces design seawater intake volumes and approach velocities through the existing intake structures as part of the Project, thereby reducing entrainment losses by an estimated 29 percent or more, depending on operating mode, and minimizing impingement rates of juvenile and adult fishes and shellfish.

Marine Biology

Information to conduct an assessment of Project impacts on marine biological resources for the AFC is available in a wide range of specific MBPP impact studies, some more recent than others. Without losing the valuable information from previous MBPP impact studies, a Technical Working Group (TWG) of regulatory agency representatives and independent scientists decided that contemporary studies should be conducted. Under the direction of the Project's TWG representing the Commission, the RWQCB, the CDFG, and the California Coastal Commission, studies of the intake and discharge were designed and undertaken. These studies were designed to update baseline conditions, verify previous findings and conclusions, and provide information to be used for issuance of the Project's

NPDES permit. The study plan developed to evaluate the modernized facility's potential intake effects is attached as Appendix 6.6A-1 (Cooling Water Intake Study Plan). The study plan describing the thermal plume characteristics and biological thermal effects studies conducted in the vicinity of the plume are included in Appendix 6.5-1 (Thermal Discharge Study Plan).

A large body of information regarding the marine resources that might be affected by the Project has been collected in intensive field surveys over the past 15 months. Findings of these contemporary studies complete an update of previous marine habitat and resource assessments within a mile of the Project and provide an adequate basis to assess potential cooling water system (CWIS) impacts of the modernized MBPP. Categorically, the impacts of the Project's proposed CWIS are those impacts associated with the intake of seawater for heat exchange and the discharge of the heated seawater. Details of the CWIS intake and discharge facility descriptions, the volumes of cooling water withdrawal and discharge, and discharge water quality, particularly temperature, are presented in Chapter 2.0 - Project Description and Section 6.5 - Water Resources.

Recent studies of the effects of the cooling water system have been completed or are well underway. A 12-month impingement study was completed on September 8, 2000 and a year-long entrainment study will be completed in early December 2000. A qualitative survey of the rocky intertidal area of Morro Rock was completed in August 1999 and a survey designed to assess the effects of the discharge was conducted in mid-September 2000. A sand beach fauna survey near the MBPP discharge was completed in August 2000, and subtidal benthic samples were collected in September 2000. A summary of recent and past aquatic biological resource studies conducted at or in the vicinity of the MBPP is shown in Table 6.6A-1. A map showing the locations of the algal, fish, and invertebrate study locations is presented as Figure 6.6A-1.

Power Plant Intake and Discharge

The existing and modernized MBPP intake and discharge systems are shown schematically in Figures 6.6A-2 and 6.6A-3, respectively. An elevation view of the shoreline intake structure is presented in Figure 6.6A-4. The peak cooling water intake and discharge water flows of the existing facility (464,000 gallons per minute [gpm]) are reduced by approximately 29 percent for the Project (330,000 gpm). The existing facility's maximum intake and discharge volume is somewhat less than the designed peak (490,000 gpm) due to degradation of the pumps (see Section 6.5 - Water Resources). The results of thermal discharge and intake impingement studies conducted during contemporary and past MBPP operations that were comparable to

TABLE 6.6A-1

AQUATIC RESOURCE STUDIES BY HABITAT TYPE CONDUCTED IN THE VICINITY OF THE MBPP

HABITAT TYPE	STUDY TYPE	TYPE OF SAMPLING CONDUCTED	SOURCE	DATE
Morro Bay				
Subtidal channels	Abundance and composition of fishes and invertebrates	Otter trawls	CDFG	1992-1999
	Abundance and composition of fishes	Otter trawls, seines, dip nets, hook and line, spearfishing	Fierstine	1968-1970
Intertidal mudflats	Abundance and composition of fishes	Bag seines	Horn	1974-1976
		Otter trawls, seines, dip nets, hook and line, spearfishing	Fierstine	1968-1970
Submerged aquatic vegetation	Abundance and composition of plant species	Vegetation Survey	Chestnut	1999
	Abundance and composition of fishes	Bag seines	Horn	1974-1976
Coastal salt marsh	Abundance and composition of plants	Vegetation Survey	Jarque	1998
Brackish marsh	Abundance and composition of plants	Vegetation Survey	Jarque	1998
Rocky intertidal/shallow subtidal	Habitat characterization	Intertidal algae and invertebrate surveys, bird surveys	SOCAL	1973
Open water	Intake effects on larval fishes and megalopal cancer crab	Entrainment and source water plankton tows	Tenera	June 1999-December 2000
	Intake effects on juvenile and adult fishes and macroinvertebrates	Impingement collections	Tenera	September 1999-September 2000
	Abundance and composition of fishes and invertebrates	Otter trawls	CDFG	1992-ongoing
	Intake effects on juvenile and adult fishes and macroinvertebrates	Impingement collections	PG&E	1978-1979

TABLE 6.6A-1

AQUATIC RESOURCE STUDIES BY HABITAT TYPE CONDUCTED IN THE VICINITY OF THE MBPP (CONTINUED)

HABITAT TYPE	STUDY TYPE	TYPE OF SAMPLING CONDUCTED	SOURCE	DATE
Estero Bay				
Sandy Beach Intertidal	Thermal Effects	Sand beach fauna surveys	Tenera	August 2000
	Habitat Characterization	Sand beach bird and fauna surveys	Dugan Minerals Management Services (NOAA)	1998-Ongoing
	Abundance and Distribution	Pismo clam surveys	CDFG	1945-Ongoing
	Habitat Characterization	Sand beach fauna surveys	SOCAL	1973
	Thermal Effects	Sand beach fauna surveys	Adams et al.	1971-1972
Sandy–Mud Subtidal	Thermal Effects	Subtidal benthic grab sampling and fish observations	Tenera	September 2000
	NPDES monitoring of benthic infauna	Subtidal benthic grab	Morro Bay/Cayucos Sanitary District	1985-ongoing
	Thermal Effects	Angler use and catch composition surveys	Steitz	1974
	Thermal Effects	Subtidal benthic grab sampling, otter trawls, and gill net sets	PG&E	1971-1972
Rocky Intertidal	Thermal Effects	Algal and invertebrate surveys and fish observations	Tenera	August 1999 and September 2000
	Thermal Effects	Angler use and catch composition surveys	Steitz	1974
	Habitat Characterization	Algal and intertidal surveys	SOCAL	1973
	Thermal Effects	Algal and invertebrate surveys and fish observations	PG&E	1972
	Thermal Effects	Algal and invertebrate surveys	North	1967-68
Rocky Subtidal	Thermal Effects	Algal and invertebrate surveys and fish observations	Tenera	August 1999 and September 2000
	Thermal Effects	Angler use and catch composition surveys	Steitz	1974
	Thermal Effects	Algal and invertebrate surveys and otter trawls and gill net fish surveys	PG&E	1972
	Thermal Effects	Algal and invertebrate surveys	North	1967-68
Kelp Beds(1)				
Open Water	Thermal Effects	Otter trawls and gill net fish surveys	PG&E	1972

(1) There are no kelp beds within the immediate vicinity of the MBPP. We did not find any studies of the kelp beds to the north of the MBPP.

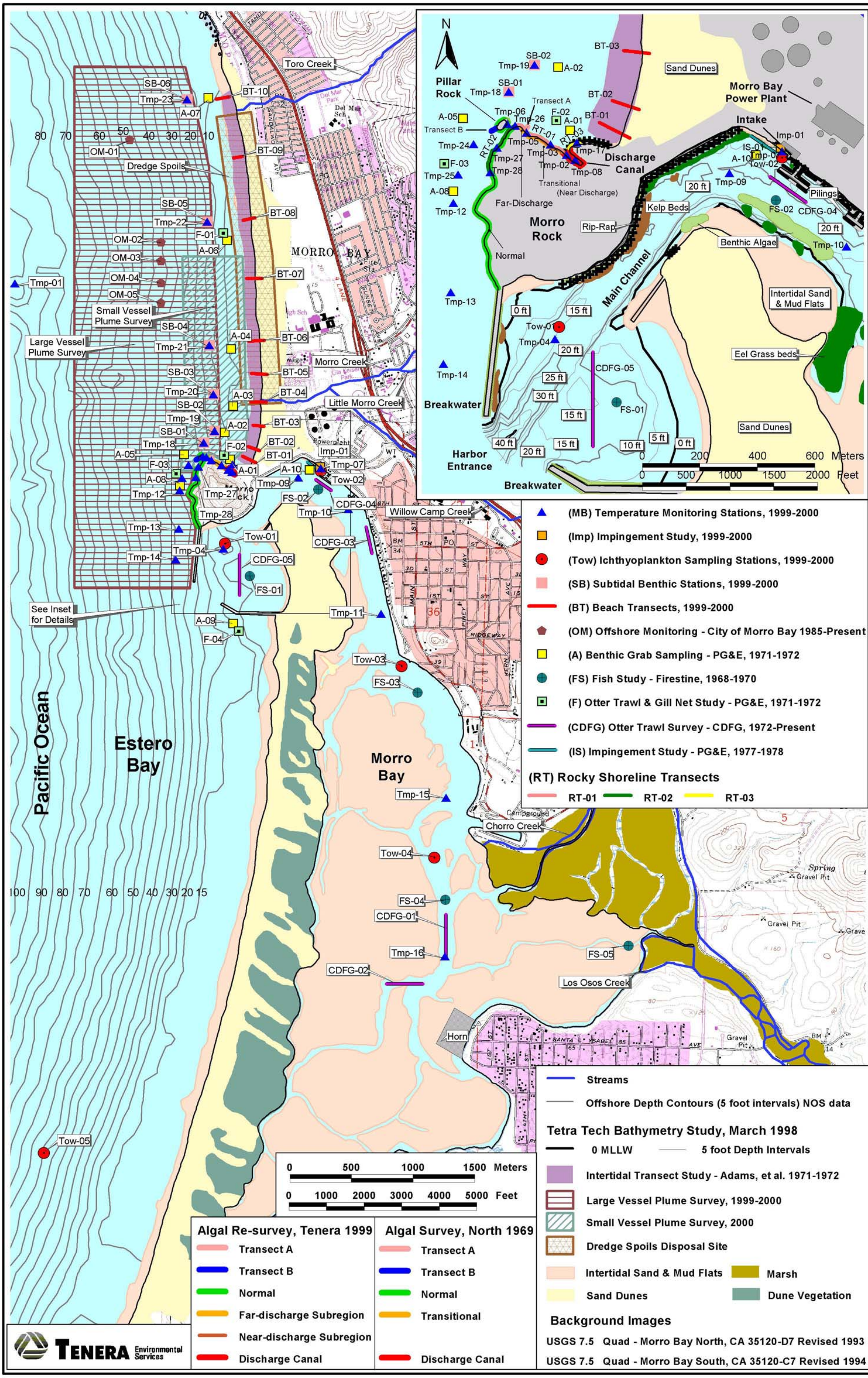


Figure 6.6A-1. Map of current and previous aquatic biological studies in the vicinity of the MBPP.

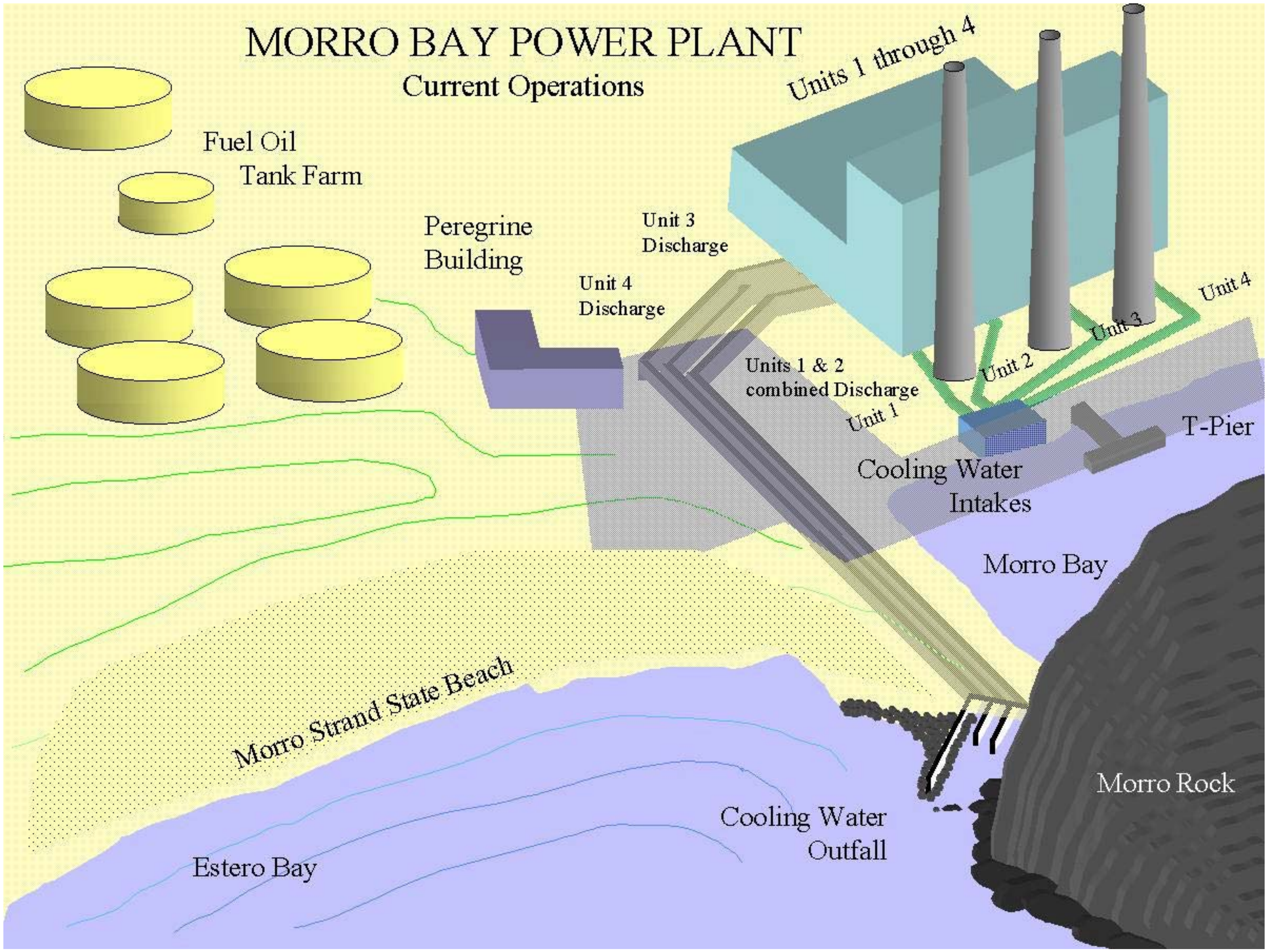


Figure 6.6A-2. Existing MBPP cooling water intake and discharge systems.

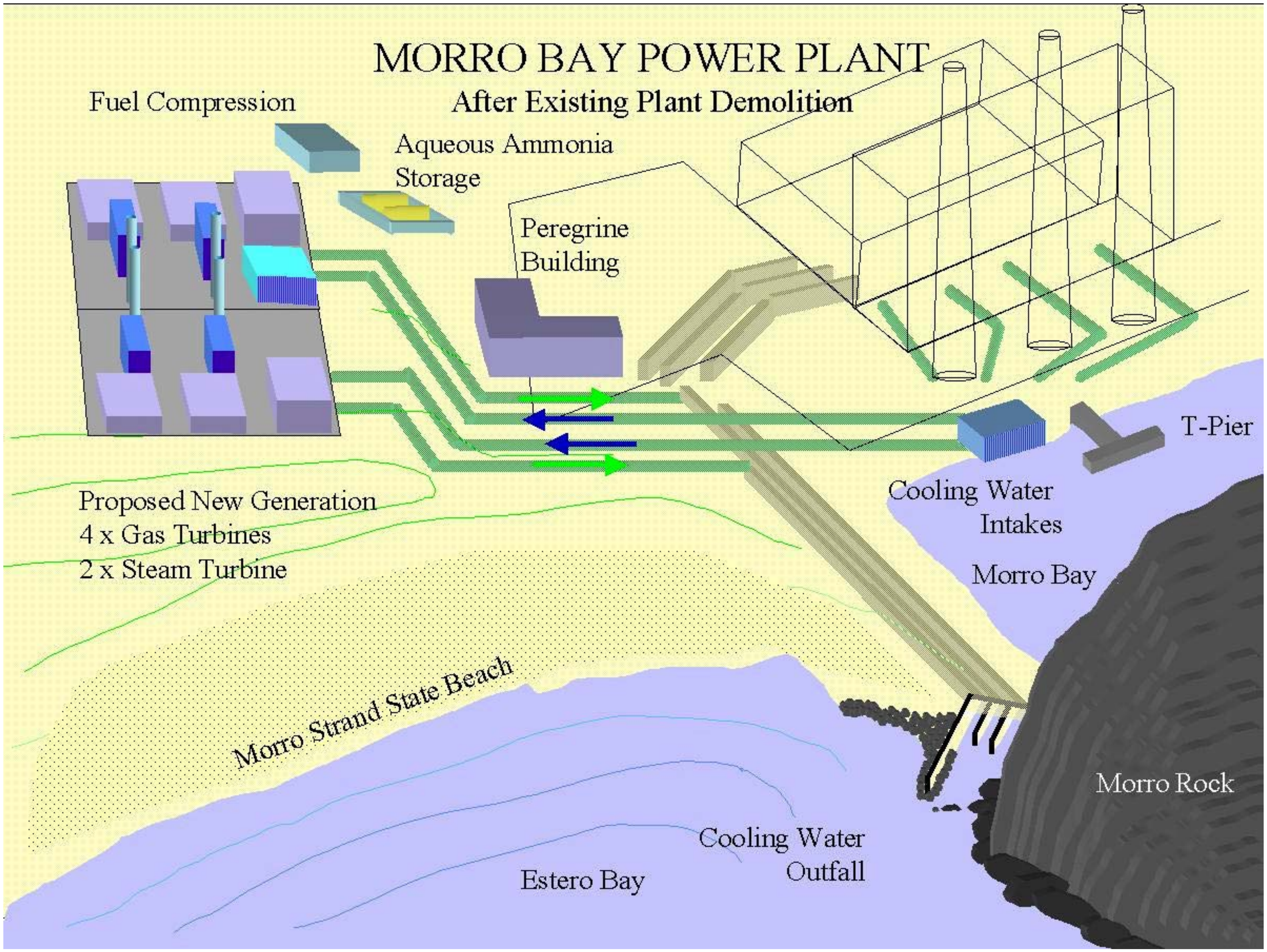


Figure 6.6A-3. Modernized MBPP showing the cooling water intake and discharge systems.

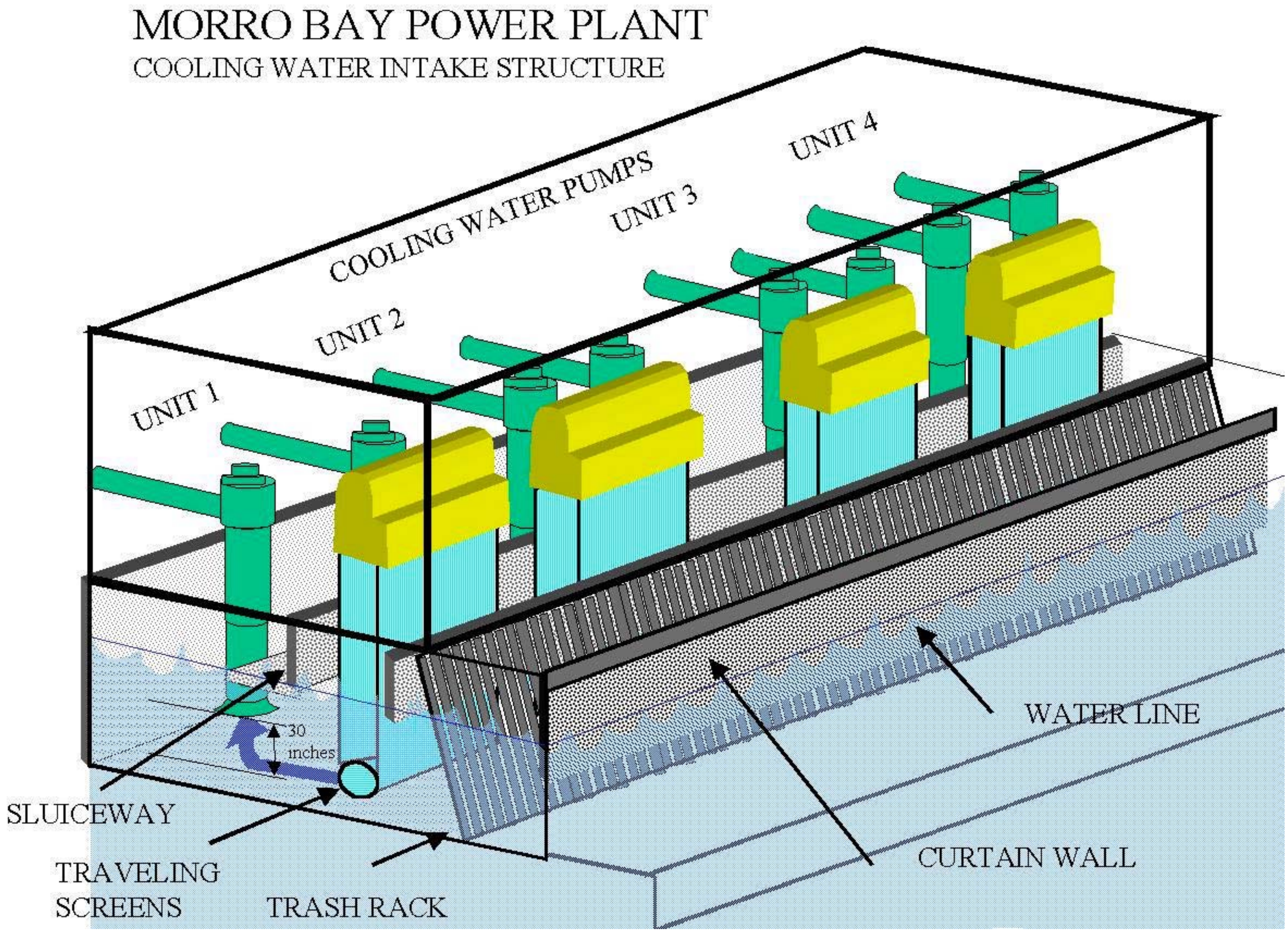


Figure 6.6A-4. MBPP intake structure (isometric view).

projected facility operations were used to assess and forecast modernized facility cooling water system impacts. The Project's reduced cooling water volume will entrain fewer larval fishes and shellfish than the existing facility and will also result in a smaller discharge plume that will reduce the potential thermal effects. The Project's lower intake approach velocities will reduce impingement rates.

CWIS impacts can potentially affect several different components of the MBPP Project's surrounding biological resources. The Project's CWIS will withdraw cooling water through the existing facility's two adjacent intake structures (Units 1 and 2 and Units 3 and 4; Figure 6.6A-3). Not only does the modernized facility significantly reduce design intake volume, the "approach to bar rack" velocities are also reduced (Section 6.5 - Water Resources). Designed approach velocities at the new combined-cycle unit during peak load and maximum water withdrawal conditions. This velocity meets current Federal recommendations for the design of intake velocities and is expected to further reduce impingement losses of the existing intake.

Even with this reduction in approach velocities, fishes and shellfish larger than the 3/8-inch screen mesh that are weak swimmers or otherwise unable to avoid the traveling screens will be impinged. Other smaller organisms, such as larval fishes and crabs, will be entrained through the screens in the cooling water flow. Entrained and impinged organisms are returned to Estero Bay through the discharge system.

The heated CWIS discharge creates a buoyant surface-plume of seawater that is carried by winds and currents north into Estero Bay. Although the volume of the discharge will be approximately 29 percent smaller than presently permitted, the thermal plume will still contact the shoreline beach and Morro Rock in the vicinity of the shoreline discharge structure (see Figures 6.5-20 through 6.5-24 in Section 6.5 - Water Resources). Previous studies have reported little to no effect of the power plant's thermal discharge on receiving water's fish and invertebrates populations. The more thermally sensitive species of attached algae along Morro Rock's shoreline have exhibited changes in species composition associated with warmed seawater temperatures, most notably in the immediate vicinity of the discharge structure. The extent of these existing discharge effects will be reduced by the modernized facility's relative reductions in discharge volume.

1999-2000 Intake Studies

Studies of the effects of the MBPP intake began in 1999. A 12-month (September 1999 to September 2000) survey of the numbers and kinds of organisms impinged at the existing MBPP intake has been completed. The study's results are summarized in AFC Section 6.6.A.2.1.1 and presented in Appendix 6.6A.2. The study's results are used in the AFC to both verify and update the findings of the 1977-1978 impingement impact assessment (PG&E, 1982) and assess potential impacts of the modernization Project's CWIS impingement impacts. Section 316(b) of the Clean Water Act requires that "…the location, design, construction and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact." Studies and evaluations of the MBPP Project's CWIS were designed to determine whether the proposed intake complies with Section 316(b) of the Clean Water Act. The determination of compliance involves an evaluation of whether the operation of the CWIS will result in an adverse environmental impact, and if so, what intake technologies are both available, feasible and cost effective in reducing impacts. Although the EPA has provided guidance (EPA, 1977) on the recommended methods and steps in the evaluation process, the experience and knowledge gained in the studies and preparation of numerous 316(b) evaluations are incorporated in the present study. The scientific approach and methods employed in the MBPP CWIS studies have been undertaken with the review and advice of the Project's TWG.

A 12-month survey of the species composition and concentration of organisms entrained began in June 1999 and will be completed in 2 months (early December 2000). After over 2 months of sampling, a 4-month lapse in the study occurred while a collection permit for tidewater goby was obtained from the USFWS. The findings from the completed 8 months of entrainment sampling are summarized in AFC Section 6.6A.2.1.1 and in Appendix 6.6A.3. The study's results as reported herein provide a thorough and nearly complete inventory of the species of fishes and cancer crabs entrained by the MBPP. The results are used to assess the potential CWIS effects of the modernized facility in terms of its designed reductions in cooling water volume, reduced approach velocities, and the composition and economic importance of species that are expected to benefit from the reductions.

Fishery population impact models are used to project potential CWIS entrainment and impingement impacts, and are based on contemporary operational field data. The projected 29 percent reduction in CWIS intake volume directly reduces the losses of entrained larval fishes as well reducing any indirect losses extrapolated to the adult populations.

<u>1999-2000 Discharge Studies</u>

Several contemporary studies were designed to examine potential thermal effects of the existing discharge plume, verify past thermal effects study data, and project the modernized plant's thermal effects. Morro Rock's marine habitat was resurveyed in August 1999 and September 2000 in the manner and methods employed in a 1969 thermal effects study by CalTech professor, Dr. Wheeler North. The results of the 1999 and 2000 resurveys are used to verify and update Dr. North's observations and to assess the potential benefits of the modernized facility's reduced discharge volume. The results of the resurveys are summarized in Section 6.6A.2.1.2 and a detailed report is attached as Appendix 6.6A-4. A resurvey of Estero Bay's Morro Strand State Beach (to the north of the MBPP discharge) was conducted on August 1 and 2, 2000 using the general approach employed in the Adams et al. (1974) study of the sand beach fauna potentially affected by the discharge. The study methods were updated and approved by the TWG (see Appendix 6.5-1 for Sand Beach Fauna Study Plan). A similar verification study of the shallow, subtidal benthos in the Estero Bay was designed and approved by the TWG to confirm and update the previously reported (PG&E, 1973) lack of thermal MBPP discharge effects (see Appendix 6.5-1 for Subtidal Benthic Study Plan). Results from the study will be used to project the potential for the modernized facility's reduced discharge volume to mitigate any existing discharge effects on the receiving water's subtidal habitat.

6.6A.1 AQUATIC RESOURCES

The MBPP is located at the intersection of three distinct geographic features: open coast, enclosed bay and tidal lagoon, and their unique habitats. Estuarine and lagoon habitats are found within the boundaries of Morro Bay, and Estero Bay is distinctly marine. Provided in the following sections are summary descriptions of estuarine and marine habitats, including the associated plant and animal species of sandy subtidal areas, intertidal mudflats, submerged aquatic vegetation, coastal salt marsh, brackish marsh, rocky intertidal areas, open water nekton and plankton.

6.6A.1.1 Morro Bay

Cooling water for the MBPP is drawn from Morro Bay through a common intake structure located just under a mile from the entrance to Morro Bay. Morro Bay is a shallow estuary, approximately 4.3 miles (6.9 kilometer) long and 1.8 miles (2.9 km) wide. Morro Rock, a 578-foot-tall (176 m) stone monolith which marks the entrance to the bay and harbor, dominates the bay's landscape and is visible from any point in Estero Bay and the surrounding coastal plain.

Two breakwaters form the entrance to the bay. The first extends 1,800 feet (549 meter) in a south-southwesterly direction from the base of Morro Rock. The second extends a similar distance to the west from the northern terminus of the sand spit that separates Morro Bay from Estero Bay. The ends of the breakwaters are separated by approximately 800 feet (244 m). A boat channel is maintained by the U.S. Army Corps of Engineers (COE) from the bay's entrance to White Point, a distance of approximately 2.5 miles. The channel is dredged every 3 to 4 years to a nominal depth of 15 feet (4.6 m) below Mean Lower Low Water (MLLW) (COE, 1997). A network of natural channels also extends throughout much of the back bay. The channels vary in depth from about 2 feet to more than 30 feet below MLLW and ultimately drain into the main boat channel.

Morro Bay receives freshwater input from the seasonally variable drainage flows of Chorro and Los Osos creeks. Total watershed of the creeks encompasses approximately 48,000 acres. At high tide the bay contains 2,100 acres of surface water. At low tide, surface water is reduced to 650 acres, and 980 acres of tidal mud flat and 470 acres of salt marsh are exposed (Gerdes et al., 1974).

The rate of tidal exchange of water in Morro Bay, as described in Section 6.5.1.4.1-Tidal Prism and in Appendix 6.5-3, varies as a function of distance from the mouth of the bay as shown in Figure 6.6A-5. For those species of Morro Bay fish and invertebrates with planktonic larvae, these differences in tidal exchange rates mean that larvae in the bay's lower reaches are approximately 15 times more likely to be transported out of the bay during medium streamflow (Tetra Tech, 1999) than larvae in the uppermost reaches. The lower rates of exchange in the upper bay provide several days of additional residency for these bay larvae before they are transported by tidal action out of their adult habitat. This tidal delay in the transport of planktonic larvae from the upper bay effectively reduces the risk of their entrainment near the harbor entrance and shifts any potential entrainment effects to populations residing in the lower bay and open ocean.

Morro Bay is a highly modified boating and marina harbor (see Section 6.5.1.4.1 - Navigational Development). Before dredging began, a coastal lagoon would normally form during the summer and fall where the present-day opening is located. It is also during this season that many of Morro Bay's resident goby species spawn possibly to take advantage of the normally closed or reduced open ocean circulation. The species found in the bay today, as well as their spawning patterns, may reflect the dramatic modification of Morro Bay tidal circulation from dredging activities. Dredging of these bay channels and the marina continue to maintain the modifications to the bay's many marsh and shallow water habitats. However, the delayed residence time of the back bay may also continue to provide an extended period of larval development that may be significant to their ability to avoid tidal transport to open ocean conditions via the harbor's entrance or the MBPP.

Morro Bay has been designated a State and National Estuary. The bay became part of the National Estuary Program (NEP) in 1995. The National Estuary Program was established in 1987, by amendments to the Clean Water Act (CWA), to identify, restore, and protect the nationally significant estuaries of the United States. The Morro Bay NEP has made significant in bringing

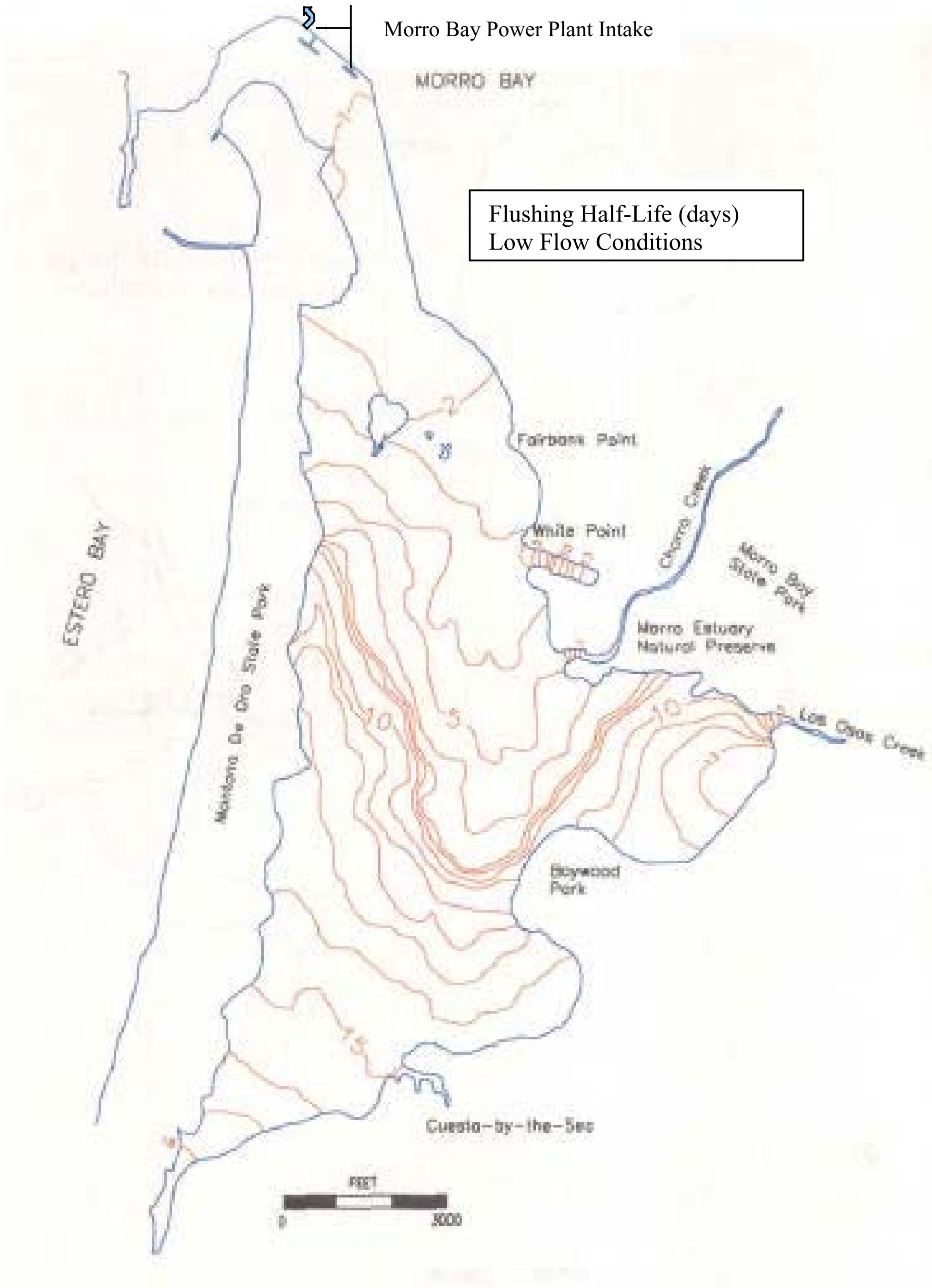


Figure 6.6A-5. Morro Bay EFDC model flushing analysis under low flow conditions. (After Tetra Tech 1999)

into focus changes needed both in planning and policy to protect the bay's future, particularly with regard to watershed management practices. The NEP has directed research aimed at gathering scientific on important information on sediment processes and of resource trends. NEP research may also include demonstration studies of interaction between watershed management and the bay's ecological processes.

6.6A.1.2 Morro Bay Resources

Dominant ecological communities in Morro Bay are intertidal mud flats, eelgrass beds, and a coastal salt marsh. The location and extent of these types of Morro Bay habitats are illustrated in Figure 6.6A-6. An overview map showing the habitats within a 1-square mile radius of the MBPP and individual habitat maps created at a 1:6,000 scale are shown in Figures 6.6A-7 and 6.6A-8a–i. The bay also contains habitats consisting of sandy subtidal, rocky intertidal (including areas created by the breakwater, wharves and pilings), and brackish marshes. Most of these habitats support aquatic vegetation. The estuary also accommodates a sizable commercial shellfish lease.

The Morro Bay habitats map (see Figure 6.6A-6) was produced on Arcview 3.1 using a variety of information sources. Digitized United States Geologic Survey (USGS) background data were fitted to a coastline obtained from the CDFG (Coast 24). Black and white habitat images scanned from the Natural Resources of Morro Bay (Gerdes et al., 1974) were sized to fit the coastline and overlaid on the background image. A theme was created for each habitat type by tracing around the area occupied by each habitat (using a "stream" extension for geographical information systems [GIS] mapping) and assigning a specific color. Marine mammal haul-out areas were mapped from field observations (CDFG unpublished data).

Other studies and data have been compiled from the available literature to provide background information specific to Morro Bay's aquatic resources. The CDFG initiated a long-term study of the Morro Bay estuary beginning on April 1992. (Locations identified in Figure 6.6A-9, Map of Previous Marine Biological Study Locations.) The primary focus of the study is to monitor the abundance of adult and juvenile fish species important to the area's commercial and recreational fisheries. Data from these otter trawls have been analyzed and are discussed in Appendix 6.6A-5. Two fishery studies were conducted in the late 1960s and early 1970s and provide valuable information on the species composition and abundance of fishes in Morro Bay. These two studies are summarized below.

6.6A.1.2.1 Diel and Seasonal Variation in Abundance and Diversity of Shallow Water Fish Populations in Morro Bay, California - Horn, 1980

Dr. Alex Horn of Cal Poly studied the diel (24-hour) and seasonal variations in species abundance, composition, and diversity of the shallow water fish community within Morro Bay. Because Morro Bay was considered to be subject to low levels of environmental stress, total species diversity was expected to be high. The study also compared Morro Bay total diversity and seasonal similarity values with the findings of three other studies conducted in similar California estuaries.

The site chosen for Horn's study was a shallow area of tidal flats and channels (considered typical bay habitat) adjacent to the western side of Baywood Point (Figure 6.6A-10). The bottom substrate was composed of mud/sand and covered with beds of eelgrass *Zostera marina*, and algal species *Gracilaria* spp. and *Ulva* spp. Water depth in sections of the study area reached 2 m (7 feet) at high tide. Samples were collected every 3 hours during a 24-hr survey in November 1974, May and August 1975, and February 1976. Captured fishes were identified, sorted, measured (standard length in mm), and weighed (grams [g]).

The 36 seine hauls (all four sampling periods) collected 11,627 fishes (197,747 g) representing 21 species. Three species, topsmelt *Atherinops affinis*, shiner perch *Cymatogaster aggregata*, and Pacific staghorn sculpin *Leptocottus armatus* composed nearly 82 percent (number of individuals) of the fishes collected. Gray smoothhound *Mustelus californicus*, jacksmelt, shiner perch and Pacific staghorn sculpin accounted for nearly 91 percent of the total biomass collected. Nearly equal numbers of species were collected during the day (14) and night (15) for all sampling periods combined, however, substantially greater numbers of individuals and biomass were collected during sampling efforts at night. Differences between the night and day sampling efforts showed greater percent similarity values for numbers of fish (68.5 percent) than for fish biomass (43.3 percent).

Four species (topsmelt, shiner perch, Pacific staghorn sculpin, and gray smoothhound) were the most abundant fishes sampled (Table 6.6A-2). The most abundant species was topsmelt (31 percent). The highest number of individuals was collected in May; the lowest levels were caught in August. Species diversity' was highest for numbers of individuals in May. Biomass was the highest in November and the lowest in February.

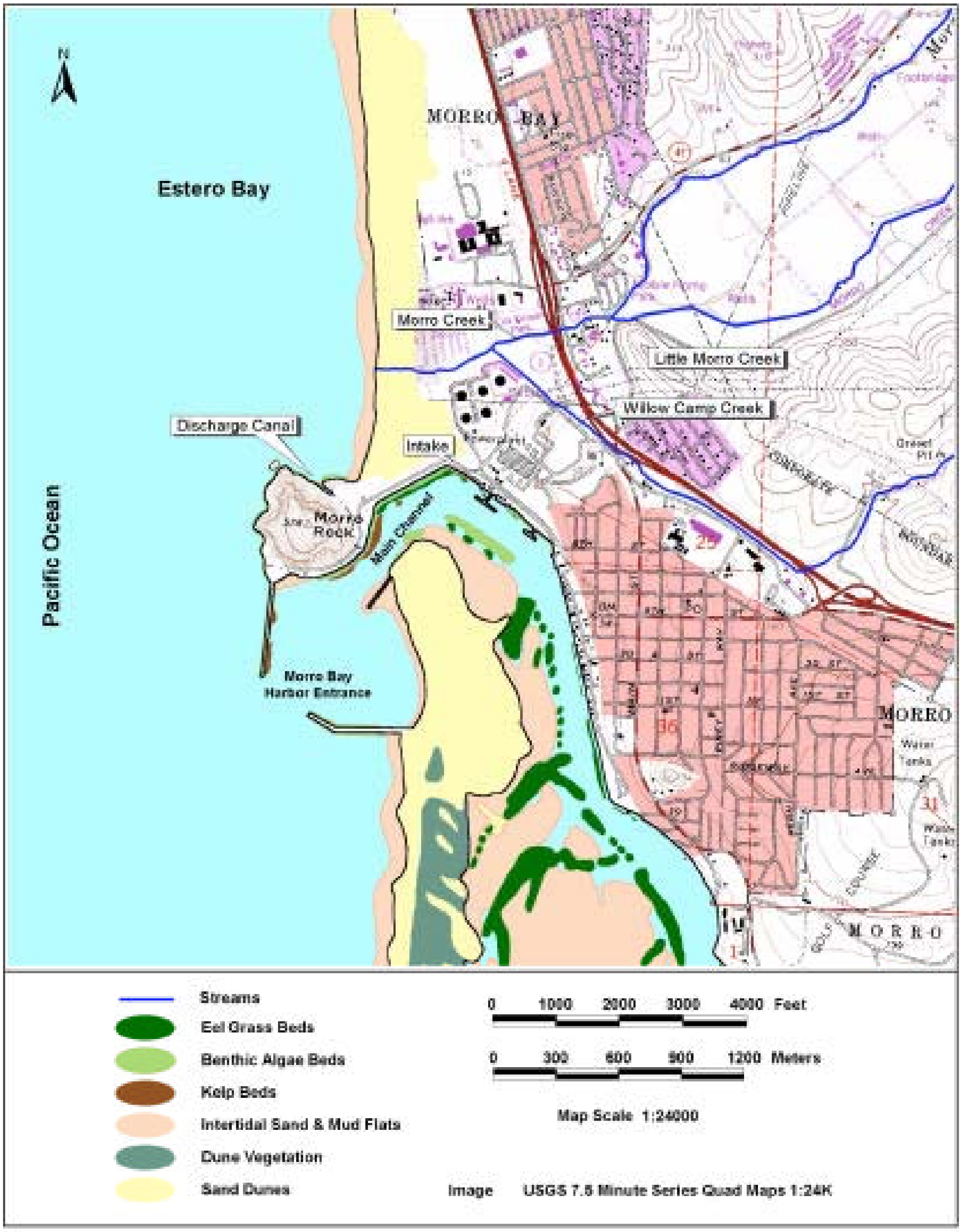


Figure 6.6A-6. Location and extent of habitat types in the vicinity of the MBPP.

Figure 6.6A-7. Overview of individual habitat maps within a one-mile radius of the MBPP.

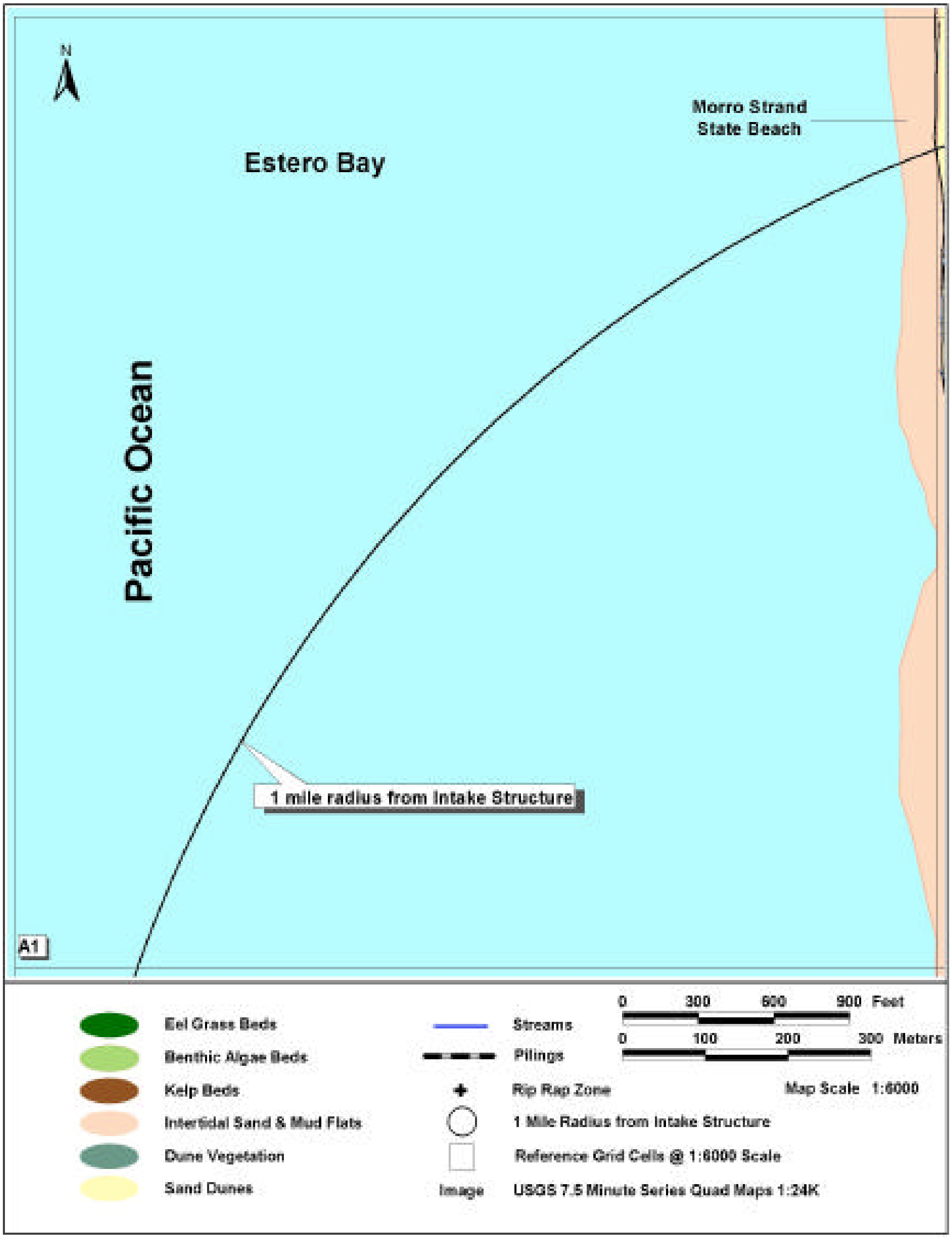


Figure 6.6A-8a. Individual habitat map of area A1 near MBPP (scale 1:6,000 scale).

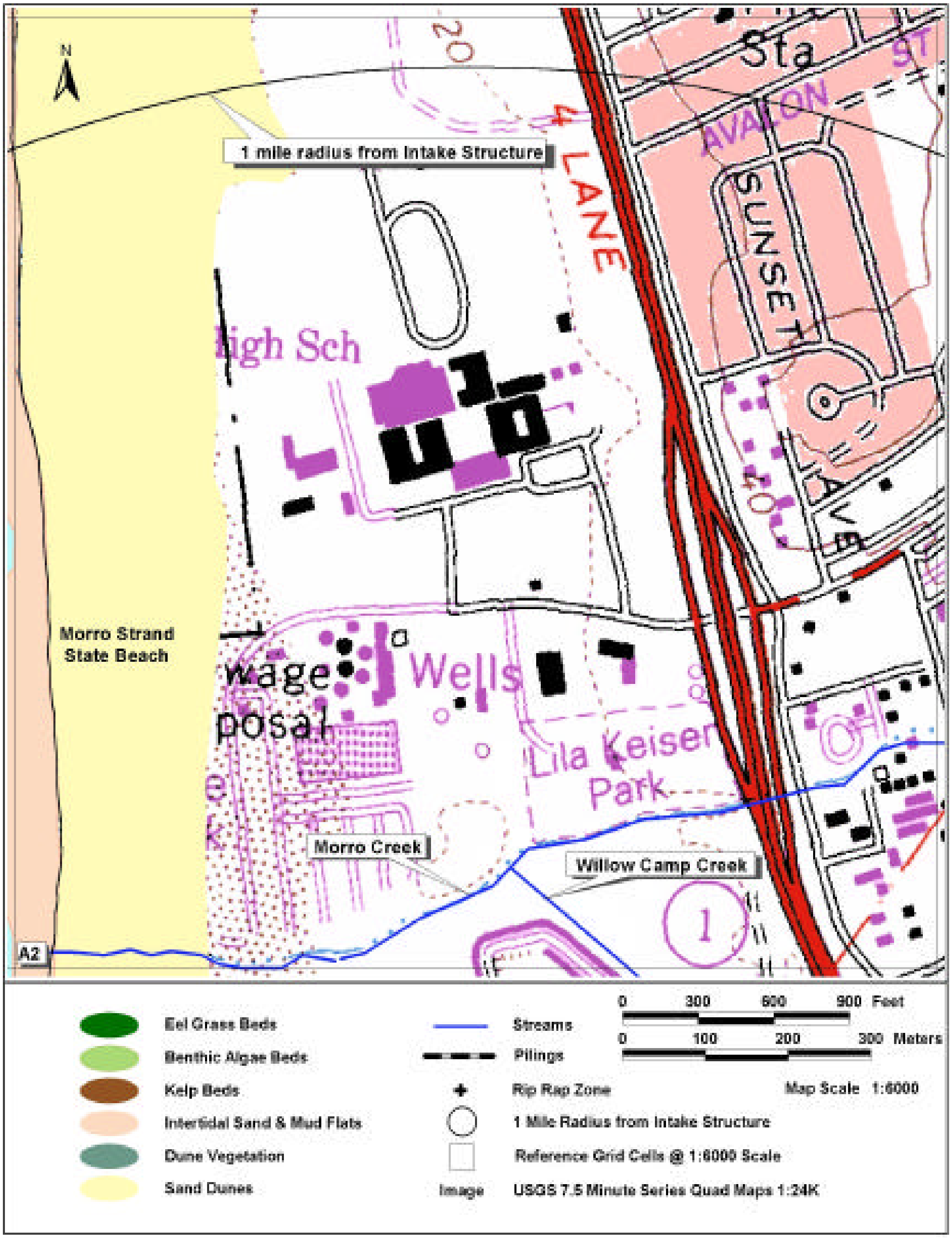


Figure 6.6A-8b. Individual habitat map of area A2 near MBPP (scale 1:6,000 scale).

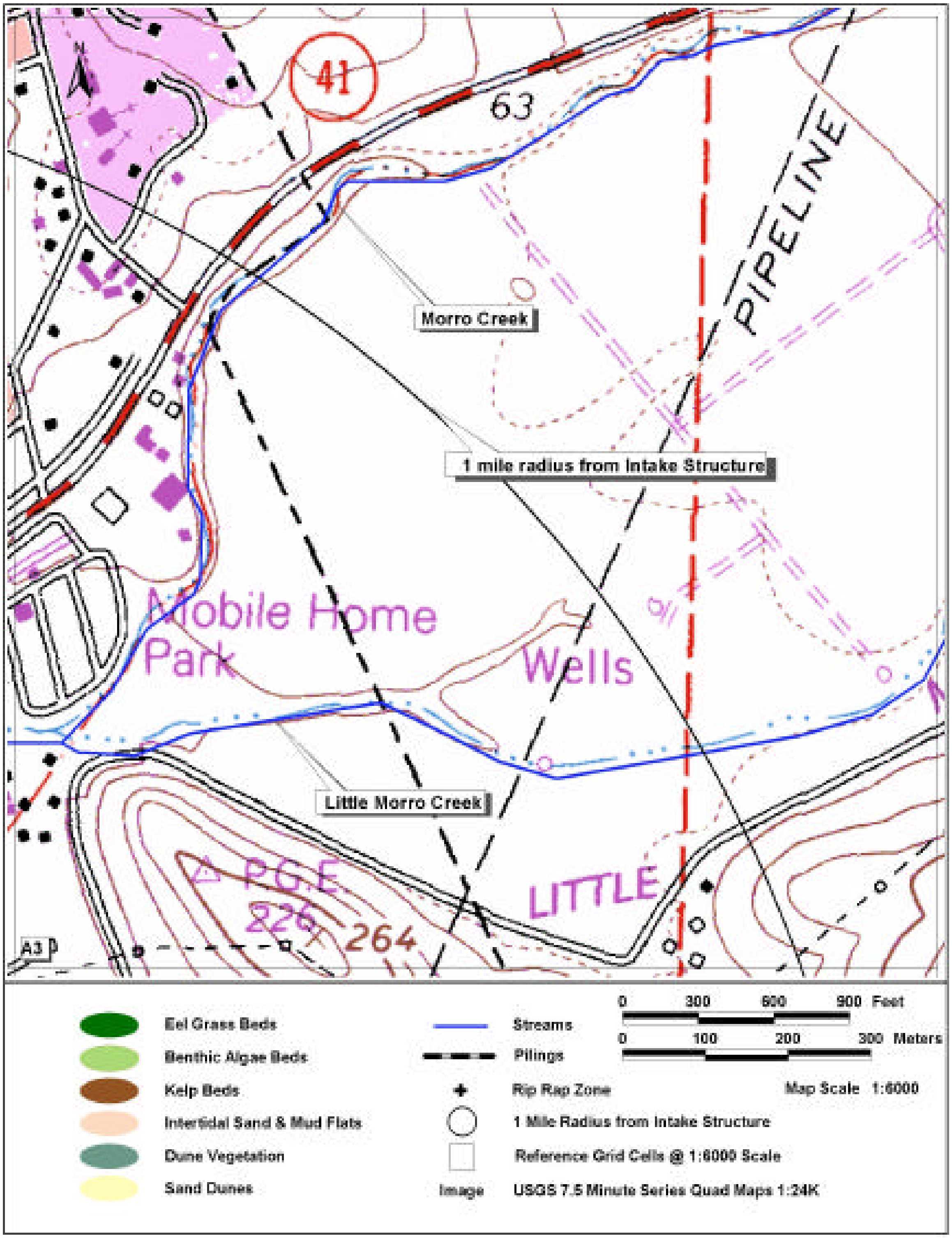


Figure 6.6A-8c. Individual habitat map of area A3 near MBPP (scale 1:6,000 scale).

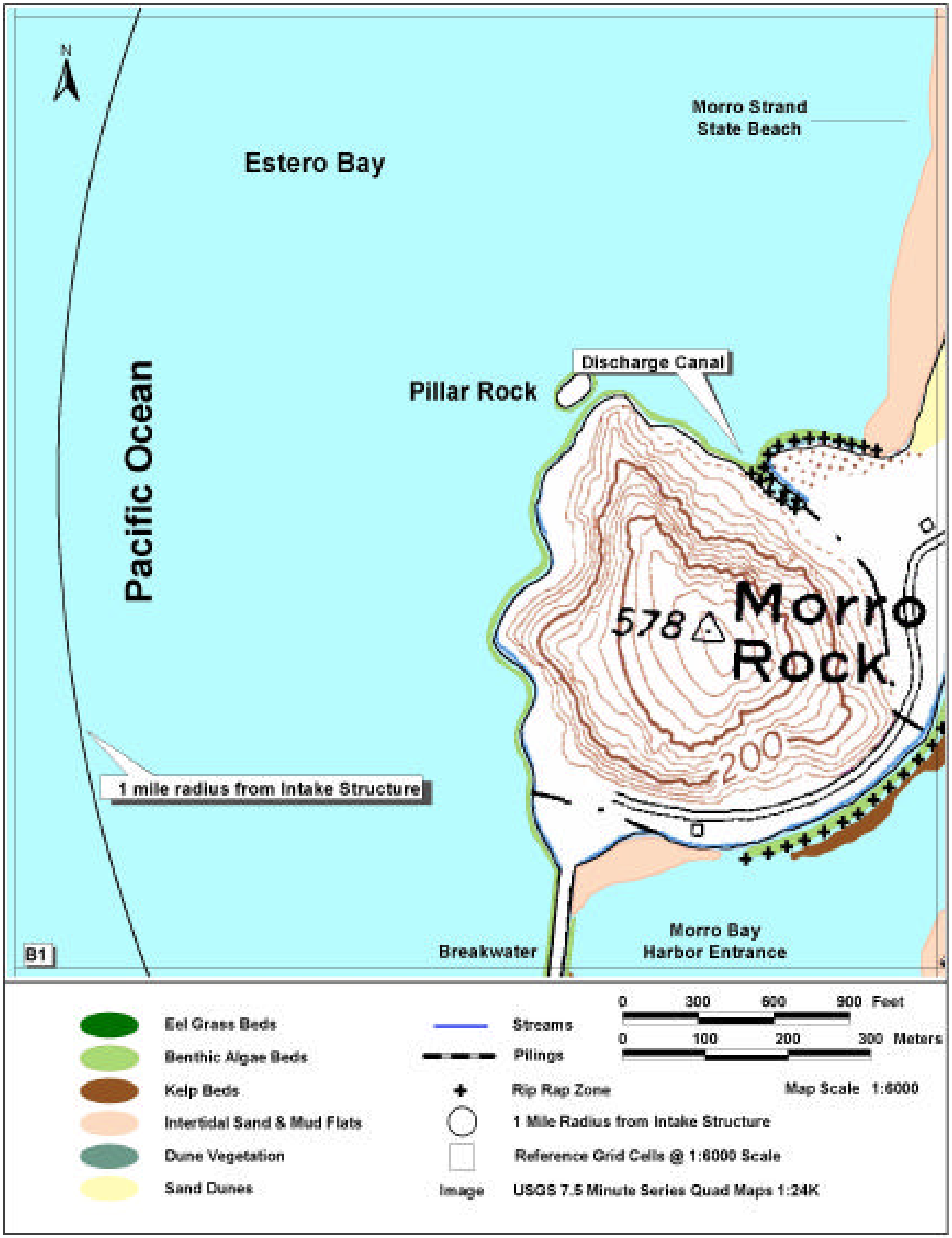


Figure 6.6A-8d. Individual habitat map of area B1 near MBPP (scale 1:6,000 scale).

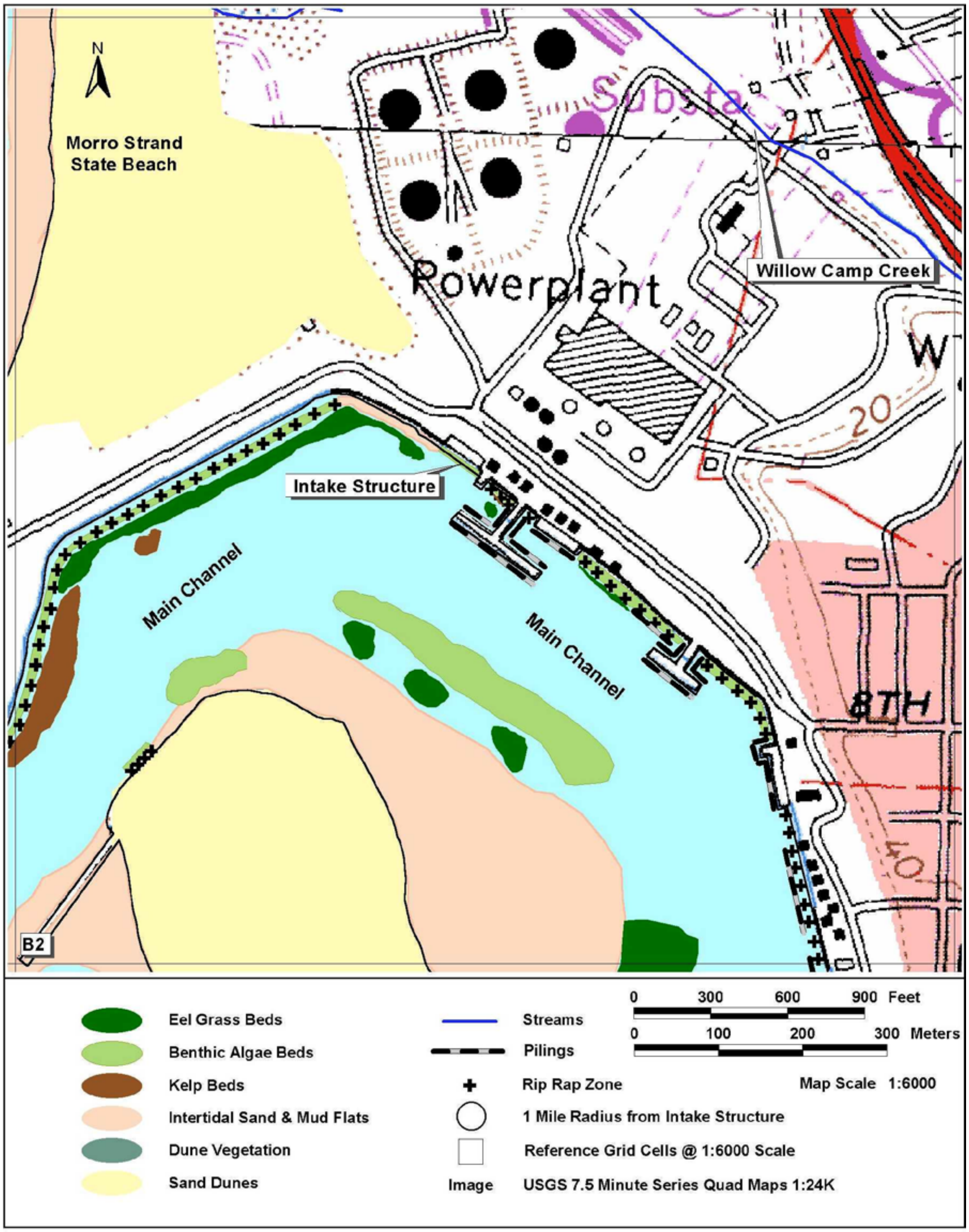


Figure 6.6A-8e. Individual habitat map of area B2 near MBPP (scale 1:6,000 scale).

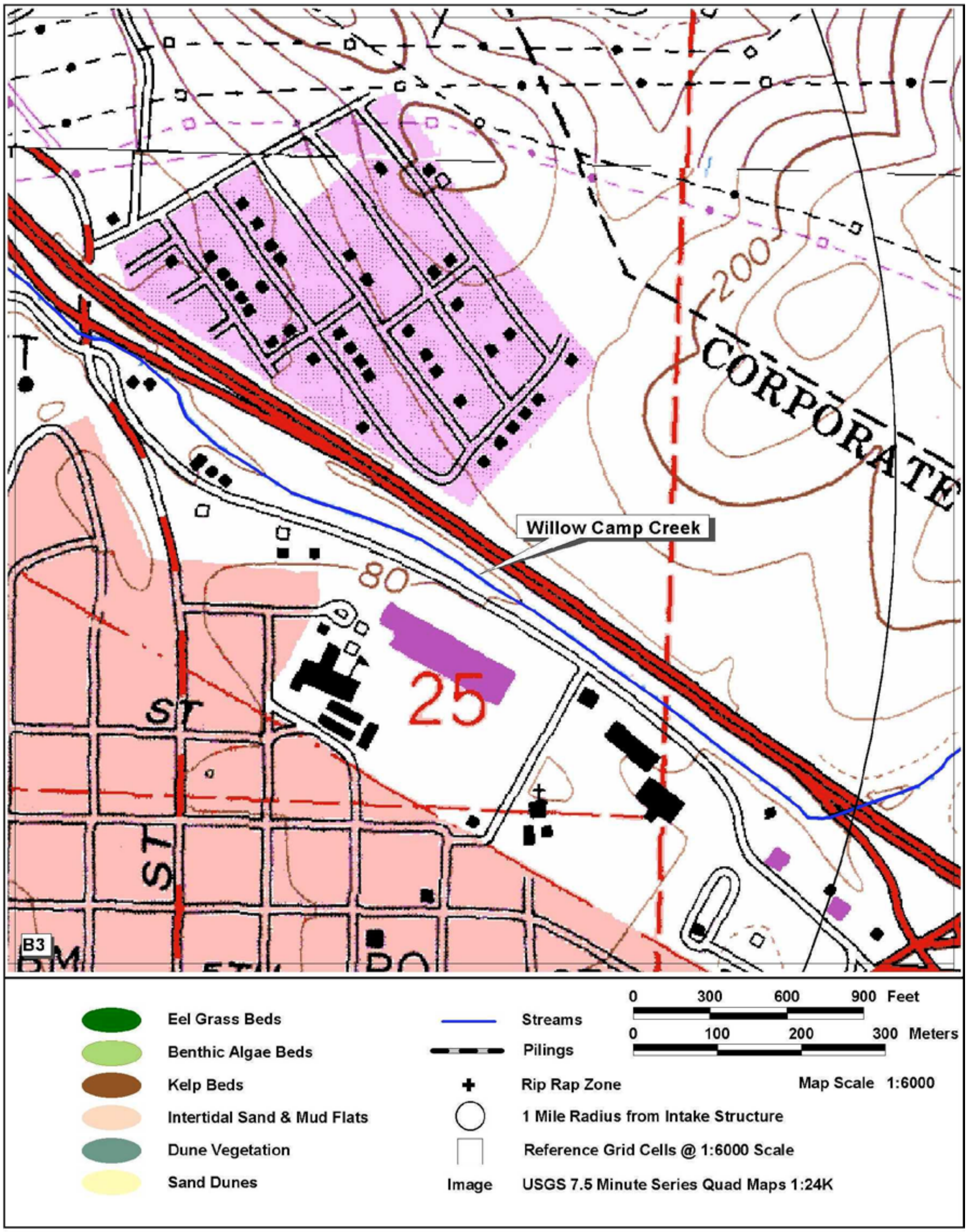


Figure 6.6A-8f. Individual habitat map of area B3 near MBPP (scale 1:6,000 scale).

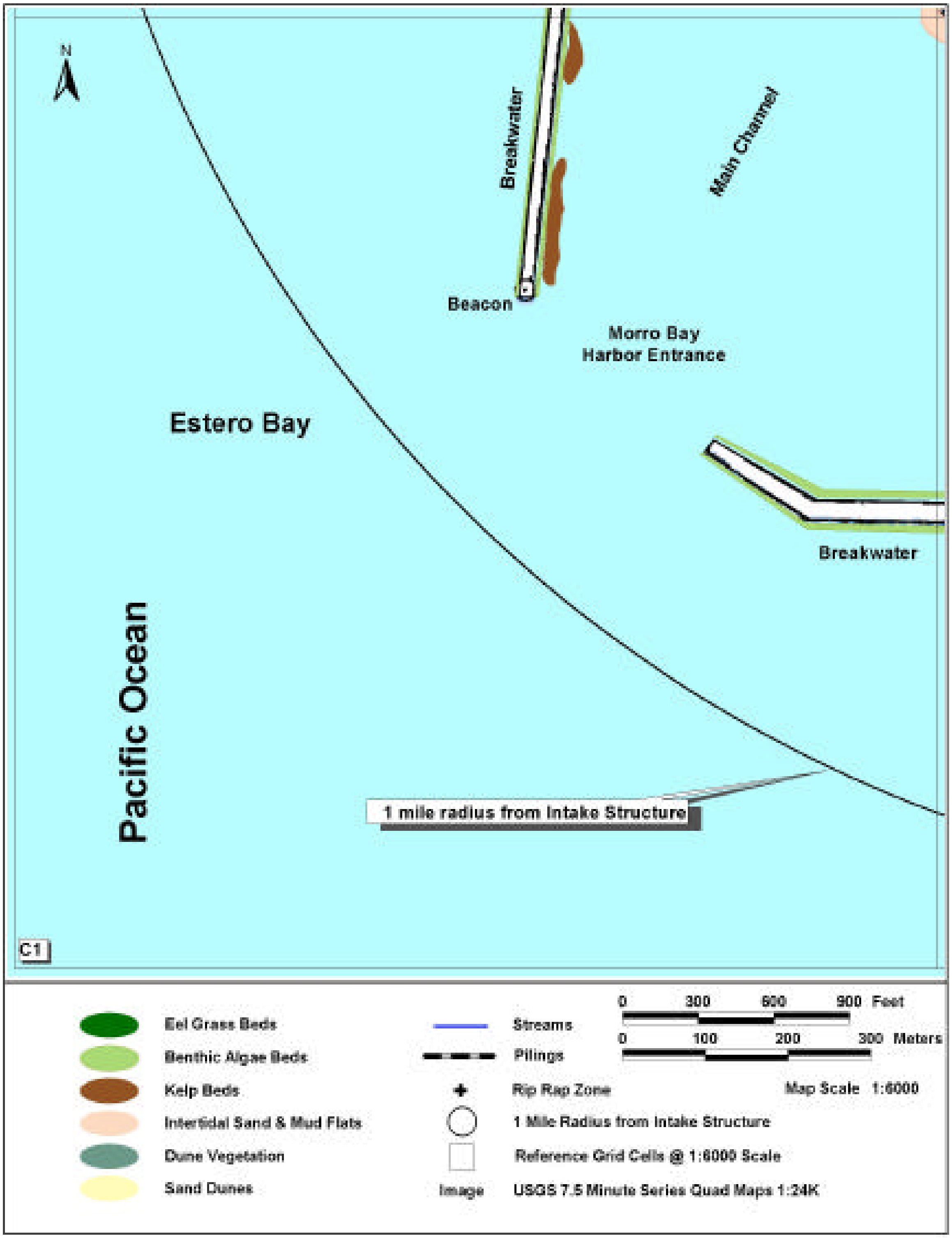


Figure 6.6A-8g. Individual habitat map of area C1 near MBPP (scale 1:6,000 scale).

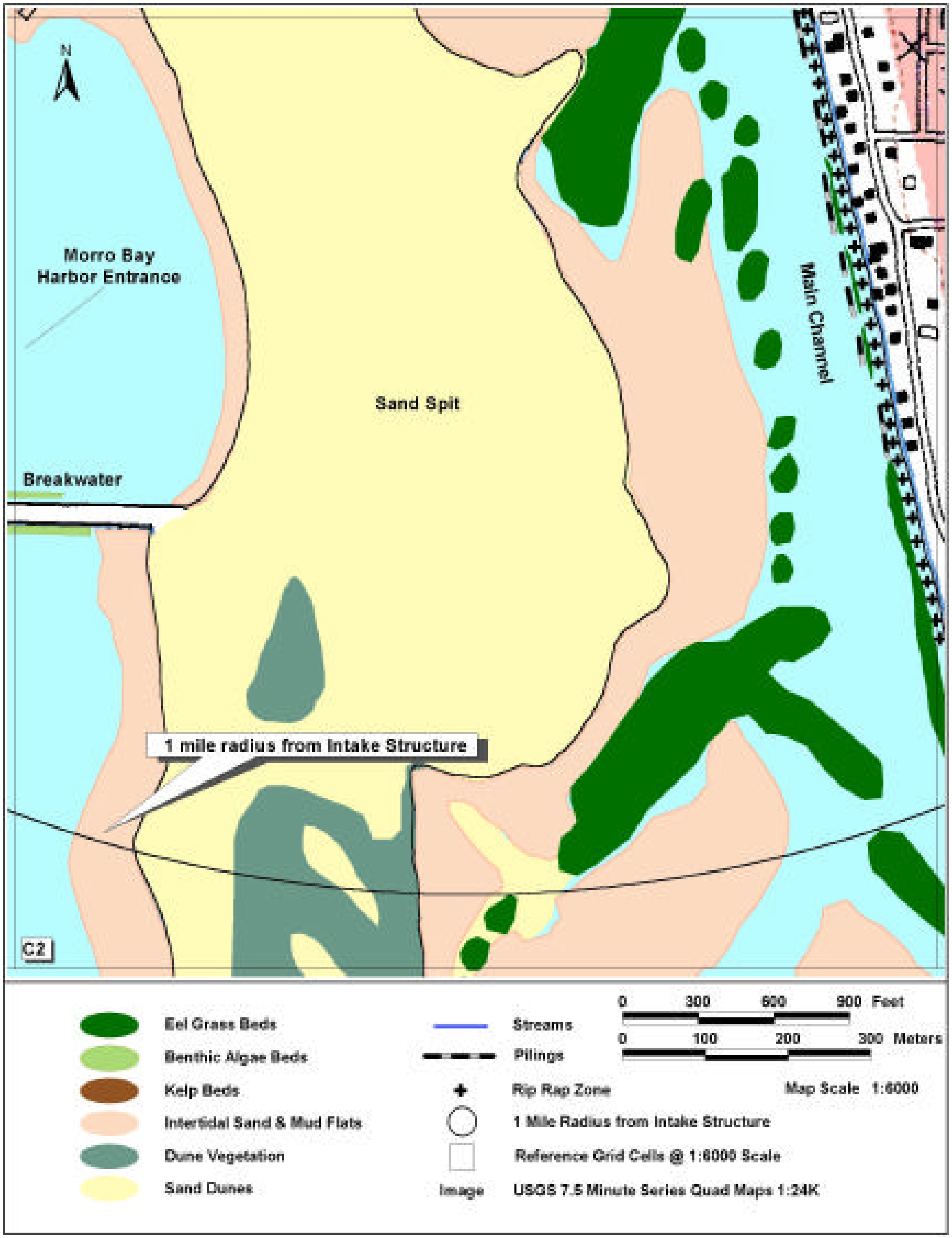


Figure 6.6A-8h. Individual habitat map of area C2 near MBPP (scale 1:6,000 scale).

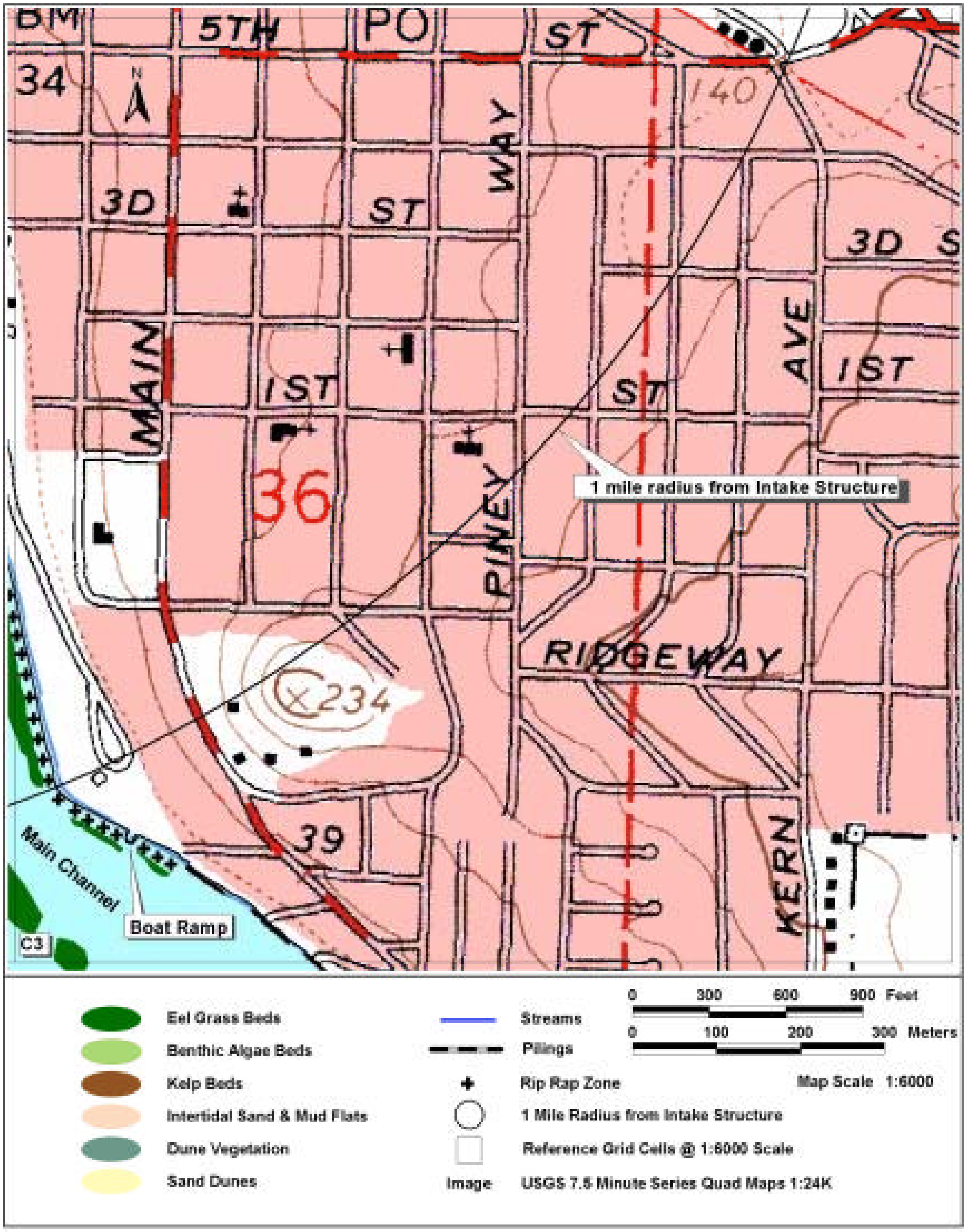


Figure 6.6A-8i. Individual habitat map of area C3 near MBPP (scale 1:6,000 scale).

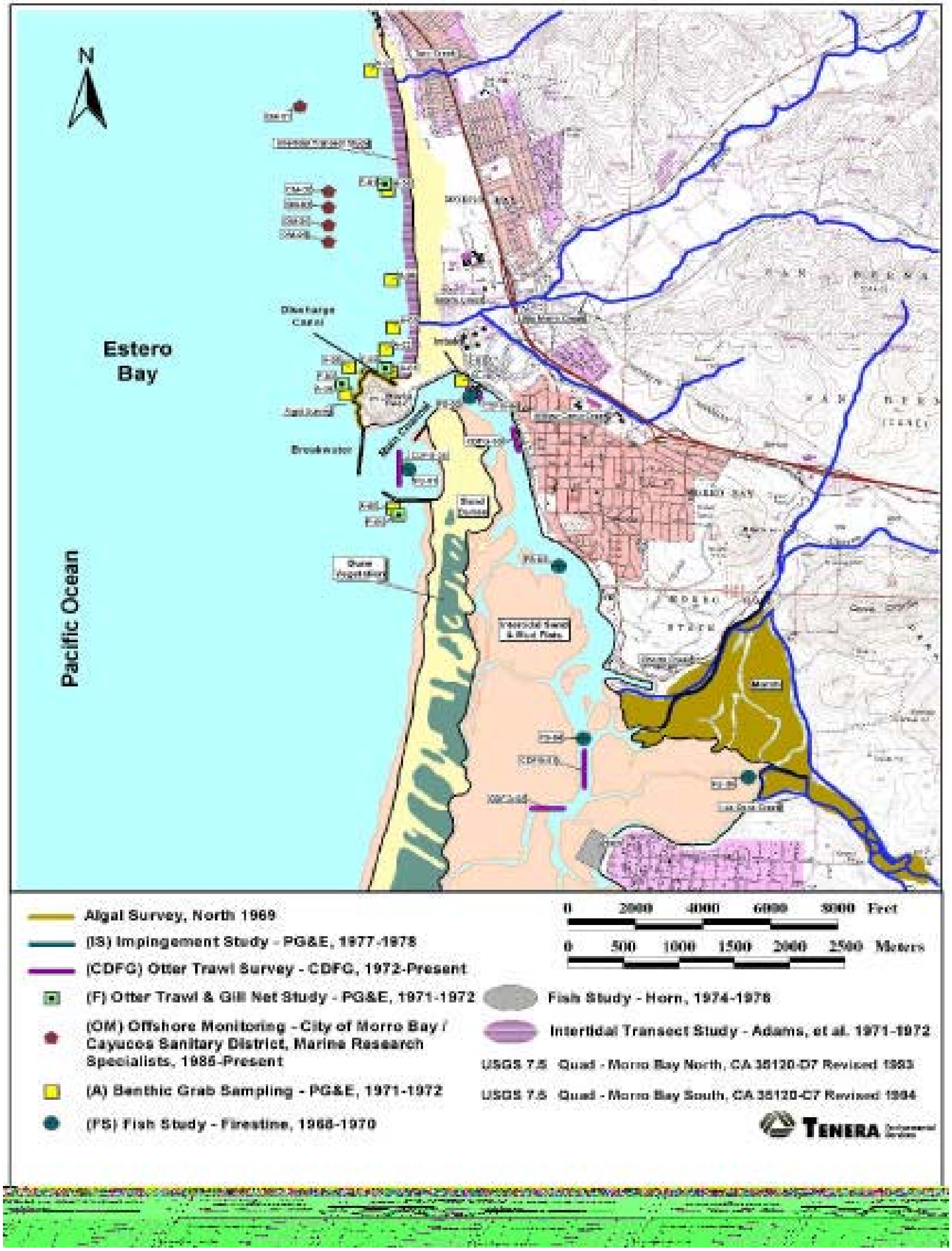


Figure 6.6A-9. Previous marine biological study locations in Morro and Estero bays.

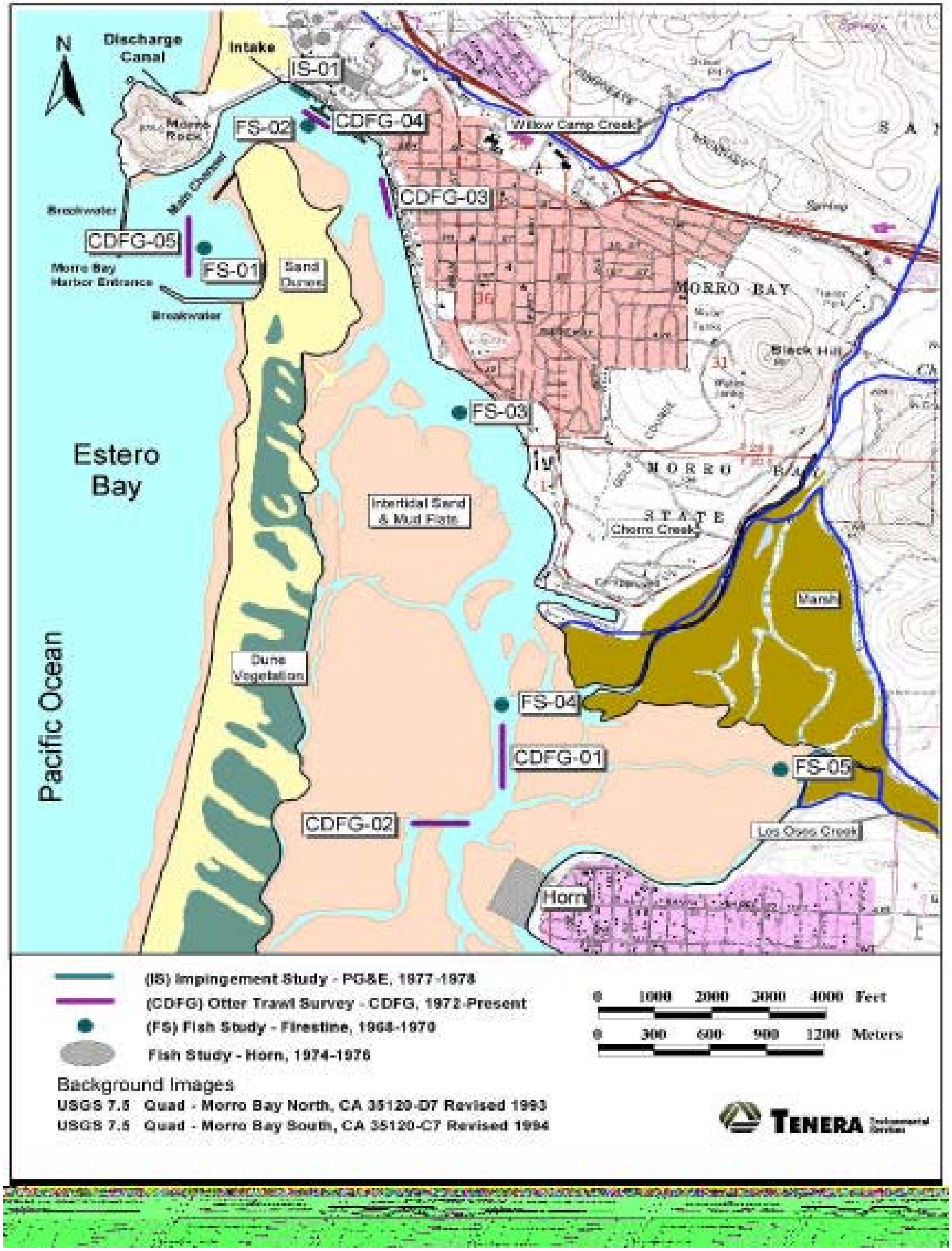


Figure 6.6A-10. Juvenile and adult fish sampling locations in Morro Bay.

TABLE 6.6A-2

NUMBERS OF INDIVIDUALS AND BIOMASS OF FISH SPECIES COLLECTED USING BEACH SEINE GEAR

	FEBRUARY 1976				MAY 1975				AUGUST 1975				NOVEMBER 1974				TOTALS			
	Individuals		Biomass		Individuals		Biomass		Individuals		Biomass		Individuals		Biomass		Individuals		Biomass	
Species	n	%	g	%	n	%	g	%	n	%	g	%	n	%	g	%	n	%	g	%
Topsmelt	351	16.0	3,996	8.0	998	23.4	40,940	41.2	309	14.2	9,099	41.1	1,960	65.5	7,856	29.7	3,618	31.1	61,891	31.3
Shiner perch	-	-	-	-	1,498	35.1	41,049	41.3	1,530	70.4	6,793	30.6	67	2.2	575	2.2	3,095	26.6	48,417	24.5
Pacific staghorn sculpin	1,668	76.2	2,063	4.1	644	15.1	3,649	3.7	272	12.5	3,725	16.8	196	6.5	4,444	16.8	2,780	23.9	13,881	7.0
Northern anchovy	-	-	-	-	909	21.3	1,532	1.5	2	0.09	3	-	397	13.3	280	1.1	1.308	11.2	1,815	0.9
California killifish	25	1.1	50	0.1	1	-	10	-	-	-	-	-	229	7.6	728	2.7	255	2.2	788	0.4
Bay pipefish	18	0.8	24	0.05	35	0.8	200	0.2	18	0.8	111	0.5	94	3.1	850	3.2	165	1.4	1,185	0.6
Shadow goby	26	1.2	49	0.1	64	1.5	158	0.2	27	1.2	94	0.4	2	0.1	2	-	119	1.0	303	0.2
Dwarf surfperch	7	0.3	152	0.3	77	1.8	152	0.2	-	-	-	-	6	0.2	149	0.6	90	0.8	453	0.2
Bay goby	43	2.0	6	0.01	-	-	-	-	-	-	-	-	1	-	4	-	44	0.4	10	-
Black surfperch	-	-	-	-	11	0.3	171	0.2	9	0.4	340	1.5	17	0.6	1,238	4.7	37	0.3	1,749	0.9
Jacksmelt	25	1.1	3,659	7.3	1	-	280	0.3	1	0.05	230	1.0	5	0.2	1,296	4.9	32	0.3	5,465	2.8
Gray smoothound	19	0.9	39,463	79.3	7	0.2	8,322	8.4	-	-	-	-	3	0.1	7,296	27.5	29	0.3	55,081	27.9
Pile surfperch	1	0.05	240	0.5	19	0.4	2,390	2.4	-	-	-	-	2	0.1	450	1.7	22	0.2	3,080	1.6
Pacific herring	1	0.05	88	0.2	-	-	-	-	-	-	-	-	13	0.4	1,276	4.8	14	0.1	1,364	0.7
Arrow goby	2	0.1	2	-	2	-	-	-	1	0.05	2	-	1	-	-	-	6	0.1	4	-
Walleye surfperch	-	-	-	-	3	0.1	121	-	-	-	-	-	1	-	50	0.2	4	-	171	0.1
Bat ray	-	-	-	-	-	-	-	-	3	0.1	1,760	7.9	-	-	-	-	3	-	1,760	0.9
Speckled sanddab	3	0.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	1	-
Diamond turbot	-	-	-	-	1	-	320	0.3	-	-	-	-	-	-	-	-	1	-	320	0.2
Starry flounder	-	-	-	-	-	-	-	-	1	0.05	8	-	-	-	-	-	1	-	8	-
Rockfishes.	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	1	-	1	-
Totals	2,189		49,793		4,271		99,295		2,173		22,165		2,994		26,494		11,627		197,747	
Total species	13				16				11				16				21			

(Source: Horn, 1980)

Results of the study indicate that both diel and seasonal variations in species composition, abundance (numbers and biomass), and diversity occurred in the shallow water fish community inhabiting Morro Bay. In addition, a large proportion of the total numbers of individuals within the area was accounted for by relatively few species. This pattern was consistent with study results from three southern California estuarine systems (Mugu Lagoon, Colorado Lagoon, and Upper Newport Bay).

Fishes Collected in Morro Bay Between January 1968 and December 1970 (Fierstine et al., 1973)
The purpose of the Fierstine study was to document the fish species that utilize Morro Bay and to determine the spatial distributions and seasonal differences of the fish community within the estuary. Specific information about these aspects of the fish community was considered important for assessment of the ecological impacts of proposed developments.

Morro Bay was divided into five sampling zones (Figure 6.6A-10). Zone I encompassed the semi exposed area between the entrance breakwaters and north to Morro Rock. Zone II extended from Morro Rock, through the commercial port area, to the launch ramp. Zone III extended from the boat launch ramp to the Morro Bay State Park Museum. Zone IV was the largest zone encompassing the entire back bay, with the exception of the estuarine channels of Chorro and Los Osos creeks. This area was defined as Zone V.

A majority of sampling was accomplished with a small otter trawl net towed from a boat. Other sampling gear used included: hook and line, SCUBA and spearfishing equipment, beach and common sense seines, and dip nets. Sampling efforts were not conducted on a regular calendar schedule and few efforts were made between August and October. Otter trawls were typically conducted at low tide when fishes were concentrated in the channels.

The sampling effort conducted by Fierstine between January 1968 and December 1970 yielded approximately 1,600 fishes, representing 66 species. The Family Embiotocidae, (black perch *Embiotoca jacksoni* and shiner perch *Cymatogaster aggregata*) accounted for 22 percent of the total. Twelve species were considered to be resident in the bay due to their presence in samples during 6 or more months of the year. Twenty-six species were collected only during a single month and were considered seasonal or occasional visitors to the bay. Sampling results for the ten most abundant species collected are summarized in Table 6.6A-3.

TABLE 6.6A-3

THE TEN MOST ABUNDANT SPECIES COLLECTED DURING THE FIERSTINE STUDY BY STATION: JANUARY 1968 AND DECEMBER 1970

SPECIES	AREA I	AREA II	AREA III	AREA IV	AREA V	TOTAL
Northern anchovy		345				345
Shiner perch		1	154	130	11	296
Black surfperch		48	45	73		166
Pacific staghorn sculpin		4	15	1	100	120
Speckled sanddab			6	77		83
Topsmelt		26	33	8	6	73
Tidewater goby					58	58
English sole			35	14		49
Lingcod	1	38	2	1		42
Walleye surfperch	8	6	13	7		34

Several species that are now the subject of concern were also collected during study. Collection efforts in Zone V yielded 58 tidewater gobies *Eucyclogobius newberryi* and one steelhead rainbow trout *Salmo gairdneri gairdneri* (renamed *Oncorhynchus mykiss*). Bocaccio rockfish *Sebastes paucispinis* were also collected during the study from Zones II and III.

The limitations of the sampling methods were discussed. Fierstine speculated on techniques that could have been employed to collect samples of unsampled or undersampled species known to frequent the bay.

6.6A.1.2.2 Subtidal Channels

The salt marshes and mud flats of the Morro Bay Estuary are drained and flooded twice a day by tidal flow through a network of channels, which provide corridors between marine habitats and intertidal feeding and nursery grounds. The main artery of this network is a navigable channel that extends from the harbor entrance inland to within 1,500 feet (457 m) of Baywood Point before splitting into two secondary channels. Both secondary channels extend in a southerly direction for more than 3,200 feet (975 m) before rising to an average depth of less than 10 feet (3 m). The main channel averages 15 feet (5 m) in depth (United States Department of Commerce, 1983).

A majority of the subtidal substrate within the estuary is a composition of sand and fine sediment. A soft mixture of mud, fine sediment, and organic material is present in sections of the main channel adjacent to and between the confluence of Los Osos and Chorro creeks and in the main channel, where secondary channels deposit sediment eroded from the mud flats. Drifting mats of eelgrass *Zostera marina* and algae carpet large areas of the channel bottom in the fall and winter (R. Hardy, pers. comm., 1999). Of the several flatfish species occurring within the main channel, the most common being the speckled sanddab *Citharichthys stigmaeus* (CDFG, 1998). Surfperches are represented in the back bay by the shiner perch *Cymatogaster aggregata* and pile surfperch *Damalichthys vacca*. Bat rays are also present.

Common crab species are the brown rock crab *Cancer antennarius*, red rock crab *Cancer productus*, yellow rock crab *Cancer anthonyi*, and slender crab *Cancer gracilis* (CDFG, 1998). The swimming crab *Portunus xantussi* is frequently found near eelgrass beds. Mats of eelgrass, *Ulva* spp., *Enteromorpha* spp., and *Gracilaria* spp. drift along the bottom of the main channel and are abundant in central potions of the bay, where they form a microhabitat for juvenile fishes and crustaceans. Associated species include English sole, juvenile plainfin midshipmen *Porichthys notatus* and postlarval gobies (arrow goby *Clevelandia ios* and bay goby *Lepidogobius lepidus*) (CDFG, 1998).

6.6A.1.2.3 Intertidal Mudflats

The intertidal mud flats, a distinct region of the Morro Bay estuary, provide habitat for a diverse community of burrowing and surface dwelling invertebrates. Approximately 1,452 acres of mud flats are exposed during low tide (Gerdes, 1970), with about 150 acres covered by vegetation, primarily sea lettuce *Ulva* spp. and green alga *Enteromorpha* spp.

Numerous species of polychaetes, gastropods and crustaceans are distributed throughout the mud flats (COE, 1973), as are bivalves, including the geoduck *Panope generosa*, Washington clam *Saxidomus nuttalli*, gaper/horseneck clam *Tresus nuttalli*, and bentnose clam *Macoma nasuta* (Spear, 1973). Other inhabitants are grapsid and xanthid crabs, innkeeper worm *Urechis caupo*, blue mud shrimp *Upogebia pugettensis*, and ghost shrimp *Callianassa californiensis* (Gerdes et al., 1974). Bat rays *Myliobatis californica* and leopard sharks *Triakis semifasciata* are the largest of the mud flat predators.

Williams Shellfish Company is allotted approximately 270 acres of California's tide and submerged lands in the back bay area of Morro Bay for aquaculture use. The company cultivates and harvests Pacific oyster *Ostrea lurida*, Manila clam *Tapes philipinarum*, Quahog clam *Mercenaria mercenaria*, and bay mussels *Mytilus edulis* (R. Hardy, pers. comm., 1999).

6.6A.1.2.4 Submerged Aquatic Vegetation

Eelgrass *Zostera marina* grows in quiet, protected bays in the lower intertidal zones and subtidally (Kozloff, 1983). Most of the approximately 120 acres (J. Chestnut, consultant, pers. comm., 1999) of eelgrass beds in Morro Bay are on the lower parts of the tidal flats and in the shallow channels in the southern bay. Eelgrass beds provide forage, spawning substrate, nursery habitat, protection and cover for invertebrates and fishes.

Larger invertebrates associated with eelgrass beds include bay shrimp *Crangon* spp., spiny cockle *Trachycardium quadragenarium*, nudibranchs (e.g., *Hermissenda crassicornis*), and anemones (e.g., *Pachycerianthus fimbriatus*) (Ware, 1996; Behrens, 1999). Four species of *Cancer* crabs, yellow shore crab *Hemigrapsus oregonensis*, moon snail *Polinices lewsii* (genus name changed to *Euspira*) and sea hare *Aplysia californica* also are common (Ware, 1996). Fish species include topsmelt *Atherinops affinis*, shiner perch *Cymatogaster agregata*, speckled sanddab *Citharichthys stigmaeus* and Pacific staghorn sculpin *Leptocottus armatus* (CDFG, 1998).

6.6A.1.2.5 Coastal Salt Marsh

Salt marshes rise above the mud flats in areas where tidal flooding favors salt-tolerant terrestrial vegetation. Salt marshes moderate the effects of erosion and siltation and may act as pollution buffers. They also absorb runoff and can trap and degrade organic waste (McConnaughey and McConnaughey, 1990). Chorro and Los Osos creeks drain westward into the central part of Morro Bay, forming a delta where 444 of the 472 acres of salt marsh are located. The remainder is scattered along the southern edges of the bay. Of the 17 plant species identified, four are dominant, pickleweed *Salicornia* spp., jaumea *Jaumea carnosa*, alkali heath *Frankenia salina*, and salt grass *Distichlis spicata* (Jarque, 1998).

Polychaete worms, crabs, snails, and amphipods are dominant in this area, which provides a food-rich, protected habitat for fishes. Topsmelt is the most abundant fish found in the marsh at high tide, followed by Pacific staghorn sculpin and arrow goby. The longjaw mudsucker *Gillichthys mirabilis* occupies crab burrows beneath the marsh vegetation remaining wetted burrows during low tide.

6.6A.1.2.6 Brackish Marsh

Brackish-water marshlands border many salt marshes. Freshwater flow in Morro Bay occurs at small springs along the shores of Baywood Park, Cuesta-by-the-Sea, and the sand spit. Brackish marsh habitat occurs adjacent to Los Osos Creek and along the upper portion of the Chorro Creek floodplain. The marsh near the Chorro Creek inlet is composed of a stand of cattails *Typha* spp., tules *Scripus* spp. (WESTEC Services, 1988), sedges *Carex* spp., and rushes *Juncus* spp. (Jarque, 1998).

Many polychaete worms and amphipod crustaceans are found in the brackish marshes. Fish species in Chorro Creek and the marsh include three-spine stickleback *Gasterosteus aculeatus*, Sacramento squawfish *Ptychocheilus grandis*, speckled dace *Rhinichthys osculus*, and California killifish *Fundulus parvispinnis* (Morro Bay NEP, 1998).

6.6A.1.2.7 Rocky Intertidal/Shallow Subtidal (Pilings, Breakwaters and Wharves)

Rocky intertidal habitat is limited within Morro Bay but supports one of the bay's most diverse plant and animal communities with virtually every phylum of marine organism represented in and around the bay's rocky intertidal zone (PG&E, 1974). Hard substrate within the bay includes the two breakwaters and the along the bay's northern shore from the west breakwater to Coleman Beach.   also extends south from the MBPP intake, under the City's waterfront wharves, to just south of the boat launch. Fairbanks Point and White Point contain the bay's only natural rocky intertidal habitat. Pier/wharf pilings and floating docks along the waterfront also support communities typically found in rocky intertidal areas.

The most prolific rocky intertidal communities occur on the hard substrate provided by the breakwater and adjacent to Morro Rock. The pilings of the North T-Pier also support a diverse fouling community. Encrusting vertebrate fauna is dominated by barnacles *Balanus* spp. Crab species are abundant, including commercial species such as brown rock crab *Cancer antennarius* and red rock crab *Cancer productus*. Smaller species include masking crab *Loxorhynchus crispatus*, decorator crab *Oregonia gracilis* and kelp crab *Pugettia producta*. Sheep crab *Loxorhynchus grandis* is the largest of the bay's crab species.

Fish species include pile surfperch *Damalichthys vacca*, black surfperch *Embiotoca jacksoni* and rubberlip surfperch *Rhacochilus toxotes*. Cottid species are numerous. Rockfishes, an important commercial and recreational group outside the bay, are abundant as juveniles near Target Rock, and under the North T-Pier. Populations of juvenile rockfishes vary considerably from year to year.

In 1996, the top five species by landing weight for hook-and-line boats were cabezon *Scorpaenichthys marmoratus*, gopher rockfish *Sebastes carnatus*, grass rockfish *Sebastes rastrelliger*, lingcod *Ophiodon elongatus*, and black-and-yellow rockfish *Sebastes chryosmelas* (CDFG, 1996).

6.6A.1.3 Estero Bay Resources

The discharge of the MBPP comes in contact with Estero Bay's shoreline habitat in the immediate vicinity of the discharge.

Estero Bay is a shallow bay extending from Point Estero in the north to Point Buchon in the south. The bay is situated on the northeast edge of the Santa Lucia Bank, a prominent extension of the continental shelf and an important fishing ground. A majority of the substrate in Estero Bay consists of sand and silt. Rocky substrate is concentrated near Estero and Buchon Points and adjacent to Morro Rock and its breakwaters.

6.6A.1.3.1 Sandy Beach Intertidal

Sandy beaches provide the majority of the intertidal habitat of Estero Bay. Relatively few species are able to live in this unstable habitat. The most successful species include arthropods, polychaetes (*Thoracophelia mucronata*), and molluscs (PG&E, 1974; Adams et al., 1974).

Common crustaceans include sand crab *Emerita analoga* and the spiny mole crab *Blepharipoda occidentalis* (Kozloff, 1983). Pismo clams *Tivela stultorum* and razor clams *Siliqua patula* occur on broad sandy beaches exposed to strong surf. The local population of Pismo clams has declined with expansion of the sea otters' range.

6.6A.1.3.2 Rocky Intertidal

The discharge of the MBPP contacts the rocky intertidal area along the north side of Morro Rock and the ped area separating the discharge structure from Morro Strand Beach.

Rocky intertidal habitat occurs primarily between Point Estero and Cayucos in the north, and from Hazard Canyon to Point Buchon in the south. Morro Rock and the harbor entrance breakwaters account for the only rocky intertidal habitat near the MBPP. Few studies have been published on the rocky intertidal areas of Estero Bay. However, several have been conducted in the vicinity of Diablo Cove, a few miles southeast of the Morro Bay harbor entrance. Because of proximity, and similarity in geography and habitat type, these surveys are representative of rocky intertidal flora and fauna present in the southern regions of Estero Bay.

In the vicinity of Diablo Cove, the most abundant marine alga is foliose red (*Iridaea flaccida*, genus name changed to *Mazaella*) (Burge and Schultz, 1973). Of the 50 species of organisms identified in the vicinity of Diablo Cove (Adams et al., 1974 as cited in PG&E, 1974), more than one-half were molluscs, primarily gastropods. Common fish species include clingfishes, gunnels, sculpins and pricklebacks, adapted to extreme variations in temperature, salinity, and oxygen. Grass rockfish, cabezon, and black-and-yellow rockfish also are able to withstand the rigors of tidal fluctuations and can be found wedged in rock crevices.

6.6A.1.3.3 Sand-Mud Subtidal

The buoyant MBPP discharge plume only comes in contact with subtidal habitats at depths less than 2 to 3 m (7 to 10 ft) in a small area immediately in front of the discharge and to the north in the surf zone of Morro Strand State Beach.

Bottom-dwelling (benthic) species appear in clumped distributions within the bay's vast expanses of sand and soft bottom. Nemertean worms, amphipods, and snails were abundant in surveys conducted in 1971-72 (PG&E, 1973). Sand dollars *Dendraster excentricus* are common. The

Pacific sanddab *Citharichthys sordidus* is the most abundant demersal fish species collected in deep water off Diablo Canyon (Burge and Schultz, 1973) and is frequently caught by recreational anglers in Estero Bay.

California halibut *Paralichthys californicus* is one of the top predators in this environment and is sought by both commercial and recreational fishermen, although most halibut landed in San Luis Obispo County in 1996 were caught outside Estero Bay (CDFG, 1996). Other common demersal species include starry flounder *Platyichthys stellatus*, sand sole *Psettichthys melanostictus* and turbot *Pleuronichthys* spp. Numerous elasmobranch species are well adapted for this habitat, including Pacific angel sharks *Squatina californica*, thornbacks *Platyrhinoidis triseriata*, and round stingrays *Urolophus halleri*. Aggregations of round stingrays are commonly found in the thermal effluent of MBPP. Shovelnose guitarfish *Rhinobatos productus* are often found in shallow regions, while spiny dogfish sharks *Squalus acanthias* are more common in deeper regions.

6.6A.1.3.4 Rocky Subtidal

The MBPP CWIS discharge plume contacts approximately 200 m (660 ft) of rocky subtidal habitat along the northern base of Morro Rock.

Subtidal rocky substrate within Estero Bay is concentrated in four regions: between Point Estero and the Cayucos Pier, from Hazard Canyon to Point Buchon, riprap adjacent to Morro Rock and its breakwaters, and rocky promontories and ridges along the beach from Cayucos to Hotel Point.

Based on surveys of Diablo Cove, important brown algae of the shallow subtidal canopy include *Cystoseria osmundacea*, *Egregia menziesii*, and *Nereocystis luetkeana*. *Botryoglossum* was the dominant red foliose algae (Burge and Schultz, 1973).

Subtidal surveys of Diablo Cove in 1970 and 1971 by CDFG identified 24 fish species. Juvenile rockfishes were dominant. Scorpaenids dominated the adult fish counts, and blue rockfish *Sebastes mystinus* were common. Other abundant species were painted greenling *Oxylebius pictus* and blackeye goby *Coryphopterus nicholsii* (Burge and Schultz, 1973). Invertebrate fauna included gastropod molluscs, echinoderms, and a variety of arthropods. The red abalone *Haliotis rufescens* was reported to be the most important commercial invertebrate species. The abalone fishery in the area has since been discontinued by a ban on commercial abalone harvest.

Fishes have replaced abalone as the most important commercial resource in Estero Bay, with rockfishes *Sebastes* spp. the focus of the area's live-fish fishery. Cabezon, lingcod, and kelp greenling *Hexagrammos decagrammus* also are harvested. Cabezon and several nearshore rockfish species have attained increased commercial importance in the last decade due to expansion of markets for live fish. Seventy-seven percent (189,000 pounds) of the state's recorded cabezon landings during 1996 were landed in Morro Bay and Port San Luis. The top five species in San Luis Obispo County by weight were cabezon, gopher rockfish, grass rockfish, lingcod, and black-and-yellow rockfish (CDFG, 1996). Rocky subtidal areas from Cambria to Point San Luis (including Estero Bay) have been subjected to intense fishing pressure since this fishery began.

6.6A.1.3.5 Kelp Beds

No kelp beds are contacted by the MBPP discharge plume.

Kelp beds are one of the most prominent features along the Pacific Coast. In kelp beds all major phyla are represented, but the most conspicuous are gastropods, polychaetes, sea stars, bivalves, sponges, tunicates, and crabs. In Estero Bay, kelp beds are distributed within the subtidal rocky areas from Point Estero to Cayucos Creek in the north and Hazard Canyon to Point Buchon in the south. Kelp is also present within Morro Bay near its entrance. Two dominant species of canopy-forming kelp are found in Estero Bay, giant kelp *Macrocystis pyrifera* and bull kelp *Nereocystis leutkeana*. In the early 1970s, kelp beds in the bay consisted almost entirely of bull kelp (Burge and Schultz, 1973). Giant kelp is now the dominant species in the northern regions of the bay. Stands of individual giant kelp plants are also present along the subtidal riprap adjacent to Morro Rock. Kelp is economically important; CDFG regulates its harvest. Kelp harvested from Estero Bay is primarily used as food for farmed abalone.

6.6A.1.3.6 Open Water Nekton and Plankton

The MBPP CWIS discharge creates a buoyant surface plume that rapidly dissipates with little or no contact with open water fishes or plankton. Studies of the MBPPs discharge on this habitat are summarized in the Section's Project Impact Assessment.

Phytoplankton form the base of the marine food chain and reside in the top 50 to 165 feet (12 to 50 m) in coastal areas (Smith, 1993), represented by diatoms and dinoflagellates. Diatoms bloom in the spring. During summer, dinoflagellates become more common as diatoms decline. When light, nutrient level, salinity and temperature are in certain proportions, blooms may occur, causing "red tides." California Department of Health Services monitors phytoplankton along the coast, conducting sampling off of Cayucos in Estero Bay and inside Morro Bay.

Seasonal abundances of northern anchovy *Engraulis mordax* and Pacific sardine *Sardinops sagax* occur in Estero Bay. Populations fluctuate dramatically, with several decades of abundance followed by greater periods of scarcity. During one sampling (PG&E, 1973), a total of 553 fishes, representing 32 species, were caught. The white surfperch *Phanerodon furcatus* was the most dominant species. Walleye surfperch, jacksmelt, silver surfperch, Pacific sanddab, and topsmelt also were common. Twenty-two percent of the fishes were caught in the ambient temperature range, approximately 9 percent in the transitional temperature range, and approximately 70 percent in the discharge temperature. The results showed that most of the species occurred equally in the ambient and discharge temperature ranges.

The barred surfperch *Amphistichus argenteus* is the focus of a small but stable commercial fishery in the area. Landings of mostly barred surfperch totaled 32,000 pounds (41 percent of state total) in San Luis Obispo County in 1996 (CDFG, 1996). The most important commercial fish species in Estero Bay is king salmon *Oncorhynchus tshawytscha*, typically present from before the opening of sport salmon season in March, until mid or late July. County landings of king salmon totaled 122,000 pounds in 1996 (CDFG, 1996). Although Estero Bay accounted for only a minor percentage of this total, the recreational salmon fishery is important economically to the Morro Bay area.

6.6A.1.4 Pelagic Seabirds

Morro Bay and Estero Bay are an integral part of the Pacific Flyway, the migratory pathway that water-associated birds follow from their northern breeding grounds to the wintering grounds. Almost since counts began in Morro Bay (1957), the area has been within the top 15 areas in the nation in terms of number of species observed (COE, 1973). Over 25,000 individual birds have been counted in the bay at one time (Gerdes et al., 1974). Migration into the bay begins around mid-June and peaks in mid-February (Gerdes et al., 1974).

The most significant waterfowl in terms of total numbers in Morro Bay is the black brandt *Branta bernicla,* a sea goose that feeds on aquatic plants, especially eelgrass and sea lettuce, in shallow bays and estuaries. The Canada goose *Branta canadensis* and the tundra swan

Cygnus columbianus are occasional winter visitors, observed regularly, but considered unusual (Gerdes et al., 1974).

Some migrants, such as the common tern *Sterna hirunda*, least-storm petral *Halocyptena microsoma* and the phalaropes (*Phalaropus fulicarius, Steganopus tricolor, Lobipes lobatus*) use the area to feed and rest during migration. The Manx shearwater *Puffinus puffinus* usually inhabits the high seas but is an occasional migrant to the bay. There have been rare observations of the California least tern *Sterna antillarum browni*, an endangered species in California (Gerdes et al., 1974).

Migratory birds account for most of Morro Bay's pelagic birdlife during winter months and make heavy use of the sand spit for resting, as it is isolated from human disturbance and provides broad expanses of shoals at low tide. Aggregations of white pelicans *Pelcanus erthrorhynchos*, mew gulls *Larus canus*, herring gulls *Larus ardentatus*, royal terns *Sterna maxima*, and elegant terns *Sterna elegans*, are regularly found as winter visitors. Pelagic birds such as the northern fulmar *Fulmarus glacialis* occur in large flocks around fishing boats. The common murre *Uriga aalge* and Cassin's auklet *Ptychoramphus aleuticus* are seen in the bay from September to May when they nest in colonies on isolated coastal cliffs (McConnaughey and McConnaughey, 1990).

A few migratory species of pelagic birds are seen during the summer months. The pink-footed shearwater *Puffinus creatopus*, sooty shearwater *Puffinus griseus*, ashy petral *Oceanodroma homochroa*, and black petral *Loomelania melania* are seen in the bay from April to October (Gerdes et al., 1974).

Seaducks such as the surf scoter *Melanitta perscipillata*, white-wing scoter *Melanitta fusca*, lesser scaup *Aythya affinis*, and bufflehead *Bucephala albeolaare* are fairly common visitors during the winter months, some remaining all year. Dabbling ducks, such as mallard *Anas platyrhynchos*, ruddy duck *Oxyura jamaicensis*, green-winged teal *Anas carolinensis*, pintail *Anas acuta* and cinnamon teal *Anas cyanoptera* are resident waterfowl. They are present all year, inhabit the shallows of the estuary, and are known to breed in the area.

Five species of grebes are found as winter visitors to the bay. Four species of loons are also noted in the bay.

An important heron and cormorant rookery is located at Fairbanks Point and has been active for over 50 years (Gerdes et al., 1974). Great blue herons *Ardea herodias*, black-crowned night herons *Nycticorax nycticora*, and Brandt's cormorants *Phalacrocorax penicillatus* are commonly observed roosting in the eucalyptus grove there.

6.6A.1.5 Fully Protected Species

Three of the species listed by the CDFG as endangered or Species of Special Concern are reported to occur in the area. These include the southern sea otter, the steelhead, and the tidewater goby. The southern sea otter comes under the jurisdiction of the Marine Mammal Protection Act of 1972 and is therefore protected by Federal mandate, which supercedes state jurisdiction. The Commerce Department's National Marine Fisheries Service announced in 1997 the listing of several populations of Pacific steelhead rainbow trout under the Federal Endangered Species Act (ESA) of 1973. The tidewater goby is listed as endangered under the Federal ESA and is considered a Species of Special Concern Class I with the CDFG. In August 1999, the USFWS issued a proposed rule under the ESA to remove the northern population of the tidewater goby (the population north of Orange County, California) from the list of federal endangered and threatened species. This would include the population of tidewater goby in the Morro Bay area.

6.6A.1.5.1 Steelhead Rainbow Trout

No MBPP operating impacts on steelhead rainbow trout (steelhead) result from the existing MBPP intake and discharge nor are any expected as a result of the reductions in intake or discharge volumes of the modernized facility. Steelhead (*Oncorhynchus mykiss*) are powerful swimmers that migrate during the spring and summer months from the open ocean through Morro Bay into both Chorro and Los Osos creeks. Juvenile steelhead usually migrate to sea in the spring when they are from 6 to 8 inches in length. Steelhead can avoid the thermal plume in Estero Bay. They have not been collected in impingement samples from the recently completed 12-month 1999 to 2000 impingement study. Larval steelhead are not found in the vicinity of the intake and therefore would not be susceptible to entrainment.

Steelhead are the anadromous form of rainbow trout found in watersheds along the Pacific Coast from Alaska to southern California. The most recent findings show that the distribution of steelhead in California has been greatly reduced. Estimates place the total statewide population at 250,000 adults (CDFG, 1996). Known spawning populations are found in coastal streams from Malibu Creek in Los Angeles County to the Smith River near the Oregon border, and in the Sacramento River system. Much of the coastline of southern Monterey and San Luis Obispo Counties is relatively undeveloped so many of the small coastal streams still contain steelhead populations. Status of the populations in the Morro Bay/San Luis Obispo area range from healthy to severely depressed (CDFG, 1996).

Steelhead migrate during the spring and summer months from the open ocean through Morro Bay into both Chorro and Los Osos Creeks. These creeks have historically supported steelhead populations and both still have remnant populations of resident steelhead (Highland, 1999). In recent years, large numbers of ocean run fish have been documented in Chorro Creek (Morro Bay NEP, 1999). They are also found in Morro and San Simeon Creeks and most of the coastal streams in the county (WESTEC Services, 1988; J. Nelson, CDFG, pers. comm., 1999).

The southern steelhead is distinguished from other California steelhead populations by their unique life history, adaptation to a semiarid climate, and geographic location. The southern steelhead is the most jeopardized of all of California's steelhead populations. The steelhead in the Chorro Creek watershed are an important genetic resource in that they represent one of the southernmost remaining runs on the Pacific Coast. The southern stocks have adapted genetically to withstand variations in habitat that are not tolerated by northern stocks (e.g., warm water temperatures, low dissolved oxygen and extended drought conditions (CDFG, 1998).

During their juvenile life phase, a fresh water habitat and low-salinity estuarine environment are vital to the steelhead's survival. Estuaries and lagoons provide optimum nursery environments for juvenile steelhead. Steelhead typically migrate to marine waters after spending 2 years in fresh water, but some remain for less than a year and others remain for up to 3 years. Juveniles migrate to sea when they are from 6 to 8 inches in length. This migration is usually in the spring, but there are steelhead entering the ocean year round throughout their range (J. Nelson, CDFG, pers. comm., 1999). Steelhead adapt quickly to higher salinity levels and probably spend no more than a week migrating from the bay to the open ocean (D. Highland, CDFG, pers. comm., 1999). They reside for 2 or 3 years in the ocean before returning to their natal stream to spawn as 4- to 5-year olds. Steelhead, unlike salmon, are capable of spawning more than once before they die.

Steelhead require clean gravel-bottom substrate and clear flowing waters for spawning. The middle reach of Chorro Creek contains the majority of spawning habitat, but most of this reach becomes dewatered during the summer months due to agricultural diversions. Spawning steelhead require cool water temperatures with a preferred temperature range from 39 to 52 degrees Farenheit (3.9 to 11.1 degrees Celcius). Steelhead prefer to spawn in areas with water velocities of about 2 fps (Bovee, 1978). Until water velocities reach 10 to 13 feet per second, the swimming ability of adult steelhead is not hampered (CDFG, 1998). Egg mortality begins to occur at 56° F (13.3° C). Steelhead have difficulty extracting oxygen from water at temperatures greater than 70° F (21.1° C) (Hooper, 1973).

Steelhead are extinct or at low levels throughout the West Coast because of a combination of human activities and poor natural conditions. Habitat degradation, hatchery production, and over-harvest have reduced the fish's ability to cope with variable environmental conditions (Capelli, 1998).

6.6A.1.5.2 Southern Sea Otter

There is no reason to expect a healthy sea otter to be adversely affected in any way by either the existing or modernized MBPP intakes or discharge. They can freely swim in and out of the discharge plume and avoid the intakes.

The current range of the southern sea otter (*Enhydra lutris nereis*) is from Cojo Cove south of Point Conception to Año Nuevo Island in Santa Cruz County. There are now roughly 2,200 sea otters (Harris, 1999) living in a 250-mile range along the central coast. The current population count has been declining at a rate of 4 percent per year since 1995 (B. Hatfield, USFWS, pers. comm., 1999). Although sea otters began to reoccupy the Morro Bay area from Estero Point to Point Buchon between 1972 and 1974 (Wild and Ames, 1974), it was not until 1982 that significant numbers of otters were found within the harbor at Morro Bay (Bodkin and Rathburn, 1988). In more recent years, fewer otters have been observed using the bay as a resting and feeding area.

Otters eat a variety of foods including clams, sea urchins, abalone, crabs, and many different types of invertebrates. A study done by the USFWS (1988), found that clams were the principal prey items of otters foraging in Morro Bay, representing 92 percent of the prey items retrieved. Washington clams (*Saxidomus nuttalli*) and gaper clams (*Tresus nuttalli*) accounted for 59.8 percent and 32.3 percent, respectively, of the total bivalves obtained. Foraging success generally increased toward the back bay and the species composition shifted from gaper to Washington clams.

The abundance of sea otters in Morro Bay is highly seasonal (Bodkin and Rathburn, 1988), and closely follows the typical pattern of late winter kelp canopy degeneration observed along much of the central California coast (USFWS, unpubl. data). It appears that canopy-forming kelp forests (e.g., *Macrocystis pyrifera*) are somehow related to male sea otter reproductive success in California. Morro Bay may be important as a winter refuge for territorial males that abandon their territories during this period (Bodkin and Rathburn, 1988).

During the Fish and Wildlife Service study (Bodkin and Rathburn, 1988) 2,291 otter observations were recorded throughout the bay. Most of these observations occurred between the harbor mouth and what is now Tidelands Park. Observations indicate that the principal areas used by otters for foraging and resting are subject to regular fluctuations. Prior to the dredging (March 1987) of the main channel, foraging otters were most frequently observed on the eastern side of the main channel between the North T Pier and Tidelands Park. The following year, otter foraging activity appeared to shift toward the back bay. Sea otters that were resting, feeding, and grooming were most often observed in the protected waters along the sand spit west of the main channel. Prior observations (Siniff and Ralls, 1985) reported otter resting activity in the kelp beds near Target Rock. From the distribution of these otter observations, foraging appears to be the activity that may draw otters to the area near the MBPP intake. With the exception of foraging, observations indicate that otters avoid the busy areas of the bay adjacent to the waterfront and the MBPP intake.

6.6A.1.5.3 Tidewater Goby

Tidewater gobies (*Eucyclogobius newberryi*), a California native species, are small fish averaging approximately two inches in length. The tidewater goby can be found at the upper ends of lagoons and brackish bays at the mouths of coastal streams ranging from Tillas Slough in Del Norte County to Aqua Hedionada Lagoon in San Diego County. It is not distributed continuously throughout its range however, and is absent in several sections of coastline in northern California. Within the Morro Bay Estuary, tidewater gobies have been documented in brackish marsh habitats near the mouths of Chorro and Los Osos Creeks, but have not been observed there since 1984 (Morro Bay NEP, 1999).

No adult tidewater gobies have been reported in the estuary in recent surveys (R. Nakamura, Cal Poly, pers. comm., 1999) nor have any been collected in the recently completed year-long impingement study (September 9, 1999 through September 8, 2000). Larvae that were tentatively identified as tidewater goby were collected in front of the MBPP cooling water intakes and at several Morro Bay source water stations during the 1999-2000 entrainment study. The identifications were verified by taxonomic experts in early August 1999. Nearly 10 percent of the verified specimens were sent to Dr. David Jacobs (UCLA) for DNA analysis. Recently completed DNA analysis, performed on these specimens, refute the identifications. None of the specimens are tidewater goby based on the DNA test results. Eighty-five percent of the specimens were genetically identified as shadow goby *Quietula y-cauda*. The DNA from the remaining specimens were from unknown gobies whose DNA did not match any of the sequencing information in the laboratory's data banks; these "unknown gobies" did not match tidewater goby DNA.

All life stages of the tidewater goby are restricted to California coastal wetlands with low salinities (<10 ppt). Most of the year tidewater gobies form loose aggregations from a few fish to several hundred fish. They congregate on sandy substrate in lagoons and lower parts of creeks in water less than three feet deep. Nesting activities begin in late April and continue through early May. Gobies require clean, coarse sand, and water temperatures ranging from 75.6 to 79.6° F (24 to 26° C), for building nesting burrows. The gobies are most abundant during the fall and late summer, and before winter flood events when lagoons and creeks can be scoured by intermittent flooding. Most gobies do not survive the winter storm season and those that do are usually sub-adults. The few fish that do survive repopulate suitable habitats in the spring (Rathburn et al., 1993). The lack of a marine phase restricts movements between populations and greatly lowers the ability of this species to recolonize an area once it has been extirpated.

6.6A.2 IMPACTS TO MARINE RESOURCES

Significance criteria were determined based on California Environmental Quality Act (CEQA) Guidelines, Appendix G, Environmental Checklist Form (approved January 1, 1999) and performance standards or thresholds adopted by responsible agencies. An impact may be considered significant if the Project results in:

- A substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS.
- Substantial interference with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impedes the use of native wildlife nursery sites.
- A conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional or state habitat conservation plan.
- A discharge that fails to provide adequate protection to beneficial uses including the protection and propagation of a balanced indigenous community of fish, shellfish, and wildlife, in and on the body of water into which the discharge is made.

The project is also required under Section 316(b) of the 1972 Federal Clean Water Act to employ the best technology available to reduce significant adverse impacts of the facility's cooling water intake system.

6.6A.2.1 Cooling Water System Effects on Marine Biology

MBPP is an ocean-sited steam electric generating facility that employs seawater in its once-through cooling water system. The site of the MBPP is a preferred location due the abundant nearshore supplies of cold ocean water for cooling water purposes. As discussed in Section 6.5.1.1, California's energy policy recognizes this attribute of coastal power plant sites and recommends such sites over inland sites and the consumptive use of California's limited freshwater supplies.

The Project includes replacement of Units 1 through 4 with two combined-cycle units. The existing intake structure will remain the same except for the replacement of the circulating water pumps. One combined-cycle unit will utilize the existing seawater intake structure for Units 1 and 2 and the discharge line for Unit 3, and the other combined-cycle unit will utilize the existing seawater intake structure for Units 3 and 4 and the discharge line for Unit 4. Currently Units 1 through 4 utilize 464,000 (280,000 + 184,000) gpm resulting in a design approach velocity of 0.5 fps. With the installation of the new units, these values will be reduced to 330,000 gpm and 0.3 fps, respectively. The design (historic), actual (current), and projected specifications of the cooling water system at MBPP are summarized in Table 6.5-1. (See also Section 6.5 - Water Resources for additional water flow and thermal discharge information.)

The analyses of the modernized MBPP intake and discharge effects consider not only the existing cooling water system effects, but also the beneficial effects of lower combined-cycle design intake and discharge flows. The maximum existing MBPP Project discharge volume will be reduced by approximately 29 percent, as compared to Units 1 through 4. With design-based discharge temperature remaining at or below the plant's 20° F (11.1° C) delta-T, the plant's discharge plume will be smaller than past thermal plumes, at equal operating capacities and a 20 percent higher electrical output (see Section 6.5. - Thermal Plume Characteristics).

Modernization of the MBPP will very simply allow the facility to produce 20 percent more electricity using approximately 29 percent less cooling water. The approximate 29 percent reduction in the facility's cooling water intake requirements from present permitted levels reduces the number of intake entrained organisms and the size of the discharge thermal plume. Both changes represent reductions in any potential impacts of the modernized MBPP cooling water system effects on Morro Bay and Estero Bay marine habitats and species.

Prior studies related to NPDES permits at MBPP have demonstrated that the existing CWIS facilities represented the best technology available. The finding is based, in part, on the facility's low numbers of impinged juvenile and adult fishes and its location in an area of typically low larval fish diversity. A year-long impingement field study (September 9, 1999 through September 8, 2000) was recently completed to confirm species composition and abundance. It is certain that the potential number of organisms entrained by the modernized MBPP intake facility will be fewer due to the nearly 29 percent reduction in cooling water system design flows from historic operations. These lower flows will also result in lower intake velocities leading to a reasonable expectation of fewer numbers of impinged fishes and shellfish.

The analysis of the modernized MBPPs intake and discharge effects is based on information from recently completed and ongoing field studies (Table 6.6A-4) and a compilation of available background literature, results of completed MBPP intake and discharge studies, and cooling water system studies at other power plants. Sample collection from the 12-month survey of Morro Bay's larval fish populations that began in June 1999 will be completed in early December. However, eight months of preliminary data, give immediate insight into the composition and abundance of the bay's larval fish species assemblage. Impingement data from September 9, 1999 through August 18, 2000 were analyzed for this AFC application. The remaining three impingement survey results (August 19, 2000 through September 8, 2000) are currently being analyzed. Results from eight months of entrainment surveys and nearly 12 months of impingement surveys are summarized in Section 6.6A.2.1.2. Detailed reports discussing the methods, data analyses, and results of the 1999-2000 impingement and entrainment studies are attached as Appendices 6.6A-2 and 6.6A-3, respectively. Summaries of reports that have specifically dealt with the potential impacts of the MBPP intake and discharge effects are included. The review of available background literature on MBPP cooling water system effects identified a number of reports that can be used to predict potential effects and impact associated with modernization of the present facility. This literature, in combination with information from the ongoing field studies described herein, forms a substantial basis for the cooling water system impact assessment.

TABLE 6.6A-4

CONTEMPORARY MBPP COOLING WATER INTAKE AND DISCHARGE BIOLOGICAL STUDIES

DATE	TYPE OF SAMPLING CONDUCTED
June 1999 - December 2000	Entrainment and source water plankton tows
September 9, 1999 through September 8, 2000	Impingement study
August 1999	Qualitative resurvey of Morro Rock thermal effects
August 2000	Sand beach fauna thermal effects survey
September 2000	Subtidal benthic thermal effects survey
September-October 2000	Rocky shoreline thermal effects survey

Various studies have been conducted over the years in the vicinity of the MBPP. Several studies examined the thermal effects of the MBPP (Table 6.6A-5). This section summarizes the methods and results of relevant studies. Locations of these previously studied areas are presented in Figure 6.6A-9.

TABLE 6.6A-5

PREVIOUS COOLING WATER INTAKE AND DISCHARGE EFFECTS STUDIES CONDUCTED AT THE MBPP

DATE	TYPE OF SAMPLING CONDUCTED	SOURCE
March 1967-January 1968	Algal studies	North, 1969
November 22-24, 1971	Benthic grab sampling; otter trawl tows	PG&E, 1973
November-December 1971	Intertidal transect study	Adams et al., 1974
February 2-4, 1972	Benthic grab sampling; otter trawl tows; gill net sets	PG&E, 1973
February-March 1972	Intertidal transect study	Adams et al., 1974
March 1, 1972	Sinking and floating gill net sets	PG&E, 1973
May 10-12, 1972	Benthic grab sampling; otter trawl tows; gill net sets	PG&E, 1973
May-June 1972	Intertidal transect study	Adams et al., 1974
July-August 1972	Intertidal transect study	Adams et al., 1974
June–October 1974	Angler use and catch composition	Steitz, 1975
July 1977–December 1978	Impingement study	PG&E, 1982

To confirm the previous findings of no significant adverse effects on beneficial uses, the potential impact of the Project on the source water and receiving water aquatic resources, site-specific information is being collected on the composition and abundance of the fishes and selected crabs that are impinged and potentially entrained. Locations of sampling areas are presented in Figure 6.6A-11. In response to concerns expressed by the CDFG, the megalopal stage of all species of cancer crabs will be identified and enumerated from all processed entrainment and source water plankton samples. The megalopal stage of the introduced, invasive European green crab (*Carcinus maenas*), if present, will be enumerated in response to concerns regarding their presence. These data will be used to estimate the potential entrainment by the CWIS intakes and estimate proportional entrainment losses of source water larval fishes and cancer crabs. Summary findings of the 1999-2000 entrainment studies are presented in Appendix 6.6A-3. All impinged fishes, decapod crabs, mollusks, and sea urchins were identified, enumerated, measured, and weighed. Impingement rates, and biomass estimates determined from these data are presented in Appendix 6.6A-2.

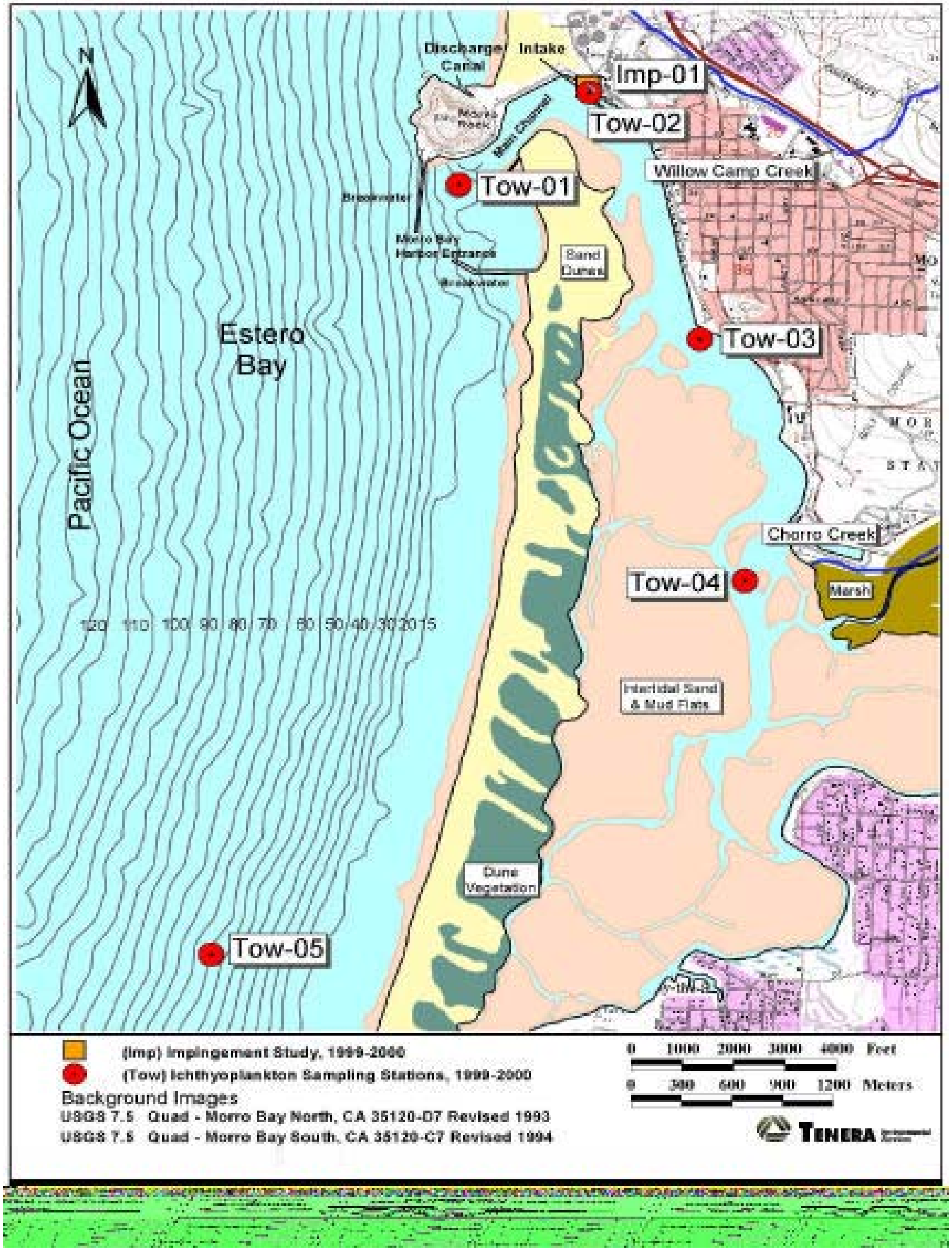


Figure 6.6A-11. Current entrainment and impingement study locations in Morro Bay.

Assessment of the MBPP Project's potential CWIS impacts is based on reports from past studies of the power plant's impacts and from contemporary studies mentioned above, including a year-long entrainment study that is nearly completed. Data from this study addresses questions regarding cooling water system intake entrainment effects. The entrainment study includes; (1) sampling in front of the intake; and (2) a source water component (sampling in the entrance to Morro Bay, an offshore location downcoast of the entrance to Morro Bay in Estero Bay, and in the back bay area of Morro Bay). A 12-month impingement study was completed on September 8, 2000. A biological survey of the MBPP discharge effects on algae and invertebrates located on Morro Rock and fishes observed in the vicinity of the rock was completed August 7 and 9, 1999. The results of this survey are included in the report in Section 6.6A.2.1.2. A survey of the sand beach habitat near the MBPP discharge was completed on August 2, 2000 and the preliminary findings are discussed in Appendix 6.6A-6. Subtidal benthic sampling was conducted in September 2000 and the preliminary results from that survey are attached as Appendix 6.6A-7. Quantitative intertidal surveys of the rocky shoreline near the MBPP discharge were conducted in September and the results from those surveys are currently being analyzed. A study plan (MBPP Modernization Project Thermal Discharge Study Plan), written with guidance from the TWG, contains descriptions of the three biological studies and is attached as Appendix 6.5-1.

A thermal plume study completed in July 1999 was used to establish the size and nature of the existing discharge plume and to facilitate development of the contemporary thermal plume characterization study plan design (Appendix 6.5-1) for projecting the dynamics of the new plume under the proposed operating scenarios.

6.6A.2.1.1 Impacts to Morro Bay

<u>Thermal Impacts</u>

Current and past studies of the distribution and dispersion of MBPPs thermal plume found no case where the plume came back on shore south of Morro Rock and entered into Morro Bay. Temperature recorders placed in many locations at various depths in Morro Bay (see Figure 6.6A-1 and Section 6.5) since 1999 have continuously recorded water temperatures while the plant was operating at varying loads and flows. Data from these recorders have not detected increased water temperatures related to the thermal discharge in Estero Bay. The results of past MBPP thermal plume studies also demonstrated the absence of any possible thermal effects on Morro Bay's habitats. The reduced size of the modernized plant's thermal plume provides additional assurance that Morro Bay's sandy subtidal, intertidal mudflats, submerged aquatic vegetation, coastal and brackish marshes and rocky intertidal habitats will not be affected by the discharge.

Entrainment Impacts

The modernized power plant will withdraw cooling water through the existing facility's two adjacent intake structures (Units 1 and 2 and Units 3 and 4; Figure 6.6A-3). Organisms smaller than the 3/8-inch mesh of the traveling screen will be entrained into the plant's CWIS and returned to the receiving water. Entrainment rates are directly related to the volume of water withdrawn by the plant. Use of state-of-the-art combined-cycle technology for the Project reduces design seawater intake volume through the existing intake structures as part of the Project, thereby reducing entrainment losses by an estimated 29 percent. Mortality rate of fish larvae does not necessarily degrade the ecosystem productivity. Most marine organisms produce enormous numbers of eggs and larvae to compensate for the extremely high natural mortality typical of marine habitats. Populations studies have shown that losses of these early life stages are generally insignificant to the eventual number of surviving adults. A practical application of the phenomena is demonstrated by the managed harvest of natural populations that sustain 30 to 50 percent losses of adults arising from these early life stages without long-term effects. The entrainment study [316(b) Resource Assessment Study] was designed to evaluate potential impacts of the CWIS effects as a part of the NPDES permit.

Phytoplankton and zooplankton populations will not be impacted by the Project's CWIS because of their short generation times, wide geographic distributions, and high population regeneration potential. The risk of localized population changes are reduced by the tidal currents that continually replenish the phytoplankton and zooplankton populations in the vicinity of the MBPP. The 29 percent reduction in cooling water intake flows will reduce the numbers of entrained phytoplankton and zooplankton.

This section is prepared in response to State[12] and Federal[13] regulatory requirements to assess whether the Project's proposed CWIS represents best intake best technology available (BTA) for minimizing the modernization Project's CWIS effects.[14] Information from studies of the operating MBBP and its CWIS effects on marine resources are used to assess the potential impacts of the intake and evaluate CWIS alternatives. The present permitted MBPP CWIS complies with its NPDES permit with BTA based in part on the facility's 316(b) CWIS study finding of low

(12) Section 316(b); 33 USC §1326 - Electrical Generating and Industrial Cooling Intake Systems. The administering agency for the above authority is the Central Coast RWQCB with oversight provided by EPA Region IX.

(13) Ibid.

(14) EPA. Development Document for Best Technology Available for the Location, Design, Construction and Capacity of Cooling Water Intake Structures for Minimizing the Adverse Environmental Impact. EPA-440/1-76/0/59. 263 pp. 1976.

potential impact along a consideration of available intake alternatives to reduce effects at a reasonable cost. The modernization Project's TWG requested Duke Energy to conduct new studies of the MBPP CWIS and to use the contemporary information from these studies along with existing information to assess potential impacts of the Project on local marine resources and evaluate CWIS BTA. The majority of the work is summarized in this section and included as appendices to the application. The study's findings are used to analyze potential impacts and evaluate CWIS alternatives. A 316(b) report will be submitted to the RWQCB in early 2001 to provide findings for the draft NPDES permit that is expected in March 2001.

Current entrainment studies began in June 1999 and will be completed in December 2000. Results of eight months of sample collections are summarized below. A detailed report of the entrainment study including methods and results is in Appendix 6.6A-3. The Fourth Quarterly Report, submitted to the RWQCB, is attached as Appendix 6.6A-8.

The purpose of this study is to describe the composition and abundance of larval fishes and megalopal crabs that could be affected by operation of the MBPP CWIS. Entrainment studies were designed to estimate larval fishes and megalopal cancer crab losses due to passage through the CWIS (assumes 100 percent through-plant mortality). Source water studies were conducted to characterize the composition and abundance of the larval fishes and megalopae that could be entrained by MBPP. Larval gobies were the most abundant fishes entrained (56 percent) and that *Cancer antennarius* constituted the majority of the crab megalopae entrained (23.6 percent). The gobies were also the most abundant taxa in source water plankton samples making up approximately 91 percent of the most abundant larvae from within Morro Bay and approximately 10 percent of the most abundant larvae collected from Estero Bay. Brown rock crab *Cancer antennarius* clearly dominated collections from in and outside of Morro Bay (i.e., Estero Bay), constituting approximately 59 percent and approximately 99 percent, respectively, of the plankton collections from those stations.

Many marine organisms have planktonic forms that can be entrained in cooling water intake systems. The TWG overseeing these studies decided to focus on groups of representative target organisms; namely larval fishes and crab megalopae. From these two groups of target organisms, particular taxa were selected in concert with the TWG for further analyses on the basis of their abundance in the samples or on other considerations (e.g., protection status, economic value, ecological importance). These selections were also based on the availability of suitable life-history information to meet assessment model requirements and on criteria outlined in EPA Draft Guidelines (EPA, 1977). The TWG determined that several assessment approaches would be applied to the data for each taxon where possible yielding more robust and comparable impact assessments.

Three of the four numerically dominant larval fish taxa collected at entrainment and in the source water are commonly associated with nearshore, shallow habitats such as bays and estuaries (gobies, combtooth blennies, and Pacific staghorn sculpin). The fourth, northern lampfish, is a pelagic, midwater fish whose adults are rarely found near shore. The three bay/estuary species demonstrate distinct abundance trends that follow lunar tide cycles; their larvae are most abundant on outgoing and at low tides within the confines of Morro Bay. It also follows that entrained northern lampfish larvae abundance does not follow a tidal cycle since adult lampfish are found offshore in deep water, too distant to be affected by any MBPP entrainment effects.

Only one of the three most abundant bay/estuary fish taxa has any economic value. None of the gobies or blennies are recreationally or commercially harvested, but Pacific staghorn sculpin is a shore-caught sportfish representing some undetermined level of indirect revenue in bait, tackle, and license sales. The tidewater goby *Eucyclogobius newberryi*, which has been reported to occur in the region of the MBPP, is a federally protected species. Population-level effects on this and the other entrained fish taxa have not yet been determined.

Four cancrid crab species constitute 92 percent of the crab megalopae entrained at MBPP. Brown rock crab numerically dominated these and the source water plankton collections during this study (i.e., 59 percent inside Morro Bay and 99 percent in Estero Bay). Their greatest abundance, during the Spring, corresponds to inferred spawning periodicity from other central California plankton surveys (Tenera Environmental, 2000). While brown rock crab are reported as annual spawners they occasionally have more than one batch per year (Carroll, 1982) accounting for the earlier peaks in entrainment abundance. Source water abundance appears to be unaffected by lunar tide cycle as could be expected given their high numbers both inside and outside of Morro Bay.

No significant entrainment impacts on Morro Bay's resident species are expected based on the small fraction (9 percent) (see Section 6.5.1.4.1-Tidal Prism and Appendix 6.5-3) of the bay's dynamic volume withdrawn for cooling purposes and the high reproductive capacity of the species. On a similar basis, it would be essentially impossible for MBPP entrainment to impact Estero Bay species. More detailed analyses of population-level effects of these entrainment losses will be determined using a combination of empirical estimates (Empirical Transport Modeling [*ETM*]) and demographic approaches (Adult Equivalent Loss [*AEL*] and Fecundity Hindcasting [*FH*]) for the RWQCBs NPDES permit and 316(b) assessment process. The *ETM* will use the source water samples to represent entrainment losses as fractions of the population at risk to entrainment in the source water. The *AEL* and *FH* models will predict and hindcast, respectively, the number of adults represented by the entrained early life stages. Larval abundance will be used to predict the number of adult equivalents they would have contributed to the population based on schedules of growth and survivorship (i.e., adult equivalent losses). Similarly, *FH* will hindcast the number of reproductively active adult females required to produce the number of larvae entrained. The use of these last two approaches depends on the availability of growth and survivorship estimates and, thus, may not be useful for taxa lacking this information.

Impingement

Organisms larger than the 3/8 inch mesh of the traveling screens that are weak swimmers or otherwise unable to avoid the intake may be impinged. Not only does the modernized facility significantly reduce design intake volume, the "approach to bar rack" velocities are also reduced (Section 6.5) thereby minimizing impingement rates of juvenile and adult fishes and shellfish. The existing Units 1 and 2 and Units 3 and 4 "approach to bar racks" velocities were measured in 1999 under full load conditions and maximum cooling water withdrawal. The existing Units 1 and 2 approach velocities of 0.37 fps will be reduced by approximately 10 percent (to 0.33 fps) for the new combined-cycle unit during peak load. An even greater reduction in the approach velocities (approximately 40 percent) will occur at the Units 3 and 4 intake from the current 0.51 fps to 0.30 fps for the combined-cycle unit during peak load. Even with this reduction in approach velocities, fishes and shellfish larger than the 3/8-inch screen mesh will be impinged. Results from the 1999-2000 and the 1978-1979 MBPP studies are summarized below.

A 12-month impingement study was completed on September 8, 2000. A detailed report of the 1999-2000 impingement study including methods and results is in Appendix 6.6A-2. Data from surveys conducted from September 1999 through August 18, 2000 were analyzed for this AFC. Additional survey data collected after August 18, 2000, are currently being processed and findings will be provided in the Draft 316(b) Resource Assessment. Methods for impingement sample collection and processing were patterned after the earlier impingement study (PG&E, 1982).

1999-2000 Impingement Study

Weekly samples were conducted at the MBPP Units 1 and 2 and Units 3 and 4 intake structures. Species composition, abundance, and biomass of fishes and invertebrates were measured.

The total estimated impingement losses at MBPP between September 6, 1999 and August 18, 2000, (expanded by using the 24-hour impingement data and the plant's actual weekly cooling water flow volume) was around 74,000 fishes weighing 1.2 metrictons and around 47,000 macroinvertebrates weighing 0.3 MT.

A variety of the fishes and invertebrates impinged at MBPP have some commercial or recreational value either as food for human consumption, reduction, live bait, or sport catch. The Pacific States Marine Fisheries Council (PSMFC) places many of these fishes into broad groups (i.e., all rockfishes) and treats some individual taxa (e.g., cabezon, lingcod, and kelp greenling) when reporting statewide fish landings (Table 6.6A-6). Using these taxonomic groupings for fishes impinged at MBPP and for which PSMFC reports landings, it becomes apparent that the economic impacts of impinged fish losses at MBPP are small. Other taxa impinged at MBPP with some economic value for which no landings data are available are the surfperches (approximately 1 percent by number of the fishes impinged), California scorpionfish (less than 1 percent by number of the fishes impinged), and Pacific mackerel (less than 1 percent by number of the fishes impinged).

Seven of the invertebrate taxa impinged during the course of this study have some commercial value (Table 6.6A-7). For the cancrid crabs, price per kilogram ($/kg) was estimated by averaging Morro Bay landings and dollar values between 1989 and 1998 from CFDG data. For *Upogebia pugettensis* and *Pandalus platyceros*, the landings and dollar values for the market categories "Ocean Shrimp" and "Prawns" were combined and averaged over the same period as above. No landings of market squid in Morro Bay were available, but a $/kg was estimated from Starr et al. (1998). As with the fishes, the projected dollar losses to the local fishery associated with MBPP impingement losses for these species are low.

Many of the taxa that occur in local waters but are not impinged have some aspect of their life histories which provides refuge from entrapment in the plant's cooling water system. Animals that are impinged are often the early life that are weak swimmers or not yet fully developed. Thus fishes and invertebrates whose early life stages progress in habitats outside of Morro Bay (e.g., rockfishes) substantially reduce their risk of impingement. Animals that are small and weak swimming as adults are less likely to be impinged in large numbers if their habitat preferences (e.g., pelagic or benthic environments) place them in areas away from the power plant intake (e.g., northern anchovy, market squid). Finally, some organisms are found primarily in bays and

TABLE 6.6A-6

APPROXIMATE DOLLAR VALUE OF ESTIMATED IMPINGEMENT LOSSES FOR SELECTED TAXONOMIC GROUPS OF FISHES AT MBPP DURING THE SURVEY PERIOD (SEPTEMBER 6, 1999-AUGUST 18, 2000)

Based on data from the Pacific States Marine Fisheries Council's (PSMFC) Pacific Fisheries Information Network (PacFIN) and Recreational Fisheries Information Network (RecFIN) internet databases unless otherwise noted.

TAXONOMIC GROUP	ESTIMATED # IMPINGED FOR SURVEY PERIOD	ESTIMATED WEIGHT (kg) IMPINGED FOR SURVEY PERIOD	1999 LANDINGS AT MORRO BAY PORTS (MT)	1999 EX VESSEL VALUE IN MORRO BAY PORTS ($)	APPROXIMATE VALUE ($) OF ESTIMATED IMPINGEMENT LOSSES AT MBPP	APPROXIMATE VALUE ($) OF ESTIMATED IMPINGEMENT LOSSES AT MBPP EXTRAPOLATED TO FISHERY-SIZED INDIVIDUALS
Rockfishes	203	14.52	397.2	$1,077,900	$39	$1,800
Kelp greenling	39	1.45	1.6	$13,400	$12	$200
Lingcod	218	1.45	13	$25,700	$3	$2,900
Cabezon	294	18.32	42.3	$517,400	$224	$3,600
Barred surfperch	78	0.47	NA	NA	$2	$200
				Grand Total:	**$280**	**$8,700**

NA=Not available.

TABLE 6.6A-7

APPROXIMATE DOLLAR VALUE OF ESTIMATED IMPINGEMENT LOSSES FOR SELECTED TAXONOMIC GROUPS OF INVERTEBRATES AT MBPP DURING THE SURVEY PERIOD (SEPTEMBER 6, 1999-AUGUST 18, 2000).

Based on data from the California Department of Fish and Game unless otherwise noted.

TAXONOMIC GROUP	ESTIMATED # IMPINGED FOR SURVEY PERIOD	ESTIMATED WEIGHT (kg) IMPINGED FOR SURVEY PERIOD	AVERAGE (1989-1998) LANDINGS IN MORRO BAY (MT)	AVERAGE (1989-1998) EX VESSEL VALUE IN MORRO BAY ($)	APPROXIMATE VALUE ($) OF ESTIMATED IMPINGEMENT LOSSES AT MBPP	APPROXIMATE VALUE ($) OF ESTIMATED IMPINGEMENT LOSSES AT MBPP EXTRAPOLATED TO FISHERY-SIZED INDIVIDUALS
Cancer Crabs			145.97	$385,600	$200	$6,310
Cancer antennarius	2,630	56.70				
Cancer anthonyi	214	1.54				
Cancer productus	531	10.16				
Cancer magister	237	2.04				
Shrimp and Prawns			193.41	$1,070,200	$4(1)	NA
Upogebia pugettensis	12	0.12				
Pandalus platyceros	7	0.55				
Loligo opalescens	15,983	36.15	none	none	$100(2)	NA
				Grand Total:	**$304**	**$6,310**

NA=Not available.

(1) This value is a first approximation which combined and averaged the market categories of "Ocean Shrimp" and "Prawns".

(2) The $/kg ($3.20) is based on the 1994 market squid catch in Monterey Bay National Marine Sanctuary ports (Starr et al., 1998).

estuaries (e.g., silversides) and are often impinged. However, these organisms have other life history adaptations (e.g., fast growing, high fecundity, competent young) which allow them to sustain this added source of mortality while maintaining healthy population levels.

Previous studies in and around Morro Bay indicate that the fishes impinged at MBPP are representative of the majority of fishes available from the surrounding habitats. In CFDGs otter trawl study of Morro Bay (initiated in 1992), very few of the top 25 species they have collected (e.g., vermilion rockfish and California halibut) have not been impinged during the survey at MBPP. Similarly, nearly all of the invertebrates impinged at MBPP are represented in CFDG otter trawl collections (CFDG unpublished data). The ten most abundant fish taxa collected by Fierstine et al. (1973) at various sites within Morro Bay (including near the harbor mouth) contain only two species not impinged at MBPP; diamond turbot *(Hypsopsetta guttulata)* and the tidewater goby *(Eucyclogobius newberryi)*. By contrast, several gobies collected by Horn (1980) near Baywood in southern Morro Bay did not occur in the impingement collections. These fishes are burrow dwelling and favor shallower, lower energy habitats which are found farther from the harbor mouth.

Prior studies of the MBPP CWIS intake effects demonstrated that the existing facilities represented the best technology available. Pacific Gas and Electric Company (PG&E) conducted a study in compliance with Section 316(b) of the CWA (PL 92-500 and 95-217) which required that the location, design, construction, and capacity of MBPP cooling water intake structure reflect the best technology available for minimizing adverse environmental impact. The study plan, based on state and federal 316(b) guidelines, was reviewed by several government agencies, including staffs of the RWQCB, State Water Resources Control Board, CDFG, and the EPA. The RWQCB decided that site-specific studies documenting the numbers of organisms entrained or impinged were not required for the MBPP because the facility was judged to be a low impact facility. The RWQCB staff concluded that results of extensive entrainment and impingement studies that were to be conducted at the Moss Landing Power Plant were sufficient to provide a basis for extrapolation to MBPP. An impingement monitoring study conducted at MBPP between July 1977 and December 1978 (PG&E, 1982), provided further information upon which an evaluation of the MBPP cooling water intake system could be based. Although entrainment studies were not required to be conducted at this site, entrained organisms were expected to include the planktonic eggs and larvae of fishes and invertebrates of species that spawn in open coastal waters and Morro Bay, such as flatfishes, gobies, rockfishes, shiner perch, and cancer crabs.

Based on laboratory tests, fish larvae, fish eggs, and macroinvertebrates exhibited a significant level of overall entrainment survival at the Moss Landing Power Plant. Striped bass at Sacramento San Joaquin power plants have entrainment survival rates as high as 80 percent depending upon operating conditions (PG&E, 1980). The number of fish and macroinvertebrates impinged was monitored at Units 3 and 4 of the MBPP (PG&E, 1982) between July 1977 and December 1978. In their review, PG&E found no evidence that entrainment and impingement losses have adversely affected general trends in species abundance and species composition of the local populations. Units 1 and 2 had been in operation for 28 years (Units 3 and 4, 20 years) with no evidence or indication of adverse effects on the fish and invertebrate populations inhabiting Morro Bay or Estero Bay. They based their conclusion on their analysis of commercial and sport species landings and results from a number of monitoring surveys near the plant (e.g., Fierstine et al., 1973; PG&E, 1973).

The finding is based, in part, on the facility's low numbers of impinged juvenile and adult fishes and its location in an area of typically low larval fish diversity of enclosed bays. With the possibility that changes over time have altered the species composition and abundance of impinged organisms, impingement field studies were initiated in September 1999 to investigate this possibility and provide a present-day baseline of any intake effects. Results from the impingement studies from September 6, 1999 through August 18, 2000 are discussed in Appendix 6.6A-2. Regardless of any differences we might find, it is certain that the potential number of organisms entrained by the modernized MBPP intake facility will be fewer due to the approximate 29 percent reduction in cooling water system design flows. These lower flows will also result in lower intake velocities leading to a reasonable expectation of fewer numbers of impinged fishes and shellfish.

1977-1978 Impingement Study (PG&E, 1982)

An impingement study was conducted at MBPP to provide data for as part of the 316(b) exemption demonstration program at Morro Bay and for use at the NRC licensing hearings for Diablo Canyon Nuclear Power Plant and (PG&E, 1982). Species composition, abundance, and biomass of fishes and invertebrates were measured. The influence of such factors as season, tide direction and displacement, debris load in source water, light and dark, unit load, and screenwash frequency were analyzed with a multivariate approach.

Impingement studies were conducted during high load power plant operating conditions comparable to those proposed and under a wide variety of seasonal biological and oceanographic conditions. Ninety-six 24-hour samples were collected between July 1977 and December 1978 from Units 3 and 4. Nine samples were collected between July and October 1978 from Units 1 and 2. Eighty-eight species of fishes and 206 macroinvertebrates were identified.

Five species comprised 86.5 percent of the total 18-month catch (N = 20,398). These were in order of abundance, shiner perch *Cymatogaster aggregata*, northern anchovy *Engraulis mordax*, bocaccio *Sebastes paucispinis*, plainfin midshipmen *Porichthys notatus*, and topsmelt *Atherinops affinis*. The estimated impingement loss of these five species totaled 51,163 fishes during 6 months of 1977 and 80,977 fishes during 1978. Estimated impingement loss for all 88 species was 62,681 for 6 months of 1977 and 95,765 fishes for 1978.

Units 3 and 4 were shown to impinge a significantly greater number of fishes than Units 1 and 2. There was a significant increase in nighttime impingement over that of daytime. Impingement was also greater on the ebb tides. The influence of debris loading and other physical variables and their possible interactions were discussed.

Data from the MBPP impingement studies were reanalyzed to cover a 1-year period so as not to duplicate seasonal catches (PG&E, 1982). Table 6.6A-8 summarizes the numbers, weights, and percentages of fishes and macroinvertebrates impinged at Units 3 and 4 of the MBPP from January 1978 through December 1978. Macroinvertebrates impinged in highest numbers were rock crab, yellow crab, market squid, red rock crab, and bay shrimp. Annual biomass was estimated based using impingement data collected from Units 3 and 4 from January through December 1978 (Table 6.6A-9).

6.6A.2.1.2 CWIS Impacts to Estero Bay

Taxonomic composition of the larval assemblage entrained at MBPP is more similar to that recorded from source water stations within Morro Bay than to the larval assemblage in Estero Bay. However, since the intake location is near the harbor mouth, both pelagic and bay/estuarine species are entrained so that the taxonomic diversity is slightly higher at the intake structure when compared with other stations within Morro Bay. Most notably, only a few taxa dominate the plankton samples collected at the intake structure (i.e., gobies, combtooth blennies, Pacific staghorn sculpin, and northern lampfish; these species comprise approximately 85 percent of the larval fish abundance entrained) and the Morro Bay source water samples (gobies, Pacific staghorn sculpin, and jacksmelt, which comprise approximately 94 percent of the larval fish abundance in the source water), but dominance is more evenly distributed in the Estero Bay larval assemblage: 16 taxa

TABLE 6.6A-8

NUMBERS, WEIGHTS, AND PERCENTAGES OF SELECTED FISHES AND MACROINVERTEBRATES COLLECTED IN IMPINGEMENT SAMPLES AT UNITS 3 AND 4 OF THE MBPP, JANUARY-DECEMBER 1978

COMMON NAME	SCIENTIFIC NAME	NUMBER	PERCENT	WEIGHT (kg)	PERCENT
Fishes					
Shiner perch	*Cymatogaster aggregata*	5,419	34.3	27.2	7.5
Northern anchovy	*Engraulis mordax*	4,164	26.5	39.4	10.8
Plainfin midshipman	*Porichthys notatus*	2,025	12.6	127.7	35.1
Topsmelt	*Atherinops affinis*	1,370	8.7	35.8	9.9
Bocaccio	*Sebastes paucispinis*	1,104	7.0	11.4	3.1
California tonguefish	*Symphurus atricauda*	310	2.0	1.7	0.5
White croaker	*Genyonemus lineatus*	226	1.4	1.6	0.4
Rockfishes	*Sebastes* spp. (1)	256	1.6	4.1	1.1
Surfperches	Embiotocidae (2)	214	1.4	25.9	7.1
Other fishes		648	7.1	88.6	32.6
Total		15,736		363.4	
Macroinvertebrates					
Rock crab	*Cancer antennarius*	379	5.3	27.8	33.3
Yellow crab	*Cancer anthonyi*	194	2.7	23.1	27.6
Slender crab	*Cancer gracilis*	20	0.3	0.4	0.5
Jordan's crab	*Cancer jordani*	53	0.7	0.1	0.1
Dungeness crab	*Cancer magister*	5	0.1	1.4	1.7
Red rock crab	*Cancer productus*	96	1.3	14.7	17.6
Lined shore crab	*Pachygrapsus crassipes*	12	0.2	<0.05	0.1
California spiny lobster	*Panulirus interruptus*	1	<0.05	<0.05	0.1
Market squid	*Loligo opalesens*	122	1.7	1.0	1.2
Octopus	*Octopus* spp.	39	0.5	3.3	3.9
Bay shrimp	*Crangon nigicauda*	93	1.3	0.1	0.1
Other macroinvertebrates		6,155	85.9	11.7	14.0
Total		7,169		83.6	

(Source PG&E, 1982)

(1) Excludes bocaccio.
(2) Excludes shiner perch.

TABLE 6.6A-9

ESTIMATED ANNUAL BIOMASS (GRAMS PER MILLION CUBIC METER FLOW) OF IMPINGED FISHES AT MBPP UNITS 3 AND 4 BASED ON IMPINGEMENT DATA COLLECTED DURING JANUARY TO DECEMBER 1978

COMMON NAME	FAMILY AND SCIENTIFIC NAME	BIOMASS
Sardines and herring	Clupeidae	0.58
Anchovies	Engraulididae	467.83
Midshipman	Batrachoididae	1,622.84
Jacksmelt and grunion	Atherinidae	1,123.15
Rockfishes	Scorpaenidae	187.62
Sculpins	Cottidae	48.24
Croakers and white sea bass	Sciaenidae	19.79
Surfperches	Embiotocidae	683.63
Kelp bass and sand bass	Serranidae	0.18
Kelpfishes and fringeheads	Clinidae	6.64
Mackerel and bonito	Scombridae	<0.01
Butterfish	Stromateidae	14.49
Flatfishes	Pleuronectidae	32.17
Other bony fishes	Other Osteichthys	111.37
Sharks and rays	Chondrichthys	588.93
Total biomass (grams/million m^3)		4,907.46

(Source: PG&E, 1982)

comprise 90 percent of the larval fish abundance. This indicates that, despite overall similarities among the lists of taxa from the three sampling locations, the dominant species in Morro and Estero Bays are represented differently within their respective larval assemblages. From the list of larval fish taxa that occur in Estero Bay, flatfishes, white croaker, and rockfishes are harvested commercially and recreationally as adults and landed in Morro Bay. These three taxa are not numerically dominant either at the MBPP intake structure or in Morro Bay source waters. Therefore, it seems unlikely that entrainment losses of larval fishes at MBPP will lead to any marked or long-term population declines in the three commercially or recreationally important taxa collected as larvae from Estero Bay.

Results from the present impingement study at MBPP indicate that only five percent of the fishes and 25 percent of the invertebrates impinged during the survey are species with recreational or commercial value. The total predicted biomass losses for all fish and invertebrate taxa, including those with commercial and recreational value, is relatively small (1.5 MT annually) before reducing it further to consider only those species with monetary value. This biomass estimate, based primarily on juvenile and young of the year (YOY) fish and invertebrate weights collected during the study, may be representative of the ultimate contribution these young organisms would make to their adult fishery landings if survivorship and catchability are considered. For comparison, consider the 1999 commercial landings reported for all rockfishes landed at the Port of Morro Bay and in Port San Luis of approximately 397 MT (PSMFC PacFIN) or the landings of cabezon over the same period: approximately 18 MT (PSMFC PacFIN). Thus, assuming that the predicted biomass losses are representative of adult contributions to respective fisheries, it appears that impingement losses due to operation of MBPPs cooling water intake system would have little effect on commercially or recreationally important fish or invertebrate populations in the vicinity of Morro Bay.

Thermal Impacts

This section is prepared in response to State[15] and Federal[16][17] regulatory requirements to assess whether the Project's proposed CWIS discharge temperatures protect the receiving water beneficial uses of Estero Bay. Particular to both statutes is the requirement that CWIS discharge

(15) Water Quality Control Plan for Control of Temperature in Coastal and Interstate Waters and Enclosed Bays and Estuaries of California (Thermal Plan), Appendix A-3. The plan was established in conjunction with 40 CFR 316(a) for thermal discharges. It is administered by the Central Coast RWQCB.

(16) Section 402; 33 USC §1342; 40 CFR Parts 122-136. This federal permit requirement is administered by the Central Coast RWQCB, with oversight provided by the State Water Resources Control Board (SWRCB) and the EPA.

(17) Section 316(a); 33 USC §1326 - Thermal Discharges. The administering agency for the above authority is the Central Coast RWQCB with oversight provided by EPA Region IX.

temperatures meet numerical limits established in the 1972 Clean Water Act and other State policy for the designated facility type. Discharge temperatures may exceed these broad policy limits where it can be demonstrated, based on site-specific conditions, that the limits are "more stringent than necessary to assure the protection and propagation of a balanced indigenous population of shellfish fish, and wildlife in and on the body of water into which the discharge is made."(18) Due to the rapid dissipation and dispersion of the buoyant thermal plume, there has been a low potential for significant thermal impact. Information from studies of the operating MBPP and its CWIS effects on marine resources are used to assess the potential impacts of the proposed intake design and evaluate CWIS alternatives. The present MBPP CWIS discharge temperatures comply with its NPDES permit temperature limits for an existing facility. These limits and other water quality standards assure that the MBPP discharge temperature protects receiving water beneficial uses.

With the proposed reduction in the Project's discharge volume the low potential for thermal impacts will be even further reduced from any that may presently exist. The modernization Project's TWG requested Duke Energy to conduct new studies of the MBPP CWIS discharge plume and receiving water resources and to use this contemporary information along with existing information to assess the Project's potential impacts. In this case, to better define the potential benefits of the Project's reduction in permitted discharge volume to the receiving waters marine resources.

Detailed description and analysis of the Project's thermal discharge and plume characteristics are presented in previous Section 6.5-Water Resources. More detailed accounts and findings of specific studies are included in appendices to the application. Both the study's findings, potential impact analysis and alternative CWIS evaluation are used to produce a required Thermal Compliance report that is submitted to the RWQCB in fulfillment of the Project's revised NPDES permit application requirements.

This buoyant surface plume of seawater that is carried by winds and currents north into Estero Bay. Although the volume of the discharge will be approximately 29 percent smaller than presently permitted, the thermal plume will still contact the beach and Morro Rock in the vicinity of the shoreline discharge structure. (See Table 6.6A-10 for a description of plume contact.) Previous studies have reported little to no effect of the power plant's thermal discharge on receiving water fish and invertebrate populations. Although discharge temperature in the MBPP modified the rocky substrate community of marine organisms living in the facility's discharge canal and a short distance

(18) Section 316(a), 40 CFR Section 125, Subpart H.

TABLE 6.6A-10

AREAS OF POTENTIAL MODERNIZED MBPP THERMAL PLUME[1] CONTACT AND SUMMARY OF AVAILABLE THERMAL EFFECTS DATA

	Morro Bay	Estero Bay	Source of Information
THERMAL PLUME			
Shoreline Plume Contact	None.	Yes, Morro Strand State Beach and Morro Rock at point of discharge. Plume rapidly mixed in surf zone.	Predictive model based on plume studies (DENA, 2000; TRC, 1999; and PG&E, 1973).
THERMAL EFFECTS			
A. Water Column Larval Fishes (ichthyoplankton)	No plume contact.	Minor plume contact.	MBPP predictive model using MLPP Units 1 through 5, Units 6 and 7 1999 plume study results.
B. Water Column Adult Fishes (pelagic fishes)	No plume contact.	Minimal contact with surface plume.	Observations made during 1999 and 2000 surveys. Predictive model based on Estero Bay study (PG&E, 1973).
C. Ocean Bottom (benthos)	No plume contact.	Shoreline discharge forms buoyant surface plume not in contact with benthos.	Subtidal benthos study (September 2000)
D. Sandy Beach	Not applicable.	Yes	Sand beach fauna study (August 2000 and predictive model of MBPP beach studies (PG&E, 1973)
E. Rocky Shore (Morro Rock, breakwater) Algae, Shellfish and Fishes	No plume contact.	Yes	August 1999 Morro Rock resurvey; September-October 2000 rocky shoreline thermal effects study, predictive model based on Morro Rock study (North, 1969), and rocky shore thermal effects and laboratory thermal tolerance literature.
F. Eelgrass (*Zostera marina*)	No plume contact.	Not applicable.	Not applicable.
G. Mudflats	No plume contact.	Not applicable.	Not applicable.
Marine mammals	No plume contact.		Thermal effects and zoogeographic literature.

(1) Assumes MBPP is operating at peak loads.

Study Locations are Found in Figure 6.6A-12.

beyond, the CWIS canal discharges directly into the high energy surf line of Estero Bay. Under the direction of Project's TWG representing the Commission, the RWQCB, CDFG, and California Coastal Commission, thermal effects studies were designed and undertaken that would update baseline conditions, verify previous findings and conclusions, and provide information to be used for the renewal of the plant's NPDES permit (see Figure 6.6A-12 for station locations). A survey of the rocky intertidal area of Morro Rock was completed in August 1999 and September 2000. A survey of sand beach fauna near the MBPP discharge was completed in August 2000, and benthic samples were collected from just beyond the beach surf zone in September 2000.

Background

The nature of the MBPP discharge and its location is well designed to minimize biological effects on the receiving water habitats. Cooling water delta-T's below 20° F (11.1° C) are discharged at the surface into a turbulent surf zone. Mixing and dispersion is rapid as the plume spreads at the surface towards open water. The horizontal direction and buoyancy of the MBPP thermal plume causes it to rapidly separate from the ocean bottom and avoid potential impacts on benthic habitat in the area of the discharge. Vertical temperature profiles of the Units 1 through 4 thermal plume were collected when both units were operating at full capacity. Samples were also collected under varying tide conditions showed the absence of thermal discharge at depths greater than 2 to 3 m (7 to 10 feet) in a small area immediately in front of the point of discharge.

The results of these thermal plume studies are found in PG&E (1973). Results from additional recent surveys of the MBPP thermal plume (June 1999) are included in previous Section 6.5 - Water Resources. The results of both sets of studies demonstrate that these turbulently mixed and relatively low discharge temperatures contact the sandy beach, subtidal benthos, open water column and rocky intertidal and subtidal habitats in the area of the discharge. The methods and findings of studies on discharge effects are summarized by habitat.

Previous studies of the existing MBPP discharge effects found no statistically significant thermal effects on the area's sandy beach, open water, or sea floor habitats (North, 1969; PG&E, 1971, 1973; Adams et al. 1974; Steitz, 1975). Aerial infrared imagery was employed to map the extent of the surface discharge plume and to statistically compare its temperature to the densities and concentrations of marine organisms occupying these habitats. Although not statistically significant, trends of increase in both species composition and abundance have been identified in relation to increasing discharge temperature. Water currents and warmer temperatures created by the Units 1 through 4 discharge attract fishes to the offshore area of the discharge plume. It is common to find large numbers of topsmelt in the discharge plume. The discharge flow movement of particles may create a feeding advantage for these planktivorous species.

Temperature effects of the discharge thermal plume were clearly evident, however, in the abundance and species composition of seaweeds (attached algae) occupying rocky substrate on Morro Rock (North, 1969). An unavoidable consequence of the location of the discharge is that it directly contacts Morro Rock. However, the location also favors the rapid dissipation of discharge temperatures into the turbulent surf zone. The results of the SCUBA surveys show that signs of thermal effects disappear very quickly along a gradient away from the discharge. The potential size of the affected area, a small fraction of Morro Rock's rocky shore habitat, is projected to decrease with the nearly 29 percent reduction in the modernized MBPP discharge volumes.

A large synoptic study of the MBPP thermal discharges from Units 1 through 4 was conducted in 1971-72 (PG&E, 1973). (See Section 6.5 - Water Resources) Results from these applied research studies of discharge effects form the basis for a predictive model of discharge effects. The studies provide predictive information on the same habitats and species that might be potentially affected by the modernized MBPP reduced intake and discharge volumes. Field studies are currently being conducted to determine if the habitats, species composition, and diversity have significantly changed, and will also establish a new baseline for future monitoring.

A map of previous study locations (see Figure 6.6A-9), with respect to the MBPP intake and discharge areas, is presented to illustrate the geographic relevance of the findings and the intake and discharge conditions that existed during the study.

This report addresses the possibility of MBPP CWIS impacts from the perspective of the area's potentially affected marine habitat and their associated species. Table 6.6A-10 summarizes geographical areas of potential plume contact and habitat types. The habitats are illustrated in previous Figure 6.6A-6 and the location of habitats studied and the various investigators are illustrated in Figure 6.6A-8 a through i.

Sandy Beach Habitat

The Estero Bay's sandy beach habitat extends in a nearly continuous reach of approximately 10 miles from Cayucos to Montana de Oro, interrupted by Morro Rock and the entrance to

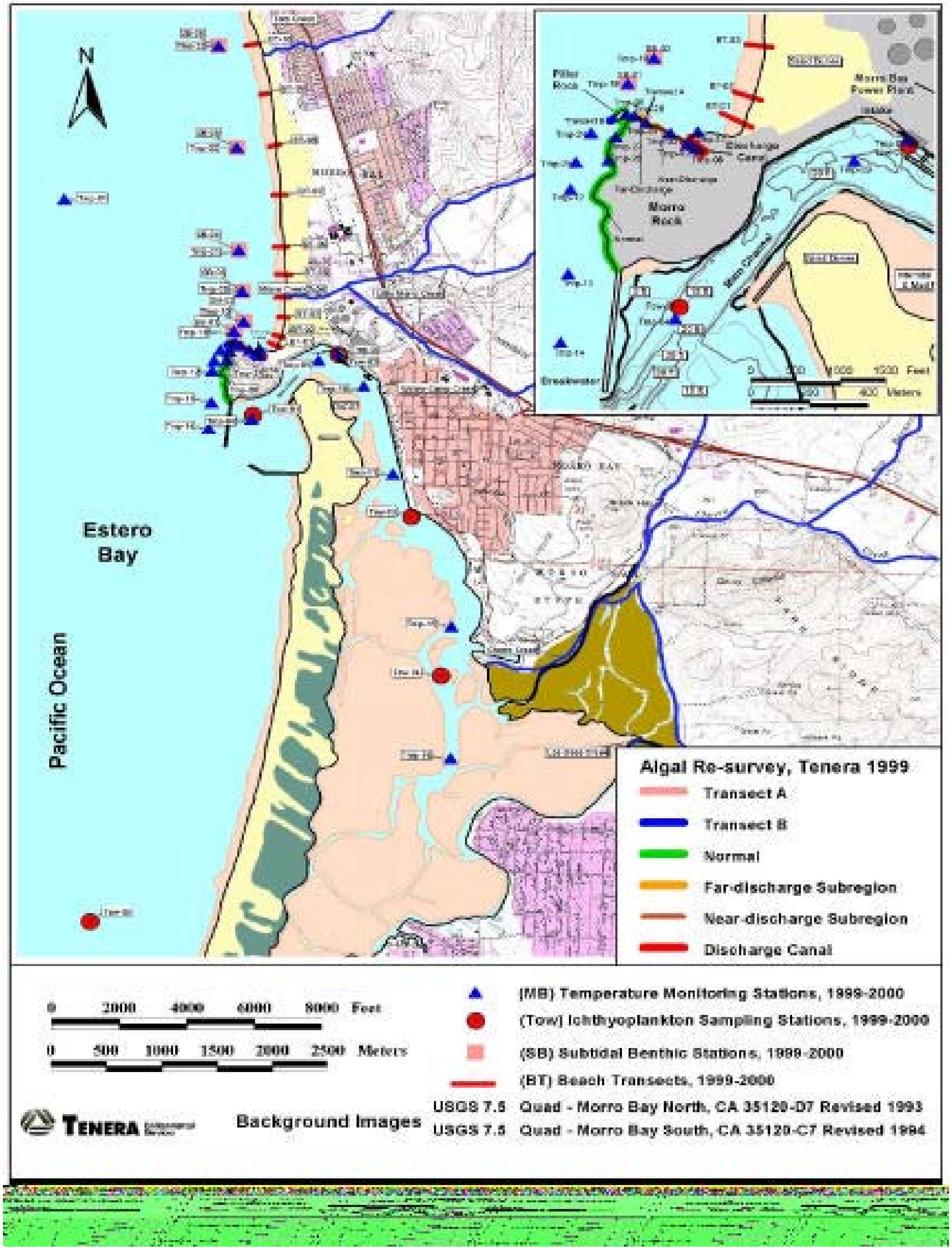


Figure 6.6A-12. Current thermal effects study locations, including locations of temperature recorders.

Morro Bay. Beach habitat in the area of Morro Bay is exposed to high-energy waves from the northwest. Large quantities of sand are annually transported on and off the beach shoreline by the strong waves and longshore currents found in this reach of the bay. The continuously changing nature of this habitat favors mobile invertebrate and fish species that adjust quickly to the depletion and accretion of beach sediments. Lacking stable substrate, attached organisms are unable to occupy this habitat, other than the scant hydroids and algae attached to Pismo clams protruding above the sandy bottom. Organisms of the sandy beach habitat are constantly moving and adjusting to their changing environment. Relatively few species are able to succeed in this habitat.

The most successful organisms are burrowers (such as bivalves and polychaete worms) and those animals that live in the surf zone and migrate up and down the beach according to the tidal cycle (sand crabs, amphipods, et al.). Some minute forms (e.g., harpacticoid copepods and isopods) also live among the sand grains in the surface layers. The three main macrofaunal groups represented in this habitat are polychaetes, molluscs, and crustaceans. Usually the dominant sandy beach taxa, in terms of numbers of species and individuals, are crustaceans. Most common in the Morro Bay area are two species of sand crabs *(Emerita analoga* and *Blepharipoda occidentalis),* a mysid *(Archaeomysis maculata),* isopods (especially *Cirolana harfordi),* and amphipods (beach hoppers; *Metopa* spp. and *Orchestoidea* spp.) (Berger, 1970).

Studies of the sandy beach habitat found no statistically significant effect of the existing Units 1 through 4 discharge and there is no reason to expect that the smaller discharge volume of the modernized MBPP will cause an effect. Sandy beach communities of worms, crustaceans and clams are adapted to a dynamic and unstable habitat of constantly changing tides, wave energy, and sediments. In addition to the unlikely possibility of detecting thermal plume effects in these constantly changing populations, the sandy beach habitat immediately inshore of the thermal discharge is designated for use as a long-term dredge spoil disposal site. The repeated disturbance of dumping dredge spoils on the beach would obviate any possibility of detecting potential thermal effects in the affected beach populations. However the TWG requested a set of samples be collected from the habitat to update previous descriptions and to reexamine the possibility of MBPP thermal plume effects. The sampling was scheduled to occur between periods when the City of Morro Bay and the COE dispose of dredge spoils and discharge waste water effluent onto the beach habitat.

August 2000 Sand Beach Fauna Study

Elevated temperatures of the MBPP Project's discharge will contact the sandy beach immediately north of the power plant's shoreline discharge. Turbulent wave action at this surf zone discharge point rapidly mixes and disperses the discharge thermal plume. Buoyancy of the thermal plume separates the plume from bottom contact as a combination of wind and currents carry it along the shoreline north into Estero Bay. During the movement of the plume away from the discharge, it continues to float to the surface in an ever thinning layer. The effect of wave mixing on the thermal plume can be seen in aerial IR thermal images where the thermal plume appears to disappear as it comes in contact with the surf zone and beach.

A survey of the sand beach habitat was conducted in August 2000. Previous studies used elements that would be applicable for testing spatial and temporal changes in the sand beach fauna adjacent to the MBPP discharge. The dynamic physical nature of the beach habitat results in a high degree of spatial and temporal variation in the fauna. For example, sand crabs are patchily distributed and can move either up or down the beach face in response to tidal height and wave exposure, and along the shoreline in response to changing beach morphology (Dugan et al., 1994). Therefore, any sample design sensitive to environmental effects such as changes in discharge characteristics must be robust enough to partition out variance due to natural factors. Stratified random designs can often overcome these difficulties and allow testing with an analysis of covariance (ANCOVA) to identify significant spatial or temporal changes in the sand beach fauna that covary with discharge plume temperatures contacting the beach habitat. Based on the results of previous MBPP thermal plume studies (PG&E, 1973) effects of the warm-water discharge on the sand beach community, if any, are expected to diminish rapidly with distance from the point of discharge. In August 2000, beach fauna was sampled at fixed intervals along vertical transects located at increasing distances from the MBPP discharge. Additionally, four replicate samples were collected along horizontal transects at the high, middle, and lower tidal elevations to allow an estimate of within area variation.

Transects were established at increasing distances along the beach upcoast from the discharge canal which encompasses a range of sites with varying amounts of plume contact. Water temperatures were continuously recorded in the MBPP discharge canal over the survey period in early August 2000, and also recorded for a 5 minute period in the wave wash zone at each transect at the time of field sampling. The sampling sites were similar to those used in the earlier study (Adams et al., 1974). Changes associated with increased temperatures (or theoretically with distance from the discharge) would be reflected as a gradient in the abundance of organisms across beach areas contacted by the plume. Results from the randomly sampled horizontal transects will be tested (ANCOVA) for covariance with plume temperatures (both measured and extrapolated) and distance from the discharge as partitioned by respective tidal elevations (model strata). The closer spacing of transects nearer the plume will allow a finer-scale determination of potential discharge effects, particularly for proposed lower discharge flow.

Field Sampling Methods

The beach sampling protocol was adapted from methods developed by the National Park Service for monitoring sand beaches in the Channel Islands National Park (Dugan et al., 1990) and methods used previously along Morro Strand State Beach by URS (1973). A set of 10 vertical transects were sampled along the beach at increasing distances north of the MBPP discharge. A 20 centimeter (cm) × 20 cm (7.9 inch × 7.9 inch) core sample was taken every 10 m (33 feet) along the vertical transects from approximately the 0.2 m to +2.7 m MLLW (0.7 ft to +9 ft MLLW) tidal elevation. Three tidal elevations on each transect were sampled with additional replicate cores. Four additional core samples (20 cm diameter × 20 cm deep) were excavated at random points along each of the horizontal transects to determine an average density of organisms at each elevation. The position of each vertical and horizontal transect was measured using differential GPS. The elevations of the horizontal and vertical transects were measured with a surveyor's level using a known USGS benchmark for a reference elevation.

Samples were placed into labeled mesh bags with 1.5 mm (0.06 inch) stretch mesh diameter consistent with published methodology (Dugan et al., 1990). Concurrent with the infaunal core sampling, shorebirds were censured in the vicinity of each transect. The physical conditions recorded at each transect were: 1) water temperature; 2) sediment grain size; 3) elevations (feet MLLW); and 4) positions of all transects.

Organisms were identified in the laboratory to the lowest practical taxonomic level. Size frequencies were determined for all sand crabs (*Emerita analoga*) and Pismo clams (*Tivela stultorum*) collected in the samples. Lengths were measured to an accuracy of 0.1 mm using vernier calipers. The reproductive (ovigerous) condition of female sand crabs was also noted.

All ten beach transects were sampled during early morning low tides on August 1 and 2, 2000. A total of 226 faunal core samples and 30 sediment grain size samples were collected.

Water temperatures recorded during the sampling collection were warmest closest to the discharge, and coolest temperatures were measured at the sampling locations farthest away from the discharge structure. The warmest water temperatures recorded on the transects were 10-11° C (50 to 52° F) cooler than the concurrent discharge temperatures and 2.8° C (5° F) above ambient seawater temperature.

Results

The beach sediments were classified as poorly graded sand comprised of terrigenous mineral sands and small shell fragments. Generally, there were finer grain sizes at the higher elevations and coarser sand and shell debris at the lower elevations. Variation in the grain size was greater in the lower beach samples. The lower beach cores from Transects BT-02 and BT-05 had some of the coarsest material. Dredge spoils from past U.S. Corps of Engineers dredging of the Morro Bay navigation channel have been deposited within the beach study area and may have affected the natural sediment grain size composition.

Preliminary data from 71 core samples yielded 22 taxa comprised of several species of polychaete worms, crustaceans (isopods, amphipods, anomuran crabs, mysid shrimps), clams, and nemertean worms. In qualitative field observations, beachhoppers (*Megalorchestia* spp.) were abundant at all transects in the upper elevation zone, particularly beneath macrophyte wrack (*Macrocystis, Nereocystis,* and *Zostera*).

Infauna at the transect closest to the discharge (100 m; 330 feet upcoast) had seven taxa in common to the transect most distant from the discharge (3,100 m; 2 miles upcoast). At both sites the polychaete worm *Euzonus mucronata*, the isopod *Excirolana chiltoni*, the amphipods *Megalorchestia* spp. and *Eohaustorius* spp., and the polychaete *Nephtys californiensis* were common, although the abundance of the organisms varied between the transects. Other taxa were observed in the field near these two transects but were not collected in the core samples. These included sand crabs *Emerita analoga* and Pismo clams *Tivela stultorum*.

Discussion

Preliminary data from this survey of beach habitat quantified the densities of macroinvertebrates on Morro Strand State Beach upcoast from the MBPP discharge and characterized their relative abundances along ten transects. Details of study findings and analysis are presented in a report on the August 2000 study included herein as Appendix 6.6A-6. All of the common taxa reported in an earlier infaunal study (Adams et al., 1974, summarized below) were also recorded in this study. The macrofauna of open coast sand beaches is not particularly diverse compared to the fauna found in more protected intertidal soft-substrate habitats (Ricketts et al., 1985). Most of the common species were quantified by collecting and screening numerous sediment core samples, but some of the larger uncommon taxa, such as Pismo clams, were too patchy to perform a distributional analysis with this method. Microscopic fauna (meiofauna) is another faunal component of sand beaches that supports many of the larger predatory species, but these microscopic forms were not sampled in the present design. For the purposes of comparing differences in fauna in relation to the thermal discharge, however, the methods used adequately characterized the beach fauna within and beyond the influence of the MBPP thermal discharge plume.

A primary goal of this study was to evaluate the magnitude and extent of potential effects resulting from the existing MBPP cooling water discharge on the receiving water's sand beach habitat and resources. Because the faunal composition at the transect closest to the discharge did not differ substantially from the fauna at the most distant transect, it can be concluded that the discharge has had little effect at this time of the year on infaunal species composition. Abundances of sand beach infauna are known to be variable and quite patchy due to changing beach morphology (McLachlan and Hesp, 1984), sediment grain size composition (Jaramillo and McLachlan, 1993) and the responses of local populations to periodic tidal fluctuations (Donn et al., 1986; Craig, 1973). This patchiness was reflected in the relatively high variation in taxon abundance among replicate core samples collected only a few meters from one another. However, by comparing mean abundances of a few common taxa across all transects, it was evident that there were no trends that could be attributed to warmer water temperatures from the discharge.

Pismo clams were once abundant on central California beaches and supported a successful recreational fishery in the Morro Bay area (Leet et al., 1992). The fishery coincided with MBPP operations throughout the late 1950s and 1960s, but in the early 1970s the clam resources declined abruptly. Predation from the expanding population of southern sea otters was the cause of the decline (Wendell et al., 1986). Since that time, the CDFG has monitored clam abundance and population size structure on Morro Strand State Beach in winter months of each year on three vertical transects 1 to 3 km (0.6 to 1.9 mi) north of the MBPP discharge (Christine Pattison, CDFG, pers. comm., 2000). Unpublished data from CDFG show that clam populations have fluctuated from lows in the early 1990s to highs in the mid-1990s. The latest survey in winter 1999-2000 found intermediate abundances of clams. The mean shell length in this local population has been approximately 35 millimeter (mm) (1.4 inch) with few individuals exceeding 60 mm (2.4 inch). This is substantially smaller than the typical minimum fishery size of 100 mm (4 inch). Continued sea otter predation and variable recruitment have prevented the population from recovering to its earlier population levels.

In conclusion, previous thermal discharges from MBPP have not measurably affected macrofaunal invertebrate populations along the Morro Strand State Beach. Several factors independent of power plant operation, such as sea otter predation, dredge spoil disposal, and coastal runoff, are probably the most important disturbance factors affecting local benthic populations. Effects from an offshore wastewater discharge pipeline of the Morro Bay/Cayucos Sanitary District are very localized and do not affect beach resources (Marine Research Specialists, 1998). The reduction in the volume of the discharge (approximately 29 percent) of the modernized Project's should continue to protect the receiving water's beneficial uses of the sand beach habitat and its biological resources.

1971-1972 Sand Beach Fauna Study

Thermal effects studies of the Estero Bay sandy beach habitat extending north of the MBPP shoreline discharge were conducted by PG&E in 1973. The study examined the relationship of intertidal beach temperature to the total number of species, abundance of each species, and the diversity of species. The location of the survey stations is shown in Figure 6.6A-13. The sampling results of their beach survey which were statistically analyzed showed no statistically significant thermal effects of the Units 1 through 4 discharge under full load operating conditions. The study's conclusion of no statistically significant discharge effects is based on the findings reported in Adams et al. (1974) which are summarized below.

Sampling Locations

During the study five sites were sampled along ten transects at quarterly intervals (see Figure 6.6A-13) on the sandy beach near the MBPP discharge. The intertidal area extending 10,000 feet (1.9 miles; 3 km) northward from Morro Rock was divided into ten transect stations at various distances from the plant discharge. The first transect, Transect 0, was positioned on the beach approximately 100 m (330 ft) from the discharge. Starting from Transect 0, the next four transects were placed at 500-foot (152 m) intervals, the following two transects at 1,000-foot (305 m) intervals and the last three transects at 2,000-foot (610 m) intervals. Five sampling sites (labeled 0.1, 0.2, 0.3, 0.4, and 0.5) were established at 100 foot (30 m) increments along each of the transects. The five sampling sites were positioned between maximum and minimum tide levels, site 0.5 being the lowest tide level. The area sampled consisted of a uniform sandy beach with similar slope along the entire length of the grid. The transect design was comparable to a previous method used for studying sandy beach fauna by Pimental (1959), Clogston, (1969) and McIntyre (1970).

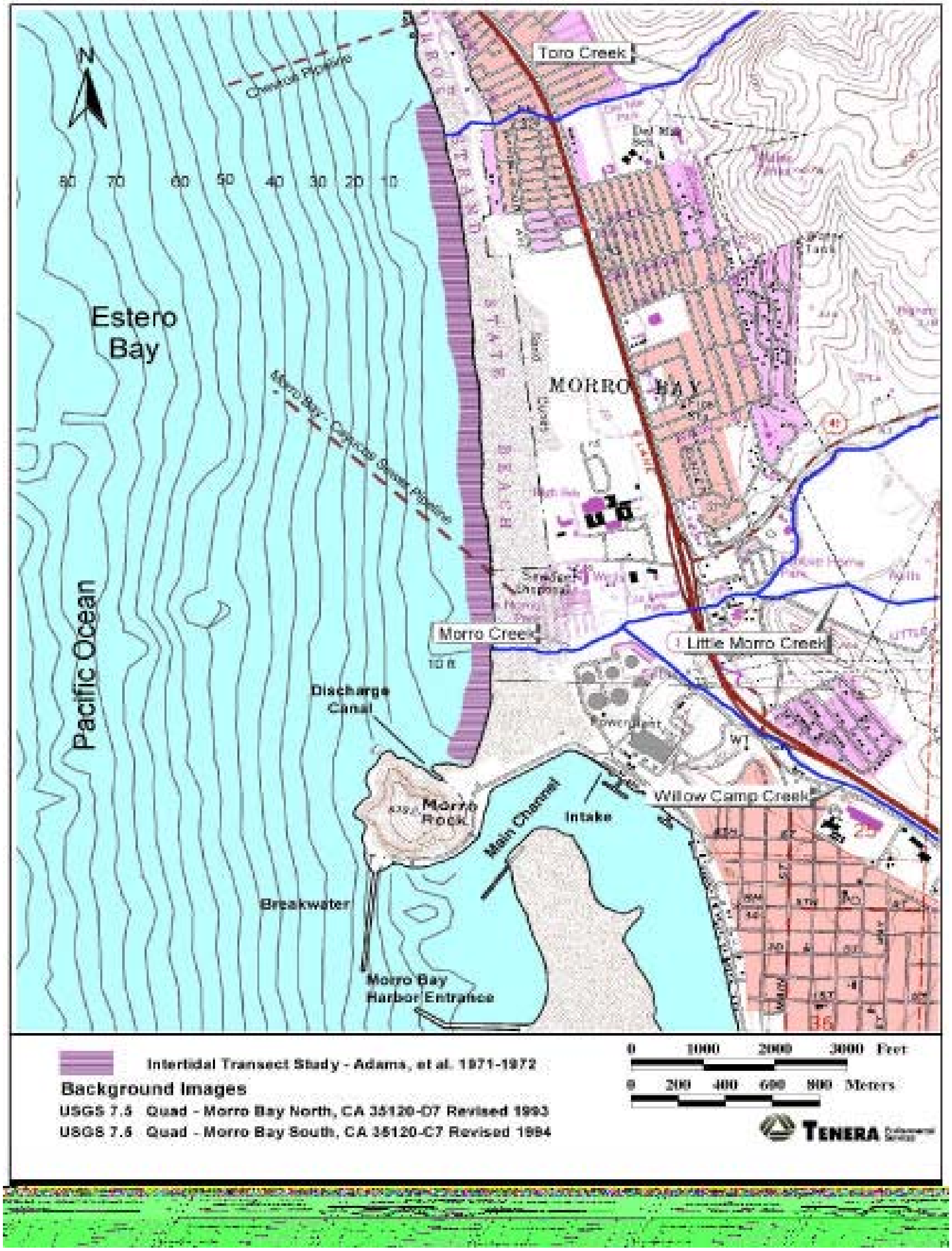


Figure 6.6A-13. Intertidal beach sampling locations from the 1971–72 survey (Adams et al., 1974).

Materials and Methods

One-third cubic meter (m^3) (11.8 cubic feet [ft^3]) of sand, divided into nine sub-samples consisting of 1/27 m^3 (13 feet x 13 feet x 13 feet) was sampled at each of the five sites. A total of 1-2/3 m^3 (58.9 ft^3) of sand was strained at each of the ten transects. Samples were sieved with ambient seawater through a 2-mm mesh screen. Organisms from the nine subsamples were combined for each site and identified in the laboratory to the lowest possible taxon.

Temperature measurements used were taken from 14 airborne infrared surveys conducted by PG&E over the period from 1963 to 1972. The intertidal transect stations were overlaid on each of the 14 images to obtain the corresponding temperatures. The average temperature was calculated for all ten transects; the transect with the lowest average temperature (Transect 10,000 at 58° F; 14.4° C) was defined as the ambient control station or delta T = 0. The delta-Ts above ambient for all other transects were calculated. Average temperatures ranged from ambient to 6.8° F (3.8° C) above ambient.

Qualitative Analysis

The intertidal stations were sampled during four quarters from 1971-1972: late November to December 1971, February to March 1972, May to June 1972, and mid-July to August 1972. During the four quarters of sampling, a total of 24,894 organisms were collected consisting of 63 taxonomic groups. Arthropoda comprised the majority of organisms collected (69.3 percent), followed by Polychaeta (28.1 percent), Mollusca (1.9 percent), and all others (0.6 percent).

The four most abundant species, in terms of numbers, were an unidentified amphipod (C1 in table), the polychaete *Thoracophelia mucronata*, the isopod *Exocirolana chiltoni*, and the sand crab *Emerita analoga*, comprising 88 percent of the organisms collected. The most commonly found organisms were the isopod *Exocirolana chiltoni* (found in 52.8 percent of the samples collected), the polychaete *Nephtys californiensis* (found in 51.7 percent), and the sand crab *Emerita analoga* (found in 47.7 percent). Ten species were categorized as dominant (50 or more individuals collected per quarter) comprising 97 percent of all animals collected. Table 6.6A-11 lists the distribution of these dominant species at each tide level. The upper beach (Stations 1 and 2) was dominated by the isopod *Exocirolana chiltoni*, the polychaete *Thoracophelia mucronata*, an unidentified amphipod, and the beach hopper *Orchestoidea corniculata*. The Pismo clam *Tivela stultorum* was more prevalent at lower tide levels (Stations 3 through 5) while the other species were irregularly distributed throughout the five tide levels.

TABLE 6.6A-11

NUMBER OF DOMINANT SPECIES COLLECTED AT EACH TIDE LEVEL FROM INTERTIDAL TRANSECTS AT ESTERO BAY: 1971 AND 1972

	NUMBER COLLECTED AT EACH TIDE LEVEL (SITE)					TOTAL
	1	2	3	4	5	
Unidentified Nemertean	32	80	29	9	6	156
Nephtys californiensis	17	88	135	89	59	388
Thoracophelia mucronata	3,181	2,986	2	0	0	6,169
Eteone dilatae	46	43	15	0	2	106
Exocirolana chiltoni	4,098	1,636	361	14	12	6,121
Orchestoidea corniculata	526	3	2	1	0	532
Unidentified Amphipod C1	1,010	7,664	49	60	28	8,811
Unidentified Amphipod D	207	383	157	3	10	760
Emerita analoga	39	367	85	282	58	831
Tivela stultorum	0	0	15	238	16	269
Total	9,156	13,250	950	696	191	24,143

(Source: Adams et al., 1974)

Data Analysis

The relationship of the delta-T with the diversity index, the number of individuals, and the number of species was determined by least squares linear regression analysis for transects by quarters, and for equivalent tidal stations by quarters (Table 6.6A-12). The maximum diversity index (3.8685) was found at Station 5 (lowest tide level) on Transect 6000. The minimum diversity index (0.5771) was found at Station 1, the highest tide level, on Transect 10,000. No significant correlations were detected in the analyses (Adams et al., 1974).

TABLE 6.6A-12

CORRELATION COEFFICIENTS FOR INCREASED TEMPERATURE VERSUS DIVERSITY INDEX, NUMBER OF ORGANISMS, AND NUMBER OF SPECIES FOR EACH QUARTER BY TRANSECT

	DIVERSITY INDEX	NUMBER OF ORGANISMS	NUMBER OF SPECIES
Quarter No. 1	.1955	.0990	.4354
Quarter No. 2	.3183	-.1369	.3648
Quarter No. 3	-.1787	.2417	.0410
Quarter No. 4	-.2146	-.0865	-.2660
Cumulative	.3651	-.1735	.2319

(Source: Adams et al., 1974)

8 degrees of freedom.

In the least squares linear regression analysis of temperature (° F) versus diversity index (tide level station by quarter), diversity was negatively correlated (P = 0.01) with temperature (r = -.7188) at Station 4 during Quarter 4. No significant correlations were detected for the other 23 data sets. Significant positive correlations with increased temperature were detected for the sand crab *Emerita analoga* and the polychaete *Thoracophelia mucronata* in the third quarter, May to June 1972 (Table 6.6A-13).

<u>Discussion</u>

Abundance of the polychaete *Thoracophelia mucronata* in Quarter No. 3 was positively correlated (P = 0.01) with temperature. Data from the study showed *Thoracophelia mucronata* had extremely clumped populations, a characteristic found in other studies by Dales (1952) and McConnaughey and Fox (1949). Adams et al. (1974) stated that the patchy distribution of this species and the large number of zero values in the data might suggest that the significant correlation was by chance. In addition, the small sample size of 10 had decreased the statistical power, thus affecting the above-discussed probabilities.

TABLE 6.6A-13

CORRELATION COEFFICIENTS FOR INCREASED TEMPERATURE VERSUS NUMBERS OF ORGANISMS OF EACH SPECIES FOUND IN EXCESS OF 50 INDIVIDUALS FOR EACH QUARTER BY TRANSECT

QUARTER NO. 1	
Nephtys californiensis	0.3183
Thoracophelia mucronata	-0.0288
Exocirolana chiltoni	-0.0654
Unidentified Amphipod D	-0.3210
Emerita analoga	0.5918

QUARTER NO. 2	
Unidentified Nemertean	-0.2071
Nephtys californiensis	0.0204
Thoracophelia mucronata	0.0220
Eteone dilatae	-0.2973
Exocirolana chiltoni	0.3592
Unidentified Amphipod D	-0.6007
Emerita analoga	-0.0716

QUARTER NO. 3	
Unidentified Nemertean	0.0986
Nephtys californiensis	0.4128
Thoracophelia mucronata	0.7843 **HS**
Exocirolana chilton	0.4646
Orchestoidea corniculata	-0.5034
Unidentified Amphipod C1	-0.6101
Unidentified Amphipod D	-0.1967
Emerita analoga	0.8067 **HS**

QUARTER NO. 4	
Thoracophelia mucronata	-0.4060
Exocirolana chiltoni	0.4539
Orchestoidea corniculata	-0.3100
Unidentified Amphipod C1	-0.4629
Unidentified Amphipod D	0.3750
Emerita analoga	0.2738
Tivela stultorum	-0.4144

8 degrees of freedom. HS = 1percent level of significance. All others nonsignificant. *(Source: Adams et al., 1974)*

A significant positive correlation between sand crab abundance and temperature was detected in Quarter No. 3. Aggregations of sand crabs are common and population abundance varied significantly from year to year. The sand crab occurred in 47.7 percent of PG&E study stations, but for all four quarters comprised only 3.3 percent of all organisms collected.

Intertidal organisms, particularly those in the upper tidal regions, have developed characteristics that enable them to tolerate environmental stresses, such as high temperatures. Adams et al. proposed that the effects of the thermal discharge on these intertidal inhabitants is "probably quite small" when compared to their normally harsh environment. Based on the parameters studied, Adams concluded the thermal impact of the cooling water discharge was statistically insignificant for the intertidal macroinvertebrate community adjacent to the MBBP.

The data show that the abundance and composition of organisms varied vertically across the beach profile within each transect. The maximum diversity was found at the lowest tide level sites, while the maximum number of individuals were found at the highest tide level sites. The beach environment is continually changing as a result of wind, waves, tides, and shifting sands. This introduced an unknown, but potentially large source of variation into the data. It is likely that these factors and the natural variability of the beach community would make effects of a thermal gradient difficult to detect.

Available Thermal Tolerance Data

Pismo Clams

Preliminary data from the August 2000 sand beach survey showed that there were no trends in abundance correlated with elevated temperatures from the MBPP discharge.

Surface plume temperatures from the modernized plant's discharge are not expected to negatively affect Pismo clams. The densities of Pismo clams in thermal studies of the Morro Bay shoreline discharge were found to increase in areas contacted by the thermal plume (Adams et al., 1974). The highest numbers of clams surveyed were located in beach habitat exposed to discharge delta-T degrees of 1.4 to 4.8° F (0.8 to 2.7° C). The authors reported findings consistent with observations that "warm-water" years have provided some of the best sets of young Pismo clams. There was no indication of detrimental effects of the power plant's thermal discharge from discharge temperatures 70.5 to 78.5° F (21.1 to 25.8° C) and delta-T's up to 20° F (11.1° C)and delta-T's of 6.8° F (3.8° C) measured on the beach.

Sand Crabs

Preliminary data from the August 2000 sand beach survey showed that there were no trends in abundance correlated with elevated temperatures from the MBPP discharge.

Dugan et al. (1994) reported the results of her studies on geographic variations in the life history characteristics of *Emertia analoga*. Water temperatures were inversely correlated with several life histories characteristics. As water temperature increased, the size of female crabs at sexual maturity, the largest ovigerous and smallest ovigerous females, and largest male crabs all declined. The remaining environmental variables tested, surf zone chlorophyll and sediment characteristics, were inconsistently correlated with life history characteristics over the 5-year study. Surf zone water temperatures varied geographically, ranging from 11.5 to 25.6° C (52.7 to 78.1° F). With the exception of geographic variations in life history characteristics, normal population levels of sand crabs were sampled within this temperature range. Based on the high thermal tolerance of sand crabs, the modernized plant's discharge is not expected to affect their population abundance or distribution in the sandy beach habitat contacted by the plume.

Sandy Subtidal Habitat

The habitat near the discharge structure is composed of sandy silts and clay. The discharge is located on the shoreline. The horizontal direction of the discharge and buoyancy of the thermal plume lifts and separates it from the ocean bottom and invertebrate species living on or in (epifauna or infauna) the sandy mud bottom (benthic) habitat.

September 2000 Subtidal Benthic Survey

Subtidal benthic samples were collected in September 2000 following the guidelines approved by the TWG. Subtidal benthic habitats, comprised of unconsolidated sediments such as sand and mud, can support diverse and productive assemblages of invertebrates and fishes. Fine sands are the predominant bottom type in the shallow waters of Estero Bay, adjacent to the MBPP. The benthic fauna can be categorized into epifauna, invertebrates occurring mainly on the sediment surface, and infauna, burrowing or sessile invertebrates occurring mainly beneath the surface. Warmer water temperatures, such as those discharged from MBPP could potentially affect this habitat by altering the abundances or reproductive characteristics of the faunal populations.

This report includes preliminary results from an initial subtidal faunal survey conducted on September 1, 2000. Additional surveys will provide data to evaluate seasonal changes in the assemblage of subtidal benthic fauna that may be related to discharge contact.

The MBPP discharges heated water from an onshore discharge canal located approximately 0.4 km (0.25 mile) west of Morro Bay harbor. Excess discharge temperatures rapidly dissipate in the surface layers of the receiving water due to buoyancy and mixing, and decrease northward along the beach and westward along Morro Rock. Although discharge temperatures fluctuate with changing electrical generation loads, Adams et al. (1974) reported that the average temperature increase in surface waters along the beach was approximately 2.0° C (3.6° F) at a distance of 0.3 km (0.19 mile) from the discharge and 0.5° C (0.9° F) at 1.0 km (0.62 mi) from the discharge.

Field Sampling Methods

Permanent sampling stations were established with concrete marker blocks at distances from 100 m to 3,000 m from the discharge along a -5 m [-16 ft] depth contour. This depth was determined to be the shallowest practical depth that a boat and divers could safely sample permanent stations due to the dangerous wave conditions that can occur along Morro Strand State Beach. Divers directly sampled the benthic fauna with a hand-held coring device rather than a boat-mounted grab sampler, which reduced the variation in sample volume between replicates. Divers could also visually census the epifauna at each station. Accurate GPS measurements allowed the stations to be relocated without the need for surface marker buoys, even in reduced water visibility conditions.

At each station, divers collected five core samples (15.5 cm diameter by 15.5 cm depth; approximately 6 inch by 6 inch). The samples were brought to the surface and sieved through a 1.0 mm screen. The residual fauna was preserved in 12 percent formalin and returned to the lab for sorting and identification. A sediment sample (5 cm diameter by 20 cm deep) was also collected at each station and analyzed for grain size distribution. Temperature data were recorded every 20 minutes at each station using a thermistor that was replaced during the sampling. The presence or absence of epifaunal taxa was noted within a radius of 5 m around the station during a timed 10 minute swim. Due to poor underwater visibility, visual censuses along measured transects were not practical.

Results

The initial survey was conducted on September 1, 2000 during a period of calm sea conditions. All six stations were sampled with a total of 226 faunal core samples and 30 sediment grain size collected. Temperature recorders were recovered from all stations.

Water Temperatures

Water temperatures at the -5 m MLLW depth from August 12-31, 2000 did not vary substantially among stations, with some of the coolest average temperatures (13.3° C) occurring at the stations closest to the discharge. If ambient temperatures at -5 m MLLW are referenced to Station SB-6, 3 km (1.86 miles) from the discharge, near-bottom temperatures as close as 100 m to the discharge were cooler than ambient. This phenomenon may be caused by an entrained counter-current along the bottom that would tend to bring cooler water toward the discharge from greater depths as the warmer surface waters flow in an offshore direction. At Station SB-1, divers noted a distinct thermocline at a depth of approximately 1 m (3.3 feet) below the surface, and an offshore surface current of approximately 0.5 kt. Temperatures fluctuated substantially at all stations during the 2-week period, from maximum temperatures slightly over 17.0° C to minimum temperatures of approximately 11.5° C. The average discharge temperature over this period was 25.7° C, ranging from 30.8° C to 17.8° C.

Sediment Grain Size

Subtidal sediments were similar between stations and were characterized as fine sands comprised of terrigenous minerals and small shell fragments. Laboratory results comparing the various size fractions by weight are pending.

Subtidal Fauna

Preliminary data from 30 core samples and from epibenthic observations yielded 30 taxa comprised of polychaete worms, nemertean worms, crustaceans (amphipods, crabs, shrimps), clams, echinoderms, and one species of fish. Most taxonomic groups occurred at all stations, with the greatest number of taxa (20) found at SB-1 and the least number of taxa (13) found at SB-4. Some of these taxa were combination categories comprising several species, so the actual number of species at each station was higher than reported.

Sand dollars (*Dendraster excentricus*) were present at all stations, but were particularly abundant ($< 700/m^2$) at Stations SB-3 and SB-4. An analysis of variance test revealed a highly significant difference in abundance among stations ($p < 0.001$) due to the high abundance of this species at the two stations. Their distribution among stations suggests that there was no gradient of abundance related to the thermal discharge at this depth. In addition, the individuals at these stations were substantially larger than at the other stations. By combining data from all stations, a size frequency distribution for the population reveals a distinctly bimodal distribution of adult and juvenile *D. excentricus* within the shallow Estero Bay area during September 2000.

The most abundant invertebrate in the core samples was the polychaete worm *Magelona pitelkai*. This is a small deposit-feeding worm that rarely exceeds 10 mm (0.4 inch) in total length.

M. pitelkai occurred at all stations except SB-4 and was most abundant at Station SB-1. An analysis of variance test revealed a highly significant difference in abundance among stations ($p < 0.001$) due to the high abundance of this species at Station SB-1.

Discussion

The shallow water infauna and epifauna adjacent to the MBPP discharge and at reference stations farther upcoast in Estero Bay is moderately diverse. Preliminary data from this study provide density estimates for several common species of amphipods, polychaetes, and echinoderms, and none of these taxa show strong gradients in abundance related to water temperature or distance from the discharge. Elevated water temperatures did not occur at any of the -5 m MLLW stations indicating that the buoyant thermal plume has no direct effect on this habitat. One of the most abundant species recorded in the study, the sand dollar *Dendraster excentricus,* had maximum abundances at a distance of 1,500 m from the discharge with lower population densities at stations to the north and south. A strong spatial gradient would be indicated by species abundances that logarithmically increased or declined with distance from the discharge.

In this study, the evidence suggests that the disturbance effect of *D. excentricus* is a significant factor controlling shallow water benthic community structure. In winter and spring, physical disturbance from wave large wave episodes probably also exerts a significant influence on the abundance and composition of the benthic fauna at the -5 m depth. Because there was no measurable increase in water temperature above ambient at any of the sampled subtidal benthic stations, and no gradients in faunal abundance with distance from the discharge, the evidence suggests that elevated water temperatures from the MBPP discharge do not have any measurable effect on shallow subtidal communities in Estero Bay. Future changes in MBPP discharge parameters should continue to protect the receiving water's beneficial uses of the shallow water benthic habitat and its biological resources.

1971-1972 Benthic Survey

Thermal effects studies of the Estero Bay subtidal benthic habitat in the vicinity of the MBPP shoreline discharge were conducted by PG&E in 1971 and 1972. The benthic sampling station locations are shown in Figure 6.6A-14. The ten stations were chosen so that sampling would occur in representative areas of the thermal plume; the discharge pathway, areas where surface waters were influenced by the discharge, and control areas. The locations, for ecological consistency, had similar substrate type, water depth, and wind/wave action exposure. Vertical temperature profiles of the Units 1 through 4 thermal plume were collected when all the units were operating at full capacity and discharging maximum volumes. Samples were also collected under varying tide conditions.

The benthic biological sampling occurred during three periods; November 22 to 24, 1971; February 2 to 4, 1972, and May 10 to 12, 1972. Benthic samples of the seafloor were collected using a 9-inch by 9-inch Ponar grab. Information recorded included the date, time, station, sample number, sediment temperature, sample volume, and water depth. Three replicate grab samples were collected at each of the 10 benthic stations. Samples were rinsed with seawater through a 0.5 mm stainless steel screen and preserved. Organisms were identified to species level when possible.

Table 6.6A-14 shows the water depths and surface temperature increments at each benthic station. Although surface temperatures were measured at each benthic sampling location, temperature data collected by aerial infrared imagery were used to compute delta-Ts for each sampling location. The water depths were corrected for tidal height differences to 0.0 feet tide level.

Margalef's diversity index was calculated for each sample and for each station by sampling period. The percent composition of the major groups (Mollusca, Crustacea, and Polychaeta) was calculated for each station by sampling period. A stepwise multiple regression program was used to test the relation between the diversity index and particle size, percent organic matter, water depth, and surface water temperature.

Results

Of the 116 species or taxa collected in the Estero Bay benthic survey, the most numerous taxa was an unidentified nemertean (49.4 percent). An unidentified amphipod, (C1) was the second most numerous at 16.9 percent. Of the 14,208 organisms collected, the C1 amphipod was also the most widely distributed, occurring in 84.4 percent of the samples. Also widely dispersed were the olive snail, *Olivella biplicata* (67.2 percent), amphipod C2 (67.2 percent), amphipod A (62.0 percent) and the moon snail, *Polinicies* spp. (58.6 percent). The rank order of major groups for all sampling periods was molluscs (25.9 percent), crustaceans (21.9 percent) and polychaetes (1.4 percent).

According to the study, the power plant influence seems to have no effect on the relative proportions of these groups (Mollusca, Crustacea and Polychaeta). In the second and third sampling periods, there was a larger proportion of Mollusca at the discharge station than in the first sampling period. In the second period, the data suggest an increase in the proportion of Mollusca at the sampling stations nearest the discharge.

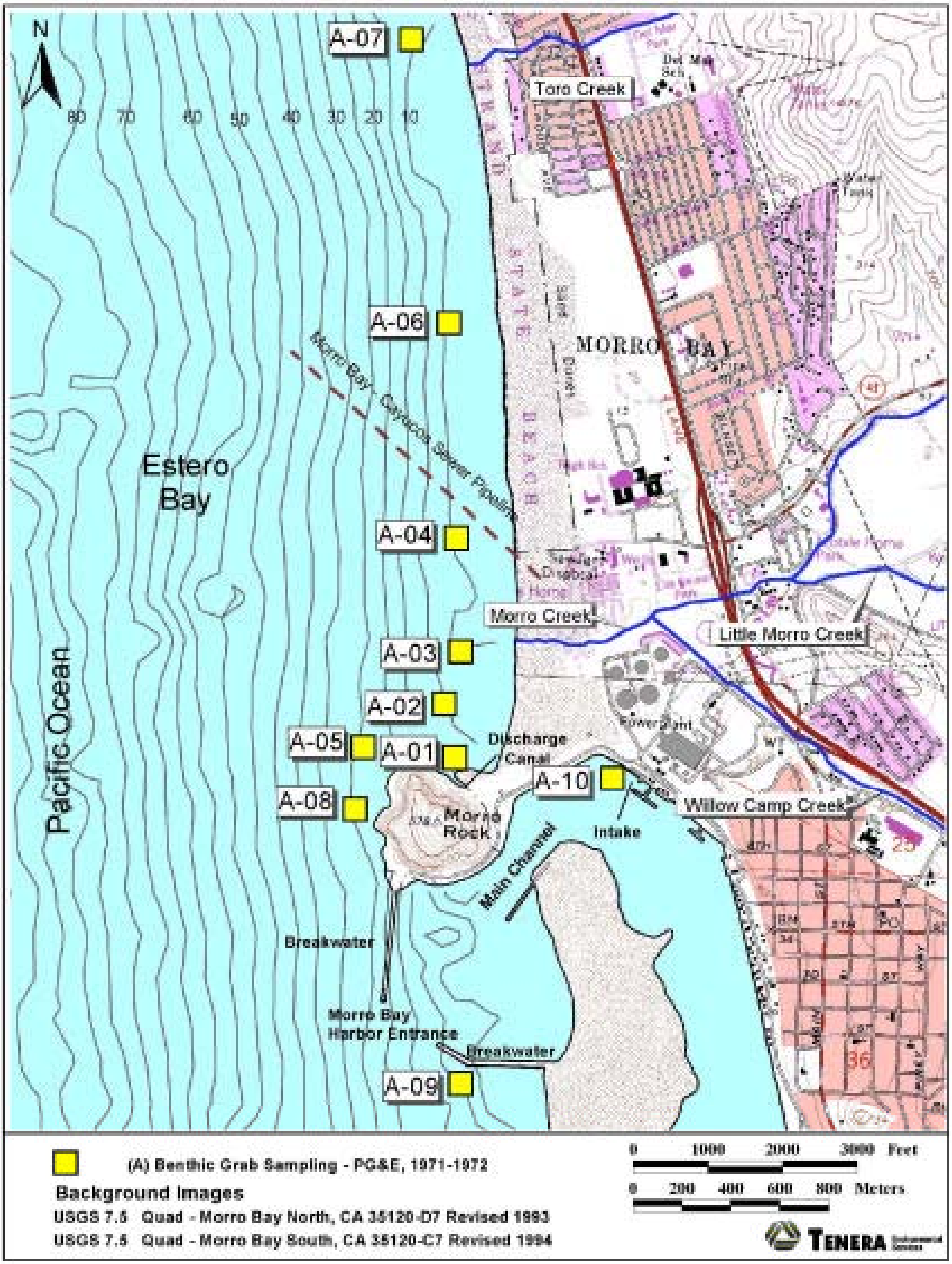


Figure 6.6A-14. Benthic sampling locations from 1971–72 survey (PG&E, 1973).

TABLE 6.6A-14

SURFACE TEMPERATURE MEASUREMENTS AT BENTHIC STATIONS AND CORRECTED WATER DEPTHS

	1	2	3	4	5	6	7	8	9	10
Average Temperature (° F)	69.9	65.7	63.0	60.1	64.4	58.8	58.1	57.4	57.2	57.2
Temperature Increment Above Ambient (° F)	12.7	8.5	5.8	2.9	7.2	1.6	0.9	0.2	0	0
Corrected Water Depths (feet)	8	17	15	14	18	9	10	23	17	15

(Source: PG&E, 1973)

Stepwise Multiple Regression Analysis

For November 1971, February 1972, and May 1972 combined, there were no significant correlations between the diversity index and any physical variable (median particle size, percent of particles in the 30 to 60 micron range, percent organic matter, water depth, and surface water temperature). This also held true for the individual sampling periods of February 1972 and May 1972. For November 1971, a positive correlation existed between the diversity index and water depth. Since the regression equation accounted for only 29.96 percent of the variance observed in the diversity index, it was not statistically significant.

The relationships between increased temperature and the diversity index, the number of species, and the number of individuals as shown by correlation coefficients are summarized in Table 6.6A-15. No significant correlations between the temperature change above ambient and the abundance or diversity of benthic organisms were found in any sampling period in the benthic survey.

TABLE 6.6A-15

CORRELATION COEFFICIENTS FOR DIVERSITY INDEX, NUMBER OF SPECIES, AND NUMBER OF ORGANISMS IN RELATION TO INCREASED TEMPERATURE

	November 23, 1971	February 2, 1972	May 11, 1972
Diversity Index	-0.1637 N.S.	0.4083 N.S.	-0.1553 N.S.
No. of Species	-0.3307 N.S.	0.1584 N.S.	-0.1069 N.S.
No. of Organisms	-0.2780 N.S.	-0.2780 N.S.	0.1108 N.S.
	n = 8	n = 9	n = 9

N.S. = Not Significant

(Source: PG&E, 1973)

Rocky Intertidal and Rocky Subtidal

The MBPP discharge plume comes in frequent contact with the rocky intertidal and shallow subtidal habitat associated with Morro Rock. The northern side of this prominent geologic feature at the point of discharge acts as an extension of the western side of the discharge canal. The underwater topography of the study area consists of a wall of rocks and huge boulders that slope steeply to a sandy bottom. Rock substrate is generally smooth with few crevices. The establishment of seaweed on rocky substrate in the area is inhibited by wave action. Temperature data and bathythermograph tracings (Cheney and Richards, 1966; PG&E, 1973) showed that in general, the MBPP thermal effluent dispersed into Estero Bay to the north and west of the discharge canal. Nearshore currents, wind, and tides influence the direction of the plume, as well as its dissipation. The west face of Morro Rock was rarely exposed to a delta-T of greater than 4 to 6° F (2 to 3° C). The thermoclines in the area were generally 3 m (9 ft) deep or less. Considerable variation in temperature was observed on the bottom during diving surveys at the end of the discharge canal. Water temperatures in this area are generally well below the upper temperature limits for most common invertebrate species and fish species easily come and go depending upon their reactions to water temperatures. However in general the most temperature sensitive seaweeds, which are more sensitive to water temperatures than invertebrates or fishes, are affected by temperatures as low as 17 to 18° C (63 to 64° F) (Tenera Inc., 1997).

A number of seaweeds species (attached macrophytes) found in Morro Rock's intertidal and subtidal habitats are sensitive to elevated ocean water temperatures. The diverse algal assemblages found along California's central coast reflect the geographical overlap of northern and southern California species. These overlapping species also exhibit temperature tolerances that reflect temperature regimes from their respective geographical regions. When these mixed northern and southern species assemblages are exposed to temperature gradient such as exists along the shoreline of Morro Rock, species gradients form that range from warm-tolerant species at the point of discharge to cool-tolerant species ambient water temperatures. Such a gradient in algal species was report by North (1969) from his SCUBA survey of Morro Rock and more recently by Tenera Environmental (1999 and 2000) from a repeated survey of North's study area. The findings of both reports show a clear gradient of changes in algal abundance and species composition away the point of MBPP discharge. These changes correlate to a number of environmental gradients such as temperature, sand scouring, light, and salinity.

Background information from surveys conducted in 1967-1968 is presented below followed by recent observations made in the same area in 1999-2000. A discussion of the changes observed during the recent survey is included.

1967-1968 Rocky Intertidal and Subtidal

The focus of the North (1969) study was the algal community of attached macrophytes within and in close proximity to the heated effluent MBPP discharge canal. The discharge canal is approximately 60 m (200 feet) long, 10 m (33 feet) wide and lined on each side with riprap. The maximum depth within the canal is about 4 m (13 feet).

North's study area was divided into three regions: the discharge canal, a transitional region, and a normal region (Figure 6.6A-15). The transitional region, which included Transect A, extended approximately 220 m (725 feet) along the northwest side of Morro Rock. Its width varied depending on the amount of rocky substrate present between the surface and sandy bottom. The normal region, which included Transect B, began at the border of the transitional region about 10 m (33 feet) from Transect A. Transect B was located 10 m from the transitional region border. Transects were oriented vertically on the rocky slopes. Rocky substrate within these regions was inspected using SCUBA. Outside the discharge canal, however, surf prevented observations shallower than 2 m (7 feet). Algal species lists were compiled for each region and the distribution and abundance of the more important species were estimated (Table 6.6A-16).

Transect Surveys

Two transects (A and B) were set up to study vertical zonation patterns of algal species on the northern exposure of Morro Rock. This area was the subject of study because it was located where warm effluent disperses along the surface and mixes with the underlying water. Since this warmer water forms a surface layer, thermal effects on vertical zonation were expected from the surface to depths of 2 to 3 m (7 to 10 feet). The study surveyed lateral changes in species composition/density and vertical shifts in normal zonation patterns downward.

TABLE 6.6A-16
SUMMARY OF ALGAL SPECIES PRESENT BY REGION

SPECIES	DISCHARGE CANAL	TRANSITIONAL REGION	NORMAL REGION
Chlorophyta			
Codium setchellii			X(1)
Ulva spp.			X(1)
Phaeophyta			
Laminaria setchellii		X(2)	
L. sinclarii			X(1)
Rhodophyta			
Aeodes gardneri			X
Agardhiella coulteri			X(1)
Ahnfeltia plicata			X
Calliarthron cheilosporioides			X(1)
Callophyllis flabellulata		X(2)	X(1)
C. heanophylla			X(1)
Cryptopleura violacea			X
Gelidium robustum			X(1)
G. coulteri			X
Gigartina volans			X(1)
Gracilariopsis sjoestedtii		X	X(1)
Gymnogongrus leptophyllus			X
Hymenena flabelligera			X
Iridaea flaccida			X(1)
I. lineare		X	X
I. splendens			X
Laurencia gardneri			X
Melobesia marginata		X	
Peyssonellia pacifica		XX(2)	X
Plocamium coccineum			X(1)
Polyneura latissima			X(1)
Polysiphonia brodiaei			X
Prionitis lanceolata		X(2)	X(1)
P. linearis			X(1)
Pterosiphonia dendroidea		X(2)	X(1)
Ptilota densa			X
Rhodymenia pacifica		X(2)	X(1)
Schizymenia epiphytica			X(1)
Spermatophyta			
Phyllospadis torreyi		X	X

(1) Noted along Transect B.
(2) Noted along Transect A.

(Source: North, 1969)

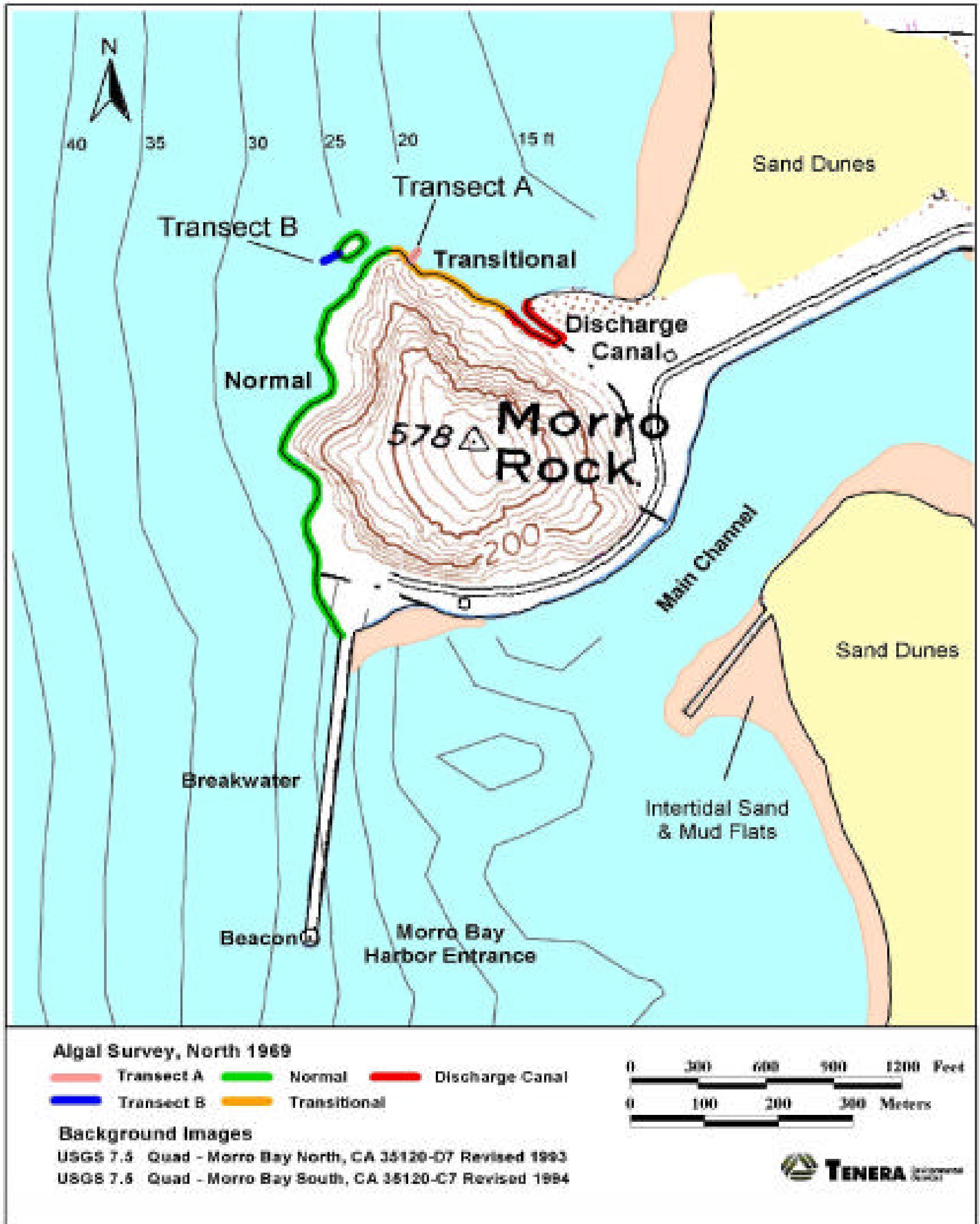


Figure 6.6A-15. Rocky intertidal sampling locations in 1967–68 (North, 1969).

SCUBA inspections of the discharge canal were conducted on three occasions between March 1967 and January 1968. The highest water temperature recorded within the discharge canal was 25.1° C (77° F) on March 1, 1967. Much of the rocky substrate was blanketed with sea anemones Anthopleura elegantissima and Anthopleura xanthogrammica. While North reported only drifting fragments of macroscopic algae in the discharge canal, J. Adams and J. Warrick (PG&E biologists) observed Iridaea (renamed Mazaella) flaccida and Corallina chilensis growing at the canal terminus.

Inspections of the transitional region were conducted on three occasions during the study period. It was difficult to examine the transitional region close to the discharge because of poor underwater visibility and unfavorable surf conditions. Sparsely distributed clumps of *Prionitis lanceolata* were noted in the intertidal zone next to the canal on March 1, 1967. The algal stands within the transition region were characterized as having low density and low species diversity. Additionally, a large proportion of the algal stands that were observed in the region were either grazed heavily or encrusted with fouling organisms. The abundance of algal species increased dramatically (from 7 species to 20) near the border of the normal region. The sessile fauna of the transition region was characterized as impoverished when compared to either the canal area or the normal zone. Low concentrations were common for the 27 animal species reported from the transition region. Fishes, it was noted, may have been the exception. The transition region was cited as being a popular area for fishing and subject to intense fishing pressure.

The normal region supported a community of plants and animals which was considered typical for exposed rocky intertidal areas of the central coast. At about Transect A, the sparse algal community of the transitional region reverted to the diverse algal cover characteristic of the normal region. This transformation occurred within a horizontal distance of approximately 10 m (33 feet). To fully describe the normal state, the entire west side of Morro Rock was surveyed and a species list was compiled. A total of 88 seaweed species and 44 animal species was recorded for this region. Nineteen of the plant species and 38 animal species were observed along Transect B. Five of the 19 seaweed species were not found elsewhere in the normal region.

Data provided to North by PG&E indicated that waters adjacent to the west face of Morro Rock were occasionally exposed to moderately diluted effluent. This effluent had the potential to affect biota within what was defined as the normal region. In order to resolve questions about the original condition of the normal region, a comparative study of the region and a control area was conducted. The control area chosen was Diablo Cove, an area of pristine rocky coast about 15 km (9 miles) south of Morro Bay. Seaweed species from near Morro Rock and Diablo Cove were tabulated according to whether they were warm or cold water forms. North concluded that the influence of intermittent, diluted effluent on species abundance and diversity within the normal region was negligible. The transitional region, however, appeared to be substantially altered.

1999 Resurvey of the Morro Rock Intertidal and Subtidal Community

This study establishes a recent thermal effects account of the intertidal and subtidal benthic marine community of Morro Rock. The surveys were completed in the late morning/early afternoon hours on August 7 and 9, 1999. Sea conditions were exceptionally calm in the transition region, which, on the days of the survey, was protected from swells out of the southwest. The normal region was more exposed to the low southwest swells (heights less than about 1 m). Underwater visibility ranged between 1 to 3 m (3 to 10 feet) in both regions.

Morro Rock is the nearest rocky habitat in the vicinity of the Morro Bay Power Plant discharge that supports benthic marine algae and invertebrates (see Figure 6.6A-16). The subtidal community was previously studied by Dr. W.J. North in 1967 and 1968 (North, 1969) and PG&E, 1971. North's study consisted of tallying the occurrences of algae and invertebrates in a series of swim-overs around Morro Rock and along two permanent vertical transects (see Figure 6.6A-15). Tenera Environmental's study was designed to establish a recent baseline and to compare present conditions to North's 1969 results (North, 1969; PG&E, 1971). We also included a quantitative survey of species abundance along North's vertical subtidal transects and additional transects within North's survey area.

Qualitative Surveys

Lists of species occurrences were developed from reconnaissance dives in North's transition and normal regions (see Figure 6.6A-16). Two divers began at the discharge terminus and swam around Morro Rock to the breakwater making up and down dives to cover a broad range of depths. The area sampled in the transition region extended from the intertidal (about the +1 m MLLW) to the subtidal at the base of the rock terminating on sand flats. The normal region was less completely sampled where slightly rougher sea conditions on the west face of Morro Rock did not permit close inspection of many intertidal and shallow-water zones. Most observations were limited to depths below -2 m (-7 feet) MLLW consistent with North's study. All algal, invertebrate, and fish species that were observed were recorded.

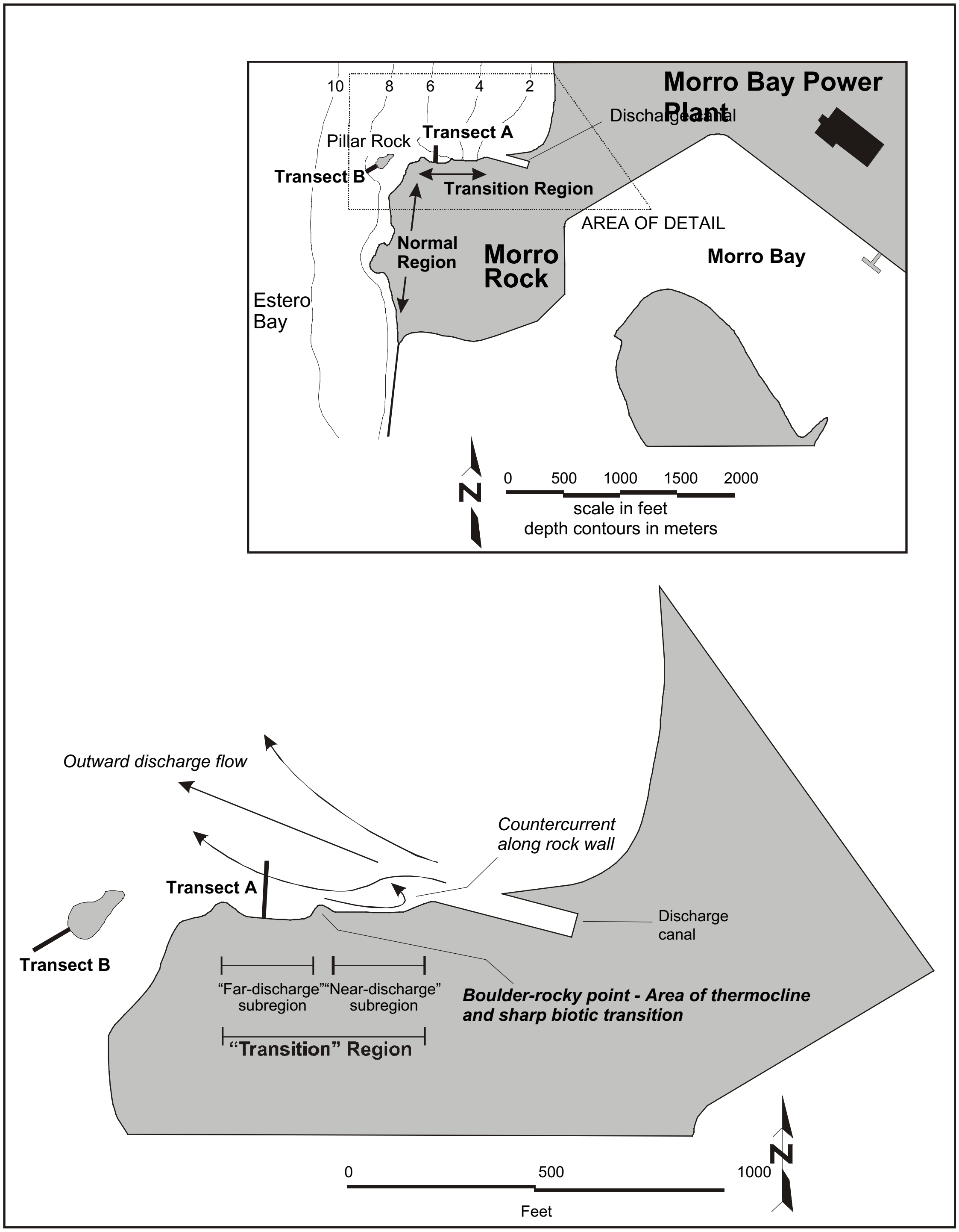


Figure 6.6A-16. Currents, thermocline, and areas of biotic transition observed on August 7 and August 9, 1999.

Note that the thermocline and location of sharp biotic transition occurred at a rocky boulder point along the rock wall. The "transition" region can be partitioned into "near-discharge" and "discharge" subregions based on differences in species composition and abundance.

Quantitative Surveys

Algal and invertebrate cover and densities were recorded along North's two vertical transects (Transects A and B in Figure 6.6A-16). At each transect a meter tape was deployed downward from the MLLW tide level to the rock base (sand flat region). The MLLW level was determined from National Oceanic and Atmospheric Administration (NOAA) predicted tide and time charts and seawater height at the time of sampling. North's Transects A and B were relocated as accurately as possible according to illustrations of locations, transect lengths, slopes, and depths provided in North (1969). Transect A terminated in water shallower than that described in North (1969). Nearby areas were inspected for other possible locations, but it appeared that the sandy sediment bedload at the base of Morro Rock had risen such that the sand flat at Transect A was about 2 m (7 feet) higher than what North previously found. Transect B was less difficult to relocate. Each transect was sampled in one meter intervals in one meter long by 2 m wide segments.

We also completed horizontal transect sampling at the top of each vertical transect to quantify algal and invertebrate abundances in shallow-water zones not sampled by North. Five adjoining 1 m x 2 m quadrants were placed at the top of each vertical transect at the MLLW tide level. The horizontal and vertical transects formed a T-shape (T-transect) sampling area. We also established and sampled a new, third T-transect directly in front of the discharge canal terminus.

Scheduling and Sampling Conditions

Surface water temperatures were noted at several locations using the dive boat electronic temperature recorder. Surface water temperatures during the August 7 survey were about 56 to 59° F (13 to 15° C) in the transition region and about 56° F in the normal region. Surface water temperatures were slightly lower on August 9 in the normal region (about 53° F; 11.7° C). However, higher water temperatures were recorded in the transition region (about 63° F; 17° C). Water temperatures at the discharge terminus were about 67° F (19° C) on August 9. Layers of fine silt covered the benthic algae and invertebrates, particularly in the transition region. Field identifications were made to the lowest taxonomic level possible. Some specimens were collected and identified in the laboratory.

Intertidal

The intertidal zone of Morro Rock is narrow due to the steep faced walls of the rock. Observations of the intertidal zone were made from a boat in combination with diver surveys. Mussels (*Mytilus* spp.) and barnacles (*Balanus* spp.) were conspicuous in both the transition and normal regions. Mussels were so densely compacted that the intertidal zone from a distance appeared as a continuous black band around Morro Rock. Sea stars (*Pisaster ochraceous*) were abundant, feeding on the mussels and barnacles. There was not a sufficient amount of shoreline observations to differentiate the transition from normal region based on intertidal invertebrate distributions.

In contrast, intertidal algal distributions supported North's observation of a normal and a transition region. Intertidal algae that were abundant in the normal region were noticeably less abundant in the transition region. In the normal region, brown kelps (*Alaria marginata* and *Laminaria setchelli*) occurred in dense stands, hanging from the rock walls along with dense clusters of the iridescent seaweed (*Mazzaella flaccida*). Both *M. flaccida* and *L. setchelli*i were present in the transition region, but in lower abundance.

Subtidal

Rocky substrate in the subtidal area along Morro Rock was nearly covered with algae or invertebrates. The transition and normal regions could not be easily differentiated based solely on species richness (numbers of taxa). In contrast to North's study, we found that the numbers of algae and invertebrates in both regions were similar (see Appendix 6.6A-4 for species comparisons between regions). The normal and transition regions could be distinguished from each other on the basis of certain species. Foliose and fleshy red algae and kelp species were more abundant with distance from the discharge. The transition region could be partitioned into two subregions; "near-discharge" and "far-discharge" (see Figure 6.6A-16). The near-discharge subregion was characterized mainly by the tube-building polychaete worm *Phragmatopoma californica* that covered 100 percent of many rocks. The encrusting bryozoan (*Waterispora subtorquata*), carnivorous snails (*Acanthina punctulata*), and aggregating anemones (*Anthopleura elegantissima*) were also most abundant in this subregion. Brown algae were lacking, except for a few individuals of giant kelp (*Macrocystis pyrifera*) that occurred within 50 m of the discharge canal terminus.

The far-discharge transition region was identified by the occurrence of several plants of the brown kelp (*Laminaria setchellii*), feather boa kelp (*Egregia menziesii*), and surfgrass (*Phyllospadix torreyi* and *P. scouleri*). The changes in biota at this location coincided with changes reported in discharge temperatures by Tenera Environmental's divers. The divers reported sensing a temperature change at the mid-point of the transition region where rock outcroppings deflect the plume away from Morro Rock.

The normal region consisted of rocky outcroppings alternating with indented surge pockets. The base of Morro Rock in this region is deeper (about 7 to 10 m; 23 to 33 feet) than the transition region. The rocky outcroppings supported dense stands of *L. setchellii*, foliose red algae, and articulated coralline algae to depths of 5 m (15 feet). Invertebrates, which were not conspicuous in this shallow-water algal zone, appeared as dense mats of tunicates and sponges that covered nearly 100 percent of the rocks beginning -5 m (-15 feet). The sides of the surge pockets were largely barren of algae and invertebrates. At the bottom of the surge pockets were dense aggregations of anemones (*Anthopleura xanthogrammica*), feeding on the mussels and barnacles that had broken loose and fallen as a result of the pounding waves.

Preliminary results from the transect surveys are consistent with broader scale dive observations. Abrupt differences in algal and invertebrate abundances were noted vertically and between transects. At the discharge terminus, total algal cover was less than 29 percent. There, dense mats of *Phragmatopoma californica* covered most of the rocks from MLLW to the bottom. Tufts of filamentous red algae (*Polysiphonia* spp., *Pterosiphonia* spp., among others) coated many *P. californica* tubes below MLLW. Transect A, located about 170 m (560 feet) from the discharge terminus, is colonized by dense stands of red algae (*Cryptopleura violacea*, *Rhodymenia* spp., *Gastroclonium subarticulatum*, among others) that covered nearly 100 percent of the rocks in the MLLW horizontal transect. A few kelp plants of *Laminaria setchellii* also occurred in the horizontal transect. Algal cover quickly diminished in abundance with depth along vertical Transect A.

Transect B, located about 240 m (790 feet) from the discharge terminus, in deeper water, is colonized by a different, yet dense algal assemblage. Foliose algae (e.g. *Mazzaella lilacina*, *Neoptilota hypnoides*, *Gelidium robustum*, *Prionitis lanceolata*, among others) and articulated coralline algae (*Calliarthron cheilosporioides*) are abundant at MLLW to depths of about -5 m, and covered 100 percent of many rocks. *Laminaria setchellii* occurs in dense stands of over a hundred plants per square meter (m^2), along with tunicates and sponges at depths below -5 m (-16 feet). The survey results of 1967/68 and 1999 at Transects A and B are compared in Figure 6.6A-17.

<u>Conclusion</u>

This study establishes a recent account of thermal effects on the intertidal and subtidal benthic marine community of Morro Rock. Surveys were conducted on August 7 and 9, 1999. Additional survey data have been collected in September 2000 and are being analyzed at the present time.

Evidence was found in species composition and abundance indicating that the north face of Morro Rock represents a thermal effects transition area. Areas further away did not appear affected by the thermal plume. Near the discharge however, further natural and temperature-related changes in species composition and abundance may still be expected to occur.

Differences in environmental factors, however, other than temperature may also explain the biological gradients observed around Morro Rock. These include shading effects from Morro Rock itself. Gradients in salinity may also occur in the study area when the power plant discharges brackish water drawn from Morro Bay during outgoing tides, particularly during periods of heavy rain runoff. Gradients in water clarity in the discharge area have also been observed (Tenera Environmental staff, unpublished observations). On some occasions the discharge plume is recognizable because it is more turbid than the ocean receiving water. On other occasions the receiving water is more turbid. During the survey, there were countercurrents of cool water along portions of the transition region where divers felt the movement of cool water towards the discharge canal terminus. Sand scour effects may also create different species assemblages between regions of Morro Rock, as well as wave impact effects.

The large dominant mats of the tube-building polychaete worm (*Phragmatopoma californica*) that were present near the discharge terminus during our study were not present several years ago (Tenera Environmental staff, unpublished observations). The presence and relatively large abundance of tubiculous polychaetes *Phragmatopoma californica* Fewkes in the proximal region of the transition area (near-discharge subregion) may favor by the presence of discharge water temperatures and flow. The colonial worm which is easily identified in its large stands of sand and parchment tubes, is described from its southern California distribution as a warm water species (Abbott & Reish, 1980). However in a study of thermal effects of the Diablo Canyon Power Plant discharge a few miles to the south of MBPP increases in *P. californica* abundance were observed in both ambient and discharge water temperatures (Tenera Inc., 1997). From these studies there is no reason to conclude any connection of the worm's abundance at the MBPP discharge to discharge temperatures.

Ocean current patterns during El Niño periods, such the recent 1996-1997 event are important mechanisms in the northern transport of California species (Barry et al., 1995; McGowan et al., 1998). Once established, *P. californica* colonies form "climax" communities that can occupy the colonized space for years. The weight of *P. californica* gametes and larvae cause them to sink

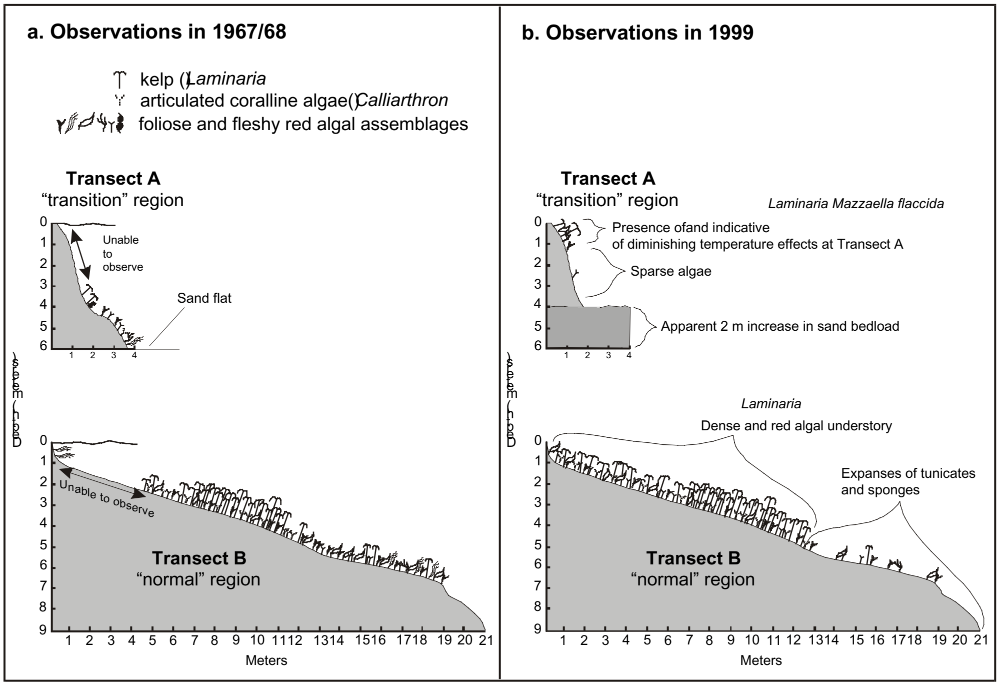


Figure 6.6A-17. Comparisons of algal assemblages in 1967/68 and 1999. Illustration shown in (a) is from Figure 3, North, 1969.

quickly to repopulate their colony (Thomas, 1994). Such a property favors their successful colonization of wave and current swept areas, possibly including current flows associated with power plant discharges.

In addition, giant kelp (*Macrocystis pyrifera*) was common in our study, but was not present during North's surveys. The receiving water benthic marine community on Morro Rock will also continue to exhibit some amount of additional change over time, particularly in the transition region. The spatial extent of change will be related in part to how discharge characteristics may vary from plant operation.

Available Algal Thermal Tolerance Data

Studies on the thermal tolerances of algae found along the central coast of California are relatively rare in the scientific literature. Therefore, laboratory studies on the expected effects of the warm water discharge on common and abundant algae were conducted to provide information to the RWQCB during the permitting of the Diablo Canyon Power Plant. These studies were done at a facility operated by PG&E at the power plant site. They provide us with thermal tolerance information on algal species that are also present in the areas contacted by the thermal discharge from the MBPP. The results of these studies are summarized in the Table 6.6A-17.

Although large beds of the bull kelp, *Nereocystis leutkeana*, are not present in the area around Morro Rock due to the lack of rocky substrate, isolated plants do occur. This species had the lowest thermal tolerance (18° C; 64.4° F) of any of the algae tested at Diablo Canyon. The thermal tolerances for two sub-canopy kelp species, *Pterygophora californica* and *Laminaria setchellii*, that are abundant in the area around Morro Rock were determined to be slightly higher at 19 and 20° C (66.2 and 68° F), respectively. The foliose red alga, *Crytopleura ruprechitiana*, that also occurs subtidally around Morro Rock, showed negative effects of temperatures ranging from 19 to 21° C (66.2 to 69.8° F).

The results of subtidal field studies at Diablo Canyon during plant operation supported the laboratory results. Impacts to all of these species were observed in the shallow subtidal areas of Diablo Cove most affected by the discharge. The areas of the cove that were deeper than 8 to 10 m (26 to 33 feet) were less frequently contacted by the thermal plume and the effects on the species found there were reduced in magnitude, except for bull kelp. Bull kelp is an annual that repopulates the cove each year, rapidly increasing in size as it grows towards the surface where contact with the thermal plume causes deterioration during late summer.

The only intertidal algal species tested that showed some potential for impacts was the red iridescent seaweed, *Mazaella flaccida*. Laboratory studies showed complete mortality in adult plants after a 60-day exposure to 22° C (71.6° F). Although only portions of the intertidal population of this alga in Diablo Cove were predicted to be affected, the operation of the power plant resulted in the loss of almost the entire population from the cove. The loss of this major habitat forming alga set in motion secondary changes throughout the intertidal community. The resulting effects, which were greater than predicted, provide an example of the level of uncertainty in which system-level predictions.

TABLE 6.6A-17

RESULTS OF LABORATORY THERMAL TOLERANCE TESTS FROM STUDIES CONDUCTED AT THE DIABLO CANYON POWER PLANT

TAXA	LIFE STAGE TESTED	THERMAL TOLERANCE	OTHER COMMENTS
Subtidal			
Nereocystis leutkeana	juvenile sporophyte	18° C	44 day exposure
Pterygophora californica	adult sporophyte	19.1° C	96 hour exposure
Laminaria setchellii	gametophyte	20.1° C	Germination of zoospores affected at temperatures > 18° C
Mazzaella cordata	gametophyte	22.7° C	Based on early development and growth of gametophytes after 15 days
Crytopleura ruprechtiana	adult sporophyte	19-21° C	96-hr exposure
Intertidal			
Mazzaella flaccida	sporophyte	22° C	Cultured and field collected sporophytes showed similar tolerance after 60 days
Gastroclonium subarticulatum	adult	23.8° C	Only limited effects after 216 hr exposure
Calliarthron tuberculosum	adult	23.8° C	Some bleaching occurred at 21° C after 216 hours. Experiment extended past 96 hr due to absence of any effects.
Phyllospadix spp.	adult	>24° C	Tolerated 24° C treatment for 216 hours. Experiment extended past 96 hour due to absence of any effects.

Source: Tenera, 1997

Kelp Habitat

The thermal discharge of the MBPP may affect individual kelp plants growing in the immediate vicinity of the discharge near the north side of Morro Rock. However, it will not affect kelp beds; none are located within the influence of the plume.

Open Water Habitat

The surface orientation and the smaller size of the Project's thermal plume will not affect the species living in Estero Bay's open water habitat. The phytoplankton and zooplankton will not be affected by the Project's thermal plume based on thermal tolerance information summarized below. Results from thermal effects studies of the fishes in the open water habitat showed that they will not be affected by the Project's thermal plume. Many fish species captured during these studies appeared to be tolerant of a wide range of temperatures due to their abundance in both ambient water temperatures and the elevated water temperatures within the thermal discharge. Others appeared to be attracted to the warm water based to their relative abundance within the thermal discharge. These studies are summarized below.

Phytoplankton

Phytoplankton will encounter the thermal plume of the modernized plant's shoreline discharge as it rises to the surface, but its temperatures will not harm the Morro and Estero bays' nearshore phytoplankton. Phytoplankton, unicellular floating algae, provide the base of the ocean's food chains. A number of studies have demonstrated their high degree of thermal tolerance. This thermal tolerance combined with the short generation times of many algal species (Fogg, 1965) increases their ability to compensate rapidly for any localized changes.

Phytoplankton studies at other estuarine and marine power plant sites found:

- During cooler months, the photosynthetic rates of entrained phytoplankton may increase, but no changes in the species composition or overall abundance of algal populations so affected would be expected (Brooks et al., 1974; Jensen and Martin, 1974; Smith et al., 1974; Hamilton et al., 1970; Heffner et al., 1971);
- During warmer months, the photosynthetic rates of entrained phytoplankton may decrease temporarily without altering the photosynthetic capacity of the receiving waterbody phytoplankton populations (Brooks et al., 1974; Jensen and Martin, 1974; Smith et al., 1974; Hamilton et al., 1970; Heffner et al., 1971);
- Discharge temperatures in excess of 32° C (90° F) are generally required before reductions in the photosynthetic capacity of entrained phytoplankton populations occur (Hamilton et al., 1970; Brooks et al., 1974). Some studies indicate that the crucial discharge temperature may be closer to 38° C (100° F) (Heffner et al., 1971; New York University, 1975). Patrick (1969) reported lethal temperatures for most algal species studied ranging from 33.1 to 45° C (91.5 to 113° F), with the majority near 43.9° C (111° F).

The thermal discharge of the modernized plant will not exceed the reported temperature tolerances of phytoplankton. Therefore, the modernized plant's discharge will not have any significant adverse impact on the Estero Bay's phytoplankton community.

Zooplankton

Zooplankton will encounter the thermal plume of the modernized plant's shoreline discharge as it rises to the surface, but its temperatures will not harm Morro and Estero Bays' nearshore and slough zooplankton. Zooplankton, organisms typically microscopic in size, are found in dense concentrations drifting in Estero Bay's ocean currents. They feed on unicellular algae, detritus, bacteria, and other zooplankton. Their rapid growth and reproduction provides the transfer of phytoplankton primary production energy to higher trophic levels such as larval fishes. Studies of zooplankton thermal tolerance suggest that, in general, temperatures in excess of 30° C (86° F) are required to cause significant mortality. Lauer et al. (1974) reported that *Acartia tonsa*, an abundant copepod in Morro and Estero bays, may tolerate 15-minute exposures to temperatures as high as 33.5° C (92.3° F). The reported thermal tolerance limit of *Acartia tonsa* and *Eurytemora affinis* are 35 and 30° C (95 and 86° F), respectively (EPA, 1971). *Calanus finmarchius* has been shown to have a thermal tolerance limit of between 26 to 29° C (78.8 to 84.2° F) (EPA, 1971). The thermal tolerance temperature of these zooplankton species is above any predicted discharge plume temperature for the modernized plant's discharge.

1971-1972 Studies of the Thermal Effects on Fishes

A fish population study conducted in 1971-72 (PG&E, 1973) was conducted within Estero Bay to address questions about the effects of the thermal discharge on fish communities and their distributions. Four sampling locations within Estero Bay were selected for study. The locations were designated F-1 through F-4, as shown in Figure 6.6A-18. Station F-1, influenced by the thermal plume, was 3 to 4° F above ambient water temperature. Station F-2, at the center of the discharge, had delta T temperatures of approximately 20° F above ambient water temperature. Stations F-3 and F-4 were not in the thermal plume and served as controls.

Collection and Processing Methods

Three capture methods were used in order to sample fish species occurring throughout the water column. Otter trawls were used to sample demersal fishes and two variations of set gill nets (floating and sinking) were used to sample fish within the water column. Time and water

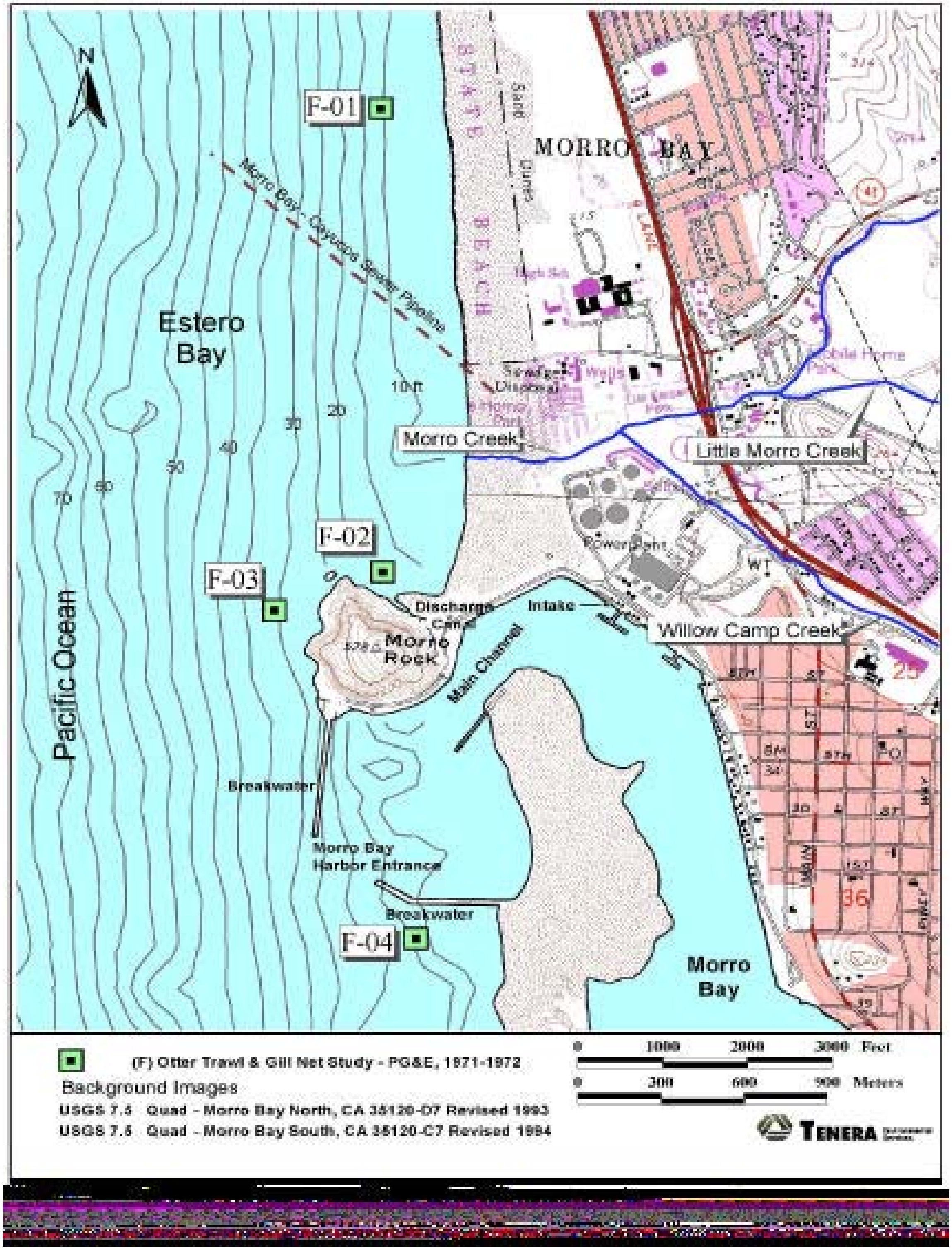


Figure 6.6A-18. Otter trawl and gill net sampling locations in 1971–72 (PG&E, 1973).

temperature profiles were recorded at each station following gill net deployment. Fishes, invertebrates, and detritus were removed following each collection. Fishes were separated by species, and their total lengths were recorded. The combined weight of all individuals within a species was recorded.

The weights and lengths of fishes captured during a sampling effort were averaged for analysis. Data were analyzed using two-way analysis of variance. The underlying assumptions for this statistical method were accepted (normality and equal variance), although the paucity of replications made these assumptions unverifiable. Data were analyzed to determine simultaneous differences between sampling stations (indicating possible thermal discharge effects) for all stations, gear types, and for each fish catch parameter. Differences between gear types for each station and fish catch parameter were also analyzed. The hypothesis that all sample means were equal was tested against an alternate hypothesis that all sample means were not equal.

<u>Results</u>

During the fish population study, a total of 553 fishes, representing 32 different taxa, was collected. Twenty-two percent of all fishes captured during the study (7.7 fish caught per unit effort) were caught in what was categorized as ambient temperature water. Transitional temperature ranges (delta-T of 3.0 to 3.7° F [1.7 to 2.1° C] above ambient) accounted for 8.9 percent of the total catch (9.8 fish caught per effort), and 69.5 percent of all fishes captured during the study (28.2 fish caught per unit effort) were taken from discharge temperatures (delta T of 12.0 to 12.1° F [16.6° C] above ambient). Of the 32 taxa collected during the study, 67 percent were taken from discharge waters. The same percentage of the species total (67 percent) was collected from ambient temperature water, however, only 38.3 percent of these were the same as the discharge species. Species captured in transitional water temperatures accounted for 29.5 percent of the total, 14.7 percent of which also occurred in the discharge temperature range. The species captured in both ambient and discharge temperature ranges (38.3 percent) were categorized as eurythermal (tolerant of a wide range of temperatures). Because of the number of individuals of these species captured in discharge temperature ranges, it was suggested that they might also be thermophilic (preferring warmer temperatures).

The results of the linear regression and correlation tests indicated a correlation, although not significant, in the third sampling period between temperature, number of species, and the diversity index for the sinking gill net gear. The nonlinear trend suggested that more species occur as water temperature increases. This seemed particularly evident at the discharge with a delta-T of 20° F (11.1° C). All catch methods had data which correlated with temperature when the entire year's sampling effort was considered, however, more data were required to properly evaluate the fishing methods used in this study.

<u>Summary</u>

Classification of species with an apparent temperature preference was performed by comparison of common species from concurrent studies at five San Francisco Bay Area/Sacramento-San Joaquin Delta power plants as well as PG&E's Humboldt Bay, Moss Landing, and Morro Bay power plants. The temperature affinity classification of fish species was based on their abundance in any one temperature zone at each power plant. Potential temperature affinities were classified according to species, temperature zone, and by power plant. Temperature affinity classifications for each species for all power plants studied were pooled for final classification. Only two species which could be categorized (using the study's criteria) as having a temperature affinity were English sole *Parophrys vetulus*, which showed preference for ambient temperatures, and topsmelt, which showed an affinity for discharge temperatures. Because of the abundance of individuals as well as diversity of species within discharge temperature zones, it was suggested that factors other than temperature, (including geographic, physical, and biotic factors/differences between power plants) might have influenced fish distributions. Seemingly, the geography of the power plant, associated substrates, and other physical factors could influence the distribution of fish, which may or may not coincide with the specified temperature zones in this study. Biotic factors including food supply and abundance of predators could also influence distribution.

Many fish species captured during this study appeared to be eurythermal due to their abundance in both ambient water temperatures and the elevated water temperatures within the thermal discharge. Others appeared to be thermophilic due to their relative abundance within the thermal discharge. Otter trawl gear and sinking gill nets were the sampling methods that yielded the highest index of diversity, indicating a fish community associated with the bottom and mid-water areas of the water column.

1974 Angler Use and Catch Composition

Information was gathered from the MBPP during a four-month creel census program in 1974 at six PG&E thermal power plants (Steitz, 1975). The program was undertaken to supplement the thermal studies program with additional biological descriptions of thermal impact areas, and to provide some specific information regarding sport fishing at MBPP.

The sampling program was established to provide such information as angler success and catch composition at individual power plants, as well as to examine any direct relationships between weather, tidal influence, and plant generating load upon the above mentioned parameters.

Creel census at the MBPP was conducted from July 9 through October 28, 1974. The 4-month sampling period was stratified into two successive 2-month sampling periods. Sampling dates were randomly selected with the restriction that each day of the week was to be sampled at least once at during the sampling period.

Methods

The shoreline near adjacent to the thermal discharge was divided into survey zones as shown in Figure 6.6A-19. Survey zones were established at the power plant for the purpose of delineating the influence of the thermal plume as related to its configuration at various tidal stages, and analyzing this influence with respect to angler success, catch composition, and possible angler use patterns.

All sampling was conducted within a legal California fishing day, beginning 1/2 hour before sunrise, and ending 1/2 hour after sunset. Bi-hourly use counts were used to provide estimates of fishing pressure as well as to supply additional information regarding specific recreational uses at areas adjacent to the power plant.

Only shore anglers were interviewed during the sampling period. The following information was recorded: number of anglers in the party, total time fished (to the nearest half-hour), total fish species caught, number of fishes kept and released by the fish species, zip code, and time of interview. At the time of the interview, the census taker also recorded the following information: air temperature, wind velocity and direction, a general rating for the weather (subjective scale), and the plant zone in which the interview took place. The tidal stage and generating load were also recorded.

Results

For the total survey period, the combined expanded angler use for all zones surveyed was estimated at 11,826 angler hours. Of the total angler hours spent, shore anglers accounted for 11,001 hours (93 percent) while boat anglers accounted for 825 angler hours. Fishing pressure was only slightly higher on weekends and holidays than it was for weekdays (Steitz, 1975).

Shore anglers were primarily concentrated in the vicinity of the discharge. Zones 1 through 3, most influenced by the thermal discharge, comprised 44.5 percent of the of the total angler use. The average catch per angler hour during the census period ranged from 1.1 fish in Zone 1 to 2.3 fish in Zone 3. The overall catch per angler hour was 1.7 fish. No fishing activity was observed in Zones 4, 5, and 11 during any of the censusing days (Steitz, 1975).

Census takers observed 20 species of fish caught during the 26 days of sampling. Three taxa accounted for 82 percent of the total catch. Jack mackerel was the most numerous species caught, and comprised approximately 53 percent of the total catch. Unidentified sculpins and jacksmelt accounted for 17.0 and 12.1 percent of the total catch, respectively. The combined catch for jack mackerel, jacksmelt, and sculpins accounted for 88 percent of the total catch in Zone 1 (closest to the discharge), 86 percent in Zone 2, and 74 percent in Zone 3. The observed distribution of total angling activity and fish catch between the different geographical zones indicated that there were higher concentrations of fish near the terminus of the discharge canal than at points distant from it along the shoreline (Steitz, 1975).

Correlation analysis examined the extent of the relationship between catch per angler per hour of each species and of all species combined (both total caught and total kept) for each zone and various independent variables. The correlation analysis found that there was a significant correlation between catch and tide elevation, tide direction, plant generation load, and time of day. Based on overall catches (and also for the most abundant species-jack mackerel), higher plant load and associated discharge temperatures were associated with increased catches. The highest rate of catch was from Zone 2 (Steitz, 1975).

Thermal Tolerances of Fishes

Topsmelt *Atherinops affinis*

Surface plume temperatures from the modernized plant's shoreline discharge will not negatively affect topsmelt. Several studies of the thermal resistance of the topsmelt have been reported. Hubbs (1965) found that the maximum upper temperature tolerance for normal egg development is

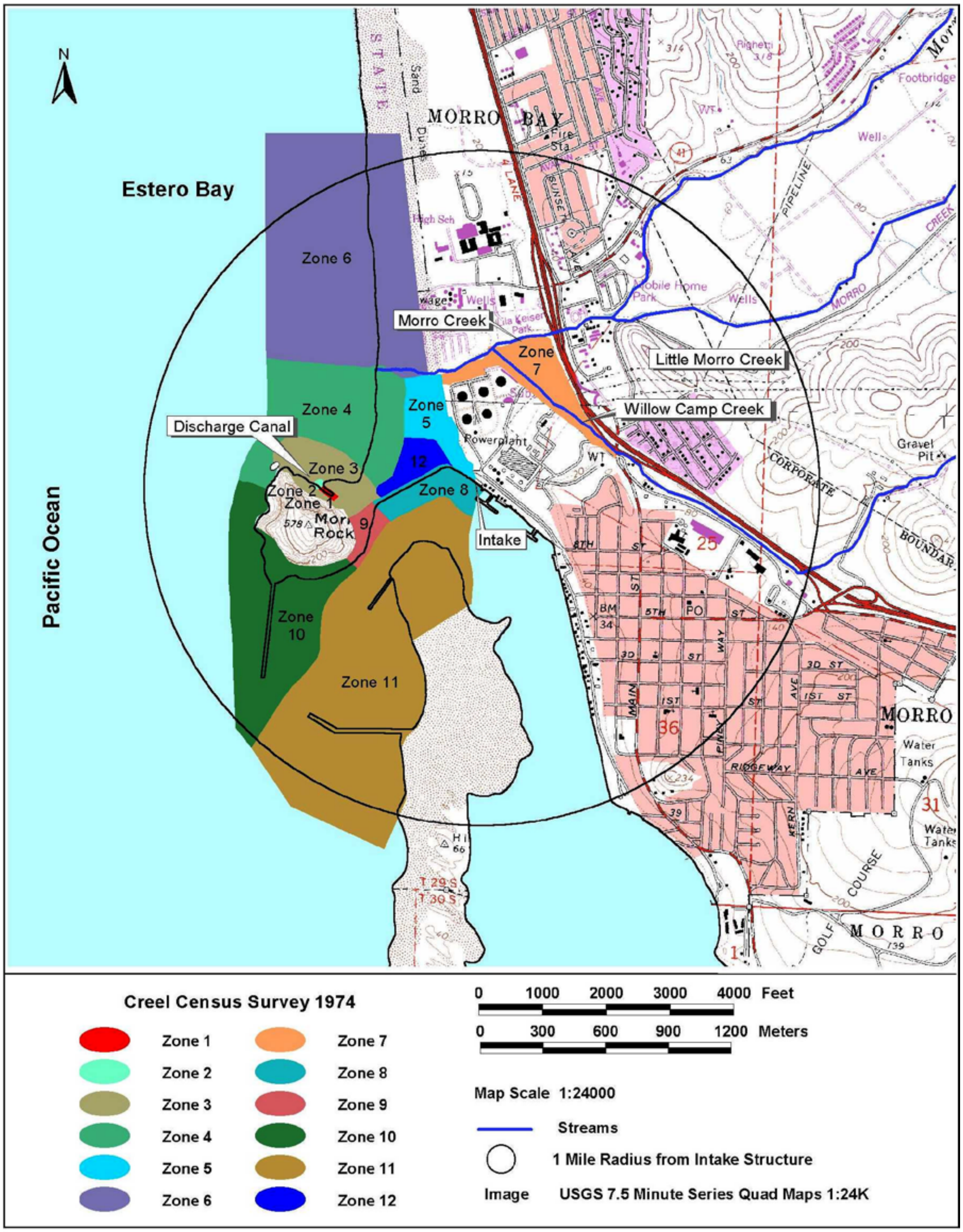
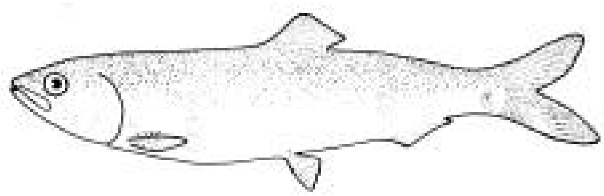


Figure 6.6A-19. Survey zone locations for angler use and catch composition study (Steitz, 1975).

between 27 and 28.5° C (81 and 83.3° F). Eggs exposed to a temperature of 28.5° C (83.3° F) expired shortly after circulatory system development. Carpelan (1955) notes the wide range of natural temperature tolerance of topsmelt (25 to 26.4° C; 77 to 79.5° F) and the species' remarkable tolerance of high temperatures (up to 33° C; 91.4° F). Doudoroff (1945) reported similar findings of the species' high temperature tolerances on specimens which he had acclimated for a period of three days at 20° C (68° F). *A. affinis* tolerated temperatures ranging from 10.4 to 31.7° C (50.7 to 89.1° F).

Pacific Herring *Clupea pallasi*



Surface plume temperatures from the modernized plant's shoreline discharge will not affect Pacific herring. A temperature tolerance range (20.8 to 24.7° C, 69.4 to 76.5° F) is reported for egg survival of the Pacific herring (EPA, 1971). Blaxter (1960) studied the effects of extreme temperatures on the larvae of Atlantic herring. The lethal temperature was determined graphically by plotting pliant dead at a given temperature against time. He found that the upper lethal temperatures for larvae acclimatized to 7.5 to 15° C (45.5 to 59° F) were 22 to 24° C (71.6 to 75.2° F).

Black Surfperch *Embiotoca jacksoni*

The water temperatures recorded in MBPP thermal plume surveys would not affect the survival of juvenile or adult black surfperch in Estero Bay. The expected nearshore temperatures of the modernized plant's discharge plume are less than the laboratory thermal tolerance of black surfperch.

LABORATORY THERMAL TOLERANCE STUDIES CONDUCTED AT THE DIABLO CANYON POWER PLANT.

Lifestage	Acclimation Temperature (°c)	96 hr-LT_{50} (°c)	Critical Thermal Maximum (°c)
Juvenile	12.2	24.5	-
Juvenile	16.0	25.6	-
Adult	16.0	-	28.8

Source:Tenera Inc., 1997

Shiner Perch *Cymatogaster aggregata*

The water temperatures recorded in MBPP thermal plume surveys would not affect the activity of juvenile or adult shiner perch in Estero Bay.

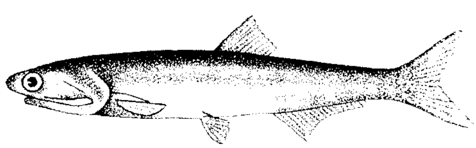
Shiner perch found in the area of the modernized plant's discharge would be attracted to discharge temperatures. Wicke (1968) found that warm summer temperatures followed by cool winter temperatures are necessary for proper embryo development. Ehrlich (communication dated September 7, 1977 from C. Ehrlich, Lockheed Center for Marine Research, Avila Beach, California) found in a series of behavioral experiments that 22.8° C (73° F) is the preferred temperature of juvenile shiner perch and 20.1° C (68.2° F) the preferred temperature of adults.

Pacific staghorn sculpin *Leptocottus armatus*

The water temperatures recorded in MBPP thermal plume surveys would not affect the survival of juvenile or adult Pacific staghorn sculpin in Estero Bay.

Morris (1961) in preliminary tolerance tests of the species found that 25° C (77° F) represented the highest temperature at which immature forms could be held without injury. In his studies of five Oregon cottid species, Pacific staghorn sculpin *Leptocottus armatus* exhibited the greatest degree of seasonal change in metabolic rate. Morris found that the rate of respiration in *L. armatus* is highest in winter and the species' Q_{10} lowest in summer. His findings suggest that the temperature resistance of *L. armatus* is higher in the summer than the winter. Altman and Dittmar (1966) reported that 29.5° C (85.1° F) represented the upper tolerance limit for the adult Pacific staghorn sculpin.

Northern Anchovy *Engraulis mordax*



Adult northern anchovy, swimming in the areas of the modernized plant's shoreline discharge, would not be affected by plume's temperatures. Thermal tolerance data for northern anchovy indicate that hatching and larval development are normal at temperatures below 27° C (81° F), although most spawning occurs at temperatures between 13 and 18° C (55 and 64° F) (Brewer, 1976). The water temperatures recorded in MBPP thermal plume surveys would not limit spawning activity or the survival of northern anchovy eggs and larvae in Estero Bay.

6.6A.2.2 Area-Related Marine Studies

These supplementary sources include studies by CDFG, the City of Morro Bay/Cayucos Offshore Monitoring and Reporting System, Standard Oil Company of Southern California, and research papers from members of the academic community.

6.6A.2.2.1 The City of Morro Bay/Cayucos Sanitary District Monitoring and Reporting Study

The City of Morro Bay/Cayucos Sanitary District, under provisions of an NPDES Permit, is required to conduct benthic surveys on the receiving waters of Estero Bay. This Monitoring and Reporting Program has been conducted semiannually (spring and fall) since 1985 to evaluate the effects of their discharge. Sediment samples are collected for chemical, physical, and benthic infaunal analysis. Regular monitoring of five benthic stations allows for any degradation of the infaunal community to be noted. Summaries of these studies conducted from 1995 through 1998 are presented in Appendix 6.6A-9.

6.6A.2.2.2 Standard Oil of California Potential Oil Spill Study

Standard Oil of California (SOCAL) conducted a study during July-August 1973 and February 1974 to collect ecological information on the sandy and rocky intertidal area of Estero Bay and the entrance to Morro Bay (URS, 1973). The objective of the study was to provide baseline information on the biotic communities that could be affected by an oil spill. Summaries of these studies are attached as Appendix 6.6A-10.

6.6A.2.2.3 Additional Information

A varied assemblage of commercial fishing boats delivers their product to the Port of Morro Bay. Many of the fisheries exploited by local boats are seasonal while others are fished throughout the year. Salmon and albacore trolling are seasonal fisheries, as is the drift gill net fishery for swordfish. Groundfish, including the *Sebastes* spp. (rockfishes) and DTS (dover sole, thornyheads, and sablefish) complexes, are landed throughout the year. Spot prawn, pink shrimp, and halibut trawlers land their product in Morro Bay, as do boats fishing for halibut with gill nets. Information regarding landings from the Port of Morro Bay from 1988 through 1998 are discussed in Appendix 6.6A-11.

The CDFG maintains a database of all commercial landings in the state. The size of each CDFG fishing block is 10 minutes of latitude by 10 minutes of longitude. Block information (fishing location) is required by CDFG to appear on each landing receipt. Port landing data, however, are generally considered a better measure of local fishing and success than block data because of inconsistencies in catch block reporting. A record of landings is useful in determining the importance of each fishery within the area. Dollar values of landings are subject to yearly variation due to the abundance of the target species and its market price. CDFG compiles landing statistics in order to assess the fishery resources of the state. Unpublished commercial and sport catch data from 1975 to 1995 have been obtained for statistical catch blocks in the vicinity of Estero Bay. Total annual commercial landings for Morro Bay from 1993 to 1998 have been gathered and organized for future analysis and assessment as needed.

A similar pattern of seasonal and year round catches occurs with sport fishing in the area. The most fundamental division of sport fishing effort in the area would be anglers fishing from shore versus anglers fishing from boats. Several local surveys have been conducted targeting the fishing efforts and success made from each group. Studies include creel surveys by PSMFC and CDFG. Both agencies are conducting ongoing studies of local party boat fleet catches.

Shorebird Survey of Morro Strand State Beach

Morro Strand State Beach, to the north of the MBPP thermal discharge, is one of the sites that is currently being surveyed as part of an assessment of shorebird populations on regional beaches and the factors that affect their distribution. The study is funded by a grant from the Minerals Management Service (MMS) in an effort to assess the shorebird resource at potential risk from activities associated with the development of offshore petroleum resources. The 3-year study is being conducted by Dr. Jenifer Dugan of the Marine Science Institute, University of California at Santa Barbara (UCSB). Sampling began in November 1998 and will extend through October 2001. Sampling includes a monthly census of shorebirds on 20 beaches in San Luis Obispo and Santa Barbara counties. Measurements of a variety of physical beach parameters are conducted at each site to characterize beach type and assess temporal changes. Semiannual survey of prey species availability are conducted to gather information about factors affecting the distribution of shorebirds and which beaches form the most important habitat.

6.6A.2.3 Pelagic Seabirds

The large numbers of pelagic seabirds found Morro Bay and Estero Bay are not at risk to operations of the MBPP cooling water system intake or discharge. As an important location for migratory birds along the Pacific Flyway, the bays provide foraging and resting areas as the birds fly from their northern breeding grounds to the wintering grounds. Migration into Morro Bay peaks in mid-February. The vast majority of the birds seek out the quiet habitat of Morro Bay, particularly the food-rich shallow mudflats and eelgrass beds. These areas found in the middle and deep interior areas of the Morro Bay provide supplies of eelgrass and sea lettuce for the black brandt *Branta bernicla*, the most numerous of the bay's visitors. Other species such as the common tern *Sterna hirunda*, least-storm petral *Halocyptena microsoma* and the phalaropes (*Phalaropus fulicarius, Steganopus tricolor, Lobipes lobatus*) use the shallow and calm areas to feed and rest, particularly during heavy winter seas. While still other species use of the sand spit for resting which offers refuge from human disturbance and broad shoals during low tide.

The location and design of the MBPP intake minimizes any potential impacts to Morro Bay's visiting or resident pelagic bird species. The intake is located along the shoreline, area of relatively deep water (approximately 20 feet; 6 m), within an area of no particularly useful habitat to the birds. It is also the area in the bay with the highest level of human activity associated with the downtown area's traffic and harbor operations. It is not area that would be attractive to birds seeking forage or refuge. In addition, the intake structures are constructed with a solid inverted weir in the form of a concrete overhang that extends from the front edge of the intake deck to approximately 6 feet below mean sea level (see Figure 6.6A-3). This weir which is designed to prevent floating objects from entering the intake facility's forebay also prevents seabirds from swimming or floating in the area of the intake and accidentally becoming involved in the intake operations.

There is no reason to expect that the MBPPs discharge into the shallow surf zone of Estero Bay could have any impact on the area's pelagic seabirds, particularly since the majority of the birds are found in Morro Bay well beyond any contact with the discharge. Seabirds utilizing the discharge area would be no more disturbed by the presence of the discharge than the relatively high level of human presence related to surfing and fishing activities at the location. Schools of fishes attracted to the flow or temperature of the discharge might in turn serve as prey to diving birds such as terns or pelicans.

6.6A.2.4 Sensitive and Fully Protected Species

Three marine species listed by the CDFG as endangered or Species of Special Concern are reported to occur in the area. These include the southern sea otter, the steelhead rainbow trout, and the tidewater goby. The tidewater goby is currently being considered by the USFWS for delisting in areas north of Orange County.

6.6A.2.4.1 Steelhead Rainbow Trout

Steelhead rainbow trout (*Oncorhynchus mykiss*) are extinct or at low levels throughout the west coast because of a combination of human activities and poor natural conditions. Habitat degradation, hatchery production, and over-harvest have reduced the fish's ability to cope with variable environmental conditions (Capelli, 1998).

No MBPP operating impacts on steelhead rainbow trout (steelhead) result from the existing MBPP intake and discharge nor are any potential impacts expected as a result of the reductions in intake or discharge volumes of the modernized facility. They have not been collected in impingement samples from the recently completed 12-month 1999-2000 impingement study. Steelhead migrate during the spring and summer months from the open ocean through Morro Bay into both Chorro and Los Osos creeks. Steelhead were observed on June 16, 2000 during a survey of Morro Creek (Section 6.6B). Juvenile steelhead usually migrate to sea in the spring when they are from 6 to 8 inches in length, but steelhead enter the ocean year round throughout their range. Larval steelhead are not found in the vicinity of the intake and therefore would not be susceptible to entrainment.

Steelhead migrations routes take both adult and juvenile steelhead through the general areas of the MBPP discharge in Estero Bay and the intake in Morro Bay. However, spawning and rearing activities occur in freshwater habitat well beyond any possible influence of the MBPP. Steelhead are strong and powerful swimmers that could not be affected by the modernized facility's approach velocities of 0.3 fps. Until water velocities reach 10 to 13 fps, the swimming ability of adult steelhead is not hampered (CDFG, 1998). Returning adults are able to easily resist intake velocities as would outmigrating yearlings as they ride tidal currents in excess 6 fps past the MBPP intakes.

Steelhead migrating past the MBPP discharge into Estero Bay might be attracted to discharge flows, in the same manner as they might investigate coastal stream flows. However, the steelhead could move at will in or out of MBPP discharge flows and also could avoid the surface plume. Although discharge thermal plumes have been observed in the past to occasionally extend as far north as the entrance to Morro Creek, the plume is only inches thick at this great distance from the point of discharge. The plumes' shoreward margins disappear in the surf zone based on information gathered from infrared (IR) aerial images of this area. Steelhead have difficulty extracting oxygen from freshwater at temperatures greater than 70º F (Hooper, 1973), but discharge plume temperatures would not be expected to exceed a degree or two above ambient in this region. Plume temperatures of even this small amount would be even less likely given reduced volumes of the modernized MBPP discharge. Steelhead can avoid discharge plume temperatures by finding ambient water temperature immediately beneath the surface discharge plume.

6.6A.2.4.2 Tidewater Goby

Tidewater gobies (*Eucyclogobius newberryi*), have been found in Morro Bay's brackish marsh habitats at the mouths of Chorro and Los Osos creeks (Horn, 1980). Larvae that were tentatively identified as tidewater goby were collected in front of the MBPP cooling water intakes and at several Morro Bay source water stations during the 1999-2000 entrainment study. The identifications were verified by taxonomic experts in early August 1999. However, recently completed DNA analysis, performed on nearly 10 percent of the specimens, refute the identifications. None of the specimens are tidewater goby based on the DNA test results. Eighty-five percent of the specimens were genetically identified as shadow goby *Quietula y-cauda*. The DNA from the remaining specimens were from unknown gobies whose DNA did not match any of the sequencing information in the laboratory's data banks; these "unknown gobies" did not match tidewater goby DNA. Moreover, no tidewater gobies were collected in samples from the recently completed 12-month 1999-2000 impingement study. All life stages of the tidewater goby are restricted to California coastal wetlands with low salinities (< 10 ppt). The lack of a marine phase restricts the ability of this species to colonize to new areas.

Most gobies do not survive the winter storm season and those that do are usually subadults. The few fish that do survive repopulate suitable habitats in the spring (Rathburn et al., 1993).

The USFWS is currently considering de-listing of the tidewater goby in areas north of Orange County.

6.6A.2.4.3 Southern Sea Otter

The abundance of sea otters in Morro Bay is highly seasonal (Bodkin and Rathburn, 1988), and closely follows the typical pattern of late winter kelp canopy degeneration observed along much of the central California coast (USFWS, unpubl. data). During the Fish and Wildlife Service study (1988) 2,291 otter observations were recorded throughout the bay. Most of these observations occurred between the harbor mouth and what is now Tidelands Park. Sea otters are most often observed resting, feeding, and grooming in the protected waters along the sand spit west of the main channel. Foraging activities of the otters might take them into the area of the MBPP intakes. However, otters appear to avoid this busy area of the bay adjacent to the waterfront and the MBPP intake. There is no reason to expect a healthy sea otter to be adversely affected in any way by either the existing or modernized MBPP intakes. Sea otters have utilized the intake cove at the Diablo Canyon Power Plant as a resting, foraging, and mating area for years without an incident or accident associated with the operation of the power plant's intake facilities.

6.6A.2.5 Summary of Marine Biological Impacts

No significant marine biological impacts are expected as a result of modernizing the MBPP. The maximum cooling water intake and discharge flows of the Project will be reduced by approximately 29 percent, and the maximum heat load from the Project's peak power production as compared to Units 1 through 4 (now 1,002 MW) will be reduced by 25 percent. By reducing the existing facility's cooling water requirements, fewer larval fishes and shellfish will be entrained and impingement effects and discharge effects will also be reduced. The reduction in approach velocities at the intake will also reduce impingement effects.

The existing facility's cooling water system intake and discharge have been continuously reviewed as an NPDES permit condition. Results of these 5-year reviews found that the intake represents best technology available and that the discharge protects the receiving water's beneficial uses. The reduced discharge volume will have the effect of lowering the potential magnitude and extent of any existing discharge impacts. Based on our review of the existing literature and results of recent studies (July 1999 and September 2000) on the thermal effects of the MBPP discharge, impacts associated with the existing discharge are limited to modified species composition of attached algal species occupying the rocky subtidal areas of Morro Rock. From available literature and reports on the facility's intake, intake impacts expressed as rates of impingement are similar to rates at most coastal and bay facilities and significantly less than others, San Onofre Nuclear Generating Station for one. Results of the recent CWIS studies, will provide the information necessary for the RWQCBs NPDES permitting process.

6.6A.2.5.1 Intake-Related Effects

The modernized facility's reduced cooling water requirements will result in intake design flows less than those measured at the existing Units 1 and 2 intake. The modernized facility's reduced intake flows are expected to reduce the amount of debris, primarily eelgrass, collected on the intake traveling screens, and thereby lower impingement rates of juvenile and adult fishes and shellfish. The existing Units 1 and 2 approach velocities of 0.37 fps will be reduced by approximately 10 percent (to 0.33 fps) for the new combined-cycle unit during maximum water withdrawal conditions. An even greater reduction in the approach velocities (approximately 40 percent) will occur at the Units 3 and 4 intake from the current 0.51 fps to 0.30 fps for the other combined-cycle unit during peak load and maximum water withdrawal conditions. Studies which investigated the impingement of fishes and shellfish at the existing facility's approach velocities found that impingement rates of organisms were closely related to rates of debris loading on the traveling screens.

The low impingement rates of the existing facility are attributed to the shallow forebay that is located flush to the shoreline. The design and location of the intake facility minimizes potential entrapment of fishes. With the reduction in design approach velocity of the new combined-cycle intake, impingement rates are expected to be reduced even further than the current facility's existing low rate. For fish species that are strong swimmers, steelhead for one, the new intake design approach velocities of 0.3 fps essentially eliminate any potential impact of the modernized facility's intakes. By comparison, on a changing tide, the velocities of the current in front of the intake frequently exceed 6 fps, or 20 times the intake velocity.

The facility's peak intake and discharge volumes will be reduced by 29 percent. With or without the power plant, far fewer than one percent of larvae would survive natural mortality. Therefore, this reduction in peak cooling water intake volume results in a direct benefit to species of entrained larval fishes and shellfish.

6.6A.2.5.2 Discharge Plume-Related Effects

As noted above, the modernized facility is designed to use less cooling water to produce more electricity. Reduced cooling water requirements will result in a smaller sized discharge plume and therefore lower the potential extent of thermal plume effects. The facility's cooling water is discharged from a canal directly into the turbulent surf zone that produces a rapidly mixed thermal plume at the point of discharge. The plume's thermal buoyancy lifts it clear of the ocean bottom at a short distance from the end of the point of discharge. Winds and currents generally carry the surface plume in a northwesterly direction in parallel and in an offshore direction away from Morro Rock. Changing patterns in local currents associated with seasonal shifts in winds, waves, and large-scale coastal currents affect the size, shape, and direction of the plume on a given set of tide conditions. This local northerly counter-flow (gyre) along Morro Strand State Beach, which was frequently observed in past plume studies, serves to carry the surface plume away from shoreline contact (see Figure 6.5-9). The reduced-volume discharge plume of the modernized facility is expected to behave in a similar manner. With its smaller volume, the modernized facility's discharge plume will mix more rapidly, buoyantly separate from the ocean bottom in a shorter distance from the point of discharge, and because of its smaller size it will contact less linear distance of shoreline.

The modernized facility's smaller sized thermal plume will reduce the potential for discharge thermal effects, although previous studies of the receiving water's water column, ocean bottom and sandy beach habitats did not detect any plume effects. Contemporary study designs and sampling methodologies for the sand beach, rocky intertidal, and subtidal benthic surveys were reviewed and approved by the TWG. Preliminary results from these surveys conducted in the habitats listed above are attached in Appendices 6.6A-6 and 6.6A-7. The effects of elevated discharge temperatures of the existing facility's thermal plume on attached marine algae have been observed along the shoreline of Morro Rock from the point of discharge to a distance of approximately 200 m (656 feet). The reduced volume of the modernized facility's discharge is expected to reduce the potential extent and magnitude of effects compared to the existing facility's historic discharge.

6.6A.2.6 Construction Impacts

6.6A.2.6.1 Marine

There are no Project plans for construction elements that will produce effects or impacts on the marine environment or associated habitats. The demolition of the existing onsite fuel oil tanks, the construction of the combined-cycle units, and the demolition of the power building and the three 450-foot-tall stacks for Units 1 through 4 will not impact the marine environment. By reusing MBPP existing intake and discharge facilities rather than disturbing new shoreline or offshore habitat, the Project is able to avoid many numerous and potentially significant impacts to the area's marine habitats. This brownfield aspect of recycling the existing MBPP site is one of the Project's environmental strengths as particularly the case for the absence of marine construction impacts.

6.6A.3 MITIGATION

6.6A.3.1 Marine

6.6A.3.1.1 Operations Impact Mitigation

The MBPP proposed intake flows through the existing intake would minimize intake approach velocities. Based on cross-sectional area and manufacturer's pump specifications, approach velocities at the bar racks (see Figure 6.6A-3) will not exceed 0.5 fps at MSL. An intake approach velocity of 0.5 fps is a design commonly used for marine CWIS to allow most juvenile and adult fishes to escape the influence of the intake withdrawal. The velocity has been found to be generally below the escape velocity of species that have been tested. Healthy juvenile and adult fishes are commonly observed and filmed swimming at will in and out of CWIS with approach velocities considerably higher than 0.5 fps.

Operation of the MBPP Project CWIS will result in mortalities to early life stages of organisms that cannot be avoided. The effects on species populations will be mitigated, if necessary, to assure that they are not significant. Mitigation may take many forms, such as: (1) avoiding the impact to the extent practical; (2) minimizing the impact; (3) rectifying the impact; (4) reducing or eliminating the impact over time; and (5) compensating for the impact. Evaluation and selection of appropriate mitigation is conducted among participating resource and regulatory agencies at the time the Commission staff prepares the Project's PSA. Habitat compensation may be used to offset the adverse effects to fish associated with power plant operations.

6.6A.3.1.2 Construction Impact Mitigation

Construction mitigation is not necessary since there is no construction impact to the marine environment.

6.6A.3.2 <u>Cumulative Impacts</u>

No cumulative impacts are expected to result from the modernized MBPPs cooling water system intake and discharge. No other intake or discharge of industrial seawater occurs within 1,000 feet (0.2 mile) of the Morro Bay intake or discharge facility. Nonpoint source stormwater runoff from parking areas and roadways is expected to occur in the area of the discharge, but in such small and infrequent amounts and any potential cumulative effect is negligible. Vessels operating in the MBPP intake and discharge area entrain small amounts of ocean water in their seawater cooling water systems and create minor thermal discharges, neither of which represent any risk of MBPP cumulative impacts.

On occasion, the MBPP discharge creates on occasion a thin surface plume that can extend north along Morro Strand Beach as far as the region of the City of Morro Bay Wastewater Treatment Plant's discharge. The City's treated sewage effluent of approximately 1.95 million gallons per day (mgd) is discharged through a multiport diffuser over a mile north of the MBPP discharge. The discharge located at a depth of 50 feet (15 m) is generally warmer and less saline than the receiving water. While mixing is rapid, the discharge appears on certain occasions at the surface as a slightly warmer, less saline plume. Considering both the infrequent coincidence of the MBPP and City of Morro Bay Wastewater Treatment Plant's discharge plumes and the relatively small delta-Ts of the two plumes at their point of overlap, there is no reason to expected any cumulative, thermal impacts. Other discharge constituents occurring in the two plumes must comply with water quality based standards at each discharge's zone of initial dilution (ZID). The water quality standards are designed to protect against any degradation of receiving water quality including a wide margin of protection incorporated as an application factor used in establishing the standards. The great distance between the two discharge-ZIDs provides additional assurance against the possibility of cumulative impacts.

6.6A.3.3 Marine Resource Mitigation Measures

Based on the above analysis of impacts, and the design and operational features that have been incorporated into the Project, no mitigation measures are needed for marine biology resources.

6.6A.3.4 Marine Resources-Significant Unavoidable Adverse Impacts

No significant unavoidable adverse impacts to marine resources are anticipated at MBPP due to the Project (i.e., due to construction or future operation of the new combined-cycle units).

RÉSUMÉS

Qualifications of Tenera Environmental scientists who participated in the preparation of the MBPP marine biological resource surveys are listed as Appendix 6.6A-12.

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