NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
2008 RECEIVING WATER MONITORING REPORT
RELIANT ENERGY MANDALAY GENERATING STATION
VENTURA COUNTY, CALIFORNIA

2008 Survey

Prepared for:

Reliant Energy

Prepared by:

MBC *Applied Environmental Sciences*
3000 Red Hill Avenue
Costa Mesa, California 92626

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
2008 RECEIVING WATER MONITORING REPORT
RELIANT ENERGY MANDALAY GENERATING STATION
VENTURA COUNTY, CALIFORNIA

2008 Survey

Prepared for:

Reliant Energy

Prepared by:

MBC *Applied Environmental Sciences*
3000 Red Hill Avenue
Costa Mesa, California 92626

March 2009

PROJECT STAFF

Reliant Energy

J. Babcock
B. Siekiel-Zdzienicki
K. Whelan

MBC Applied Environmental Sciences

Project Manager — D. G. Vilas

Marine Scientists

D. S. Beck
S. M. Beck
M. D. Curtis
T. C. Duvall
E. F. Miller
R. H. Moore
C. L. Paquette
D. G. Vilas

Technicians

N. M. Burkes
W. H. Dossett
J. R. Nunez
F. C. Petry
J. L. Rankin
J. J. Sloan
B. L. Smith

Project Coordinator

M. R. Pavlick

Editor

D. G. Vilas

TABLE OF CONTENTS

	Page
LIST OF FIGURES	v
LIST OF TABLES	vii
EXECUTIVE SUMMARY	ix
CHAPTER 1 — INTRODUCTION	1-1
DESCRIPTION OF THE GENERATING STATION	1-1
DESCRIPTION OF THE STUDY AREA	1-1
Physiography	1-2
Submarine Physiography	1-4
Climate	1-4
Ocean Currents	1-4
Longshore Drift	1-5
Tides	1-5
Upwelling	1-5
RECEIVING WATER CHARACTERISTICS	1-6
Temperature	1-6
Salinity	1-6
Dissolved Oxygen	1-6
Hydrogen Ion Concentration	1-7
BENEFICIAL USES OF RECEIVING WATERS	1-7
Industrial Service Supply	1-7
Navigation	1-7
Water Contact Recreation	1-7
Non-contact Water Recreation	1-7
Commercial and Sport Fishing	1-7
Marine Habitat	1-7
Wildlife Habitat	1-7
Preservation of Biological Habitats	1-7
Rare, Threatened, or Endangered Species	1-8
Migration of Aquatic Organisms	1-8
Spawning, Reproduction, and/or Early Development	1-8
Shellfish Harvesting	1-8
SCOPE OF THE MONITORING PROGRAM	1-8
STATION LOCATIONS	1-8
FIELD OBSERVATIONS	1-8
STATISTICAL ANALYSES	1-10
DETECTION/REPORTING LIMITS	1-12
CHAPTER 2 — WATER COLUMN MONITORING	2-1
MATERIALS AND METHODS	2-1
RESULTS	2-2
DISCUSSION	2-6
CONCLUSION	2-8
CHAPTER 3 — SEDIMENT CHARACTERISTICS	3-1
MATERIALS AND METHODS	3-1
RESULTS	3-2
DISCUSSION	3-3
CONCLUSION	3-7

Page

CHAPTER 4 — MUSSEL BIOACCUMULATION 4-1

CHAPTER 5 — BENTHIC INFAUNA 5-1
MATERIALS AND METHODS 5-1
RESULTS 5-2
DISCUSSION 5-5
CONCLUSION 5-7

CHAPTER 6 — DEMERSAL FISH AND MACROINVERTEBRATES 6-1
MATERIALS AND METHODS 6-1
RESULTS 6-2
DISCUSSION 6-6
CONCLUSION 6-10

CHAPTER 7 — IMPINGEMENT 7-1
MATERIALS AND METHODS 7-1
RESULTS 7-2
DISCUSSION 7-4
CONCLUSION 7-6

CHAPTER 8 — LITERATURE CITED 8-1
PERSONAL COMMUNICATIONS 8-7

APPENDICES

A Receiving water monitoring specifications
B Receiving water quality parameters by station
C Sediment grain size techniques and statistical parameters by station
D Sediment chemistry by station
E Mussel tissue chemistry by station
F Infauna data by station
G Demersal fish and macroinvertebrate trawl data by station
H Fish and macroinvertebrate heat treatment and normal operation data

LIST OF FIGURES

Page

Figure 1-1. Diagram of the Mandalay Generating Station cooling water system. Mandalay Generating Station NPDES, 2008 1-2
Figure 1-2. Location of the study area. Mandalay Generating Station NPDES, 2008 1-3
Figure 1-3. Surface circulation in the Southern California Bight (from Hickey 1992). Mandalay Generating Station NPDES, 2008. 1-5
Figure 1-4. Location of the monitoring stations. Mandalay Generating Station NPDES, 2008 1-9
Figure 2-1. Location of the water column sampling stations. Mandalay Generating Station NPDES, 2008 2-1
Figure 2-2. Tidal rhythms during water column sampling, summer survey. Mandalay Generating Station NPDES, 2008 2-2
Figure 2-3. False color surface temperature contour plots, surf zone water quality, and temperature and dissolved oxygen vertical profiles during flood and ebb tides, summer survey. Mandalay Generating Station NPDES, 2008 2-3
Figure 2-4. Surf zone water quality, and hydrogen ion concentration (pH) and salinity vertical profiles during flood and ebb tides, summer survey. Mandalay Generating Station NPDES, 2008 2-5
Figure 3-1. Location of the benthic sampling stations. Mandalay Generating Station NPDES, 2008 3-1
Figure 3-2. Comparison of sediment mean grain size 1990 - 2008. Mandalay Generating Station NPDES, 2008 3-4
Figure 3-3. Comparison of sediment metal concentrations and percent fines by station, 1990 - 2008. Mandalay Generating Station NPDES, 2008 3-6
Figure 5-1. Location of the benthic sampling stations. Mandalay Generating Station NPDES, 2008 5-1
Figure 5-2. Diver-operated box corer used to collect infaunal samples. Mandalay Generating Station NPDES, 2008 5-1
Figure 5-3. Two-way coincidence table resulting from normal (station) and inverse (species) classification dendrograms for the 12 most abundant infaunal species. Mandalay Generating Station NPDES, 2008 5-4
Figure 5-4. Comparison of infaunal community parameters, 1978 - 2008. Mandalay Generating Station NPDES, 2008 5-6
Figure 6-1. Location of the trawl sampling stations. Mandalay Generating Station NPDES, 2008 6-1
Figure 6-2. Proportional abundance of fishes caught in trawl sampling. Pie charts size based on total relative abundance. Mandalay Generating Station NPDES, 2008 6-2
Figure 6-3. Two-way coincidence table resulting from normal (station) and inverse (species) classification dendrograms for fish taken by otter trawl. Mandalay Generating Station NPDES, 2008 6-4
Figure 6-4. Length frequency analysis for queenfish collected by otter trawl sampling. Mandalay Generating Station NPDES, 2008 6-5
Figure 6-5. Length frequency analysis for shiner perch collected by otter trawl sampling. Mandalay Generating Station NPDES, 2008 6-5
Figure 6-6. Length frequency analysis for speckled sanddab collected by otter trawl sampling. Mandalay Generating Station NPDES, 2008 6-5

Page

Figure 6-7. Abundance/min fished of white croaker, queenfish, northern anchovy, and the remaining species taken during summer otter trawl sampling, 1990-2008. Mandalay Generating Station NPDES, 2008 6-6
Figure 6-8. Abundance/min fished of shiner perch and speckled sanddab taken during summer otter trawl sampling, 1990-2008. Mandalay Generating Station NPDES, 2008 6-7
Figure 6-9. Abundance/min fished of Pacific sand dollar, blackspotted bay shrimp, graceful crab, and the remaining species taken during summer otter trawl sampling, 1990-2008. Mandalay Generating Station NPDES, 2008 6-9
Figure 7-1. Length frequency of top smelt impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2008 7-3
Figure 7-2. Length frequency of shiner perch impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2008 7-3
Figure 7-3. Length frequency of Pacific staghorn sculpin impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2008 . . . 7-3
Figure 7-4. Annual abundance of shiner perch, topsmelt, and remaining fish species impinged, and total cooling water flow, 2001-2008. Mandalay Generating Station NPDES, 2008 7-4
Figure 7-5. Annual impinged Pacific staghorn sculpin abundance (heat treatment + estimated normal operation), 2001-2008. Mandalay Generating Station NPDES, 2008 7-5
Figure 7-6. Annual abundance of striped shore crab, California two-spot octopus, littlenect clam, and remaining macroinvertebrate species, 2001-2008. Mandalay Generating Station NPDES, 2008 7-5
Figure 7-7. Annual impinged California spiny lobster abundance (heat treatment + estimated normal operation), 2001-2008. Mandalay Generating Station NPDES, 2008 7-6

LIST OF TABLES

Page

Table 1-1. Latitude/longitude coordinates of sampling stations. Mandalay Generating Station NPDES, 2008 . . . 1-10
Table 2-1. Summary of water quality parameters during flood and ebb tides at offshore stations. Mandalay Generating Station NPDES, 2008 . . . 2-2
Table 2-2. Summary of water quality parameters during flood and ebb tides at surf-zone stations. Mandalay Generating Station NPDES, 2008 . . . 2-4
Table 3-1. Sediment grain size parameters. Mandalay Generating Station NPDES, 2008 . . . 3-2
Table 3-2. Sediment metal concentrations (mg/dry kg). Mandalay Generating Station NPDES, 2008 . . . 3-3
Table 5-1. Number of infaunal species and individuals by phylum. Mandalay Generating Station NPDES, 2008 . . . 5-2
Table 5-2. Infaunal community parameters. Mandalay Generating Station NPDES, 2008 . . . 5-3
Table 5-3. The 12 most abundant infaunal species. Mandalay Generating Station NPDES, 2008 . . . 5-4
Table 6-1. Abundance and catch parameters for fish species taken by otter trawl. Mandalay Generating Station NPDES, 2008 . . . 6-3
Table 6-2. Biomass (kg) of fish species taken by otter trawl. Mandalay Generating Station NPDES, 2008 . . . 6-3
Table 6-3. Measured length (mm) of fish species taken by otter trawl. Mandalay Generating Station NPDES, 2008 . . . 6-5
Table 6-4. Abundance and catch parameters for macroinvertebrate species taken by otter trawl. Mandalay Generating Station NPDES, 2008 . . . 6-6
Table 6-5. Rank of index of community importance for the top ten fish species collected during trawl surveys and contingency table of Spearman’s coefficient of rank correlations by years. Mandalay Generating Station NPDES, 2008 . . . 6-8
Table 6-6. Rank of index of community importance for the five invertebrate species collected during trawl surveys and contingency table of Spearman’s coefficient of rank correlations by years. Mandalay Generating Station NPDES, 2008 . . . 6-10
Table 7-1. Fish abundance and biomass (kg) impinged during one heat treatment survey and estimated normal daily operation. Mandalay Generating Station NPDES, 2008 . . . 7-2
Table 7-2. Macroinvertebrate abundance and biomass (kg) of macroinvertebrate species impinged during one heat treatment survey and estimated normal daily operation. Mandalay Generating Station NPDES, 2008. . . . 7-4

EXECUTIVE SUMMARY

The 2008 National Pollutant Discharge Elimination System (NPDES) marine monitoring program for the Reliant Energy Mandalay Generating Station was conducted in accordance with specifications set forth by the California Regional Water Quality Control Board, Los Angeles Region (LARWQCB) in NPDES Permit No. CA0001180 dated 26 April 2001. The 2008 NPDES program was modified to facilitate the generating station's participation in the fourth comprehensive regional survey of coastal ocean waters in the Southern California Bight (Bight '08). The 2008 studies included physical monitoring of the receiving waters and underlying sediments, and biological sampling of the benthic infaunal, fish, and macroinvertebrate assemblages. Results of the 2008 surveys were compared among stations and with previous studies to determine if the beneficial uses of the receiving waters continue to be protected.

WATER COLUMN MONITORING

In summer 2008, water quality parameters at the offshore stations were relatively consistent among stations and between tides. Water column temperature did not appear to be influenced by the thermal discharge during flood tide, though slightly less saline near-surface water found at the two upcoast stations on the 20-ft isobath and at the shoreline stations on flood tide suggested some local freshwater influence from the discharge plume. Shoreline temperatures on flood tide also indicated the presence of a thermal plume at, and upcoast, of the discharge channel. Warmer near-surface water temperatures found at surf zone and offshore stations on the 20-ft isobath upcoast of the discharge also suggested the presence of a warm water surface lens at these stations during ebb tide. Still, water temperatures and salinity were typical of the area and within the range of natural variability observed during previous surveys. Dissolved oxygen (DO) concentrations were consistent during both tides, with values similar to those found commonly in previous studies and well above the level of biological concern. Higher DO concentrations in the study area later in the day were noted, a likely result of increased photosynthetic activity. Similarly, pH was very consistent during the survey and comparable to results observed previously and natural conditions found commonly throughout the study area.

Warmer and slightly less salty surface water was observed near the discharge and among some nearby stations, attributable to tidal influences on the thermal discharge from the generating station. These patterns have been observed in the area in previous surveys and the resulting parameters were similar to natural conditions found commonly throughout the study area. While water quality measurements indicated the presence of a cooling water discharge from the Mandalay Generating Station in 2008, the influence was localized did not appear to have an adverse effect on receiving waters in the study area.

SEDIMENT CHARACTERISTICS

Sediment Grain Size

In 2008, sediments were analyzed from four stations offshore the Mandalay Generating Station. Sediment distribution characteristics were similar among all stations, though the two upcoast stations and the two downcoast stations were most similar to each other. Sediments were generally composed of about 96% sand with lesser amounts of fine material (silt and clay) and mean grain sizes in the fine sand category. Sediments upcoast of the discharge (Station B3) were coarsest, comprised of almost 97% sand while finest sediment sediments occurred at the station farthest downcoast of the discharge (Station B4). The degree of influence of the discharge on local sediments varies from year to year, and the localized and transitory influence near the discharge noted in some previous surveys was not observed in 2008. The similarity of grain size characteristics at the two downcoast stations and at the discharge and intermediate upcoast station suggest that sediment distribution was primarily influenced by normal nearshore processes which influence grain size such as currents, waves and sand movement. Sediment characteristics offshore of the Mandalay Generating Station discharge in

2008 were similar to those found previously in the area and appear to be affected primarily by natural causes.

Sediment Chemistry

In 2008 metal concentrations were lowest overall at Station B1, though levels, particularly for copper and zinc, were similar among all stations Although higher than levels found in 2006, which were among the lowest reported in the area, metal concentrations in 2008 were similar to results found commonly in previous surveys. Sediment metal concentrations have remained relatively consistent in the area since 1990 and have been consistently lower than mean metal concentrations found in sediments at shallow (5-30 m) coastal stations throughout southern California. While metal levels typically vary slightly from year to year, no long-term patterns of metal concentrations relative to the discharge were apparent. As in previous surveys, sediment metal levels were well below concentrations determined to be potentially toxic to marine organisms. Concentrations of sediment metals in 2008 did not appear to be influenced by the operation of the Mandalay Generating Station.

MUSSEL BIOACCUMULATION

As part of the resource exchange for participation in the Bight '08 Regional Monitoring Program, mussel bioaccumulation analysis was required only if resident mussels were located in the discharge area. No mussels were located in the study area in 2008. Mussel tissue bioaccumulation studies, including transplantation of mussels into the area, if necessary, will continue in 2009.

BENTHIC INFAUNA

The infaunal community in 2008 was comprised primarily of small annelid worms, arthropods, and mollusks. As part of the resource exchange for participation in the Bight '08 Regional Monitoring Program, the number of stations sampled was reduced from five to four, and the number of replicated collected at each station was reduced from four to two. Abundance averaged 57 individuals per station (2,850 individuals/m^2), which, based on density of organisms, was about one-third that in 2007 and about one-half the long-term mean for the four stations for summer surveys conducted in the study area since 1978. A total of 34 species was taken, with a mean of 15 species per station (11 species per replicate), and a mean species diversity (H') of 2.26. Mean species richness was below that in 2007 and was also slightly below the long-term mean, while mean species diversity was greater than in 2007 and was very near the long-term mean. The Southern California Benthic Response Index (BRI), an abundance-weighted average pollution tolerance of species occurring in a sample, indicated that the communities at all of the stations were healthy. BRI values for 2008 were slightly below both those in 2007 and the mean of values since 2006, the first year that the index was used. Infaunal parameters such as abundance and species richness showed some relationship to sediment characteristics, as values were generally lower where sediments were coarser, upcoast of the generating station, and abundance was highest farthest downcoast, where sediments were finest. However, species richness and diversity were highest near the generating station discharge, where sediments were about average for the study area.

Infaunal community composition was rather uniform throughout the study area. The communities immediately downcoast of the generating station and farthest downcoast were most similar to each other, while those at and upcoast of the generating station were somewhat alike. The polychaete annelid *Apoprionospio pygmaea*, the ostracod *Euphilomedes longiseta*, and the amphipod *Rhepoxynius menziesi* were the most abundant species overall, together comprising over one-half of all the individuals in the collection. *Apoprionospio pygmaea* has usually been the most abundant species in the area. Other moderately abundant species in 2008 included the polychaetes *Mediomastus acutus* and *Onuphis* sp A, the clams *Tellina modesta* and *Donax gouldii*, and the amphipod *Mandibulophoxus gilesi*. Many of these constituents of the community are efficient burrowers, well adapted to the sandy, nearshore environment found offshore of the generating station.

Overall, the communities found in 2008 were similar to those encountered previously in the study area and are typical of the shallow subtidal habitat in the Southern California Bight. Infaunal community parameters and composition appeared to be somewhat related to sediment characteristics, and no adverse effects from the generating station discharge were found.

DEMERSAL FISH AND MACROINVERTEBRATES

In 2008, 1,010 fish weighing 21.40 kg representing 17 species were taken during the 2008 summer trawl sampling. Queenfish (*Seriphus politus*) was the most abundant species, followed by shiner perch (*Cymatogaster aggregata*) and speckled sanddab (*Citharichthys stigmaeus*). Cumulatively, these three species accounted for 86% of the total abundance. Spatially, the fewest fish were taken at Station T4 where bottom water temperature was the lowest, with the highest abundance recorded at Station T1. All but seven queenfish were taken at Station T1.

A total of 799 individuals of nine macroinvertebrate species weighing 2.66 kg were collected during the 2008 monitoring year. Blackspotted bay shrimp (*Crangon nigromaculata*) overwhelmingly dominated the annual abundance in 2008, accounting for 97% of the total abundance. There was no distinct spatial distribution in the macroinvertebrate catch with similar abundances and dominance by blackspotted bay shrimp found at each station.

Fish and macroinvertebrate species composition were similar to those in past surveys in the study area. This similarity of species composed primarily of frequently occurring and long-term dominant species indicates a relatively stable assemblage typical of the nearshore, soft-bottom community remains in the area. While spatial differences were apparent, variability in fish and macroinvertebrate communities in the area appeared to be related to natural differences in local fish and macroinvertebrates populations and their response to water temperature, among other things. There is no indication that plant operations have adversely affected the fish or macroinvertebrate populations offshore of the Mandalay Generating Station.

IMPINGEMENT

To evaluate fish loss at the Mandalay Generating Station, fish impingement was monitored during one heat treatment and six normal operation surveys during the 2008 monitoring year. Based on these surveys, an estimated total fish abundance of 10,754 individuals representing 19 species and weighing more than 203 kg were impinged at the generating station. Overall, fish abundance impinged in 2008 was greater than that in 2007, but less than recorded in the 2005 and 2006. In addition, an estimated 309 individuals representing seven macroinvertebrate species and weighing more than 14 kg were impinged during the study year, the third highest total since data was reported in 2001.

Species reported in 2008 were similar to those collected in previous surveys, suggesting that a core group of species remains in the area despite differences in abundance from year to year. Over time, abundances have fluctuated independently of the cooling water flow volumes which suggests that natural variability in the local populations was the most important factor influencing the observed interannual variability. There is no indication that plant operations have adversely affected the fish or macroinvertebrate populations in the vicinity of the Mandalay Generating Station intake canal.

CONCLUSIONS

The overall results of the 2008 NPDES monitoring program indicated that operation of the Mandalay Generating Station had no detectable adverse effects on the beneficial uses of the receiving waters.

CHAPTER 1 — INTRODUCTION

This report presents and discusses the results of the 2008 receiving water monitoring studies conducted for the Mandalay Generating Station which is owned and operated by Reliant Energy. The 2008 monitoring program was conducted in accordance with specifications set forth in National Pollutant Discharge Elimination System (NPDES) Monitoring and Reporting Program No. 2093 (Permit No. CA0001180) issued by the California Regional Water Quality Control Board, Los Angeles Region (LARWQCB) on 26 April 2001 (Appendix A). The 2008 NPDES program was modified to facilitate the generating station's participation in the fourth comprehensive regional survey of coastal ocean waters in the Southern California Bight (Bight '08) (Appendix A). Results of the 2008 surveys were compared among stations and with past physical and biological studies to determine if the generating station discharge is having an adverse effect on the marine environment, and if the beneficial uses of the receiving waters are being protected. Sampling included physical and chemical monitoring of receiving waters and sediments, and biological monitoring of infaunal, fish, and macroinvertebrate assemblages. Resident mussels for tissue analysis were not found in the survey area in 2008.

DESCRIPTION OF THE GENERATING STATION

The Mandalay Generating Station is located on the California coast, approximately 4.8 kilometers (km) west of the City of Oxnard in Ventura County. The generating station consists of two steam-electric generating units, each rated at 215 megawatts (Mw), and one gas turbine unit rated at 147 Mw. Steam is supplied to the steam-electric units by two gas-fired boilers, each rated at 707,600 kilograms (kg) of steam per hour.

Cooling water is supplied to the station from the ocean via the Edison Canal from Channel Islands Harbor, 4.8 km downcoast, at a rate of approximately 176,000 gallons per minute (gpm). Water enters the station through a screening facility which removes large marine organisms, trash, and other debris. Cooling water is pumped to the two steam condensers where its temperature is elevated approximately 12.2°C when the units are operating at full capacity. The warmed effluent is returned to the ocean across the beach via a rock-lined canal (Figure 1-1).

Approximately 9,800 gpm (6%) of the main cooling water is diverted before it reaches the steam condensers and is directed to an auxiliary heat exchanger which is used to cool distilled water used in auxiliary station equipment. The temperature of this seawater is elevated approximately 5°C before it joins the main cooling-water flow in the discharge conduit. An additional 3,200 gpm (2%) is diverted to an auxiliary cooling-water heat exchanger for the gas turbine unit where its temperature is raised a maximum of 9°C. The turbine unit is operated only when needed and does not use cooling water.

Two of four circulator pumps were operating during the survey on 17 September 2008, discharging 126.1 mgd. The intake temperature was 21.1°C and the discharge temperature was 25.0°C, a difference of 3.9°C. During 2008, the Mandalay Generating Station steam plants operated at 12.64% of their total operating capacity (Siekiel-Zdzienicki 2008, pers. comm.).

DESCRIPTION OF THE STUDY AREA

The physiography, climate, and hydrography of the southern California coastal region contribute to the character of the study area and, therefore, affect the influence of thermal discharges in coastal waters. Oceanographic, biological, and meteorological elements are all characterized by short- and long-period cyclical variations as well as non-periodic trends. Winds, tides, and currents are particularly important since they have the greatest impact on the fate of the thermal plume itself.

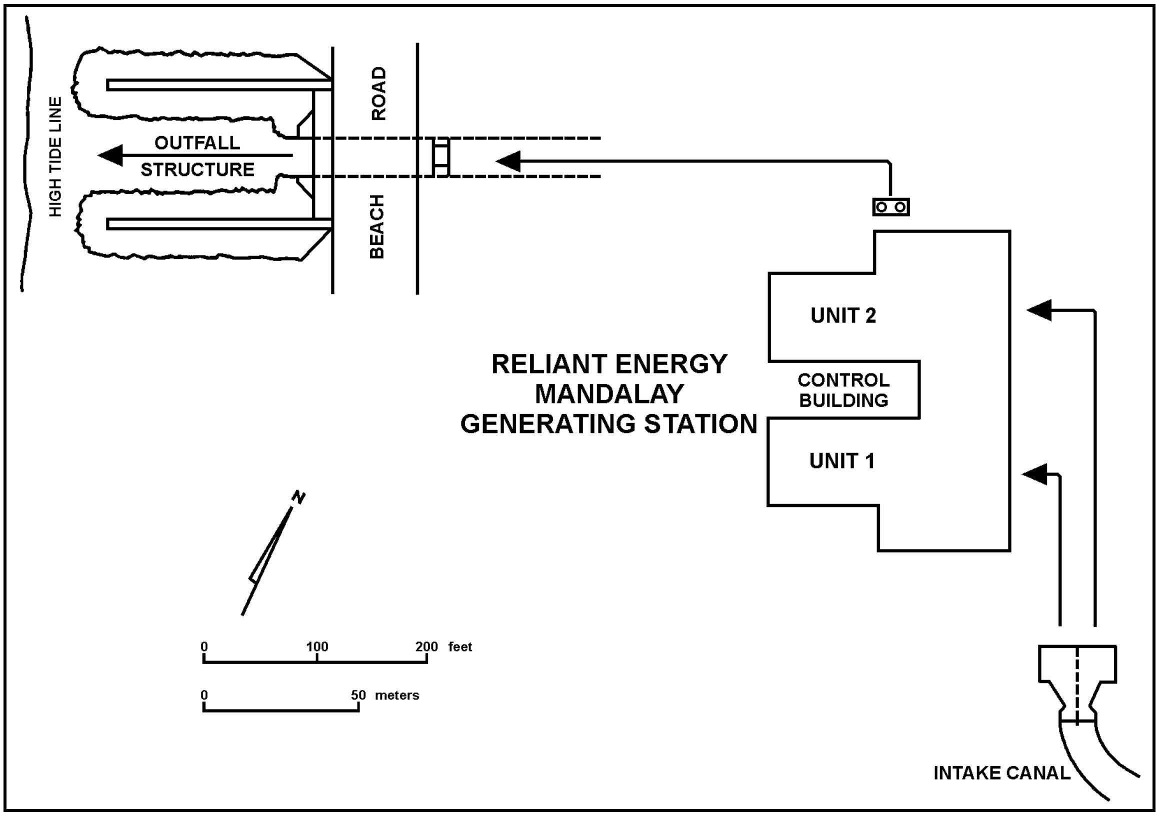


Figure 1-1. Diagram of the Mandalay Generating Station cooling water system. Mandalay Generating Station NPDES, 2007.

Physiography

The general orientation of the coastline between Point Conception and the Mexican border is from northwest to southeast. The continental margin has been slowly emerging over time, resulting in a predominantly cliffed coastline, broken by coastal plains in the Oxnard-Ventura, Los Angeles, and San Diego areas. Drainage of the coastal region is by many relatively short streams which normally flow only during rain storms. Only a small part of the storm drainage actually reaches the ocean because most is impounded by dams and diverted for other uses.

The Mandalay Generating Station is situated on the coastal plain of the Ventura Basin, approximately 30 km northwest of Point Mugu and 3 km south of the mouth of the Santa Clara River (Figure 1-2). The Ventura Basin is defined by the Ventura River delta to the north and the barrier beaches at Point Mugu to the south. Prominent natural features of this stretch of coast include straight sandy beaches, the dunes along Mandalay Beach, and the marshes and lagoon in the naval reservation near Point Mugu.

The eight islands offshore southern California strongly influence water circulation and general oceanographic characteristics of the entire Southern California Bight. The mainland shelf is narrow along the coast, ranging in width from less than 1.6 to more than 19 km, averaging approximately 7 km. Seaward of the shelf is an irregular and geologically complex region known as the continental borderland, which consists of numerous ridges and basins extending from near the surface to depths in excess of 2,400 meters (m).

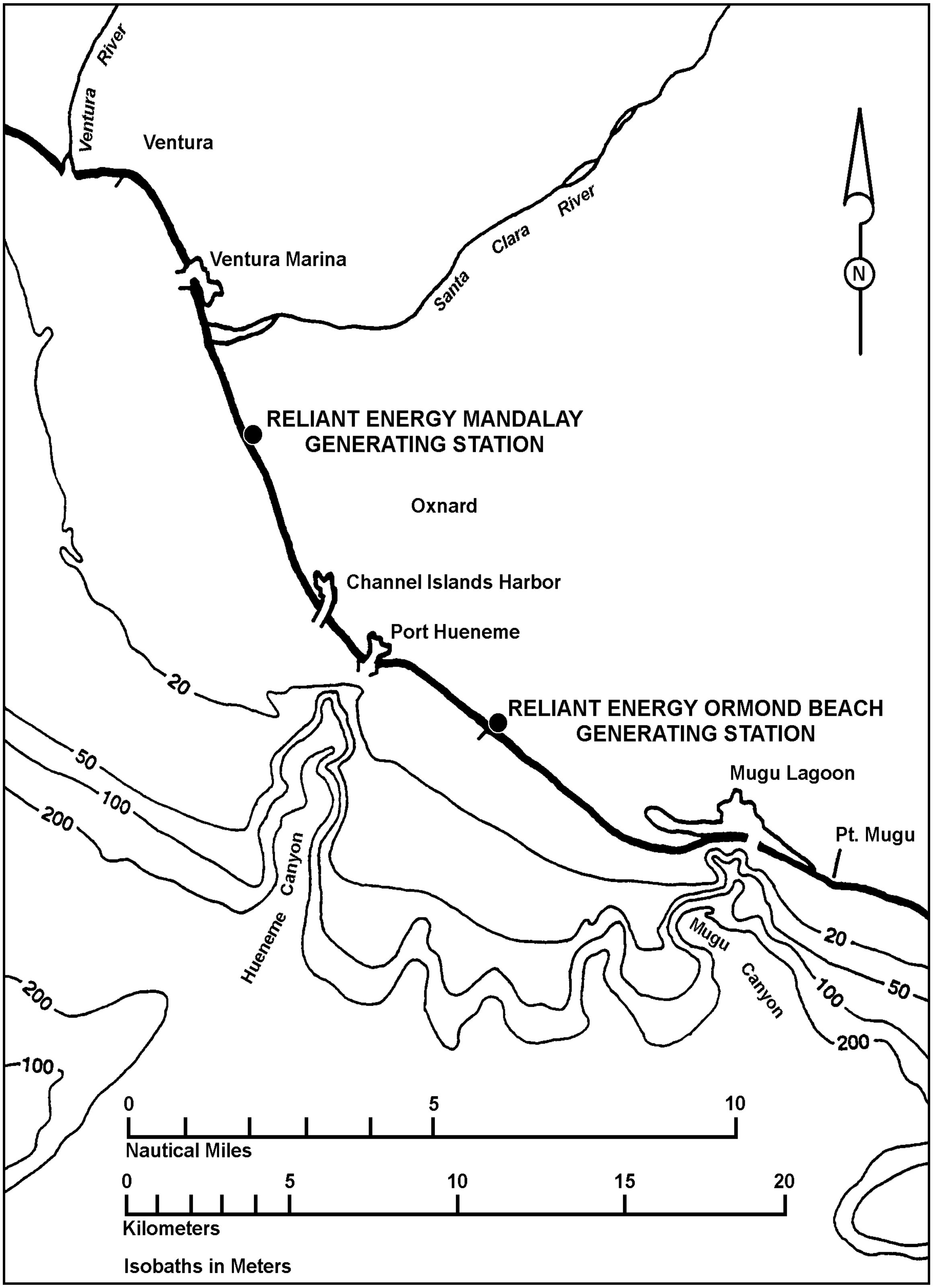


Figure 1-2. Location of the study area. Mandalay Generating Station NPDES, 2008.

Submarine Physiography

The submarine physiography of the Ventura Basin is characterized by two distinct areas divided by the Hueneme Canyon (IRC 1973). To the northwest of the Hueneme Canyon is a broad gently sloping sea floor and to the southeast a narrower, steeper slope (Figure 1-2). Mugu Canyon cuts into the slope near the southeastern boundary of the basin.

Offshore at Mandalay Beach, the 20 fathom (fm) (36 m) contour is 12.8 to 16.0 km from shore while further south in the basin, it is closer (3.2 to 6.4 km) to shore. The head of Hueneme Submarine Canyon approaches the shoreline so closely that the 20 fm isobath is within 100 m of the jetties at Port Hueneme. There are no major irregularities in bathymetry between Hueneme Canyon and the mouth of the Ventura River.

Marked changes in bottom topography close to shore can result in irregular current patterns and variable current velocities. Nearshore circulation in the study area is affected by Hueneme and Mugu Canyons, Port Hueneme, Channel Islands Harbor, the Ventura Marina, and the mouth of the Santa Clara River. None of the studies conducted at the Mandalay Generating Station indicated that the tidal prism from the harbors and marinas in the area significantly influence current speed and direction near the generating station (IRC 1973).

Climate

Southern California is in a climatic regime broadly defined as Mediterranean, which is characterized by short, mild winters and warm, dry summers. Long-term annual precipitation near the coast averages about 46 centimeters (cm), of which 90% occurs between November and April. Monthly mean air temperatures along the coast range from 8.3°C in winter to 20.6°C in summer, with daily minima dropping slightly below freezing and maxima reaching above 37°C.

Sea breezes, which develop from differential heating between land and sea masses, combine with the prevailing winds from the northwest during summer months to produce strong onshore winds. Summer sea breezes typically start at about noon and may continue through late afternoon, with speeds reaching 37 km/hour (hr). In late fall and winter, reverse pressure systems frequently develop; coastal winds tend to be from the southeast and the sea breezes typically blow from 1300 hr to as late as 2000 hr.

Ocean Currents

Water in the northern Pacific Ocean is driven eastward by prevailing winds until it impinges on the western coast of North America where it divides and flows both north and south. The southern component comprises the California Current, a diffuse and meandering water mass which generally flows to the southeast, following the coast. There is no fixed western boundary to this current, but more than 90% of its transport is within 725 km of the California coast. South of Point Conception, the California Current generally flows along the Patton Escarpment (160 km offshore) and approaches the coast again near Cape Colnett, Baja California (Figure 1-3). Off Baja California part of the California Current turns north forming a counter-current in the Southern California Bight known as the Southern California Countercurrent. Part of this countercurrent flows through the Santa Barbara Channel and then rejoins the California Current while the rest turns and flows south nearshore. Nearshore, coastal currents are strongly influenced by a combination of wind, tides, and local physiography. Therefore, short-term observations of currents near the coast often vary in both direction and speed.

Surface speed in the countercurrent ranges between 5.5 and 11 centimeters per second (cm/s). The general flow pattern is complicated by eddies in the Channel Islands region and fluctuates

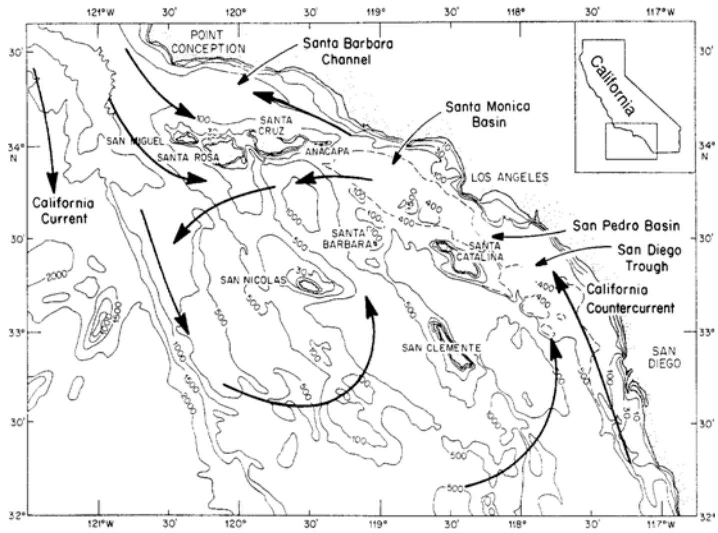


Figure 1-3. Surface circulation in the Southern California Bight (from Hickey 1992). Mandalay Generating Station NPDES, 2008.

seasonally, being more strongly developed in summer and autumn, and weak or occasionally absent in winter and spring.

Longshore Drift

Longshore currents typically move sand parallel to shore and thus toward the heads of submarine canyons either upcoast or downcoast. In the Hueneme area southeast of Mandalay, the net littoral sediment transport, or longshore drift, is downcoast at the rate of 600,000 to 900,000 m^3 per year. When the entrance to Port Hueneme was constructed, the upcoast jetty effectively trapped or diverted the natural sand supply that was formerly available to beaches in the Ormond Beach area. That portion of sediment not trapped by the jetty was lost into deep water at the head of the Hueneme Canyon. Approximately 900,000 m^3 per year are eroded downcoast of the jetties. Slightly more than 1,500,000 m^3 of sediment are dredged and bypassed biannually around the trap. Erosion southeast of the harbor continues, however, at a rate of approximately 1,500,000 m^3 per year.

Channel Islands Harbor was designed to prevent sediment loss into Hueneme Canyon. The detached breakwater at the harbor entrance provides a shadow zone which traps sediment upcoast of the northwest jetty. In 1960-61, dredging of the sand trap, the entrance channel, and the first phase of development at Channel Islands Harbor provided about 4,120,000 m^3 of sand which were used for beach nourishment (IRC 1973). To the northwest of the Mandalay Generating Station the normal southeasterly movement of sediment from the Ventura River area is interrupted by the trap effect of Ventura Marina breakwater and jetties.

Tides

Tides along the California coast are mixed, semidiurnal, with two unequal highs and two unequal lows during each 25 hr period. The tide is a long-period wave that is a combination of semidiurnal components (each having nearly 12 hr periods) and diurnal components with nearly 25 hr periods. In the eastern North Pacific Ocean, the tide wave rotates in a counterclockwise direction so that tidal extremes occur progressively later in the day northwards along the coast. As a result, flood tide currents flow upcoast and ebb tide currents flow downcoast.

Upwelling

The predominant northwesterly winds are responsible for large scale upwelling along the California coast. From about February to October, these winds induce offshore movement of surface water which is replaced by the upwelling of deeper ocean waters. The upwelled water is colder, more saline, lower in oxygen, and higher in nutrient concentrations than surface waters. Thus, upwelling not only alters the physical properties of the surface waters but also enhances biological productivity.

RECEIVING WATER CHARACTERISTICS

The capacity of the marine environment to assimilate heated cooling water depends on its ability to dilute and disperse the thermal discharge. The extent to which these functions are accomplished depends on the quantity and temperature of the thermal effluent relative to normal ocean temperatures and ocean current patterns as well as other characteristics of the receiving waters. These factors are the primary determinants of the fate and effect of thermal effluent discharge. The following discussion focuses on natural physical and chemical oceanographic characteristics that influence the local marine biota.

Temperature

Natural water temperatures fluctuate throughout the year in response to seasonal and diurnal variations in currents; meteorological conditions such as wind, air temperature, relative humidity, and cloud cover; and parameters such as ocean waves and turbulence. Natural temperature is defined by the California State Water Resources Control Board (SWRCB 1972) as "the temperature of the receiving water at locations, depths, and times which represent conditions unaffected by any elevated temperature waste discharge or irrigation return waters."

Daily surface water temperatures may be expected to vary 1°C to 2°C in summer and 0.3°C to 1°C in winter on the average. Factors contributing to rapid daytime warming of the sea surface are weak winds, clear skies, and warm air temperatures; factors that limit diurnal temperature ranges are overcast skies, moderate air temperatures, and mixing of the surface waters by winds and waves.

Between July 1970 and January 1973 natural surface water temperatures at nearby Ormond Beach ranged from 11.4°C in December 1971 to 22.0°C in August of the same year. During 1971-1972 minimum and maximum surface water temperatures at a control station offshore from the Mandalay Generating Station were 11.6°C and 22.7°C, respectively (IRC 1973).

When there is a large difference between surface and bottom water temperatures, a steep temperature gradient between adjacent water layers of different temperatures (i.e., a thermocline) may develop. Natural thermoclines are formed when absorption of solar radiation at the sea surface develops a stable stratification, separating surface from subsurface layers. Off southern California, a reasonably sharp thermocline is normally found in summer in the upper 30 m of the water column; in winter thermoclines are weakly defined. Artificial thermoclines may result when warm water from a thermal discharge overlies cooler receiving waters.

Salinity

Salinity is a measure of the concentration of salts in water which can be expressed as a weight of salts dissolved in a volume of water. Typically, the concentration of salts in the ocean is roughly 35 grams per kilogram of water and can be expressed as 35 parts per thousand (ppt). Although relatively constant in the open ocean, salinity fluctuates in coastal environments as a result of the introduction of freshwater runoff and direct rainfall, and through the evaporation of freshwater. Between 1965 and 1971 surface salinity at the Ventura Marina ranged from a minimum of 24.1 ppt, which was associated with rainfall runoff, to a maximum of approximately 33.9 ppt (IRC 1973).

Dissolved Oxygen

Dissolved oxygen (DO) is utilized by aquatic plants and animals in their metabolic processes; it is replenished by gaseous exchange with the atmosphere and as a byproduct of photosynthesis. High values generally result from photosynthetic activity and low values from mixing of surface waters with oxygen-depleted subsurface waters. Between July 1970 and January 1973, concentrations in surface waters offshore Ormond Beach ranged from 7.3 milligrams per liter (mg/l) to 11.0 mg/l (IRC 1973).

Hydrogen Ion Concentration

The hydrogen ion concentration (pH) in southern California surface waters varies narrowly around a mean of approximately 8.1 and decreases slightly with depth. However, values will naturally approach 8.6 during phytoplankton blooms, which rapidly metabolize carbonates in the surface waters. Values can also drop below 7.9, although this generally occurs in waters below 100 meters, or in confined water ways such as harbors, where organic decomposition and reduced circulation will lead to an accumulation of acidic byproducts. In annual and semiannual monitoring conducted offshore of the Mandalay Generating Station between 1986 and 2006, pH was found to range from 7.32 to 8.56 (MBC 1986, 1988, 1990, 1994-2001a, 2002-2006a, 2007a; Ogden 1991-1993).

BENEFICIAL USES OF RECEIVING WATERS

The Water Quality Control Plan for the Santa Clara River Basin (California Regional Water Quality Control Board 1994) lists beneficial uses of waters in the nearshore and offshore zones of the Santa Clara-Calleguas Hydrographic Unit, which includes Mandalay and the study area. These uses are:

Industrial Service Supply (IND) - Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well re-pressurization.

Navigation (NAV) - Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

Water Contact Recreation (REC-1) - Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.

Non-contact Water Recreation (REC-2) - Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Commercial and Sport Fishing (COMM) - Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.

Marine Habitat (MAR) - Uses of water that support marine ecosystems including, but not limited to, preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).

Wildlife Habitat (WILD) - Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

Preservation of Biological Habitats (BIOL) - Uses of water that support designated areas or habitats, such as Areas of Special Biological Significance (ASBS), established refuges, parks, sanctuaries, ecological reserves, or other areas where the preservation or enhancement of natural resources requires special protection.

Rare, Threatened, or Endangered Species (RARE) - Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened, or endangered.

Migration of Aquatic Organisms (MIGR) - Uses of water that support habitats necessary for migration, acclimatization between fresh and salt water, or other temporary activities by aquatic organisms.

Spawning, Reproduction, and/or Early Development (SPWN) - Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

Shellfish Harvesting (SHELL) - Uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sports purposes.

Although all of the above uses may not directly apply to the generating station's receiving waters at all times, they may be reasonably assumed to constitute occasional beneficial uses of nearshore waters in the study area.

SCOPE OF THE MONITORING PROGRAM

The 2008 monitoring program for the Mandalay Generating Station was conducted by MBC Applied Environmental Sciences (MBC) in accordance with specifications set forth in the NPDES Monitoring and Reporting Program (Appendix A). The monitoring program included winter and summer water column profiling, summer sediment sampling for grain size and chemistry, mussel sampling for bioaccumulation, summer biological sampling for benthic infauna, and winter and summer trawling for fish and macroinvertebrates. In addition, the impingement of fish and invertebrate species on the intake screens were monitored periodically and total yearly impingement estimated from monitoring results and plant operations.

STATION LOCATIONS

The locations of the monitoring stations are described in Appendix A and shown on Figure 1-4. The 2008 monitoring program included 17 water quality (RW) stations, four trawl (T) stations, and five sediment and benthic infauna (B) stations.

FIELD OBSERVATIONS

As part of the resource exchange for participation in the Bight '08 Regional Monitoring Program, winter receiving water surveys were eliminated from 2008 monitoring program requirements (Appendix A). The NPDES water quality monitoring summer survey was conducted on 17 September, benthic sampling was conducted on 18 September, and a demersal fish and invertebrate trawl survey was conducted on 19 September 2008. Latitude and longitude coordinates for all receiving water (RW), benthic (B), and trawl (T) stations are listed in Table 1-1.

During the summer surveys, no oil sheens, grease or red tide (plankton bloom) were observed at any of the stations. During the water quality survey, slightly to moderately turbid water was noted at all offshore stations during the flood tide and at Stations RW11, RW13, RW14, and RW16 during the ebb tide. A strong sewage odor was noted at receiving water Stations RW6, RW13, and RW15 during the flood tide monitoring and drift kelp (*Macrocystis pyrifera*) was noted during ebb tide at Stations RW11, RW14, and RW16. Slight turbidity was also noted at all surf-zone water quality

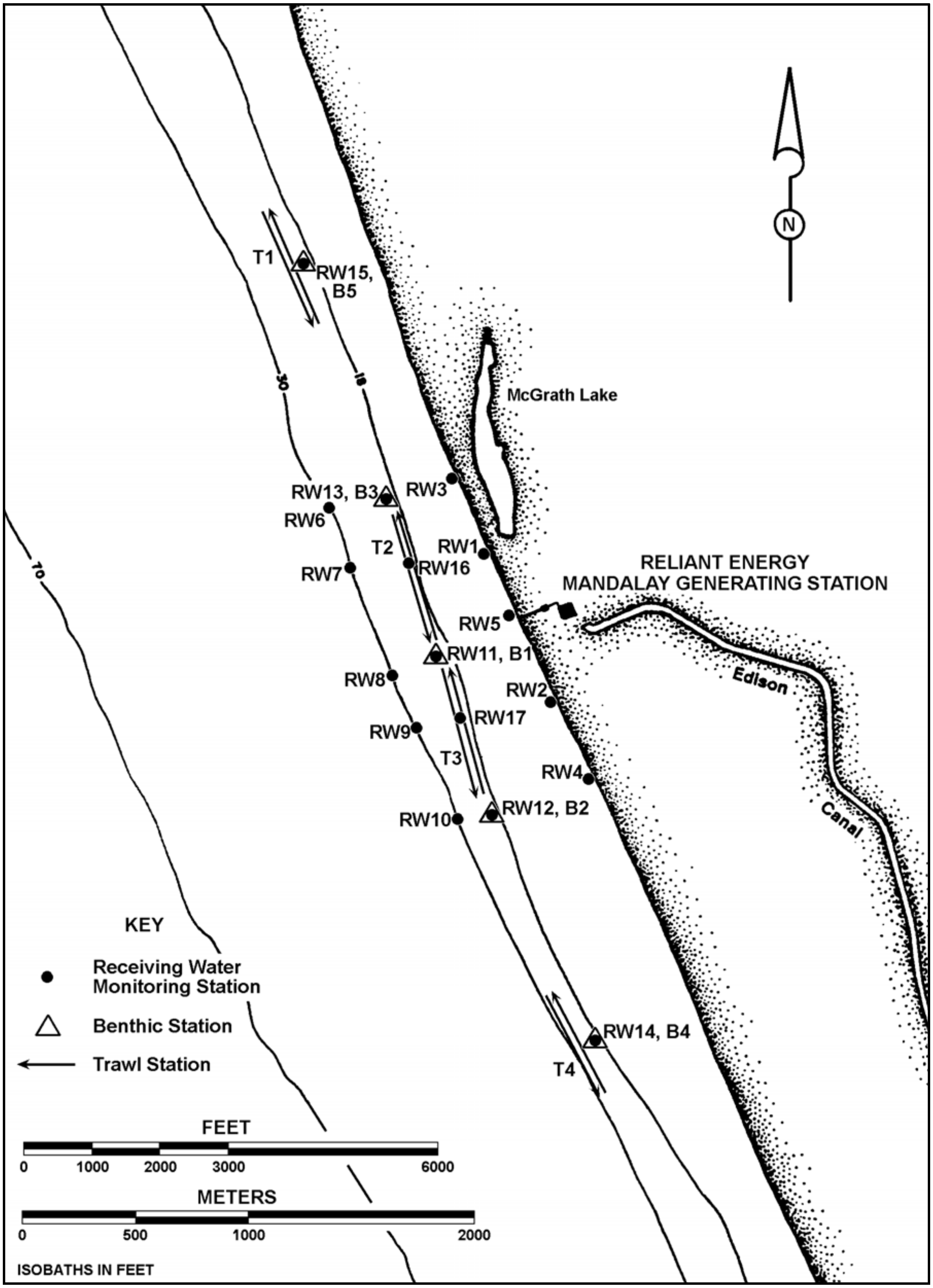


Figure 1-4. Location of the monitoring stations. Mandalay Generating Station NPDES, 2008.

stations during both tidal surveys. Slightly turbid water was again noted at all stations during benthic sampling and demersal fish trawls.

Western gulls (*Larus occidentalis*) and Heermann's gulls (*Larus heermanni*) were seen at most stations during all three survey days. Cormorants (*Phalacrocorax* spp) and terns (Laridae) were observed at most of the offshore water quality stations, at surf-zone Station RW5, benthic Stations B3 and B4, and throughout the trawl survey area. Sanderlings (*Calidris alba*) and marbled godwits (*Limosa fedoa*) were observed at all surf-zone water quality stations during both tidal surveys. One shearwater (*Puffinus* sp) was seen at offshore Station RW7 during the ebb tide water quality monitoring. California sea lions (*Zalophus californianus*) were observed at trawl Stations T2 and T3. California brown pelicans (*Pelecanus occidentalis californicus*) were seen at water quality Stations RW3, RW6, RW10, RW12 through RW14, and RW16 during flood tide monitoring and at Stations RW2, RW3, RW5, RW6, RW13, and RW15 on ebb tide monitoring. California brown pelicans were also noted at benthic Station B3 and throughout the trawl survey area. No California least terns (*Sternula antillarum browni*) were observed during any of the survey days.

Table 1-1. Latitude/longitude coordinates of sampling stations. Mandalay Generating Station NPDES, 2008.

Stations			
Water Quality	Benthic	Latitude	Longitude
RW1		34°12.54'	119°15.29'
RW2		34°12.19'	119°15.10'
RW3		34°12.69'	119°15.36'
RW4		34°12.01'	119°14.99'
RW5		34°12.36'	119°15.19'
RW6		34°12.58'	119°15.81'
RW7		34°12.40'	119°15.73'
RW8		34°12.22'	119°15.59'
RW9		34°12.06'	119°15.50'
RW10		34°11.88'	119°15.35'
RW11	B1	34°12.30'	119°15.40'
RW12	B2	34°11.94'	119°15.20'
RW13	B3	34°12.65'	119°15.58'
RW14	B4	34°11.40'	119°14.92'
RW15		34°13.17'	119°15.93'
RW16		34°12.47'	119°15.51'
RW17		34°12.11'	119°15.31'
Trawl Stations	Heading	Latitude	Longitude
T1	130°	34°13.37'	119°15.98'
T2	138°	34°12.62'	119°15.61'
T3	130°	34°12.12'	119°15.33'
T4	150°	34°11.52'	119°15.05'

STATISTICAL ANALYSES

Summary statistics developed from the biological data include the number of individuals, which for trawls is expressed as both number per trawl and per standard sample area, and for infauna, number per grab and density per m^2; number of species; and Shannon-Wiener (Shannon and Weaver 1962) species diversity (H') index. The diversity equation is as follows:

Shannon-Wiener

$$H' = -\sum_{j=1}^{s} \frac{n_j}{N} \ln \frac{n_j}{N}$$

where: H' = species diversity
n_j = number of individuals in the j^{th} species
S = total number of species
N = number of individuals

The Southern California Benthic Response Index (BRI) is an abundance-weighted average pollution tolerance of species occurring in a sample, and is a measure of the condition of marine and estuarine benthic communities (Smith et al. 2003). It classifies benthic communities as “reference” (i.e., undisturbed) or one of four levels of response to increased disturbance. The index formula is:

Benthic Response

$$BRI_s = \frac{\sum_{i=1}^{n} \sqrt[3]{a_{si} \; p_i}}{\sum_{i=1}^{n} \sqrt[3]{a_{si}}}$$

where: BRI_s = BRI value for sampling unit s_i
n = number of species with pollution tolerance scores in s_i
p_i = pollution tolerance of species *I*
a_{si} = abundance of species *I* in *s*

Species pollution tolerances p_i were determined during BRI development as the position of the abundance distribution of species *I* on a gradient between the most and least disturbed sites. Species without pollution tolerance values are not included in the calculation. Pollution tolerance values were not assigned to species if the data were insufficient to assign a value. The index was developed for benthic samples that were sieved through a 1-mm mesh screen. Pollution tolerance scores were derived for coastal shelf samples for shallow (10-30 m deep), mid-depth (>30-120 m deep), and deep (>120-324 m deep) habitats, and for bay and harbor habitat samples, northern (Point Conception to Newport Bay) and southern (Dana Point to the U.S.-Mexico border). The species names for which scores are available are based on Edition 5 of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) list of invertebrate species (SCAMIT 2008).

Evenness (J') is a measure of the degree to which a sampled community is dominated by one or a few species. Values of evenness range from 1.0 (all species with identical abundances) to 0 (Pielou 1977). The evenness equation is as follows:

$$J' = \frac{H'}{\ln S}$$

where: J' = Evenness
H' = Shannon-Wiener Index
S = number of species within the community

Biological data were subjected to log transformations (when necessary) and classified (clustered) using NCSS 2000 Hierarchial Clustering (Hintze 1998). Cluster analysis provides a graphic representation of the relationship between species, their individual abundance, and spatial occurrence among the stations sampled. In theory, if physical conditions were identical at all stations, the biological community would be expected to be identical as well. In practice this is never the case, but it is expected that the characteristics of adjacent stations would be more similar than those distant from one another. The dendrogram shows graphically the degree of similarity (and dissimilarity) between observed characteristics and the expected average. The two-way analysis utilized in this study illustrates groupings of species and stations, as well as their relative abundance, expressed as a percent of the overall mean. Two classification analyses are performed on each set; in one (normal analysis) the sites are grouped on the basis of the species which occurred in each, and in the other (inverse analysis) the species are grouped according to their distribution among the sites. Each analysis involves three steps. The first is the calculation of an inter-entity distance (dissimilarity) matrix using Euclidean distance (Clifford and Stephenson 1975) as the measure of dissimilarity.

Euclidean distance

$$D = \left[\sum_{1}^{n} \left(x_1 - x_2 \right) \right]^{1/2}$$

where: D = Euclidean distance between two entities
x_1 = score for one entity
x_2 = score for other entity
n = number of attributes

The second procedure, referred to as sorting, clusters the entities into a dendrogram based on their dissimilarity. The group average sorting strategy is used in construction of the dendrogram (Boesch 1977). In step three, the dendrograms from both the site and species classifications are combined into a two-way coincidence table. The relative abundance values of each species are replaced by symbols (Smith 1976) and entered into the table. In the event of extreme high abundance of a single species, abundance data are transformed using a natural log transformation [ln(x)].

Community importance for benthic infaunal species and trawled fish and macroinvertebrates was tested using the Index of Relative Importance (IRI): IRI = Rank(Rank of abundance + Rank of Frequency of Occurrence) (Stephens and Zerba 1981). Spearman's rank correlation was used to test for similarities in the distribution of IRI ranks between the annual surveys.

Estimates of historic community importance were calculated for the ten most abundant fish species and the five most abundant macroinvertebrate species. The annual Index of Community Importance (ICI) was calculated as described by Allen et al. (2002): ICI = (% Number + % Biomass) X % Frequency of Occurrence. Annual rank order of ICI was determined. Spearman's rank correlation was used to determine potential similarities between the years based on the rank of ICI by species.

DETECTION / REPORTING LIMITS

Detection/reporting limits used in reporting chemistry results are interpreted as the smallest amount of a given analyte that can be measured above the random noise inherent in any analytical tool. Thus, any value below the detection/reporting limits cannot be considered a reliable estimate of analyte concentration. Therefore, where a test for a given analyte results in a level below the detection/reporting limit, a "none detected" (ND) value has been assigned. The complication of what numerical value to substitute for ND in statistical calculations is addressed by the Environmental Protection Agency (EPA 1989, Section 5.3.3). When values for a given analyte are ND for all stations, then means and standard deviations will also be considered ND. However, when an analyte is detected at some stations and not at others, statistical calculations can be made by substituting ND values with either (a) zero, (b) one-half the average detection limit, or (c) the average detection limit (EPA 1989). Determining which substitution to use is based on whether or not substantial information exists to support the historical presence or absence of a given analyte at the station location. Since chemistry analyses have repeatedly resulted in ND values at the same stations through past surveys, ND values have been replaced with zeros in performing statistical calculations. As the ability to detect chemicals in increasingly smaller concentrations has improved greatly with time, detection/reporting limits differ in virtually all past surveys; this would confound any yearly comparison if options (b) or (c) from above were used. Historical raw data are presented in the appendices for possible supplementary study.

CHAPTER 2 — WATER COLUMN MONITORING

Water column measurements of physical and chemical characteristics such as water temperature, dissolved oxygen concentration, hydrogen ion concentration, and salinity are important components of a discharge monitoring program. Because biological communities exist in equilibrium within the marine environment, changes in the properties of these characteristics can result in potentially adverse impacts to these communities. As the properties within the receiving waters can vary naturally on a relatively small scale, water quality monitoring is designed to assess these parameters in a way that helps determine the scale of seasonal and tidally driven oceanographic influences with respect to the point of discharge. Long-term monitoring of these parameters can help determine whether deviations from expected patterns exist that may indicate impacts from the discharge on local biological communities and to determine whether the beneficial uses of the receiving waters remain protected.

MATERIALS AND METHODS

In 2008, as part of the resource exchange for participation in the Bight '08 Regional Monitoring Program, winter water quality sampling was not required (Appendix A). Winter surveys will resume during the 2009 monitoring year. Water quality monitoring was conducted during summer at 17 receiving water (RW) stations located within the surrounding waters of the Mandalay Generating Station discharge channel (Figure 2-1). Stations RW1 through RW5 are positioned along the beach within the surf-zone. Stations RW6 through RW10 are positioned along the 30-foot (ft) isobath and Stations RW11 through RW17 are positioned along the 20-ft isobath. Water temperature, dissolved oxygen (DO) concentration, hydrogen ion concentration, and salinity were recorded during ebbing and flooding tides.

Water quality monitoring at surf-zone stations was conducted by collecting surface water samples from the surf-zone. Water samples were analyzed in the field using a Eureka Manta water quality analyzer. Monitoring at offshore stations was conducted using a Sea-Bird Water Quality Monitoring System (SBE 25). Sea-Bird data were processed using Sea-Bird proprietary software (SeaSoft). The resulting data, along with field readings from the surf-zone stations, were imported into Microsoft Office Excel 2000 spreadsheets for further reduction and analysis. Vertical water quality profiles were constructed with SigmaPlot version 9. Color contour images depicting sea surface temperatures were constructed with TecPlot version 9.

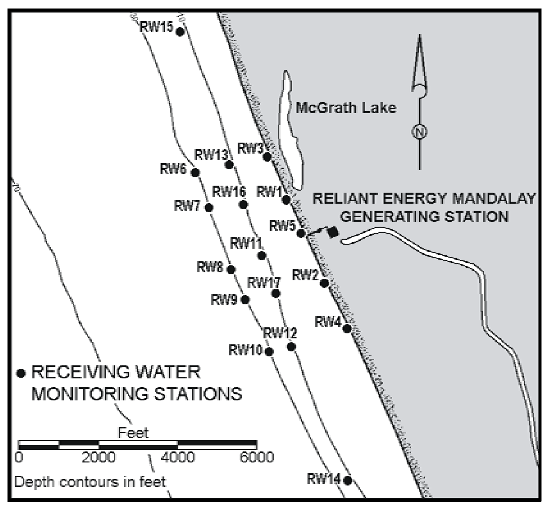


Figure 2-1. Location of the water column sampling stations. Mandalay Generating Station NPDES, 2008.

Summer water quality was monitored at Stations RW1 through RW17 on 17 September 2008 during flood and ebb tides. On the day of monitoring, the tide rose from a low of +1.0 ft Mean Lower Low Water (MLLW) at 0449 hours (hr) to a high of +5.9 ft MLLW at 1056 hr, then fell to a low of +0.3 ft MLLW 1739 hr (Figure 2-2). At surf-zone Stations RW1 through RW5, flood tide was sampled between 0645 and 0830 hr and ebb tide was sampled between 1200 and 1315 hr. At offshore Stations RW6 through RW17, flood tide was sampled between 0645 and 0815 hr and ebb tide was sampled between 1200 and 1330 hr. Skies at the surf-zone stations were overcast with winds from the northwest at 2 to 3 knots during the morning flood tide. By the afternoon ebb tide, skies were partly cloudy (50% cloud coverage) to mostly clear (15% cloud coverage) with winds from the west at 5 to 7 knots. At the offshore stations during flood tide, skies were mostly cloudy (90% cloud coverage) with winds from the northwest at 2 to 3 knots.

During ebb tide, skies were partly cloudy (30 to 50% cloud coverage) with winds from the west at 10 to 12 knots. Offshore and surf-zone sea conditions were west at 2 to 3 ft.

RESULTS

Water quality monitoring was conducted during flood and ebb tides offshore and alongshore of the Mandalay Generating Station to determine potential effects of the generating station discharge on receiving waters. Receiving water monitoring stations are shown in Figure 2-1. Flood tide was sampled in the early morning while ebb tide was sampled early afternoon. On the day of the summer sampling two of four circulating pumps were in operation with a flow of 126.1 mgd and a discharge temperature of 25.0°C, approximately 4°C above the intake temperature (Siekiel-Zdzienicki 2008, pers. comm.). Water quality data for flood and ebb tides are presented in Figures 2-3 and 2-4 and summarized in Tables 2-1 and 2-2. Raw data are presented in Appendix B.

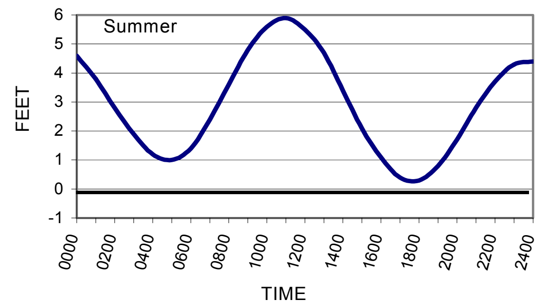


Figure 2-2. Tidal rhythms during water column sampling, summer survey. Mandalay Generating Station NPDES, 2008.

Water Temperature

During offshore monitoring, surface water temperature during flood tide averaged 16.57°C and ranged from 16.20°C at Station RW14, 5,910 ft downcoast of the discharge on the 20-ft isobath, to 17.04°C at Station RW10, 2,360 downcoast of the discharge at 30 ft depth (Table 2-1, Figure 2-3 and Appendix B). Surface water temperatures during ebb tide averaged 16.57°C and ranged from 15.78°C at Station RW14 to 17.69°C at Station RW13, 2,360 ft upcoast of the discharge on the 20-ft isobath. Although average surface temperatures were the same during both tides, similar surface temperatures between tides was noted only at four of the five stations on the 30-ft isobath and at Station RW17, 1,180 ft downcoast of the discharge at a depth of 20 ft. At the stations offshore and upcoast of the discharge on the 20-ft isobath, surface temperatures were 0.5°C warmer on average during ebb tide, with the greatest difference between tides (1.1°C) found at Station RW13, 2,360 upcoast of the discharge. At the three offshore stations farthest downcoast of the discharge, temperatures dropped an average of 0.9°C between flood and ebb tide, with the greatest difference (1.2°C) recorded at Station RW10.

Table 2-1. Summary of water quality parameters during flood and ebb tides at offshore stations. Mandalay Generating Station NPDES, summer 2008.

	Temp. (°C)		D.O. (mg/l)		pH		Salinity (psu)		Temp. (°C)		D.O. (mg/l)		pH		Salinity (psu)	
	Summer															
	Surface								Bottom							
	flood	ebb	flood	ebb	flood	ebb	flood	ebb	flood	ebb	flood	ebb	flood	ebb	flood	ebb
Mean	16.57	16.57	7.79	8.31	8.18	8.22	33.35	33.36	14.59	15.07	7.92	8.31	8.17	8.20	33.39	33.37
Minimum	16.20	15.78	7.73	8.08	8.17	8.19	33.30	33.34	13.94	14.57	7.85	8.20	8.15	8.19	33.37	33.29
Maximum	17.04	17.69	7.83	8.45	8.19	8.24	33.37	33.38	15.46	15.79	8.15	8.45	8.18	8.22	33.41	33.41

Temperature decreased from surface to bottom at all stations during both tides except at Station RW9, 1,180 ft downcoast of the discharge at a depth of 30 ft, where temperatures were slightly higher at a depth of one meter than at the surface, and at Station RW17 where the bottom temperature was slightly higher than the temperature reported at one meter off the bottom, both on flood tide (Table 2-1, Figure 2-3 and Appendix B). Most stations showed mild thermal gradients in the upper 2 to 4 m, above and below which temperature reductions with depth were more moderate.

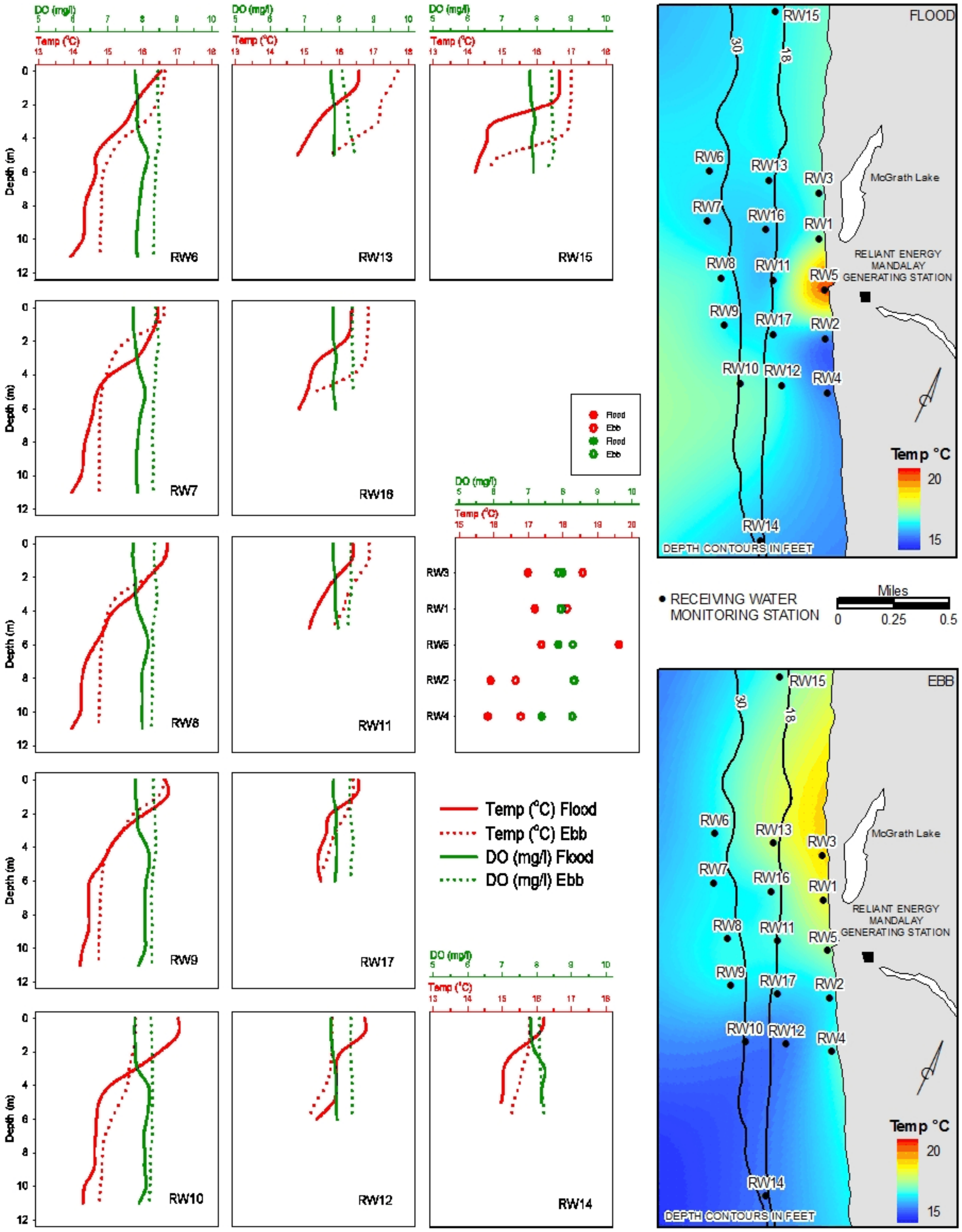


Figure 2-3. False color surface temperature contour plots, surf zone water quality, and temperature and dissolved oxygen vertical profiles during flood and ebb tides, summer survey. Mandalay Generating Station NPDES, 2008.

Thermoclines exceeding 1°C temperature change within one meter depth were recorded at Station RW15, 5,910 ft upcoast of the discharge at 20 ft on both tides, and near bottom at Station RW16, 1,180 ft upcoast of the discharge on the 20-ft isobath on ebb tide. In general, greatest surface-to-bottom temperature differences were found at stations on the 30-ft isobath on both tides, with the greatest differences of 2.8°C and 2.0°C, on flood and ebb tide, respectively, found at Station RW8, offshore of the discharge at 30 ft. Average bottom water temperatures were 14.59°C during flood tide and 15.07°C during ebb tide. Near-bottom water temperatures were generally colder on flood tide. Coolest bottom water temperatures were recorded at Station RW6, 2,360 ft upcoast of the discharge at 30 ft, on flood tide, with similar temperatures found near bottom at the three stations (RW6, RW7, and RW8) offshore and upcoast of the discharge along the 30-ft isobath. Warmest bottom temperatures were recorded at Station RW17 on flood tide and at Station RW11, offshore of the discharge at 20 ft, on ebb tide.

At surf-zone stations, surface water temperatures during flood tide averaged 17.11°C and ranged from 15.83°C at Station RW4, 2,360 ft downcoast of the discharge, to 19.62°C at Station RW5, at the discharge (Table 2-2 and Figure 2-3). Surface water temperatures during ebb tide averaged 17.50°C and ranged from 16.63°C at Station RW2, 1,180 ft downcoast of the discharge to 18.57°C at Station RW3, 2,360 downcoast of the discharge.

Dissolved Oxygen

During summer, offshore surface DO concentration during flood tide averaged 7.79 mg/l and ranged from 7.73 mg/l at Station RW8 to 7.83 mg/l at Station RW11, offshore of the discharge at 20 ft (Table 2-1, Figure 2-3 and Appendix B). Surface DO concentrations during ebb tide averaged 8.31 mg/l and ranged from 8.08 mg/l at Station RW13 to 8.45 mg/l at Station RW13. Surface dissolved oxygen concentrations were similar among stations during both tides, with higher surface values reported throughout the survey area during ebb tide. Still, DO concentrations were relatively consistent, varying by less than 0.8 mg/l among stations, between tides and with depth. Dissolved oxygen concentrations were more variable with depth on flood tide, with values increasing in the upper 4 to 6 meters, with only slight decreases from the maxima depth to the bottom. On ebb tide, only moderate reductions or slight increases in DO with depth to the bottom were found. The greatest surface-to-bottom DO differentials were increases of less than 0.4 mg/l at Stations RW14 and RW13 on flood and ebb tide, respectively. Average bottom DO values in summer were 7.92 mg/l during flood tide and 8.31 mg/l during ebb tide. Lowest bottom DO value (7.85 mg/l) was recorded at Station RW7, 1,180 ft upcoast of the discharge at 30 ft on flood tide, and the highest value (8.45 mg/l) was recorded at RW13 on ebb tide.

Table 2-2. Summary of water quality parameters during flood and ebb tides at surf-zone stations. Mandalay Generating Station NPDES, summer 2008.

	Temp. (°C)		D.O. (mg/l)		pH		Salinity (psu)	
	Summer							
	flood	ebb	flood	ebb	flood	ebb	flood	ebb
Mean	17.11	17.50	7.91	8.13	8.02	8.24	32.42	32.80
Minimum	15.83	16.63	7.39	7.86	7.83	8.20	32.20	32.70
Maximum	19.62	18.57	8.34	8.32	8.08	8.28	32.60	33.00

At surf-zone stations, surface DO concentrations during flood tide averaged 7.91 mg/l and ranged from 7.39 mg/l at Station RW4 to 8.34mg/l at Station RW2 (Table 2-2 and Figure 2-3). Surface DO concentrations during ebb tide averaged 8.13 mg/l and ranged from 7.86 mg/l at Station RW3 to 8.32 mg/l at Station RW2.

Hydrogen Ion Concentration

Surface pH values at offshore stations averaged 8.18 during flood tide and 8.22 during ebb tide (Table 2-1, Figure 2-4 and Appendix B). Flood tide pH values ranged from 8.17 at Stations RW13 and RW15 to 8.19 at Stations RW10 and RW17. Ebb tide pH values ranged from 8.19 at five of the offshore stations to 8.24 at Station RW15. Bottom pH values averaged 8.17 during flood tide

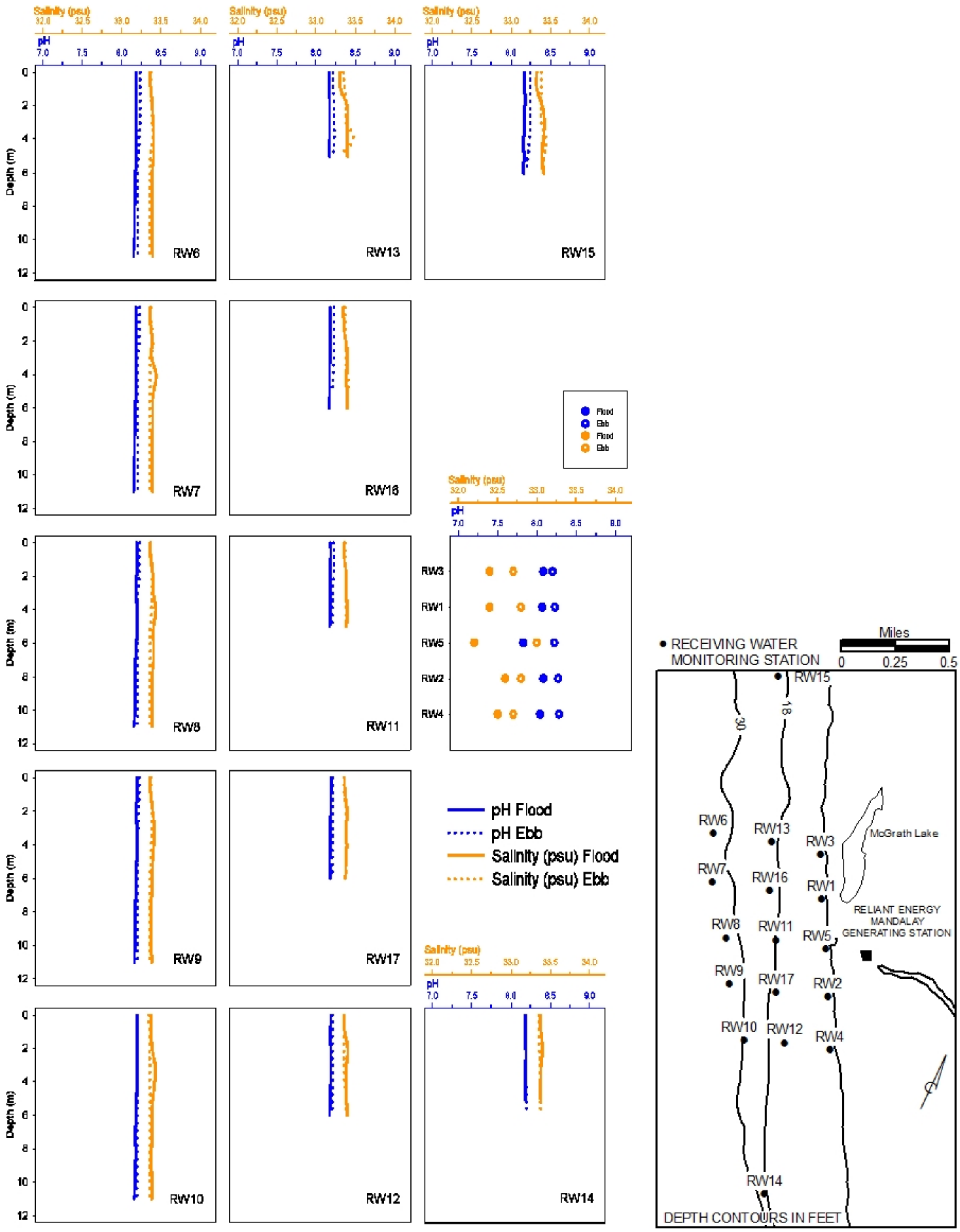


Figure 2-4. Surf zone water quality, and hydrogen ion concentration (pH) and salinity vertical profiles during flood and ebb tides, summer survey. Mandalay Generating Station NPDES, 2008.

and 8.20 on ebb tide. Flood tide bottom values ranged from 8.15 at Stations RW6, RW7 and RW8 to 8.18 at four stations. Ebb tide bottom pH values ranged from 8.19 at Station RW15 to 8.22 at Station RW13. Hydrogen ion values were very consistent throughout the water column, although generally slightly higher on ebb tide. In summer, pH values were notably uniform, varying by no more than 0.1 among stations, between tides and with depth.

At surf-zone stations, surface pH values averaged 8.02 during flood tide and 8.24 during ebb tide (Table 2-2 and Figure 2-4). Hydrogen ion concentrations varied by less than 0.5 units among stations, between tides and with depth. Highest pH value was recorded at Stations RW2 and RW3 on flood tide and at Station RW4 8.28 on ebb tide.

Salinity

Summer surface salinity averaged 33.35 practical salinity units (psu - which correlates one-to-one with parts per thousand [ppt]) during flood tide and 33.36 on ebb tide (Table 2-1, Figure 2-4 and Appendix B). Salinity increased with depth at most stations on both tides, with slightly higher values and more variability in the upper 5 m during flood tide. Subsurface salinity maxima values were found at some stations on both tides, most notably at Stations RW7, RW13 and RW15 on flood tide and at Station RW13 on ebb tide. Near-bottom water salinities averaged 33.39 psu on flood tide and 33.37 psu during ebb tide. Salinity values throughout the water column varied by 0.2 psu or less among stations, between tides and with depth, with maximum surface-to-bottom difference (an increase) of 0.08 psu at Station RW15 on flood tide.

At surf-zone stations, surface salinity readings averaged 32.42 psu during flood tide and 32.8 psu during ebb tide (Table 2-2 and Figure 2-4). Salinity varied by 0.4 psu during flood tide and 0.3 psu during ebb tide. Lowest salinity values were recorded at Station RW5 on flood tide and Stations RW3 and RW4 on ebb tide. Highest salinity values were recorded at Station RW2 during flood tide and at Station RW5 on ebb tide.

DISCUSSION

Water quality monitoring was conducted on two tides during summer to determine potential influence of the Mandalay Generating Station discharge on the receiving waters. During the water quality sampling, two of four circulating pumps were in operation with a flow of 126.1 mgd and a discharge temperature of 25.0°C, approximately 4°C above the intake temperature (Siekiel-Zdzienicki 2008, pers. comm.). Surface temperatures in 2008 were typical of summer surveys in the area, though slightly higher than values found in the area in 2007 (MBC 1986, 1988, 1990, 1994-2001a, 2002-2006a, 2007a; Ogden 1991-1993). During flood tide, temperatures at the offshore stations generally declined with increasing depth, and mild thermal gradients were found in the upper 6 m of the water column and near bottom (Figure 2-3). At the station farthest upcoast, a relatively strong thermocline was noted between 2 and 3 m. Surface temperatures were relatively similar among stations with a range of less than 1°C. This resemblance of surface temperatures, including at the upcoast station where the thermocline was recorded, suggests a natural cause for this strong thermal gradient and not the influence of a warm water lens from the thermal discharge. Similarly, slightly warmer surface waters noted at stations downcoast and offshore of the discharge appeared to be a result of natural oceanographic conditions and not related to the discharge. Except at two downcoast stations on the 20-ft isobath, bottom temperatures were lower and temperature through the water column more variable on flood tide than during the later ebb tide. In the surf zone on flood tide, temperatures were highest at the discharge channel, indicating the presence of a thermal plume. Elevated temperatures in the surf zone diminished with distance upcoast indicating a relatively localized influence from the discharge upcoast on the shoreline. No thermal influence was noted at the downcoast shoreline stations. While warmer water was noted at some surf zone stations, a thermal plume did not extend to the offshore stations on flood tide.

On ebb tide, surface temperatures were more variable than reported on flood tide, varying by almost 2°C among stations. Temperatures at stations along the 30-ft isobath (and at Station RW17 on the 20-ft isobath) were very similar to temperatures found during the early morning flood tide, except at the station farthest downcoast where the surface temperature was lower on ebb tide. (Figure 2-3). Lower surface temperatures were also recorded at the two stations farthest downcoast on the 20-ft isobath, indicating naturally occurring cooler water moved into the downcoast area on ebb tide. Surface temperatures at the remaining 20-ft stations, offshore and upcoast of the discharge were warmer on ebb tide, with the highest surface temperature reported 2,360 ft upcoast of the discharge. While temperatures were relatively consistent with depth at the downcoast stations, temperature profiles were relatively similar at the remaining stations to those found during flood tide, with mild thermal gradients at most of these stations. As on flood tide, a relatively strong thermocline was found at the station farthest upcoast between 4 and 5 m, as well as at the 20 ft station 1,180 ft upcoast of the discharge. Bottom temperatures on ebb tide were similar to flood tide values except at the four stations where surface warming was indicated and temperatures were higher throughout the water column. In the surf zone, the highest temperature occurred 2,360 ft upcoast of the discharge, with an elevated water temperature also indicated midway between this station and the discharge. The temperature at the discharge was also slightly elevated compared to offshore and downcoast surf zone stations. The warmer near-surface water temperatures found offshore to the 20-ft isobath and upcoast of the discharge suggest the presence of a warm water surface lens from the thermal plume at these stations during ebb tide. Similar patterns have been observed in the area previously and reflect tidal influences on the thermal discharge from the generating station on the day of sampling. Still, even in areas influenced by the thermal field, surface temperatures were typical of the area during previous surveys (MBC 1986, 1988, 1990, 1994-2001a, 2002-2006a, 2007a; Ogden 1991-1993).

The concentration of dissolved oxygen in seawater is affected by physical, chemical, and biological variables. High DO levels may be the result of cool water temperatures (solubility of oxygen in water inversely correlates with temperature), active photosynthesis, and/or mixing at the air-water interface (Sverdrup et al. 1942). Conversely, low concentrations may result from high water temperatures, high rates of organic decomposition, and/or extensive mixing of surface waters with oxygen-poor subsurface waters. Dissolved oxygen concentrations typically fluctuates in the nearshore temperate environment around 7.5 mg/l (Kennish 2001), with a threshold of biological concern of 5 mg/l.

In summer, DO values were similar among offshore stations, varying by less than 0.8 mg/l between tides and among stations and with depth. Dissolved oxygen concentrations were more variable with depth on flood tide, with values increasing with depth in the upper 4 to 6 m, then only slight decreases from the maxima depth to the bottom (Figure 2-3). On ebb tide, only moderate reductions or slight increases in DO with depth to the bottom were found. Differences in DO values between tides were more noticeable in the upper water column, where lower values were found on flood tide. The generally higher DO levels found later in the day were consistent with replenishment by photosynthetic activity, with greatest increases in the upper water column above the depth of the thermal gradients. In the surf zone, DO concentrations were reduced farthest downcoast on flood tide and farthest upcoast on ebb tide, while highest values were found downcoast of the discharge on both tides. Concentrations were comparable between tides. Reductions in DO at surf zone stations related to higher discharge temperatures observed during previous surveys was not noted (MBC 1986, 1988, 1990, 1994-2001a, 2002-2006a, 2007a; Ogden 1991-1993). In 2008 dissolved oxygen concentrations were in the range previously recorded offshore the generating station, and well above the level of concern on both tides.

In the open ocean, pH remains fairly constant due to the buffering capacity of sea water (Sverdrup et al. 1942). However, in nearshore areas, pH may vary due to physical, chemical, and biological influences. For instance, in areas with a large organic influx, such as bays, estuaries, and near river mouths, microbial decomposition can alter pH levels. Along with a reduction in DO, decomposition also results in the production of humic acids, which reduces pH (Duxbury and Duxbury 1984). Decreased pH values may also occur in areas of fresh water influx, since fresh water generally has a lower pH than salt water. In contrast, phytoplankton blooms, which are often associated with nearshore upwelling, may initially cause an increase in pH. High photosynthetic rates increase the removal of carbon dioxide from water, thus reducing the bicarbonate concentration, resulting in an increase in pH.

In summer, pH was very consistent throughout the water column at offshore stations, though slightly more variable between tides at the surf stations. Offshore, pH varied by less than 0.1 units during the survey, while pH values varied by up to 0.5 units among stations and between tides in the surf zone (MBC 1986, 1988, 1990, 1994-2001a, 2002-2006a, 2007a; Ogden 1991-1993). Slightly higher values occurred at all stations during ebb. At the shoreline discharge station, pH values were slightly lower than those recorded up- and downcoast during flood tide, likely a result of slightly lower salinity water in the discharge channel. In 2008 all pH values were consistent with concentrations previously recorded in the study area.

Salinity in the open ocean is generally 35 psu (ppt). However, in nearshore areas subjected to freshwater influx, salinity is usually slightly lower. In southern California, salinity values of nearshore waters are generally between 33 and 34 ppt (Dailey et al. 1993). Reductions in nearshore salinity usually result from freshwater input, while slight increases are often associated with upwelling of colder, more saline waters.

At the offshore stations in 2008, salinity increased with depth at most stations on both tides, with slightly higher values and more variability in the upper 4 m during flood tide. An exception occurred at the two upcoast stations on the 20-ft isobath, where near-surface levels were slightly lower on flood tide. Subsurface salinity maxima were recorded at some stations on both tides. Still, salinity was very uniform during the sampling, varying by 0.2 psu or less among stations, between tides and with depth. At the shoreline stations, salinity was lower during the flood tide sampling than on ebb tide, particularly near the discharge. Lower values at the surf zone, as well at the upcoast 20-ft stations, suggests some local freshwater influence from the discharge plume on flood tide, likely from urban and agricultural runoff into the harbor and intake canal that supplies cooling water to the generating station. All values reported in 2008 were typical of the nearshore waters of southern California and within values found previously in the area (MBC 2002-2006a, 2007a). While surface salinity appeared to be slightly reduced as a result of operation of the generating station, the influence was local and similar to natural conditions found commonly throughout the study area.

CONCLUSION

In 2008, water quality parameters were relatively consistent among stations and between tides. Warmer and slightly less salty surface water was observed near the discharge and at some nearby stations, attributable to tidal influences on the thermal discharge from the generating station. These patterns have been observed in the area in previous surveys and the resulting parameters were similar to natural conditions found commonly throughout the study area. While water quality measurements indicated the presence of a cooling water discharge from the Mandalay Generating Station in 2008, the influence was localized did not appear to have an adverse effect on receiving waters in the study area.

CHAPTER 3 — SEDIMENT CHARACTERISTICS

Marine sediment characteristics are affected by both natural and anthropogenic influences. Tides, currents, and wave action all influence sediment grain size by suspending and transporting fine-grained material, resulting in coarser sediments in dynamic areas and finer sediments in areas of reduced currents and wave action. Coastal streams and rivers contribute sediments as well as contaminants to the marine environment, with variable influence from year-to-year depending on yearly rain amounts. In coastal environments, man-made structures such as jetties and breakwaters alter water movement and may result in changes in local sediment characteristics and deposition patterns, while sand replenishment projects can influence sediment characteristics over large intertidal and subtidal areas. In addition to influencing grain size, anthropogenic inputs may contribute contaminants, including metals, to the environment, which can bind to sediments. Sediment grain size and sediment chemistry trends are useful in characterizing year-to-year differences that may be related to either natural or anthropogenic influences.

MATERIALS AND METHODS

As part of the resource exchange for participation in the Bight '08 Regional Monitoring Program, the number of sediment stations sampled in 2008 was reduced from five to four (Appendix A). Stations sampled in 2008 were the same as those sampled during the Bight '03 Regional Monitoring Program, which also reduced monitoring effort in exchange for participation in the regional monitoring program. Sediment studies at all five stations will recommence in 2009.

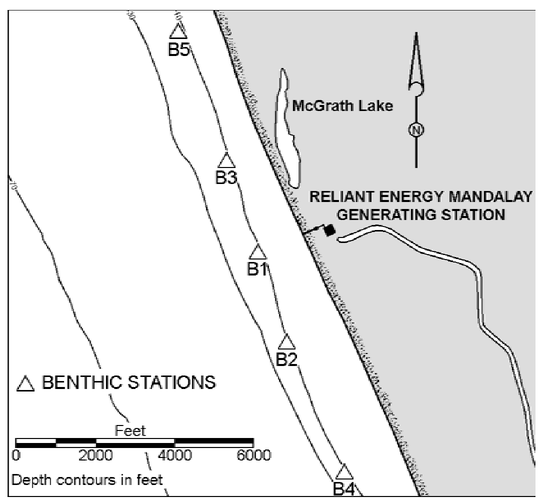


Figure 3-1. Location of the benthic sampling stations. Mandalay Generating Station NPDES, 2008.

Bottom samples for sediment grain size and sediment chemistry analyses were collected at Stations B1 through B4 during the summer of 2008 (Figure 3-1). All samples were collected *in situ* by biologist-divers in conjunction with infauna sampling.

Sediment Grain Size

A sample of sediments for grain size analysis was taken at each station using a 3.5-cm-diameter, 15-cm-long plastic core tube. The sample was transferred to a plastic bag for laboratory analysis.

The size distributions of sediment particles were determined using two techniques: laser light diffraction to measure the amount and patterns of light scattered by a particle's surface for the sand/silt/clay fraction, and standard sieving for the gravel fraction. Laboratory data from the two methods were combined and presented in tabular format. Resulting analyses include mean and median grain size, standard deviation of the grain size, sorting, skewness, and kurtosis. Data were plotted as size-distribution curves. Additional details are provided in Appendix C-1.

Sediment Chemistry

Samples for sediment chemistry analysis were taken from the upper two centimeters of the sediments at each station. To ensure that sediments were not contaminated by contact with metal, cleaned glass collection jars were filled with seawater and taken to the sea floor by biologist-divers where sediment samples were collected directly with the jars.

On the surface sediments were kept on ice while in the field, and maintained at approximately 4°C until laboratory procedures began. Replicate sediment samples were composited by the analytical laboratory prior to analysis and reported as station results. Sediment was analyzed for total percent solids and four metals: chromium, copper, nickel, and zinc. Standard Methods (SM) method 2540 B was used in determining total percent solids, and Environmental Protection Agency (EPA) method 6020 was used for metal analysis.

RESULTS

Sediment chemistry and grain size samples were collected by biologist-divers at Stations B1 through B4 on 18 September 2008 between 1000 and 1130 hours. Skies were mostly clear (15% cloud coverage) with winds from the west at 5 to 9 knots. Seas were west at 2 to 3 ft.

Sediment Grain Size

Sediment distribution curves and parameters describing sediment grain size characteristics for each station are presented in Appendix C and are summarized in Table 3-1. Grain size is expressed in phi (Φ) units, which are inversely related to grain diameter (Appendix C-1).

Sediments at the four stations in 2008 were composed primarily of sand, with smaller amounts of silt and clay (Table 3-1). Gravel was not collected at any station in 2008. Overall, sediments from the four stations averaged about 96% sand, 3% silt, and 1% clay, with an average mean grain size of 2.32 phi (201 µm, fine sand). Sediments were finest at Station B4, 5,910 ft downcoast of the discharge, where mean grain size was 2.49 phi (178 µm, fine sand). Sediments were coarsest at Station B3, 2,360 ft upcoast of the discharge, where mean grain size was 2.11 phi (231 µm, fine sand).

Table 3-1. Sediment grain size parameters. Mandalay Generating Station NPDES, 2008.

	Station					
Parameter	B1	B2	B3	B4	Mean	S.D.
% Gravel	0.00	0.00	0.00	0.00	0.00	0.00
% Sand	96.20	95.89	96.62	93.66	95.59	1.32
% Silt	2.68	2.94	2.18	4.73	3.13	1.11
% Clay	1.12	1.17	1.20	1.61	1.28	0.23
Mean grain size						
phi	2.36	2.33	2.11	2.49	2.32	0.16
µm	195	198	231	178	201	22
Sorting (ϕ)	0.757	0.716	0.736	0.887	0.774	0.077
Skewness	-0.025	0.011	-0.021	0.011	-0.006	0.020
Kurtosis	1.239	1.406	1.225	1.690	1.390	0.216

Sorting is a measure of the spread of the particle distribution curve, with poorly-sorted sediments composed of a broad range of particle size classes, while well-sorted sediments contain fewer size classes. In 2008, sorting averaged 0.774 phi overall, and sediments were moderately sorted at all stations (Table 3-1). Sediment distribution curves at all stations were essentially unimodal, with a peak in the fine sand category at all stations with variable amounts of sediments in other size categories and slight secondary peaks at all stations in the medium sand category (Appendix C-2).

Skewness and kurtosis tell how closely the grain size distribution approaches the normal Gaussian probability curve. More extreme skewness and kurtosis values indicate non-normal distributions. Skewness is a measure of the symmetry of the particle distribution curve; a value of zero indicates a symmetrical distribution of fine and coarse materials around the median of the curve, while a value greater then zero (positive) indicates an excess of fine material, and a negative value indicates an excess of coarse material. Skewness in 2008 averaged -0.006 and ranged narrowly from -0.025 at Station B1, offshore of the discharge, to 0.011 at both Station B2, 2,360 ft downcoast of the discharge, and Station B4 (Table 3-1). Skewness values were also nearly identical at Stations B1 and B3 (-0.025 and -0.021, respectively). At Stations B1 and B3, sediments were very slightly skewed toward coarse material, while sediments at Stations B2 and B4 were similarly skewed toward fine material.

Kurtosis is a measure of the peakedness of the particle distribution curve. A kurtosis value of 1.0 represents a normal particle distribution curve while a value greater than 1.0 indicates a leptokurtic (peaked) distribution with better sorting in the central portion of the curve than in the tails. A value less than 1.0 indicates a platykurtic (flattened) distribution and a lack of dominance by any one size category. Kurtosis values were greater than 1.0, indicating leptokurtic (excessively peaked) distributions, with dominance by a narrow range of size classes (Table 3-1). Kurtosis in 2008 ranged from 1.225 at Station B3 to 1.690 at Station B4, and averaged 1.390.

Sediment Chemistry

Sediment samples collected at the four benthic stations were analyzed for chromium, copper, nickel, and zinc. Values are reported as dry weight. Sediment metal concentrations are presented in Appendix D and summarized in Table 3-2. Metal concentrations were similar among stations, though lowest concentrations of all metals were found offshore of the discharge at Station B1.

Table 3-2. Sediment metal concentrations (mg/dry kg). Mandalay Generating Station NPDES, 2008.

	Station								Reporting
Metal	B1	B2	B3	B4	Mean	S.D.	ERL	ERM	Limits
Chromium	4.51	7.74	6.67	6.85	6.44	1.37	81	370	0.125 - 0.131
Copper	2.93	3.48	3.28	3.60	3.32	0.29	34	270	0.125 - 0.131
Nickel	4.95	6.77	6.84	6.75	6.33	0.92	20.9	51.6	0.125 - 0.131
Zinc	16.3	18.8	17.4	20.0	18.1	1.6	150	410	1.25 - 1.31

ERL = Effects Range Low ERM = Effects Range Medium

Chromium. Sediment chromium concentrations averaged 6.44 mg/kg and ranged from 4.51 mg/kg at Station B1 to 7.74 mg/kg at Station B2 (Table 3-2).

Copper. Sediment copper concentrations averaged 3.32 mg/kg and ranged from 2.93 mg/kg at Station B1 to 3.60 mg/kg at Station B4 (Table3-2).

Nickel. Sediment nickel concentrations averaged 6.33 mg/kg and ranged from 4.95 mg/kg at Station B1 to 6.84 mg/kg at Station B3 (Table 3-2).

Zinc. Sediment zinc concentrations averaged 18.1 mg/kg and ranged from 16.3 mg/kg at Station B1 to 20.0 mg/kg at Station B4 (Table 3-2).

DISCUSSION

Sediment Grain Size

In 2008, sediments were analyzed from four stations offshore the Mandalay Generating Station. (Station B5, farthest upcoast of the discharge point was not sampled in 2008, but will be included in the 2009 sampling program.) Sediments in 2008 were similar among all stations, with sediments composed of about 96% sand with lesser amounts of fine material (silt and clay) and mean grain sizes in the fine sand category. Sediments upcoast of the discharge (Station B3) were coarsest, comprised of almost 97% sand with a mean grain size of 2.11 phi (231 µm), while finest sediments occurred at the station farthest downcoast of the discharge (Station B4), with mean a grain size of 2.49 phi (178 µm), and a greater contribution by fine material (6%). Sediment distributions offshore of the Mandalay Generating Station in 2008 were relatively similar, with low skewness values, dominance by fine sand, with a discernible contribution by medium sand and a small, but well distributed contribution of fine material (Appendix C-1). Though sediment distribution characteristics were similar among all stations, the two upcoast stations and the two downcoast stations were most similar to each other.

Mean grain size in 2008 was coarser than the long-term mean grain size for the area, but finer than that found in 2007 (Figure 3-2; Appendix C-3). In 2006, mean grain size in the study area was among the finest on record, although slightly coarser than in 2005. However, in 2007, sediments at the discharge were the third coarsest found in the area long term, which skewed the overall survey mean. In 2008, sediments at Station B1 were notably finer than in 2007, and more typical of the sediments previously common in the area. This year, sediment grain sizes in the fine sand category at all stations was typical of fine to very fine sand commonly found offshore of the generating station (MBC 1990, 1994, 1997-2001a, 2002-2006a, 2007a; Ogden 1991-1993). In regional sampling conducted in 2003, sediments from shallow (5-30 m) coastal stations throughout the Southern California Bight averaged 31% fines overall, considerably higher than found in the survey area in 2008 or commonly in previous surveys (Schiff et al. 2006; Figure 3-2; Appendix C-3).

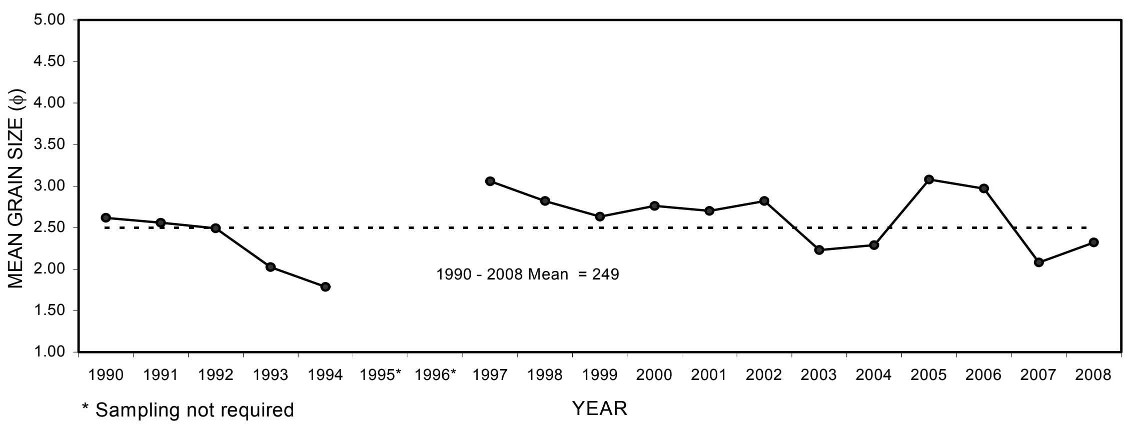


Figure 3-2. Comparison of sediment mean grain size, 1990 - 2008. Mandalay Generating Station NPDES, 2008.

There has been great year-to-year variability in grain size among stations off the generating station. Still, some sediment distribution trends have been observed in the area. The smallest mean grain size has historically been found at Station B5, farthest upcoast and nearest the Santa Clara River, in all but five surveys since 1990 (excluding 1998, 2003 and this year when this station was not sampled) (Appendix C-3). Sediments in this area are likely more affected by flow and sediment deposition from the river than by generating station operations. In contrast, coarsest sediments occurred at the discharge seven times during 17 surveys since 1990, at the farthest downcoast station four times, at the intermediate upcoast station three times, at the intermediate downcoast station twice and at the farthest upcoast station once (MBC 1990, 1994, 1997-2001a, 2002-2006a, 2007a; Ogden 1991-1993). No annual surveys have recorded the finest sediments at the discharge.

The similarity of grain size characteristics at the two downcoast stations and at the discharge and intermediate upcoast station suggest that sediment distribution was primarily influenced by normal nearshore processes which influence grain size such as currents, waves and sand movement. In 2007, coarse sediments offshore of the discharge channel appeared be influenced by turbulence associated with the cooling water discharge (MBC 2007a). This localized and transitory effect near the discharge has been noted in some previous surveys, but was not observed in 2008 (MBC 1990, 1994, 1997-2001a, 2002-2006a, 2007a; Ogden 1991-1993). Sediment characteristics offshore of the Mandalay Generating Station discharge in 2008 were similar to those found locally and to sediment characteristics previously observed in the area and appeared to be influenced primarily by natural causes.

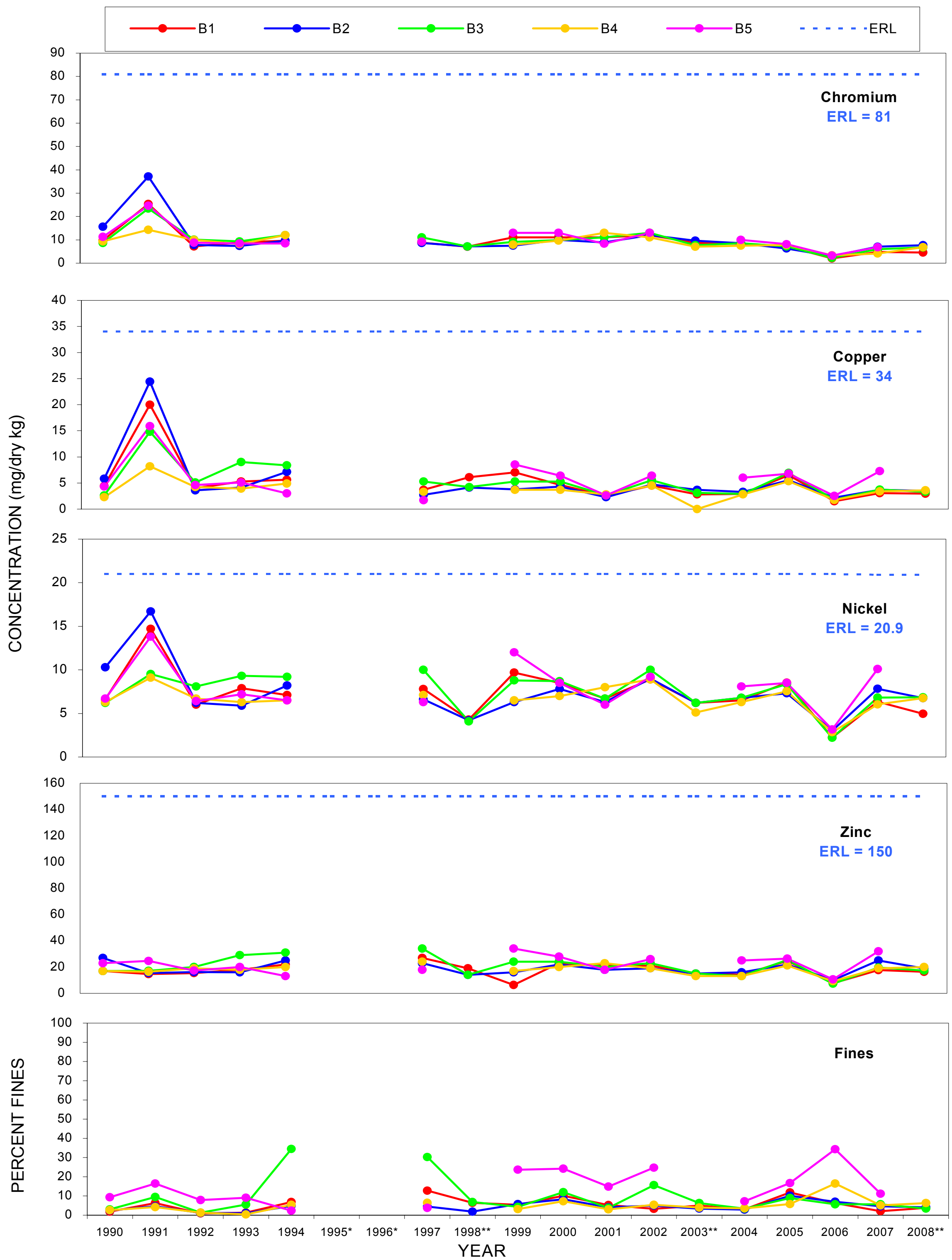
Sediment Chemistry

In 2008, sediments at four stations off the Mandalay Generating Station were analyzed for the presence and concentration of chromium, copper, nickel, and zinc. Though metals were lowest overall at Station B1, metal concentrations, particularly for copper and zinc, were similar among all stations (Table 3-2; Figure 3-3). In general, metal levels in 2008 were slightly lower than occurred in 2007 at Station B1, and slightly higher at Station B4. All sediment metal values reported in 2008 were higher than respective levels reported at the stations in 2006, when metal values were among the lowest found in the area (MBC 1990, 1994, 1997-2001a, 2002-2006a, 2007a; Ogden 1991-1993). In 2008, the mean concentration of all metals was nearly twice to three times the levels detected in 2006, but similar to levels reported in previous years, including 2007, and generally lower than the long-term means.

Differences in metal concentrations among sites are often directly related to the amount of fine-grained material in the sediment. Fine-grained sediments may contain higher amounts of metals due to the greater available surface area (Ackermann 1980, de Groot et al. 1982). Comparisons should take into account the relative amounts of fine and coarse sediments. Sediments in the study area have consistently been sandy. In some previous years, including 2007, the largest percentages of fines (silt and clay combined) and in general, highest concentrations of metals were usually recorded farthest upcoast of the discharge (Station B5) near the Santa Clara River (Figure 3-3). Similarly, lowest metal concentrations are commonly found either offshore of the discharge or farthest downcoast, where percent sand is frequently highest and mean grain size largest (MBC 1990, 1994, 1997-2001a, 2002-2006a, 2007a; Ogden 1991-1993). While in 2008 lowest concentrations of all metals were found offshore of the discharge, highest percentage of sand and greatest mean grain size were found upcoast of the discharge, and higher metal concentrations did not appear to be related to finer sediments. Because of an overall similarity in sediment characteristics and relatively low metal concentrations typically found in the sediments, metal levels in 2008 do not appear to relate to the amount of fine material in the sediments.

Metal levels reported in 2008 throughout the Mandalay study area were within the range found in sediments within the Southern California Bight and were lower than or comparable to levels found by the National Oceanographic and Atmospheric Administration (NOAA) at other sandy, offshore sites in southern California (NOAA 1991a). Mean concentrations of metals off the generating station in 2008 were also similar or lower than the mean metal concentrations found in sediments at shallow (5–30 m) coastal stations sampled in 2003 from throughout the Southern California Bight (Schiff et al. 2006).

Concentrations of metals in the study area have consistently been below levels determined to be potentially toxic to benthic organisms. Ranges of potential toxicity were developed by NOAA (NOAA 1991b) and later updated (Long et al. 1995) using data from spiked sediment bioassays, sediment-water equilibrium partitioning, and the co-occurrence of adversely affected fauna and contaminant levels in the field. Chemical concentrations believed to be associated with adverse biological effects from the various independent studies were compared for each parameter and the lower 10 percentile was designated as the “Effects Range-Low” (ERL). Concentrations below the ERL represent a minimal effects range; a range intended to estimate conditions where effects would be rarely observed (Long et al. 1995). Metal concentrations have never exceeded their respective ERLs in the study area, and in 2008 were again well below the levels of concern (Figure 3-3).



*No sampling required; ** 1998 - only three stations required, 2003 and 2008 - only four stations required

Figure 3-3. Comparison of sediment metal concentrations and percent fines by station, 1990 - 2008. Mandalay Generating Station NPDES, 2008.

Pollutants come from a variety of sources of both industrial and domestic origin. Oil and gasoline combustion releases many substances, including cadmium, copper, chromium, lead, mercury, and zinc. These and other metals are also used in paints, pigments, batteries, manufacturing, and protective coatings. Aerial fallout is a diffuse and potentially large source of contaminants derived from other sources, and may include metals, chlorinated hydrocarbons, and PAHs (SCCWRP 1973, 1986). As these contaminants accumulate on the ground, they are washed into rivers by rainfall, and are eventually deposited in the ocean.

Sediment metal concentrations have remained relatively consistent in the area since 1990. In 2008 metal concentrations were similar among stations. Although higher than levels reported in 2006, metal concentrations in 2008 were similar to results found commonly in previous surveys, including 2007. Highest metal concentrations were found variously in the study area, though lowest metal levels occurred offshore of the discharge. Metal concentration did not appear to be related to sediment characteristics in 2008, likely due to an overall similarity in both the sediment characteristics and metal levels among all stations. Metal levels typically vary slightly from year to year and no long-term patterns of metal concentrations relative to the discharge were apparent. Concentrations of sediment metals in 2008 did not appear to be influenced by the operation of the Mandalay Generating Station.

CONCLUSION

Sediment Grain Size

In 2008, sediments were analyzed from four stations offshore the Mandalay Generating Station. Sediment distribution characteristics were similar among all stations, though the two upcoast stations and the two downcoast stations were most similar to each other. Sediments were generally composed of about 96% sand with lesser amounts of fine material (silt and clay) and mean grain sizes in the fine sand category. Sediments upcoast of the discharge (Station B3) were coarsest, comprised of almost 97% sand while finest sediment sediments occurred at the station farthest downcoast of the discharge (Station B4). The degree of influence of the discharge on local sediments varies from year to year, and the localized and transitory influence near the discharge noted in some previous surveys was not observed in 2008. Sediment characteristics offshore of the Mandalay Generating Station discharge in 2008 were similar to those found previously in the area and appear to be affected primarily by natural causes.

Sediment Chemistry

In 2008 metal concentrations were lowest overall at Station B1, though levels, particularly for copper and zinc, were similar among all stations Although higher than levels found in 2006, which were among the lowest reported in the area, metal concentrations in 2008 were similar to results found commonly in previous surveys, and sediment metal concentrations have remained relatively consistent in the area since 1990. While metal levels typically vary slightly from year to year, no long-term patterns of metal concentrations relative to the discharge were apparent. As in previous surveys, sediment metal levels were well below concentrations determined to be potentially toxic to marine organisms. Concentrations of sediment metals in 2008 did not appear to be influenced by the operation of the Mandalay Generating Station.

CHAPTER 4 — MUSSEL BIOACCUMULATION

Concentrations of many toxic substances in water are often too low or transitory to be reliably detected through the analysis of water samples. Also, many toxic substances are not water-soluble, but are instead associated with sediments or organic tissues. Tissues from aquatic organisms are preferably sampled because they accumulate and concentrate toxic substances to levels which may be hundreds of times the levels found in water samples, thus facilitating the detection of pollutants. Mussels are excellent subjects for this purpose because they 1) are sessile, 2) are long-lived, 3) can be transplanted and maintained in areas were they do not occur, and 4) reliably concentrate toxic pollutants from the water (SWRCB 1995, 2000).

As part of the resource exchange for participation in the Bight '08 Regional Monitoring Program, mussel bioaccumulation analysis was required only if resident mussels were located in the discharge area (Appendix A). On 18 September 2008, biologist-divers searched in the vicinity of and offshore of the discharge and were unable to locate resident mussels in the project area.

CHAPTER 5 — BENTHIC INFAUNA

The benthic infauna, invertebrates that live in the bottom sediments, are an important part of the marine ecosystem. These animals are a major food source for fish and other larger invertebrates, and contribute to nutrient recycling. Some species are highly sensitive to effects of human activities, while others thrive under altered conditions. The assessment of the benthic community is, therefore, a major component of many marine monitoring programs, which document both existing conditions and trends over time.

The benthic infaunal community offshore of the Mandalay Generating Station has been sampled as part of the NPDES environmental monitoring program since 1978. Benthic samples were collected in both winter and summer from 1978 to 1988, and only in summer since 1990. Five stations have been sampled in all surveys except in 1998 (only three stations) and 2003 and 2008 (four stations, with only two replicates each, one-half the number of replicates in all other surveys). New in 2006 was inclusion of the Southern California Benthic Response Index (BRI) which was developed to provide a scientifically valid criterion or threshold that can be used to distinguish “healthy” and “unhealthy” benthic communities (Smith et al. 2003).

MATERIALS AND METHODS

As part of the resource exchange for participation in the Bight ‘08 Regional Monitoring Program, the number of stations and replicates sampled was reduced, and was the same as during the Bight ‘03 Regional Monitoring Program (Appendix A). Sampling at all five stations will resume in 2009. Biologist-divers collected sediment cores for analysis of infaunal composition at Stations B1 through B4 on 18 September 2008 between 1000 and 1130 hours (Figure 5-1). Skies were mostly clear with winds from the west at 5 to 9 kn. Seas were from the west at 2 to 3 ft. Two replicate cores were collected at each station using a hand-held, diver-operated box corer which collects a uniform sample of 100.0 cm^2 surface area to a depth of 10.0 cm, for a total sample volume of 1.0 liter (l) (Figure 5-2). The box corer was pushed into the sediment and a closing blade was swung across the mouth of the box. The core was then withdrawn from the sediment and sealed by a neoprene cover for transport to the surface. Samples were washed in the field on a 0.5-mm mesh stainless-steel screen, labeled, and fixed in buffered 10% formalin-seawater.

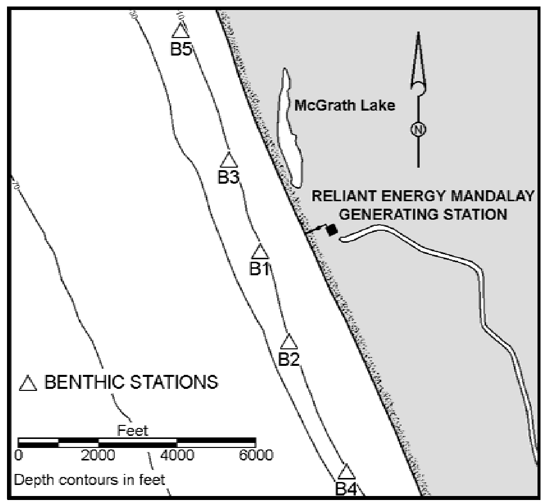


Figure 5-1. Location of the benthic sampling stations. Mandalay Generating Station NPDES, 2008.

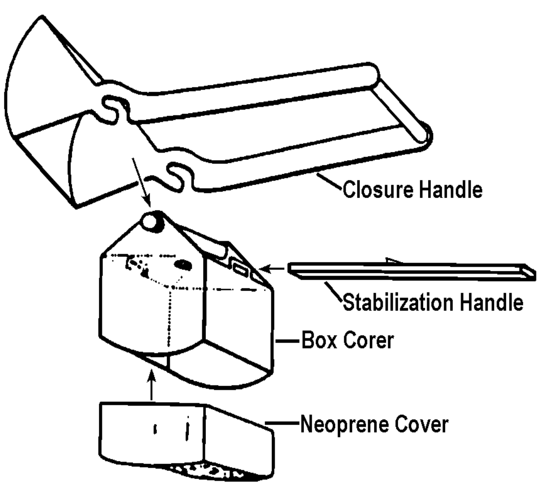


Figure 5-2. Diver-operated box corer used to collect infaunal samples. Mandalay Generating Station NPDES, 2008.

In the laboratory, samples were transferred to 70% isopropyl alcohol, sorted to major taxonomic groups, identified to the lowest practical taxonomic level, and counted. Identifications and nomenclature followed the usage accepted by the Southern California Association of Marine Invertebrate Taxonomists

(SCAMIT 2008). Representative specimens were added to MBC's reference collection. Following identification, the weight of organisms in major taxonomic groups was obtained for each replicate. Specimens were placed on small, pre-weighed mesh screens that had been immersed in 70% isopropyl alcohol, blotted on a paper towel, and air-dried for five minutes. Large organisms were weighed separately. Data are presented by station and replicate in Appendix F.

RESULTS

Species Composition. In 2008, the infauna samples from the four benthic stations offshore of the Mandalay Generating Station contained a total of 228 individuals representing 34 species in six phyla (major taxonomic groups) (Table 5-1, Appendices F-1 and F-2). Annelids (segmented worms) and arthropods were equally abundant, each group comprising 43% of the individuals in the collection, followed by mollusks and nemerteans (ribbon worms), with 10% and 2% of the collection, respectively. Annelids were the most speciose group, with 41% of the species, followed by arthropods with 32% of the species, and nemerteans and mollusks with 12% and 9% of the species, respectively. The two other phyla each represented less than 3% of the species and much less than 1% of the total abundance.

Table 5-1. Number of infaunal species and individuals by phylum. Mandalay Generating Station NPDES, 2008.

	Station					Percent
Parameter	B1	B2	B3	B4	Total	Total
Number of species						
Annelida	5	7	5	8	14	41.2
Arthropoda	5	6	7	5	11	32.4
Nemertea	2	2	-	-	4	11.8
Mollusca	3	1	1	1	3	8.8
Echinodermata	1	-	-	-	1	2.9
Nematoda	1	-	-	-	1	2.9
Total	17	16	13	14	34	100
Number of individuals						
Annelida	19	24	25	31	99	43.4
Arthropoda	22	22	17	38	99	43.4
Mollusca	10	6	1	6	23	10.1
Nemertea	3	2	-	-	5	2.2
Echinodermata	1	-	-	-	1	0.4
Nematoda	1	-	-	-	1	0.4
Total	56	54	43	75	228	

Abundance. Abundance averaged 57 individuals per station (29 individuals per replicate, or 2,850 individuals/m^2), and ranged from 43 individuals at Station B3, upcoast of the generating station, to 75 individuals at Station B4, farthest downcoast (Table 5-2, Appendices F-2 and F-3).

Species Richness. The number of species averaged 15 per station, or 11 species per replicate (Table 5-2, Appendices F-2 and F-3). Species richness ranged from 13 species at Station B3 to 17 species at Station B1, near the generating station discharge.

Species Diversity (H'). Shannon-Wiener species diversity averaged 2.26 per station (1.93 per replicate) and ranged from 1.92 at Station B4 to 2.46 at Station B1 (Table 5-2, Appendices F-2 and F-3).

Benthic Response Index. The Southern California Benthic Response Index (BRI) is the abundance-weighted average pollution tolerance of species occurring in a sample. The pollution tolerance scores (p_i) for shallow coastal shelf habitat (10 to 30 m) were used in the computations, even though the stations are shallower than the depth range recommended for application of the index. In addition, the screen mesh size used for sieving the samples from the study area (0.5 mm) was smaller than the mesh size used for the samples from which the BRI was developed (1 mm). BRI values averaged 7.9 for the four stations, and ranged from -1.3 at Station B4 to 13.2 at Station B3 (Table 5-2). The value for the station offshore of the discharge was 8.5, very near the study area mean.

Biomass. Biomass totaled 0.88 g and averaged 0.22 g per station (11 g/m^2), ranging from 0.09 g at Station B3 to 0.30 g at Station B4 (Table 5-2, Appendix F-4). About one-half of the total biomass was contributed by annelids.

Table 5-2. Infaunal community parameters. Mandalay Generating Station NPDES, 2008.

	Station					
Parameter	B1	B2	B3	B4	Total	Mean
Number of species						
Total	17	16	13	14	34	15
Rep. Mean	13	11	8	11		11
Rep. S.D.	0	1	1	0		
Number of individuals						
Total	56	54	43	75	228	57
Rep. Mean	28	27	22	38		29
Rep. S.D.	0	1	12	6		
Density (#/m^2)						2,850
Diversity (H')						
Total	2.46	2.42	1.93	1.92	2.58	2.26
Rep. Mean	2.26	2.00	1.65	1.82		1.93
Rep. S.D.	0.01	0.03	0.18	0.04		
Benthic Respose Index (BRI)						
Total	8.5	11.2	13.2	-1.3	5.9	7.9
Biomass (g)						
Total	0.22	0.27	0.09	0.30	0.88	0.22
Rep. Mean	0.11	0.13	0.04	0.15		0.11
Rep. S.D.	0.12	0.02	0.00	0.01		
g/m^2						11.00

Community Composition. Twelve species each represented 1% or more of the individuals in the infauna collection (Table 5-3 and Appendix F-2). These 12 species together were only 35% of the species in the collection but contributed 88% of the individuals. Four of the species occurred at all stations, while two species occurred at only two stations. All but one of the top 12 species occurred at Station B2, immediately downcoast of the generating station, while five of the top 12 were absent from Station B4. Only three phyla were represented among the most abundant species: six species were arthropods, four were annelids, and two were mollusks. The most abundant species was the polychaete annelid *Apoprionospio pygmaea*, followed by the ostracod *Euphilomedes longiseta* and the amphipod *Rhepoxynius menziesi*. These three species together comprised more than one-half of the individuals in the collection, even though *E. longiseta* was not found at Station B3.

Cluster Analyses. Normal (station) and inverse (species) cluster analyses were performed on the 12 most abundant species in the infauna collection (Table 5-3). The four study-area stations clustered into two groups, based on their relative abundances of the numerically dominant species (Figure 5-3). Stations B2 and B4, the two downcoast stations, clustered most closely together, while Stations B1 and B3 clustered together at almost the same level.

Table 5-3. The 12 most abundant infaunal species. Mandalay Generating Station NPDES, 2008.

		Station					Percent	Cum.
Phylum	Species	B1	B2	B3	B4	Total	Total	Percent
AN	*Apoprionospio pygmaea*	9	9	18	20	56	25	25
AR	*Euphilomedes longiseta*	1	10	-	26	37	16	41
AR	*Rhepoxynius menziesi*	11	7	8	8	34	15	56
AN	*Mediomastus acutus*	6	4	4	-	14	6	62
MO	*Tellina modesta*	2	6	-	6	14	6	68
AN	*Onuphis* sp A SCAMIT 1992	2	5	-	3	10	4	72
AR	*Mandibulophoxus gilesi*	5	1	3	-	9	4	76
MO	*Donax gouldii*	7	-	1	-	8	4	80
AR	*Anchicolurus occidentalis*	3	1	1	2	7	3	83
AN	*Scoloplos armiger* Cmplx	1	2	1	1	5	2	85
AR	*Americhelidium shoemakeri*	-	1	2	-	3	1	86
AR	*Eohaustorius sawyeri*	-	2	1	-	3	1	88

AN = Annelida; AR = Arthropoda; MO = Mollusca

The 12 most abundant species separated into three groups, based on their similarity of occurrence (Figure 5-3). Species Group A was comprised primarily of moderately abundant species, while Groups B and C included the more abundant species, except *Mediomastus acutus*, which fell into Group A. Groups B and C clustered together at a relatively high level, indicating a degree of dissimilarity in occurrence (Group C species occurred at all four stations while Group B species were absent from Station B3). The polychaete annelid *Onuphis* sp A and the clam *Tellina modesta* clustered most closely, due to their similarities in abundance at three stations.

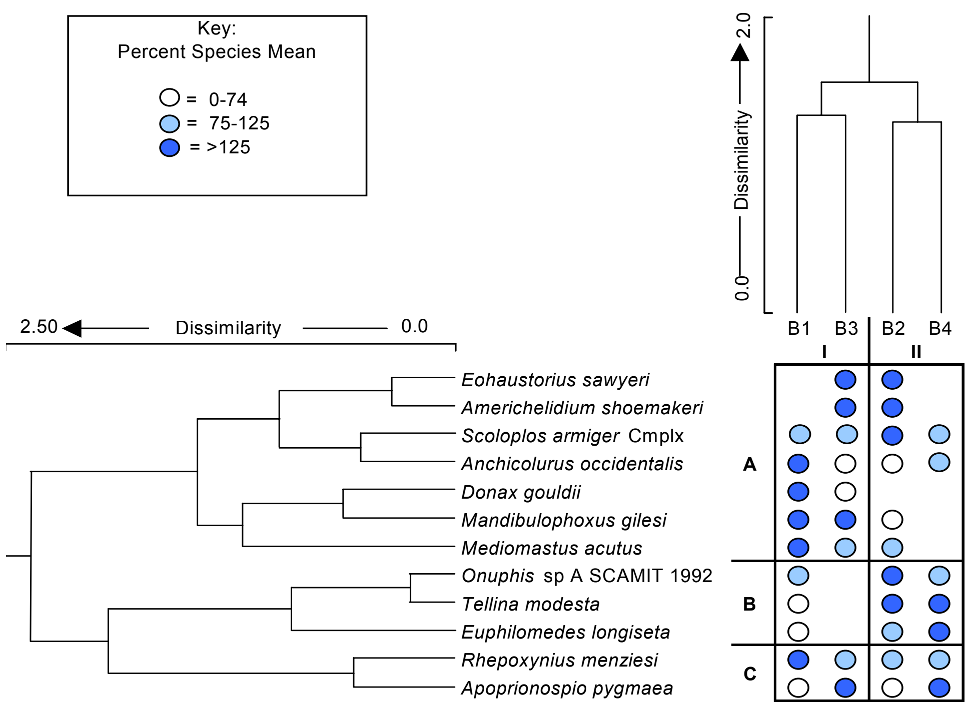


Figure 5-3. Two-way coincidence table resulting from normal (station) and inverse (species) classification dendrograms for the 12 most abundant infaunal species. Mandalay Generating Station NPDES, 2008.

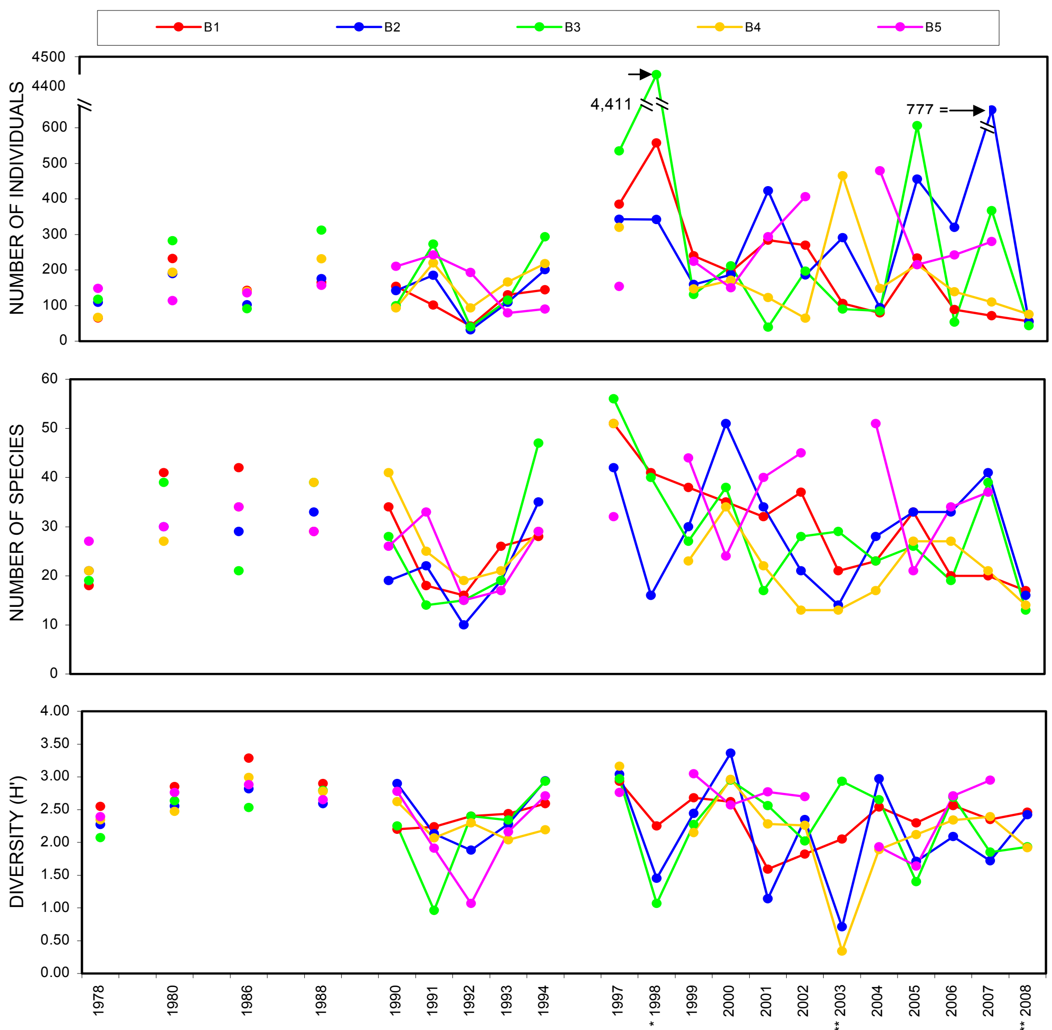
DISCUSSION

The infauna community in the study area in 2008 was comprised primarily of small annelid worms, arthropods, and mollusks. Abundance was highest farthest downcoast, but species richness and diversity were highest near the generating station discharge, with similar values immediately downcoast. Abundance, biomass and the Benthic Response Index value for the station nearest the discharge were near the average for the study area. Abundance, species richness, and biomass were lowest and the BRI value was highest upcoast of the generating station. All of the BRI values were at the low end of the range for the Reference category for the shallow coastal shelf, indicating undisturbed, or healthy, communities. In general, communities were similar among the four study-area stations. However, those at the two stations downcoast of the generating station were most alike, even though their abundances were quite different. The communities near and upcoast of the generating station were also similar to each other in composition, again despite differences in abundance and species richness.

Infaunal organisms reflect the substrate in which they live (Johnson 1970, Gray 1974). The coastline at the Mandalay Generating Station is exposed to ocean swell from both the south and west, and the shallow subtidal sediments are routinely subject to disturbance from normal wave activity and infrequent severe disturbance during storms. Sediments are generally coarse, with little organic matter, due to the winnowing effect of moving water. Usually, coarse sediments support smaller and less diverse infaunal communities than do finer sediments (Barnard 1963). This pattern was seen to some degree in the 2008 communities, as abundance and species richness were lower where sediments were coarser, upcoast of the generating station. In addition, abundance was highest where sediments were finest, farthest downcoast. However, species richness and diversity were relatively low at that location. In some circumstances, particle sorting plays a role in community characteristics, with poorly-sorted sediments providing more ecological niches. Sediments throughout the study area were moderately sorted, however, with little difference among stations. Species occupying the nearshore habitat are adapted to both coarse sediment and nearly constant disruption of the substrate (Oliver et al. 1980). Although small, they are capable of reburying themselves quickly if dislodged. Several of these species were abundant in 2008, including *Euphilomedes longiseta*, *Rhepoxynius menziesii* and other amphipods such as *Mandibulophoxus gilesi*, *Americhelidium shoemakeri*, and *Eohaustorius sawyeri*, the clams *Tellina modesta* and *Donax gouldii*, and the cumacean *Anchicolurus occidentalis*. In addition, their life history strategies, such as frequent and abundant production of young, allow them to rapidly repopulate habitat severely disrupted by winter storms.

Species that comprised the infauna communities in 2008 are typical of the shallow nearshore environment (Barnard 1963, Dexter 1978). *Apoprionospio pygmaea,* the most abundant species, is a generalist, living in tubes built below the shifting surface layer of sediment, and is wide-spread in sandy shallow-water habitats along the coast of southern California (MBC 2008a-d). It has been the most abundant species in the study area since 1978, although it was the top species in only 11 of the 21 summer surveys (Appendix F-5) (MBC 1979, 1981, 1986, 1988, 1990, 1994, 1997-2001a, 2002-2006a, 2007a; Ogden 1991-1993). Other commonly abundant species include *Mediomastus acutus*, Pacific sand dollar (*Dendraster excentricus*), the cumacean *Diastylopsis tenuis*, *Rhepoxynius menziesi*, the polychaete annelids *Scoloplos armiger*, *Chone eiffelturris*, *Spiophanes bombyx*, and *Owenia collaris*, the clam *Siliqua lucida*, the nemertean *Carinoma mutabilis*, and *Tellina modesta*. All of these except *Spiophanes bombyx*, *Owenia collaris*, and *Siliqua lucida* were found in the study area in 2008. A few species have occurred only sporadically but have been highly abundant in some years. Gould beanclam (*Donax gouldii*) was extremely abundant in 1998 but was seen in only six other years, and it was not abundant in any of those years. The ostracod *Euphilomedes carcharodonta* was very abundant in 1997 but has been seen in only five other surveys. Other inconsistently occurring but sometimes abundant species include the annelids *Magelona pitelkai*, *Goniada littorea*, and *Pectinaria californiensis*, *Mandibulophoxus gilesi*, *Americhelidium shoemakeri*, *Euphilomedes longiseta*, the sea anemone *Zaolutus actius*, and the amphipods *Photis macinerneyi* and *Rhepoxynius* sp A, only two of which were found in 2008. Despite these differences, comparison of the communities observed since 1978 shows that a core group of species has persisted. The Spearman rank correlation, based on the Index of Relative Importance, suggests that, based on the numerically dominant species, community composition in 2001 was very similar to those in most other years, including from 2002 to 2008, while the community in 1997 was least similar to those in other years (Appendix F-6).

In 2008, mean abundance for the study area, based on density of organisms, was about one-third that for the same four stations in 2007, and was slightly less than one-half the mean of 6,490 individuals/m^2 for those stations in summer surveys since 1978 (MBC 1979, 1981, 1986, 1988, 1990, 1994, 1997-2001a, 2002-2006a, 2007a; Ogden 1991-1993). Abundances have usually been similar among stations, although values have differed considerably among stations in some years, particularly in 1997 and 1998 and from 2001 to 2007 (Figure 5-4). (Values for 2003 and 2008 would be about twice those indicated in Figure 5-4 if four replicates had been collected at each station instead of only two.) Highest abundance has usually been found either immediately upcoast or



Sampling was not required in years not shown; * 1998 - only three stations required; **2003 and 2008 only four stations and two reps required.

Figure 5-4. Comparison of infaunal community parameters, 1978 - 2008. Mandalay Generating Station NPDES, 2008.

downcoast of the generating station and, on average, abundance has been lowest near the generating station discharge. The high value for Station B3 in 1998 was due to extremely high numbers of Gould beanclam; with beanclams excluded because of their extraordinary abundance in that year, mean density for the four study-area stations would be 5,580 individuals/m^2. Species richness and diversity have also been dissimilar among stations in some years, with extremely wide ranges in numbers of species in 1998, 2000, 2002, and 2004, and in diversity in 2001 and 2003. On average, species richness has been equally high at and immediately upcoast of the generating station, while species diversity has been highest nearest the discharge. Species richness has generally been lowest farthest downcoast and species diversity has been lowest immediately upcoast of the generating station. Mean species richness in 2008 was considerably below that for the same four stations in 2007 but was only slightly below the long-term mean. Mean species diversity, however, was greater than that in 2007 and was very near the long-term mean. The mean of the BRI values was slightly lower than both that in 2007 and the mean since 2006, the first year in which the index was used.

Despite the occasional disparities noted above, the long-term means have been similar throughout the study area, indicating that the infaunal community has been quite consistent. The year-to-year fluctuations have generally been area-wide. Biological events such as settlement of new recruits, competition, or failure to reproduce, combined with natural oceanographic events, result in occasionally large spatial or temporal changes in abundance and community composition.

CONCLUSION

The infauna communities in the nearshore shallow subtidal environment in the vicinity of the Mandalay Generating Station in 2008 were similar to those found in previous studies conducted since 1978. The communities were typical of the nearshore habitat in the Southern California Bight, and the Benthic Response Index values for all stations indicated that the communities were healthy. Infaunal parameters appeared to be somewhat related to sediment characteristics, as values for most infaunal parameters were lowest where sediments were coarsest, upcoast of the generating station, and abundance was highest farthest downcoast where sediments were finest. However, species richness was highest near the generating station discharge, where sediments were about average for the study area. No adverse pattern related to the generating station discharge was apparent.

CHAPTER 6 — DEMERSAL FISH AND MACROINVERTEBRATES

In recent years, demersal fish and macroinvertebrate communities have come under greater scrutiny due to their close proximity to potentially impacted sediments. Numerous sites associated with discharges, either from municipal wastewater treatment plants or power plant once through cooling water systems, are the subject of ongoing monitoring within the Southern California Bight (Cross and Allen 1993). Trawl surveys of the demersal fish and macroinvertebrate assemblages within the receiving waters of Mandalay Generating Station began in 1971, with a total of eight surveys from 1971 to 1988. Beginning in 1990, surveys were conducted annually during winter and summer, as required by National Pollutant Discharge Elimination System permit requirements. The goal of this monitoring is to assess the effects of the heated seawater discharged from the station on the local marine fauna. Intra-annual and interannual variation was examined to assess the composition and stability of the populations within the receiving waters.

MATERIALS AND METHODS

In exchange for supporting the Bight ‘08 Regional Monitoring Program, only summer trawls were conducted in 2008 (Appendix A). Otter trawl sampling for fishes and macroinvertebrates was conducted at Stations T1 through T4 on 19 September 2008 between 0730 and 1030 hours. Skies were clear with winds from the west at 10 to 12 knots. Seas were west at 4 to 6 ft.

Trawl paths for the four stations were parallel to the shoreline along the 20-ft isobath (Figure 6-1). Stations T2 and T3 were centered 1,180 ft upcoast and downcoast of the discharge, respectively, with portions of the trawl path directly offshore the discharge. Stations T1 and T4 acted as reference sites and were centered approximately 5,910 ft upcoast and downcoast of the discharge. Two replicate tows were made at each station with a 25-ft wide semi-balloon otter trawl net. The headrope was equipped with regularly spaced floats, while the footrope was weighted with chain and equipped with plastic rollers to reduce fouling. The body of the net consisted of 1.5-inch (in) bar mesh with a 0.5-in bar mesh liner in the cod end.

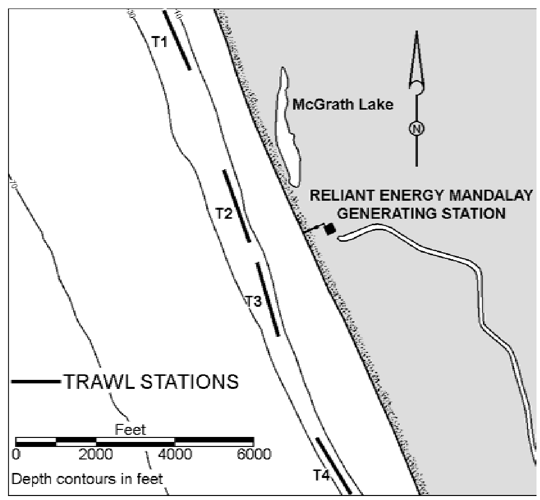


Figure 6-1. Location of the trawl sampling stations. Mandalay Generating Station NPDES, 2008.

During each replicate, the otter trawl net was towed at 2.0 to 2.5 knots for ten minutes. Time was measured from the point at which the net began fishing at the bottom to the time retrieval began. Fish and epibenthic macroinvertebrates from each catch were separated from debris and identified to the lowest possible taxonomic category. Up to 200 individual fish of each species were measured to the nearest millimeter (mm) standard length (SL), disc width (DW) or total length (TL), where appropriate and examined for external parasites, anatomical anomalies, or other abnormalities. Aggregate weight, in kilograms (kg), was recorded by species. All individuals of species represented by 200 individuals or less were weighed; for species with more than 200 per trawl, the 200 measured individuals were weighed separately from the remaining fish. Total species abundance was then estimated based on the weight of the 200 measured individuals by the following equation: Estimated abundance = (Unmeasured Fish Weight)/(Mean Weight of Measured Individuals). Macroinvertebrates were counted and aggregate weights recorded. In cases of high abundance (>200 individuals), the total abundance was estimated in the same fashion as was used for fish. Specimens were returned to the sea after processing, except in cases of rare occurrence or uncertain identity. These individuals were retained for later confirmation and inclusion in the MBC voucher collection.

All field data were recorded on preprinted data sheets and later entered into Microsoft Excel spreadsheets. In-house quality assurance/quality control (QA/QC) protocols were followed to ensure accurate transcription into digital format. Descriptive (summary) statistics were performed using Microsoft Excel. Summary statistics included abundance, biomass, number of species, Shannon-Wiener species diversity index (H'; Shannon and Weaver 1962), and evenness index (J': Pielou 1977). The index of community importance (ICI) (Allen et al. 2002) was calculated for the ten most abundant fish species and five most abundant macroinvertebrate species taken during annual trawl surveys, 1990-2008.

Species and station relationships for fish were graphically derived through hierarchical clustering analysis and two-way coincidence tables. A minimum of 10 individuals per species was used as the criterion for inclusion in the cluster analysis. Abundance was natural log (ln+1) transformed before the calculation of the inter-entity distance (dissimilarity) matrix. Cluster diagrams were drawn based on these dissimilarities. In this analysis, a dissimilarity value of 1.5 was determined *a priori* as the minimal value indicating a significant separation between faunal and station groups.

Length frequency histograms were created to examine potential age structure of the sampled assemblage. The five most abundant species overall were included in the length frequency analysis. Individual lengths were rounded to the nearest 10-mm (i.e., 35-44 mm SL = 40 mm SL) for inclusion in the length frequency histograms.

RESULTS

Monitoring data are presented in both tabular and graphical format. The complete 2008 data records, including fish lengths by centimeter size class, are presented in Appendix G. Bottom water temperatures during the trawls ranged from 15.5°C at Station T4 to 16.7°C at Station T2, but the temperatures were above 16.4°C at all stations other than Station T4.

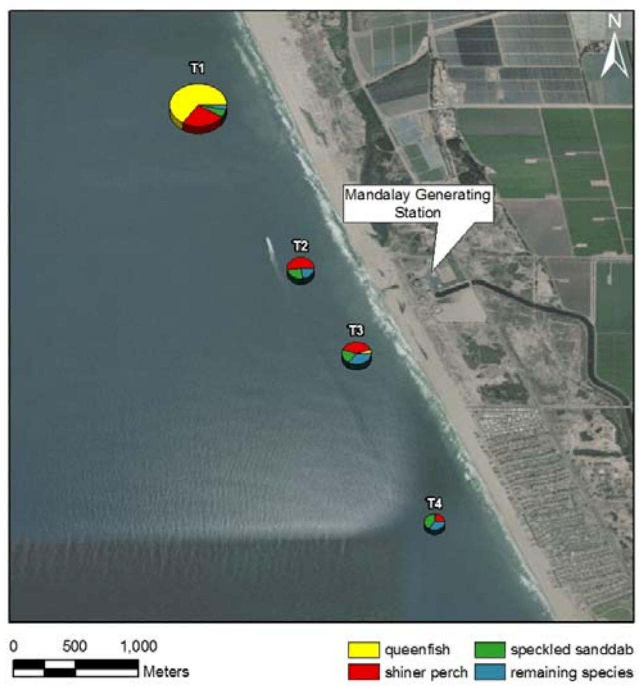


Figure 6-2. Proportional abundance of fishes caught in trawl sampling. Pie charts size based on total relative abundance. Mandalay Generating Station NPDES, 2008.

Fish

In 2008, a total of 1,010 fish of 17 species weighing 21.40 kg was recorded during otter trawl sampling (Tables 6-1 and 6-2). Overall fish species diversity was 1.55, while evenness was 0.55. Sampling at Station T1 collected 62% of the abundance and 77% of the biomass, with 623 fish weighing 16.41 kg (Figure 6-2). The catch at Station T3 ranked second in abundance with 163 individuals taken, while Station T2 ranked second in biomass with 2.23 kg. Lowest abundance and biomass in 2008 was reported at Station T4 with 80 individuals weighing 0.55 kg. Species diversity was highest at Station T3 (*H'* = 1.89) and lowest at Station T1 (*H'* = 0.96), while evenness was highest at Station T4 (*J'* = 0.93) and lowest at Station T1 (*J'* = 0.40).

Table 6-1. Abundance and catch parameters for fish species taken by otter trawl. Mandalay Generating Station NPDES, 2008.

Species	T1	T2	T3	T4	Total	% Total
queenfish	400	-	7	-	407	40
shiner perch	171	75	67	19	332	33
speckled sanddab	32	37	30	33	132	13
kelp pipefish	1	6	9	20	36	4
pricklebreast poacher	5	14	16	-	35	3
barcheek pipefish	3	-	5	8	16	2
walleye surfperch	-	2	12	-	14	1
barred surfperch	2	5	3	-	10	1
northern anchovy	3	2	5	-	10	1
Pacific staghorn sculpin	1	-	6	-	7	1
bat ray	4	-	-	-	4	<1
California halibut	-	-	2	-	2	<1
thornback	1	-	-	-	1	<1
shovelnose guitarfish	-	1	-	-	1	<1
Pacific angel shark	-	1	-	-	1	<1
California lizardfish	-	1	-	-	1	<1
fantail sole	-	-	1	-	1	<1
Total Abundance	623	144	163	80	1,010	
Number of Species	11	10	12	4	17	
Diversity (H')	0.96	1.39	1.89	1.28	1.55	
Evenness (J')	0.40	0.60	0.76	0.93	0.55	

Table 6-2. Biomass (kg) of fish species taken by otter trawl. Mandalay Generating Station NPDES, 2008.

Species	T1	T2	T3	T4	Total	% Total
bat ray	8.30	-	-	-	8.30	39
queenfish	6.14	-	0.11	-	6.25	29
shiner perch	0.83	0.51	0.60	0.21	2.15	10
speckled sanddab	0.31	0.54	0.40	0.25	1.50	7
Pacific angel shark	-	0.90	-	-	0.90	4
thornback	0.70	-	-	-	0.70	3
California halibut	-	-	0.47	-	0.47	2
Pacific staghorn sculpin	0.05	-	0.21	-	0.26	1
pricklebreast poacher	0.02	0.07	0.08	-	0.17	1
barred surfperch	0.02	0.07	0.05	-	0.14	1
walleye surfperch	-	0.03	0.10	-	0.13	1
kelp pipefish	0.00	0.02	0.04	0.07	0.12	1
fantail sole	-	-	0.11	-	0.11	1
northern anchovy	0.03	0.01	0.04	-	0.08	<1
shovelnose guitarfish	-	0.07	-	-	0.07	<1
barcheek pipefish	0.01	-	0.01	0.02	0.04	<1
California lizardfish	-	0.02	-	-	0.02	<1
Total Biomass (kg)	16.41	2.23	2.22	0.55	21.40	

Note: 0.00 = < 0.005, Anomalies due to rounding

Queenfish (*Seriphus politus*) was the most abundant species taken in 2008 with 407 individuals, all but seven of which were recorded at Station T1 (Table 6-1). Shiner perch (*Cymatogaster aggregata*) and speckled sanddab (*Citharichthys stigmaeus*) ranked second and third in abundance with 332 and 132 individuals, respectively. Both species were widely distributed across the sampling area, although shiner perch were much more abundant at Station

T1 (Figure 6-2). Each of the remaining 14 species contributed less than 5% to the total abundance or 139 fish, cumulatively.

Four bat rays (*Myliobatis californica*) taken at Station T1 contributed the most to biomass for the survey at 8.30 kg, or 39% of the total (Table 6-2). Queenfish accounted for an additional 29%, or 6.25 kg, with 98% taken at Station T1. The remaining two highly abundant species, shiner perch and speckled sanddab, contributed the third and fourth most weight to the catch with 2.15 kg and 1.50 kg each, respectively. Each of the remaining 13 species contributed 0.90 kg, or less.

Nine species were included in the cluster analysis forming three groups while the four stations divided into two groups (Figure 6-3). Group A included four species that were absent at Station T4 (Group II) and generally abundant at the remaining three stations (Group I). The four species in Group B were generally cosmopolitan across the sampling area and were the only species collected in high enough numbers at Station T4 to be included in the analysis. The most abundant species, queenfish, formed Group C largely based on its very high abundance at Station T1 and absence at Stations T2 and T4. Stations T1 and T3 were both in Group I, but they exhibited less dissimilarity than any other station pair, largely due to the distribution of queenfish.

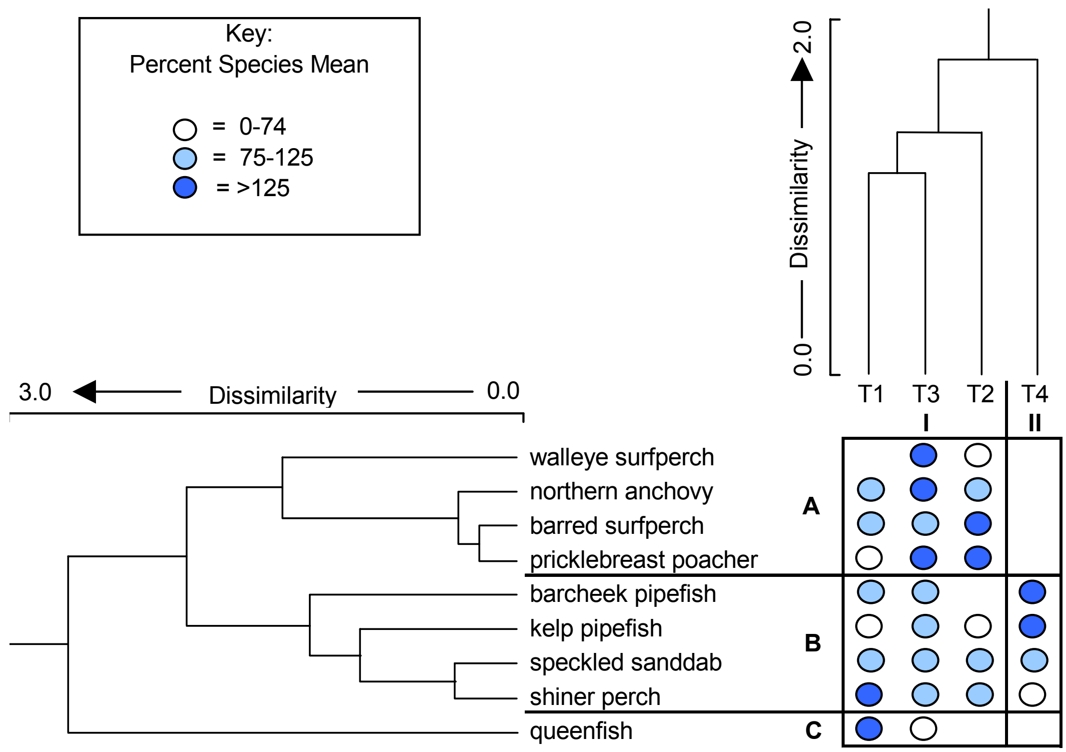


Figure 6-3. Two-way coincidence table resulting from normal (station) and inverse (species) classification dendrograms for fish taken by otter trawl. Mandalay Generating Station NPDES, 2008.

Fish Length

Fishes taken during the 2008 trawl sampling ranged from a 25-mm SL speckled sanddab to a 770-mm DW bat ray (Table 6-3). The 239 queenfish that were measured in 2008 ranged in size from 82 mm to 148 mm SL with a mean length of 99 mm SL. Their length-frequency distribution indicated eight 10-mm size classes, with most in the 100-mm SL size class (Figure 6-4). Shiner perch (n = 332) taken in 2008 averaged 61 mm SL ranging from 38 to 107 mm SL.

Table 6-3. Measured length (mm) of fish species taken by otter trawl. Mandalay Generating Station NPDES, 2008.

Species	Number	Min	Max	Mean	SD
barcheek pipefish	16	181	232	207	15
barred surfperch	10	71	85	78	5
bat ray*	4	660	770	715	45
California halibut	2	222	255	239	23
California lizardfish	1	146	146	146	-
fantail sole	1	185	185	185	-
kelp pipefish	36	179	264	215	22
northern anchovy	10	64	121	95	19
Pacific angel shark**	1	440	440	440	-
Pacific staghorn sculpin	7	105	141	124	14
pricklebreast poacher	35	65	95	83	7
queenfish	239	82	148	99	9
shiner perch	332	38	107	61	10
shovelnose guitarfish**	1	240	240	240	-
speckled sanddab	132	25	112	85	15
thornback**	1	485	485	485	-
walleye surfperch	14	66	80	71	3

* = Disc Width, ** = Total Length

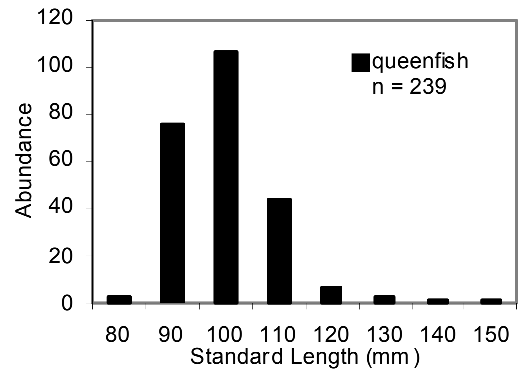


Figure 6-4. Length frequency analysis for queenfish collected by otter trawl sampling. Mandalay Generating Station NPDES, 2008.

Length frequency analysis found most of the individuals taken were in the 60-mm SL size class (Figure 6-5). A total of 132 speckled sanddab were measured in 2008, with individuals ranging from 25 to 112 mm SL and mean length of 85 mm SL. Their lengths fit a bimodal distribution with peak abundances in the 80- and 100-mm SL size classes (Figure 6-6).

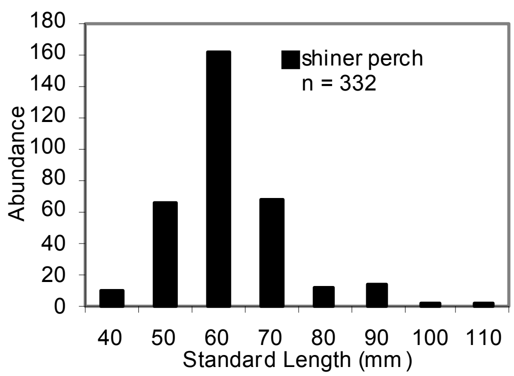


Figure 6-5. Length frequency analysis for shiner perch collected by otter trawl sampling. Mandalay Generating Station NPDES, 2008.

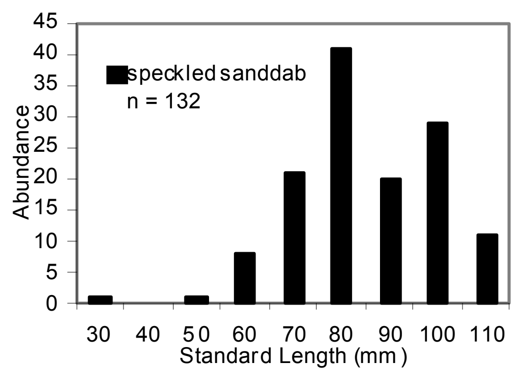


Figure 6-6. Length frequency analysis for speckled sanddab collected by otter trawl sampling. Mandalay Generating Station NPDES, 2008.

Macroinvertebrates

A total of 799 macroinvertebrates weighing 2.66 kg representing nine species were recorded during the 2008 trawl survey (Table 6-4). Abundance was generally similar across all stations, with trawls at Stations T1 and T3 collecting slightly more than 200 individuals and trawls at Stations T2 and T4 averaging slightly less. Species richness ranged from two (Station T1) to seven (Station T3). Four species each were taken at Stations T2 and T4. Species diversity was low overall (H' = 0.16) and ranged from H' = 0.03 at Station T1 to H' = 0.20 at Station T3. Species evenness was similarly low, with all stations less than J' = 0.15. Biomass was highest at Station T3 (1.50 kg) but generally low (< 0.55 kg) at the remaining three stations.

Blackspotted bay shrimp (*Crangon nigromaculata*) accounted for nearly the entire 2008 catch (97%) with 779 individuals (Table 6-4). They occurred in similar abundances at all stations during the survey. Graceful crab (*Metacarcinus gracilis*) was the only other macroinvertebrate species collected at all four stations. It contributed another 1% to overall abundance with 11 individuals taken. The remaining seven species each contributed less than 1% of the total catch, or nine individuals, cumulatively.

Table 6-4. Abundance and catch parameters for macroinvertebrate species taken by otter trawl. Mandalay Generating Station NPDES, 2008.

Species	T1	T2	T3	T4	Total	% Total
blackspotted bay shrimp	220	180	203	176	779	97
graceful crab	1	3	2	5	11	1
sheep crab	-	1	1	-	2	<1
yellow crab	-	1	1	-	2	<1
mottled pea crab	-	-	1	-	1	<1
California spiny lobster	-	-	1	-	1	<1
cryptic kelp crab	-	-	1	-	1	<1
sea pansy	-	-	-	1	1	<1
Pacific rock crab	-	-	-	1	1	<1
Total Abundance	221	185	210	183	799	
Number of species	2	4	7	4	9	
Diversity (H')	0.03	0.15	0.20	0.19	0.16	
Evenness (J')	0.04	0.11	0.11	0.14	0.07	
Biomass (kg)	0.41	0.52	1.50	0.23	2.66	
Fish parasites (not included above):						
none	-	-	-	-	-	

DISCUSSION

In 2008, 1,010 individual fish from 17 species weighing 21.4 kg were collected during trawl surveys of the demersal community in the receiving waters offshore of the Mandalay Generating Station discharge channel. Comparisons with summer surveys since 1990 ranks the 2008 fish abundance/minute fished as the fourth lowest since 1990 (Figure 6-7). The historic variability in catch rates was primarily influenced by the abundances of white croaker (*Genyonemus lineatus*) and queenfish, although northern anchovy (*Engraulis mordax*) has been taken in high abundances on a few occasions. Recently, including

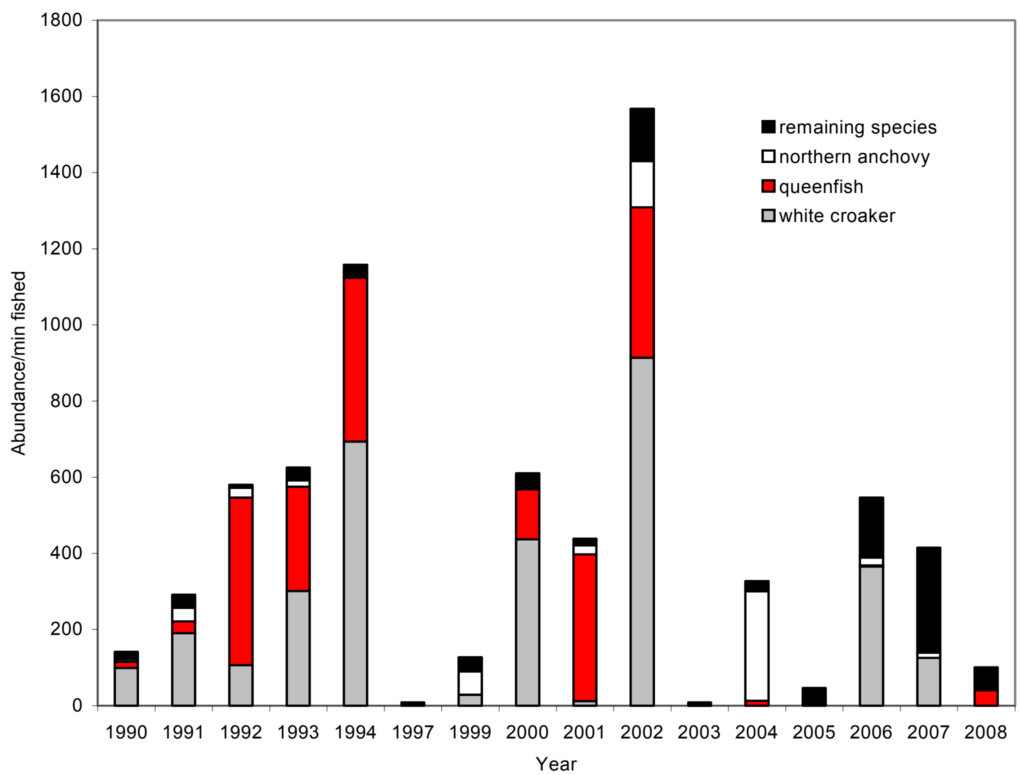


Figure 6-7. Abundance/min fished of white croaker, queenfish, northern anchovy, and the remaining species taken during summer otter trawl sampling, 1990-2008. Mandalay Generating Station NPDES, 2008.

2008, shiner perch and speckled sanddab have become more abundant as queenfish and white croaker abundances have declined (Figure 6-8). The catch rate for both species in 2008 was less than their peak values recorded in 2007, but still more than most summer surveys since 1990.

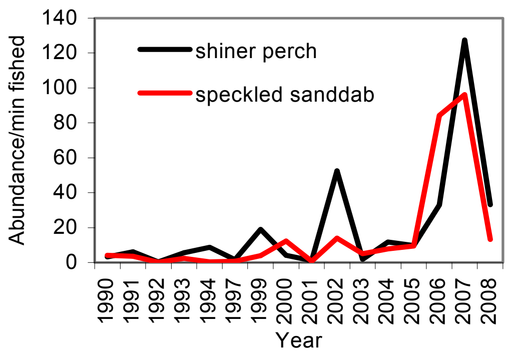


Figure 6-8. Abundance/min fished of shiner perch and speckled sanddab taken during summer otter trawl sampling, 1990-2008. Mandalay Generating Station NPDES, 2008.

Spatially, few fish were captured in the cooler (15.5°C) area at Station T4, while generally similar catches were made at the remaining stations where temperatures were similar between 16.4 and 16.7°C. Queenfish were predominantly taken upcoast of the discharge (Station T1, 16.6°C), with only seven additional individuals recorded downcoast of the discharge at Station T3 (16.4°C). Shiner perch also indicated a preference for the 16°C plus waters, but it was recorded in the cooler area as well. Speckled sanddab was generally cosmopolitan across the isotherms, while kelp pipefish (*Syngnathus californiensis*) was substantially more abundant in the cooler water.

Since 1990, a core species group has dominated the demersal community offshore of Mandalay Generating Station (Table 6-5). Historically, queenfish and white croaker have consistently been the two most dominant species, however, since the 1997-1998 El Niño their populations have been more variable and, in general, in decline (Figure 6-7; Miller et al. in review [a]). Since 1997, shiner perch, kelp pipefish, and speckled sanddab have increased in their community importance, often overshadowing white croaker and queenfish. In 2008, queenfish and shiner perch tied for the first rank in community importance, largely due to the abundance and frequency of occurrence at each of the sampling stations. Comparisons between sampling years based on species dominance reflects this discontinuity between demersal fish communities found prior to and since 1997 (Table 6-5). While significant correlations were found between fish communities during the years from 1990 to 1994, since 1997, few correlations were found between years. The assemblage collected in 2005 was negatively correlated with the results for 1990 through 1992. Results from 2008 were significantly related to 2003 (a reduced effort Regional Monitoring year) and 2004 (normal sampling), but not 1997 (reduced effort).

Queenfish was the most abundant species taken during the 2008 trawl survey (Table 6-1). Since 1990, queenfish has been among the most dominant species in total abundance and community importance (Table 6-5 and Figure 6-7). Individuals taken in 2008 were largely comprised of fish near their first birthday, based on the length frequency analysis (Miller et al. in review [b]). Overall, queenfish populations throughout the Southern California Bight have been in decline since the mid-1970s when the oceanographic regime shifted from cool to warm (McGowan et al. 1993, Miller et al. in review [a]). The large 1997-1998 El Niño and 1999 La Niña both appeared to negatively impact area queenfish populations (Miller et al. in review [a]).

Considered a habitat generalist, queenfish is abundant over soft substrate, such as that present offshore of Mandalay (Allen 1982, Allen 1985), ranging from Baja California, Mexico to the Oregon Coast (Miller and Lea 1972). Nocturnal in nature, queenfish aggregate in dense schools during daylight hours, then disperse and actively feed on mysids and gammaridean amphipods at night (Hobson and Chess 1976). During day-night studies, impingement of queenfish has been shown to be much greater at night (SCE 1986). Allen and DeMartini (1983) observed consistently higher abundances of queenfish during night trawls.

Table 6-5. Rank of index of community importance for the top ten fish species collected during trawl surveys and contingency table of Spearman's coefficient of rank correlations by years. Mandalay Generating Station NPDES, 2008.

Species	1990	1991	1992	1993	1994	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
queenfish	2	2	1	1	1	6	3	1	1	1	2	2	3	3	4	1
white croaker	1	1	2	2	1	2	1	1	3	1	5	6	4	1	2	6
northern anchovy	3	2	3	4	4	5	1	6	2	3	1	1	6	4	2	3
shiner perch	4	5	6	5	3	2	3	5	6	4	1	3	1	2	1	1
thornback	3	3	6	3	3	2	2	4	4	3	7	4	3	2	2	4
kelp pipefish	7	7	7	7	7	7	2	2	2	2	2	2	2	2	2	2
speckled sanddab	4	6	7	6	8	3	5	3	8	7	1	4	1	2	2	3
walleye surfperch	6	3	5	4	5	4	7	5	4	7	4	4	2	4	6	4
white seaperch	3	3	3	6	3	3	4	7	7	4	6	7	3	5	7	7
barred surfperch	4	3	4	6	5	4	10	7	9	9	7	5	3	10	7	6
1990	-	**0.83**	**0.78**	**0.73**	**0.84**	0.32	0.48	0.26	0.30	0.57	-0.19	-0.20	**-0.72**	0.15	-0.01	-0.21
1991	-	-	**0.92**	**0.80**	**0.72**	0.07	0.38	0.11	0.40	0.44	-0.24	-0.11	**-0.85**	-0.11	-0.22	-0.30
1992	-	-	-	**0.64**	**0.75**	-0.08	0.20	0.03	0.36	0.41	-0.22	-0.15	**-0.75**	-0.29	-0.41	-0.25
1993	-	-	-	-	**0.76**	0.22	0.39	0.44	0.52	0.54	-0.08	0.11	-0.48	0.25	0.11	0.10
1994	-	-	-	-	-	0.36	0.44	0.26	0.38	**0.62**	-0.23	-0.15	-0.51	0.19	0.04	-0.05
1997	-	-	-	-	-	-	0.07	-0.05	-0.48	-0.13	-0.23	-0.58	0.08	0.42	0.33	-0.34
1999	-	-	-	-	-	-	-	0.44	**0.70**	**0.83**	0.21	0.37	-0.52	0.58	0.62	0.20
2000	-	-	-	-	-	-	-	-	0.59	**0.72**	0.22	0.25	0.07	**0.79**	0.43	0.44
2001	-	-	-	-	-	-	-	-	-	**0.86**	0.28	**0.65**	-0.38	0.30	0.27	0.49
2002	-	-	-	-	-	-	-	-	-	-	0.10	0.33	-0.45	0.54	0.36	0.30
2003	-	-	-	-	-	-	-	-	-	-	-	**0.68**	0.36	0.28	0.60	**0.75**
2004	-	-	-	-	-	-	-	-	-	-	-	-	0.07	0.11	0.47	**0.86**
2005	-	-	-	-	-	-	-	-	-	-	-	-	-	0.21	0.24	0.43
2006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0.80**	0.34
2007	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.59

Shiner perch was the second most abundant fish species in 2008, with the third highest summer abundance/min fished since 1990 (Figure 6-8). In recent years, shiner perch has become much more abundant, often ranking first in community importance (Figure 6-8 and Table 6-5). Historically, shiner perch has been periodically abundant in southern California, especially during colder water years such as 1999 and 2000. The species ranges from San Quintin, Baja California, to Alaska, in depths from the surface to 480 ft (Miller and Lea 1972). Allen (1985) observed the shiner perch distribution to encompass all soft substrates throughout its range, with a notably low abundance in the vicinity of kelp bed and rocky reef habitats. In regional demersal fish monitoring conducted throughout the Southern California Bight, shiner perch were somewhat more abundant in 1998, accounting for 0.7% of the demersal fish catch, compared to 2003 when they contributed 0.4% to the overall abundance (Allen et al. 2002, Allen et al. 2007). Previous age and growth information (Odenweller 1975) reported shiner perch in the Age-I class to average 56.8 mm SL and Age-II class fish to average 87.8 mm SL. These data indicate most of the individuals caught in trawls offshore of Mandalay in 2008 were approximately one year old (Figure 6-5).

In 2008, speckled sanddab was the third most abundant fish species collected (Table 6-1). It is the fourth most abundant species in the area, long-term, and has been taken during every survey year (Figure 6-8). In regional sampling, speckled sanddab abundances increased between 1998 and 2003, accounting for 1.8 and 11% of the total fish catch, respectively (Allen et al. 2002, Allen et al. 2007), suggesting that the species has recently increased in abundance in southern California. Since 2002, speckled sanddab has been a more important member of the local demersal fish community, ranking no less than fourth in any year (Table 6-5). Prior to 2002, speckled sanddab typically ranked fifth or lower in community importance, although there were exceptions.

Speckled sanddab is a non-schooling species commonly associated with soft-bottom habitats throughout the shallow nearshore environment of southern California (Allen 1982, Allen 1985). A sandy-bottom species that feeds mainly during the day, speckled sanddab hunts primarily by sight on epifaunal invertebrates (Ford 1965, Allen 1982). This typically small sanddab has not been an important part of the commercial catch, although it is present in some of the commercial landings. Sanddabs, however, are frequently sought by recreational anglers (Allen and Leos 2001). The similarity of abundances among years of this species suggests that the fish assemblage of the nearshore, soft-bottom community remains stable in the area. The bimodal distribution in the length frequency distribution suggests two cohorts, or possibly two year classes were sampled in 2008.

In 2008, a total of 799 macroinvertebrate individuals were collected from nine species, although blackspotted bay shrimp accounted for nearly all of the abundance (97%). No spatial distribution pattern was apparent in the macroinvertebrate catches. Total catch at all four stations fluctuated around 200 individuals and blackspotted bay shrimp was highly dominant at each station. The macroinvertebrate catch rate in 2008 was the lowest recorded in summer surveys since 2004, and substantially lower than the last two years (Figure 6-9). The numerical dominance of blackspotted bay shrimp in 2008 was consistent with recent years, such as in 2007 when it represented 94% of all macroinvertebrates taken during winter and summer trawl sampling (MBC 2007a). Historically, Pacific sand dollar (*Dendraster excentricus*) was commonly dominant in the local macroinvertebrate community, but this pattern shifted in 2003, and blackspotted bay shrimp have dominated the local community since (Table 6-6 and Figure 6-9).

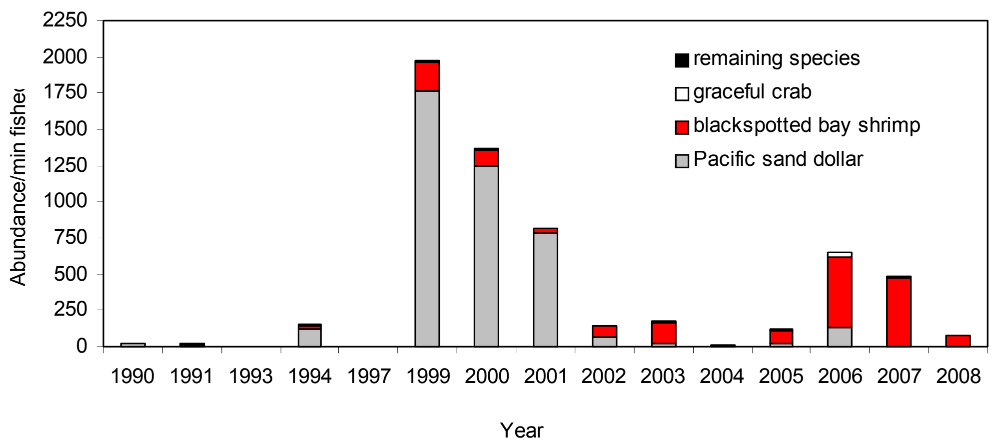


Figure 6-9. Abundance/min fished of Pacific sand dollar, blackspotted bay shrimp, graceful crab, and the remaining species taken during summer otter trawl sampling, 1990-2008. Mandalay Generating Station NPDES, 2008.

Blackspotted bay shrimp is common in trawl surveys in southern California, and annual abundance off some areas of California has varied widely, sometimes by more than tenfold (Siegfried 1989). In regional trawl monitoring conducted throughout the Southern California Bight in 1998, blackspotted bay shrimp was the most abundant macroinvertebrate species collected on the inner shelf, accounting for 0.7% of the total macroinvertebrate catch (Allen et al. 2002). In 2003 regional monitoring, blackspotted bay shrimp was the most abundant macroinvertebrate species collected in bays and harbors, accounting for 1.2% of the total macroinvertebrate catch (Allen et al. 2007). The species plays an important role in the coastal food web, feeding on small epibenthic and benthic fauna over mud and sand bottoms. In turn, blackspotted bay shrimp are preyed on by a number of fish, including Pacific staghorn sculpin (*Leptocottus armatus*), brown smoothhound (*Mustelus henlei*) and white croaker (Ware 1979, Siegfried 1989). Ovigerous females (those with eggs) are found in coastal embayments in summer but are uncommon in winter. Seasonal migrations of some crangonid shrimp have been linked to changing seawater temperatures (Siegfried 1989).

Table 6-6. Rank of index of community importance for the five invertebrate species collected during trawl surveys and contingency table of Spearman's coefficient of rank correlations by years. Mandalay Generating Station NPDES, 2008.

Species	1990	1991	1993	1994	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Pacific sand dollar	1	1	2	1	1	1	1	1	1	2	1	2	3	4	3
blackspotted bay shrimp	4	2	1	2	2	2	2	2	2	1	3	1	1	1	1
graceful crab	3	3	3	3	3	4	3	3	3	3	2	3	2	2	2
tuberculate pear crab	5	3	3	4	3	3	4	4	4	4	4	4	4	3	3
sand star	2	3	3	5	3	5	5	5	5	5	5	5	5	4	3
1990	-	0.45	0.11	0.30	0.45	0.10	0.30	0.30	0.30	0.00	0.40	0.00	-0.20	-0.67	-0.34
1991	-	-	0.88	0.89	**1.00**	0.89	0.89	0.89	0.89	0.78	0.67	0.78	0.45	-0.06	0.13
1993	-	-	-	0.78	0.88	0.78	0.78	0.78	0.78	0.89	0.45	0.89	0.67	0.34	0.50
1994	-	-	-	-	0.89	0.90	**1.00**	**1.00**	**1.00**	0.90	0.90	0.90	0.70	0.21	0.34
1997	-	-	-	-	-	0.89	0.89	0.89	0.89	0.78	0.67	0.78	0.45	-0.06	0.13
1999	-	-	-	-	-	-	0.90	0.90	0.90	0.80	0.70	0.80	0.50	0.10	0.11
2000	-	-	-	-	-	-	-	**1.00**	**1.00**	0.90	0.90	0.90	0.70	0.21	0.34
2001	-	-	-	-	-	-	-	-	**1.00**	0.90	0.90	0.90	0.70	0.21	0.34
2002	-	-	-	-	-	-	-	-	-	0.90	0.90	0.90	0.70	0.21	0.34
2003	-	-	-	-	-	-	-	-	-	-	0.70	**1.00**	0.90	0.56	0.67
2004	-	-	-	-	-	-	-	-	-	-	-	0.70	0.60	0.10	0.22
2005	-	-	-	-	-	-	-	-	-	-	-	-	0.90	0.56	0.67
2006	-	-	-	-	-	-	-	-	-	-	-	-	-	0.82	0.89
2007	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0.92**

CONCLUSION

Fish and macroinvertebrate species composition were similar to those in past surveys in the study area. This similarity of species composed primarily of frequently occurring and long-term dominant species indicates a relatively stable assemblage typical of the nearshore, soft-bottom community remains in the area. Fish and macroinvertebrate abundances were lower than those found in recent summer surveys, but within the range found previously in the area. While spatial differences were apparent, variability in fish and macroinvertebrate communities in the area appeared to be related to natural differences in local fish and macroinvertebrates populations. There is no indication that plant operations have adversely affected the fish or macroinvertebrate populations offshore of the Mandalay Generating Station.

CHAPTER 7 — IMPINGEMENT

Once through cooling water systems are commonly used by electric power generating stations sited adjacent to large water bodies (e.g., lake, river, bay, coastal ocean). Such systems may potentially entrap organisms present in the source water entrained into the cooling system. Cooling water is typically screened prior to entering the condensers to remove material that may interfere with the proper operation of the system.

Mandalay Generating Station is located on the coast approximately 4.8 km west of the City of Oxnard, California. Two units are supplied by the once through cooling (OTC) water system. Cooling water is supplied to the system via Edison Canal, a 4-km long canal which connects to Channel Islands Harbor at its northern end, located approximately 4.8 km downcoast of the generating station. Water enters the plant through two angled 5.9 meter-wide intake bays. Debris is removed as cooling water passes through two pairs of trash racks, with 57 mm mesh, as well as two pairs of vertical slide screens, which measured 3.5 meters wide by 6.4 meters high with 12.7 mm mesh. The slide screens are operated parallel to one another and perpendicular to the intake flow. One slide screen is deployed while the other is cleaned of debris by a high pressure wash that automatically activates by pressure differential across the screen. All debris was accumulated in a trash basket where impingement samples were taken.

Impingement was monitored by Proteus Sea Farms International, Inc., Ojai, California, during two distinct operational modes, normal operation and heat treatments. Normal operation refers to the typical daily operational mode of the OTC water system. Historically, heat treatments were periodically conducted to reduce biofouling by recirculating the heated discharge water throughout the cooling water system until the temperature at the slide screens reached or exceeded 100°F (Graham et al. 1977). All organisms within the influence of the heated waters succumb and were typically impinged upon the slide screens. All heat treatments in 2008 were monitored.

MATERIALS AND METHODS

At Mandalay Generating Station, one heat treatment was conducted on 6 June 2008. During the heat treatment, accumulated material was sorted and processed. Fish and macroinvertebrates were identified to the lowest practical taxonomic level. Up to 50 individuals of each fish species were measured to the nearest millimeter (mm) standard length (SL) or other appropriate length (disc width [DW] or total length [TL]), aggregate biomass (kg) was recorded for all measured and unmeasured individuals. Total abundance for species with more than 50 individuals was estimated by dividing the total weight of the unmeasured individuals by the mean weight of the measured individuals of that species. Macroinvertebrates were also sorted to the lowest possible taxonomic category, counted and an aggregate weight (kg) taken. California spiny lobster (*Panulirus interruptus*) were counted, carapace length (CL) measured to the nearest millimeter, and an aggregate weight (kg) recorded.

Normal operation surveys were performed in addition to heat treatment monitoring. To assess the impingement of organisms during periods of normal operation at the generating station, surveys were conducted during representative periods of operation, usually over 24 hours. During these surveys, the sliding screens and trash baskets were cleared of all debris at the start of the sampling period. At the end of the survey period all accumulated material was processed using the same method described for heat treatment surveys. A total of six normal operation surveys were conducted during the 2008 monitoring year: one in 2007 (November), and five in 2008 (January, February, April, June, and August).

Due to variation in daily operating patterns, all normal operation survey fish and macroinvertebrate data was extrapolated over reported circulated water volumes, in million gallons, to determine the estimated monthly impingement by the equation: Estimated Impingement = (Abundance/Survey water volume) x Analysis period water volume. The analysis period flow volume is listed in Appendix H-4 and includes flows represented by the normal operation survey. Annual abundance represents the summation of all estimated monthly impingement abundances and abundance totals from the heat treatment survey. Biomass values were analyzed in the same fashion.

Data was recorded in the field on preprinted data sheets by Proteus Sea Farms. Field sheets were provided to MBC for transcription into digital format. Species-specific lengths were rounded to the nearest 10-mm bin, i.e., 35-44 mm SL = 40 mm SL bin. Abundance per size class was plotted using MS Excel. Data from both survey types were utilized for length frequency analysis.

RESULTS

Impingement sampling results, including a master species list, for the sample year 2008 (1 October 2007 to 30 September 2008) are presented in Appendix H. One heat treatment and six normal operation surveys were conducted in 2008.

Fish

An estimated total of 10,754 fish weighing 203.7 kg representing 19 species was impinged in 2008 at Mandalay Generating Station (Table 7-1). Over 99% of the impinged abundance (10,692) and biomass (202.1 kg) occurred during normal daily operation, with 62 fish of six species weighing 1.6 kg recorded during the single heat treatment survey. One species, jack mackerel (*Trachurus symmetricus*), was collected only during the heat treatment survey while the remaining five heat treatment species were taken in both survey types.

Table 7-1. Fish abundance and biomass (kg) impinged during one heat treatment survey and estimated normal daily operation. Mandalay Generating Station NPDES, 2008.

	Heat Treat.		Obs. Norm. Op.		Est. Norm. Op.		Annual Total		Percent Total	
Taxa	Abu.	Biom. (kg)	Abu.	Biom. (kg)	Abu.	Biom. (kg)	Abu.	Biom. (kg)	Abu.	Biom. (kg)
topsmelt	-	-	647	19.125	4,263	113.998	4,263	113.998	40	56
shiner perch	42	0.881	212	1.495	3,913	21.756	3,955	22.637	37	11
Pacific staghorn sculpin	12	0.126	40	0.748	825	20.777	837	20.903	8	10
queenfish	-	-	14	0.035	706	1.766	706	1.766	7	1
bay pipefish	-	-	3	0.011	161	0.614	161	0.614	1	<1
northern anchovy	-	-	4	0.030	132	1.209	132	1.209	1	1
crevice kelpfish	5	0.018	5	0.039	118	0.736	123	0.754	1	<1
California killifish	-	-	2	0.012	110	0.665	110	0.665	1	<1
Pacific sardine	-	-	18	0.627	100	3.491	100	3.491	1	2
white seaperch	-	-	16	2.097	89	11.675	89	11.675	1	6
deepbody anchovy	1	0.015	1	0.019	60	1.148	61	1.163	1	1
spotted kelpfish	-	-	1	0.002	60	0.121	60	0.121	1	<1
California corbina	-	-	1	0.337	60	20.357	60	20.357	1	10
longjaw mudsucker	-	-	1	0.019	50	0.959	50	0.959	<1	<1
yellowfin goby	-	-	4	0.083	22	0.462	22	0.462	<1	<1
California halibut	-	-	2	0.120	11	0.668	11	0.668	<1	<1
bat ray	1	0.490	1	0.300	6	1.670	7	2.160	<1	1
pricklebreast poacher	-	-	1	0.005	6	0.028	6	0.028	<1	<1
jack mackerel	1	0.029	-	-	-	-	1	0.029	<1	<1
Total	62	1.559	973	25.104	10,692	202.100	10,754	203.659		
Number of taxa	6		18		18		19			

Topsmelt (*Atherinops affinis*), with an estimated 4,263 individuals, ranked first in both abundance and biomass (114.0 kg). All topsmelt were collected during normal operation surveys of the cooling water system (Table 7-1). Shiner perch (*Cymatogaster aggregata*) was second in abundance overall, with 42 individuals weighing 0.9 kg impinged during the heat treatments and an estimated 3,913 weighing 21.8 kg impinged during normal operations, for a total annual abundance of 3,955 individuals with a biomass of 22.6 kg. A total of 837 Pacific staghorn sculpin (*Leptocottus armatus*) weighing 20.9 kg ranked third overall, with 706 queenfish (*Seriphus politus*) weighing 1.8 kg fourth in total annual abundance. Each of the remaining 15 species contributed 1% or less to the annual catch, cumulatively accounting for an additional 993 individuals. California corbina (*Menticirrhus undulatus*; 20.4 kg), white seaperch (*Phanerodon furcatus*; 11.7 kg), and Pacific sardine (*Sardinops sajax*, 3.5 kg) each contributed an additional 2% or more to the annual impinged biomass. The remaining 13 species each contributed 1% or less to the total annual biomass, or 10.6 kg, cumulatively.

Length Frequency Analysis

In 2008, twelve size classes of topsmelt were taken in impingement samples (Figure 7-1). Topsmelt were unimodally distributed with the peak abundance recorded in the 140-mm SL size class, although several individuals less than 100 mm SL were also recorded. Shiner perch were represented by 10 size classes in a near-normal distribution centered on the 70-mm SL size class (Figure 7-2). The 12 size classes of Pacific staghorn sculpin were dominated by individuals in the 60- to 80-mm SL size classes, with four, or less, individuals in each of the remaining nine size classes (Figure 7-3).

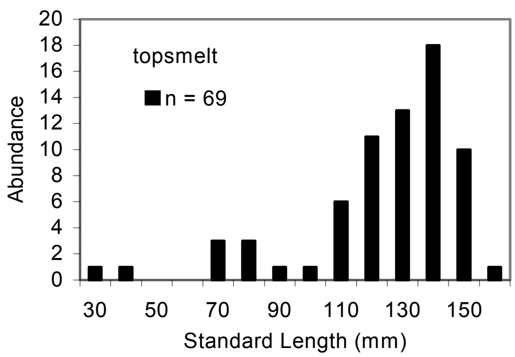


Figure 7-1. Length frequency of top smelt impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2008.

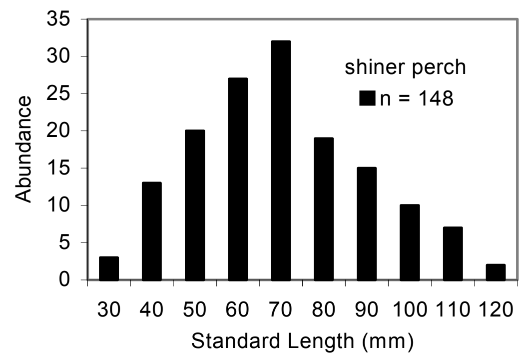


Figure 7-2. Length frequency of shiner perch impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2008.

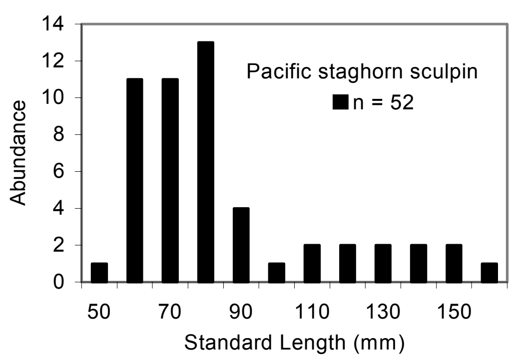


Figure 7-3. Length frequency of Pacific staghorn sculpin impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2008.

Macroinvertebrates

An estimated total of 309 macroinvertebrates of seven species and weighing 14.3 kg were impinged at Mandalay Generating Station in 2008 (Table 7-2). The heat treatment accounted for 11 individuals, all California spiny lobster, weighing 1.2 kg. California spiny lobster was impinged only during the heat treatment and no other macroinvertebrate species were recorded during this survey.

California two-spot octopus (*Octopus bimaculatus/bimaculoides*), yellowleg shrimp (*Farfantepenaeus californiensis*), striped shore crab (*Pachygrapsus crassipes*), and purple shore crab (*Hemigrapsus nudus*) cumulatively accounted for 93% of the total abundance, with an estimated total of 88, 78, 60, and 60 individuals each, respectively (Table 7-2). Two of these, California two-spot octopus (10.0 kg) and yellowleg shrimp (2.7 kg), combined to contribute 89% to the total annual biomass. Together, California spiny lobster, California aglaja (*Navanax inermis*), and blackspotted bay shrimp (*Crangon nigromaculata*) contributed 23 individuals weighing 1.3 kg. The two shore crabs accounted for an additional 0.3 kg.

Table 7-2. Macroinvertebrate abundance and biomass (kg) of macroinvertebrate species impinged during one heat treatment survey and estimated normal daily operation. Mandalay Generating Station NPDES, 2008.

	Heat Treat.		Obs. Norm. Op.		Est. Norm. Op.		Annual Total		Percent Total	
Species	Abu.	Biom. (kg)	Abu.	Biom. (kg)	Abu.	Biom. (kg)	Abu.	Biom. (kg)	Abu.	Biom. (kg)
California two-spot octopus	-	-	2	0.195	88	10.018	88	10.018	28	70
yellowleg shrimp	-	-	2	0.083	78	2.670	78	2.670	25	19
California spiny lobster	11	1.158	-	-	-	-	11	1.158	4	8
striped shore crab	-	-	1	0.004	60	0.242	60	0.242	19	2
California aglaja	-	-	1	0.028	6	0.156	6	0.156	2	1
blackspotted bay shrimp	-	-	1	0.002	6	0.011	6	0.011	2	<1
purple shore crab	-	-	1	0.001	60	0.060	60	0.060	19	<1
Total	11	1.158	8	0.313	298	13.157	309	14.315		
Number of Species	1		6		6		7			

DISCUSSION

The total abundance of impinged fish in 2008 was among the lowest recorded since 2001 (Figure 7-4). Since 2001, impingement monitoring at Mandalay Generating Station has recorded notable cycles of fish abundances, with highly abundant years (2002, 2005, and 2006) contrasted with low abundance years (2001, 2003, 2007, and 2008). Only 2004 appeared to be “average”. Changes in total annual cooling water flow does not accurately reflect trends in impingement, suggesting a lack of direct relationship between cooling water flow and fish impingement (Figure 7-4). Rather, the apparent discontinuity between the two suggests other factors, such as source population densities, impart a greater effect on the annual impingement abundance than does the operation of the cooling water system.

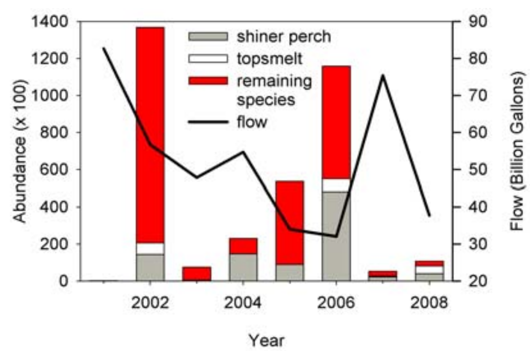


Figure 7-4. Annual abundance of shiner perch, topsmelt, and remaining fish species impinged and total cooling water flow, 2001-2008. Mandalay Generating Station NPDES, 2008.

Seasonal precipitation may act as one of many factors influencing impingement at the generating station other than the operation of the cooling water system. The abundance of several species, especially topsmelt, can be influenced by recent rainfall, which often precipitates anomalously high impingement (MBC 2006b). At Mandalay Generating Station, 88% of the observed normal operation abundance was recorded during the 5 February 2008 normal operation survey, two days following 0.4 inches of rainfall in Ventura (Weather Underground 2008). The rapid change in salinity that presumably accompanied the freshwater runoff into the canal after the storm event may have impaired the osmotic balance of fishes in the area. This likely weakened them, lessening their ability to swim against the intake current and leading to their subsequent impingement.

Consistent with recent trends, topsmelt and shiner perch were among the most abundant species impinged at the generating station in 2008 (Figure 7-4). Topsmelt were first reported in 2002 and have been common in surveys since 2006 while California grunion (*Leuresthes tenuis*), closely related to topsmelt, was collected in high abundances each year from 2002 to 2005 (MBC 2002-2005). Shiner perch were recorded every year since 2001, although their abundances have varied each year (Figure 7-4). They were the second most abundant species in 2008 as well as second most abundant since 2001. Pacific staghorn sculpin, the third most abundant species impinged in 2008, has been recorded every year since 2001 in variable abundances, although numbers over the last three years have remained consistent, with relatively high abundances peaking in 2008 (Figure 7-5). As was seen in the total fish abundance, Pacific staghorn sculpin abundances do not exhibit a pattern similar to that of total cooling water flow.

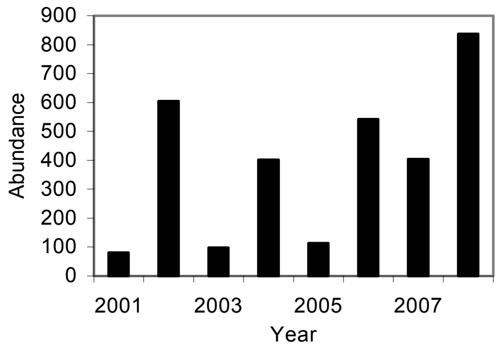


Figure 7-5. Annual impinged Pacific staghorn sculpin abundance (heat treatment + estimated normal operation), 2001-2008. Mandalay Generating Station NPDES, 2008.

Topsmelt are common in nearshore tidal waters, ranging from the Gulf of California to Vancouver Island, British Columbia (Love et al. 2005). Common around soft-bottom habitat, topsmelt frequently reside in bays and harbors throughout southern California such as Channel Islands Harbor (Allen 1985). Topsmelt spawn in late spring and early summer, attaching eggs in a mass on marine vegetation, including eelgrass and low-growing algae in bays and harbors, and possibly on kelp (Gregory 2001). The majority of topsmelt measured in 2008 were either less than one year old or between their first and second birthdays (Hart 1973, Gregory 2001).

The size of the shiner perch impinged in 2008 (Figure 7-2) indicates multiple year classes, with most near one year old (Eckmayer 1979). Shiner perch range from San Quintin Bay, Baja California to Sitka, Alaska (Love et al. 2005). Emmett et al. (1991) reports shiner perch occur primarily in shallow-water marine, bay, and estuarine habitats, taking up a demersal lifestyle over sandy and muddy bottoms.

Pacific staghorn sculpin range from San Quintin, Baja California, Mexico to Port Moeller on the Bering Sea from shallow tidepools to depths of 91 m (Miller and Lea 1972, Love et al. 2005). Common to bays and estuaries throughout its range, Pacific staghorn sculpin has been recorded in 13 bays or estuaries in California and Baja California, ranging from the Kalamath River mouth to Bahia de San Quintin, and has been commonly observed during impingement sampling at stations drawing seawater from bays and harbors (Allen et al. 2006, MBC 2007b). Moyle (2002) reported that Pacific staghorn sculpins move freely between salinity regimes, with juveniles most abundant in coastal streams. Pacific staghorn sculpins mature at 120 to 150 mm SL (4.7 to 5.9 in), or one year old (Moyle 2002). Tasto (1975) indicated that spawning takes place between mid-December and mid-March with peaks in January and February.

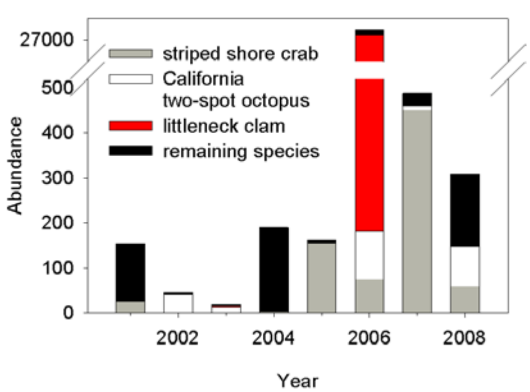


Figure 7-6. Annual abundance of striped shore crab, California two-spot octopus, littleneck clam, and remaining macroinvertebrate species, 2001-2008. Mandalay Generating Station NPDES, 2008.

Macroinvertebrate impingement in 2008 was consistent with that recorded in recent years, although the total abundance was lower than reported in 2006 and 2007 (Figure 7-6). With the exception of the anomalous occurrence in 2006 of 27,020 Pacific littleneck clams (*Protothaca staminea*) impinged during a single heat treatment, striped shore crab, though fourth in abundance in 2008, ranks as the most abundant macroinvertebrate impinged at Mandalay Generating Station. California two-spot octopus has also contributed a substantial portion of the long term abundance, ranking first in both 2002 and again in 2008. Yellowleg shrimp, the most abundant species in 2008, was reported for only the second time with about five times the abundance taken in 2006 (MBC 2006a). All macroinvertebrate species impinged in 2008 are commonly reported in the Southern California Bight, especially during impingement sampling at facilities drawing seawater from coastal bays and harbors (Morris et al. 1980, MBC 2007b,c).

California spiny lobster, a commercially important macroinvertebrate has been recorded in the generating station impingement samples since 2002 (Figure 7-7). In 2008, California spiny lobster was only collected during the heat treatment survey, and abundance was the third highest reported. Since the mid-1970s, California spiny lobster abundances appear to be generally increasing within the Southern California Bight based on commercial landings (Barsky 2001). This highly valued crustacean commonly inhabits caves and crevices of rocky substrate throughout its range from Monterey Bay, California to Manzanillo, Mexico (Barsky 2001). The California spiny lobster fishing season, both recreational and commercial, within State of California waters has been limited to early October through mid-March (Barsky 2001).

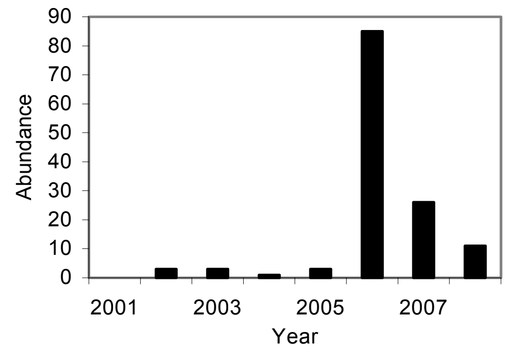


Figure 7-7. Annual impinged California spiny lobster abundance (heat treatment + estimated normal operation), 2001-2008. Mandalay Generating Station NPDES, 2008.

CONCLUSION

Overall, impingement monitoring at Mandalay Generating Station in 2008 recorded abundances within recent ranges for both fish and macroinvertebrates. Impinged fish abundances were greater than reported in 2007, but well short of that recorded from 2004 through 2006. Still, the core species group of topsmelt, shiner perch, and Pacific staghorn sculpin persisted, though in reduced abundances. Macroinvertebrates impinged in 2008 were more abundant than in most years since 2001, although less than that reported in 2006 and 2007. As with fish, a similar core species group persisted. Abundances of both phylogenetic groups showed no relationship to the volume of cooling water circulated by the facility since 2001, indicating that other factors, including source densities and seasonal precipitation probably exerted more effect on the impingement abundances than did the operation of the cooling water system. The similarity of species composed primarily of frequently occurring and long-term dominant species indicates a relatively stable assemblage typical of southern California embayments. There is no indication that plant operations have adversely affected the fish or macroinvertebrate populations in the vicinity of the Mandalay Generating Station intake canal.

CHAPTER 8 — LITERATURE CITED

Ackermann, F. 1980. A procedure for correcting the grain size effect in heavy metal analyses of estuarine and coastal sediments. Environ. Tech. Letters 1:518-527.

Allen, L.G. 1985. A habitat analysis of the nearshore marine fishes from southern California. Bull. South Calif. Acad. Sci. 84(3): 133-155.

Allen, L.G. and E.E. DeMartini. 1983. Temporal and spatial patterns of nearshore distribution and abundance of the pelagic fishes off San Onofre-Oceanside, California. Fish. Bull., U.S. 81(3):569-586.

Allen, L.G., A. M. Findlay, C.M. Phalen. 2002. Structure and standing stock of the fish assemblages of San Diego Bay, California from 1994 to 1999. Bull. Southern California Acad. Sci. 101(2):49-85.

Allen, L.G., M. M. Yoklavich, G. M. Cailliet, and M. H. Horn. 2006. Bays and estuaries. Pp. 119-148. *In.* The ecology of marine fishes: California and adjacent waters, Allen, L. G., D. J. Pondella II, and M. H. Horn. Univ. Calif. Press.

Allen, M.J. 1982. Functional structure of the soft-bottom fish communities of the southern California shelf. Ph.D. thesis, Univ. Calif., San Diego, La Jolla, CA. 577 p. (avail. Univ. Microfilms Internat., Ann Arbor, MI 48106).

Allen, M. J. and R. Leos. 2001. Sanddabs. Pages 201-203 *in* Leet, W.S., C.M. Dewees, R. Klingbeil, and E.J. Larson (eds.) California's Living Marine Resources: A Status Report. University of California, Agriculture and Natural Resources Publication SG01-11, 592pp.

Allen, M.J., T. Mikel, D. Cadien, J.E. Kalman, E.T. Jarvis, K.C. Schiff, D.W. Diehl, S.L. Moore, S. Walther, G. Deets, C. Cash, S. Watts, D.J. Pondella II, V. Raco-Rands, C. Thomas, R. Gartman, L. Sabin, W. Power, A.K. Groce, and J. L. Armstrong. 2007. Southern California Bight 2003 Regional Monitoring Program: IV: Demersal Fishes and Megabenthic Invertebrates. Southern California Coastal Water Research Project, Costa Mesa, CA. 340 p.

Barnard, J.L. 1963. Relationship of benthic Amphipoda to invertebrate communities of inshore sublittoral sands of southern California. Pac. Nat. 3(15):439-467.

Barsky, K.C. 2001. California spiny lobster. In: W. S. Leet, C. M. Dewees, R. Klingbeil, and E. J. Larson (eds). California's living marine resources.

Boesch, D.F. 1977. Application of numerical classification in ecological investigations of water pollution. U.S. Environmental Protection Agency EPA-600/3-77-033. 115 p.

California Regional Water Quality Control Board. 1994. Basin plan for the coastal watersheds of Los Angeles and Ventura Counties, Los Angeles Region (4). Approved by State Water Resources Control Board November 17, 1994.

Clifford, H.T., and W. Stephenson. 1975. An Introduction to Numerical Classification. Academic Press, New York. 229 p.

Cross, J .N., and L.G. Allen. 1993. Chapter 9. Fishes. Pages 459-540 *in* M.D. Dailey, D.J. Reish, and J.W. Anderson (eds.) Ecology of the southern California bight: a systhesis and interpretation. University of California Press, Berkeley, CA.

Dailey, M.D., J.W. Anderson, D.J. Reish, and D.S. Gorsline. 1993. The Southern California Bight: Background and setting. *In*: Dailey, M.D., D.J. Reish, and J.W. Anderson (Eds.). Ecology of the Southern California Bight: A synthesis and interpretation. Univ. of Calif. Press, Berkeley, Calif. 926 p.

de Groot, A.J., K.H. Zschuppe, and W. Salomons. 1982. Standardization of methods of analysis for heavy metals in sediments. Hydrobiologia 92:689-695.

Dexter, D.H. 1978. The infauna of a subtidal, sand-bottom community at Imperial Beach, California. Calif. Fish and Game 64(4):268-279.

Duxbury, A.C., and A. Duxbury. 1984. An Introduction to the World's Oceans. Addison-Wesley Publishing Co., Menlo Park, CA. 549 p.

Eckmayer, W.J. 1979. Age and growth of four surfperches (Embiotocidae) from the outer harbor of Anaheim Bay, California. Calif. Fish and Game. 65(4):265-272.

Emmett, R.L., S.L. Stone, S.A. Hinton, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries, Vol. II. Species life history summaries. ELMR Rep. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, MD. 329 p.

EPA. See United States Environmental Protection Agency.

Ford, R.F. 1965. Distribution, population dynamics, and behavior of a bothid flatfish, *Citharichthys stigmaeus*. Ph.D. dissertation. University of California, San Diego. La Jolla, CA.

Graham, J.W., J.N. Stock and P.H. Benson. 1977. Further studies on the use of heat treatment to control biofouling in seawater cooling systems. Oceans 23A-1:23A-6.

Gray, J.S. 1974. Animal-sediment relationships. Oceanogr. Mar. Biol. Ann. Rev. 12:223-261.

Gregory, P.A. 2001. Silversides. Pages 243-245 *in*: California's Living Marine Resources: A Status Report. Eds. Leet, W. S., C. M. Dewees, R. Klingbeil, E. J. Larson. University of California Press, Agriculture and Natural Resources Publication SG01-11. 592 p

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Can., Bull. 180. 740 p.

Hickey, B.M. 1992. Circulation over the Santa Monica-San Pedro Basin and Shelf. Progress in Oceanography 30:37-115.

Hintze, J. L. 1998. NCSS 2000 statistical system for windows. Number cruncher statistical systems, Kaysville, UT.

Hobson, E.S. and J.R. Chess. 1976. Trophic interactions among fishes and zooplankters near shore at Santa Catalina Island, California. Fish. Bull., U.S. 74(3)567-598.

Intersea Research Corporation. 1973. Thermal effect study for the Mandalay Steam Plant, March 1973 progress report. Prepared for Southern California Edison Company.

IRC. see Intersea Research Corporation

Johnson, R.G. 1970. Variations in diversity within benthic marine communities. Am. Nat. 104(937):285-300.

Kennish, M.J. 2001. Practical Handbook of Marine Science, 3rd Edition, CRC Press, Boca Raton, FL. 876 p.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environ. Management 19(1):81-97.

Love, M.S., C.W. Mecklenburg, T.A. Mecklenburg, and L.K. Thorsteinson. 2005. Resource Inventory of Marine and Estuarine Fishes of the West Coast and Alaska. U. S. Department of the Interior, USGS, Seattle, WA. OCS Study MMS 2005-030.

MBC. See Marine Biological Consultants, Inc. or MBC Applied Environmental Sciences.

Marine Biological Consultants, Inc. 1979. National Pollutant Discharge Elimination System reporting and monitoring program, Mandalay Generating Station winter and summer 1978 surveys. Prepared for Southern California Edison Company, 79-RD-37. April 1979, 53 p. with appendices.

Marine Biological Consultants, Inc. 1981. National Pollutant Discharge Elimination System receiving water monitoring program, Mandalay Generating Station winter and summer 1980 surveys. Prepared for Southern California Edison Company, March 1981 81-RD-20. 50 p. with appendices.

MBC Applied Environmental Sciences. 1986. National Pollutant Discharge Elimination System, 1986 receiving water monitoring report, Mandalay Generating Station, Ventura County, California. Prepared for Southern California Edison Company, SCE Research and Development Ser. 86-RD-58. 40 p. plus appendices.

MBC Applied Environmental Sciences. 1988. National Pollutant Discharge Elimination System, 1988 receiving water monitoring report, Mandalay Generating Station, Ventura County, California. Prepared for Southern California Edison Company, SCE Research and Development Ser. 88-RD-52. 41 p. plus appendices.

MBC Applied Environmental Sciences. 1990. National Pollutant Discharge Elimination System, 1990 receiving water monitoring report, Mandalay Generating Station, Ventura County, California. Prepared for Southern California Edison Company, SCE Research and Development Ser. 90-RD-89. 40 p. plus appendices.

MBC Applied Environmental Sciences. 1994. National Pollutant Discharge Elimination System, 1994 receiving water monitoring report, Mandalay Generating Station, Ventura County, California. Prepared for Southern California Edison Company, SCE Research and Development Ser. 94-RD-010. 46 p. plus appendices.

MBC Applied Environmental Sciences. 1995. National Pollutant Discharge Elimination System 1995 receiving water monitoring report, Los Angeles Region. Prepared for Los Angeles Dept. of Water and Power and Southern California Edison Company. 96-RD-001. 110 p. plus appendices.

MBC Applied Environmental Sciences. 1996. National Pollutant Discharge Elimination System 1996 receiving water monitoring report, Los Angeles Region. Prepared for Los Angeles Dept. of Water and Power and Southern California Edison Company. 97-RD-001. 134 p. plus appendices.

MBC Applied Environmental Sciences. 1997. National Pollutant Discharge Elimination System, 1997 receiving water monitoring report, Mandalay Generating Station, Ventura County, California. Prepared for Southern California Edison Company, SCE Research and Development Ser. 97-EA-01. 45 p. plus appendices.

MBC Applied Environmental Sciences. 1998. National Pollutant Discharge Elimination System, 1998 receiving water monitoring report, Reliant Energy Mandalay Generating Station, Ventura County, California. Prepared for Southern California Edison Company and Reliant Energy. 98-EA-06. 33 p. plus appendices.

MBC Applied Environmental Sciences. 1999. National Pollutant Discharge Elimination System, 1999 receiving water monitoring report, Reliant Energy Mandalay Generating Station, Ventura County, California. Prepared for Southern California Edison Company and Reliant Energy. 99-EA-05. 50 p. plus appendices.

MBC Applied Environmental Sciences. 2000. National Pollutant Discharge Elimination System, 2000 receiving water monitoring report, Reliant Energy Mandalay Generating Station, Ventura County, California. Prepared for Reliant Energy. 54 p. plus appendices.

MBC Applied Environmental Sciences. 2001a. National Pollutant Discharge Elimination System, 2001 receiving water monitoring report, Reliant Energy Mandalay Generating Station, Ventura County, California. Prepared for Reliant Energy. 58 p. plus appendices.

MBC Applied Environmental Sciences. 2001b. National Pollutant Discharge Elimination System 2001 receiving water monitoring report, Reliant Energy Ormond Beach Generating Station, Ventura County, California. Prepared for Reliant Energy. 46 p. plus appendices.

MBC Applied Environmental Sciences. 2001c. National Pollutant Discharge Elimination System, 2001 receiving water monitoring report, AES Huntington Beach L.L.C. Generating Station, Orange County, California. Prepared for AES Huntington Beach L.L.C. 54 p. plus appendices.

MBC Applied Environmental Sciences. 2002. National Pollutant Discharge Elimination System, 2002 receiving water monitoring report, Reliant Energy Mandalay Generating Station, Ventura County, California. Prepared for Reliant Energy. 61 p. plus appendices.

MBC Applied Environmental Sciences. 2003. National Pollutant Discharge Elimination System, 2003 receiving water monitoring report, Reliant Energy Mandalay Generating Station, Ventura County, California. Prepared for Reliant Energy. 53 p. plus appendices.

MBC Applied Environmental Sciences. 2004. National Pollutant Discharge Elimination System, 2004 receiving water monitoring report, Reliant Energy Mandalay Generating Station, Ventura County, California. Prepared for Reliant Energy. 60 p. plus appendices.

MBC Applied Environmental Sciences. 2005. National Pollutant Discharge Elimination System, 2005 receiving water monitoring report, Reliant Energy Mandalay Generating Station, Ventura County, California. Prepared for Reliant Energy. 60 p. plus appendices.

MBC Applied Environmental Sciences. 2006a. National Pollutant Discharge Elimination System, 2006 receiving water monitoring report, Reliant Energy Mandalay Generating Station, Ventura County, California. Prepared for Reliant Energy. 72 p. plus appendices.

MBC Applied Environmental Sciences. 2006b. National Pollutant Discharge Elimination System, 2006 receiving water monitoring report, Haynes and AES Alamitos L.L.C. Generating Station, Los Angeles County, California. Prepared for AES Alamitos L.L.C., and Los Angeles Department of Water and Power. 86 p. plus appendices .

MBC Applied Environmental Sciences. 2007a. National Pollutant Discharge Elimination System, 2007 receiving water monitoring report, Reliant Energy Mandalay Generating Station, Ventura County, California. Prepared for Reliant Energy. 78 p. plus appendices.

MBC Applied Environmental Sciences. 2007b. National Pollutant Discharge Elimination System, 2007 receiving water monitoring report, AES Redondo Beach Generating Station L.L.C., Los Angeles County, California. Prepared for AES Redondo Beach L.L.C. 72 p. plus appendices.

MBC Applied Environmental Sciences. 2007c. National Pollutant Discharge Elimination System, 2007 receiving water monitoring report, Harbor Generating Station, Los Angeles County, California. Prepared for City of Los Angeles Department of Water and Power. 62 p. plus appendices.

MBC Applied Environmental Sciences. 2008a. National Pollutant Discharge Elimination System 2008 receiving water monitoring report, Reliant Energy Ormond Beach Generating Station, Ventura County, California. Prepared for Reliant Energy. In prep.

MBC Applied Environmental Sciences. 2008b. National Pollutant Discharge Elimination System, 2008 receiving water monitoring report, AES Redondo Beach Generating Station L.L.C., Los Angeles County, California. Prepared for AES Redondo Beach L.L.C. In prep.

MBC Applied Environmental Sciences. 2008c. National Pollutant Discharge Elimination System, 2008 receiving water monitoring report, Scattergood and El Segundo Generating Stations, Los Angeles County, California. Prepared for Los Angeles Department of Water and Power, Los Angeles, CA and El Segundo Power L.L.C. In prep.

MBC Applied Environmental Sciences. 2008d. National Pollutant Discharge Elimination System, 2008 receiving water monitoring report, Haynes and AES Alamitos L.L.C. Generating Station, Los Angeles County, California. Prepared for AES Alamitos L.L.C., and Los Angeles Department of Water and Power. In prep.

Miller, D.J. and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dept. Fish Game Fish Bulletin 157: 235 p.

Miller, E.F., D.J. Pondella, II, D.S. Beck, and K.T. Herbinson. in review (a). Historic population and recruitment trends of California croakers (Family Sciaenidae) and the effects of overfishing, once through cooling, and oceanography. Fisheries Research.

Miller, E.F., J.P. Williams, D.J. Pondella, II, and K.T. Herbinson. in review (b). Life history, ecology, and long-term demographics of queenfish (*Seriphus politus*). Marine and Coastal Fisheries.

Morris, R.H., D.P. Abbott, and E.C. Haderlie (eds.). 1980. Intertidal Invertebrates of California. Stanford Univ. Press.

Moyle, P.B. 2002. Inland fishes of California. Univ. Calif. Press, Los Angeles, CA. 502 p.

National Oceanic and Atmospheric Administration. 1991a. National Status and Trends Program - Second summary of data on chemical contaminants in sediments from the National Status and Trends Program. NOAA Tech. Mem. NOS OMA 59. NOAA Office of Ocean. and Marine Assess., Rockville, MD. 29 p. plus append.

National Oceanic and Atmospheric Administration. 1991b. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. NOAA Tech. Mem. NOS OMA 52, Seattle WA. 175 p. plus appendices.

NOAA. See National Oceanic and Atmospheric Administration.

Odenweller, D. B. 1975. The life history of the shiner surfperch, *Cymatogaster aggregata* Gibbons, in Anaheim Bay, California. *In*: Lane, E. D. and C. W. Hill (eds.), The Marine Resources of Anaheim Bay, Calif. Dept. Fish Game. Fish. Bull., 165: 195 p.

Ogden Environmental and Energy Services Co. 1991. National Pollutant Discharge Elimination Systems reporting and monitoring program, Mandalay Generating Station, Ventura County, California. Prepared for Southern California Edison Company, Rosemead, CA. 91-RD-29. 46 p. plus appendices.

Ogden Environmental and Energy Services Co. 1992. National Pollutant Discharge Elimination Systems reporting and monitoring program, Mandalay Generating Station, Ventura County, California. Prepared for Southern California Edison Company, Rosemead, CA. 92-RD-13. 49 p. plus appendices.

Ogden Environmental and Energy Services Co. 1993. National Pollutant Discharge Elimination Systems reporting and monitoring program, Mandalay Generating Station, Ventura County, California. Prepared for Southern California Edison Company, Rosemead, CA. 93-RD-11. 51 p. plus appendices.

Oliver, J.S., P.N. Slattery, L.W. Hulberg, and J.W. Nybakken. 1980. Relationships between wave disturbance and zonation of benthic invertebrate communities along a subtidal high-energy beach in Monterey Bay, California. Fish. Bull. 78(2):437-454.

Pielou, E.C. 1977. Mathematical ecology. John Wiley and Sons, New York. 384 p.

SCAMIT. See Southern California Association of Marine Invertebrate Taxonomists

SCCWRP. See Southern California Coastal Water Research Project.

SCE. See Southern California Edison Company.

Schiff, K., K. Maruya and K. Christensen. 2006. Southern California Bight 2003 Regional Monitoring Program: II. Sediment Chemistry. Southern California Coastal Water Research Project. Westminster, CA.

Shannon, C.H., and W. Weaver. 1962. The Mathematical Theory of Communication. Univ. of Illinois Press, Urbana, IL. 117 p.

Siegfried, C.A. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)–crangonid shrimp. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.125). U.S. Army Corps of Engineers, TR EL-82-4. 18 p.

Smith, R.W. 1976. Numerical analysis of ecological survey data. Ph.D. Dissertation. University of Southern California, Department of Biology, Los Angeles, CA. 401 p.

Smith, R., A. Ranasinghe, S. Weisberg, D. Montagne, D. Cadien, T. Mikel, R. Velarde, and A. Dalkey. 2003. Extending the Southern California Benthic Response Index to Assess Benthic Conditions in Bays. Southern California Coastal Water Research Project Technical Report 410. December 2003.

Southern California Association of Marine Invertebrate Taxonomists. 2008. A Taxonomic Listing Macro- and Megainvertebrates from Infaunal and Epibenthic Programs in the Southern

California Bight, Edition 5. Southern California Association of Marine Invertebrate Taxonomists. Los Angeles, CA. 210 p.

Southern California Coastal Water Research Project. 1973. The ecology of the Southern California Bight: Implications for water quality management. SCCWRP, El Segundo, CA. SCCWRP TR104. 531 p.

Southern California Coastal Water Research Project. 1986. Contaminant levels in the sea-surface microlayer. Pages 6-8 *in* So. Calif. Coastal Water Res. Proj. - 1986. SCCWRP, Long Beach, CA.

Southern California Edison Company. 1986. Report on 1985 data. Marine environmental analysis and interpretation, San Onofre Nuclear Generating Station. September 1986. 86-RD-26. 271 p. plus tables and figures.

State Water Resources Control Board. 1972. Water quality control plan, ocean waters of California, guidelines for technical reports and monitoring programs. 65 p.

State Water Resources Control Board. 1995. State mussel watch program 1987-93 data report. 94-1WQ. 23 p. plus appendices.

State Water Resources Control Board. 2000. State mussel watch program 1995-1997 data report. 23 p. plus appendices.

Stephens, J.S. Jr. and K.E. Zerba. 1981. Factors affecting fish diversity on a temperate reef. Env. Biol. Fish. 6:111-121.

Sverdrup, H.U., M.W. Johnson, and R.H. Fleming. 1942. The Oceans: Their physics, chemistry, and general biology. Prentice-Hall, Inc., Englewood Cliffs, NY. 1060 p. plus appendices.

SWRCB. See State Water Resources Control Board.

Tasto, R.N. 1975. Aspects of the biology of Pacific staghorn sculpin, *Leptocottus armatus* Girard, in Anaheim Bay. *In* Lane, E.D. and C. W. Hill, eds. The Marine Resources of Anaheim Bay. 195 p.

United States Environmental Protection Agency. 1989. Data evaluation, Chapter 5, section 3.3 *in* Risk assessment guidance for Superfund, EPA Solid waste and emergency response OS-230.

Ware, R.R. 1979. The food habits of white croaker *Genyonemus lineatus* and an infaunal analysis near areas of waste discharge in outer Los Angeles Harbor. M. S. thesis, Calif. State Univ., Long Beach, Long Beach, CA. 113 p.

Weather Underground. 2008. Accessed 23 December 2008. http://www.wunderground.com/weatherstation/WXDailyHistory.asp?ID=KCASANBU2&day=3&year=2008&month=2

PERSONAL COMMUNICATION

Siekiel-Zdzienicki, B.J. 2008. Reliant Energy Mandalay Generating Station.

APPENDIX A

Receiving water monitoring specifications

V. RECEIVING WATER MONITORING

A. Receiving Water

1. Pursuant to the Code of Federal Regulations [40 CFR § 122.41(j) and §122.48(b)], the monitoring program for a discharger receiving a NPDES permit must determine compliance with NPDES permit conditions, and demonstrate that State water quality standards are met.

2. Since compliance monitoring focuses on the effects of point source discharge, it is not designed to assess impacts from other sources of pollution (e.g., nonpoint source runoff, aerial fallout) nor to evaluate the current status of important ecological resources on a regional basis.

B. Regional Database

1. Several efforts are underway to develop and implement a comprehensive regional monitoring program for the Southern California Bight. These efforts

have the support and participation from regulatory agencies, dischargers, and environmental groups. The goal is to establish a regional program to address public health concerns, monitor trends in natural resources and nearshore habitats, and assess regional impacts from all contaminant sources.

2. Two pilot regional monitoring programs were conducted; one during the summer of 1994 and another in 1998. The purpose of the pilot programs were to test an alternative sampling design that combines elements of compliance monitoring with a broader regional assessment approach. The pilot program was designed by USEPA, the State Board, and three Boards (Los Angeles, Santa Ana, and San Diego) in conjunction with the Southern California Coastal Water Research Project and participating discharger agencies.

   The pilot regional monitoring programs included the following components: microbiology; water quality; sediment chemistry; sediment toxicity testing; benthic infauna; demersal fish; and bioaccumulation.

3. The two pilot regional monitoring programs were funded primarily, by resource exchanges with the participating discharger agencies. During the year when pilot regional monitoring was scheduled, USEPA and this Regional Board eliminated portions of the routine compliance monitoring programs for that year, while retaining certain critical compliance monitoring elements. A certain percentage of the traditional sampling sites were also retained to maintain continuity of the historical record and to allow comparison of different sampling designs. The exchanged resources were redirected to complete sampling within the regional monitoring program design. Thus, the Discharger's overall level of effort for the 1994 and 1998 pilot programs remained approximately the same as the compliance monitoring programs.

4. Given the apparent benefits realized by the first two regional monitoring programs, it is probable that similar comprehensive sampling efforts will be repeated for the California Bight at periodic intervals (perhaps every four or five years). At the present time, it appears likely that the next regional monitoring program will be attempted during the summer of 2002 - 2003.

5. We anticipate that future regional monitoring programs will be funded in a similar manner. Revisions to the routine compliance monitoring program will be made under the discretion of the USEPA and this Regional Board as necessary to accomplish this goal; and may include resource exchanges in the number of parameters to be monitored, the frequency of monitoring, or the number, type, and location of samples collected.

6. The compliance monitoring programs for the Mandalay Generating Station, and other major ocean dischargers will serve as the framework for the regional

monitoring program. However, substantial changes to these programs may be required to fulfill the goals of regional monitoring, while retaining the compliance monitoring component required to evaluate the potential impacts from NPDES discharges. Revisions to the existing program will be made under the discretion of the USEPA and this Regional Board as necessary to accomplish this goal; and may include a reduction or increase in the number of parameters to be monitored, the frequency of monitoring, or the number, type, and location of samples collected.

C. Monitoring for Algicide Spraying

The Discharger periodically sprays the banks of the Mandalay Intake Canal with an algicide to control algal growth in the intake canal. The Discharger shall notify the Regional Board at least two weeks prior to each application of algicide. Water samples shall be collected at a minimum of three locations (Wooley Road, 5th Street and Unocal Bridge, or other locations subject to approval by the Executive Officer) and analyzed for total residual oxidant concentrations. The Discharger also shall conduct visual observations of the canal following algicide applications to assess the effectiveness of the spraying program in controlling algal growth and to observe any unusual mortality of fish or invertebrates. The Discharger shall report the results of sample analysis and visual observations, as well as a description of the amounts and locations of all algicide applications, in the appropriate monthly monitoring report to the Regional Board.

D. Receiving Water Monitoring

The receiving water monitoring program shall consist of periodic biological surveys of the area surrounding the discharge, and shall include studies of those physical-chemical characteristics of the receiving water which may be impacted by the discharge.

Location of Sampling Stations (see Attached Figure 1):

1. Receiving water stations in the surf zone shall be located as follows:

    a. Station RW1 - 1180 feet upcoast of the discharge channel.

    b. Station RW2 - 1180 feet downcoast of the discharge channel.

    c. Station RW3 - 2360 feet upcoast of the discharge channel.

    d. Station RW4 - 2360 feet downcoast of the discharge channel.

    e. Station RW5 - At the discharge channel.

2. Receiving water stations offshore of the discharge area shall be located as follows:

   a. Station RW6 - directly offshore of station RW13 at a depth of 30 feet.

   b. Station RW7 - directly offshore of station RW16 at a depth of 30 feet.

   c. Station RW8 – directly offshore of station RW11 at a depth of 30 feet.

   d. Station RW9 – directly offshore of station RW17 at a depth of 30 feet.

   e. Station RW10 – directly offshore of station RW12 at a depth of 30 feet.

   f. Station RW11 – directly offshore of station RW5 at a depth of 20 feet.

   g. Station RW12 – directly offshore of station RW4 at a depth of 20 feet.

   h. Station RW13 – directly offshore of station RW3 at a depth of 20 feet.

   i. Station RW14 – 5,910 feet downcoast of the discharge channel at a depth of 20 feet.

   j. Station RW15 – 5,910 feet upcoast of the discharge channel at a depth of of 20 feet.

   k. Station RW16 – directly offshore of station RW1 at a depth of 20 feet.

   l. Station RW17 – directly offshore of station RW2 at a depth of 20 feet.

3. Benthic stations shall be located as follows:

   a. Station B1 shall be located directly beneath Station RW11.

   b. Station B2 shall be located directly beneath Station RW12.

   c. Station B3 shall be located directly beneath Station RW13.

   d. Station B4 shall be located directly beneath Station RW14.

   e. Station B5 shall be located directly beneath Station RW15.

4. Trawling stations shall be located as follows:

   a. Station T1 – Parallel to the shore at a depth of 20 feet, extending equidistant to either side of Station RW15.

   b. Station T2 – Parallel to the shore at a depth of 20 feet, extending equidistant to either side of Station RW16.

   c. Station T3 – Parallel to the shore at a depth of 20 feet, extending equidistant to either side of Station RW17.

   d. Station T4 – Parallel to the shore at a depth of 20 feet, extending equidistant to either side of Station RW14.

E. Type and Frequency of Sampling:

1. Surface temperatures, dissolved oxygen levels and pH shall be measured semiannually (summer and winter) each year at Stations RW1 through RW5. All stations shall be sampled on both a flooding tide and an ebbing tide during each semiannual survey.

2. Temperature profiles shall be measured semiannually (summer and winter) each year at Stations RW6 through RW17 from surface to bottom at a minimum of one-meter intervals. Dissolved oxygen levels and pH shall be measured semiannually at least at the surface, mid-depth and bottom at each station. All stations shall be sampled on both a flooding tide and an ebbing tide during each semiannual survey.

3. Impingement sampling for fish and commercially important macroinvertebrates shall be conducted at least once every two months at intake Serial No. 002. Impingement sampling shall coincide with heat treatments for at least three of the six sampling events during the year.

   Fish and macroinvertebrates shall be identified to the lowest possible taxon. For each intake point, data reported shall include numerical abundance of each fish and macroinvertebrate species, wet weight of each species (when combined weight of individuals in each species exceeds 0.2 kg), number of individuals in each 1-centimeter size class (based on standard length) for each species and total number of species collected. When large numbers of given species are collected, length/weight data need only be recorded for 50 individuals and total number and total weight may be estimated based on aliquots samples. Total fish impinged per heat treatment or sampling event shall be reported and data shall be expressed per unit volume water entrained.

4. Native California mussels (Mytilus Californianus) shall be collected during the summer from the discharge conduit, as close to the point of discharge as possible, for bioaccumulation monitoring. The mussels shall be collected and analyzed as described in Appendix A of the *California State Mussel Watch Marine Water Quality Monitoring Program 1985-86* (Water Quality Monitoring Report No. 87-2WQ). Mussel tissue shall be analyzed for copper, chromium, nickel, and zinc at a minimum.

5. Sampling by otter trawl shall be conducted semiannually (summer and winter) each year along transects at Stations T1 through T4. Trawls are specialized gear used in large open water areas of reservoirs, lakes, large rivers, estuaries, and offshore marine areas. They are used to gain information on a particular species of fish rather than on overall fish populations. The otter trawl is used to capture near-bottom and bottom fishes.

   a. Trawl net dimensions shall be as follows:

      1. At least a 25 ft throat width.

      2. 1.5 in mesh-size (body).

      3. 0.5 in mesh-size (linear in the cod end).

   b. Two replicate trawls shall be conducted at each station for a duration of 10 minutes each at a uniform speed between 2.0 and 2.5 knots.

   c. The identity, size (standard length), wet weight, and number of fish in each trawl shall be reported. The number of fish affected by abnormal growth or disease, such as fin erosion, lesions, and papillomas, shall be reported. Fish species shall be reported in rank order of abundance and frequency of occurrence for each trawl. The Shannon-Wiener diversity index shall also be computed for each trawl.

   d. All commercially important macroinvertibrates shall be identified, enumerated, and reported in the same manner as fish species.

6. Benthic sampling shall be conducted annually during the summer at Stations B1 through B5.

a. One liter sediment core samples shall be collected by divers at each of the benthic stations for biological examination and determination of biomass and diversity, and for sediment analyses. Four replicates shall be obtained at each station for benthic analyses, and each shall be analyzed separately. A fifth sample shall be taken at each station for sediment analyses and general description.

b. Each benthic replicate sample shall be sieved through a 0.5 mm standard mesh screen. All organisms recovered shall be enumerated an identified to the lowest taxon possible. Infaunal organisms shall be reported as concentrations per liter for each replicate and each station. Total abundance, number of species and Shannon-Weiner diversity indices shall be calculated (using natural logs) for each replicate and each station.

   Biomass shall be determined as the wet weight in grams or milligrams retained on a 0.5 millimeter screen per unit volume (e.g., 1 liter) of sediment. Biomass shall be reported for each major taxonomic group (e.g., polychaetes, crustaceans, mollusks) for each replicate and each station.

c. Sediment grain size analyses shall be performed on each sediment sample (sufficiently detailed to calculate percent weight in relation to the size). Sub-samples (upper tow centimeters) shall be taken from each sediment sample and analyzed for copper, chromium, nickel and zinc.

7. The following general observations or measurement at receiving water, benthic and trawl stations shall be reported:

   a. Tidal stage, time, and date of monitoring.

   b. General water conditions.

   c. Color of the water.

   d. Appearance of oil films or greases, or floatable materials.

   e. Extent of visible turbidity or color patches.

   f. Direction of tidal flow.

   g. Description of odor, if any, of the receiving water.

h. Depth at each station for each sampling period.

i. Presence or absence of red tide.

j. Presence and activity of marine life.

k. Presence of the California Least Tern and California Brown Pelican.

8. During the discharge of calcareous material (excluding heat treatment discharge) to the receiving waters, the following observations or measurements shall be recorded and reported in the next monitoring report:

a. Date and times of discharge(s).

b. Estimate of volume and weigh of discharge(s).

c. Composition of discharge(s).

d. General water conditions and weather conditions.

e. Appearance and extent of any oil films or grease, floatable material or odors.

f. Appearance and extent of visible turbidity or color patches.

g. Presence of marine life.

h. Presence and activity of the California least tern and the California brown pelican.

Reliant Energy Incorporated
Mandalay Generating Station
Monitoring and Reporting Program No. CI-2093

CA0001180

SUMMARY OF RECEIVING WATER MONITORING PROGRAM

Constituent	Units	Stations	Type of Sample	Minimum Frequency of Analysis
Temperature	°C	RW1-RW5	surface	semiannually (flood, ebb)
Temperature	°C	RW6-RW17	vertical profile	semiannually (flood, ebb)
Dissolved oxygen	mg/L	RW1-RW5	surface	semiannually (flood, ebb)
Dissolved oxygen	mg/L	RW6-RW17	vertical profile	semiannually (flood, ebb)
pH	pH Units	RW1-RW5	surface	semiannually (flood, ebb)
pH	pH Units	RW6-RW17	vertical profile	semiannually (flood, ebb)
Fish and macro Invertebrates	----	T1-T4	trawl	semiannually
Fish and macro Invertebrates	----	Intake Serial No. 002	impinge-ment	bimonthly
Benthic Infauna	----	B1-B5	grab	annually
Sediments	----	B1-B5	grab	annually
Mussels	----	Discharge Serial No. 001	tissue	annually

The receiving water monitoring report containing the results of semiannual and annual monitoring shall be received at the Regional Board on March 1 of each year following the calendar year of data collection.

Reliant Energy Incorporated
Mandalay Generating Station
Monitoring and Reporting Program No. CI-2093

CA0001180

VI. STORM WATER MONITORING AND REPORTING

The Discharger shall implement the Monitoring and Reporting Requirements for individual dischargers contained in the general permit for *Dischargers of Storm Water Associated with Industrial Activities* (State Board Order No. 97-030-DWQ) adopted on April 17, 1997. The monitoring reports shall be received at the Regional Board by July 1 of each year. Indicate in the report the Compliance File CI-2093.

Ordered by: ______________________
Dennis A. Dickinson
Executive Officer

Date: April 26, 2001

/COD

Reliant Energy Incorporated
Mandalay Generating Station
Monitoring and Reporting Program No. CI-2093

CA0001180

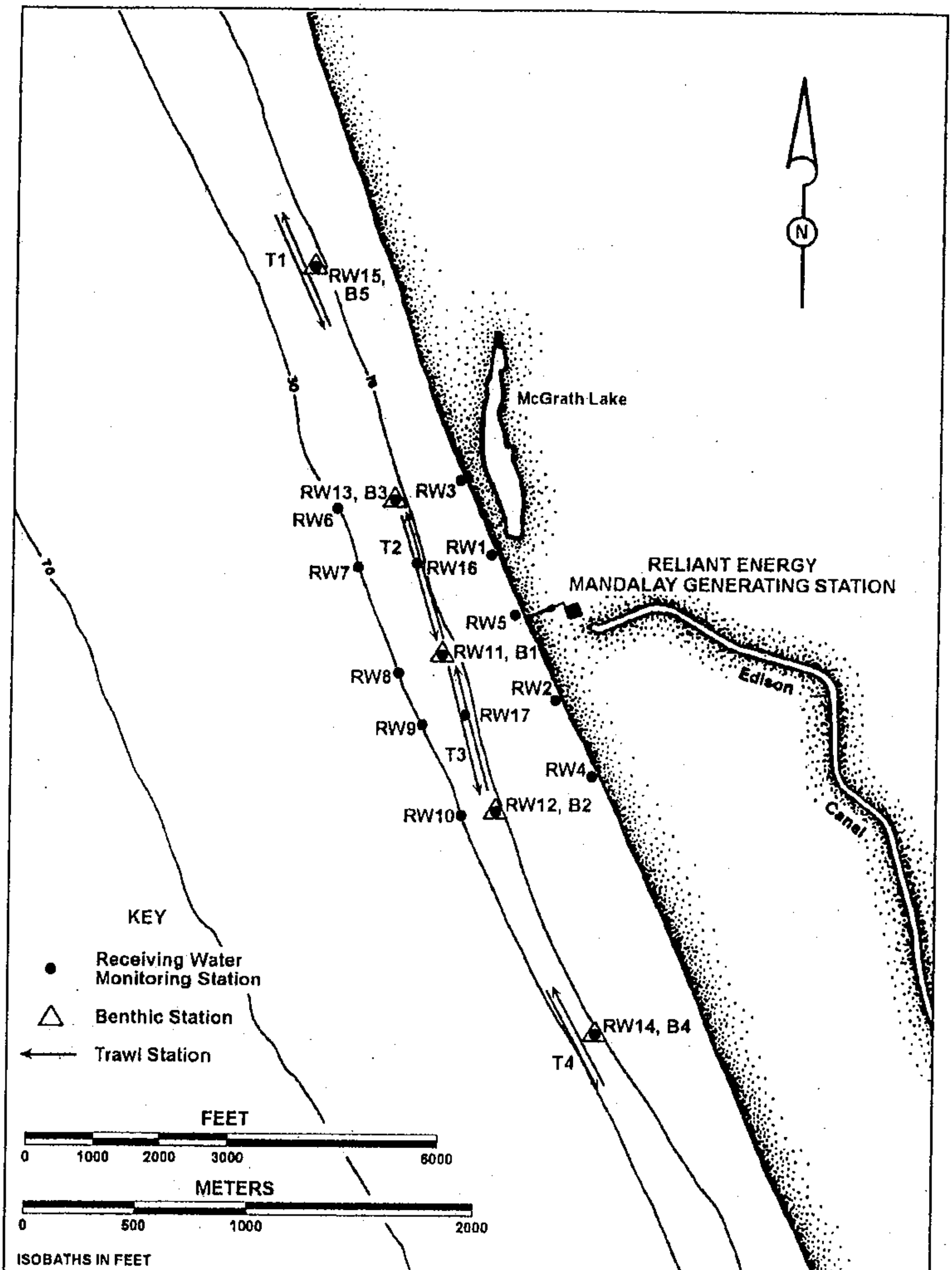


Figure 1. Locations of the sampling stations. Reliant Energy Mandalay Generating Station.

California Regional Water Quality Control Board
Los Angeles Region

320 W. 4th Street, Suite 200, Los Angeles, California 90013
Phone (213) 576-6600 FAX (213) 576-6640 - Internet Address: http://www.waterboards.ca.gov/losangeles

Linda S. Adams
Cal/EPA Secretary

Arnold Schwarzenegger
Governor

February 7, 2008

Ms. Julie Babcock
Environmental, Western Region Operations
Reliant Energy
7251 S. Amigo St., Suite 120
Las Vegas, NV 89119

PARTICIPATION IN BIGHT'08 REGIONAL MONITORING OF COASTAL OCEAN WATERS MANDALAY GENERATING STATION (NPDES PERMIT NO. CA0001180, CI2093) ORMOND BEACH GENERATING STATION (NPDES PERMIT NO. CA0001198, CI5619)

Dear Ms. Babcock:

As you know, planning is underway for the fourth comprehensive regional survey of coastal ocean waters in the Southern California Bight (Bight'08). As we have done in the past, the Los Angeles Regional Board and the United States Environmental Protection Agency plan to facilitate your agency's participation in the Bight'08 study through a resource exchange by diverting a portion of the routine compliance monitoring into this program. As before, our goal is to implement the regional monitoring program without significantly increasing the total cost of your monitoring requirements. Your letter of January 21, 2008, outlined a reduced monitoring program for 2008, which you are directed to implement as specified below:

1. Reliant Mandalay Generating Station

   a. Eliminate 2008 winter receiving water monitoring surveys that normally would be conducted as part of compliance monitoring.

   b. For the 2008 summer receiving water monitoring survey, retain water quality sampling at all receiving water stations for compliance monitoring purposes and retain four benthic infaunal sampling stations (B1, B2, B3 and B4) with sediment chemistry and grain size analyses at each station; however, reduce benthic sampling to collection of only two replicate samples. Retain trawling at all sampling stations (10-minute trawls, one replicate per station). Retain mussel bioaccumulation monitoring (if resident mussels are located in the discharge area) and fish impingement monitoring as normally required.

2. Reliant Ormond Beach Generating Station

   a. Eliminate 2008 winter receiving water monitoring surveys that normally would be conducted as part of compliance monitoring.

   b. For the 2008 summer receiving water monitoring survey, retain water quality sampling at all receiving water stations for compliance monitoring purposes and retain four benthic infaunal sampling stations (B2, B3, B4 and B5) with sediment chemistry and grain size analyses at each station; however, reduce benthic sampling to collection of only two replicate samples. * Retain trawling at all sampling stations (10-minute trawls, one replicate per station). Retain mussel bioaccumulation monitoring (if resident mussels are located in the discharge area) and fish impingement monitoring as normally required. ** Trawling not required for Ormond Beach Generating Station. M. Lyons 2/20/2008*

In exchange for the reduced monitoring program commitments outlined above, Reliant Energy has agreed to direct MBC Applied Environmental Sciences (MBC) to act on their behalf and perform services valued at $17,300 in exchange for the reduced sampling at the Mandalay Generating Station and $22,100 for the Ormond Beach Generating Station. The Bight'08 survey will be administered by the Southern California Coastal Water Research Project (SCCWRP), which will coordinate the distribution of assignments and project effort. MBC will coordinate with SCCWRP directly to most efficiently and effectively provide services to the Bight'08 program. We understand that Reliant Energy would prefer to see their effort distributed into marinas, estuaries and nearshore zones within the northern project area of the Bight, particularly within Channel Islands Harbor. However, as Reliant Energy realizes, the actual locations and types of sampling to be performed will be determined by SCCWRP. The normal receiving water monitoring program should be resumed beginning in 2009.

We appreciate your interest and cooperation in participating in this valuable regional monitoring survey. If you have any questions, please contact Michael Lyons at (213) 576-6718, as he is the staff person most familiar with this project.

Sincerely,

Tracy J. Egoscue
Executive Officer

Cc: Terry Fleming, U.S. Environmental Protection Agency, Region IX (WTR-2)
David Vilas, MBC Applied Environmental Sciences, Carlsbad
Ken Schiff, Southern California Coastal Water Research Project

APPENDIX B

Receiving water quality parameters by station

Appendix B. Water quality parameters at each receiving water monitoring station during flood and ebb tides. Mandalay Generating Station NPDES, summer 2008.

	Depth (m)	Temp. (°C) FLOOD	Temp. (°C) EBB	Oxygen (mg/l) FLOOD	Oxygen (mg/l) EBB	pH FLOOD	pH EBB	Salinity (psu) FLOOD	Salinity (psu) EBB
Surf Zone									
RW1	0	17.19	18.12	7.98	7.93	8.07	8.23	32.4	32.8
RW2	0	15.91	16.63	8.34	8.32	8.08	8.27	32.6	32.8
RW3	0	16.99	18.57	7.99	7.86	8.08	8.20	32.4	32.7
RW4	0	15.83	16.78	7.39	8.27	8.04	8.28	32.5	32.7
RW5	0	19.62	17.38	7.87	8.29	7.83	8.22	32.2	33.0
Offshore									
RW6	0	16.55	16.65	7.78	8.45	8.18	8.23	33.35	33.37
	1	16.11	16.61	7.83	8.43	8.18	8.23	33.37	33.37
	2	15.77	16.40	7.86	8.46	8.18	8.23	33.39	33.38
	3	15.53	16.08	7.84	8.48	8.18	8.23	33.40	33.39
	4	15.04	15.43	7.96	8.51	8.19	8.22	33.40	33.39
	5	14.66	15.09	8.16	8.41	8.18	8.21	33.41	33.37
	6	14.66	14.88	8.05	8.39	8.18	8.21	33.39	33.37
	7	14.49	14.82	7.97	8.36	8.17	8.21	33.39	33.36
	8	14.34	14.81	7.91	8.34	8.16	8.21	33.38	33.36
	9	14.32	14.80	7.86	8.34	8.16	8.21	33.38	33.36
	10	14.27	14.78	7.83	8.33	8.16	8.21	33.38	33.36
	11	13.94	14.77	7.85	8.33	8.15	8.20	33.39	33.36
RW7	0	16.45	16.62	7.74	8.40	8.18	8.23	33.37	33.37
	1	16.39	16.45	7.74	8.41	8.18	8.23	33.37	33.37
	2	16.15	15.55	7.79	8.47	8.18	8.22	33.38	33.40
	3	15.82	15.15	7.85	8.41	8.18	8.21	33.38	33.37
	4	15.08	14.96	7.94	8.39	8.19	8.20	33.44	33.37
	5	14.69	14.81	8.08	8.34	8.18	8.20	33.41	33.36
	6	14.59	14.78	8.00	8.31	8.17	8.20	33.39	33.36
	7	14.48	14.77	7.91	8.31	8.17	8.20	33.39	33.36
	8	14.34	14.76	7.86	8.29	8.16	8.20	33.38	33.36
	9	14.29	14.76	7.82	8.32	8.16	8.20	33.38	33.36
	10	14.22	14.76	7.84	8.30	8.16	8.20	33.39	33.36
	11	13.96	14.75	7.85	8.31	8.15	8.20	33.39	33.36
RW8	0	16.74	16.71	7.73	8.35	8.19	8.23	33.36	33.36
	1	16.61	16.59	7.73	8.34	8.19	8.22	33.37	33.37
	2	16.17	16.15	7.79	8.39	8.19	8.22	33.40	33.38
	3	15.76	15.34	7.81	8.42	8.18	8.21	33.40	33.38
	4	15.16	15.02	7.88	8.39	8.19	8.20	33.43	33.38
	5	14.91	14.89	8.07	8.29	8.19	8.20	33.41	33.36
	6	14.63	14.82	8.16	8.31	8.19	8.20	33.40	33.36
	7	14.37	14.79	8.07	8.29	8.18	8.20	33.40	33.36
	8	14.26	14.78	7.98	8.29	8.17	8.20	33.38	33.36
	9	14.23	14.77	8.00	8.28	8.17	8.20	33.38	33.36
	10	14.21	14.75	7.99	8.28	8.17	8.20	33.38	33.36
	11	13.96	14.74	8.00	8.26	8.15	8.20	33.38	33.36

Appendix B. (Cont.).

	Depth (m)	Temp. (°C) FLOOD	Temp. (°C) EBB	Oxygen (mg/l) FLOOD	Oxygen (mg/l) EBB	pH FLOOD	pH EBB	Salinity (psu) FLOOD	Salinity (psu) EBB
RW9	0	16.66	16.64	7.80	8.31	8.19	8.22	33.36	33.37
	1	16.71	16.43	7.81	8.33	8.19	8.22	33.37	33.37
	2	16.07	15.75	7.85	8.36	8.19	8.21	33.39	33.39
	3	15.45	15.44	7.89	8.37	8.19	8.21	33.41	33.38
	4	15.08	15.05	8.14	8.40	8.20	8.20	33.41	33.38
	5	14.80	14.88	8.20	8.34	8.19	8.20	33.39	33.37
	6	14.48	14.82	8.11	8.29	8.18	8.20	33.39	33.36
	7	14.44	14.78	8.07	8.26	8.18	8.20	33.38	33.36
	8	14.45	14.78	8.07	8.27	8.18	8.20	33.37	33.36
	9	14.44	14.75	8.07	8.28	8.18	8.20	33.37	33.36
	10	14.28	14.74	8.08	8.26	8.17	8.20	33.37	33.35
	11	14.19	14.73	7.89	8.28	8.16	8.20	33.38	33.35
RW10	0	17.04	15.80	7.78	8.25	8.19	8.20	33.37	33.35
	1	17.03	15.79	7.77	8.26	8.19	8.20	33.37	33.35
	2	16.50	15.74	7.81	8.28	8.19	8.20	33.39	33.35
	3	15.81	15.63	7.86	8.29	8.20	8.20	33.42	33.36
	4	15.08	15.57	8.17	8.29	8.20	8.20	33.42	33.36
	5	14.74	15.35	8.19	8.30	8.19	8.20	33.40	33.36
	6	14.67	15.11	8.13	8.28	8.18	8.19	33.39	33.36
	7	14.65	14.93	8.05	8.29	8.18	8.19	33.38	33.36
	8	14.61	14.84	8.07	8.23	8.18	8.19	33.38	33.36
	9	14.59	14.83	8.06	8.24	8.18	8.19	33.37	33.36
	10	14.33	14.79	8.11	8.22	8.17	8.19	33.38	33.35
	11	14.29	14.75	7.90	8.20	8.16	8.19	33.38	33.35
RW11	0	16.39	16.85	7.83	8.33	8.18	8.23	33.36	33.37
	1	16.34	16.85	7.83	8.33	8.18	8.23	33.36	33.37
	2	15.92	16.54	7.88	8.36	8.18	8.23	33.39	33.39
	3	15.57	16.26	7.89	8.34	8.18	8.21	33.39	33.39
	4	15.31	16.10	7.90	8.27	8.18	8.20	33.40	33.38
	5	15.14	15.79	7.97	8.27	8.18	8.20	33.39	33.41
RW12	0	16.73	15.79	7.77	8.34	8.19	8.20	33.35	33.35
	1	16.70	15.79	7.77	8.34	8.18	8.21	33.37	33.35
	2	16.06	15.79	7.81	8.33	8.18	8.20	33.40	33.35
	3	15.94	15.74	7.89	8.35	8.19	8.21	33.39	33.36
	4	15.93	15.62	7.92	8.37	8.18	8.21	33.38	33.36
	5	15.82	15.34	7.91	8.38	8.18	8.21	33.39	33.38
	6	15.35	15.10	7.94	8.37	8.18	8.20	33.40	33.38
RW13	0	16.57	17.69	7.78	8.08	8.17	8.22	33.30	33.34
	1	16.46	17.46	7.79	8.15	8.17	8.22	33.31	33.37
	2	15.86	17.18	7.86	8.24	8.18	8.23	33.39	33.39
	3	15.38	17.14	7.86	8.26	8.18	8.23	33.40	33.39
	4	15.07	16.44	7.86	8.37	8.17	8.23	33.40	33.48
	5	14.79	15.73	7.85	8.45	8.17	8.22	33.40	33.29
RW14	0	16.20	15.78	7.82	8.08	8.18	8.19	33.37	33.35
	1	16.03	15.78	7.84	8.08	8.18	8.19	33.38	33.36
	2	15.37	15.75	7.95	8.07	8.19	8.19	33.40	33.36
	3	15.05	15.57	8.23	8.11	8.19	8.19	33.38	33.37
	4	15.03	15.49	8.16	8.14	8.18	8.19	33.38	33.37
	5	14.98	15.32	8.15	8.17	8.18	8.20	33.37	33.37
	6		15.27		8.23		8.20		33.37

Appendix B. (Cont.).

	Depth (m)	Temp. (°C) FLOOD	Temp. (°C) EBB	Oxygen (mg/l) FLOOD	Oxygen (mg/l) EBB	pH FLOOD	pH EBB	Salinity (psu) FLOOD	Salinity (psu) EBB
RW15	0	16.65	17.01	7.81	8.42	8.17	8.24	33.33	33.38
	1	16.65	17.00	7.81	8.44	8.18	8.24	33.33	33.38
	2	16.31	16.99	7.85	8.42	8.18	8.24	33.40	33.38
	3	14.81	16.94	7.95	8.47	8.17	8.24	33.43	33.38
	4	14.56	16.57	7.85	8.45	8.16	8.24	33.41	33.44
	5	14.37	15.04	7.89	8.49	8.16	8.21	33.39	33.42
	6	14.22	14.57	7.90	8.21	8.16	8.19	33.41	33.40
RW16	0	16.37	16.85	7.83	8.38	8.18	8.23	33.35	33.37
	1	16.33	16.85	7.81	8.37	8.18	8.23	33.35	33.37
	2	16.15	16.82	7.83	8.36	8.18	8.23	33.38	33.38
	3	15.47	16.76	7.91	8.39	8.18	8.23	33.40	33.38
	4	15.19	16.40	7.85	8.38	8.17	8.22	33.39	33.41
	5	15.07	15.31	7.83	8.41	8.17	8.21	33.39	33.41
	6	14.84		7.90		8.17		33.40	
RW17	0	16.55	16.39	7.83	8.31	8.19	8.22	33.36	33.36
	1	16.44	16.39	7.83	8.30	8.19	8.22	33.37	33.36
	2	15.75	16.20	7.92	8.33	8.19	8.22	33.40	33.38
	3	15.64	15.92	7.90	8.37	8.18	8.21	33.39	33.38
	4	15.46	15.73	7.93	8.40	8.18	8.21	33.39	33.38
	5	15.38	15.59	7.92	8.35	8.18	8.20	33.38	33.38
	6	15.46	15.29	7.89	8.35	8.18	8.20	33.37	33.39

APPENDIX C

Sediment grain size techniques and statistical parameters by station

Appendix C-1. Grain size techniques.

Sediment Grain Size Analysis

Analysis of sediment samples for size distribution characteristics are performed using two techniques. Sediments in the gravel size range (> 2.0 mm in diameter) are analyzed using a series of standard sieves having screen openings of 0.5 phi increments (diameter in phi units = $-\log_2$ diameter in mm, or = -ln diameter in mm ÷ ln 2). The sand-silt-clay fraction of sediments [-1 phi through 4 phi (2.0 mm through 0.0625 mm) for sand], [4 phi through 8 phi (0.0625 mm through 0.004 mm) for silt, 8 phi and greater for clay (0.0039 mm and smaller)] is analyzed by laser light diffraction. The sample is suspended in a suspension column and continuously circulated through the laser beam. The laser beam passes through the sample where the suspended particles scatter incident light. Fourier optics collect diffracted light and focus it on to three sets of detectors. A composite, time-averaged diffraction pattern is measured by 126 detectors. Sizes are computed and summed into normal distribution classifications.

Laboratory data from the two methods are mathematically combined and entered into a computer program which calculates and prints size-distribution characteristics and plots both interval and cumulative frequency distribution curves.

Analysis of the plotted cumulative size frequency curves is performed as described by Inman (1952). The median, 5th, 16th, 84th, and 95th percentiles (converted to phi notation) of the sediment distribution curve is used to calculate mean grain size diameter, sorting coefficient, and measures of skewness and kurtosis. Where sediment distribution coincides with a normal distribution curve, the 16th and 84th percentiles represent diameters one standard deviation on either side of the mean. The following formulas are used in the calculations:

1. Mean Diameter (M_ϕ) is the average particle size in the central 68% of the distribution.

$$M_\phi = \left(\phi_{16} + \phi_{50} + \phi_{84}\right) / 3$$

2. Sorting (σ_ϕ) measures the uniformity (or non-uniformity) of particle quantities in each size category of the sediment distribution. A σ_ϕ value under 0.35ϕ indicates that particles are very well sorted (i.e. sediments are primarily composed of a narrow range of size classes, or a single size class), while a value of over 4.0ϕ indicates that the sediments are extremely poorly sorted, or evenly distributed among size classes.

$$\sigma_\phi = \frac{\phi_{84} - \phi_{16}}{4} + \frac{\phi_{95} - \phi_5}{6.6}$$

3. Skewness (α_ϕ) is a measure of the direction and extent of departure of the mean from the median (in a normal or symmetrical curve they coincide). In symmetrical curves, α_ϕ=0.00 with limits of -1.00 and +1.00. Negative values indicate the particle distribution is skewed toward larger particle diameters, while positive values indicate the distribution is skewed toward smaller particle diameters.

$$\alpha_\phi = \frac{\phi_{16} + \phi_{84} - 2\phi_{50}}{2\left(\phi_{84} - \phi_{16}\right)} + \frac{\phi_5 + \phi_{95} - 2\phi_{50}}{2\left(\phi_{95} - \phi_5\right)}$$

4. Kurtosis (β_ϕ) is a measure of how far the sediment distribution curve departs from a normal Gaussian shape at its peak. Curves with greater than normal amounts of sediment at their modes will be sharp or leptokurtic ($\beta_\phi > 1$). Those with fatter tails and lower peaks than expected are termed platykurtic ($\beta_\phi < 1$). β_ϕ = 1.00 for a normal curve. Curve category interpretations are based on Folk (1974).

$$\beta_\phi = \frac{\phi_{95} - \phi_5}{2.44\left(\phi_{75} - \phi_{25}\right)}$$

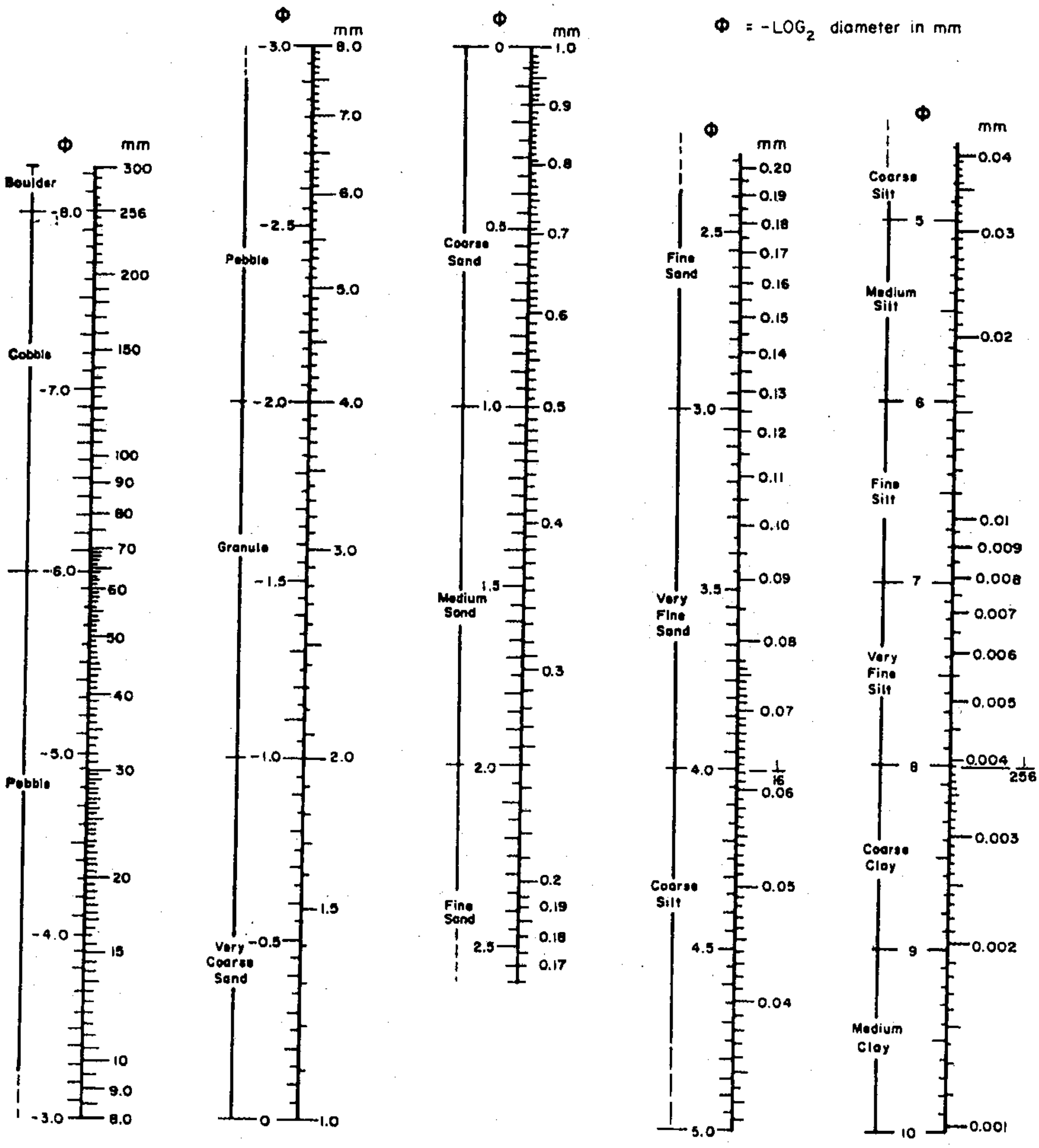
LITERATURE CITED

Folk, R. L. 1974. Petrology of sedimentary rocks. Hemphill Publishing Co., Austin, TX. 182 p.

Inman, D. L. 1952. Measures for describing the size distribution of sediments. J. Sed. Pet. 22:125-145.

Appendix C-1. (Cont.).

Phi - Millimeter Conversion Figure



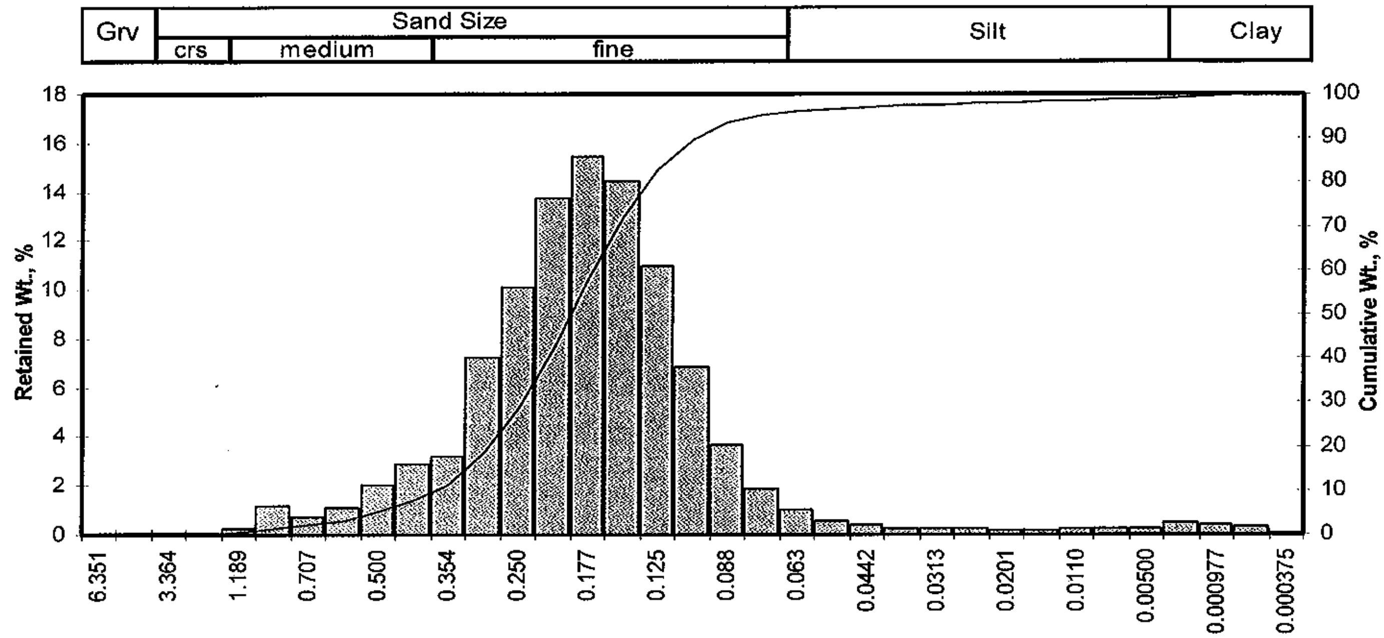
Measurement sorting values for a large number of sediments has suggested the following verbal classification scale for sorting:

σ_I under	.35 ϕ,	very well sorted
	.35-.50 ϕ,	well sorted
	.50-.71 ϕ,	moderately well sorted
	.71-1.0 ϕ	moderately sorted
	1.0-2.0 ϕ,	poorly sorted
	2.0-4.0 ϕ,	very poorly sorted
	over 4.0 ϕ,	extremely poorly sorted

Appendix C-2. Sediment grain size distribution and statistical parameters by station. Mandalay Generating Station NPDES, 2008.

PTS Laboratories, Inc. — **Particle Size Analysis - ASTM D4464M**

Client:	Calscience	**PTS File No:**	38923
Project:	N/A	**Sample ID:**	MGS B1
Project No:	08-10-1029	**Depth, ft:**	N/A



Opening Inches	Opening Millimeters	Phi of Screen	U.S. No.	Sample Weight, grams	Increment Weight, percent	Cumulative Weight, percent
0.2500	6.351	-2.67	1/4	0.00	0.00	0.00
0.1873	4.757	-2.25	4	0.00	0.00	0.00
0.1324	3.364	-1.75	6	0.00	0.00	0.00
0.0787	2.000	-1.00	10	0.00	0.00	0.00
0.0468	1.189	-0.25	16	0.22	0.22	0.22
0.0331	0.841	0.25	20	1.14	1.14	1.36
0.0278	0.707	0.50	25	0.67	0.67	2.03
0.0234	0.595	0.75	30	1.06	1.06	3.09
0.0197	0.500	1.00	35	2.01	2.01	5.11
0.0166	0.420	1.25	40	2.84	2.84	7.95
0.0139	0.354	1.50	45	3.20	3.20	11.15
0.0117	0.297	1.75	50	7.18	7.19	18.34
0.0098	0.250	2.00	60	10.10	10.11	28.45
0.0083	0.210	2.25	70	13.70	13.71	42.16
0.0070	0.177	2.50	80	15.40	15.42	57.58
0.0059	0.149	2.75	100	14.40	14.41	71.99
0.0049	0.125	3.00	120	10.90	10.91	82.90
0.0041	0.105	3.25	140	6.83	6.84	89.74
0.0035	0.088	3.50	170	3.64	3.64	93.38
0.0029	0.074	3.75	200	1.83	1.83	95.22
0.0025	0.063	4.00	230	0.98	0.98	96.20
0.0021	0.053	4.25	270	0.57	0.57	96.77
0.00174	0.0442	4.50	325	0.36	0.36	97.13
0.00146	0.0372	4.75	400	0.26	0.26	97.39
0.00123	0.0313	5.00	450	0.21	0.21	97.60
0.000986	0.0250	5.32	500	0.22	0.22	97.82
0.000790	0.0201	5.64	635	0.18	0.18	98.00
0.000615	0.0156	6.00		0.17	0.17	98.17
0.000435	0.0110	6.50		0.23	0.23	98.40
0.000308	0.00781	7.00		0.22	0.22	98.62
0.000197	0.00500	7.65		0.26	0.26	98.88
0.000077	0.00195	9.00		0.45	0.45	99.33
0.000038	0.000977	10.00		0.36	0.36	99.69
0.000019	0.000488	11.00		0.28	0.28	99.97
0.000015	0.000375	11.38		0.03	0.03	100.00
TOTALS				**99.90**	**100.00**	**100.00**

Cumulative Weight Percent greater than			
Weight percent	Phi Value	Particle Size Inches	Particle Size Millimeters
5	0.99	0.0199	0.505
10	1.41	0.0148	0.376
16	1.67	0.0124	0.315
25	1.91	0.0104	0.265
40	2.21	0.0085	0.216
50	2.38	0.0076	0.192
60	2.54	0.0068	0.172
75	2.82	0.0056	0.142
84	3.04	0.0048	0.122
90	3.27	0.0041	0.104
95	3.72	0.0030	0.076

Measure	Trask	Inman	Folk-Ward
Median, phi	2.38	2.38	2.38
Median, in.	0.0076	0.0076	0.0076
Median, mm	0.192	0.192	0.192
Mean, phi	2.30	2.35	2.36
Mean, in.	0.0080	0.0077	0.0077
Mean, mm	0.203	0.196	0.195
Sorting	1.368	0.686	0.757
Skewness	1.007	-0.033	-0.025
Kurtosis	0.227	0.993	1.239
Grain Size Description (ASTM-USCS Scale)	Fine sand (based on Mean from Trask)		

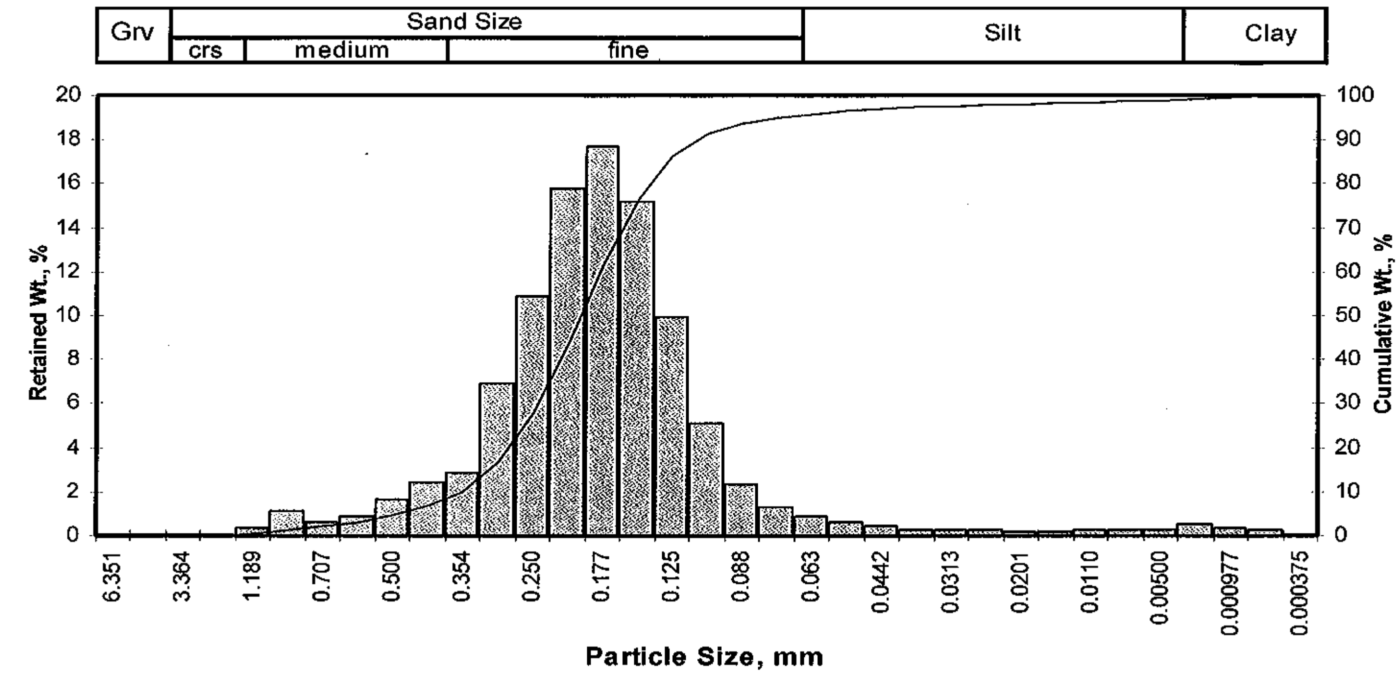
Description	Retained on Sieve #	Weight Percent
Gravel	4	0.00
Coarse Sand	10	0.00
Medium Sand	40	7.95
Fine Sand	200	87.27
Silt	>0.005 mm	3.66
Clay	<0.005 mm	1.12
	Total	100

Appendix C-2. (Cont.).

PTS Laboratories, Inc.

Particle Size Analysis - ASTM D4464M

Client:	Calscience	**PTS File No:**	38923
Project:	N/A	**Sample ID:**	MGS B2
Project No:	08-10-1029	**Depth, ft:**	N/A



Opening Inches	Opening Millimeters	Phi of Screen	U.S. No.	Sample Weight, grams	Increment Weight, percent	Cumulative Weight, percent
0.2500	6.351	-2.67	1/4	0.00	0.00	0.00
0.1873	4.757	-2.25	4	0.00	0.00	0.00
0.1324	3.364	-1.75	6	0.00	0.00	0.00
0.0787	2.000	-1.00	10	0.00	0.00	0.00
0.0468	1.189	-0.25	16	0.37	0.37	0.37
0.0331	0.841	0.25	20	1.08	1.08	1.45
0.0278	0.707	0.50	25	0.59	0.59	2.04
0.0234	0.595	0.75	30	0.88	0.88	2.92
0.0197	0.500	1.00	35	1.67	1.67	4.59
0.0166	0.420	1.25	40	2.45	2.45	7.04
0.0139	0.354	1.50	45	2.83	2.83	9.87
0.0117	0.297	1.75	50	6.94	6.94	16.81
0.0098	0.250	2.00	60	10.90	10.90	27.70
0.0083	0.210	2.25	70	15.80	15.80	43.50
0.0070	0.177	2.50	80	17.70	17.70	61.20
0.0059	0.149	2.75	100	15.20	15.20	76.39
0.0049	0.125	3.00	120	9.91	9.91	86.30
0.0041	0.105	3.25	140	5.06	5.06	91.36
0.0035	0.088	3.50	170	2.34	2.34	93.70
0.0029	0.074	3.75	200	1.30	1.30	95.00
0.0025	0.063	4.00	230	0.89	0.89	95.89
0.0021	0.053	4.25	270	0.62	0.62	96.51
0.00174	0.0442	4.50	325	0.42	0.42	96.93
0.00146	0.0372	4.75	400	0.30	0.30	97.23
0.00123	0.0313	5.00	450	0.24	0.24	97.47
0.000986	0.0250	5.32	500	0.24	0.24	97.71
0.000790	0.0201	5.64	635	0.20	0.20	97.91
0.000615	0.0156	6.00		0.19	0.19	98.10
0.000435	0.0110	6.50		0.24	0.24	98.34
0.000308	0.00781	7.00		0.22	0.22	98.56
0.000197	0.00500	7.65		0.27	0.27	98.83
0.000077	0.00195	9.00		0.48	0.48	99.31
0.000038	0.000977	10.00		0.37	0.37	99.68
0.000019	0.000488	11.00		0.29	0.29	99.97
0.000015	0.000375	11.38		0.03	0.03	100.00
TOTALS				**100.00**	**100.00**	**100.00**

Cumulative Weight Percent greater than			
Weight percent	Phi Value	Particle Size Inches	Particle Size Millimeters
5	1.04	0.0191	0.486
10	1.50	0.0139	0.352
16	1.72	0.0119	0.303
25	1.94	0.0103	0.261
40	2.19	0.0086	0.218
50	2.34	0.0078	0.197
60	2.48	0.0070	0.179
75	2.73	0.0059	0.151
84	2.94	0.0051	0.130
90	3.18	0.0043	0.110
95	3.75	0.0029	0.074

Measure	Trask	Inman	Folk-Ward
Median, phi	2.34	2.34	2.34
Median, in.	0.0078	0.0078	0.0078
Median, mm	0.197	0.197	0.197
Mean, phi	2.28	2.33	2.33
Mean, in.	0.0081	0.0078	0.0078
Mean, mm	0.206	0.199	0.198
Sorting	1.315	0.610	0.716
Skewness	1.006	-0.017	0.011
Kurtosis	0.227	1.218	1.406

Grain Size Description (ASTM-USCS Scale)	Fine sand (based on Mean from Trask)

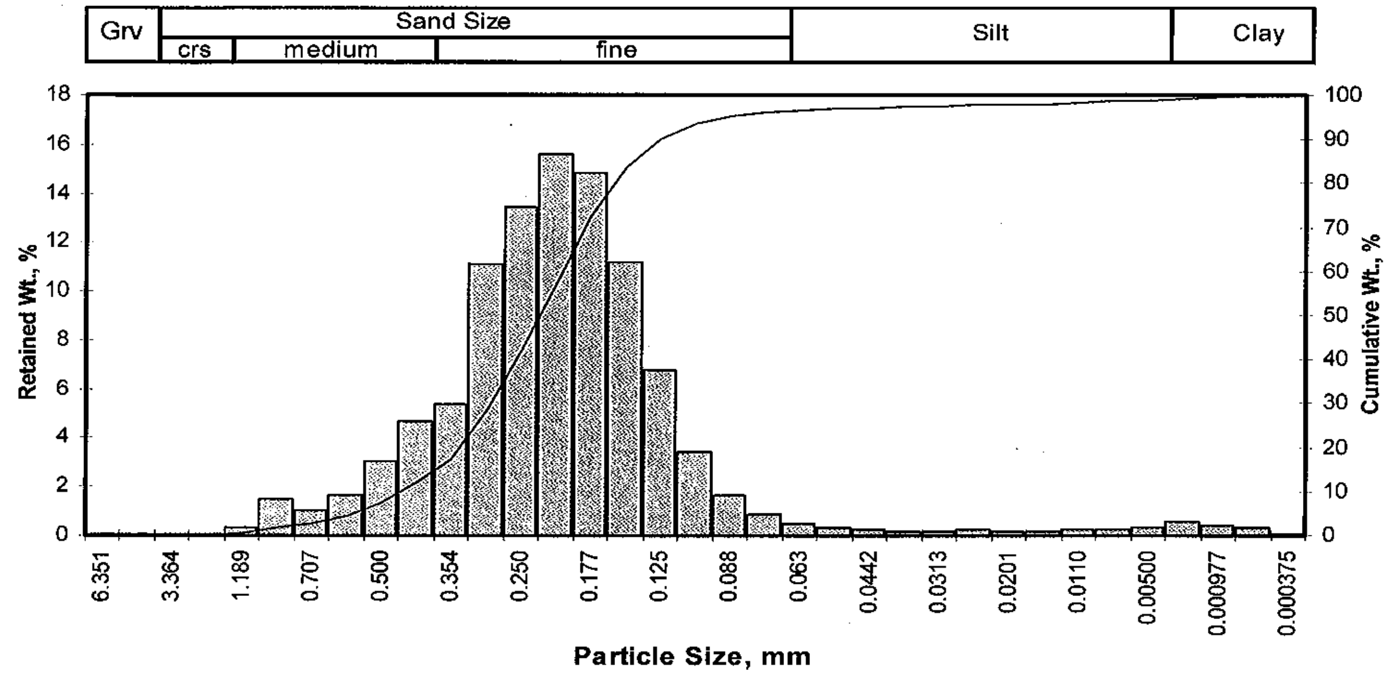
Description	Retained on Sieve #	Weight Percent
Gravel	4	0.00
Coarse Sand	10	0.00
Medium Sand	40	7.04
Fine Sand	200	87.96
Silt	>0.005 mm	3.83
Clay	<0.005 mm	1.17
	Total	100

Appendix C-2. (Cont.).

PTS Laboratories, Inc.

Particle Size Analysis - ASTM D4464M

Client:	Calscience	**PTS File No:**	38923
Project:	N/A	**Sample ID:**	MGS B3
Project No:	08-10-1029	**Depth, ft:**	N/A



Opening		Phi of	U.S.	Sample Weight,	Increment Weight,	Cumulative Weight,
Inches	Millimeters	Screen	No.	grams	percent	percent
0.2500	6.351	-2.67	1/4	0.00	0.00	0.00
0.1873	4.757	-2.25	4	0.00	0.00	0.00
0.1324	3.364	-1.75	6	0.00	0.00	0.00
0.0787	2.000	-1.00	10	0.00	0.00	0.00
0.0468	1.189	-0.25	16	0.28	0.28	0.28
0.0331	0.841	0.25	20	1.51	1.51	1.79
0.0278	0.707	0.50	25	0.99	0.99	2.78
0.0234	0.595	0.75	30	1.60	1.60	4.38
0.0197	0.500	1.00	35	3.01	3.01	7.39
0.0166	0.420	1.25	40	4.62	4.62	12.01
0.0139	0.354	1.50	45	5.39	5.39	17.40
0.0117	0.297	1.75	50	11.10	11.10	28.50
0.0098	0.250	2.00	60	13.40	13.40	41.90
0.0083	0.210	2.25	70	15.60	15.60	57.50
0.0070	0.177	2.50	80	14.80	14.80	72.30
0.0059	0.149	2.75	100	11.20	11.20	83.50
0.0049	0.125	3.00	120	6.75	6.75	90.25
0.0041	0.105	3.25	140	3.41	3.41	93.66
0.0035	0.088	3.50	170	1.61	1.61	95.27
0.0029	0.074	3.75	200	0.85	0.85	96.12
0.0025	0.063	4.00	230	0.50	0.50	96.62
0.0021	0.053	4.25	270	0.31	0.31	96.93
0.00174	0.0442	4.50	325	0.22	0.22	97.15
0.00146	0.0372	4.75	400	0.19	0.19	97.34
0.00123	0.0313	5.00	450	0.17	0.17	97.51
0.000986	0.0250	5.32	500	0.20	0.20	97.71
0.000790	0.0201	5.64	635	0.17	0.17	97.88
0.000615	0.0156	6.00		0.18	0.18	98.06
0.000435	0.0110	6.50		0.23	0.23	98.29
0.000308	0.00781	7.00		0.23	0.23	98.52
0.000197	0.00500	7.65		0.28	0.28	98.80
0.000077	0.00195	9.00		0.51	0.51	99.31
0.000038	0.000977	10.00		0.38	0.38	99.69
0.000019	0.000488	11.00		0.28	0.28	99.97
0.000015	0.000375	11.38		0.03	0.03	100.00
TOTALS				**100.00**	**100.00**	**100.00**

Cumulative Weight Percent greater than			
Weight	Phi	Particle Size	
percent	Value	Inches	Millimeters
5	0.80	0.0226	0.574
10	1.14	0.0178	0.453
16	1.44	0.0146	0.370
25	1.67	0.0124	0.314
40	1.96	0.0101	0.256
50	2.13	0.0090	0.228
60	2.29	0.0080	0.204
75	2.56	0.0067	0.170
84	2.77	0.0058	0.147
90	2.99	0.0050	0.126
95	3.46	0.0036	0.091

Measure	Trask	Inman	Folk-Ward
Median, phi	2.13	2.13	2.13
Median, in.	0.0090	0.0090	0.0090
Median, mm	0.228	0.228	0.228
Mean, phi	2.05	2.10	2.11
Mean, in.	0.0095	0.0092	0.0091
Mean, mm	0.242	0.233	0.231
Sorting	1.361	0.667	0.736
Skewness	1.010	-0.042	-0.021
Kurtosis	0.220	0.992	1.225
Grain Size Description (ASTM-USCS Scale)	Fine sand (based on Mean from Trask)		

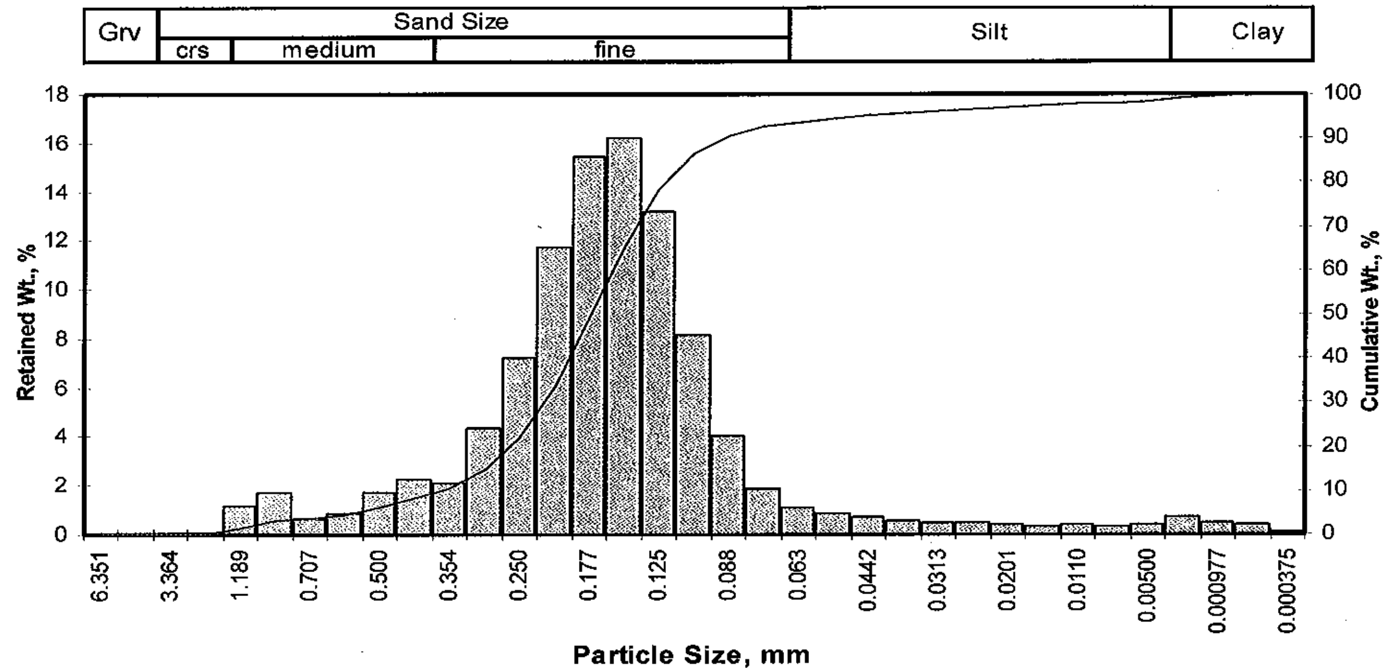
Description	Retained on Sieve #	Weight Percent
Gravel	4	0.00
Coarse Sand	10	0.00
Medium Sand	40	12.01
Fine Sand	200	84.11
Silt	>0.005 mm	2.68
Clay	<0.005 mm	1.20
	Total	100

Appendix C-2. (Cont.).

PTS Laboratories, Inc.

Particle Size Analysis - ASTM D4464M

Client:	Calscience	**PTS File No:**	38923
Project:	N/A	**Sample ID:**	MGS B4
Project No:	08-10-1029	**Depth, ft:**	N/A



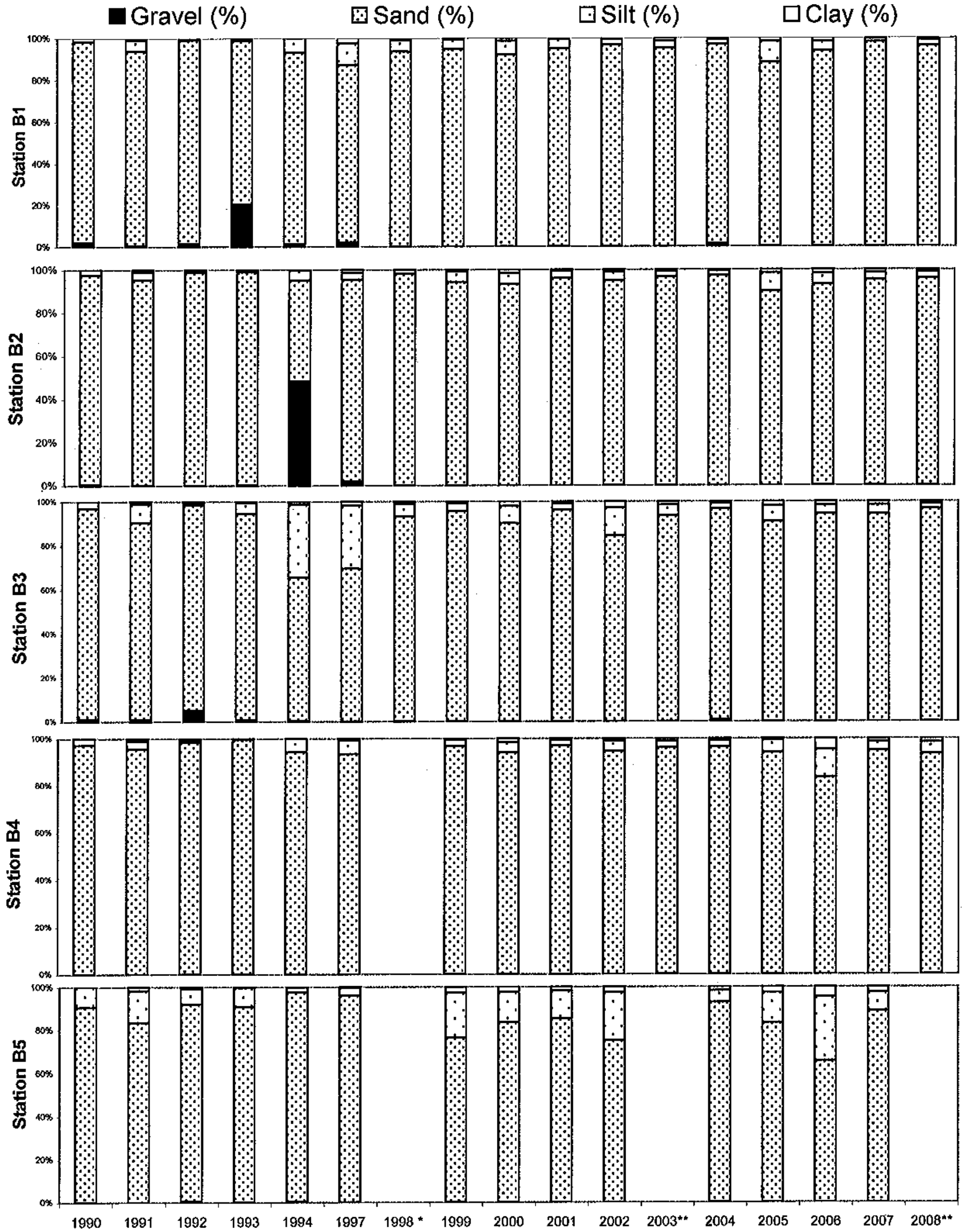
Opening Inches	Opening Millimeters	Phi of Screen	U.S. No.	Sample Weight, grams	Increment Weight, percent	Cumulative Weight, percent
0.2500	6.351	-2.67	1/4	0.00	0.00	0.00
0.1873	4.757	-2.25	4	0.00	0.00	0.00
0.1324	3.364	-1.75	6	0.00	0.00	0.00
0.0787	2.000	-1.00	10	0.00	0.00	0.00
0.0468	1.189	-0.25	16	1.20	1.20	1.20
0.0331	0.841	0.25	20	1.69	1.69	2.89
0.0278	0.707	0.50	25	0.61	0.61	3.50
0.0234	0.595	0.75	30	0.82	0.82	4.32
0.0197	0.500	1.00	35	1.74	1.74	6.06
0.0166	0.420	1.25	40	2.27	2.27	8.33
0.0139	0.354	1.50	45	2.06	2.06	10.39
0.0117	0.297	1.75	50	4.36	4.36	14.76
0.0098	0.250	2.00	60	7.24	7.24	22.00
0.0083	0.210	2.25	70	11.70	11.70	33.70
0.0070	0.177	2.50	80	15.40	15.41	49.11
0.0059	0.149	2.75	100	16.20	16.21	65.32
0.0049	0.125	3.00	120	13.20	13.21	78.52
0.0041	0.105	3.25	140	8.14	8.14	86.66
0.0035	0.088	3.50	170	4.00	4.00	90.67
0.0029	0.074	3.75	200	1.87	1.87	92.54
0.0025	0.063	4.00	230	1.12	1.12	93.66
0.0021	0.053	4.25	270	0.85	0.85	94.51
0.00174	0.0442	4.50	325	0.68	0.68	95.19
0.00146	0.0372	4.75	400	0.55	0.55	95.74
0.00123	0.0313	5.00	450	0.44	0.44	96.18
0.000986	0.0250	5.32	500	0.45	0.45	96.63
0.000790	0.0201	5.64	635	0.35	0.35	96.98
0.000615	0.0156	6.00		0.31	0.31	97.29
0.000435	0.0110	6.50		0.36	0.36	97.65
0.000308	0.00781	7.00		0.34	0.34	97.99
0.000197	0.00500	7.65		0.40	0.40	98.39
0.000077	0.00195	9.00		0.71	0.71	99.10
0.000038	0.000977	10.00		0.49	0.49	99.59
0.000019	0.000488	11.00		0.37	0.37	99.96
0.000015	0.000375	11.38		0.04	0.04	100.00
TOTALS				**100.00**	**100.00**	**100.00**

Cumulative Weight Percent greater than		Particle Size	
Weight percent	Phi Value	Inches	Millimeters
5	0.85	0.0219	0.556
10	1.45	0.0144	0.365
16	1.79	0.0114	0.289
25	2.06	0.0094	0.239
40	2.35	0.0077	0.196
50	2.51	0.0069	0.175
60	2.67	0.0062	0.157
75	2.93	0.0052	0.131
84	3.17	0.0044	0.111
90	3.46	0.0036	0.091
95	4.43	0.0018	0.046

Measure	Trask	Inman	Folk-Ward
Median, phi	2.51	2.51	2.51
Median, in.	0.0069	0.0069	0.0069
Median, mm	0.175	0.175	0.175
Mean, phi	2.43	2.48	2.49
Mean, in.	0.0073	0.0071	0.0070
Mean, mm	0.185	0.179	0.178
Sorting	1.352	0.688	0.887
Skewness	1.010	-0.048	0.011
Kurtosis	0.197	1.606	1.690
Grain Size Description (ASTM-USCS Scale)		Fine sand (based on Mean from Trask)	

Description	Retained on Sieve #	Weight Percent
Gravel	4	0.00
Coarse Sand	10	0.00
Medium Sand	40	8.33
Fine Sand	200	84.20
Silt	>0.005 mm	5.85
Clay	<0.005 mm	1.61
	Total	**100**

Appendix C-3. Long-term sediment composition by size catagory, 1990 - 2008. Mandalay Generating Station NPDES, 2008.



Regional Monitoring Years: *1998 only three stations required; **2003 and 2008 only four stations required

APPENDIX D

Sediment chemistry by station

Calscience Environmental Laboratories, Inc.

Analytical Report

nelac

MBC Applied Environmental Sciences	Date Received: 09/22/08
3000 Redhill Avenue	Work Order No: 08-09-1990
Costa Mesa, CA 92626-4524	Preparation: EPA 3050B
	Method: EPA 6020
	Units: mg/kg
Project: MGS 08208A	Page 1 of 1

Client Sample Number	Lab Sample Number	Date /Time Collected	Matrix	Instrument	Date Prepared	Date/Time Analyzed	QC Batch ID
MGS B1-(1,2,3)	08-09-1990-13-A	09/18/08 00:00	Solid	ICP/MS A	09/23/08	09/24/08 16:21	080923L01

Comment(s): -Results are reported on a dry weight basis.

Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Chromium	4.51	0.125	1		Nickel	4.95	0.125	1	
Copper	2.93	0.125	1		Zinc	16.3	1.25	1	

Client Sample Number	Lab Sample Number	Date /Time Collected	Matrix	Instrument	Date Prepared	Date/Time Analyzed	QC Batch ID
MGS B2-(1,2,3)	08-09-1990-14-A	09/18/08 00:00	Solid	ICP/MS A	09/23/08	09/24/08 16:26	080923L01

Comment(s): -Results are reported on a dry weight basis.

Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Chromium	7.74	0.129	1		Nickel	6.77	0.129	1	
Copper	3.48	0.129	1		Zinc	18.8	1.29	1	

Client Sample Number	Lab Sample Number	Date /Time Collected	Matrix	Instrument	Date Prepared	Date/Time Analyzed	QC Batch ID
MGS B3-(1,2,3)	08-09-1990-15-A	09/18/08 00:00	Solid	ICP/MS A	09/23/08	09/24/08 16:30	080923L01

Comment(s): -Results are reported on a dry weight basis.

Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Chromium	6.67	0.126	1		Nickel	6.84	0.126	1	
Copper	3.28	0.126	1		Zinc	17.4	1.26	1	

Client Sample Number	Lab Sample Number	Date /Time Collected	Matrix	Instrument	Date Prepared	Date/Time Analyzed	QC Batch ID
MGS B4-(1,2,3)	08-09-1990-16-A	09/18/08 00:00	Solid	ICP/MS A	09/23/08	09/24/08 16:34	080923L01

Comment(s): -Results are reported on a dry weight basis.

Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Chromium	6.85	0.131	1		Nickel	6.75	0.131	1	
Copper	3.60	0.131	1		Zinc	20.0	1.31	1	

Client Sample Number	Lab Sample Number	Date /Time Collected	Matrix	Instrument	Date Prepared	Date/Time Analyzed	QC Batch ID
Method Blank	096-10-002-1,229	N/A	Solid	ICP/MS A	09/23/08	09/23/08 12:07	080923L01

Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Chromium	ND	0.100	1		Nickel	ND	0.100	1	
Copper	ND	0.100	1		Zinc	ND	1.00	1	

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

7440 Lincoln Way, Garden Grove, CA 92841-1427 • TEL:(714) 895-5494 • FAX: (714) 894-7501

Calscience Environmental Laboratories, Inc.

Analytical Report

MBC Applied Environmental Sciences		Date Received:	09/22/08
3000 Redhill Avenue		Work Order No:	08-09-1990
Costa Mesa, CA 92626-4524			

Project: MGS 08208A

Client Sample Number	Lab Sample Number	Date Collected	Matrix
MGS B1-(1,2,3)	08-09-1990-13	09/18/08	Solid

Parameter	Result	RL	DF	Qual	Units	Date Prepared	Date Analyzed	Method
Solids, Total	80.1	0.100	1		%	N/A	09/24/08	SM 2540 B

Client Sample Number	Lab Sample Number	Date Collected	Matrix
MGS B2-(1,2,3)	08-09-1990-14	09/18/08	Solid

Parameter	Result	RL	DF	Qual	Units	Date Prepared	Date Analyzed	Method
Solids, Total	77.5	0.100	1		%	N/A	09/24/08	SM 2540 B

Client Sample Number	Lab Sample Number	Date Collected	Matrix
MGS B3-(1,2,3)	08-09-1990-15	09/18/08	Solid

Parameter	Result	RL	DF	Qual	Units	Date Prepared	Date Analyzed	Method
Solids, Total	79.5	0.100	1		%	N/A	09/24/08	SM 2540 B

Client Sample Number	Lab Sample Number	Date Collected	Matrix
MGS B4-(1,2,3)	08-09-1990-16	09/18/08	Solid

Parameter	Result	RL	DF	Qual	Units	Date Prepared	Date Analyzed	Method
Solids, Total	76.5	0.100	1		%	N/A	09/24/08	SM 2540 B

Client Sample Number	Lab Sample Number	Date Collected	Matrix
Method Blank		N/A	Solid

Parameter	Result	RL	DF	Qual	Units	Date Prepared	Date Analyzed	Method
Solids, Total	ND	0.100	1		%	N/A	09/24/08	SM 2540 B

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

7440 Lincoln Way, Garden Grove, CA 92841-1427 • TEL:(714) 895-5494 • FAX: (714) 894-7501

Calscience Environmental Laboratories, Inc.

Quality Control - Spike/Spike Duplicate

MBC Applied Environmental Sciences	Date Received:	09/22/08
3000 Redhill Avenue	Work Order No:	08-09-1990
Costa Mesa, CA 92626-4524	Preparation:	EPA 3050B
	Method:	EPA 6020

Project MGS 08208A

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	MS/MSD Batch Number
08-09-0501-6	Solid	ICP/MS A	09/23/08	09/23/08	080923S01

Parameter	MS %REC	MSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Chromium	105	97	80-120	4	0-20	
Copper	73	53	80-120	5	0-20	3
Nickel	107	101	80-120	5	0-20	
Zinc	4X	4X	80-120	4X	0-20	Q

RPD - Relative Percent Difference , CL - Control Limit

7440 Lincoln Way, Garden Grove, CA 92841-1427 • TEL:(714) 895-5494 • FAX: (714) 894-7501

Calscience Environmental Laboratories, Inc.

Quality Control - PDS / PDSD

MBC Applied Environmental Sciences	Date Received	09/22/08
3000 Redhill Avenue	Work Order No:	08-09-1990
Costa Mesa, CA 92626-4524	Preparation:	EPA 3050B
	Method:	EPA 6020

Project: MGS 08208A

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	PDS/PDSD Batch Number
08-09-0501-6	Solid	ICP/MS A	09/23/08	09/23/08	080923S01

Parameter	PDS %REC	PDSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Chromium	99	99	75-125	0	0-20	
Copper	105	99	75-125	1	0-20	
Nickel	102	103	75-125	1	0-20	
Zinc	4X	4X	75-125	4X	0-20	Q

RPD - Relative Percent Difference , CL - Control Limit

7440 Lincoln Way, Garden Grove, CA 92841-1427 • TEL:(714) 895-5494 • FAX: (714) 894-7501

Calscience Environmental Laboratories, Inc.

Quality Control - Duplicate

MBC Applied Environmental Sciences
3000 Redhill Avenue
Costa Mesa, CA 92626-4524

Date Received: N/A
Work Order No: 08-09-1990

Project: MGS 08208A

Matrix: Solid

Parameter	Method	QC Sample ID	Date Analyzed	Sample Conc	DUP Conc	RPD	RPD CL	Qualifiers
Solids, Total	SM 2540 B	MGS B4-(1,2,3)	09/24/08	76.5	76.3	0	0-25	

RPD - Relative Percent Difference , CL - Control Limit

7440 Lincoln Way, Garden Grove, CA 92841-1427 • TEL:(714) 895-5494 • FAX: (714) 894-7501

Calscience Environmental Laboratories, Inc.

Quality Control - LCS/LCS Duplicate

MBC Applied Environmental Sciences		Date Received:	N/A
3000 Redhill Avenue		Work Order No:	08-09-1990
Costa Mesa, CA 92626-4524		Preparation:	EPA 3050B
		Method:	EPA 6020

Project: MGS 08208A

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	LCS/LCSD Batch Number
096-10-002-1,229	Solid	ICP/MS A	09/23/08	09/23/08	080923L01

Parameter	LCS %REC	LCSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Chromium	103	103	80-120	0	0-20	
Copper	109	109	80-120	0	0-20	
Nickel	106	105	80-120	0	0-20	
Zinc	105	103	80-120	2	0-20	

RPD - Relative Percent Difference , CL - Control Limit

7440 Lincoln Way, Garden Grove, CA 92841-1427 • TEL:(714) 895-5494 • FAX: (714) 894-7501

Calscience Environmental Laboratories, Inc.

Glossary of Terms and Qualifiers

Work Order Number: 08-09-1990

Qualifier	Definition
*	See applicable analysis comment.
1	Surrogate compound recovery was out of control due to a required sample dilution, therefore, the sample data was reported without further clarification.
2	Surrogate compound recovery was out of control due to matrix interference. The associated method blank surrogate spike compound was in control and, therefore, the sample data was reported without further clarification.
3	Recovery of the Matrix Spike (MS) or Matrix Spike Duplicate (MSD) compound was out of control due to matrix interference. The associated LCS and/or LCSD was in control and, therefore, the sample data was reported without further clarification.
4	The MS/MSD RPD was out of control due to matrix interference. The LCS/LCSD RPD was in control and, therefore, the sample data was reported without further clarification.
5	The PDS/PDSD associated with this batch of samples was out of control due to a matrix interference effect. The associated batch LCS/LCSD was in control and, hence, the associated sample data was reported with no further corrective action required.
A	Result is the average of all dilutions, as defined by the method.
B	Analyte was present in the associated method blank.
C	Analyte presence was not confirmed on primary column.
E	Concentration exceeds the calibration range.
H	Sample received and/or analyzed past the recommended holding time.
J	Analyte was detected at a concentration below the reporting limit and above the laboratory method detection limit. Reported value is estimated.
ME	LCS Recovery Percentage is within LCS ME Control Limit range.
N	Nontarget Analyte.
ND	Parameter not detected at the indicated reporting limit.
Q	Spike recovery and RPD control limits do not apply resulting from the parameter concentration in the sample exceeding the spike concentration by a factor of four or greater.
U	Undetected at the laboratory method detection limit.
X	% Recovery and/or RPD out-of-range.
Z	Analyte presence was not confirmed by second column or GC/MS analysis.

7440 Lincoln Way, Garden Grove, CA 92841-1427 • TEL:(714) 895-5494 • FAX: (714) 894-7501

APPENDIX E

Mussel tissue chemistry by station

Appendix E

As part of the resource exchange for participation in the Bight '08 Regional Monitoring Program, mussel bioaccumulation analysis was required only if resident mussels were located in the discharge area (Appendix A). On 18 September 2008, biologist-divers searched in the vicinity of and offshore of the discharge and were unable to locate resident mussels in the project area.

APPENDIX F

Infauna data by station

Appendix F-1. Infaunal master species list. Mandalay Generating Station NPDES, 2008.

PHYLUM (Phy)
- Subphylum or Class
  - *Species*

NEMERTEA (NE)
- Anopla
  - *Carinoma mutabilis*
  - *Micrura* sp
- Enopla
  - *Amphiporus cruentatus*
  - *Tetrastemma candidum*

NEMATODA (NT)
  - Nematoda

MOLLUSCA (MO)
- Bivalvia
  - *Donax gouldii*
  - *Tellina modesta*
  - *Tivela stultorum*

ANNELIDA (AN)
- Polychaeta
  - *Amaeana occidentalis*
  - *Apoprionospio pygmaea*[1]
  - *Chone eiffelturris*[2]
  - *Dispio uncinata*
  - *Glycera macrobranchia*[3]
  - *Hesionella mccullochae*
  - *Magelona californica*
  - *Mediomastus acutus*

PHYLUM
- Subphylum or Class
  - Species

ANNELIDA (AN) Cont
- Polychaeta (cont)
  - *Nephtys caecoides*
  - *Onuphis eremita*
  - *Onuphis eremita parva*
  - *Onuphis* sp A SCAMIT 1992[4]
  - *Paraonella platybranchia*
  - *Scoloplos armiger* Cmplx

ARTHROPODA (AR)
- Ostracoda
  - *Euphilomedes longiseta*
- Malacostraca
  - *Americhelidium shoemakeri*[5]
  - *Anchicolurus occidentalis*
  - *Caprella* cf *verrucosa*
  - *Diastylopsis tenuis*
  - *Eohaustorius sawyeri*
  - *Lamprops quadriplicatus*
  - *Leptocuma forsmani*
  - *Mandibulophoxus gilesi*
  - *Mysidopsis intii*
  - *Rhepoxynius menziesi*[6]

ECHINODERMATA (EC)
- Echinoidea
  - *Dendraster excentricus*

The following footnotes indicate names used in previous surveys:

1 *Apoprionospio pygmaeus*
2 *Chone* sp SD1 Pt. Loma 1997
3 *Glycera convoluta*
4 *Onuphis* sp 1 Pt. Loma 1983
5 *Synchelidium shoemakeri*
6 *Paraphoxus epistomus, Rhepoxynius epistomus*

Appendix F-2. Infauna results by station. Mandalay Generating Station NPDES, 2008.

Phylum	Species	Station B1	B2	B3	B4	Total	Percent Total
AN	*Apoprionospio pygmaea*	9	9	18	20	56	24.56
AR	*Euphilomedes longiseta*	1	10	-	26	37	16.23
AR	*Rhepoxynius menziesi*	11	7	8	8	34	14.91
AN	*Mediomastus acutus*	6	4	4	-	14	6.14
MO	*Tellina modesta*	2	6	-	6	14	6.14
AN	*Onuphis* sp A SCAMIT 1992	2	5	-	3	10	4.39
AR	*Mandibulophoxus gilesi*	5	1	3	-	9	3.95
MO	*Donax gouldii*	7	-	1	-	8	3.51
AR	*Anchicolurus occidentalis*	3	1	1	2	7	3.07
AN	*Scoloplos armiger* Cmplx	1	2	1	1	5	2.19
AR	*Americhelidium shoemakeri*	-	1	2	-	3	1.32
AR	*Eohaustorius sawyeri*	-	2	1	-	3	1.32
AN	*Chone eiffelturris*	-	1	-	1	2	0.88
AN	*Glycera macrobranchia*	-	-	-	2	2	0.88
AN	*Onuphis eremita*	-	2	-	-	2	0.88
AN	*Onuphis eremita parva*	-	-	-	2	2	0.88
AR	*Diastylopsis tenuis*	2	-	-	-	2	0.88
NE	*Tetrastemma candidum*	2	-	-	-	2	0.88
AN	*Amaeana occidentalis*	-	-	-	1	1	0.44
AN	*Dispio uncinata*	-	-	1	-	1	0.44
AN	*Hesionella mccullochae*	-	1	-	-	1	0.44
AN	*Magelona californica*	-	-	-	1	1	0.44
AN	*Nephtys caecoides*	1	-	-	-	1	0.44
AN	*Paraonella platybranchia*	-	-	1	-	1	0.44
AR	*Caprella* cf *verrucosa*	-	-	1	-	1	0.44
AR	*Lamprops quadriplicatus*	-	-	-	1	1	0.44
AR	*Leptocuma forsmani*	-	-	1	-	1	0.44
AR	*Mysidopsis intii*	-	-	-	1	1	0.44
EC	*Dendraster excentricus*	1	-	-	-	1	0.44
MO	*Tivela stultorum*	1	-	-	-	1	0.44
NE	*Amphiporus cruentatus*	1	-	-	-	1	0.44
NE	*Carinoma mutabilis*	-	1	-	-	1	0.44
NE	*Micrura* sp	-	1	-	-	1	0.44
NT	Nematoda	1	-	-	-	1	0.44
	Number of individuals	56	54	43	75	228	
	Number of species	17	16	13	14	34	
	Diversity (H')	2.46	2.42	1.93	1.92	2.58	

Appendix F-3. Infaunal data by station and replicate. Mandalay Generating Station NPDES, 2008.

Station B1

Phylum	Species	Replicate B1-I	B1-II	Total	Percent Composition	Density No./m²
AR	*Rhepoxynius menziesi*	8	3	11	19.64	275.0
AN	*Apoprionospio pygmaea*	3	6	9	16.07	225.0
MO	*Donax gouldii*	2	5	7	12.50	175.0
AN	*Mediomastus acutus*	1	5	6	10.71	150.0
AR	*Mandibulophoxus gilesi*	4	1	5	8.93	125.0
AR	*Anchicolurus occidentalis*	2	1	3	5.36	75.0
AN	*Onuphis* sp A SCAMIT 1992	1	1	2	3.57	50.0
AR	*Diastylopsis tenuis*	2	-	2	3.57	50.0
MO	*Tellina modesta*	1	1	2	3.57	50.0
NE	*Tetrastemma candidum*	1	1	2	3.57	50.0
AN	*Nephtys caecoides*	-	1	1	1.79	25.0
AN	*Scoloplos armiger* Cmplx	1	-	1	1.79	25.0
AR	*Euphilomedes longiseta*	-	1	1	1.79	25.0
EC	*Dendraster excentricus*	-	1	1	1.79	25.0
MO	*Tivela stultorum*	-	1	1	1.79	25.0
NE	*Amphiporus cruentatus*	1	-	1	1.79	25.0
NT	Nematoda	1	-	1	1.79	25.0

Summary

Parameter	Replicate B1-I	Replicate B1-II	Station Total	Replicate Mean	Replicate S.D.
Number of individuals	28	28	56	28.0	0.0
Number of species	13	13	17	13.0	0.0
Diversity (H')	2.27	2.26	2.46	2.26	0.01

Station B2

Phylum	Species	Replicate B2-I	B2-II	Total	Percent Composition	Density No./m²
AR	*Euphilomedes longiseta*	10	-	10	18.52	250.0
AN	*Apoprionospio pygmaea*	3	6	9	16.67	225.0
AR	*Rhepoxynius menziesi*	-	7	7	12.96	175.0
MO	*Tellina modesta*	2	4	6	11.11	150.0
AN	*Onuphis* sp A SCAMIT 1992	1	4	5	9.26	125.0
AN	*Mediomastus acutus*	4	-	4	7.41	100.0
AN	*Onuphis eremita*	1	1	2	3.70	50.0
AN	*Scoloplos armiger* Cmplx	1	1	2	3.70	50.0
AR	*Eohaustorius sawyeri*	-	2	2	3.70	50.0
AN	*Chone eiffelturris*	-	1	1	1.85	25.0
AN	*Hesionella mccullochae*	-	1	1	1.85	25.0
AR	*Americhelidium shoemakeri*	-	1	1	1.85	25.0
AR	*Anchicolurus occidentalis*	1	-	1	1.85	25.0
AR	*Mandibulophoxus gilesi*	1	-	1	1.85	25.0
NE	*Carinoma mutabilis*	1	-	1	1.85	25.0
NE	*Micrura* sp	1	-	1	1.85	25.0

Summary

Parameter	Replicate B2-I	Replicate B2-II	Station Total	Replicate Mean	Replicate S.D.
Number of individuals	26	28	54	27.0	1.4
Number of species	11	10	16	10.5	0.7
Diversity (H')	1.98	2.02	2.42	2.00	0.03

Appendix F-3. (Cont.).

Station B3

Phylum	Species	Replicate B3-I	Replicate B3-II	Total	Percent Composition	Density No./m²
AN	*Apoprionospio pygmaea*	14	4	18	41.86	450.0
AR	*Rhepoxynius menziesi*	8	-	8	18.60	200.0
AN	*Mediomastus acutus*	2	2	4	9.30	100.0
AR	*Mandibulophoxus gilesi*	-	3	3	6.98	75.0
AR	*Americhelidium shoemakeri*	2	-	2	4.65	50.0
AN	*Dispio uncinata*	1	-	1	2.33	25.0
AN	*Paraonella platybranchia*	1	-	1	2.33	25.0
AN	*Scoloplos armiger* Cmplx	1	-	1	2.33	25.0
AR	*Anchicolurus occidentalis*	-	1	1	2.33	25.0
AR	*Caprella* cf *verrucosa*	1	-	1	2.33	25.0
AR	*Eohaustorius sawyeri*	-	1	1	2.33	25.0
AR	*Leptocuma forsmani*	-	1	1	2.33	25.0
MO	*Donax gouldii*	-	1	1	2.33	25.0

Summary

Parameter	Replicate B3-I	Replicate B3-II	Station Total	Replicate Mean	Replicate S.D.
Number of individuals	30	13	43	21.5	12.0
Number of species	8	7	13	7.5	0.7
Diversity (H')	1.52	1.78	1.93	1.65	0.18

Station B4

Phylum	Species	Replicate B4-I	Replicate B4-II	Total	Percent Composition	Density No./m²
AR	*Euphilomedes longiseta*	12	14	26	34.67	650.0
AN	*Apoprionospio pygmaea*	8	12	20	26.67	500.0
AR	*Rhepoxynius menziesi*	1	7	8	10.67	200.0
MO	*Tellina modesta*	5	1	6	8.00	150.0
AN	*Onuphis* sp A SCAMIT 1992	1	2	3	4.00	75.0
AN	*Glycera macrobranchia*	1	1	2	2.67	50.0
AN	*Onuphis eremita parva*	1	1	2	2.67	50.0
AR	*Anchicolurus occidentalis*	1	1	2	2.67	50.0
AN	*Amaeana occidentalis*	-	1	1	1.33	25.0
AN	*Chone eiffelturris*	-	1	1	1.33	25.0
AN	*Magelona californica*	1	-	1	1.33	25.0
AN	*Scoloplos armiger* Cmplx	-	1	1	1.33	25.0
AR	*Lamprops quadriplicatus*	1	-	1	1.33	25.0
AR	*Mysidopsis intii*	1	-	1	1.33	25.0

Summary

Parameter	Replicate B4-I	Replicate B4-II	Station Total	Replicate Mean	Replicate S.D.
Number of individuals	33	42	75	37.5	6.4
Number of species	11	11	14	11.0	0.0
Diversity (H')	1.84	1.79	1.92	1.82	0.04

Appendix F-4. Infaunal wet weight biomass data (g). Mandalay Generating Station NPDES, 2008.

Sta-Rep	Annelida	Arthropoda	Mollusca	Echinodermata	Misc.	Total
B1-I	0.0109	0.0088	<0.0001	-	0.0043	0.0240
B1-II	0.0415	0.0127	0.1355	0.0108	<0.0001	0.2005
Total	0.0524	0.0215	0.1355	0.0108	0.0043	0.2245
B2-I	0.0289	0.0364	<0.0001	-	0.0572	0.1225
B2-II	0.1349	0.0037	0.0054	-	-	0.1440
Total	0.1638	0.0401	0.0054	-	0.0572	0.2665
B3-I	0.0405	0.0017	-	-	-	0.0422
B3-II	<0.0001	0.0080	0.0395	-	-	0.0475
Total	0.0405	0.0097	0.0395	-	-	0.0897
B4-I	0.1096	0.0133	0.0336	-	-	0.1565
B4-II	0.0791	0.0224	0.0413	-	-	0.1428
Total	0.1887	0.0357	0.0749	-	-	0.2993
Grand Total	0.4454	0.1070	0.2553	0.0108	0.0615	0.8800

Notes:

- = no animals

Appendix F-5. Yearly abundance of the top 40 infaunal species, 1978 - 2008. Mandalay Generating Station NPDES, 2008.

Phy	Species	Year 1978	1980	1986	1988	1990	1991	1992	1993	1994	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	Percent Total
AN	*Apoprionospio pygmaea*	86	213	17	175	52	490	170	128	203	100	658	28	143	569	354	719	86	744	113	86	56	5190	21.45
MO	*Donax gouldii*	-	-	-	-	-	-	-	-	-	-	3064	-	2	-	-	6	-	1	1	3	8	3085	12.75
AN	*Mediomastus acutus*	5	1	-	-	-	-	-	1	58	35	1026	28	12	103	83	3	40	6	22	38	14	1475	6.09
EC	*Dendraster excentricus*	12	1	43	17	87	14	14	-	10	103	52	75	34	41	15	7	4	3	27	788	1	1348	5.57
AR	*Diastylopsis tenuis*	123	163	75	33	12	9	5	11	88	45	2	51	56	7	19	-	4	424	74	32	2	1235	5.10
AR	*Rhepoxynius menziesi*	17	25	20	61	43	14	18	14	34	-	35	270	84	67	71	64	85	36	30	55	34	1077	4.45
AN	*Scoloplos armiger* Cmplx	61	28	20	111	187	149	55	69	43	71	16	10	10	20	12	18	33	4	-	-	5	922	3.81
AN	*Chone eiffelturris*	-	-	-	-	-	-	-	-	-	-	14	1	20	7	25	5	290	10	242	49	2	665	2.75
AN	*Spiophanes bombyx*	14	51	92	46	17	2	3	154	60	15	13	8	43	4	2	-	12	76	6	4	-	622	2.57
AN	*Owenia collaris*	5	40	-	2	10	88	9	44	2	130	8	31	111	5	29	1	1	-	10	31	-	557	2.30
MO	*Siliqua lucida*	-	17	9	112	-	4	-	-	82	62	22	31	6	17	11	-	1	12	12	42	-	440	1.82
NE	*Carinoma mutabilis*	-	3	16	18	7	18	28	19	25	24	78	17	18	29	28	7	14	11	52	23	1	436	1.80
AR	*Euphilomedes carcharodonta*	-	1	1	3	-	-	-	-	47	333	-	-	-	-	2	-	-	-	-	-	-	387	1.60
MO	*Tellina modesta*	2	18	29	2	4	-	-	1	11	101	2	19	46	20	8	1	23	3	25	57	14	386	1.59
AN	*Magelona pitelkai*	9	131	-	38	13	21	14	24	20	5	-	1	-	8	6	5	1	3	-	-	-	299	1.24
AN	*Goniada littorea*	21	26	6	-	6	2	-	3	6	11	36	74	37	5	9	-	4	11	12	4	-	273	1.13
AR	*Euphilomedes longiseta*	-	-	-	2	10	22	-	-	-	-	3	-	3	5	54	12	12	6	28	31	37	225	0.93
AR	*Americhelidium shoemakeri*	4	-	-	1	7	-	-	-	8	3	-	5	23	68	25	13	18	2	5	34	3	219	0.90
CN	*Zaolutus actius*	-	4	-	-	-	-	-	-	-	99	4	7	40	4	17	-	-	-	-	39	-	214	0.88
AN	*Pectinaria californiensis*	-	1	9	60	3	-	-	-	4	112	-	1	6	-	2	-	1	-	-	8	-	207	0.86
AN	*Nephtys caecoides*	6	4	8	5	9	24	8	11	14	3	3	6	11	9	19	21	8	2	10	12	1	194	0.80
AR	*Photis macinerneyi*	-	-	13	45	-	-	-	-	4	20	2	5	10	6	1	-	-	58	3	14	-	181	0.75
AR	*Rhepoxynius* sp A SCAMIT 1987	2	5	9	12	26	11	-	-	23	37	-	4	11	12	12	-	2	4	3	-	-	173	0.71
MO	*Mactromeris catilliformis*	-	-	-	-	-	-	-	-	-	12	-	-	-	14	120	-	1	1	12	2	-	162	0.67
AN	*Mediomastus* spp	-	9	16	17	12	7	4	-	-	-	91	2	1	2	-	-	-	-	-	-	-	161	0.67
AN	*Armandia brevis*	-	7	-	5	-	1	-	-	7	3	6	9	-	6	3	-	11	46	3	50	-	157	0.65
AR	*Mandibulophoxus gilesi*	14	-	-	-	-	36	15	-	4	15	-	-	3	-	-	4	23	-	-	11	9	134	0.55
AN	*Magelona sacculata*	2	23	47	22	16	4	-	-	-	-	-	-	-	2	6	-	-	-	-	-	-	122	0.50
MO	*Solen sicarius*	2	-	9	16	3	5	2	5	3	20	20	3	6	-	-	1	-	-	16	7	-	118	0.49
AN	*Spiophanes duplex*	4	17	-	11	-	-	-	4	3	1	1	-	5	1	-	-	-	70	-	-	-	117	0.48
AN	*Onuphis eremita*	-	-	-	-	11	9	-	45	1	1	17	-	1	-	1	19	-	-	-	8	2	115	0.48
NE	Lineidae	-	-	-	1	-	-	-	-	-	9	22	13	5	4	2	1	24	10	14	5	-	110	0.45
AN	*Mediomastus ambiseta*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	61	5	20	6	-	105	0.43
AR	*Anchicolurus occidentalis*	-	-	-	2	-	3	-	1	2	4	-	19	4	1	1	1	4	35	15	2	7	101	0.42
AN	*Chone albocincta*	-	-	-	-	5	14	-	5	9	62	-	-	-	-	1	-	-	-	-	-	-	96	0.40
AR	*Isocheles pilosus*	12	1	-	75	1	-	-	-	-	1	-	-	2	1	-	-	-	-	-	-	-	93	0.38
AN	*Dispio uncinata*	9	20	10	6	2	-	-	-	1	4	-	4	9	7	-	1	-	12	-	2	1	88	0.36
AN	*Glycera macrobranchia*	1	1	-	1	13	3	4	3	3	6	4	1	1	4	8	2	6	6	6	7	2	82	0.34
AR	*Edotia sublittoralis*	1	7	-	1	-	-	-	-	1	35	1	-	2	-	3	-	-	18	9	4	-	82	0.34
AR	*Eohaustorius barnardi*	17	12	9	4	1	-	-	-	5	11	1	1	4	7	2	-	-	-	1	-	-	75	0.31
	Number of individuals	504	1008	612	1041	699	1021	399	599	946	1737	5311	896	915	1161	1123	952	885	1726	843	1595	228	24201	
	Number of species	52	75	68	72	70	53	35	38	81	91	59	82	79	75	75	38	75	60	57	69	34	321	
	Number of stations / reps	5/4	5/4	5/4	5/4	5/4	5/4	5/4	5/4	5/4	5/4	3/4	5/4	5/4	5/4	5/4	4/2	5/4	5/4	5/4	5/4	4/2		
	Diversity (H')	2.81	2.98	3.38	3.04	3.03	2.15	2.28	2.46	3.21	3.30	1.46	3.01	3.32	2.39	2.88	1.25	2.82	2.09	2.84	2.43	2.58	3.43	

NOTE: From 1978 to 1988 infaunal samples were collected in summer and winter. In this appendix, only summer samples are considered.
Note: 0.00 = < 0.005

Appendix F-6. Index of Relative Importance for the top 16 infaunal organisms observed during infaunal sampling and contigency table of Spearman rank correlation coefficients by year, 1990 - 2008. Mandalay Generating Station NPDES, 2008.

Species	1990	1993	1994	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Apoprionospio pygmaea	**2**	4	**1**	3	3	6	**1**	**1**	**1**	**1**	**1**	**1**	3	**2**	**1**
Rhepoxynius menziesi	**2**	3	6	14	3	**1**	4	**2**	**2**	**2**	**2**	4	5	5	**2**
Dendraster excentricus	**2**	**1**	12	4	3	**2**	9	3	7	4	9	11	6	**1**	9
Carinoma mutabilis	10	6	7	9	**2**	11	10	3	4	4	7	5	3	7	9
Diastylopsis tenuis	6	6	3	8	13	4	3	10	6	12	11	**2**	**1**	9	8
Mediomastus acutus	12	9	4	10	**1**	8	11	3	5	8	5	9	7	7	4
Scoloplos armiger Cmplx	**1**	**2**	8	6	11	10	12	7	10	3	4	10	14	14	5
Tellina modesta	11	9	11	7	13	9	4	6	11	10	5	11	8	3	3
Chone eiffelturris	12	9	15	14	10	13	7	11	7	9	**2**	8	**1**	4	7
Siliqua lucida	12	9	**2**	5	8	6	13	8	9	12	12	7	10	6	11
Owenia collaris	6	9	14	**2**	12	5	**2**	13	3	10	12	15	11	10	11
Spiophanes bombyx	5	8	4	11	8	11	7	14	14	12	8	3	12	11	11
Goniada littorea	9	9	13	12	7	3	6	12	12	12	10	6	9	11	11
Magelona pitelkai	8	5	10	13	15	13	15	9	13	7	12	13	14	14	11
Donax gouldii	12	9	15	14	6	15	14	15	16	6	15	14	13	13	6
Euphilomedes carcharodonta	12	9	8	**1**	15	15	15	15	14	12	15	15	14	14	11
1990	1	**0.84**	0.22	0.18	0.09	**0.52**	0.45	0.40	0.35	0.47	0.40	0.35	0.06	0.10	0.21
1993	-	-	0.30	0.06	0.20	0.33	0.11	**0.58**	0.32	**0.66**	0.39	0.34	0.14	0.15	0.28
1994	-	-	-	0.27	0.21	0.25	0.14	0.46	0.36	0.01	0.25	**0.67**	0.22	0.17	0.18
1997	-	-	-	-	-0.21	0.17	0.12	0.08	0.20	-0.11	-0.17	-0.21	-0.14	0.10	-0.17
1998	-	-	-	-	-	0.33	0.14	**0.55**	0.46	**0.51**	0.43	0.42	0.44	0.47	0.40
1999	-	-	-	-	-	-	**0.64**	**0.49**	**0.60**	0.09	0.27	0.40	0.44	**0.50**	0.16
2000	-	-	-	-	-	-	-	0.30	**0.63**	0.07	0.49	**0.51**	**0.62**	**0.55**	0.35
2001	-	-	-	-	-	-	-	-	**0.71**	**0.68**	**0.70**	0.44	**0.52**	**0.66**	**0.64**
2002	-	-	-	-	-	-	-	-	-	0.47	**0.57**	0.43	**0.70**	**0.61**	0.45
2003	-	-	-	-	-	-	-	-	-	-	**0.55**	0.09	0.19	0.29	**0.66**
2004	-	-	-	-	-	-	-	-	-	-	-	**0.57**	**0.56**	**0.57**	**0.72**
2005	-	-	-	-	-	-	-	-	-	-	-	-	**0.63**	0.38	0.29
2006	-	-	-	-	-	-	-	-	-	-	-	-	-	**0.77**	0.45
2007	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.49

APPENDIX G

Demersal fish and macroinvertebrate trawl data by station

Appendix G-1. Species list of fish and macroinvertebrate species taken by otter trawl. Mandalay Generating Station NPDES, 2008.

Phylum / Class / Family / Species	Common name
Cnidaria	
Anthozoa	
Renillidae	
Renilla koellikeri	sea pansy
Arthropoda	
Malacostraca	
Cancridae	
Romaleon antennarius	Pacific rock crab
Metacarcinus gracilis	graceful crab
Metacarcinus anthonyi	yellow crab
Crangonidae	
Crangon nigromaculata	blackspotted bay shrimp
Epialtidae	
Pugettia richii	cryptic kelp crab
Majidae	
Loxorhynchus grandis	sheep crab
Palinuridae	
Panulirus interruptus	California spiny lobster
Pinnotheridae	
Opisthopus transversus	mottled pea crab
Chordata	
Chondrichthyes	
Myliobatidae	
Myliobatis californica	bat ray
Platyrhinidae	
Platyrhinoidis triseriata	thornback
Rhinobatidae	
Rhinobatos productus	shovelnose guitarfish
Squatinidae	
Squatina californica	Pacific angel shark
Chordata (cont.).	
Actinopterygii	
Agonidae	
Stellerina xyosterna	pricklebreast poacher
Cottidae	
Leptocottus armatus	Pacific staghorn sculpin
Embiotocidae	
Amphistichus argenteus	barred surfperch
Cymatogaster aggregata	shiner perch
Hyperprosopon argenteum	walleye surfperch
Engraulidae	
Engraulis mordax	northern anchovy
Paralichthyidae	
Xystreurys liolepis	fantail sole
Citharichthys stigmaeus	speckled sanddab
Paralichthys californicus	California halibut
Sciaenidae	
Seriphus politus	queenfish
Syngnathidae	
Syngnathus californiensis	kelp pipefish
Syngnathus exilis	barcheek pipefish
Synodontidae	
Synodus lucioceps	California lizardfish

Appendix G-2. Abundance of fish species in trawl replicates. Mandalay Generating Station NPDES, 2008.

	T1		T2		T3		T4		Annual	Percent
Species	I	II	I	II	I	II	I	II	Total	Total
Seriphus politus	368	32	-	-	3	4	-	-	407	40
Cymatogaster aggregata	93	78	36	39	30	37	12	7	332	33
Citharichthys stigmaeus	17	15	26	11	16	14	14	19	132	13
Syngnathus californiensis	-	1	3	3	6	3	11	9	36	4
Stellerina xyosterna	2	3	8	6	11	5	-	-	35	3
Syngnathus exilis	2	1	-	-	4	1	3	5	16	2
Hyperprosopon argenteum	-	-	-	2	10	2	-	-	14	1
Amphistichus argenteus	2	-	2	3	3	-	-	-	10	1
Engraulis mordax	2	1	2	-	2	3	-	-	10	1
Leptocottus armatus	1	-	-	-	1	5	-	-	7	1
Myliobatis californica	1	3	-	-	-	-	-	-	4	<1
Paralichthys californicus	-	-	-	-	1	1	-	-	2	<1
Platyrhinoidis triseriata	-	1	-	-	-	-	-	-	1	<1
Rhinobatos productus	-	-	-	1	-	-	-	-	1	<1
Squatina californica	-	-	1	-	-	-	-	-	1	<1
Synodus lucioceps	-	-	1	-	-	-	-	-	1	<1
Xystreurys liolepis	-	-	-	-	-	1	-	-	1	<1
Total abundance	488	135	79	65	87	76	40	40	1,010	
Species	9	9	8	7	11	11	4	4	17	
Diversity (H')	0.76	1.22	1.38	1.28	1.94	1.70	1.28	1.25	1.55	
Area Trawled (m^2)	3,040.5	2,938.4	2,734.9	2,850.1	2,680.0	2,901.0	2,613.4	2,691.7		
Abundance less than 30 mm SL.										
Engraulis mordax	-	-	-	1	-	-	-	-	1	
Total Abundance < 30 mm SL	-	-	-	1	-	-	-	-	1	

Appendix G-3. Biomass (kg) of fish species in trawl replicates. Mandalay Generating Station NPDES, 2008.

	T1		T2		T3		T4		Annual	Percent
Species	I	II	I	II	I	II	I	II	Total	Total
Myliobatis californica	1.90	6.40	-	-	-	-	-	-	8.30	39
Seriphus politus	5.70	0.44	-	-	0.05	0.06	-	-	6.25	29
Cymatogaster aggregata	0.45	0.38	0.21	0.30	0.30	0.30	0.17	0.04	2.15	10
Citharichthys stigmaeus	0.15	0.16	0.47	0.07	0.20	0.20	0.12	0.13	1.50	7
Squatina californica	-	-	0.90	-	-	-	-	-	0.90	4
Platyrhinoidis triseriata	-	0.70	-	-	-	-	-	-	0.70	3
Paralichthys californicus	-	-	-	-	0.29	0.18	-	-	0.47	2
Leptocottus armatus	0.05	-	-	-	0.04	0.17	-	-	0.26	1
Stellerina xyosterna	0.01	0.02	0.04	0.03	0.06	0.02	-	-	0.17	1
Amphistichus argenteus	0.02	-	0.03	0.04	0.05	-	-	-	0.14	1
Hyperprosopon argenteum	-	-	-	0.03	0.08	0.02	-	-	0.13	1
Syngnathus californiensis	-	0.00	0.01	0.01	0.02	0.02	0.04	0.03	0.12	1
Xystreurys liolepis	-	-	-	-	-	0.11	-	-	0.11	1
Engraulis mordax	0.03	0.01	0.01	-	0.02	0.03	-	-	0.08	<1
Rhinobatos productus	-	-	-	0.07	-	-	-	-	0.07	<1
Syngnathus exilis	0.01	0.00	-	-	0.01	0.00	0.01	0.02	0.04	<1
Synodus lucioceps	-	-	0.02	-	-	-	-	-	0.02	<1
Total Biomass (kg)	8.31	8.11	1.68	0.54	1.11	1.11	0.33	0.22	21.40	
Biomass (kg) less than 30 mm SL.										
Engraulis mordax	-	-	-	0.00	-	-	-	-	0.00	
Total Biomass (kg)	-	-	-	0.00	-	-	-	-	0.00	

Note: 0.00 = < 0.005, Anomalies due to rounding

Appendix G-4. Length of fish species in trawl replicates. Mandalay Generating Station NPDES. Summer 2008.

MGS T1-I	Length (cm)														
Species	4	5	6	7	8	9	10	11	12	13	14	15	18	19	50
Amphistichus argenteus	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Citharichthys stigmaeus	-	-	2	3	10	1	-	1	-	-	-	-	-	-	-
Cymatogaster aggregata	6	26	49	12	-	-	-	-	-	-	-	-	-	-	-
Engraulis mordax	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-
Leptocottus armatus	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
*Myliobatis californica**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Seriphus politus	-	-	-	-	2	60	89	41	6	-	1	1	-	-	-
Stellerina xyosterna	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Syngnathus exilis	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-

MGS T1-II	Length (cm)												
Species	4	5	6	7	8	9	10	11	13	20	24	49	51
Citharichthys stigmaeus	-	-	1	4	3	5	2	-	-	-	-	-	-
Cymatogaster aggregata	2	38	31	7	-	-	-	-	-	-	-	-	-
Engraulis mordax	-	-	-	-	1	-	-	-	-	-	-	-	-
*Myliobatis californica**	-	-	-	-	-	-	-	-	-	-	-	1	2
*Platyrhinoidis triseriata***	-	-	-	-	-	-	-	-	-	-	-	1	-
Seriphus politus	-	-	-	-	1	15	14	1	1	-	-	-	-
Stellerina xyosterna	-	-	-	1	1	1	-	-	-	-	-	-	-
Syngnathus californiensis	-	-	-	-	-	-	-	-	-	-	1	-	-
Syngnathus exilis	-	-	-	-	-	-	-	-	-	1	-	-	-

MGS T2-I	Length (cm)											
Species	5	6	7	8	9	10	11	15	18	19	21	44
Amphistichus argenteus	-	-	1	1	-	-	-	-	-	-	-	-
Citharichthys stigmaeus	-	-	-	8	-	12	6	-	-	-	-	-
Cymatogaster aggregata	1	24	11	-	-	-	-	-	-	-	-	-
Engraulis mordax	-	1	-	-	-	-	1	-	-	-	-	-
*Squatina californica***	-	-	-	-	-	-	-	-	-	-	-	1
Stellerina xyosterna	-	-	-	3	5	-	-	-	-	-	-	-
Syngnathus californiensis	-	-	-	-	-	-	-	-	1	1	1	-
Synodus lucioceps	-	-	-	-	-	-	-	1	-	-	-	-

MGS T2-II	Length (cm)										
Species	4	5	6	7	8	9	10	11	19	21	24
Amphistichus argenteus	-	-	-	-	3	-	-	-	-	-	-
Citharichthys stigmaeus	-	-	-	1	2	3	4	1	-	-	-
Cymatogaster aggregata	1	1	23	12	2	-	-	-	-	-	-
Hyperprosopon argenteum	-	-	-	1	1	-	-	-	-	-	-
*Rhinobatos productus***	-	-	-	-	-	-	-	-	-	-	1
Stellerina xyosterna	-	-	-	1	2	2	1	-	-	-	-
Syngnathus californiensis	-	-	-	-	-	-	-	-	1	2	-

Appendix G-4. (Cont.)

MGS T3-I	Length (cm)														
Species	6	7	8	9	10	11	12	13	19	20	21	22	23	24	26
Amphistichus argenteus	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-
Citharichthys stigmaeus	1	1	4	5	4	1	-	-	-	-	-	-	-	-	-
Cymatogaster aggregata	12	9	1	6	1	1	-	-	-	-	-	-	-	-	-
Engraulis mordax	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-
Hyperprosopon argenteum	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Paralichthys californicus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Seriphus politus	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-
Stellerina xyosterna	-	1	3	7	-	-	-	-	-	-	-	-	-	-	-
Syngnathus californiensis	-	-	-	-	-	-	-	-	1	2	1	-	1	1	-
Syngnathus exilis	-	-	-	-	-	-	-	-	1	-	1	2	-	-	-

MGS T3-II	Length (cm)														
Species	3	6	7	8	9	10	11	12	13	14	19	21	22	24	25
Citharichthys stigmaeus	1	1	-	2	4	4	2	-	-	-	-	-	-	-	-
Cymatogaster aggregata	-	20	11	3	3	-	-	-	-	-	-	-	-	-	-
Engraulis mordax	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-
Hyperprosopon argenteum	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Leptocottus armatus	-	-	-	-	-	-	2	1	-	2	-	-	-	-	-
Paralichthys californicus	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Seriphus politus	-	-	-	-	-	1	2	-	1	-	-	-	-	-	-
Stellerina xyosterna	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-
Syngnathus californiensis	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2
Syngnathus exilis	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Xystreurys liolepis	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-

MGS T4-I	Length (cm)										
Species	6	7	8	9	10	18	20	21	22	23	24
Citharichthys stigmaeus	-	5	6	1	2	-	-	-	-	-	-
Cymatogaster aggregata	1	1	4	5	1	-	-	-	-	-	-
Syngnathus californiensis	-	-	-	-	-	1	1	3	3	2	1
Syngnathus exilis	-	-	-	-	-	-	-	-	3	-	-

MGS T4-II	Length (cm)													
Species	5	6	7	8	9	10	18	19	20	21	22	23	24	26
Citharichthys stigmaeus	1	3	7	6	1	1	-	-	-	-	-	-	-	-
Cymatogaster aggregata	-	2	4	1	-	-	-	-	-	-	-	-	-	-
Syngnathus californiensis	-	-	-	-	-	-	1	2	-	3	1	-	1	1
Syngnathus exilis	-	-	-	-	-	-	1	-	1	1	1	1	-	-

* = Disc Width, ** = Total Length

Fish diseases, abnormalities, and paratism		
Species	Sta-Rep	Note
None		

Appendix G-5. Abundance of macroinvertebrate species in trawl replicates. Mandalay Generating Station NPDES, 2008.

Species	T1 I	T1 II	T2 I	T2 II	T3 I	T3 II	T4 I	T4 II	Annual Total	Percent Total
Crangon nigromaculata	96	124	97	83	136	67	82	94	779	97
Metacarcinus gracilis	-	1	1	2	1	1	2	3	11	1
Loxorhynchus grandis	-	-	-	1	-	1	-	-	2	<1
Metacarcinus anthonyi	-	-	-	1	1	-	-	-	2	<1
Opisthopus transversus	-	-	-	-	1	-	-	-	1	<1
Panulirus interruptus	-	-	-	-	1	-	-	-	1	<1
Pugettia richii	-	-	-	-	1	-	-	-	1	<1
Renilla koellikeri	-	-	-	-	-	-	-	1	1	<1
Romaleon antennarius	-	-	-	-	-	-	-	1	1	<1
Total Abundance	96	125	98	87	141	69	84	99	799	
Species	1	2	2	4	6	3	2	4	9	
Diversity (H')	0.00	0.11	0.50	0.55	0.18	0.20	0.48	0.80	0.32	
Evenness (J')	0.00	0.16	0.73	0.40	0.10	0.18	0.69	0.58	0.15	
Area Trawled (m^2)	3,040.5	2,938.4	2,734.9	2,850.1	2,680.0	2,901.0	2,613.4	2,691.7		
Fish Parasites Not Included Above										
none	-	-	-	-	-	-	-	-	-	

Appendix G-6. Biomass (kg) of macroinvertebrates species in trawl replicates. Mandalay Generating Station NPDES, 2008.

Species	T1 I	T1 II	T2 I	T2 II	T3 I	T3 II	T4 I	T4 II	Annual Total	Percent Total
Crangon nigromaculata	0.19	0.21	0.18	0.11	0.20	0.10	0.09	0.10	1.18	0
Loxorhynchus grandis	-	-	-	0.07	-	1.00	-	-	1.07	0
Metacarcinus gracilis	-	0.01	0.10	0.06	0.04	0.05	0.02	0.02	0.29	0
Panulirus interruptus	-	-	-	-	0.10	-	-	-	0.10	0
Metacarcinus anthonyi	-	-	-	0.00	0.01	-	-	-	0.01	0
Renilla koellikeri	-	-	-	-	-	-	-	0.00	0.00	<1
Opisthopus transversus	-	-	-	-	0.00	-	-	-	0.00	<1
Pugettia richii	-	-	-	-	0.00	-	-	-	0.00	<1
Romaleon antennarius	-	-	-	-	-	-	-	0.00	0.00	<1
Total Biomass (kg)	0.19	0.22	0.28	0.24	0.35	1.15	0.11	0.13	2.66	
Fish parasites not included above										
none	-	-	-	-	-	-	-	-	-	

Note: 0.00 = < 0.005, Anomalies due to rounding

Appendix G-7. Abundance of the top 20 fish species in trawl replicates, 1978 - 2008. Mandalay Generating Station NPDES, 2008.

Species	1978	1980	1986	1988	1990	1991	1992	1993	1994	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	Percent Total	F.O.
Genyonemus lineatus	6713	8446	1464	1150	1592	2291	2756	3043	7237	20	363	5363	1033	9342	-	16	4632	3656	1255	-	60372	49.1	18
Seriphus politus	966	4889	830	195	957	1341	6049	3009	5483	-	76	1352	4630	3971	8	138	1106	34	3	407	35444	28.8	19
Engraulis mordax	1476	494	2	52	88	359	1469	159	115	-	640	256	383	1216	9	3322	202	231	251	10	10734	8.7	19
Citharichthys stigmaeus	36	8	40	64	76	217	4	75	16	7	143	219	38	224	51	476	325	1148	1481	132	4780	3.9	20
Cymatogaster aggregata	107	24	-	4	33	63	4	58	88	17	190	42	11	529	18	118	135	330	1277	332	3380	2.7	19
Syngnathus californiensis	-	-	-	-	-	-	-	-	-	-	80	149	104	179	3	118	346	245	70	36	1330	1.1	10
Amphistichus argenteus	210	172	46	223	38	95	29	115	41	18	1	33	9	42	-	45	67	4	29	10	1227	1.0	19
Phanerodon furcatus	245	321	2	17	18	26	5	5	80	12	25	-	1	225	-	-	23	39	-	-	1044	0.8	15
Hyperprosopon argenteum	335	340	8	18	-	50	5	26	28	1	1	16	37	28	1	9	53	67	-	14	1037	0.8	18
Platyrhinoidis triseriata	27	21	12	16	6	56	4	167	2	3	13	14	6	52	-	2	24	15	18	1	459	0.4	19
Stellerina xyosterna	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	-	25	329	35	404	0.3	4
Paralichthys californicus	25	54	66	58	21	27	1	8	11	-	2	5	1	4	-	-	1	6	5	2	297	0.2	17
Menticirrhus undulatus	15	3	79	-	-	3	2	33	19	-	2	73	24	9	-	8	6	3	1	-	280	0.2	15
Synodus lucioceps	17	5	-	-	8	-	1	2	4	-	1	1	26	115	-	1	9	-	10	1	201	0.2	14
Syngnathus exilis	3	-	-	77	5	-	-	-	58	-	-	-	-	-	-	-	-	-	36	16	195	0.2	6
Umbrina roncador	2	-	11	1	-	1	-	79	50	-	-	-	3	-	-	-	-	-	-	-	147	0.1	7
Parophrys vetulus	22	8	5	49	7	-	-	1	4	1	7	-	-	15	-	1	13	10	1	-	144	0.1	14
Xystreurys liolepis	-	10	17	10	1	3	1	1	5	1	39	27	1	16	-	-	1	-	1	1	135	0.1	16
Ophidion scrippsae	1	3	9	-	8	45	-	28	4	-	1	5	-	-	-	-	18	-	-	-	122	0.1	10
Rhinobatos productus	6	11	6	22	13	18	-	19	2	-	1	2	-	2	-	-	1	4	3	1	111	0.1	15
Number of individuals	10299	14986	2648	2009	2896	4674	10399	6892	13296	89	1597	7616	6324	16056	91	4304	7062	5866	4852	1010	122966		
Number of species	41	35	29	24	23	30	21	28	33	10	25	22	24	27	7	22	33	25	31	17	69		
Total Biomass (kg)	501.0	1165.4	113.2	76.6	133.8	88.1	112.2	78.8	178.3	2.5	42.8	159.1	87.1	289.3	1.3	107.5	73.9	59.1	101.6	21.4	3392.8		
Stations / Replicates	14/1	12/1	3/2	3/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/1	4/2	4/2	4/2	4/2	4/2			
Seasons	W / S	W / S	W / S	W / S	W / S	W / S	W / S	W / S	W / S	S	W / S	W / S	W / S	W / S	S	W / S	W / S	W / S	W / S	S			
Number of Trawls	28	24	12	12	16	16	16	16	16	8	16	16	16	16	4	16	16	16	16	16			

Note: F.O. = Frequency of Occurrence; W = winter, S = summer

Appendix G-8. Abundance of the top 20 macroinvertebrate species in trawl replicates, 1978 - 2008. Mandalay Generating Station NPDES, 2008.

Species	1978	1980	1986	1988	1990	1991	1992	1993	1994	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	Percent Total
Dendraster excentricus	10	-	3,853	165	536	681	5	3	1,322	11	17,860	12,878	11,761	2,832	132	47	529	6,002	158	-	58,785	62.1
Crangon nigromaculata	55	8	237	116	246	402	18	70	353	5	2,232	3,340	732	1,011	706.	3,046	7,485	7,370	5,546	779	33,757	35.6
Metacarcinus gracilis	3	3	3	1	141	7	-	4	5	-	12	19	103	59	16	93	76	737	164	11	1,457	1.5
Pyromaia tuberculata	1	-	-	-	-	-	-	-	1	-	46	2	3	1	1	1	6	53	14	-	129	0.1
Astropecten verrilli	95	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	98	0.1
Farfantepenaeus californicus	-	38	1	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	3	-	49	0.1
Pleurobranchia bachei	-	-	-	-	-	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45	0.0
Panulirus interruptus	3	2	2	-	2	1	2	2	1	-	1	11	3	4	-	-	-	2	5	1	42	0.0
Portunus xantusii	12	-	-	-	-	5	-	4	5	-	6	1	1	-	-	3	3	1	1	-	42	0.0
Polyorchis pencillata	-	-	1	1	-	-	-	-	-	-	23	5	-	3	-	-	-	6	1	-	40	0.0
Heptacarpus stimpsoni	-	-	-	-	4	-	-	-	12	-	-	-	-	-	-	-	-	8	15	-	39	0.0
Metacarcinus anthonyi	-	-	9	6	2	1	-	-	2	-	-	1	1	-	-	3	-	7	4	2	38	0.0
Heptacarpus sp A of MBC	-	-	-	-	4	-	-	-	26	-	-	-	-	-	-	-	-	-	-	-	30	0.0
Loxorhynchus grandis	1	2	-	-	2	4	-	2	-	2	-	-	-	2	-	-	1	4	6	2	28	0.0
Caudina arenicola	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	2	-	13	1	-	18	0.0
Nassarius perpinguis	-	-	1	-	-	-	-	-	-	-	-	-	1	4	-	1	-	7	1	-	15	0.0
Opisthopus transversus	5	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	14	0.0
Randallia ornata	10	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	12	0.0
Renilla kollikeri	-	-	-	-	-	-	-	-	-	-	6	-	1	1	-	-	-	-	-	1	9	0.0
Romaleon antennarius	3	-	-	-	-	1	-	4	-	-	-	-	-	-	-	-	-	-	-	1	9	0.0
Number of Individuals	215	57	4,115	292	949	1,156	25	92	1,730	18	20,191	16,266	12,612	3,923	855	3,199	8,101	14,215	5,924	799	94,734	
Number of species	17	6	15	8	14	15	3	10	12	3	12	11	12	12	4	11	7	16	17	9	53	
Total Biomass (kg)	N/A	N/A	N/A	2.14	10.39	12.91	0.06	3.44	3.09	0.08	28.92	40.64	63.05	29.00	2.42	6.93	31.67	38.11	15.30	2.66	290.81	
Stations / Replicates	14/1	12/1	3/2	3/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/2	4/1	4/2	4/2	4/2	4/2	4/2		
Seasons	W / S	W / S	W / S	W / S	W / S	W / S	W / S	W / S	W / S	S	W / S	W / S	W / S	W / S	S	W / S	W / S	W / S	W / S	S		
Number of Trawls	28	24	12	12	16	16	16	16	16	8	16	16.00	16	16	4	16	16	16	16	8		
Parasitic species (not included above):																						
Elthusa vulgaris	9	-	1	2	-	19	31	11	34	-	2	2	-	31	15	4	4	95	43	-	303	
Elthusa sp	-	-	-	-	6	-	-	-	-	-	-	3	5	-	-	52	52	-	-	-	118	
Elthusa californica	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	4	
Nerocila sp	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	3	
Copepoda	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	
Bopyridae, unid.	-	-	-		-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	2	

Notes: N/A = not available; W = winter, S = summer

APPENDIX H

Fish and macroinvertebrate heat treatment data

Appendix H-1. Species list of impinged fish and macroinvertebrate species. Mandalay Generating Station NPDES, 2008.

Phylum Class Family Taxa	Common name
Arthropoda	
Malacostraca	
Crangonidae	
Crangon nigromaculata	blackspotted bay shrimp
Grapsidae	
Pachygrapsus crassipes	striped shore crab
Hemigrapsus nudus	purple shore crab
Palinuridae	
Panulirus interruptus	California spiny lobster
Penaeidae	
Farfantepenaeus californiensis	yellowleg shrimp
Mollusca	
Cephalopoda	
Octopodidae	
Octopus bimaculatus/bimaculoides	California two-spot octopus
Gastropoda	
Aglajidae	
Navanax inermis	California aglaja
Chordata	
Chondrichthyes	
Myliobatidae	
Myliobatis californica	bat ray
Actinopterygii	
Agonidae	
Stellerina xyosterna	pricklebreast poacher
Atherinopsidae	
Atherinops affinis	topsmelt
Carangidae	
Trachurus symmetricus	jack mackerel
Clinidae	
Gibbonsia elegans	spotted kelpfish
Gibbonsia montereyensis	crevice kelpfish
Clupeidae	
Sardinops sagax	Pacific sardine
Cottidae	
Leptocottus armatus	Pacific staghorn sculpin
Embiotocidae	
Phanerodon furcatus	white seaperch
Cymatogaster aggregata	shiner perch
Engraulidae	
Engraulis mordax	northern anchovy
Anchoa compressa	deepbody anchovy
Fundulidae	
Fundulus parvipinnis	California killifish
Gobiidae	
Acanthogobius flavimanus	yellowfin goby
Gillichthys mirabilis	longjaw mudsucker
Paralichthyidae	
Paralichthys californicus	California halibut
Sciaenidae	
Menticirrhus undulatus	California corbina
Seriphus politus	queenfish
Syngnathidae	
Syngnathus leptorhynchus	bay pipefish

Appendix H-2. Abundance of fish impinged during normal operations by survey date. Mandalay Generating Station NPDES, 2008.

Species	11/2/2007	1/4/2008	2/5/2008	4/26/2008	6/17/2008	8/22/2008	Total Abundance
Atherinops affinis	-	2	628	10	6	1	647
Cymatogaster aggregata	34	-	156	-	22	-	212
Leptocottus armatus	7	-	28	-	4	1	40
Sardinops sagax	-	-	18	-	-	-	18
Phanerodon furcatus	-	-	16	-	-	-	16
Seriphus politus	14	-	-	-	-	-	14
Gibbonsia montereyensis	-	1	3	-	-	1	5
Acanthogobius flavimanus	-	-	4	-	-	-	4
Engraulis mordax	-	-	2	-	2	-	4
Syngnathus leptorhynchus	2	-	-	-	1	-	3
Fundulus parvipinnis	1	-	-	-	1	-	2
Paralichthys californicus	-	-	2	-	-	-	2
Anchoa compressa	-	-	-	-	1	-	1
Gibbonsia elegans	-	-	-	-	1	-	1
Gillichthys mirabilis	1	-	-	-	-	-	1
Menticirrhus undulatus	-	-	-	-	1	-	1
Myliobatis californica	-	-	1	-	-	-	1
Stellerina xyosterna	-	-	1	-	-	-	1
Total Abundance	59	3	859	10	39	3	973
Number of Taxa	6	2	11	1	9	3	18

Appendix H-3. Biomass (kg) of fish impinged during normal operations by survey date. Mandalay Generating Station NPDES, 2008.

Taxa	11/2/2007	1/4/2008	2/5/2008	4/26/2008	6/17/2008	8/22/2008	Total Biomass (kg)
Atherinops affinis	-	0.002	18.930	0.103	0.071	0.019	19.125
Phanerodon furcatus	-	-	2.097	-	-	-	2.097
Cymatogaster aggregata	0.160	-	1.221	-	0.114	-	1.495
Leptocottus armatus	0.306	-	0.390	-	0.050	0.002	0.748
Sardinops sagax	-	-	0.627	-	-	-	0.627
Menticirrhus undulatus	-	-	-	-	0.337	-	0.337
Myliobatis californica	-	-	0.300	-	-	-	0.300
Paralichthys californicus	-	-	0.120	-	-	-	0.120
Acanthogobius flavimanus	-	-	0.083	-	-	-	0.083
Gibbonsia montereyensis	-	0.002	0.030	-	-	0.007	0.039
Seriphus politus	0.035	-	-	-	-	-	0.035
Engraulis mordax	-	-	0.011	-	0.019	-	0.030
Anchoa compressa	-	-	-	-	0.019	-	0.019
Gillichthys mirabilis	0.019	-	-	-	-	-	0.019
Fundulus parvipinnis	0.006	-	-	-	0.006	-	0.012
Syngnathus leptorhynchus	0.005	-	-	-	0.006	-	0.011
Stellerina xyosterna	-	-	0.005	-	-	-	0.005
Gibbonsia elegans	-	-	-	-	0.002	-	0.002
Total Biomass (kg)	0.531	0.004	23.814	0.103	0.624	0.028	25.104

Appendix H-4. Estimated monthly abundance of fish impinged during normal operations. Manalay Generating Station NPDES, 2008.

	2007			2008			Total
Species	Nov	Jan	Feb	Apr	Jun	Aug	Abundance
Atherinops affinis	-	53	3,496	278	362	74	4,263
Cymatogaster aggregata	1,715	-	869	-	1,329	-	3,913
Leptocottus armatus	353	-	156	-	242	74	825
Seriphus politus	706	-	-	-	-	-	706
Syngnathus leptorhynchus	101	-	-	-	60	-	161
Engraulis mordax	-	-	11	-	121	-	132
Gibbonsia montereyensis	-	27	17	-	-	74	118
Fundulus parvipinnis	50	-	-	-	60	-	110
Sardinops sagax	-	-	100	-	-	-	100
Phanerodon furcatus	-	-	89	-	-	-	89
Anchoa compressa	-	-	-	-	60	-	60
Gibbonsia elegans	-	-	-	-	60	-	60
Menticirrhus undulatus	-	-	-	-	60	-	60
Gillichthys mirabilis	50	-	-	-	-	-	50
Acanthogobius flavimanus	-	-	22	-	-	-	22
Paralichthys californicus	-	-	11	-	-	-	11
Myliobatis californica	-	-	6	-	-	-	6
Stellerina xyosterna	-	-	6	-	-	-	6
Total Abundance	2,975	80	4,783	278	2,354	222	10,692
Analysis Flow (10^6 gallons)	9,207	2,859	1,411	3,519	11,864	8,868	

Appendix H-5. Estimated monthly biomass (kg) of fish impinged during normal operations. Mandalay Generating Station NPDES, 2008.

	2007			2008			Total
Species	Nov	Jan	Feb	Apr	Jun	Aug	Biomass (kg)
Atherinops affinis	-	0.053	105.391	2.863	4.289	1.402	113.998
Cymatogaster aggregata	8.072	-	6.798	-	6.886	-	21.756
Leptocottus armatus	15.438	-	2.171	-	3.020	0.148	20.777
Menticirrhus undulatus	-	-	-	-	20.357	-	20.357
Phanerodon furcatus	-	-	11.675	-	-	-	11.675
Sardinops sagax	-	-	3.491	-	-	-	3.491
Seriphus politus	1.766	-	-	-	-	-	1.766
Myliobatis californica	-	-	1.670	-	-	-	1.670
Engraulis mordax	-	-	0.061	-	1.148	-	1.209
Anchoa compressa	-	-	-	-	1.148	-	1.148
Gillichthys mirabilis	0.959	-	-	-	-	-	0.959
Gibbonsia montereyensis	-	0.053	0.167	-	-	0.516	0.736
Paralichthys californicus	-	-	0.668	-	-	-	0.668
Fundulus parvipinnis	0.303	-	-	-	0.362	-	0.665
Syngnathus leptorhynchus	0.252	-	-	-	0.362	-	0.614
Acanthogobius flavimanus	-	-	0.462	-	-	-	0.462
Gibbonsia elegans	-	-	-	-	0.121	-	0.121
Stellerina xyosterna	-	-	0.028	-	-	-	0.028
Total Biomass (kg)	26.790	0.106	132.582	2.863	37.693	2.066	202.100
Analysis Flow (10^6 gallons)	9,207	2,859	1,411	3,519	11,864	8,868	

Appendix H-6. Length frequency of impinged fish measured during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2008.

	Size Class (cm)																				Total
Species	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	27	30	Measured
Acanthogobius flavimanus	-	-	-	-	-	-	-	-	-	1	2	1	-	-	-	-	-	-	-	-	4
Anchoa compressa	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	2
Atherinops affinis	1	1	-	-	3	3	1	1	6	11	13	18	10	1	-	-	-	-	-	-	69
Cymatogaster aggregata	3	13	20	27	32	19	15	10	7	2	-	-	-	-	-	-	-	-	-	-	148
Engraulis mordax	-	-	-	-	1	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-	4
Fundulus parvipinnis	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	2
Gibbonsia elegans	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Gibbonsia montereyensis	-	-	1	1	3	1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	10
Gillichthys mirabilis	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Leptocottus armatus	-	-	1	11	11	13	4	1	2	2	2	2	2	1	-	-	-	-	-	-	52
Menticirrhus undulatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
*Myliobatis californica**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Paralichthys californicus	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	2
Phanerodon furcatus	-	-	-	-	-	-	-	-	-	-	1	-	-	4	2	4	4	1	-	-	16
Sardinops sagax	-	-	-	-	-	-	-	-	1	7	1	2	4	3	-	-	-	-	-	-	18
Seriphus politus	-	2	7	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14
Stellerina xyosterna	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Syngnathus leptorhynchus	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	-	-	-	3
Trachurus symmetricus	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1

Note: * = Disc Width

Appendix H-7. Abundance of macroinvertebrates impinged during normal operations by survey date. Mandalay Generating Station NPDES, 2008.

Species	11/2/2007	1/4/2008	2/5/2008	4/26/2008	6/17/2008	8/22/2008	Total Abundance
Farfantepenaeus californiensis	1	-	-	1	-	-	2
Octopus bimaculatus/bimaculoides	-	-	-	1	1	-	2
Crangon nigromaculata	-	-	1	-	-	-	1
Hemigrapsus nudus	-	-	-	-	1	-	1
Navanax inermis	-	-	1	-	-	-	1
Pachygrapsus crassipes	-	-	-	-	1	-	1
Total Abundance	1	-	2	2	3	-	8
Number of Species	1	-	2	2	3	-	6

Appendix H-8. Biomass (kg) of macroinvertebrates impinged during normal operations by survey date. Mandalay Generating Station NPDES, 2008.

Species	11/2/2007	1/4/2008	2/5/2008	4/26/2008	6/17/2008	8/22/2008	Total Biomass(kg)
Octopus bimaculatus/bimaculoides	-	-	-	0.054	0.141	-	0.195
Farfantepenaeus californiensis	0.016	-	-	0.067	-	-	0.083
Navanax inermis	-	-	0.028	-	-	-	0.028
Pachygrapsus crassipes	-	-	-	-	0.004	-	0.004
Crangon nigromaculata	-	-	0.002	-	-	-	0.002
Hemigrapsus nudus	-	-	-	-	0.001	-	0.001
Total Biomass (kg)	0.016	-	0.030	0.121	0.146	-	0.313

Appendix H-9. Estimated monthly abundance of macroinvertebrates impinged during normal operations. Mandalay Generating Station NPDES, 2008.

	2007			2008			Total
Species	Nov	Jan	Feb	Apr	Jun	Aug	Abundance
Octopus bimaculatus/bimaculoides	-	-	-	28	60	-	88
Farfantepenaeus californiensis	50	-	-	28	-	-	78
Hemigrapsus nudus	-	-	-	-	60	-	60
Pachygrapsus crassipes	-	-	-	-	60	-	60
Crangon nigromaculata	-	-	6	-	-	-	6
Navanax inermis	-	-	6	-	-	-	6
Total Abundance	50	-	12	56	180	-	298
Number of Species	1	-	2	2	3	-	6
Analysis Flow (10^6 gallons)	9,207	2,859	1,411	3,519	11,864	8,868	

Appendix H-10. Estimated monthly biomass (kg) of macroinvertebrates impinged during normal operations. Mandalay Generating Station NPDES, 2008.

	2007			2008			Total
Species	Nov	Jan	Feb	Apr	Jun	Aug	Biomass(kg)
Octopus bimaculatus/bimaculoides	-	-	-	1.501	8.517	-	10.018
Farfantepenaeus californiensis	0.807	-	-	1.863	-	-	2.670
Pachygrapsus crassipes	-	-	-	-	0.242	-	0.242
Navanax inermis	-	-	0.156	-	-	-	0.156
Hemigrapsus nudus	-	-	-	-	0.060	-	0.060
Crangon nigromaculata	-	-	0.011	-	-	-	0.011
Total Biomass(kg)	0.807	-	0.167	3.364	8.819	-	13.157

Appendix H-11. Total one percent or more abundance of fish impinged during heat treatments and estimated normal operations, 2001 - 2008. Mandalay Generating Station NPDES, 2008.

	Year									Percent	
Taxa	2001	2002	2003	2004	2005	2006	2007	2008	Total	Total	Mean
Leuresthes tenuis	-	114883	6502	4273	39910	-	-	-	165568	46.92	20696.0
Cymatogaster aggregata	27	14305	563	14709	8883	48209	2295	3955	92946	26.34	11618.3
Engraulis mordax	3	101	1	1607	3137	45950	263	132	51194	14.51	6399.3
Atherinops affinis	-	6232	-	-	-	6830	463	4263	17788	5.04	2223.5
Lepidogobius lepidus	-	-	-	-	79	3665	4	-	3748	1.06	468.5
Hyperprosopon ellipticum	-	-	-	-	-	3664	-	-	3664	1.04	458.0
Phanerodon furcatus	-	1	-	45	20	3369	10	89	3534	1.00	441.8
Number of individuals	186	136,749	7,424	23,053	53,598	115,829	5,270	10,754	352,863		44,108
Number of taxa	6	20	11	13	20	28	26	19	49		17.9

Note: 0.00 = <0.005.

Appendix H-12. Total abundance of the top five macroinvertebrates impinged during heat treatments and estimated normal operations, 2001 - 2007. Mandalay Generating Station NPDES, 2008.

	Year									Percent	
Species	2001	2002	2003	2004	2005	2006	2007	2008	Total	Total	Mean
Protothaca staminea	-	-	4	-	-	27020	-	-	27024	8189.09	3378.0
Pachygrapsus crassipes	27	-	1	4	156	76	451	60	775	234.85	96.9
Octopus bimaculoides	1	41	12	-	-	106	10	88	258	78.18	32.3
Navanax inermis	-	-	-	48	-	153	-	6	207	62.73	25.9
Hemigrapsu nudus	-	-	-	129	-	-	-	60	189	57.27	23.6
Number of individuals	154	46	20	190	163	27,475	488	309	28,845		3,606
Number of species	5	3	4	8	3	7	4	7	16		5