# NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
# 2006 RECEIVING WATER MONITORING REPORT
# RELIANT ENERGY MANDALAY GENERATING STATION
# VENTURA COUNTY, CALIFORNIA

**2006 Survey**

**Prepared for:**

**Reliant Energy**

**Prepared by:**

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

# NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
# 2006 RECEIVING WATER MONITORING REPORT
# RELIANT ENERGY MANDALAY GENERATING STATION
# VENTURA COUNTY, CALIFORNIA

## 2006 Survey

**Prepared for:**

**Reliant Energy**

**Prepared by:**


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


**March 2007**

# PROJECT STAFF

## Reliant Energy

G. Norfolk
B. Siekiel-Zdzienicki
R. Whaley

## *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
A. K. Morris
C. L. Paquette
D. G. Vilas

### Technicians

D. A. Cronce
W. H. Dossett
N. M. Johnson
B. C. Kay
A. D. Macleod
J. C. May
F. C. Petry
J. L. Rankin
J. J. Sloan
B. L. Smith
B. L. Young

### Project Coordinator

M. R. Pavlick

### Editor

D. G. Vilas

# TABLE OF CONTENTS

**Page**


LIST OF FIGURES . . . v
LIST OF TABLES . . . vii
EXECUTIVE SUMMARY . . . ix

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

WATER COLUMN MONITORING . . . 13
MATERIALS AND METHODS . . . 13
RESULTS . . . 14
DISCUSSION . . . 22
CONCLUSION . . . 25

SEDIMENT CHARACTERISTICS . . . 26
MATERIALS AND METHODS . . . 26
Sediment Grain Size . . . 26
Sediment Chemistry . . . 26
RESULTS . . . 27
Sediment Grain Size . . . 27
Sediment Chemistry . . . 28

**Page**

DISCUSSION . . . . . 28
Sediment Grain Size . . . . . 28
Sediment Chemistry . . . . . 29
CONCLUSION . . . . . 32
Sediment Grain Size . . . . . 32
Sediment Chemistry . . . . . 32

MUSSEL BIOACCUMULATION . . . . . 33
MATERIALS AND METHODS . . . . . 33
RESULTS . . . . . 33
DISCUSSION . . . . . 34
CONCLUSION . . . . . 37

BENTHIC INFAUNA . . . . . 38
MATERIALS AND METHODS . . . . . 38
RESULTS . . . . . 39
DISCUSSION . . . . . 42
CONCLUSION . . . . . 45

DEMERSAL FISH AND MACROINVERTEBRATES . . . . . 46
MATERIALS AND METHODS . . . . . 46
RESULTS . . . . . 47
DISCUSSION . . . . . 54
CONCLUSION . . . . . 58

IMPINGEMENT . . . . . 59
MATERIALS AND METHODS . . . . . 59
RESULTS . . . . . 60
DISCUSSION . . . . . 62
CONCLUSION . . . . . 64

LITERATURE CITED . . . . . 65
PERSONAL COMMUNICATIONS . . . . . 72

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. Diagram of the Mandalay Generating Station cooling water system. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 2
Figure 2. Location of the study area. Mandalay Generating Station NPDES, 2006 . . . . . . . . . 3
Figure 3. Surface circulation in the Southern California Bight (from Hickey 1992). Mandalay Generating Station NPDES, 2006. . . . . . . . . . 5
Figure 4. Location of the monitoring stations. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 9
Figure 5. Location of the water column sampling stations. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 13
Figure 6. Tidal rhythms during water column sampling, winter and summer surveys. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 14
Figure 7. False color surface temperature contour plots, surf zone water quality, and temperature and dissolved oxygen vertical profiles during flood and ebb tides, winter survey. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 16
Figure 8. 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, 2006 . . . . . . . . . . 18
Figure 9. Surf zone water quality, and hydrogen ion concentration (pH) and salinity vertical profiles during flood and ebb tides, winter survey. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 20
Figure 10. Surf zone water quality, and hydrogen ion concentration (pH) and salinity vertical profiles during flood and ebb tides, summer survey. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 21
Figure 11. Location of the benthic sampling stations. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 26
Figure 12. Comparison of sediment mean grain size 1990 - 2006. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 29
Figure 13. Comparison of sediment metal concentrations and percent fines by station, 1990 - 2006. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 30
Figure 14. Comparison of mean chromium, copper, nickel, and zinc concentrations in mussel tissue at discharge and at reference sites, 1999 - 2006. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 36
Figure 15. Location of the benthic sampling stations. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 38
Figure 16. Diver-operated box corer used to collect infaunal samples. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 38
Figure 17. Two-way coincidence table resulting from normal (station) and inverse (species) classification dendrograms for the 20 most abundant infaunal species. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 42
Figure 18. Comparison of infaunal community parameters, 1978-2006. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 44
Figure 19. Location of the trawl sampling stations. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 46
Figure 20. Abundance and mean density (number of individuals/1000 $m^2$) of fishes collected by otter trawl by season and station. Mandalay Generating Stations NPDES, 2006 . . . . . . . . . . 48
Figure 21. Total biomass (kg) of otter trawl collected fish species by season and station. Mandalay Generating Station NPDES, 2006 . . . . . . . . . . 49

**Page**


Figure 22. Two-way coincidence table resulting from normal (station) and inverse (species) classification dendrograms for fish taken by otter trawl, winter survey. Mandalay Generating Station NPDES, 2006 . . . . . 50

Figure 23. Length frequency analysis for white croaker (*Genyonemus lineatus*) collected by otter trawl during winter (n = 3) and summer (n = 1,365) sampling. Mandalay Generating Station NPDES, 2006 . . . . . 52

Figure 24. Length frequency analysis for speckled sanddab (*Citharichthys stigmaeus*) collected by otter trawl during winter (n = 306) and summer (n = 842) sampling. Mandalay Generating Station NPDES, 2006 . . . . . 52

Figure 25. Length frequency analysis for shiner perch (*Cymatogaster aggregata*) collected by otter trawl during winter (n = 1) and summer (n = 329) sampling. Mandalay Generating Station NPDES, 2006 . . . . . 52

Figure 26. Abundance of macroinvertebrates collected by otter trawl by season and station. Mandalay Generating Station NPDES, 2006 . . . . . 53

Figure 27. Long-term abundance of fishes collected by otter trawl by season and station. Mandalay Generating Station NPDES, 2006 . . . . . 55

Figure 28. Long-term abundance of macroinvertebrates collected by otter trawl by season and station. Mandalay Generating Station NPDES, 2006 . . . . . 57

Figure 29. Length frequency of shiner perch (*Cymatogaster aggregata*) impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2006 . . . . . 61

Figure 30. Length frequency of topsmelt (*Atherinops affinis*) impinged impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2006 . . . . . 61

Figure 31. Length frequency of northern anchovy (*Engraulis mordax*) impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2006 . . . . . 61

Figure 32. Annual estimated abundance of fish impinged during heat treatment and normal operation surveys and annual reported circulating water volume (mg). Mandalay Generating Station NPDES, 2006 . . . . . 63

# LIST OF TABLES

**Page**

Table 1. Latitude/longitude coordinates of sampling stations. Mandalay Generating Station NPDES, 2006 . . . . . 10
Table 2. Summary of water quality parameters during flood and ebb tides at offshore stations. Mandalay Generating Station NPDES, 2006 . . . . . 15
Table 3. Summary of water quality parameters during flood and ebb tides at surf-zone stations. Mandalay Generating Station NPDES, 2006 . . . . . 17
Table 4. Sediment grain size parameters. Mandalay Generating Station NPDES, 2006 . . . 27
Table 5. Sediment metal concentrations (mg/dry kg). Mandalay Generating Station NPDES, 2006 . . . . . 28
Table 6. Mussel tissue metal concentrations (dry weight and reporting limits, mg/dry kg; wet weight and EDL, mg/wet kg). Mandalay Generating Station NPDES, 2006 . . . . . 34
Table 7. Number of infaunal species and individuals by phylum. Mandalay Generating Station NPDES, 2006 . . . . . 39
Table 8. Infaunal community parameters. Mandalay Generating Station NPDES, 2006 . . . 40
Table 9. The 20 most abundant infaunal species. Mandalay Generating Station NPDES, 2006 . . . . . 41
Table 10. Abundance and catch parameters for fish species taken by otter trawl. Mandalay Generating Station NPDES, 2006 . . . . . 48
Table 11. Biomass (kg) of fish species taken by otter trawl. Mandalay Generating Station NPDES, 2006 . . . . . 49
Table 12. Measured length (mm) of fish species taken by otter trawl. Mandalay Generating Station NPDES, 2006 . . . . . 51
Table 13. Abundance and catch parameters for macroinvertebrate species taken by otter trawl. Mandalay Generating Station NPDES, 2006 . . . . . 53
Table 14. The 20 most abundant fish species taken during otter trawl surveys, 1978 - 2006. Mandalay Generating Station NPDES, 2006 . . . . . 56
Table 15. Estimated abundance and biomass (kg) of fish species impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2006. . . . . . 60
Table 16. Estimated abundance of macroinvertebrate species impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2006 . . . . . 62
Table 17. Estimated biomass (kg) of macroinvertebrate species impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2006 . . . . . 62

# EXECUTIVE SUMMARY

The 2006 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 2006 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 2006 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

No thermal influence from the Mandalay Generating Stations discharge was noted during the winter sampling in 2006. In summer, a warm water surface lens was noted upcoast of the discharge during the morning flood tide, while during ebb tide warm near-surface water temperatures were found at the two nearest upcoast stations, the station offshore of discharge, and more notably at the nearest station downcoast of the discharge. At the surf zone stations, temperatures were highest at the discharge channel during both tides. Temperatures were also somewhat elevated upcoast of the discharge on both tides compared with the downcoast stations, with influence from the plume decreasing with distance from the discharge. These 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. Even in areas influenced by the thermal field, surface temperatures were typical of the area during previous surveys. Low near bottom dissolved oxygen concentration in winter appeared to be related to extensive red tides occurring in the area on the day of sampling, while all DO values found during the summer sampling were typical of the area and well above the level of biological concern. Values of pH were somewhat more variable in winter than during summer, likely a result of lower surface water salinities and red tide conditions in winter. Still, pH varied relatively narrowly and values were similar to levels found in previous sampling. Slightly reduced salinities found in surface waters in winter were probably a result of seasonal freshwater flow from the Santa Clara River upcoast of the generating station. Flow from the Santa Clara River may also have influenced salinities upcoast of the generating station during summer, while some freshwater influence from the discharge plume was also apparent. This influence, however, was local and similar to natural conditions found commonly throughout the study area.

With the exception of the warm water plume and slightly less salty surface water near the discharge during summer, variations in water quality parameters observed in 2006 can be attributed to natural physical and biological processes. Water quality measurements indicated that in 2006 the cooling water discharge from the Mandalay Generating Station did not have an adverse effect on receiving waters in the study area.

## SEDIMENT CHARACTERISTICS

### Sediment Grain Size

In 2006, sediments were analyzed from five stations offshore the Mandalay Generating Station. Mean grain size in the study area in 2006 was among the smallest since 1997, but still somewhat coarser than in 2005. Overall, sediments were composed of a greater percentage of fine material (silt and clay) than common, due to greater than normal contribution of fines at the stations farthest upcoast and downcoast of the discharge. Sediments were similar at the three stations nearest the discharge channel (Stations B1 through B3) where sediments were composed of 93% to 95% sand with mean grain sizes in the fine sand category. Sediments at the stations farthest downcoast and upcoast of the discharge (Stations B4 and B5, respectively) were finer, with mean grain sizes in the very fine sand category, and greater contributions by fine material (16% at Station B4 and 34% at Station B5). The degree of influence of the discharge on local sediments varies from year to year, suggesting a localized and transitory effect near the discharge in past surveys. However, sediment composition and distribution in the study area in 2006 appeared to be affected primarily by natural causes and not by the operations of the Mandalay Generating Station.

**Sediment Chemistry**

In 2006, sediments at five stations off the Mandalay Generating Station were analyzed for the presence and concentration of chromium, copper, nickel, and zinc. Metal concentrations were similar among stations and among the lowest values reported in the area. Although highest metal concentrations in 2006 appeared to be related to percent of fine material in the sediments, the mean concentrations of metals at all stations were one-half to one-third both the levels detected in 2005 and the long-term means. Sediment metal concentrations have remained relatively uniform in the area since 1990 and have been consistently lower than mean metal concentrations found in sediments at shallow (15–100 ft) 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 2006 did not appear to be influenced by the operation of the Mandalay Generating Station.

## MUSSEL BIOACCUMULATION

In 2006, mussels were not found in the vicinity of the Mandalay Generating Station discharge channel. For that reason, donor mussels were purchased from a commercial supplier in Carlsbad, California and transplanted to a mooring offshore of the Mandalay discharge where the mussels were allowed to acclimate for a period of 94 days. Tissues from the mussels at the discharge were analyzed for bioaccumulation of the metals chromium, copper, nickel, and zinc. Results were compared with those from mussels collected at the donor site at the time of the transplant and to mussels collected from the Hermosa Beach Pier in Santa Monica Bay, which served as the reference site.

Concentrations of chromium in mussel tissues transplanted into the vicinity of the discharge were elevated in 2006, but were lower than levels in source mussels and in mussels collected from a Santa Monica Bay reference site. Elevated chromium levels were also found at other sites throughout southern California in 2006. Other than chromium, metal levels in 2006 were generally lower than occurred in 2005, with the exception of a continuing trend of increasing zinc at the discharge. Concentrations of copper, nickel and zinc at the discharge were similar to values found previously in the area and at the donor and reference sites. While elevated chromium was found at all sites in 2006, concentrations of copper, nickel and zinc did not exceed levels in mussels considered elevated for bay mussels by the SMWP. With the exception of chromium, which appeared to have increased in several areas throughout southern California and was lowest near the discharge, the comparatively low tissue metal levels and similarity of tissue metal levels among sites and previous studies, suggests that the operation of the Mandalay Generating Station is not elevating metal concentrations above background levels.

## BENTHIC INFAUNA

The infaunal community in 2006 was comprised primarily of small annelid worms, arthropods, mollusks, nemertean worms, and echinoderms. Abundance averaged 169 individuals per station (4,215 individuals/$m^2$), which was about one-half that in 2005 and was below the long-term mean for the study area. A total of 57 species was taken, with a mean of 27 species per station and mean species diversity (H') of 2.48, both similar to their long-term means. Infaunal parameter values showed some relationship to sediment characteristics, as they were generally lower nearest the generating station and immediately upcoast, where sediments were coarser, and increased both upcoast and downcoast, where sediments were finer. Nearest the generating station, abundance, and species richness were below the area means, while species diversity was above the mean. Diversity was lowest immediately downcoast of the generating station due to the strong numerical dominance of the community by a single species, *Chone* sp SD1. Biomass did not correspond well with abundance, as several medium-sized Pacific sand dollars (*Dendraster excentricus*) were present where abundance was relatively low. All infaunal community parameters in 2006 were typical of the area and within the range of values found previously throughout the study area. The Southern California Benthic Response Index (BRI), an abundance-weighted average pollution tolerance of species occurring in a sample, was applied for the first time in 2006. All values were low, within the category indicating undisturbed, or healthy, shallow coastal shelf communities.

Infaunal community composition was similar among stations. The annelids *Chone* sp SD1 and *Apoprionospio pygmaea* were the most abundant species overall, although they were not the dominant species at two of the five stations. *Chone* sp SD1 was not particularly abundant in previous years except 2004, while *A. pygmaea* has been the most abundant species in more than one-half of the summer surveys since 1978. Other abundant species included the cumacean *Diastylopsis tenuis*, the nemertean (ribbon worm) *Carinoma mutabilis*, the amphipod *Rhepoxynius menziesii*, and the ostracod *Euphilomedes longiseta*. The communities found in 2006 were similar to those encountered in previous studies conducted in the study area since 1978 and are typical of the nearshore shallow subtidal environment in the Southern California Bight. No pattern of community parameters or composition related to proximity to the generating station was apparent.

## DEMERSAL FISH AND MACROINVERTEBRATES

In 2006, fish communities were similar to what has been recorded in recent surveys, while macroinvertebrate abundance has increased, particularly numbers of common species. A total of 5,866 individuals representing 25 fish species weighing 59.04 kg and a total of 14,215 individuals representing 16 macroinvertebrate species weighing 38.11 kg were collected during the 2006 monitoring year. No significant differences in fish communities were detected between stations adjacent to the discharge and both upcoast and downcoast reference stations. Slight decreases in abundance were recorded at the stations adjacent to the discharge among the summer macroinvertebrate community. In contrast, fish communities did not show such localized effects, but rather a generally increased abundance downcoast of the discharge. Variability in fish and macroinvertebrate communities in the area appeared to be related to natural and seasonal differences in local populations and not related to operations at the Mandalay Generating Station.

## IMPINGEMENT

To evaluate fish loss at the Mandalay Generating Station, fish impingement was monitored during one heat treatment and nineteen normal operation surveys in 2006. Based on these surveys, an estimated total of 112,161 individuals representing 28 fish species and weighing more than 1,500 kg were impinged at the generating station in 2006. Overall impinged abundance and biomass estimates for the monitoring year represent the second highest since 2002. In addition, an estimated 27,475 individuals representing seven macroinvertebrate species and weighing greater than 67 kg were impinged during the study year, the highest total since data was reported in 2001. From 2001 to 2005, the average number of normal operation surveys per year was five. For the 2006 monitoring year, however, the number normal operation surveys performed was increased as part of a special study for 316(b) compliance. These additional surveys may account for the increase in fish abundance during the 2006 monitoring year. All fish and macroinvertebrate species collected were typical of the bay and nearshore environment from which the generating station withdraws its cooling water. There was no indication that plant operations are adversely affecting the local marine macrofaunal community.

## CONCLUSIONS

The overall results of the 2006 NPDES monitoring program indicated that operation of the Mandalay Generating Station had no detectable adverse effects on the beneficial uses of the receiving waters.

# INTRODUCTION

This report presents and discusses the results of the 2006 receiving water monitoring studies conducted for the Mandalay Generating Station which is owned and operated by Reliant Energy. The 2006 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). Results of the 2006 surveys were compared among stations and with past physical oceanographic 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, sediments, and mussel tissue, and biological monitoring of infaunal, fish, and macroinvertebrate assemblages.

## 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 oil- or 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).

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, usually less than about 30 hours per year.

None of the four circulator pumps were operating during the winter survey on 26 April 2006; however, the intake temperature was 18.3°C and temperature at the discharge was 21.7°C, a difference of 3.3°C. During the summer survey, 23 August 2006, four circulator pumps were operating, discharging 240 mgd. The intake temperature was 21.1°C and the discharge temperature 33.3°C, for a temperature increase of 12.2°C for the water flowing across the condensers. During 2006, the Mandalay Generating Station steam plants operated at 11.36% of their total operating capacity (Siekiel-Zdzienicki 2006, 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.

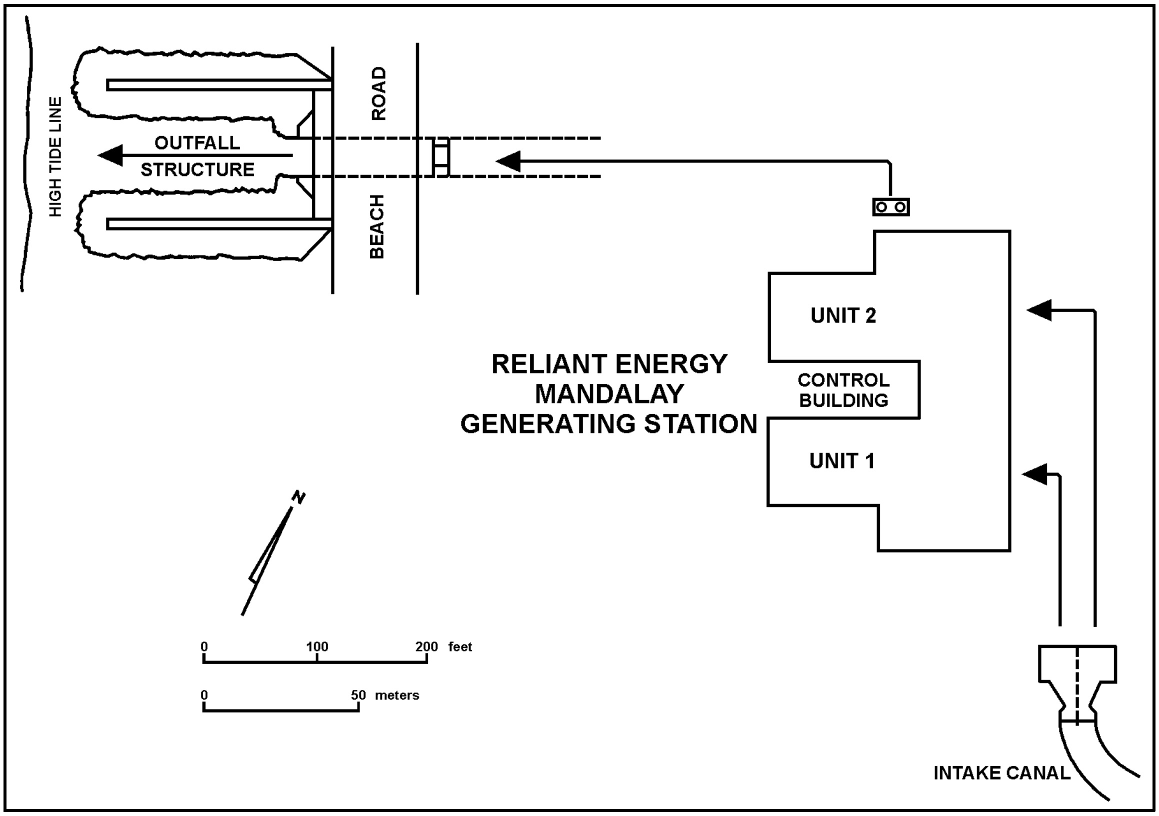



**Figure 1. Diagram of the Mandalay Generating Station cooling water system. Mandalay Generating Station NPDES, 2006.**

## 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 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).

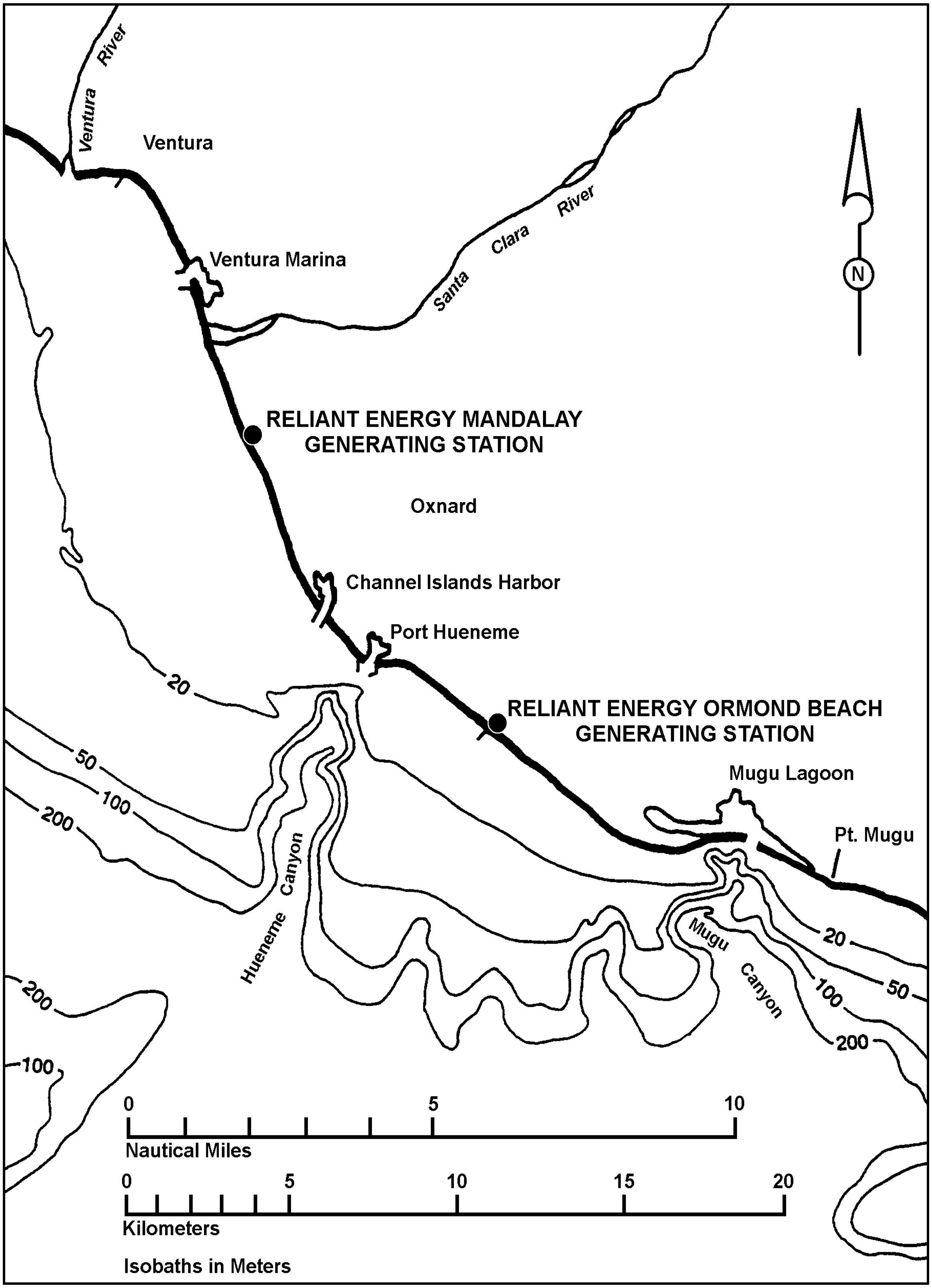



**Figure 2. Location of the study area. Mandalay Generating Station NPDES, 2006.**

**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 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 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

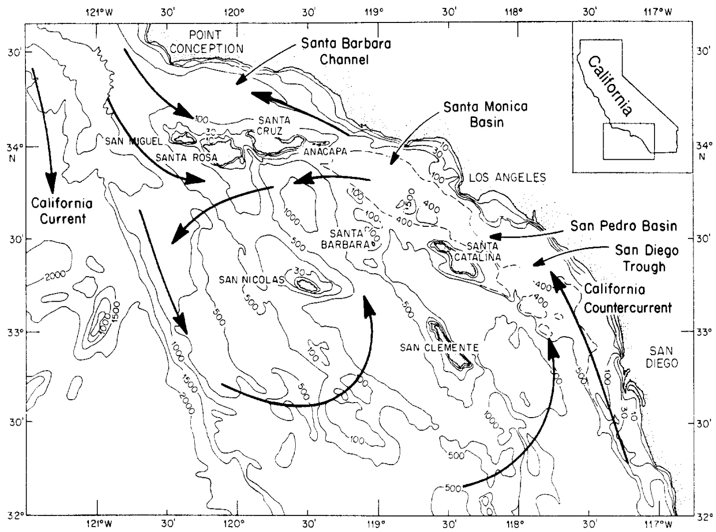


**Figure 3. Surface circulation in the Southern California Bight (from Hickey 1992). Mandalay Generating Station NPDES, 2006.**

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. Maximum pH values recorded during four quarterly surveys conducted offshore Ormond Beach between December 1973 and September 1974 were 8.0 to 8.6 (EQA/MBC 1975).

**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 2006 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.

## STATION LOCATIONS

The locations of the monitoring stations are described in Appendix A and shown on Figure 4. The 2006 monitoring program included 17 water quality (RW) stations, four trawl (T) stations, and five sediment and benthic infauna (B) stations.

## FIELD OBSERVATIONS

The NPDES trawl surveys were conducted on 25 April and 25 August, receiving water quality monitoring surveys were conducted on 26 April and 23 August, and benthic sampling was conducted on 24 August 2006. Latitude and longitude coordinates for all receiving water (RW), trawl (T), and benthic (B) stations are listed in Table 1.

During the winter surveys, no oil sheens, grease, or floatables were observed at any of the stations. At the receiving water stations, an extensive red tide (plankton bloom) was observed and the water was moderately to heavily turbid at all stations. The water within the trawl sampling area was observed to be turbid. Western gulls (*Larus occidentalis*) were seen at all trawl stations and most of the receiving water stations. Five unidentified terns (*Sterna* spp) were observed at Station T4 and two black oystercatchers (*Haematopus bachmani*) were seen at Station RW8. Willets (*Catoptrophorus semipalmatus*) and a great blue heron (*Ardea herodias*) were noted at Station RW5. A harbor seal (*Phoca vitulina*) was seen at Station T3 and three gray whales *(Eschrichtius robustus*) were observed at Station T4. California brown pelicans (*Pelecanus occidentalis californicus*) were

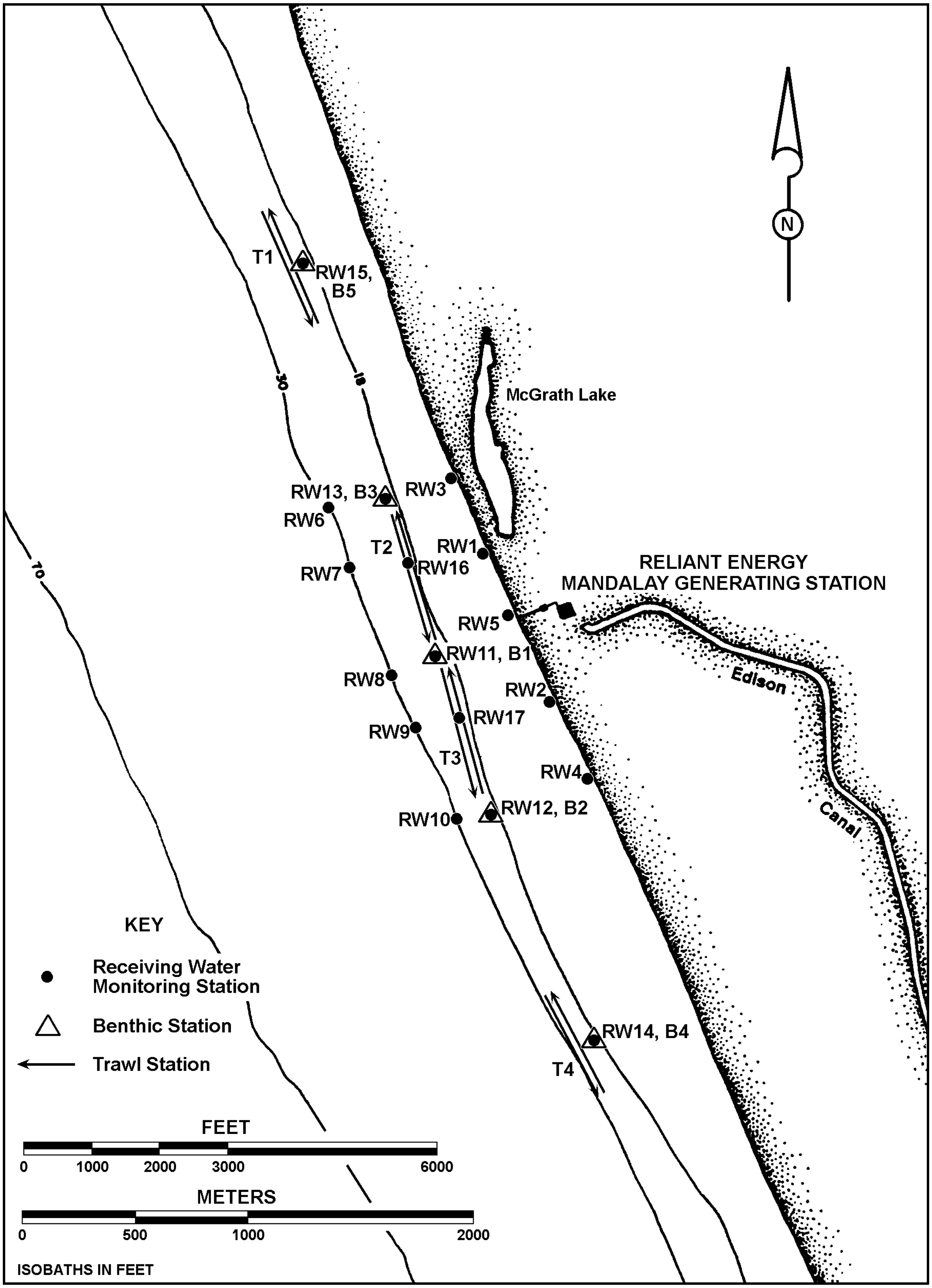



**Figure 4. Location of the monitoring stations. Mandalay Generating Station NPDES, 2006.**

seen throughout the trawl sampling area and at the receiving water stations. No California least terns (*Sterna antillarum browni*) were observed during any of the winter surveys.

During the summer surveys, no oil sheens, grease, or red tide were observed at any of the stations. The water was slightly to moderately turbid at the offshore receiving water stations, sediment core collection stations, and within the trawl sampling area. Drift kelp (*Macrocystis pyrifera*) and wood were noted at all surf-zone receiving water stations, offshore Stations RW7, RW8, RW11, RW15, and all sediment core collection stations. Western gulls were seen throughout all survey areas. Cormorants (*Phalacrocorax* sp) were noted at Stations RW11, RW13, RW15, RW17, B2, and B3. Harbor seals were seen at Stations B1 and T3. A small pod of bottlenose dolphins (*Tursiops truncatus*) were observed at Stations RW4 and RW13. California brown pelicans were seen at Stations T3, T4, and at most receiving water and sediment core collection stations. No California least terns were observed during any of the summer surveys.

**Table 1. Latitude/longitude coordinates of sampling stations. Mandalay Generating Station NPDES, 2006.**

| 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 | B5 | 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 4 of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) list of invertebrate species (SCAMIT 2001).

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)].

**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 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 © 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 © from above were used. Historical raw data are presented in the appendices for possible supplementary study.

## 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

Water quality monitoring was conducted at 17 receiving water (RW) stations located within the surrounding waters of the Mandalay Generating Station discharge channel (Figure 5). 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 concentration, hydrogen ion concentration, and salinity were recorded during ebbing and flooding tides, during winter and summer surveys.

Winter water quality was monitored at Stations RW1 through RW17 on 26 April 2006 during flood and ebb tides. At surf-zone Stations RW1 through RW5, flood tide was monitored between 0650 and 0758 hours (hr) and ebb tide was monitored between 1245 and 1545 hr. At offshore Stations RW6 through RW17, flood tide was monitored between 0637 and 0739 hr and ebb tide was monitored between 1158 and 1250 hr (Figure 6). On the day of monitoring, the tide rose from a low of -0.6 ft Mean Lower Low Water (MLLW) at 0315 hr to a high of +4.6 ft MLLW at 0916 hr, then fell to a low of +0.5 ft MLLW at 1502 hr. Skies at surf-zone stations were mostly to partly cloudy with winds that changed from northwest at 5 to 7 kn to southwest at 9 to 10 kn. Seas were west at 1 to 2 ft. At offshore stations, skies were partly cloudy with winds from the southeast at 3 to 7 kn. Seas were west at 2 to 3 ft.

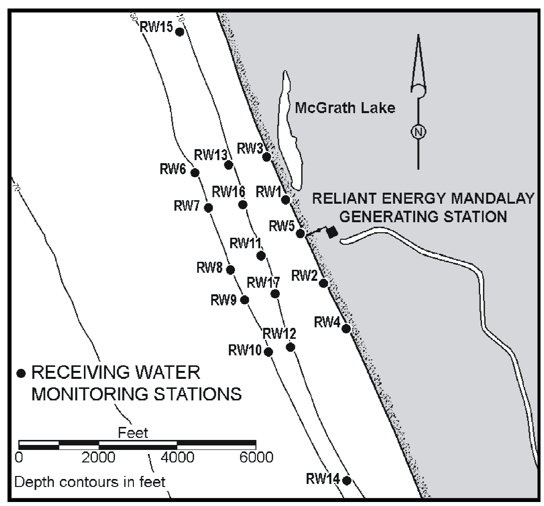



**Figure 5. Location of the water column sampling stations. Mandalay Generating Station NPDES, 2006.**

Summer water quality was monitored at Stations RW1 through RW17 on 23 August 2006 during flood and ebb tides. At surf-zone Stations RW1 through RW5, flood tide was monitored between 0700 and 0800 hr and ebb tide was monitored between 1300 and 1359 hr. At offshore Stations RW6 through RW17, flood tide was monitored between 0613 and 0708 hr and ebb tide was monitored between 1200 and 1257 hr (Figure 6). On the day of monitoring, the tide rose from a low of -0.3 ft MLLW at 0423 hr to a high of +4.4 ft MLLW at 1037 hr, then fell to a low of +1.9 ft MLLW at 1556 hr. Skies at surf-zone stations were overcast in the morning and cleared by the afternoon. Winds were from the west at 2 to 5 kn and seas were west at 1 to 3 ft. At offshore stations, skies were overcast and foggy in the morning and clear by the afternoon. Winds were from the west at 3 to 13 kn. Seas were west at 1 to 3 ft.

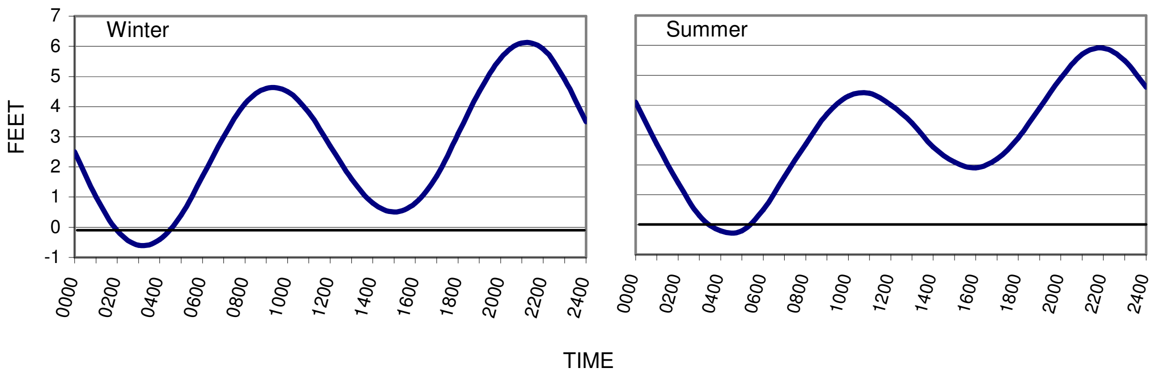



**Figure 6. Tidal rhythms during water column sampling, winter and summer surveys. Mandalay Generating Station NPDES, 2006.**

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 YSI 556 Multi-Probe System (YSI) water quality analyzer. During the winter ebb tide surf-zone monitoring, the conductivity/salinity probe of the YSI water quality analyzer malfunctioned. Since salinity monitoring is not included in permitting requirements, only two surf-zone salinity readings were reported for the afternoon ebb tide sampling. Monitoring at offshore stations was conducted using a Sea-Bird Water Quality Monitoring System (SBE 9/17). Data were processed using the Sea-Bird proprietary software (SeaSoft). The resulting data 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.

## RESULTS

Water quality monitoring was conducted during flood and ebb tides, in winter and summer, 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 5. During both seasons, flood tide was sampled in the early morning, while ebb tide was sampled late morning or early afternoon. During the winter sampling no circulating pumps were operating, while on the day of the summer sampling all four circulating pumps were in operation with a flow of 240 mgd and a discharge temperature of 33.3°C (Siekiel-Zdzienicki 2006, pers. comm.). Seasonal water quality data for flood and ebb tides are presented in Figures 7 through 10 and summarized in Table 2. Raw data are presented in Appendix B.

### Water Temperature

During winter monitoring, offshore surface water temperatures during the morning flood tide averaged 13.68°C and ranged from 12.87°C at Station RW15, 5,910 ft upcoast of the discharge on the 20-ft isobath, to 13.92°C at Station RW10, 2,360 ft downcoast of the discharge on the 30-ft isobath (Table 2 and Figure 7). Surface water temperatures during ebb tide averaged 15.07°C and ranged from 14.04°C at Station RW10 to 15.89°C at Station RW7, 1,180 ft upcoast of the discharge on the 30-ft isobath. At all stations, surface temperatures during late morning ebb tide monitoring were slightly higher than early morning flood tide monitoring. On average, temperatures at all stations were 1.4°C higher during the later tide, with the greatest increase between tides (2.2°C) found at Station RW13, 2,360 ft upcoast of the discharge on the 20-ft isobath (Appendix B-1). Temperature decreased from surface to bottom at all stations during both tides. Strong thermal gradients were observed in the upper 2 to 3 m of the water column at all stations on both tides.

Thermoclines exceeding 1°C temperature change within 1-m depth were found at Stations RW13 and RW16, 1,180 ft upcoast of the discharge on the 20-ft isobath on flood tide, and at all stations on ebb tide. Average bottom water temperatures were 11.59°C during flood tide and 11.69°C on ebb tide. Coolest bottom water temperatures were recorded at stations along the 30-ft isobath and warmest bottom temperature was recorded at Station RW14, 5,910ft downcoast of the discharge on the 20-ft isobath, on flood tide and at Station RW13 on ebb tide.

**Table 2. Summary of water quality parameters during flood and ebb tides at offshore stations. Mandalay Generating Station NPDES, 2006.**

| | Temp. (°C) | | D.O. (mg/l) | | pH | | Salinity (psu) | | Temp. (°C) | | D.O. (mg/l) | | pH | | Salinity (psu) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Winter** | | | | | | | | | | | | | | | |
| | Surface | | | | | | | | Bottom | | | | | | | |
| | flood | ebb | flood | ebb | flood | ebb | flood | ebb | flood | ebb | flood | ebb | flood | ebb | flood | ebb |
| Mean | 13.68 | 15.07 | 8.65 | 13.39 | 8.00 | 8.27 | 32.31 | 32.66 | 11.59 | 11.69 | 5.12 | 6.40 | 7.60 | 7.73 | 33.68 | 33.66 |
| Minimum | 12.87 | 14.04 | 7.35 | 10.00 | 7.83 | 8.06 | 31.86 | 32.13 | 11.18 | 11.33 | 4.63 | 5.36 | 7.54 | 7.67 | 33.65 | 33.60 |
| Maximum | 13.92 | 15.89 | 9.43 | 18.29 | 8.05 | 8.56 | 33.26 | 33.04 | 12.29 | 12.29 | 6.72 | 8.71 | 7.75 | 7.79 | 33.70 | 33.69 |
| | **Summer** | | | | | | | | | | | | | | | |
| | Surface | | | | | | | | Bottom | | | | | | | |
| | flood | ebb | flood | ebb | flood | ebb | flood | ebb | flood | ebb | flood | ebb | flood | ebb | flood | ebb |
| Mean | 16.59 | 17.06 | 7.50 | 7.82 | 8.14 | 8.17 | 33.41 | 33.39 | 15.48 | 14.69 | 7.39 | 7.67 | 8.13 | 8.16 | 33.52 | 33.49 |
| Minimum | 16.03 | 16.05 | 7.41 | 7.18 | 8.11 | 8.08 | 33.17 | 33.08 | 14.54 | 14.25 | 7.20 | 7.33 | 8.10 | 8.15 | 33.49 | 33.45 |
| Maximum | 16.97 | 20.09 | 7.62 | 8.80 | 8.17 | 8.24 | 33.58 | 33.47 | 16.41 | 15.69 | 7.54 | 7.94 | 8.16 | 8.18 | 33.55 | 33.63 |

At surf-zone stations in winter, surface water temperatures during flood tide averaged 13.37°C and ranged from 13.33°C at Station RW1, 1,180 ft upcoast of the discharge channel, to 13.41°C at both Stations RW2 and RW4, 1,180 ft and 2,360 ft downcoast of the discharge channel, respectively (Table 3 and Figure 7). Surface water temperatures during ebb tide averaged 16.03°C and ranged from 15.87°C at Station RW2 to 16.25°C at Station RW5 at the discharge channel. Water temperatures varied at all stations by about 2.7°C between tides, while during each tide temperatures were similar throughout the surf zone, varying by less than 0.4°C among stations.

**Table 3. Summary of water quality parameters during flood and ebb tides at surf-zone stations. Mandalay Generating Station NPDES, 2006.**

| | Temp. (°C) | | D.O. (mg/l) | | pH | | Salinity (psu) | | Temp. (°C) | | D.O. (mg/l) | | pH | | Salinity (psu) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Winter** | | | | | | | | **Summer** | | | | | | | |
| | flood | ebb | flood | ebb | flood | ebb | flood | ebb | flood | ebb | flood | ebb | flood | ebb | flood | ebb |
| Mean | 13.37 | 16.03 | 8.47 | 9.31 | 8.03 | 8.38 | 33.21 | 33.75 | 17.01 | 19.87 | 8.64 | 8.23 | 8.07 | 8.14 | 33.63 | 33.66 |
| Minimum | 13.33 | 15.87 | 8.42 | 9.00 | 7.94 | 8.30 | 32.97 | 33.52 | 16.20 | 18.08 | 8.30 | 7.31 | 7.92 | 8.01 | 33.27 | 33.45 |
| Maximum | 13.41 | 16.25 | 8.54 | 9.50 | 8.10 | 8.44 | 33.45 | 33.97 | 18.48 | 24.85 | 8.88 | 8.58 | 8.14 | 8.21 | 33.79 | 33.82 |

During summer monitoring, offshore surface water temperature during flood tide averaged 16.59°C and ranged from 16.03°C at Station RW11, offshore of the discharge on the 20-ft isobath to 16.97°C at Station RW16 (Table 2 and Figure 8). Surface water temperatures during ebb tide averaged 17.06°C and ranged from 16.05°C at Station RW10 to 20.09°C at Station RW17, 1,180 ft downcoast of the discharge on the 20-ft isobath. At stations along the 30-ft isobath, surface temperatures during afternoon ebb tide monitoring were similar to or lower than temperatures found during the early morning flood tide. Similar or slightly lower afternoon temperatures were also found in surface waters at Stations RW12 and RW14, the farthest stations downcoast on the 20-ft isobath, and at Station RW15, farthest upcoast at 20 ft. At the remaining stations, the two nearest upcoast, offshore of and nearest downcoast of the discharge on the 20-ft isobath, surface temperatures were an average of 1.75°C higher on ebb tide, with the highest differential between tides (3.63°C) found

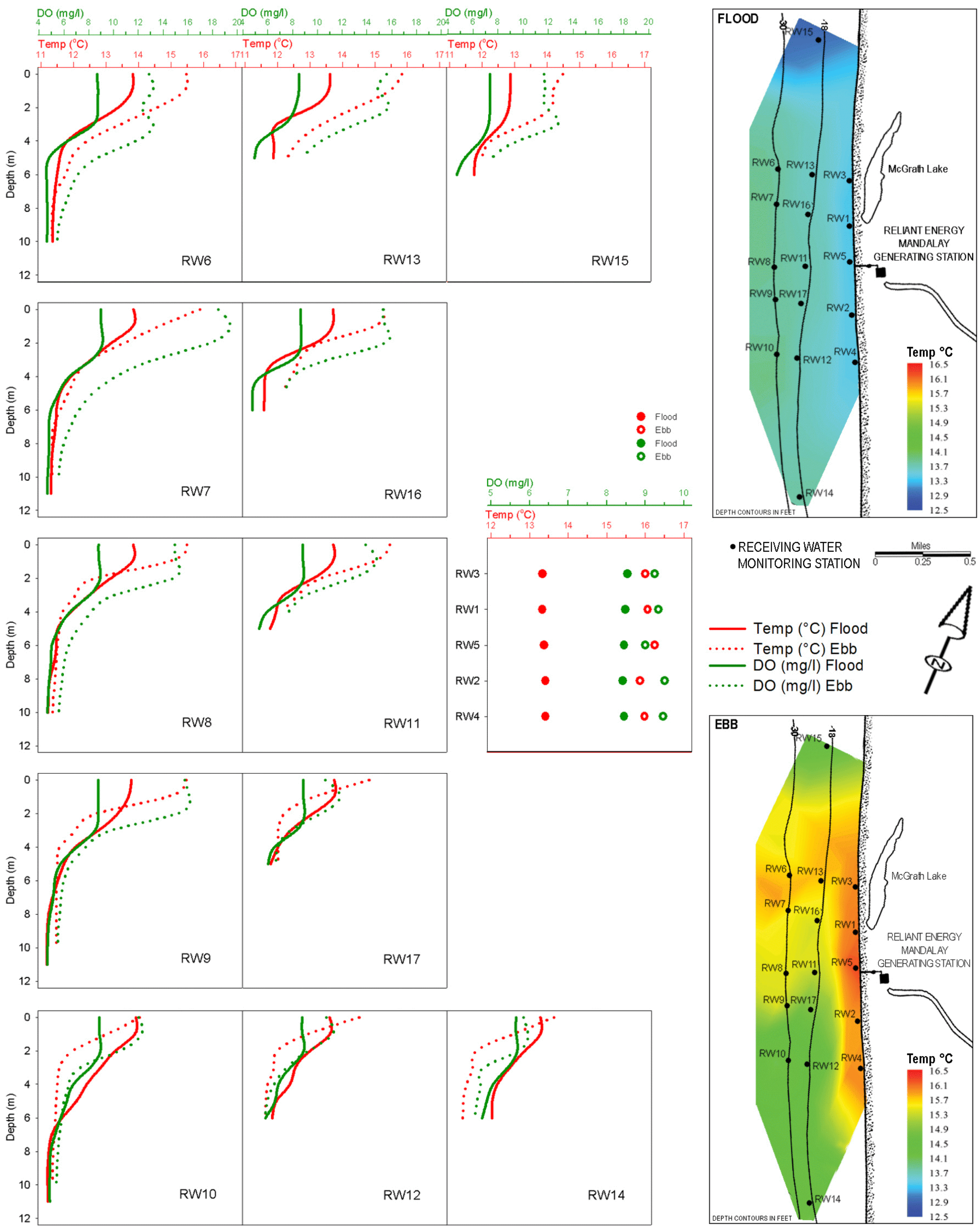



**Figure 7. False color surface temperature contour plots, surf zone water quality, and temperature and dissolved oxygen vertical profiles during flood and ebb tides, winter survey. Mandalay Generating Station NPDES, 2006.**

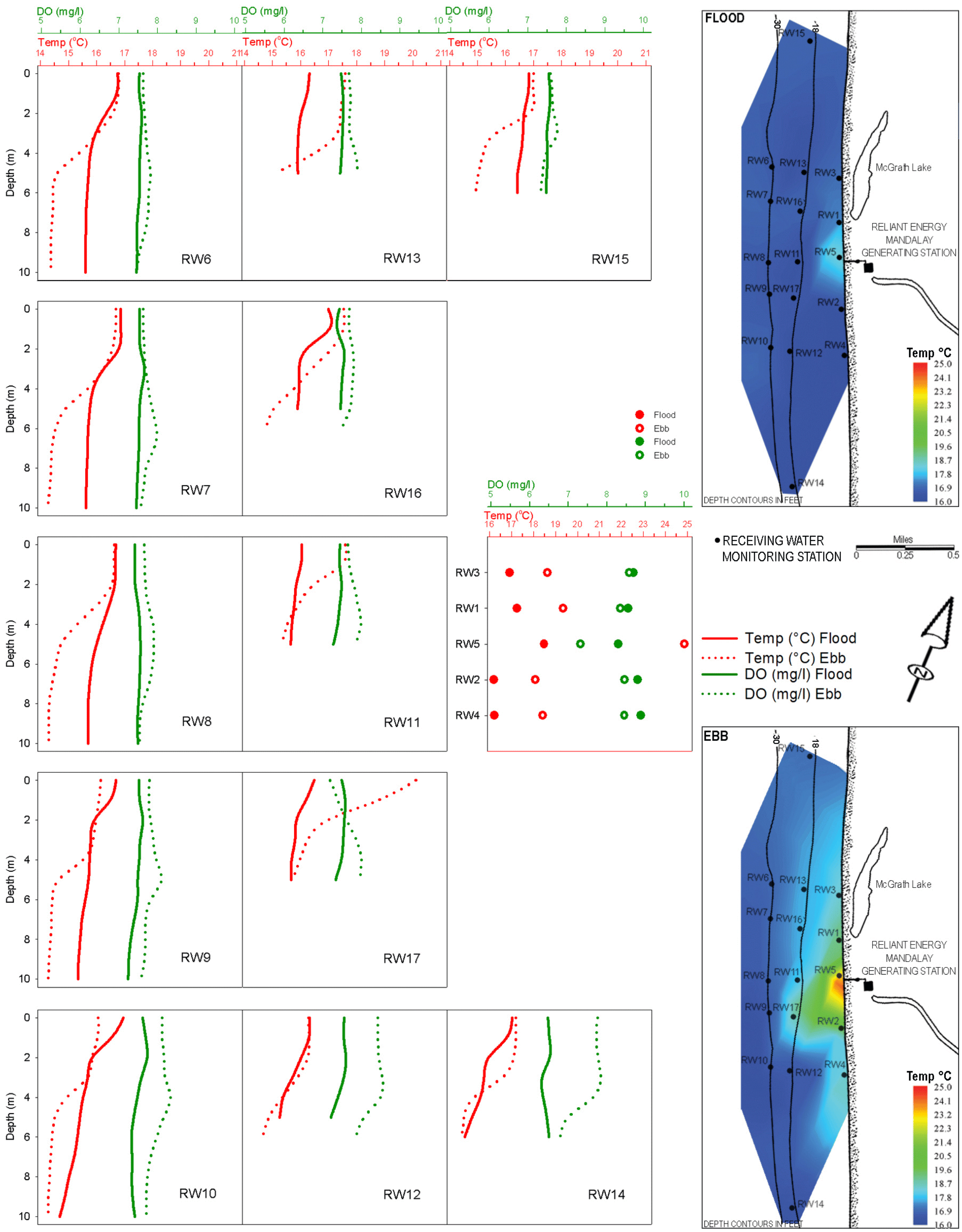



**Figure 8. False color surface temperature contour plots, surf zone water quality, and temperature and dissolved oxygen vertical profiles during flood and ebb tides, summer survey. Mandalay Generating Station NPDES, 2006.**

at Station RW17 (Appendix B-2). Temperature decreased from surface to bottom at all stations during flood tide except at Station RW16, where temperatures were slightly higher at 1-m depth than at the surface. In summer, most stations showed mild thermal gradients in the upper 2 to 4 m, above and below which temperature reductions with depth were more moderate. Near-bottom water temperatures were generally colder on ebb tide, resulting in stronger, and slightly deeper, thermal gradients at most stations than found on flood tide. Thermoclines exceeding 1°C temperature change within 1-m depth were found at Stations RW11, RW14, RW15, and RW17. Average bottom water temperatures were 15.48°C during flood tide and 14.69°C during ebb tide. Coolest bottom water temperatures were recorded at Station RW14 on flood tide, generally at stations along the 30-ft isobath, and farthest downcoast on the 20-ft isobath on ebb tide. Warmest bottom temperatures were recorded at Station RW15 on flood tide and Station RW17 on ebb tide.

At surf-zone stations in summer, surface water temperatures during flood tide averaged 17.01°C and ranged from 16.20°C at Stations RW2 to 18.48°C at Station RW5 (Table 3 and Figure 8). Surface water temperatures during ebb tide averaged 19.87°C and ranged from 18.08°C at Station RW2 to 24.85°C at Station RW5. Temperatures recorded at Station RW5 was 1.8°C higher than the average temperature at the other surf-zone stations on flood tide, and 6.2°C warmer on ebb tide.

**Dissolved Oxygen**

During winter monitoring, offshore surface dissolved oxygen (DO) concentration during flood tide averaged 8.65 mg/l and ranged from 7.35 mg/l at Station RW15 to 9.43 mg/l at Station RW14 (Table 2 and Figure 7). Surface DO concentrations during ebb tide averaged 13.39 mg/l and ranged from 10.00 mg/l at Station RW14 to 18.29 mg/l at Station RW7. Subsurface DO concentration maxima were recorded within the upper two to four meters of the water column at all stations on both tides. A second, slightly deeper maxima was noted on ebb tide at Stations RW6 and RW13, both 2,360 ft upcoast of the discharge on the 30- and 20-ft isobaths, respectively. Dissolved oxygen concentrations rapidly declined below the subsurface maxima at depths of about three to five meters prior to gradually declining with depth to the bottom. More pronounced gradients were found during the afternoon ebb tide when surface DO concentrations were higher. Maximum surface-to-bottom DO differentials occurred at Station RW7 where DO concentration decreased by 4.28 mg/l during flood tide and 12.73 mg/l during ebb tide (Appendix B-1). Near bottom DO concentrations were relatively similar between tides at the deepest and downcoast stations. Average bottom DO values were 5.12 mg/l during flood tide and 6.40 mg/l during ebb tide. The lowest bottom DO values, 4.63 mg/l on flood tide and 5.36 mg/l on ebb tide, occurred at Stations RW6 and RW10, respectively, both deep stations. Highest near-bottom DO concentrations, 6.72 mg/l on flood tide and 8.71 mg/l on ebb tide, were found at Stations RW14 and RW13, respectively.

At surf-zone stations in winter, surface DO concentrations during flood tide averaged 8.47 mg/l and ranged from 8.42 mg/l at Station RW2 to 8.54 mg/l at Station RW3 (Table 3 and Figure 7). Surface DO concentrations during ebb tide averaged 9.31 mg/l and ranged from 9.00 mg/l at Station RW5 to 9.50 mg/l at Station RW2.

During summer monitoring, offshore surface DO concentration during flood tide averaged 7.50 mg/l and ranged from 7.41 mg/l at Station RW16 to 7.62 mg/l at Station RW10 (Table 2 and Figure 8). Surface DO concentrations during ebb tide averaged 7.82 mg/l and ranged from 7.18 mg/l at Station RW17 to 8.80 mg/l at Station RW14. The greatest difference in surface water DO between tides (0.87 mg/l) was found at Station RW12, 2,360 ft downcoast of the discharge on the 20-ft isobath. Dissolved oxygen concentrations were similar throughout the summer sampling, varying by less than 1.7 mg/l between tides, among stations and with depth (Appendix B2). Dissolved oxygen concentrations were relatively consistent with depth on both tides, with slight subsurface maxima in the upper 4 to 8 meters at all stations with only moderate reductions, and at some stations slight increases, in DO with depth to the bottom. Dissolved oxygen concentrations throughout the water column were generally higher and slightly more variable with depth during the afternoon ebb tide, except at Station RW17 where DO concentrations were lower in the upper two meters on ebb tide than during flood tide. Average bottom DO values in summer were 7.39 mg/l during flood tide and 7.67mg/l during ebb tide. Lowest bottom DO value (7.20 mg/l) was recorded at Station RW12 on flood tide and the highest value (7.94 mg/l) was recorded at Station RW17 on ebb tide.

At surf-zone stations in summer, surface DO concentrations during flood tide averaged 8.64 mg/l and ranged from 8.30 mg/l at Station RW5 to 8.88 mg/l at Station RW4 (Table 3 and Figure 8). Surface DO concentrations during ebb tide averaged 8.23 mg/l and ranged from 7.31mg/l at Station RW5 to 8.58 mg/l at Station RW3.

**Hydrogen Ion Concentration**

During winter monitoring, offshore surface hydrogen ion concentrations (pH) averaged 8.00 during flood tide and 8.27 during ebb tide (Table 2 and Figure 9). Flood tide pH values ranged from 7.83 at Station RW15 to 8.05 at Station RW14. Ebb tide pH values ranged from 8.06 at Station RW14 to 8.56 at Station RW7. Bottom pH values averaged 7.60 during flood tide and 7.73 on ebb tide. Flood tide bottom values ranged from 7.54 at Station RW15 to 7.75 at Station RW14. Ebb tide bottom pH values ranged from 7.67 at Station RW6 to 7.79 at Station RW13. Hydrogen ion concentrations during flood tide decreased with depth at all stations, with greatest declines found at about 2 to 4 m depth. Values ranged narrowly on flood tide, varying by about 0.4 units among stations and depths during the morning flood tide (Appendix B-1). Hydrogen ion values were more variable during the afternoon ebb tide, with higher pH values found throughout the water column at most stations and greater variability with depth. The greatest surface-to-bottom difference on ebb tide (0.88) was found at Station RW7.

At surf-zone stations in winter, surface pH values averaged 8.03 during flood tide and 8.38 during ebb tide (Table 3). Hydrogen ion concentrations varied by 0.5 units among stations and between tides. Highest pH values were recorded at Station RW3 on both tides (Figure 9).

Surface pH values in the summer averaged 8.14 during flood tide and 8.17 during ebb tide (Table 2 and Figure 10). Flood tide pH values ranged from 8.11 at Station RW16 to 8.17 at Station RW15. Ebb tide pH values ranged from 8.08 at Station RW17 to 8.24 at Station RW14. Bottom pH values averaged 8.13 during flood tide and 8.16 on ebb tide. Flood tide bottom values ranged from 8.10 at Station RW14 to 8.16 at Stations RW7, RW13 and RW15. Ebb tide bottom pH values ranged from 8.15 at Stations RW6 though RW9 and Station RW16 to 8.18 at Station RW17. Hydrogen ion values were very consistent throughout the water column, although generally slightly higher, particularly at downcoast stations, on ebb tide. In summer, pH values were notably uniform, varying by no more than 0.16 among stations, between tides and with depth.

At surf-zone stations in summer, surface pH values averaged 8.07 during flood tide and 8.14 during ebb tide (Table 3). Hydrogen ion concentrations varied by less than 0.30 units among stations and between tides. Highest pH value was recorded at Station RW3 (Figure 10).

**Salinity**

During winter monitoring, offshore surface salinity readings averaged 32.31 practical salinity units (psu) during flood tide and 32.66 psu during ebb tide (Table 2 and Figure 9). Lower salinity values were recorded within the upper four meters at all stations during both tides, with generally lower surface salinities during the morning flood tide. Salinity increased with depth at all stations on both tides, with the greatest differences found in the upper 4 m of the water column. Bottom salinities were very similar between tides and among stations. Average bottom salinity values were

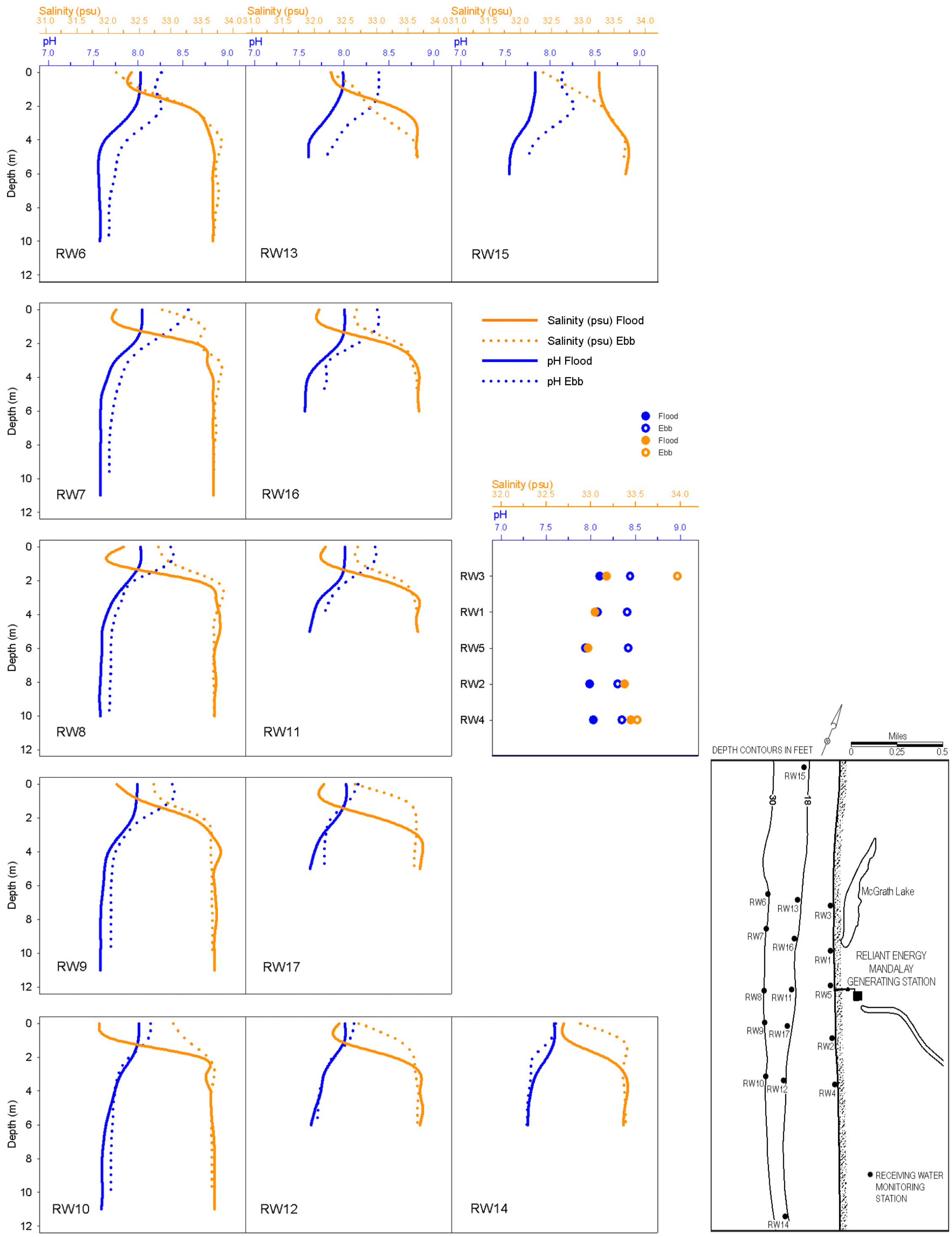



**Figure 9. Surf zone water quality, and hydrogen ion concentration (pH) and salinity vertical profiles during flood and ebb tides, winter survey. Mandalay Generating Station NPDES, 2006.**

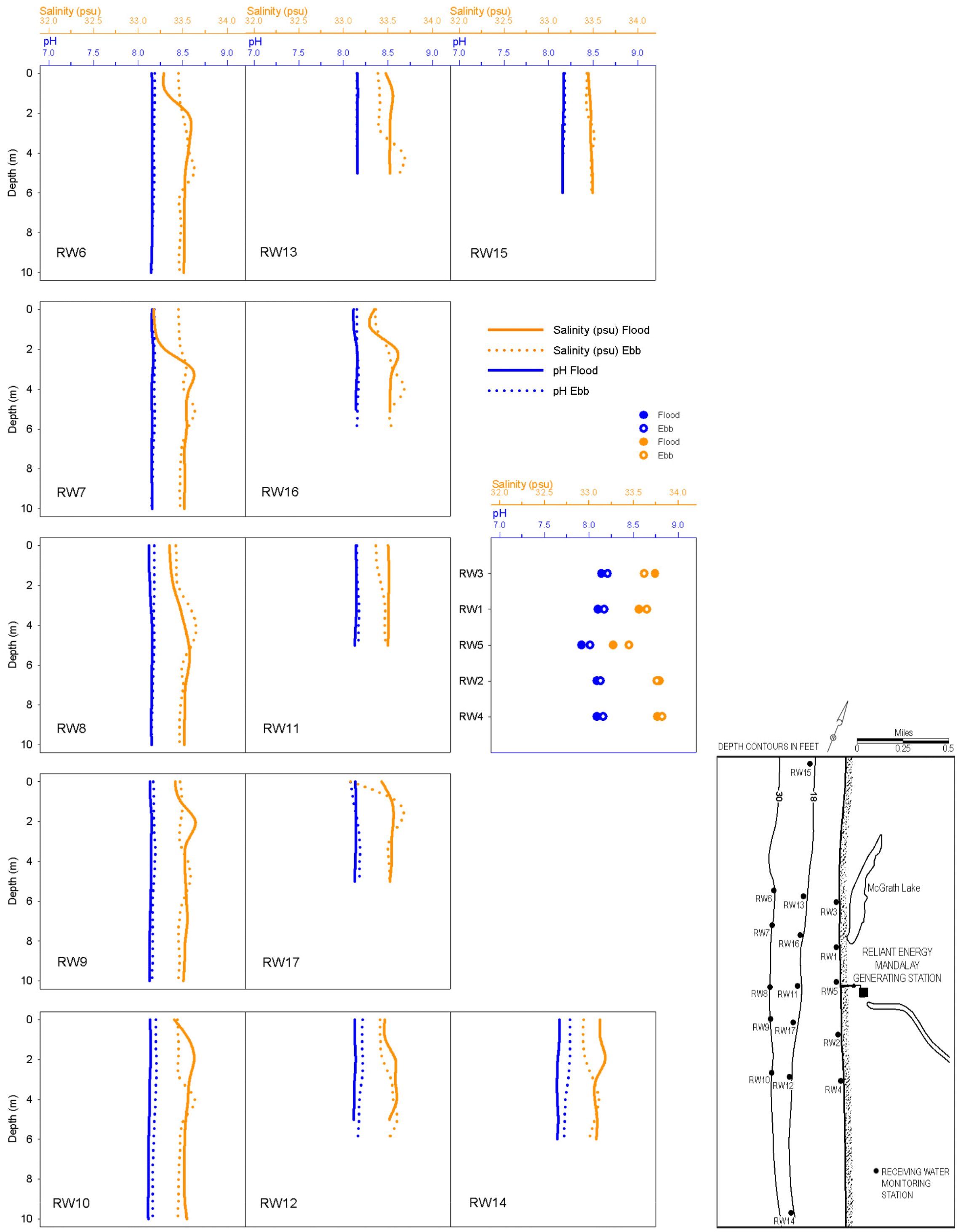



**Figure 10. Surf zone water quality, and hydrogen ion concentration (pH) and salinity vertical profiles during flood and ebb tides, summer survey. Mandalay Generating Station NPDES, 2006.**

33.68 psu during flood tide and 33.66 psu during ebb tide. The maximum surface-to-bottom differences were 1.84 psu at Station RW10 during flood tide and 1.56 psu at Station RW6 during ebb tide (Appendix B-1).

At surf-zone stations in winter, surface salinity readings averaged 33.21 psu during flood tide and 33.75 psu during ebb tide (Table 3 and Figure 9). Salinity varied by 0.48 psu during flood tide and 0.45 psu during ebb tide (Appendix B-1). During the ebb tide monitoring, the conductivity/salinity probe of the water quality analyzer malfunctioned after recording only two surf-zone salinity readings. Lowest salinity values were recorded at Station RW5 on flood tide and at Station RW4 on ebb tide. Highest salinity values were recorded at Station RW4 during flood tide and RW3 during ebb tide.

Summer surface salinity averaged 33.41 psu during flood tide and 33.39 on ebb tide (Table 2 and Figure 10). Salinities ranged from 33.17 to 33.58 psu during flood tide and 33.08 to 33.47 psu during ebb tide. Near-bottom water salinities averaged 33.52 psu during flood tide and 33.49 psu during ebb tide. Lower salinity surface waters were found at most stations on one or both tides, below which salinity was relatively uniform with depth on both tides. Salinity values throughout the water column varied by 0.60 psu or less among stations, between tides and with depth, with maximum surface-to-bottom difference of 0.43 psu at Station RW17 on ebb tide (Appendix B-2).

At surf-zone stations, surface salinity readings averaged 33.63 psu during flood tide and 33.66 psu during ebb tide (Table and Figure 10). Salinity varied by 0.52 psu during flood tide and 0.37 psu during ebb tide (Appendix B-2). Lowest salinity values were recorded at Station RW5 on both tides. Highest salinity values were recorded at Station RW2 during flood tide and RW4 during ebb tide.

## DISCUSSION

Water quality monitoring was conducted on two tides each during winter and summer to determine potential influence of the Mandalay Generating Station discharge on the receiving waters. During the winter sampling, no circulating pumps were in operation at the Mandalay Generating Station (Siekiel-Zdzienicki 2006, pers. comm.). At all offshore stations, surface temperatures during late morning or early afternoon ebb tide monitoring were slightly higher than early morning flood tide monitoring, likely a result of solar insolation,. On average, temperatures at all stations were 1.4°C higher during the later tide, with smaller between tide differences observed at the downcoast stations. Temperature decreased from surface to bottom at all stations during both tides, with strong thermal gradients in the upper 2 to 3 m of the water column at all stations on both tides. Thermoclines exceeding 1°C temperature change within 1-m depth were found at two stations upcoast of the discharge on the 20-ft isobath on flood tide, and at all stations on ebb tide. Surface temperatures were more similar among stations during the morning flood tide than found during ebb tide, while bottom temperatures were generally similar at stations between tides. At surf-zone stations in winter, surface water temperatures reported during the late morning ebb tide were about 2.7°C higher than found on flood tide. During each tide temperatures were similar throughout the surf zone, varying by less than 0.4°C among stations. Water temperatures in 2006 were typical of winter sampling results commonly reported in winter surveys (MBC 1986, 1988, 1990, 1994-2001a, 2002-2005a; Ogden 1991-1993). Water temperatures nearest the discharge channel were similar to those found throughout the sampling area and no thermal influence from the Mandalay Generating Station discharge was evident during the 2006 winter sampling.

During the summer water quality sampling, all four circulating pumps were in operation with a flow of 240 mgd and a discharge temperature of 33.3°C or 12.2°C above ambient intake water temperature (Siekiel-Zdzienicki 2006, pers. comm.). As in winter, surface temperatures in 2006 were typical of summer surveys in the area (MBC 1986, 1988, 1990, 1994-2001a, 2002-2005a; Ogden

1991-1993). In summer, temperatures at the offshore stations during morning flood tide were fairly consistent with depth throughout the water column with mild thermal gradients. Temperature decreased from surface to bottom at all stations during flood tide except at Station RW16, where temperatures were slightly higher at 1-m depth than at the surface, suggesting the influence of warm water in the area from the discharge. On ebb tide, near-bottom water temperatures were generally colder than during flood tide, resulting in stronger, and slightly deeper, thermal gradients at most stations than found on flood tide, with thermoclines. found at several stations. Surface temperatures at offshore stations along the 30-ft isobath on ebb tide were very similar to or lower than temperatures found during the early morning flood tide. Similar or slightly lower afternoon temperatures were also found in surface waters at Stations RW12 and RW14, the farthest stations downcoast on the 20-ft isobath, and at Station RW15, farthest upcoast at the same depth. At the remaining stations on the 20-ft isobath, the two nearest upcoast stations, the station offshore of discharge and more notably at the nearest station downcoast of the discharge, warmer near-surface water temperatures suggested the presence of a warm water surface lens from the thermal plume. Similarly at the surf zone stations, temperatures were highest at the discharge channel during both tides. Temperatures were also somewhat elevated upcoast of the discharge on both tides compared with the downcoast stations, with influence from the plume decreasing with distance from the discharge. These 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. Even in areas influenced by the thermal field, surface temperatures were typical of the area during previous surveys.

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.

During the winter survey, subsurface DO concentration maxima were recorded within the upper two to four meters of the water column at all offshore stations on both tides. A second, slightly deeper maxima was noted on ebb tide at Stations RW6 and RW13, both 2,360 ft upcoast of the discharge on the 30- and 20-ft isobaths, respectively. Dissolved oxygen concentrations rapidly declined below the subsurface maxima at depths corresponding to the thermal gradients, below which DO concentrations continued to gradually decline with depth to the bottom. This trend, along with the very high DO near-surface values (up to 19.23 mg/l) found at some stations during ebb tide are consistent with DO levels found associated with red tides, which were noted to be extensive in the area during winter sampling. Near-bottom DO concentrations were similar between tides, but DO generally increased throughout the water column by the time of the later ebb sampling, attributable to increased phytoplanktonic photosynthesis following the early morning sampling. Dissolved oxygen concentrations below the threshold of biological concern of 5.00 mg/l were found below 5- to 8-m depth at several stations during the early morning flood tide sampling. Values below the threshold of biological concern were also noted during the winter 2005 sampling. These reduced values are undoubtedly related to natural conditions such as a high rate of organic decomposition of red tide organisms near bottom and not generating station operations. In winter surf zone monitoring, DO concentrations were similar among stations during both tides and well above the level of concern, with higher levels found later in the day. All DO values from the winter survey were within the range previously found in the area (MBC 1986, 1988, 1990, 1994-2001a, 2002-2005a; Ogden 1991-1993).

In summer, DO values were more similar among offshore stations and between tides than during the winter surveys, with concentrations that varied less throughout the water column and between tides than in winter. Dissolved oxygen concentrations in the upper water column in summer were generally higher during the later ebb tide sampling except at the Station RW17 downcoast of the discharge, where thermal influence from the discharge was most notable. Dissolved oxygen concentrations were relatively consistent with depth on both tides, with slight subsurface maxima in the upper 4 to 8 meters at all stations with only moderate reductions, and at some stations slight increases, in DO with depth to the bottom. Generally higher DO levels during the afternoon sampling were consistent with replenishment by photosynthetic activity at most stations. The similarity of DO levels with depth suggests that during the summer sampling the water column was fairly well mixed during both tides. In the surf zone, DO concentrations were slightly reduced at the discharge compared to the other stations on both tides, with a greater reduction found during the later ebb tide sampling. These reductions are likely related to the higher temperatures found at the discharge, however, DO concentrations at that station were above the level of concern on both tides. Dissolved oxygen concentrations were in the range previously recorded offshore the generating station (MBC 1986, 1988, 1990, 1994-2001a, 2002-2005a; Ogden 1991-1993) and were well above the level of biological concern.

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 winter, pH values at the offshore stations were more variable between tides and with depth than during summer sampling (Figure 9 and 10). Hydrogen ion concentrations throughout the study area ranged by more than 1.0 unit between tides in winter, although values were more consistent within each tidal cycle. Higher pH near the surface on both tides was likely related to the slightly lower salinity of the surface waters in winter. Increased pH values and higher variability through the water column during the afternoon was likely related to increased photosynthetic activity of the extensive red tide observed in the area in winter.

In summer, pH was very consistent throughout the water column, although generally slightly higher on ebb tide. Still, hydrogen ion values were notably uniform, varying by no more than 0.16 units among stations, between tides and with depth. At the surf zone stations, pH was relatively consistent among tides during both winter and summer, with slightly higher values found during the later ebb sampling during both seasons. Hydrogen ion concentrations were highest at the station farthest upcoast during all monitoring in 2006, but no pattern related to the discharge was apparent. In 2006 all pH values were consistent with concentrations previously recorded in the study area (MBC 1986, 1988, 1990, 1994-2001a, 2002-2005a; Ogden 1991-1993) and did not appear to be related to operation of the thermal discharge.

Salinity in the open ocean is generally 35 parts per thousand (ppt). However, in nearshore areas subjected to freshwater influx, salinity is usually slightly lower. Direct measurements of salinity are impractical, however, requiring the evaporation of one kilogram of seawater to obtain a final weight of salts. The most efficient measurement of salinity is determined by the electrical conductivity of seawater, which is precisely measured through the use of a CTD (conductivity-temperature-depth) instrument and is reported in “practical salinity units” (psu) which correlates one-to-one with ppt. 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, deeper, more saline waters.

In winter, salinity values at the offshore stations were reduced within the upper four meters at all stations during both tides, with generally lower surface salinities during the morning flood tide. Salinity increased with depth at all stations on both tides, with bottom salinities very similar between tides and among stations. Slightly lower salinities were also noted at the discharge and upcoast surf zone station during flood tide. Although not raining at the time of the survey the slightly lower salinity of the surface waters in winter were probably a result of seasonal freshwater flow from the Santa Clara River upcoast of the generating station. During summer, lower salinity surface waters were again found at most offshore stations on one or both tides, below which salinity was relatively uniform with depth on both tides. Flow from the Santa Clara River also may have influenced salinity at the upcoast station during summer, especially during the morning tide. Lower values at the surf zone discharge on both tides and at offshore Station RW17 on ebb tide, however, suggests some local freshwater influence from the discharge plume, likely from urban and agricultural runoff into the harbor and intake canal that supply cooling water to the generating station. Still, all values reported in 2006 were typical of the nearshore waters of southern California. 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 winter 2006, water temperatures were similar throughout the sampling area and no thermal influence from the Mandalay Generating Station discharge was evident. In summer, a warm water surface lens was noted upcoast of the discharge during the morning flood tide, while during ebb tide, warm near-surface water temperatures were found at the two nearest upcoast stations, the station offshore of discharge, and more notably at the nearest station downcoast of the discharge. At the surf zone stations, temperatures were highest at the discharge channel during both tides. Temperatures were also somewhat elevated upcoast of the discharge on both tides compared with the downcoast stations, with influence from the plume decreasing with distance from the discharge. These 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. Even in areas influenced by the thermal field, surface temperatures were typical of the area during previous surveys. Low near bottom dissolved oxygen concentration in winter appeared to be related to extensive red tides occurring in the area on the day of sampling, while all DO values found during the summer sampling were typical of the area and well above the level of biological concern. Values of pH were somewhat more variable in winter than during summer, likely a result of lower surface water salinities and red tide conditions in winter. Still, pH varied relatively narrowly and values were similar to levels found in previous sampling. Slightly reduced salinities found in surface waters in winter were probably a result of seasonal freshwater flow from the Santa Clara River upcoast of the generating station. Flow from the Santa Clara River may also have influenced salinities upcoast of the generating station during summer, while some local freshwater influence from the discharge plume was also noted. This influence, however, was local and similar to natural conditions found commonly throughout the study area. With the exception of the warm water plume and slightly less salty surface water near the discharge during summer, variations in water quality parameters observed in 2006 can be attributed to natural physical and biological processes. Water quality measurements indicated that in 2006 the cooling water discharge from the Mandalay Generating Station did not have an adverse effect on receiving waters in the study area.

# 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

Bottom samples for sediment grain size and sediment chemistry analyses were collected at Stations B1 through B5 during the summer of 2006 (Figure 11). 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 from a grab 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.

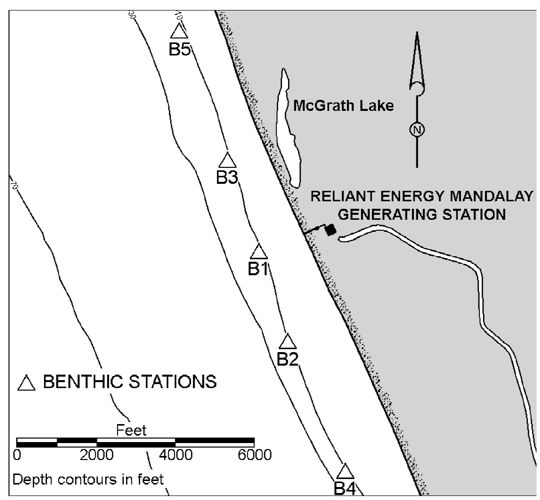



**Figure 11. Location of the benthic sampling stations. Mandalay Generating Station NPDES, 2006.**

### 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. Environmental Protection Agency (EPA) method 160.3 was used in determining percent solids and EPA method 6020 for metal analysis.

## RESULTS

Sediment chemistry and grain size were collected by biologist-divers at Stations B1 through B5 on 24 August 2006 between 1100 and 1229 hours. Skies were overcast with winds from the west at 2 to 3 kn. Seas were from the west at 4 to 5 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 4. Grain size is expressed in phi (Φ) units, which are inversely related to grain diameter (Appendix C-1).

Sediments at the five stations in 2006 were composed primarily of sand, with smaller amounts of silt and clay (Table 4). Gravel was not collected at any station in 2006. Overall, sediments from the five stations sampled averaged about 86% sand, 11% silt, and 3% clay, with an average mean grain size of 2.97 phi (128 µm, fine sand). Sediments were finest at Station B5, 5,910 ft upcoast of the discharge, where mean grain size was 3.79 phi (72 µm, very fine sand). Sediments were coarsest offshore of the discharge channel at Station B1, where mean grain size was 2.59 phi (166 µm, fine sand).

**Table 4. Sediment grain size parameters. Mandalay Generating Station NPDES, 2006.**

| | Station | | | | | | |
|---|---|---|---|---|---|---|---|
| Parameter | B1 | B2 | B3 | B4 | B5 | Mean | S.D. |
| % Gravel | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| % Sand | 93.64 | 92.99 | 94.30 | 83.58 | 65.64 | 86.03 | 12.21 |
| % Silt | 4.67 | 5.17 | 4.06 | 11.80 | 29.73 | 11.09 | 10.88 |
| % Clay | 1.69 | 1.84 | 1.64 | 4.62 | 4.63 | 2.88 | 1.59 |
| Mean grain size | | | | | | | |
| phi | 2.59 | 2.94 | 2.71 | 3.09 | 3.79 | 2.97 | 0.47 |
| µm | 166 | 130 | 153 | 117 | 72 | 128 | 37 |
| Sorting (ϕ) | 0.740 | 0.654 | 0.665 | 1.286 | 1.158 | 0.901 | 0.299 |
| Skewness | 0.179 | 0.150 | 0.143 | 0.482 | 0.356 | 0.262 | 0.151 |
| Kurtosis | 1.518 | 1.439 | 1.272 | 2.502 | 1.972 | 1.741 | 0.498 |

Sorting, a measure of the spread of the particle distribution curve, averaged 0.901 phi overall, representing moderately sorted sediments (Table 4). Sorting values ranged from 0.654 phi (moderately well sorted) at Station B2, 2,360 ft downcoast of the discharge to 1.286 phi (poorly sorted) at Station B4, 5,910 ft downcoast of the discharge. Sorting at the stations nearest the discharge, Stations B1, B2 and B3 (2,360 ft upcoast of the discharge) ranged narrowly with sediments in the moderately- to moderately-well sorted categories. Sediments at the stations farthest downcoast and upcoast, Stations B4 and B5, respectively, were poorly sorted. Poorly-sorted sediments are composed of a broad range of particle size classes, while well-sorted sediments contain fewer size classes. Sediment distribution curves at all stations were essentially unimodal, with a peak in the fine sand category and variable amounts of sediments in other size categories (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. Distribution curves were positive at all stations indicating a skewness toward finer material at all stations. Skewness ranged from 0.143 at Station B3 to 0.482 at Station B4 (Table 4).

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 4). Kurtosis ranged from 1.272 at Station B3 to 2.502 at Station B4, and averaged 1.741.

### Sediment Chemistry

Sediment samples collected at the five 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 5. Metal concentrations were similar among stations, with highest values generally found at stations farthest from the generating station discharge.

**Table 5. Sediment metal concentrations (mg/dry kg). Mandalay Generating Station NPDES, 2006.**

| | Station | | | | | | | | | Reporting |
|---|---|---|---|---|---|---|---|---|---|---|
| Metal | B1 | B2 | B3 | B4 | B5 | Mean | S.D. | ERL | ERM | Limits |
| Chromium | 2.06 | 2.98 | 2.25 | 3.39 | 3.25 | 2.79 | 0.60 | 81 | 370 | 0.04 - 0.05 |
| Copper | 1.48 | 2.18 | 1.81 | 1.73 | 2.53 | 1.95 | 0.41 | 34 | 270 | 0.04 - 0.05 |
| Nickel | 2.23 | 3.03 | 2.21 | 2.85 | 3.16 | 2.70 | 0.45 | 20.9 | 51.6 | 0.04 - 0.05 |
| Zinc | 7.76 | 10.1 | 7.30 | 9.30 | 10.6 | 9.0 | 1.4 | 150 | 410 | 0.4 - 0.5 |

ERL = Effects Range Low
ERM = Effects Range Medium

**Chromium.** Sediment chromium concentrations averaged 2.79 mg/kg and ranged from 2.06 mg/kg at Station B1 to 3.39 mg/kg at Station B4 (Table 5).

**Copper.** Sediment copper concentrations averaged 1.95 mg/kg and ranged from 1.48 mg/kg at Station B1 to 2.53 mg/kg at Station B5 (Table 5).

**Nickel.** Sediment nickel concentrations averaged 2.70 mg/kg and ranged from 2.21 mg/kg at Station B3 to 3.16 mg/kg at Station B5 (Table 5).

**Zinc.** Sediment zinc concentrations averaged 9.0 mg/kg and ranged from 7.3 mg/kg at Station B3 to 10.6 mg/kg at Station B5 (Table 5).

## DISCUSSION

### Sediment Grain Size

In 2006, sediments were analyzed from five stations offshore the Mandalay Generating Station. Sediments were similar at the three stations nearest the discharge channel (Stations B1 through B3) where sediments were composed of 93% to 95% sand with lesser amounts of fine material (silt and clay) and mean grain sizes in the fine sand category. Sediments at the stations farthest downcoast and upcoast of the discharge (Stations B4 and B5, respectively) were finer, with mean grain sizes in the very fine sand category, and greater contributions by fine material (16% at Station B4 and 34% at Station B5). Particle distribution curves at all stations were skewed toward finer material.

Mean grain size in the study area in 2006 was among the finest on record, although slightly coarser than in 2005 (Figure 12; Appendix C-3). Despite being slightly coarser than in 2005, the high percentages of fine material at Stations B4 and B5 in 2006 resulted in the highest overall mean contribution of fines in the area since 1980, and the smallest station mean grain size (3.79 phi, 72 µm at Station B5) since 1997. Smallest mean grain size has been found at Station B5 in 13 of 17 surveys since 1978 (excluding 1998 and 2003 when the sampling program was limited to three or four stations)(Appendix C-3). There has been great year-to-year variability in grain size among stations off the generating station. In the 17 surveys since 1978 (excluding 1998 and 2003), coarsest sediments occurred at the discharge six times, including this year, at the farthest downcoast station six times, at the intermediate upcoast station four times and at the intermediate downcoast station once. No annual surveys have recorded the finest sediments at the discharge.

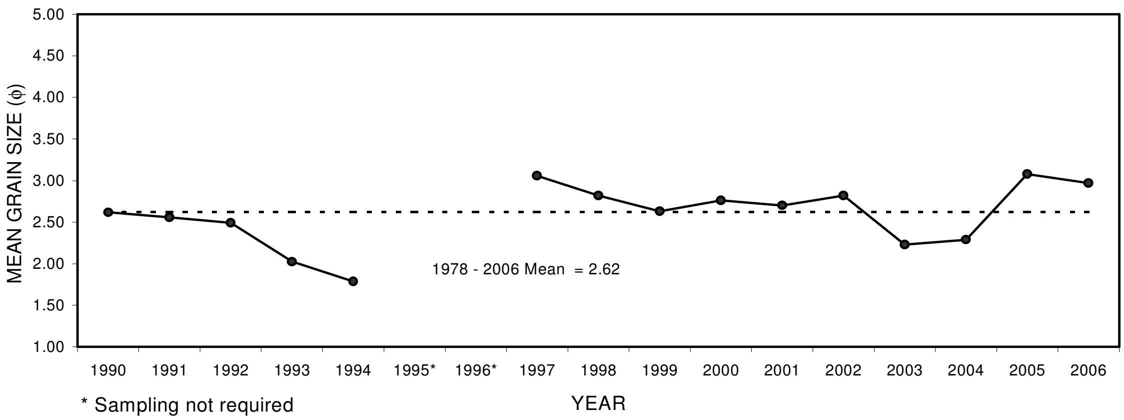


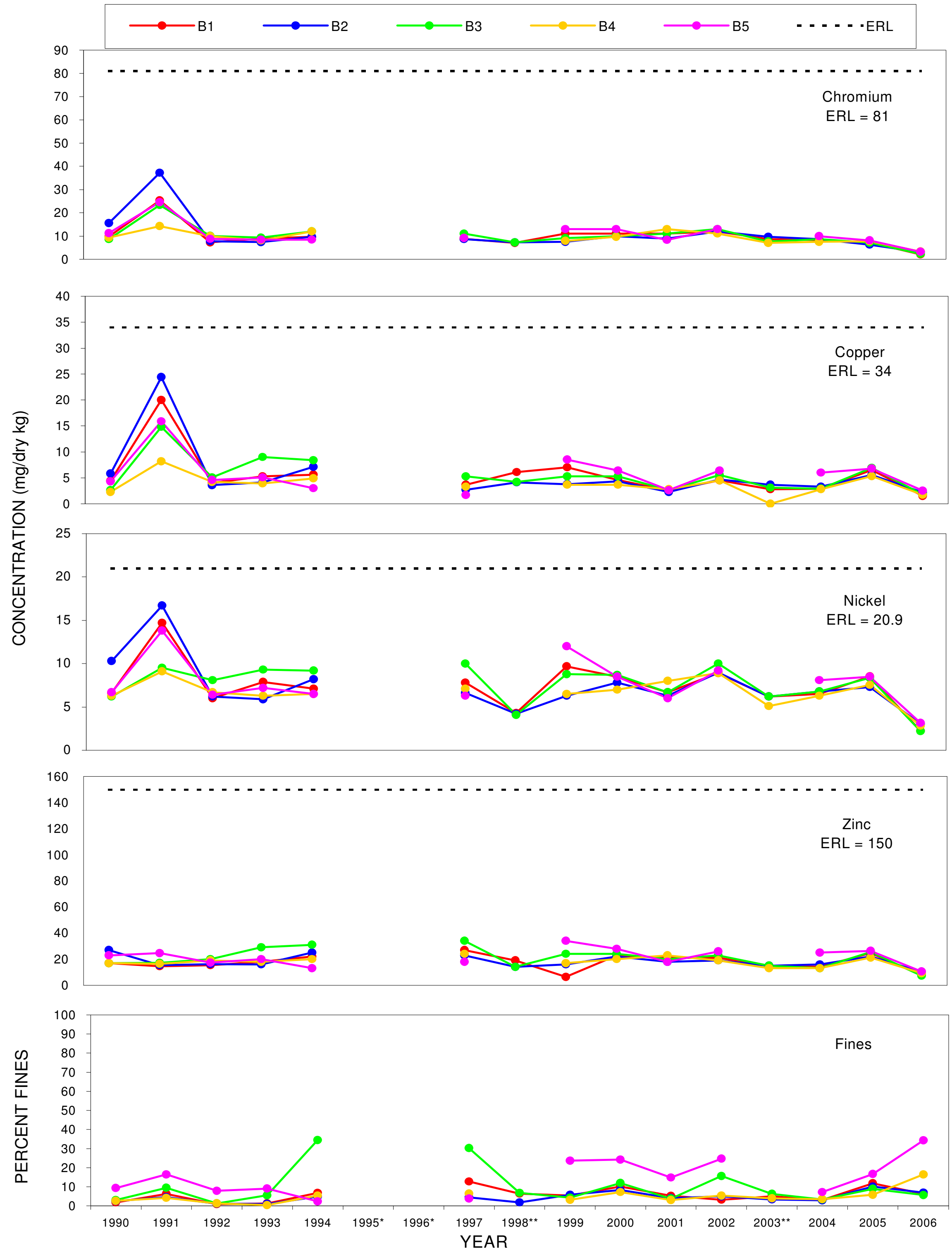

**Figure 12. Comparison of sediment mean grain size, 1990 - 2006. Mandalay Generating Station NPDES, 2006.**

While in previous years coarse sediments at the discharge could be attributed to turbulence (which prevents finer sediments from settling) associated with the cooling water discharge, the similarity of grain size characteristics among the central three stations in 2006 suggests that sediment composition and distribution at these stations were similarly influenced by natural causes. The higher than typical amount of fine material at Stations B4 and B5 may be related to a natural redistribution of fine sediments in the area following heavier than normal rainfall and higher than typical percentages of fine material found at all stations in 2005. As in previous years, sediments at Station B5 appear to influenced by inputs from the nearby Santa Clara River. Aside from a possible localized and transitory effect near the discharge, sediment characteristics offshore of the Mandalay Generating Station discharge in 2006 were similar to those found previously in the area and appear to be influenced primarily by natural causes

## Sediment Chemistry

In 2006, sediments at five stations off the Mandalay Generating Station were analyzed for the presence and concentration of chromium, copper, nickel, and zinc. Metal levels were similar among stations (Figure 13; Appendix D-2). Chromium and nickel were detected at all stations at the lowest levels since 1990 and all metal values reported were among the lowest found in the area. In 2006, the mean concentration of all metals was one-half to one-third both the levels detected in 2005 and the long-term means for the area. Highest concentrations of metals in 2006 occurred where percentages of fine material was highest at either the farthest downcoast or farthest upcoast stations. Lowest concentrations of metals were generally recorded at or 2,360 ft upcoast of the discharge.

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).




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

**Figure 13. Comparison of sediment metal concentrations and percent fines by station, 1990 - 2006. Mandalay Generating Station NPDES, 2006.**

Comparisons should take into account the relative amounts of fine and coarse sediments. Sediments in the study area have consistently been sandy. In previous years, as in 2006, the largest percentages of fines (silt and clay combined) were usually recorded upcoast of the discharge at Station B5 (Figure 13). In 2006, however a relatively large percentage of the sediments at Station B4 was also comprised of fine sediments. Not unexpectedly, highest concentrations of copper, nickel and zinc were found at Station B5 while chromium was highest at Station B4. Lowest metal concentrations occurred either offshore of the discharge or upcoast, the stations where percent sand was highest and mean grain size was largest. Because of an overall similarity in sediment characteristics and relatively low metal concentrations typically found in the sediments, in previous surveys metal levels have not always appeared to relate to the amount of fine material in the sediments (MBC 1990, 1994, 1997-2001a, 2002-2005a; Ogden 1991-1993). In 2006, however, metal concentrations and percentage of fine material appeared to be related despite the low metal levels.

Metal values observed in 2006 were among the lowest ever reported at all stations. Metal levels 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 2006 were 3.3 to 9.6 times less than the mean metal concentrations found in sediments at shallow (15–100 ft) 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 (Figure 13).

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 2006 metal concentrations were similar among stations and among the lowest values reported in the area. Although highest metal concentrations in 2006 appeared to be related to percent of fine material in the sediments, the mean concentrations of all metals were one-half to one-third both the levels detected in 2005 and the long-term means for the area. 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 2006 did not appear to be influenced by the operation of the Mandalay Generating Station.

## CONCLUSION

### Sediment Grain Size

In 2006, sediments were analyzed from five stations offshore the Mandalay Generating Station. Sediments were similar at the three stations nearest the discharge channel (Stations B1 through B3) where sediments were composed of 93% to 95% sand with lesser amounts of fine material (silt and clay) and mean grain sizes in the fine sand category. Sediments at the stations farthest downcoast and upcoast of the discharge (Stations B4 and B5, respectively) were finer, with mean grain sizes in the very fine sand category, and greater contributions by fine material (16% at Station B4 and 34% at Station B5). The degree of influence of the discharge on local sediments varies from year to year, suggesting a localized and transitory effect near the discharge. However, sediment composition and distribution in the study area in 2006 appeared to be affected primarily by natural causes and not by the operations of the Mandalay Generating Station.

### Sediment Chemistry

In 2006 metal concentrations were similar among stations and among the lowest values reported in the area. Although highest metal concentrations in 2006 appeared to be related to percent of fine material in the sediments, the mean concentrations of all metals were one-half to one-third both the levels detected in 2005 and the long-term means for the area. 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 2006 did not appear to be influenced by the operation of the Mandalay Generating Station.

## 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).

### MATERIALS AND METHODS

Because the Mandalay discharge does not have an offshore structure, it has been necessary to transplant mussels for tissue analysis to an offshore mooring maintained in the area since 2001 for that purpose. In previous years, donor mussels were typically collected at the Ormond Beach generating station discharge buoy located downcoast of the Mandalay generating station. Replacement of the Ormond buoy in early 2006, however, eliminated this site as a mussel source this year. As a result, in 2006, live bay mussels (*Mytilus galloprovincialis*) were purchased from a commercial mussel distributor, Carlsbad Aquafarms, for transplant into the Mandalay area. Donor mussels were harvested from Agua Hedionda Lagoon in Carlsbad, California on 17 July 2006, cleaned and placed within protective enclosures that allowed unrestricted water flow to the mussels, and transplanted to the Mandalay mooring off the Mandalay discharge canal on 18 July 2006. Additional mussels from the donor site were frozen for later analysis and comparison with the transplanted mussels. On 20 October 2006, after 94 days, the transplanted mussels were retrieved and returned to the laboratory for chemical analysis.

Forty-five (45) transplanted bay mussels with shell lengths averaging 61 mm were collected from the mooring and returned to the laboratory for chemical analysis. Three replicate samples, each a composite of the tissue from 15 mussels, were analyzed for concentrations of the metals chromium, copper, nickel, and zinc according to methods used in the California State Mussel Watch Program (SMWP, Appendix A, and SWRCB 1986). The same methods were used with the bay mussels collected from the donor site and from another set of bay mussels collected on 22 June 2006 from the Hermosa Beach Pier in Santa Monica Bay, which served as a reference site.

During sample analysis, metals are detectable at very low concentrations. The level below which the analytical method will no longer detect the analyte is referred to as the method detection limit (MDL). However, concentrations are only reported when results can be confirmed by exceeding a confidence level, termed the reporting limit (RL). If metal concentrations are detected at a level below the RL the results cannot reliably be reported and sample results are reported as none detected (ND). Beginning in 2005, analytical reporting limits for bioaccumulated metals were lower than in previous years (MBC 2001a, 2002-2005a). As a result, concentrations of some metals in 2005 and 2006 were reported at lower levels than possible during previous surveys. For QA/QC purposes, the analytical laboratory may randomly analyze one sample twice to confirm results and provide the results from both analyses. While both replicates are usually very similar, some differences in metal concentrations are typical, and the highest value determined during either analysis is presented in the results.

### RESULTS

In 2006, chromium, copper, nickel, and zinc were detected in all mussel tissue replicates from the generating station area, the donor site and at a pier reference site (Table 6 and Appendix E).

Chromium concentrations in mussels from the generating station ranged from 5.86 to 9.48 mg/dry kg with a mean of 7.12 mg/dry kg (Table 6). Mean chromium concentration at the discharge was slightly lower than at the donor site (7.91 mg/dry kg), and about 30% lower than the mean concentration at the reference site (10.05 mg/dry kg).

**Table 6. Mussel tissue metal concentrations (dry weight and reporting limits, mg/dry kg; wet weight and EDL, mg/wet kg). Mandalay Generating Station NPDES, 2006.**

| | Dry Weight | | | | | | Wet Weight | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Replicate | | | | | Reporting | Replicate | | | | | | |
| Metal | 1 | 2 | 3 | Mean | SD | Limits | 1 | 2 | 3 | Mean | SD | EDL 85 | EDL 95 |
| Discharge | | | | | | | | | | | | | |
| Chromium | 9.48 | 6.03 | 5.86 | 7.12 | 2.04 | 0.05 | **1.34** | **0.89** | **0.88** | **1.04** | 0.26 | 0.73 | 1.60 |
| Copper | 6.63 | 8.671 | 5.387 | 6.90 | 1.66 | 0.05 | 0.93 | 1.27 | 0.81 | 1.01 | 0.24 | 2.28 | 4.28 |
| Nickel | 1.461 | 2.322 | 1.216 | 1.666 | 0.581 | 0.05 | 0.21 | 0.34 | 0.18 | 0.24 | 0.09 | 0.78 | 1.06 |
| Zinc | 159.354 | 100.454 | 82.324 | 114.044 | 40.273 | 0.05 | 22.47 | 14.77 | 12.43 | 16.56 | 5.25 | 42.92 | 52.60 |
| % Solids | 14.1 | 14.7 | 15.1 | 14.6 | | 0.1 | - | - | - | - | - | - | - |
| Donor Site | | | | | | | | | | | | | |
| Chromium | 6.47 | 7.34 | 9.92 | 7.91 | 1.79 | 0.05 | **1.27** | **1.38** | **1.73** | **1.46** | 0.24 | 0.73 | 1.60 |
| Copper | 4.686 | 4.792 | 9.19 | 6.22 | 2.57 | 0.05 | 0.92 | 0.90 | 1.60 | 1.14 | 0.40 | 2.28 | 4.28 |
| Nickel | 0.479 | 0.503 | 0.861 | 0.614 | 0.214 | 0.05 | 0.09 | 0.09 | 0.15 | 0.11 | 0.03 | 0.78 | 1.06 |
| Zinc | 90.194 | 89.064 | 105.954 | 95.071 | 9.442 | 0.05 | 17.77 | 16.74 | 18.44 | 17.65 | 0.85 | 42.92 | 52.60 |
| % Solids | 19.7 | 18.8 | 17.4 | 18.6 | - | 0.1 | - | - | - | - | - | - | - |
| Pier Reference Site (Hermosa Beach Pier) | | | | | | | | | | | | | |
| Chromium | 9.17 | 9.89 | 11.1 | 10.05 | 0.98 | 0.05 | **1.60** | **1.51** | **1.60** | **1.57** | 0.05 | 0.73 | 1.60 |
| Copper | 5.09 | 6.7 | 5.73 | 5.84 | 0.81 | 0.05 | 0.89 | 1.03 | 0.83 | 0.91 | 0.10 | 2.28 | 4.28 |
| Nickel | 0.48 | 0.56 | 0.65 | 0.56 | 0.09 | 0.05 | 0.08 | 0.09 | 0.09 | 0.09 | 0.01 | 0.78 | 1.06 |
| Zinc | 70.6 | 73.8 | 87.3 | 77.2 | 8.9 | 0.05 | 12.4 | 11.3 | 12.6 | 12.1 | 0.7 | 42.92 | 52.60 |
| % Solids | 17.5 | 15.3 | 14.4 | 15.7 | - | 0.1 | - | - | - | - | - | - | - |

EDL = Elevated Data Levels **Blue** values exceed EDL 85 **Red** values exceed EDL 95

Copper concentrations from the discharge averaged 6.90 mg/dry kg with a range from 5.39 to 8.67 mg/dry kg (Table 6). Copper was highest at the discharge, but still relatively similar among the sites. Mean concentration at the donor site was 6.22 mg/dry kg, while the lowest level occurred at the reference site (5.84 mg/dry kg).

Nickel levels in mussels from the discharge ranged from 1.22 to 2.32 mg/dry kg with a mean of 1.67 mg/dry kg (Table 6). Nickel at the discharge was nearly three times the mean concentration at the donor site (0.61 mg/dry kg) or at the reference site (0.56 mg/dry kg).

Zinc concentrations at the discharge site ranged from 82.32 to 159.35 mg/dry kg, with a mean concentration of 114.04 mg/dry kg (Table 6). Zinc concentrations were highest at the discharge, with a mean concentration at the donor site of 95.07 mg/dry kg and a mean at the reference site of 77.2 mg/dry kg.

## DISCUSSION

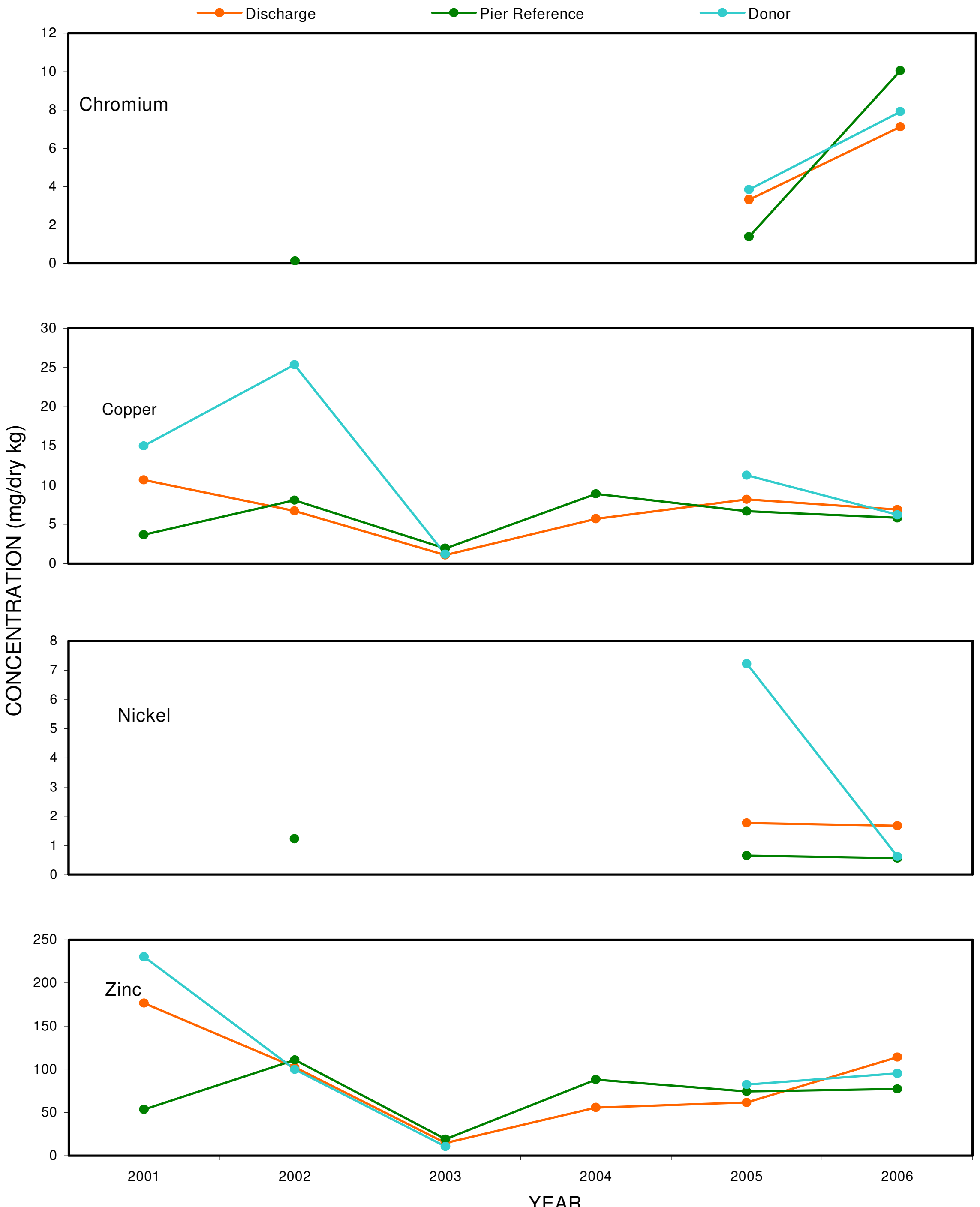
The SMWP monitors levels of metals and organic pollutants in both native California mussels (*Mytilus californianus*) and bay mussels (*Mytilus galloprovincialis*). Bioaccumulation of pollutants by the two species was found to be comparable, although some differences were found between the mussels, likely related to habitat preference (SWRCB 1995, 2000). California mussels are preferentially used for analysis. However, a resident population of mussels is sometimes not available in an area, such as offshore of the Mandalay Generating Station discharge. Therefore, mussels are transplanted into the area for at least 90 days. All analytical results are reported on a dry weight basis; however, wet weight concentrations were calculated for comparison with evaluation criteria.

Water quality standards for evaluating bioaccumulation in mussel tissues are primarily based on human or animal health criteria, and several standards of comparison are currently available (SWRCB 1995, 2000). However, action levels for only a few organic chemicals have been determined. Because of this, the SMWP developed a method of comparison among samples based on elevated data levels (EDL). The EDL for any particular substance is based on a ranking of statewide tissue levels for that substance from the ongoing SMWP. Elevated data levels are determined for each species and may vary depending on whether the mussels are resident or transplanted. Elevated data levels are updated periodically based on recent data. In the EDL ranking system the 50$^{th}$ percentile corresponds to the median of all values rather than to a mean. The 85$^{th}$ percentile (EDL 85) indicates that a chemical is markedly elevated from the median. The 95$^{th}$ percentile (EDL 95) indicates values that are highly elevated above the median. While no studies have strictly compared these values, this information is useful in determining if a particular substance has been found in unusually high concentrations and in comparing local results to recent statewide results.

In 2006, mussels were not found in the vicinity of the Mandalay Generating Station discharge channel. For that reason, donor mussels were purchased from a commercial supplier in Carlsbad, California and transplanted to a mooring offshore of the Mandalay discharge where the mussels were allowed to acclimate for a period of 94 days. Results were compared with those from mussels collected at the donor site at the time of the transplant and to mussels collected from the Hermosa Beach Pier in Santa Monica Bay, which served as a reference site.

Chromium was reported in all replicates from the generating station discharge, in the donor mussels, and at the reference site. Tissue concentrations of chromium in mussels in 2006 were detected at levels about twice those found in the area in 2005 (Table 6, Figure 14). Prior to 2005, chromium levels were below the reporting limits in mussel tissue sampling near the discharge and in donor site mussels, except at the reference site in 2002 (Appendix E; MBC 2001a, 2002-2005a). Chromium undoubtedly occurred in tissues from the area prior to 2005, but at levels which could not reliably be reported with previous analytical reporting limits. Still, most chromium concentrations at the discharge and at the donor site in 2005 were found at levels that exceeded previous reporting limits, suggesting that chromium in the area was higher than in preceding years. Levels were even higher in 2006, suggesting that chromium levels in the area recently increased. In 2005, the mean concentration of chromium in mussel tissues from the reference site was about one-third lower than the levels found at the discharge or donor site; however, in 2006 levels from the reference site (where levels were more than seven times higher than in 2005) were about 30% higher than levels in mussels from the other sites. Higher than normal chromium levels were noted in mussels at the discharge, the Agua Hedionda donor site, and the Santa Monica Bay reference site, as well as from other areas throughout southern California in 2006 (MBC 2006a-f, in prep.). Wet-weight chromium levels in mussels from the Mandalay discharge exceeded the EDL 85 for bay mussels indicating that chromium was elevated in the study area in 2006. Replicate chromium levels in mussel tissue from the donor site and the Hermosa Beach Pier reference site exceeded the EDL 85 or EDL 95 for bay mussels, indicating that chromium was elevated or highly elevated at these sites.

Copper was detected in all replicates in 2006. Copper concentrations in mussels from the discharge were lower than levels found in the area in 2005, higher than levels found in the area since 2002 (particularly 2003), but lower than levels found in the area in 2001, the first year of mussel tissue monitoring (Figure 14; Appendix E-2). While copper levels in donor mussels has been variable (likely related to use of copper-based antifouling paints on the buoy used as a donor site in previous years), copper levels at both the discharge and the reference site have remained comparatively stable since 2001. In 2006, copper levels were similar among sites, with the highest mean concentration found at the discharge and the lowest at the Hermosa Beach reference site. Wet-weight copper levels at the discharge and at the donor and reference sites were below the EDL




Note: Chromium and nickel not detected in prior years

**Figure 14. Comparison of mean chromium, copper, nickel, and zinc concentrations in mussel tissue at discharge and at reference sites, 2001 - 2006. Mandalay Generating Station NPDES, 2006.**

85 value for bay mussels, indicating that in 2006 copper concentrations were below levels considered elevated by the SMWP.

In 2006, nickel was reported in all replicates from the discharge, the donor site and the reference site. In 2005 nickel was detected in mussels from the discharge at levels below the reporting limits from most previous tissue sampling, while nickel at the donor site was notably higher (Appendix E-2, MBC 2001a, 2002-2005a). Prior to 2005, nickel was unreported in mussels from the discharge or donor areas. In 2006, nickel levels at both the discharge and the reference site were similar to and slightly lower than levels found in 2005, while at the donor site levels were markedly lower than in 2005 (Figure 14). While nickel at the discharge was nearly three times the mean concentration at either the donor site or at the reference site in 2006, concentrations in mussel tissues collected at all sites were below the EDL 85 values for resident populations of bay mussels, indicating that nickel levels were not found at levels considered elevated by the SMWP.

Zinc was detected in all mussel tissue replicates in 2006. Zinc concentrations from the discharge area were the highest found in the area since 2001, and continue a trend of increasing zinc concentrations in mussels since 2003 (Appendix E-2, MBC 2001a, 2002-2005a). In 2006, zinc levels at the discharge were about twice 2005 levels and higher than levels found at both the donor site and the reference site (Figure 14). Still, wet-weight zinc concentrations from the discharge were notably lower than the EDL 85 values for bay mussels, indicating that zinc levels were not elevated near the Mandalay discharge. Wet-weight concentrations of zinc at both the donor site and the reference site were also below levels considered elevated.

## CONCLUSIONS

Concentrations of chromium in mussel tissues transplanted into the vicinity of the discharge were elevated in 2006, but were lower than levels in source mussels at the time of the transplant and in mussels collected from a Santa Monica Bay reference site. Elevated chromium levels were also found at other sites throughout southern California in 2006. Other than chromium, metal levels in 2006 were generally lower than in 2005, with the exception of a continuing trend of increasing zinc at the discharge. Concentrations of copper, nickel and zinc at the discharge were similar to values found previously in the area and at the donor and reference sites. While elevated chromium was found at all sites in 2006, concentrations of copper, nickel and zinc did not exceed levels in mussels considered elevated for bay mussels by the SMWP. With the exception of chromium, which appeared to have increased in several areas throughout southern California and was lowest near the discharge, the comparatively low tissue metal levels and similarity of tissue metal levels among sites and previous studies, suggests that the operation of the Mandalay Generating Station is not elevating metal concentrations above background levels.

## 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 (four stations, with only two replicates each, one-half the number of replicates in all other surveys). New for 2006 is presentation 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

Biologist-divers collected sediment cores for analysis of infaunal composition at Stations B1 through B5 on 24 August 2006 between 1100 and 1229 hours (Figure 15). Skies were overcast with winds from the west at 2 to 3 kn. Seas were from the west at 1 to 3 ft. Four 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 16). The box corer was pushed into the sediment and a closing blade is 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.

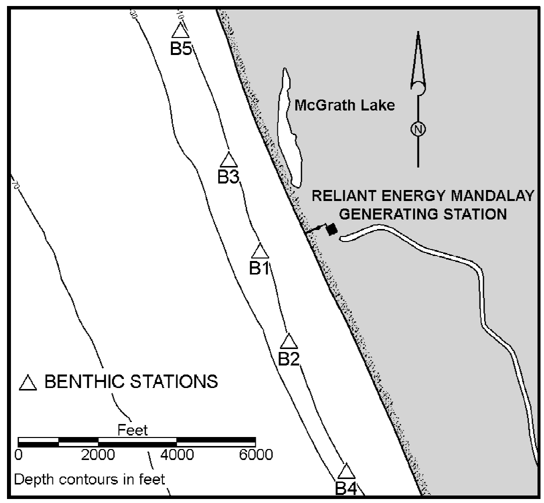



**Figure 15. Location of the benthic sampling stations. Mandalay Generating Station NPDES, 2006.**

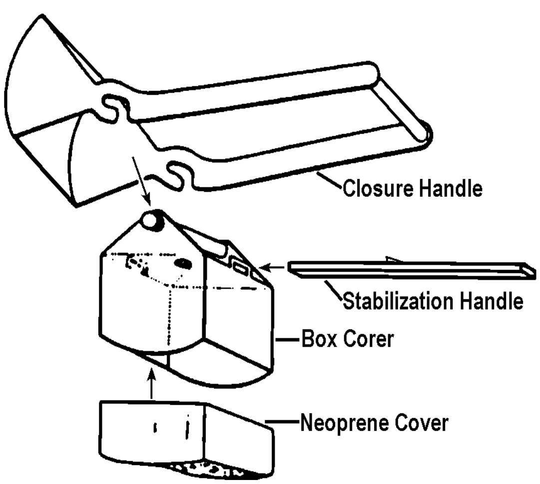



**Figure 16. Diver-operated box corer used to collect infaunal samples. Mandalay Generating Station NPDES, 2006.**

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 2001). 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 2006, the infauna samples from the five benthic stations offshore of the Mandalay Generating Station contained a total of 843 individuals representing 57 species in nine phyla (major taxonomic groups) (Table 7, Appendices F-1 and F-2). Annelids (segmented worms) and arthropods were the most abundant phyla, comprising 57% and 22% of the individuals, respectively. Annelids comprised up to 70% of the individuals at Station B2, immediately downcoast of the generating station, but only 21% at Station B1, nearest the generating station, where arthropods were more abundant, comprising almost 42% of the individuals found there. Mollusks, nemertean (ribbon) worms, and echinoderms (primarily sand dollars) were also abundant, with about 9%, 8%, and 3% of the total collection. The other four phyla each represented less than 1% of the total abundance. Annelids and arthropods were also the most diverse phyla, with accounting for 35% and 32% of the species, respectively, followed by mollusks (14%), nemerteans (7%), and echinoderms (5%). The other four phyla each comprised less than 2% of the species.

**Table 7. Number of infaunal species and individuals by phylum. Mandalay Generating Station NPDES, 2006.**

| | Station | | | | | | Percent |
|---|---|---|---|---|---|---|---|
| Parameter | B1 | B2 | B3 | B4 | B5 | Total | Total |
| Number of species | | | | | | | |
| Annelida | 7 | 13 | 9 | 14 | 13 | 20 | 35.1 |
| Arthropoda | 7 | 10 | 5 | 6 | 9 | 18 | 31.6 |
| Mollusca | 2 | 3 | 3 | 2 | 6 | 8 | 14.0 |
| Nemertea | 2 | 4 | 1 | 2 | 3 | 4 | 7.0 |
| Echinodermata | 2 | 1 | 1 | 1 | 2 | 3 | 5.3 |
| Cnidaria | - | 1 | - | 1 | - | 1 | 1.8 |
| Nematoda | - | - | - | 1 | - | 1 | 1.8 |
| Phorona | - | - | - | - | 1 | 1 | 1.8 |
| Platyhelminthes | - | 1 | - | - | - | 1 | 1.8 |
| Total | 20 | 33 | 19 | 27 | 34 | 57 | |
| Number of individuals | | | | | | | |
| Annelida | 19 | 225 | 18 | 76 | 140 | 478 | 56.7 |
| Arthropoda | 37 | 58 | 14 | 35 | 39 | 183 | 21.7 |
| Mollusca | 7 | 7 | 11 | 2 | 46 | 73 | 8.7 |
| Nemertea | 17 | 24 | 7 | 10 | 14 | 72 | 8.5 |
| Echinodermata | 9 | 2 | 3 | 13 | 2 | 29 | 3.4 |
| Cnidaria | - | 2 | - | 1 | - | 3 | 0.4 |
| Nematoda | - | - | - | 2 | - | 2 | 0.2 |
| Platyhelminthes | - | 2 | - | - | - | 2 | 0.2 |
| Phorona | - | - | - | - | 1 | 1 | 0.1 |
| Total | 89 | 320 | 53 | 139 | 242 | 843 | |

**Abundance.** Abundance averaged 169 individuals per station (42 individuals per replicate, or 4,215 individuals/$m^2$), and ranged from 53 individuals at Station B3, immediately upcoast of the generating station, to 320 individuals at Station B2 (Table 8, Appendices F-2 and F-3). Abundance near the generating station (89 individuals) was about one-half the mean for the study area.

**Species Richness.** The number of species averaged 27 per station, or 13 species per replicate (Table 8, Appendices F-2 and F-3). Values ranged from 19 species at Station B3 to 34 species at Station B5, farthest upcoast. The 20 species taken at Station B1 was less than the study-area mean.

**Species Diversity (H').** Shannon-Weiner species diversity averaged 2.48 per station and ranged from 2.09 at Station B2 to 2.71 at Station B5 (Table 8, Appendices F-2 and F-3). The value at the location nearest the generating station was 2.56, slightly above the area mean.

**Table 8. Infaunal community parameters. Mandalay Generating Station NPDES, 2006.**

| | Station | | | | | | |
|---|---|---|---|---|---|---|---|
| Parameter | B1 | B2 | B3 | B4 | B5 | Total | Mean |
| Number of species | | | | | | | |
| Total | 20 | 33 | 19 | 27 | 34 | 57 | 27 |
| Rep. Mean | 10 | 16 | 8 | 11 | 19 | | 13 |
| Rep. S.D. | 4 | 1 | 2 | 3 | 3 | | |
| Number of individuals | | | | | | | |
| Total | 89 | 320 | 53 | 139 | 242 | 843 | 169 |
| Rep. Mean | 22 | 80 | 13 | 35 | 61 | | 42 |
| Rep. S.D. | 10 | 5 | 4 | 26 | 21 | | |
| Density (#/$m^2$) | | | | | | | 4,215 |
| Diversity (H') | | | | | | | |
| Total | 2.56 | 2.09 | 2.69 | 2.34 | 2.71 | 2.84 | 2.48 |
| Rep. Mean | 2.02 | 1.79 | 1.97 | 1.76 | 2.47 | | 2.00 |
| Rep. S.D. | 0.51 | 0.24 | 0.18 | 0.30 | 0.16 | | |
| Benthic Respose Index (BRI) | | | | | | | |
| Total | 2.7 | 7.3 | 13.5 | 13.1 | 17.4 | 10.3 | 10.8 |
| Biomass (g) | | | | | | | |
| Total | 22.86 | 1.84 | 3.66 | 30.65 | 0.85 | 59.86 | 11.97 |
| Rep. Mean | 5.71 | 0.46 | 0.92 | 7.66 | 0.21 | | 2.99 |
| Rep. S.D. | 11.06 | 0.08 | 1.62 | 8.54 | 0.10 | | 4.28 |
| g/$m^2$ | | | | | | | 299.28 |

**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 10.8 for the five stations, and ranged from 2.7 at Station B1 to 17.4 at Station B5 (Table 8).

**Biomass.** Biomass totaled 59.86 g and averaged 11.97 g per station (299 g/$m^2$), ranging from 0.85 g at Station B5 to 30.65 g at Station B4 (Table 8, Appendix F-4). About 92% of the total biomass was contributed by only 19 individuals: 18 medium-sized Pacific sand dollars (*Dendraster excentricus*) and one sea sweet potato (*Molpadia arenicola*). Twelve of the sand dollars were found at Station B4; the other large individuals were found at Stations B1 and B3.

**Community Composition.** Twenty species each represented 1% or more of the individuals in the infauna collection (Table 9 and Appendix F-2). These 20 species together were only 35% of the species in the collection but contributed 89% of the individuals. Nine of the species occurred at all stations, while one species, the clam *Mactromeris catilliformis*, occurred at only one station and another clam, *Siliqua lucid*, and the isopod *Edotia sublittoralis* occurred at only two stations each. All but one of the top 20 species were found at Station B5. Eight of the most abundant species were annelids, five were arthropods, four were mollusks, two were nemerteans, and one was an echinoderm (Pacific sand dollar). The two most abundant species, the annelids *Chone* sp SD1 and *Apoprionospio pygmaea*, comprised 29% and 13% of all individuals collected, respectively. However, *Chone* sp SD1 was the most abundant species at only two locations, Stations B2 and B4 (where it comprised 48% and 40% of the communities, respectively), while *A. pygmaea* was the most abundant species at Station B5. The cumacean *Diastylopsis tenuis*, the nemertean *Carinoma* *mutabilis*, and the amphipod *Rhepoxynius menzies* were also abundant. *Carinoma* and *R. menziesi* were the dominant species at Station B1, each comprising 18% of the community at that station, while the clam *Solen sicarius* was the dominant species at Station B3, even though it comprised only 15% of the individuals at that location.

**Table 9. The 20 most abundant infaunal species. Mandalay Generating Station NPDES, 2006.**

| | | Station | | | | | | Percent | Cum. |
|---|---|---|---|---|---|---|---|---|---|
| Phylum | Species | B1 | B2 | B3 | B4 | B5 | Total | Total | Percent |
| AN | *Chone* sp SD1 Pt. Loma 1997 | 1 | 154 | 4 | 55 | 28 | 242 | 29 | 29 |
| AN | *Apoprionospio pygmaea* | 4 | 35 | 2 | 4 | 68 | 113 | 13 | 42 |
| AR | *Diastylopsis tenuis* | 5 | 40 | 7 | 5 | 17 | 74 | 9 | 51 |
| NE | *Carinoma mutabilis* | 16 | 12 | 7 | 9 | 8 | 52 | 6 | 57 |
| AR | *Rhepoxynius menziesi* | 16 | 5 | 2 | 6 | 1 | 30 | 4 | 61 |
| AR | *Euphilomedes longiseta* | 9 | - | 1 | 16 | 2 | 28 | 3 | 64 |
| EC | *Dendraster excentricus* | 8 | 2 | 3 | 13 | 1 | 27 | 3 | 67 |
| MO | *Tellina modesta* | 2 | - | 2 | 1 | 20 | 25 | 3 | 70 |
| AN | *Mediomastus acutus* | 2 | 5 | 2 | 2 | 11 | 22 | 3 | 73 |
| AN | *Mediomastus ambiseta* | - | 5 | - | 1 | 14 | 20 | 2 | 75 |
| MO | *Solen sicarius* | 5 | 1 | 8 | 1 | 1 | 16 | 2 | 77 |
| AR | *Anchicolurus occidentalis* | 4 | 3 | 3 | 2 | 3 | 15 | 2 | 79 |
| NE | Lineidae | 1 | 7 | - | 1 | 5 | 14 | 2 | 80 |
| AN | *Goniada littorea* | - | 6 | - | 3 | 3 | 12 | 1 | 82 |
| MO | *Mactromeris catilliformis* | - | - | - | - | 12 | 12 | 1 | 83 |
| MO | *Siliqua lucida* | - | 5 | - | - | 7 | 12 | 1 | 85 |
| AN | *Onuphis* sp 1 Pt. Loma 1983 | 2 | 2 | 3 | - | 4 | 11 | 1 | 86 |
| AN | *Nephtys caecoides* | 7 | - | 2 | 1 | - | 10 | 1 | 87 |
| AN | *Owenia collaris* | - | 7 | 2 | - | 1 | 10 | 1 | 88 |
| AR | *Edotia sublittoralis* | 1 | - | - | - | 8 | 9 | 1 | 89 |

AN = Annelida; AR = Arthropoda; EC = Echinodermata; MO = Mollusca; NE = Nemertea

**Cluster Analyses.** Normal (station) and inverse (species) cluster analyses were performed on the 20 most abundant species in the infauna collection (Table 9). The five study-area stations clustered into two groups, based on their relative abundances of the numerically dominant species (Figure 17). The communities in Station Group I (Stations B1, B3, and B4) were more similar to each other than to the communities at Stations B2 and B5 (Group II). Stations B1 and B3 clustered most closely because of the similarity of community composition; their communities were small and were dominated by species other than *Chone* sp SD1 and *Apoprionospio pygmaea*. Station B4 clustered next with Station B1 and B3; its community was dominated by *Chone* sp SD1 but *A. pygmaea* was not abundant while several other species were. Stations B2 and B5 clustered together rather distantly, as one was dominated by *Chone* sp SD1 (Station B2) and the other by *A. pygmaea* (Station B5). A few species, such as *Diastylopsis tenuis*, were more abundant at these two stations, while several species that were moderately abundant elsewhere were absent or uncommon.

The 20 most abundant species separated into four groups, based on their similarity of occurrence (Figure 17). As a group, species in Group B clustered most closely, including those that were moderately abundant but were absent or not abundant at the Group II stations. Species in Group A clustered next most closely. This group consisted of additional moderately abundant species that were occurred primarily at Group II stations. Species Groups C and D were least similar to the other two groups and included species that were generally very abundant at Station Group II. Group C consisted of only three species: *Carinoma mutabilis* and *Diastylopsis tenuis* clustered most closely, even though *C. mutabilis* was most abundant at Station B1 (in Station Group I); *Apoprionospio pygmaea* clustered next with these two species at a relatively high level. *Chone* sp SD1, alone in Species Group D, clustered with Group C.

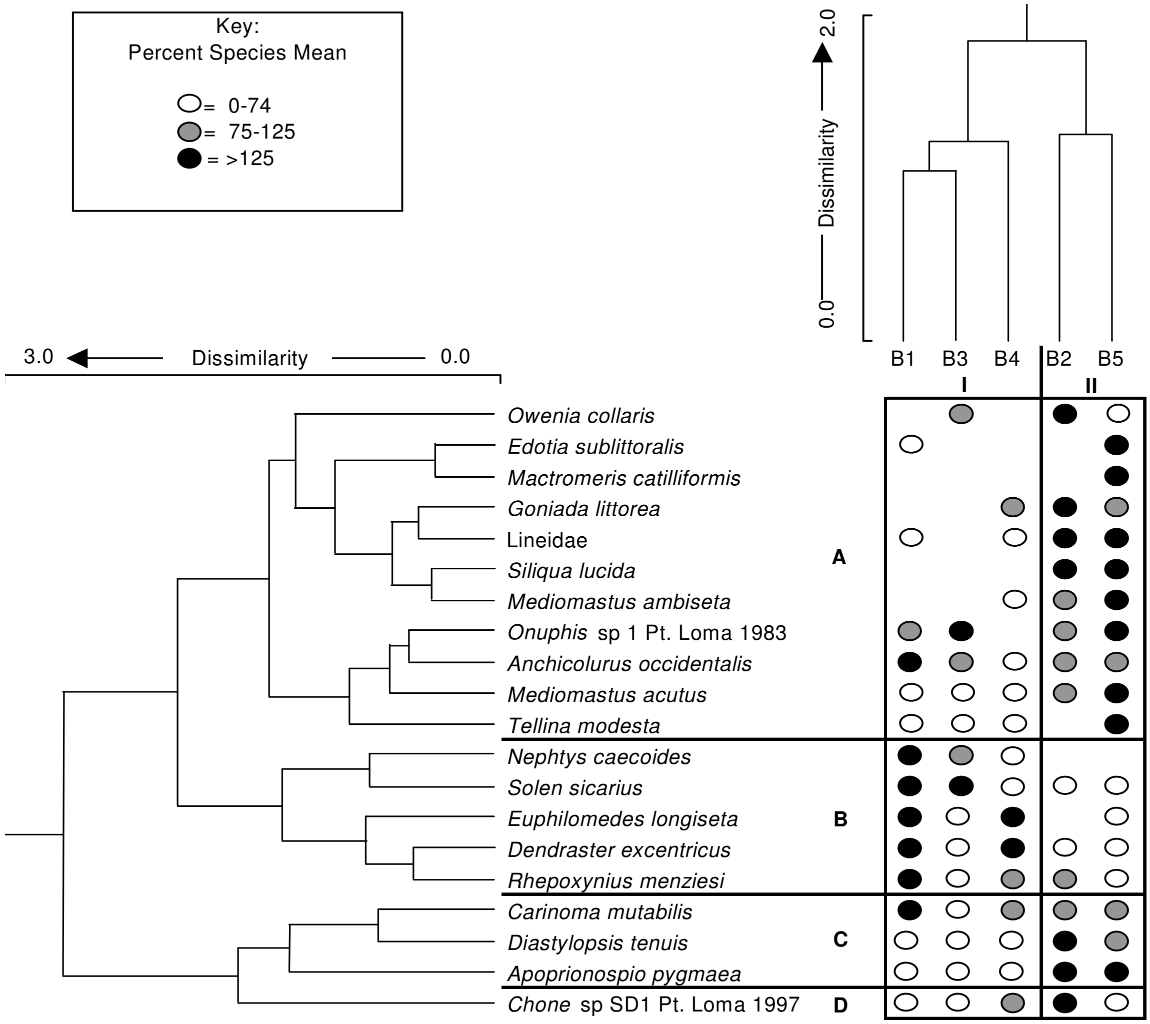



**Figure 17. Two-way coincidence table resulting from normal (station) and inverse (species) classification dendrograms for the 20 most abundant infaunal species. Mandalay Generating Station NPDES, 2006.**

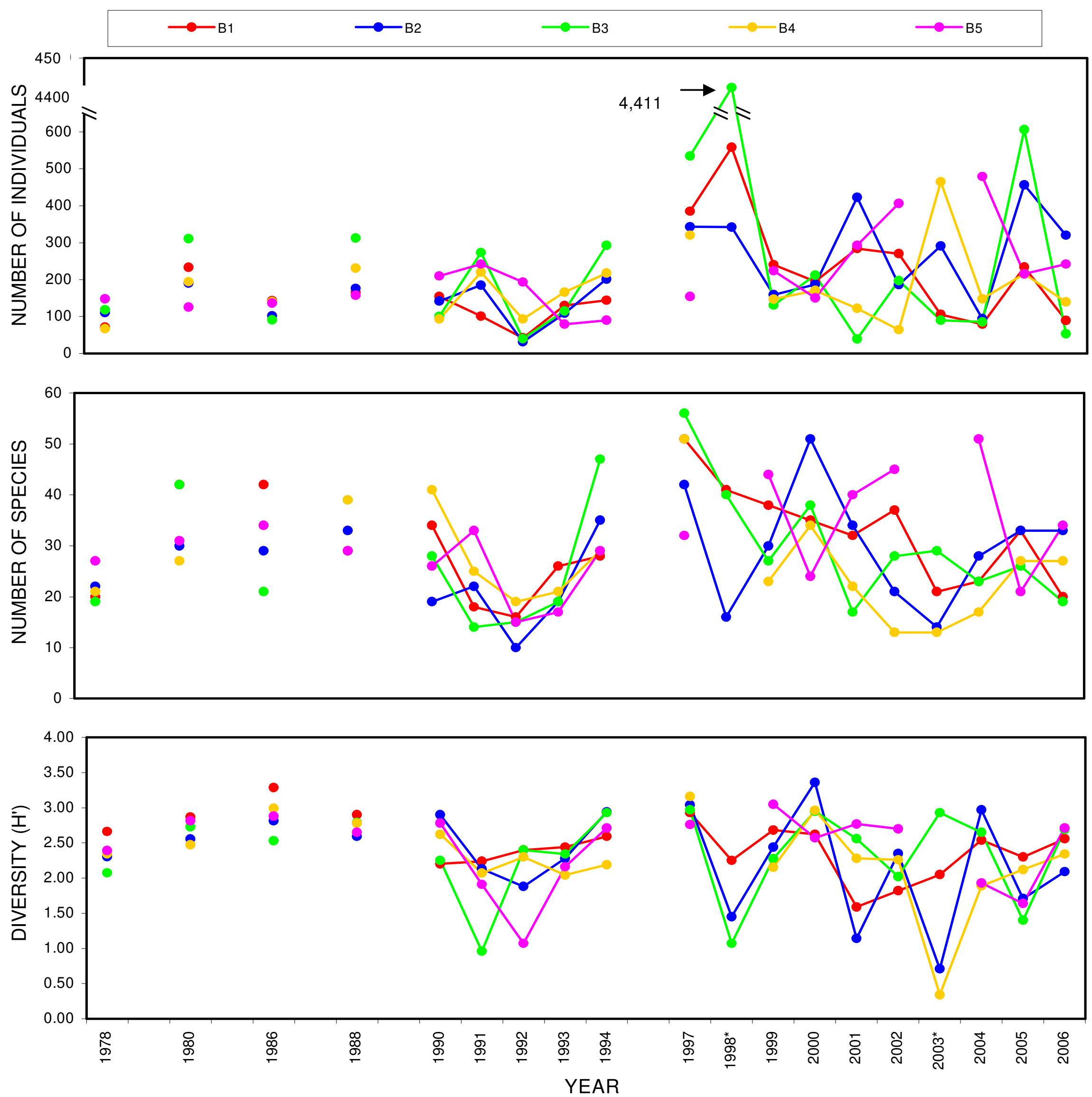
## DISCUSSION

The infauna community in the study area in 2006 was comprised primarily of small annelid worms, arthropods, mollusks, nemertean worms, and echinoderms. Abundance and species richness were lowest immediately upcoast of the generating station and generally increased both upcoast and downcoast, although values were higher immediately downcoast of the generating station than farthest downcoast. Abundance and species richness nearest the generating station were only slightly greater than immediately upcoast. Species diversity was similar among stations, although values were relatively high at the locations nearest and immediately upcoast of the generating station because of low abundances and absence of strong numerical dominance of the communities by a single species. Diversity was lowest (even though species richness was highest) immediately downcoast of the generating station due to the dominance of the community by *Chone* sp SD1. Biomass did not correspond well with abundance, as several medium-sized Pacific sand dollars were present where abundance was relatively low. The Benthic Response Index (BRI) was lowest nearest the generating station and increased slightly both upcoast and downcoast. All values were low, within the Reference category for the shallow coastal shelf, indicating undisturbed, or healthy, communities. In general, the communities nearest the generating station and immediately upcoast were most alike, with similar abundances and community compositions. Sediment characteristics were also similar between these two locations. Least similar to these were the communities farthest upcoast and immediately downcoast of the generating station, where abundances and species richness were high. Sediment at these locations were finer than average. Overall, however, the communities were comparable throughout the study area.

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, due to the winnowing effect of moving water, with little organic matter. Usually, coarse sediments support smaller and less diverse infaunal communities than do finer sediments (Barnard 1963). This pattern was seen in the 2006 communities. Particle sorting also plays a role, with well-sorted sediments providing fewer ecological niches. This was apparent to some degree, as the sediments nearest and immediately upcoast and downcoast of the generating station were better sorted. However, the community immediately downcoast was abundant and high in species richness. The 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. Good examples are the nemertean *Carinoma mutabilis* and the amphipod *Rhepoxynius menziesii*, both of which were most abundant where sediments were coarsest (nearest the generating station). 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 2006 are typical of the shallow nearshore environment (Barnard 1963, Dexter 1978). The pattern of species dominance relating to sediment characteristics was similar to those observed in several previous surveys (MBC 1999-2001a, 2002-2005a). The most abundant species, *Chone* sp SD1, is a tube dwelling feather-duster worm that uses its branched tentacles to filter the water for food. This species was not particularly abundant in previous years except 2004 when it was the top species and the communities in the study area were very similar to those in 2006 (Appendix F-5). *Apoprionospio pygmaea,* the second 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 2005b-e). It was the most abundant species found in the study area since 1978, although it was the top species in only 10 of the 18 summer surveys (MBC 1979, 1981, 1986, 1988, 1990, 1994, 1997-2001a, 2002-2005a; Ogden 1991-1993). Other common species include *Mediomastus acutus, Diastylopsis tenuis*, *Rhepoxynius menziesii*, Pacific sand dollar, *Owenia collaris*, and *Carinoma mutabilis*, all of which were among the community dominants in 2006. Most of the sand dollars were small but 18 medium-sized individuals comprised 71% of the total community biomass. Medium to large sand dollars were also abundant in 1999 and 2001. Because of their activities, medium- to large-sized sand dollars are important to the infaunal community. They disturb the sediment as they position themselves on edge, but also stabilize the sediment by reducing erosion and provide protection from predators for other organisms (Merrill and Hobson 1970, Smith 1981). Subtidal sand dollar beds contain similar numbers of species as the surrounding habitat, but may have a slightly different community composition. The communities in which sand dollars were abundant in 2006 did not differ from those without sand dollars. Some species that have usually been among the top species in the past were absent or not abundant in 2006 (*Scoloplos armiger* and *Spiophanes bombyx*, for example). 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 it was seen in only four other years and only one individual was found in 2006; the ostracod *Euphilomedes carcharodonta* was very abundant in 1997 but was seen in only five other surveys and was absent in 2006. *Euphilomedes longiseta* has also been sporadic, but was abundant in 2006. Despite these differences, comparison of the communities observed since 1978 shows that a number of species have persisted.

In 2006, mean abundance for the study area was one-half that in 2005. Immediately upcoast of the generating station abundance was less than 9% of that in the previous year; however, at one location, farthest upcoast, abundance was actually greater than in 2005 (Figure 18). Values for there and for the sampling location immediately downcoast of the generating station were greater than the long-term means for those locations; all other values were considerably below their means (MBC 1979, 1981, 1986, 1988, 1990, 1994, 1997-2001a, 2002-2005a; Ogden 1991-1993). Mean species richness in 2006 was slightly below that in 2005, as well as the long-term mean. As with abundance, the number of species seen farthest upcoast was greater than in 2005, and both



Sampling was not required in years not shown, * 1998 - only three stations required, 2003 - only four stations required.

**Figure 18. Comparison of infaunal community parameters, 1978 - 2006. Mandalay Generating Station NPDES, 2006.**

there and immediately downcoast of the generating station, species richness values were above the long-term means for those locations. Because of the relatively low abundance and moderate species richness, species diversity in 2006 was higher than in 2005 and was very near the long-term mean.

From 1978 to 2006, values for infauna community parameters have been similar among the stations in the study area in some years but have differed considerably in others (Figure 18) (MBC 1979, 1981, 1986, 1988, 1990, 1994, 1997-2001a, 2002-2005a; Ogden 1991-1993). Abundance was widely disparate among stations in 1997 (abundance at Station B3 was more than three times that at Station B5), in 1998 (abundance at Station B3 was more than 12 times that at Station B2), and in all of the surveys since 2001 (values for 2003 would be about twice those indicated in Figure 18 if four replicates had been collected at each station instead of only two). Species richness was notably dissimilar among stations in 1998, 2002, and 2004, and species diversity, in 2001 and 2003. On average, however, abundance has been greatest immediately upcoast of the discharge because of extremely high abundance of Gould beanclam in one year (1998). With those individuals excluded, abundance has been highest (and most consistent) immediately downcoast of the discharge. Mean density of organisms for the study area as a whole has been about 6,330 individuals/$m^2$ (5,220 individuals/$m^2$, excluding Gould beanclam). Long-term abundance near the generating station, although lowest of the study area (a mean density of 4,910 individuals/$m^2$), was not substantially different from the area-wide mean, and abundance was highest at that location during three of the past summer surveys. On average, species richness has been highest farthest upcoast and second highest nearest the generating station, while diversity has been highest nearest the generating station and second highest farthest upcoast. 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 off the generating station in 2006 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 indicated that the communities were healthy. Infaunal parameters appeared to be somewhat related to sediment characteristics, as most values were slightly lower than average nearest the generating station and immediately upcoast, where sediments were coarser, and highest farthest upcoast, where sediments were finest. No pattern related to the generating station discharge was apparent.

## 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 inter-annual variation was examined to assess the composition and stability of the populations within the receiving waters.

### MATERIALS AND METHODS

Two trawl surveys were conducted in 2006 (25 April and 25 August) to sample the demersal fish and macroinvertebrate communities at four sites offshore of Mandalay Generating Station (Figure 19). The April surveys were conducted between 0717 and 1030 hr under cloudy skies with northeast winds at 3 to 5 kn, before switching to southwest at 3 to 5 kn after 1000 hr, with swells out of the west at 2 to 3 ft. August surveys were conducted under cloudy skies between 739 and 1108 with winds out of the west at 3 to 8 kn and mixed seas, swells out of the west at 2 to 3 ft and south at 3 to 5 ft.

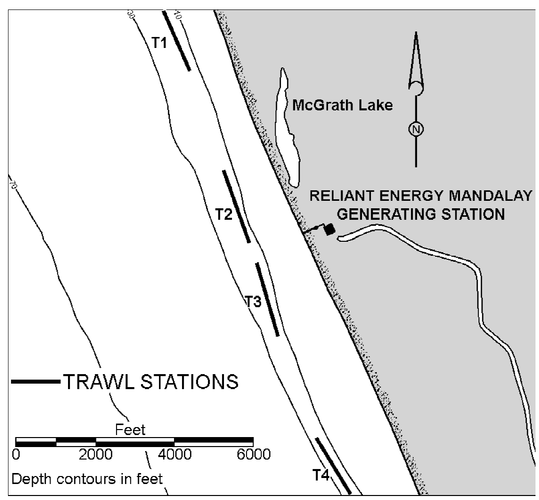



**Figure 19. Location of the trawl sampling stations. Mandalay Generating Station NPDES, 2006.**

Trawl paths for the four stations were parallel to the shoreline along the 20-ft isobath (Figure 19). 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. A Lotek® LTD-50 temperature and depth data logger was fixed to one of the otter trawl doors to record bottom temperature every 4 seconds. Area ($m^2$) sampled was computed by multiplying the distance traveled, based on start and stop fishing GPS coordinates, by the width of the net mouth (7.62 m).

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. Each catch was immediately separated from debris and sorted to the lowest possible taxonomic category. Fishes were identified and up to 200 individuals 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; individuals of species in excess of 200 were weighed separately, and their abundance estimated based on the weight of the 200 individuals measured by the following equation: Estimated abundance = (Unmeasured

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 was recorded on preprinted data sheets and later entered into Microsoft Excel 2000 spreadsheets. In-house quality assurance/quality control (QA/QC) protocols were followed to ensure accurate transcribing into digital format. Checked data was archived in the MBC trawl database in Microsoft Access 2000. Parametric and non-parametric analytical statistics were performed using Number Cruncher Statistical Software 2000 (Hintze 1998). Descriptive (summary) statistics were performed using Microsoft Excel 2000. Summary statistics included abundance, biomass, number of species, Shannon-Wiener species diversity index (H'; Shannon and Weaver 1962), and evenness index (J': Pielou 1977).

Prior to statistical analysis, all abundances were standardized to density (abundance/1000m$^2$) based on net sampling width and trawl path length and pooled across the two seasonal surveys. Due to the non-normal distribution of the data, as indicated by high skewness (> 6) and kurtosis (> 47), all comparisons were made with a Kruskall-Wallis non-parametric analysis of variance (H) at the $p = 0.05$ significance level (Sokal and Rohlf 1995). Station data were pooled across seasons prior to statistical analysis due to low sample size. Species and station relationships within seasons were graphically derived through hierarchical clustering analysis and two-way coincidence tables. An abundance minimum of 10 individuals per species in each season 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 groups.

Species length was represented by length frequency histograms to examine potential age structure of the sampled assemblage. The three most abundant species overall were included in the length frequency analysis. Species-specific lengths were rounded to the nearest 10-mm bin by season, i.e. 35-44 mm SL = 40 mm SL bin.

## RESULTS

Overall, little variation was observed between bottom water temperatures within each season-specific survey. Bottom water temperatures averaged 11.5°C during winter surveys. During summer surveys, bottom water temperatures averaged 14.8°C, on average.

### Fish

A total of 5,866 individuals representing 25 fish species weighing 59.04 kg was collected during the 2006 monitoring year (Tables 10 and 11). Overall species diveristy (H') was 1.28 while evenness (J') was 0.40, indicating a high number of species collected with a relatively few species numerically dominating the overall catch (Table 10). Summer abundances and densities greatly exceeded their winter counterparts (Figure 20). Within each season, the highest abundances were recorded at Station T4, while density was highest at Station T4 during winter surveys and at Station T3 during summer surveys. No significant difference (Kruskall-Wallis, df = 3, H = 2.18, p = 0.54) was detected between stations when pooled across the stations. No fish species were recorded with abnormalities or fish parasites during the annual surveys.

White croaker (*Genyonemus lineatus*) numerically dominated the overall sample with 62% of the total abundance, or 3,656 individuals (Table 10). Speckled sanddab (*Citharichthys stigmaeus*) was the next most abundant species with nearly 20% of the annual total, or 1,148 individuals and one of only two species collected at all four stations during both seasons. Of the remaining 31 species, only shiner perch (*Cymatogaster aggregata*), kelp pipefish (*Syngathus californiensis*), also taken at all stations during both surveys, northern anchovy (*Engraulis mordax*), and walleye surfperch (*Hyperprosopon argenteum*) accounted for greater than 1% of the total abundance, or greater than 66 individuals. Ten species of the remaining 19 were represented by five individuals or less during both surveys.

**Table 10. Abundance and catch parameters for fish species taken by otter trawl. Mandalay Generating Station NPDES, 2006.**

| | Winter | | | | | Summer | | | | | Annual | Percent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | T1 | T2 | T3 | T4 | Total | T1 | T2 | T3 | T4 | Total | Total | Total |
| white croaker | 1 | - | 2 | - | 3 | 714 | 166 | 1,548 | 1,225 | 3,653 | 3,656 | 62.3 |
| speckled sanddab | 59 | 19 | 49 | 179 | 306 | 179 | 187 | 120 | 356 | 842 | 1,148 | 19.6 |
| shiner perch | - | - | - | 1 | 1 | 9 | 121 | 28 | 171 | 329 | 330 | 5.6 |
| kelp pipefish | 7 | 7 | 9 | 17 | 40 | 39 | 78 | 62 | 26 | 205 | 245 | 4.2 |
| northern anchovy | 12 | 1 | 16 | - | 29 | 34 | 139 | 17 | 12 | 202 | 231 | 3.9 |
| walleye surfperch | - | - | - | - | - | 1 | - | 8 | 58 | 67 | 67 | 1.1 |
| white seaperch | - | - | - | - | - | - | 6 | 13 | 20 | 39 | 39 | 0.7 |
| queenfish | - | - | - | - | - | - | 2 | 1 | 31 | 34 | 34 | 0.6 |
| pricklebreast poacher | - | 2 | - | - | 2 | 8 | 10 | 2 | 3 | 23 | 25 | 0.4 |
| thornback | 2 | - | - | - | 2 | - | 2 | 8 | 3 | 13 | 15 | 0.3 |
| Pacific staghorn sculpin | - | - | - | - | - | 2 | 1 | 10 | 2 | 15 | 15 | 0.3 |
| spiny dogfish | - | - | - | - | - | 4 | 1 | 7 | - | 12 | 12 | 0.2 |
| English sole | 1 | 2 | 1 | 1 | 5 | - | - | 1 | 4 | 5 | 10 | 0.2 |
| California halibut | - | - | - | - | - | - | - | 3 | 3 | 6 | 6 | 0.1 |
| bay goby | 1 | - | - | 5 | 6 | - | - | - | - | - | 6 | 0.1 |
| white seabass | - | - | - | - | - | 1 | 2 | - | 1 | 4 | 4 | 0.1 |
| barred surfperch | - | - | - | - | - | - | - | - | 4 | 4 | 4 | 0.1 |
| shovelnose guitarfish | - | - | 1 | - | 1 | 1 | - | 1 | 1 | 3 | 4 | 0.1 |
| bat ray | 1 | - | - | - | 1 | 1 | - | - | 2 | 3 | 4 | 0.1 |
| vermillion rockfish | - | - | - | 3 | 3 | - | - | - | - | - | 3 | 0.1 |
| California corbina | - | - | - | - | - | 1 | 1 | - | 1 | 3 | 3 | 0.1 |
| Pacific angel shark | - | - | - | - | - | 1 | 1 | - | - | 2 | 2 | 0.0 |
| California tonguefish | - | - | - | - | - | - | - | 1 | - | 1 | 1 | 0.0 |
| Pacific pompano | - | - | - | - | - | - | - | 1 | - | 1 | 1 | 0.0 |
| hornyhead turbot | - | - | - | - | - | - | - | - | 1 | 1 | 1 | 0.0 |
| Total Abundance | 84 | 31 | 78 | 206 | 399 | 995 | 717 | 1,831 | 1,924 | 5,467 | 5,866 | |
| Number of Species | 8 | 5 | 6 | 6 | 12 | 14 | 14 | 17 | 19 | 23 | 25 | |
| Diversity (H') | 1.03 | 1.10 | 1.07 | 0.53 | 0.91 | 0.95 | 1.73 | 0.71 | 1.21 | 1.20 | 1.28 | |
| Evenness (J') | 0.50 | 0.68 | 0.60 | 0.30 | 0.37 | 0.36 | 0.66 | 0.25 | 0.41 | 0.38 | 0.40 | |

Note: 0.0 = < 0.05

White croaker also dominated the biomass during the 2006 monitoring year with 12.05 kg, or slightly greater 20% of the total biomass, followed closely by Pacific angel shark (*Squatina californica*) with 11.70 kg and speckled sanddab with 10.96 kg (Table 11). Bat ray (*Myliobatis californica*) and thornback (*Platyrhinoidis triseriata*) also contributed greatly to the overall recorded biomass with 7.11 and 5.97 kg each, respectively. The remaining fish species collected each accounted for less than 5% of the total biomass.

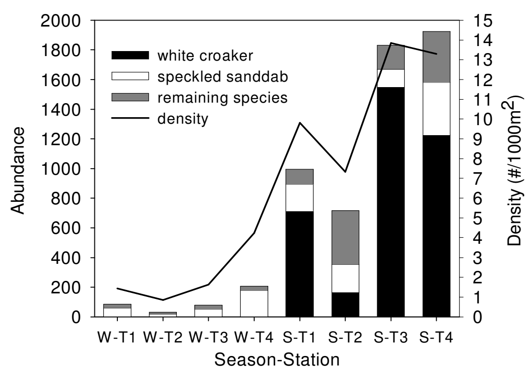



**Figure 20. Abundance and mean density (number of individuals/1000m$^2$) of fishes collected by otter trawl by season and station. Mandalay Generating Station NPDES, 2006.**

Winter sampling collected 399 individuals from 12 species with a overall seasonal species diversity of 0.91 and evenness of 0.37 (Table 10). Speckled sanddab was the most abundant species recorded with 306 individuals, or nearly 77% of the total. Of the remaining 11 species, kelp pipefish and northern anchovy were second and third highest in abundance, with 40 and 29 individuals, respectively. The remaining nine species cumulatively represented 24 individuals. Due to the overall low abundance, cluster analysis was not preformed since only three species met the *a priori* requirement of a minimum of ten individuals.

**Table 11. Biomass (kg) of fish species taken by otter trawl. Mandalay Generating Station NPDES, 2006.**

| | Winter | | | | | Summer | | | | | Annual | Percent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | T1 | T2 | T3 | T4 | Total | T1 | T2 | T3 | T4 | Total | Total | Total |
| white croaker | 0.00 | - | 0.00 | - | 0.01 | 1.46 | 0.33 | 4.66 | 5.59 | 12.04 | 12.05 | 20.4 |
| Pacific angel shark | - | - | - | - | - | 0.70 | 11.00 | - | - | 11.70 | 11.70 | 19.8 |
| speckled sanddab | 0.44 | 0.12 | 0.46 | 1.62 | 2.64 | 1.60 | 1.64 | 1.38 | 3.70 | 8.32 | 10.96 | 18.6 |
| bat ray | 0.40 | - | - | - | 0.40 | 0.51 | - | - | 6.20 | 6.71 | 7.11 | 12.0 |
| thornback | 0.92 | - | - | - | 0.92 | - | 0.80 | 3.50 | 0.75 | 5.05 | 5.97 | 10.1 |
| spiny dogfish | - | - | - | - | - | 0.72 | 0.25 | 1.56 | - | 2.53 | 2.53 | 4.3 |
| shiner perch | - | - | - | 0.02 | 0.02 | 0.04 | 0.26 | 0.05 | 1.98 | 2.33 | 2.36 | 4.0 |
| California halibut | - | - | - | - | - | - | - | 0.65 | 1.02 | 1.67 | 1.67 | 2.8 |
| queenfish | - | - | - | - | - | - | 0.00 | 0.03 | 0.66 | 0.70 | 0.70 | 1.2 |
| walleye surfperch | - | - | - | - | - | 0.01 | - | 0.07 | 0.56 | 0.63 | 0.63 | 1.1 |
| Pacific staghorn sculpin | - | - | - | - | - | 0.07 | 0.04 | 0.45 | 0.04 | 0.60 | 0.60 | 1.0 |
| California corbina | - | - | - | - | - | 0.24 | 0.11 | - | 0.19 | 0.54 | 0.54 | 0.9 |
| kelp pipefish | 0.01 | 0.01 | 0.01 | 0.03 | 0.06 | 0.06 | 0.13 | 0.14 | 0.06 | 0.38 | 0.44 | 0.7 |
| northern anchovy | 0.02 | 0.00 | 0.07 | - | 0.10 | 0.06 | 0.15 | 0.07 | 0.06 | 0.33 | 0.43 | 0.7 |
| white seaperch | - | - | - | - | - | - | 0.05 | 0.15 | 0.22 | 0.41 | 0.41 | 0.7 |
| shovelnose guitarfish | - | - | 0.11 | - | 0.11 | 0.06 | - | 0.06 | 0.13 | 0.25 | 0.36 | 0.6 |
| English sole | 0.04 | 0.10 | 0.04 | 0.03 | 0.21 | - | - | 0.03 | 0.07 | 0.10 | 0.30 | 0.5 |
| hornyhead turbot | - | - | - | - | - | - | - | - | 0.10 | 0.10 | 0.10 | 0.2 |
| pricklebreast poacher | - | 0.00 | - | - | 0.00 | 0.02 | 0.04 | 0.01 | 0.02 | 0.08 | 0.09 | 0.1 |
| barred surfperch | - | - | - | - | - | - | - | - | 0.06 | 0.06 | 0.06 | 0.1 |
| California tonguefish | - | - | - | - | - | - | - | 0.03 | - | 0.03 | 0.03 | 0.0 |
| Pacific pompano | - | - | - | - | - | - | - | 0.01 | - | 0.01 | 0.01 | 0.0 |
| vermillion rockfish | - | - | - | 0.01 | 0.01 | - | - | - | - | - | 0.01 | 0.0 |
| bay goby | 0.00 | - | - | 0.00 | 0.00 | - | - | - | - | - | 0.00 | 0.0 |
| white seabass | - | - | - | - | - | 0.00 | 0.00 | - | 0.00 | 0.00 | 0.00 | 0.0 |
| Total Biomass (kg) | 1.83 | 0.23 | 0.70 | 1.72 | 4.48 | 5.54 | 14.79 | 12.84 | 21.40 | 54.57 | 59.04 | |

Note: 0.0 = < 0.05

Station-specific abundance and density peaked at Station T4 during the winter, with slightly over 200 individuals and a demersal fish density of approximately 3 fish/1000m$^2$, principally speckled sanddab (Figure 20). Stations T1 and T3 were relatively similar in both parameters, while season minimums for abundance and density were recorded at Station T2. Notably, white croaker was taken in very low abundance during winter sampling. Biomass was highest at Station T1 during the winter survey, followed closely by Station T4 (Figure 21). Substantially less biomass was recorded at the remaining two stations, with 0.70 and 0.23 kg each at Station T3 and Station T2, respectively.

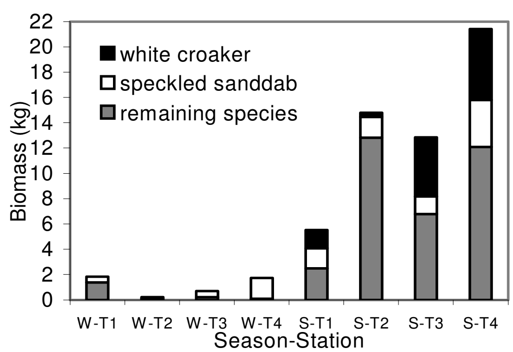



**Figure 21. Total biomass (kg) of otter trawl collected fish species by season and station. Mandalay Generating Station NPDES, 2006.**

The summer survey recorded 5,467 individuals representing 23 species weighing 54.57 kg (Tables 10 and 11). Overall species diversity (H') was moderate at 1.20, while evenness (J') was low at 0.38, indicating a moderately diverse community with only a few species collected in relatively high abundance (Table 10). Species richness was highest at Station T4, while diversity and evenness were highest at Station T2. Seasonal minimums in diversity and evenness were recorded at Station T1, with a tie in fewest species at Stations T1 and T2 (Table 10).

White croaker was collected in high abundances during the summer surveys (Figure 20), with a total catch of 3,653 individuals (Table 10). Speckled sanddab abundances represented approximately one-quarter that of white croaker, but was the second most abundant species collected with 842 individuals. The third, fourth, and fifth most abundant species, shiner perch, kelp pipefish, and northern anchovy, were represented by 329, 205, and 202 individuals, respectively. The remaining species were each represented by less than 70 individuals In total, 12 species were taken in abundances of ten individuals or more.

A two-way coincidence table of the 12 species represented by ten individuals or more segregated into three groups based on station abundance (Figure 22). White croaker and speckled sanddab separated from the remaining species based on their relatively high abundances at Station T4 to form Group C. Three species observed in high numbers at Station T2, northern anchovy, kelp pipefish, shiner perch, formed Group B. The remaining seven species included in the analysis clustered into Group A. Similar analyses of the station-specific abundances indicate a definitive segregation based on relation to the discharge, with both stations upcoast of the discharge forming Group I, while the stations downcoast of the discharge formed Group II. Stations T3 and T4, both downcoast of the discharge, were more dissimilar than the upcoast stations. Group I was characterized by a relatively high abundance of the species in Group B, while species form Groups A and C generally occurred in low abundance, or entirely

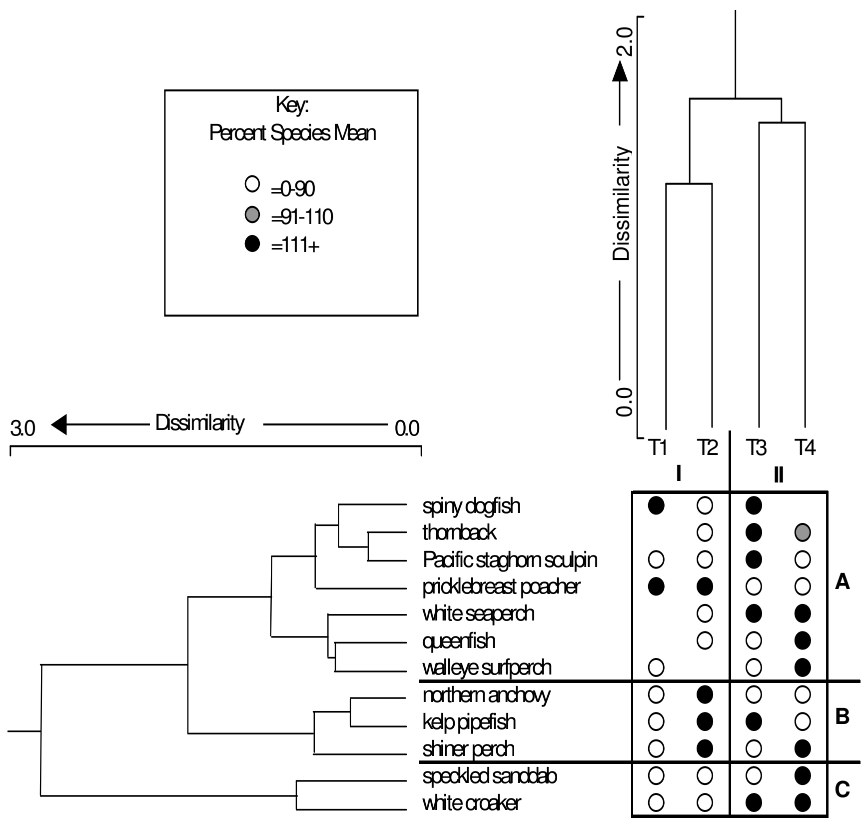



**Figure 22. Two-way coincidence table resulting from normal (station) and inverse (species) classification dendrograms for fish taken by otter trawl, summer survey. Mandalay Generating Station NPDES, 2006.**

absent from samples collected at Stations T1 and T2. Species from Group C were present in relatively high abundances at Station T4.

Summer biomass species composition closely resembled abundance, with the exception of a two relatively large Pacific angel sharks accounting for greater than 20% of the seasonal biomass with 11.70 kg (Table 11). Despite the large size of the Pacific angel sharks, white croaker dominated the biomass with 12.04 kg. Other species comprising relatively high proportions of the total trawl caught biomass include speckled sanddab, bat ray, and thornback, with 8.32 kg, 6.71 kg, and 5.05 kg, respectively. The remaining species each contributed was less than 3.0 kg biomass (Table 11).

Similar to abundance, peak biomass was recorded at Station T4 in summer (Figure 21). Station T2 exhibited the second highest biomass. However, by removing the single, large Pacific angle shark at Station T2, the summer trawl biomass by station proportionally reflects abundance.

### Fish Length

Fish lengths for the annual survey ranged from a 16-mm SL white seabass (*Atractoscion nobilis*) to a 1,040-mm TL Pacific angel shark (Table 12). Recorded lengths for white croaker, speckled sanddab, and shiner perch were examined with length frequency analysis.

**Table 12. Measured length (mm) of fish species taken by otter trawl. Mandalay Generating Station NPDES, 2006.**

| | Winter | | | | | Summer | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Species | Number | Min | Max | Mean | SD | Number | Min | Max | Mean | SD |
| barred surfperch | - | - | - | - | - | 4 | 70 | 90 | 78.3 | 9.5 |
| bat ray** | 1 | 310 | 310 | 310 | - | 3 | 330 | 680 | 484 | 178.7 |
| bay goby | 6 | 29 | 32 | 30.5 | 1.0 | - | - | - | - | - |
| California corbina | - | - | - | - | - | 3 | 162 | 237 | 202.3 | 37.8 |
| California halibut | - | - | - | - | - | 6 | 225 | 292 | 256.5 | 25.1 |
| California tonguefish* | - | - | - | - | - | 1 | 140 | 140 | 140.0 | - |
| English sole | 5 | 130 | 155 | 138.8 | 9.5 | 5 | 50 | 158 | 102.4 | 48.4 |
| hornyhead turbot | - | - | - | - | - | 1 | 150 | 150 | 150.0 | - |
| kelp pipefish | 40 | 119 | 223 | 171.5 | 26.6 | 205 | 107 | 254 | 187.9 | 22.6 |
| northern anchovy | 29 | 50 | 103 | 69.4 | 12.5 | 202 | 30 | 112 | 52.4 | 19.7 |
| Pacific angel shark* | - | - | - | - | - | 2 | 429 | 1040 | 734.5 | 432.0 |
| Pacific pompano | - | - | - | - | - | 1 | 66 | 66 | 66.0 | - |
| Pacific staghorn sculpin | - | - | - | - | - | 15 | 84 | 188 | 121.0 | 24.4 |
| pricklebreast poacher | 2 | 28 | 32 | 30.0 | 2.8 | 23 | 60 | 95 | 76.0 | 8.5 |
| queenfish | - | - | - | - | - | 34 | 35 | 155 | 105.6 | 23.3 |
| shiner perch | 1 | 96 | 96 | 96.0 | - | 329 | 30 | 107 | 56.0 | 23.4 |
| shovelnose guitarfish* | 1 | 290 | 290 | 290.0 | - | 3 | 245 | 340 | 278.0 | 53.7 |
| speckled sanddab | 306 | 24 | 173 | 77.2 | 16.4 | 842 | 30 | 115 | 73.3 | 20.4 |
| spiny dogfish | - | - | - | - | - | 12 | 327 | 450 | 397.0 | 39.5 |
| thornback | 2 | 430 | 435 | 432.5 | 3.5 | 13 | 276 | 513 | 395.6 | 68.6 |
| vermillion rockfish | 3 | 34 | 39 | 36.7 | 2.5 | - | - | - | - | - |
| walleye surfperch | - | - | - | - | - | 67 | 63 | 82 | 71.0 | 3.9 |
| white croaker | 3 | 48 | 50 | 49.3 | 1.2 | 1365 | 30 | 143 | 51.3 | 10.4 |
| white seabass | - | - | - | - | - | 4 | 16 | 19 | 17.8 | 1.3 |
| white seaperch | - | - | - | - | - | 39 | 57 | 91 | 73.6 | 9.0 |

* = Total Length, ** = Disc Width

White croaker lengths averaged 49 mm SL during the winter, and 51 mm SL during the summer (Table 12). Analysis was largely based on the summer assemblage; three individuals were measured during winter, while 1,365 white croaker were measured during the summer survey. Length frequency analysis for white croaker indicates a modal distribution centered at 50 mm SL, with similarly high abundances in both the 40 and 60 mm SL size classes (Figure 23).

Speckled sanddab averaged 77 mm SL during winter sampling and 73 mm SL during summer sampling (Table 12). Three hundred and six individuals were collected in winter and 842 in summer, with all individuals measured (Figure 24). Lengths for both seasons indicate a modal distribution centered at 80 mm SL. Winter caught individuals exhibited relatively low abundances in all other size classes. In comparison, summer caught individuals exhibited relatively high abundances in all size classes ranging from 40 to 100 mm SL, including the peak at 80 mm SL.

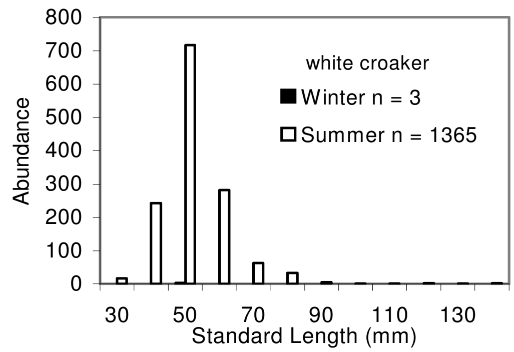



**Figure 23. Length frequency analysis for white croaker (*Genyonemus lineatus*) collected by otter trawl during winter (n = 3) and summer (n = 1,365) sampling. Mandalay Generating Station NPDES, 2006.**

During winter sampling, a single shiner perch was collected which measured 96 mm SL (Table 12). Summer sampling measured 329 individuals, with a mean length of 56 mm SL. The length frequency distribution was weakly bimodal, with the stronger mode centered at 40 mm SL, and a lesser peak detected at 100 mm SL (Figure 25).

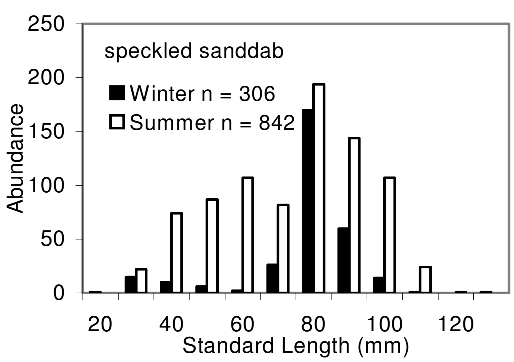



**Figure 24. Length frequency analysis for speckled sanddab (*Citharichthys stigmaeus*) collected by otter trawl during winter (n = 306) and summer (n = 842) sampling. Mandalay Generating Station NPDES, 2006.**

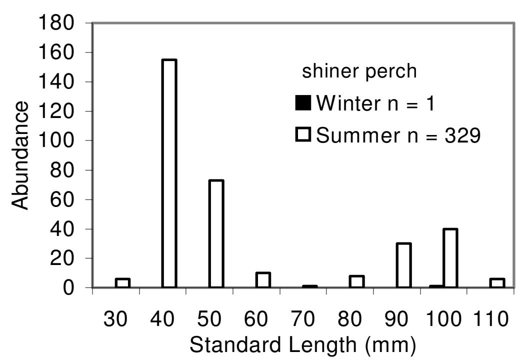



**Figure 25. Length frequency analysis for shiner perch (*Cymatogaster aggregata*) collected by otter trawl during winter (n = 1) and summer (n = 329) sampling. Mandalay Generating Station NPDES, 2006.**

## Macroinvertebrates

A total of 14,215 individuals representing 16 macroinvertebrate species weighing 38.11 kg were collected during the 2006 monitoring year (Table 13). Overall species diversity was 0.91 and evenness was 0.33, both indices reflecting a low species richness with overall abundance numerically dominated by only one or two species.

Blackspotted bay shrimp (*Crangon nigromaculata*) dominated the annual abundance with nearly 52% of the total or 7,370 individuals, followed closely by Pacific sand dollar (*Dendraster excentricus*) which accounted for 42% of the total or 6,002 individuals (Table 13). Of the remaining 14 species, graceful crab (*Cancer gracilis*) accounted for another 5% of the total annual

**Table 13. Abundance and catch parameters for macroinvertebrates species taken by otter trawl. Mandalay Generating Station NPDES, 2006.**

| | Winter | | | | | Summer | | | | | Annual | Percent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | T1 | T2 | T3 | T4 | Total | T1 | T2 | T3 | T4 | Total | Total | Total |
| blackspotted bay shrimp | 291 | 360 | 873 | 1,055 | 2,579 | 2,448 | 912 | 970 | 461 | 4,791 | 7,370 | 51.8 |
| Pacific sand dollar | - | 213 | 4 | 4,422 | 4,639 | - | 2 | - | 1,361 | 1,363 | 6,002 | 42.2 |
| graceful crab | 1 | 17 | 30 | 347 | 395 | 17 | 35 | 69 | 221 | 342 | 737 | 5.2 |
| tuberculate pear crab | - | 1 | 2 | 41 | 44 | - | 4 | 3 | 2 | 9 | 53 | 0.4 |
| sweet potatoe sea cucumber | - | 1 | 9 | - | 10 | - | - | 2 | 1 | 3 | 13 | 0.1 |
| Stimpson coastal shrimp | - | - | - | - | - | - | 3 | 1 | 4 | 8 | 8 | 0.1 |
| fat western nassa | 2 | 3 | - | 2 | 7 | - | - | - | - | - | 7 | 0.0 |
| yellow crab | - | - | - | 1 | 1 | 2 | 3 | 1 | - | 6 | 7 | 0.0 |
| red jellyfish | - | 1 | 1 | 1 | 3 | - | - | 2 | 1 | 3 | 6 | 0.0 |
| sheep crab | - | - | - | - | - | 3 | - | - | 1 | 4 | 4 | 0.0 |
| California spiny lobster | - | - | - | - | - | - | 2 | - | - | 2 | 2 | 0.0 |
| sea mouse unid | - | - | - | - | - | - | 2 | - | - | 2 | 2 | 0.0 |
| California two-spot octopus | - | - | - | - | - | - | - | 1 | - | 1 | 1 | 0.0 |
| globose sand crab | - | - | - | - | - | - | - | - | 1 | 1 | 1 | 0.0 |
| mottled pea crab | - | - | - | - | - | - | - | 1 | - | 1 | 1 | 0.0 |
| Xantus swimming crab | - | - | - | - | - | - | - | 1 | - | 1 | 1 | 0.0 |
| Total Abundance | 294 | 596 | 919 | 5,869 | 7,678 | 2,470 | 963 | 1,051 | 2,053 | 6,537 | 14,215 | |
| Number of species | 3 | 7 | 6 | 7 | 8 | 4 | 8 | 10 | 9 | 15 | 16 | |
| Diversity (H') | 0.06 | 0.83 | 0.25 | 0.73 | 0.87 | 0.06 | 0.27 | 0.33 | 0.88 | 0.75 | 0.91 | |
| Evenness (J') | 0.06 | 0.43 | 0.14 | 0.37 | 0.42 | 0.04 | 0.13 | 0.14 | 0.40 | 0.28 | 0.33 | |
| Biomass (kg) | 0.90 | 2.00 | 2.83 | 15.80 | 21.52 | 3.44 | 2.33 | 3.38 | 7.45 | 16.59 | 38.11 | |
| Fish parasites (not included above): | | | | | | | | | | | | |
| fish louse | 3 | - | 3 | 25 | 31 | 8 | 15 | 4 | 37 | 64 | 95 | |

Note: 0.0 = < 0.05

abundance with 737 individuals. The remaining 13 species were each represented by less than 55 individuals, or less than 1% of the total abundance.

Winter sampling recorded 7,678 individuals from 8 species weighing 21.52 kg (Table 13). Pacific sand dollar accounted for over 60% of the total seasonal abundance with 4,639 individuals, or nearly double that of the next most abundant species, blackspotted bay shrimp, with 2,579 individuals. Graceful crab was the third most abundant species with 395 individuals, while the remaining species were represented by less than 45 individuals each.

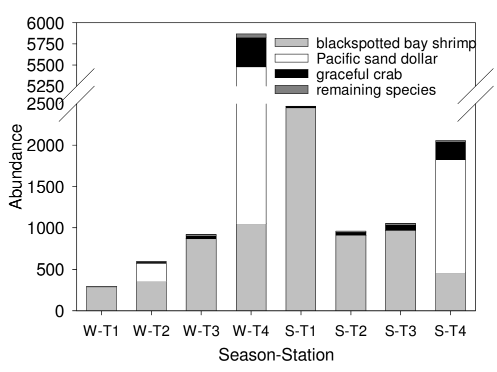



**Figure 26. Abundance of macroinvertebrates collected by otter trawl by season and station. Mandalay Generating Station NPDES, 2006.**

Numbers of the three most abundant species were highest at Station T4 where total number of individuals was nearly six times that of the station with the second highest abundance (Station T2)(Figure 26). Overall, trawl-caught abundances increased with distance from upcoast to downcoast. Total seasonal species diversity and evenness indices were relatively low at 0.87 and 0.42, respectively (Table 13). Both indices were lowest at Station T1, where blackspotted bay shrimp represented nearly 99% of the entire macroinvertebrate catch (Figure 26). Peak diversity (0.83) and evenness values (0.43) were calculated for the macroinvertebrate community at Station T2 due to the relatively high abundances of both blackspotted bay shrimp and Pacific sand dollar (Table 13 and

Figure 26). Macroinvertebrate biomass peaked at Station T4 (15.80 kg), while lowest biomass was recorded at Station T1(Table 13).

Summer survey abundance was lower than during winter survey, although greater species richness was observed during the summer (Table 13). A total of 6,537 individuals representing 15 species weighing 16.59 kg was recorded during summer sampling. Overall species diversity during summer sampling was 0.75 while evenness was 0.28, indicating a less diverse community than was encountered during the winter survey. Although more species were collected during the summer survey, a greater proportion of the total abundance was represented by the two most abundant species, blackspotted bay shrimp and Pacific sand dollar.

Blackspotted bay shrimp was the most abundant macroinvertebrate species in summer, nearly twice the winter catch total with 4,791 individuals (Table 13). Pacific sand dollar abundances were about one-third of the winter abundance, with 1,363 individuals collected during the summer survey. Graceful crab remained the third most abundant species collected, with abundance slightly reduced from winter with 342 individuals. The remaining species collectively represented a total abundance of 41 individuals, or less than 1% of the total catch.

In the summer, abundances at Station T1 was the greatest, with blackspotted bay shrimp comprising nearly the entire macroinvertebrate sample (Table 13 and Figure 26). Surveys adjacent to the outfall, Stations T2 and T3, recorded the lowest abundances during the annual surveys, with numbers at both stations higher in summer. Abundance at Station T4 was about one-third that observed during winter, with Pacific sand dollar again the most abundant species (Figure 26).

Species diversity in summer increased with distance downcoast from Station T1, ranging from 0.06 at Station T1 to a seasonal peak at Station T4 with 0.88 (Table 13). Species evenness followed a similar distribution. This trend mirrors graceful crab abundance across the sampling array (Figure 26). Macroinvertebrate biomass peaked during summer sampling at Station T4 at 7.45 kg, principally due to the presence of greater abundances of graceful crabs, followed by the assemblages at Station T1 and T3 with 3.44 and 3.38 kg, respectively (Table 13). Lowest biomass was recorded during sampling at Station T3 with 2.33 kg.

Several fish lice were collected free from host species during the annual surveys (Table 13). Thirty-one individuals were collected during the winter surveys, with most occurring at Station T4. During summer surveys, 64 fish lice were observed, again with Station T4.

## DISCUSSION

In 2006, 5,866 individual fish from 25 species weighing 59.04 kg were collected during trawl surveys of the demersal community in the receiving waters of Mandalay Generating Station. Seasonal variation in the abundance of observed fish species was recorded throughout the area, with differences supporting activity patterns, rather than anthropogenic impacts. The consistency of the station abundance patterns across both seasonal surveys suggests continued habitat preferences for the species caught. The substantial difference in densities between the seasons is more attributable to the natural movement patterns associated with any of a number of natural influences, such as reproduction or seasonal migration patterns.

Abundances in 2006 were slightly less than the long-term mean (Figure 27). The decline from 2005 abundances were slight, and well within the previously recorded inter-annual variation. Annual surveys during 2006 recorded a dominance of white croaker, while queenfish abundances were notably reduced, a trend which has been observed in previous years. Speckled sanddab abundances in 2006 were the highest on record, more than doubling the previous high of 476 individuals in 2004 (Table 14). Species richness was less than what was recorded during 2005, but consistent with previous surveys.

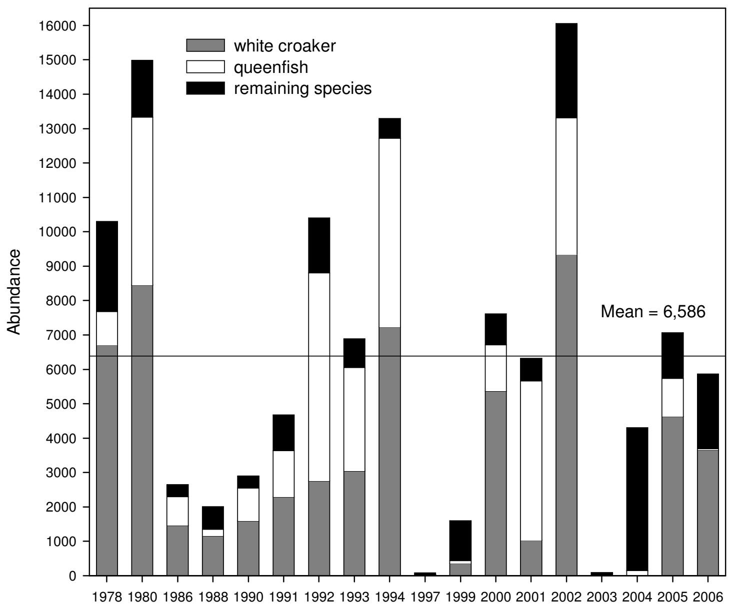



**Figure 27. Long-term abundance of fishes collected by otter trawl by season and station. Mandalay Generating Station NPDES, 2006.**

White croaker was the most abundant fish collected in 2006 as it has been in 13 of 18 sampling years since 1978 (Table 14). In 2006, 3,656 individuals accounted for 62% of the total catch, with nearly the entire catch occurring during summer surveys. During the winter, white croaker were nearly absent from the trawl area. Variations in abundances are common in schooling species such as white croaker, which are reported to undergo seasonal onshore/offshore movements associated with spawning (Love et al. 1984). An opposing pattern was observed in 2005, where the majority of the annual white croaker catch occurred during the winter, with minimal abundances recorded during summer. White croaker are highly abundant throughout the Southern California Bight, as indicated by their dominance during the 1998 Bight-wide demersal fish survey, accounting for 28% of the total fish catch and 26% of the total biomass (Allen et al. 2002).

White croaker is typically abundant over sandy nearshore areas (Hobson and Chess 1976, Allen and DeMartini 1983) at depths of 15 to 22 m (Love et al. 1984), and is an important sport fish commonly caught from piers and jetties throughout the Southern California Bight (Eschmeyer et al. 1983). Most of the commercial catch is sold as fresh fish, although a small amount is used for live bait. White croaker are common from British Columbia to Baja California in loose schools from the surf zone to depths of 600 ft, and in shallow bays, sloughs, and lagoons (Love et al. 1984, Moore and Wild 2001). They are primarily nocturnal and tend to occur inshore during the day in resting schools, remaining nearshore at night to feed on bottom-dwelling polychaetes and crustaceans (Ware 1979, Allen 1982). Juveniles (less than 130 mm SL) are usually limited to shallow nearshore areas and embayments, which they may use as nursery grounds.

Although white croaker spawning can occur throughout the year, distinct seasonal peaks are generally found in January through April (Love et al. 1984, Goldberg 1976). White croaker individuals typically mature at approximately one year at a length of 120 to 130 mm SL (Love et al. 1984). Summer collections averaged 51 mm SL, with length frequency analysis indicating the majority of the community were young of the year (YOY). Proportionally few individuals were mature, based on Love et al. (1984).

In 2006, speckled sanddab was the second most abundant fish species collected with 1,148 individuals recorded. Speckled sanddab was one of two fish species present at all four stations during both seasons, with distinctly greater abundances found downcoast of the

**Table 14. The 20 most abundant fish species taken during trawl surveys, 1978 - 2006. Mandalay Generating Station NPDES, 2006.**

| | Year | | | | | | | | | | | | | | | | | | Grand | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 1978 | 1980 | 1986 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994 | 1997 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Total | Total |
| white croaker | 6,713 | 8,446 | 1,464 | 1,150 | 1,592 | 2,291 | 2,756 | 3,043 | 7,237 | 20 | 363 | 5,363 | 1,033 | 9,342 | - | 16 | 4,632 | 3,656 | 59,117 | 50.5 |
| queenfish | 966 | 4,889 | 830 | 195 | 957 | 1,341 | 6,049 | 3,009 | 5,483 | - | 76 | 1,352 | 4,630 | 3,971 | 8 | 138 | 1,106 | 34 | 35,034 | 29.9 |
| northern anchovy | 1,476 | 494 | 2 | 52 | 88 | 359 | 1,469 | 159 | 115 | - | 640 | 256 | 383 | 1,216 | 9 | 3,322 | 202 | 231 | 10,473 | 8.9 |
| speckled sanddab | 36 | 8 | 40 | 64 | 76 | 217 | 4 | 75 | 16 | 7 | 143 | 219 | 38 | 224 | 51 | 476 | 325 | 1,148 | 3,167 | 2.7 |
| shiner surfperch | 107 | 24 | - | 4 | 33 | 63 | 4 | 58 | 88 | 17 | 190 | 42 | 11 | 529 | 18 | 118 | 135 | 330 | 1,771 | 1.5 |
| kelp pipefish | - | - | - | - | - | - | - | - | - | - | 80 | 149 | 104 | 179 | 3 | 118 | 346 | 245 | 1,224 | 1.0 |
| barred surfperch | 210 | 172 | 46 | 223 | 38 | 95 | 29 | 115 | 41 | 18 | 1 | 33 | 9 | 42 | - | 45 | 67 | 4 | 1,188 | 1.0 |
| white seaperch | 245 | 321 | 2 | 17 | 18 | 26 | 5 | 5 | 80 | 12 | 25 | - | 1 | 225 | - | - | 23 | 39 | 1,044 | 0.9 |
| walleye surfperch | 335 | 340 | 8 | 18 | - | 50 | 5 | 26 | 28 | 1 | 1 | 16 | 37 | 28 | 1 | 9 | 53 | 67 | 1,023 | 0.9 |
| thornback | 27 | 21 | 12 | 16 | 6 | 56 | 4 | 167 | 2 | 3 | 13 | 14 | 6 | 52 | - | 2 | 24 | 15 | 440 | 0.4 |
| California halibut | 25 | 54 | 66 | 58 | 21 | 27 | 1 | 8 | 11 | - | 2 | 5 | 1 | 4 | - | - | 1 | 6 | 290 | 0.2 |
| California corbina | 15 | 3 | 79 | - | - | 3 | 2 | 33 | 19 | - | 2 | 73 | 24 | 9 | - | 8 | 6 | 3 | 279 | 0.2 |
| California lizardfish | 17 | 5 | - | - | 8 | - | 1 | 2 | 4 | - | 1 | 1 | 26 | 115 | - | 1 | 9 | - | 190 | 0.2 |
| yellowfin croaker | 2 | - | 11 | 1 | - | 1 | - | 79 | 50 | - | - | - | 3 | - | - | - | - | - | 147 | 0.1 |
| English sole | 22 | 8 | 5 | 49 | 7 | - | - | 1 | 4 | 1 | 7 | - | - | 15 | - | 1 | 13 | 10 | 143 | 0.1 |
| barcheek pipefish | 3 | - | - | 77 | 5 | - | - | - | 58 | - | - | - | - | - | - | - | - | - | 143 | 0.1 |
| fantail sole | - | 10 | 17 | 10 | 1 | 3 | 1 | 1 | 5 | 1 | 39 | 27 | 1 | 16 | - | - | 1 | - | 133 | 0.1 |
| basketweave cusk-eel | 1 | 3 | 9 | - | 8 | 45 | - | 28 | 4 | - | 1 | 5 | - | - | - | - | 18 | - | 122 | 0.1 |
| shovelnose guitarfish | 6 | 11 | 6 | 22 | 13 | 18 | - | 19 | 2 | - | 1 | 2 | - | 2 | - | - | 1 | 4 | 107 | 0.1 |
| spiny dogfish | 6 | 37 | 3 | - | - | 5 | - | - | - | - | - | - | 1 | - | - | - | 41 | 12 | 105 | 0.1 |
| Survey totals | | | | | | | | | | | | | | | | | | | | |
| Number of individuals | 10,299 | 14,986 | 2,648 | 2,009 | 2,896 | 4,674 | 10,399 | 6,892 | 13,296 | 89 | 1,597 | 7,616 | 6,324 | 16,056 | 91 | 4,304 | 7,062 | 5,866 | 117,104 | |
| Number of species | 41 | 35 | 29 | 24 | 23 | 30 | 21 | 28 | 33 | 10 | 25 | 22 | 24 | 27 | 7 | 23 | 33 | 25 | 65 | |

discharge. It is the fourth most abundant species in the area long-term and has been taken during every survey year (Table 14). In 2006, speckled sanddab abundances were the highest on record for the area. 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 present in some of the commercial landings, speckled sanddab 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. Unfortunately, no age at length data is available for speckled sanddab in the primary literature.

Shiner perch was the third most abundant species in 2006. It has been periodically abundant in southern California, especially during colder water years such as 1999 and 2000, and ranges from San Quintin, Baja California, to Alaska, in depths from the surface to 480 ft. (Miller and Lea 1972). Allen (1985) observed 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. There is no targeted fishery for shiner perch due to their small size, although they do occur as incidental catches in many of the soft-bottom fisheries, such as the California halibut (*Paralichthys californicus*) trawl fishery. Shiner perch is fifth in long-term abundance overall in trawl surveys since 1978. 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 2006 were one year old or less with another group at approximately two years old.

In 2006, 14,215 macroinvertebrate individuals were collected from 16 species. Macroinvertebrate abundance in 2006 nearly tripled the long-term mean of 4,890 individuals, and was the highest recorded since 2001 (Figure 28). Two species, blackspotted bay shrimp and Pacific sand dollar, accounted for 94% of the total abundance. Winter abundances were slightly greater than those recorded during summer surveys. In winter 2006, abundances downcoast of the discharge were substantially higher than all other stations, while abundances at the upcoast reference station were the lowest recorded during the survey. In contrast, during summer surveys upcoast and downcoast reference stations were substantially higher than was recorded immediately adjacent to the discharge. Abundances at Stations T1 through T3 were substantially higher during the summer than during the winter. The lower abundances recorded adjacent to the discharge during the summer may reflect a highly localized, but not substantial, effect of the warm water discharge on the macrobenthic inbertebrate community. Overall increases in abundance at these stations in comparison to winter sampling, as well as the overall increases in macroinvertebrate abundance suggests that any effect of the discharge is transient at best, with no indication of long-term effects on the macroinvertebrate community.

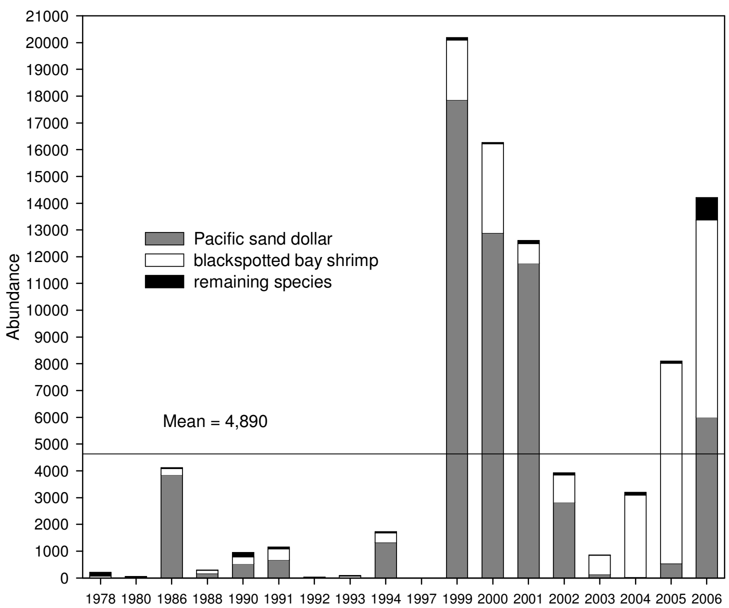



**Figure 28. Long-term abundance of macroinvertebrates collected by otter trawl by season and Station. Mandalay Generating Station NPDES, 2006.**

Surveys during 2006 continued a trend beginning with the summer 2002 survey, with blackspotted bay shrimp replacing Pacific sand dollar as the numerically dominant macroinvertebrate species in the area (Figure 28; MBC 1990, 1994, 1997-2001a, 2002-2005a; Ogden 1991-1993). This species is also common in trawl surveys at other locations in southern California, and plays an important role in the coastal food web. Blackspotted bay shrimp prefers mud and sand bottoms, feeding on small epibenthic and benthic fauna. 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). Annual abundance off some areas of California has varied widely, sometimes by more than tenfold (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).

Pacific sand dollar has been the most abundant macroinvertebrate in five winter surveys and nine summer surveys since 1978 (Appendix H-13; MBC 1979, 1981, 1986, 1988, 1990, 1994, 1997-2001a, 2002-2005a; Ogden 1991-1993). A large recruitment of Pacific sand dollars occurred off Mandalay between the summer 1997 and winter 1999 trawl surveys. Average size of the sand dollars off Mandalay increased from 0.13 and 0.12 kg per 100 individuals in winter and summer 1999 to 0.18 and 0.26 kg per 100 individuals in winter and summer 2000 and then doubled to 0.40 and 0.56 kg in winter and summer 2001. Average size of the sand dollars collected by trawl again increased to 0.68 kg and 0.94 kg per 100 individuals in winter and summer 2002 (MBC 1999-2001a, 2002). At the same time that the size of the individuals was increasing, the number of individuals caught in trawl surveys declined every year from 1990 to 2004, with only 47 Pacific sand dollars taken in 2004 trawls. Pacific sand dollar abundance again increased in 2005, and the increase has continued into 2006, with numbers higher than found in the area since 2001. Erratic recruitment is common in this species (Timko 1975), and although the reproductive strategy of

Pacific sand dollar is one of dispersal, larval settlement is often highest within or adjacent to existing sand dollar beds which already contain up to several hundred adults per square meter, perhaps in response to a chemical cue from the adults (Highsmith 1982).

## CONCLUSION

In 2006, fish communities were similar to what has been recorded in recent surveys, while macroinvertebrate abundance has increased due to increased numbers of common species. No significant differences in fish communities were detected between stations adjacent to the discharge and both upcoast and downcoast reference stations. Slight decreases in abundance were recorded at the stations adjacent to the discharge among the summer macroinvertebrate community. In contrast, fish communities did not show such localized effects, but rather a generally increased abundance downcoast of the discharge. Variability in fish and macroinvertebrate communities in the area appeared to be related to natural and seasonal differences in local populations and not related to operations at the Mandalay Generating Station. The results of this investigation suggest that the beneficial uses of the receiving waters were being maintained.

# IMPINGEMENT

Once through cooling water systems are commonly utilized by power generating stations adjacent to large water bodies (lake, river, bay, coastal ocean). These systems may potentially entrap organisms present in the source water utilized by the once-through-cooling (OTC) system. Cooling water is filtered 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. There are two units (1 and 2) which employ the use of once through cooling. 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. Cooling water enters the plant through two angled 5.9 meter-wide intake bays. To remove debris cooling water passes through two pairs of trash racks with 57.15 mm mesh as well as two pairs of vertical slide screens, which are 3.5 meters wide by 6.4 meters high with 12.7 mm mesh. The slide screens are positioned parallel to one another and perpendicular to the intake flow. One slide screen is deployed while the other is cleaned of debris by the use of a high pressure wash, which is activated automatically by pressure differential across the screen. All debris is discharged into a trash basket. Fish and macroinvertebrates are collected from these baskets.

Fish 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, usually over a 24-hour period. Coastal generating stations with OTC water systems periodically use hot water from the condensers to reduce biofouling. This is achieved by maintaining a temperature which exceeds the critical thermal tolerance of the biofouling organism, such as mussels. The use of hot water is more commonly referred to as a heat treatment. In this process, fish and macroinvertebrates unable to escape the intake area are similarly exposed to elevated temperatures, often causing mortality.

## MATERIALS AND METHODS

At the Mandalay Generating Station, all heat treatments were monitored in 2006. During heat treatments, 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 per event 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, and sex of select species. Total abundance for species with greater 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 taken. California spiny lobster (*Panulirus interruptus*) were counted, carapace length (CL) measured to the nearest millimeter, sexed, and an aggregate weight recorded.

In addition to heat treatment monitoring, monthly normal operation surveys were performed as well. To assess the impingement of organisms during periods of normal operation at the generating station, 24-hr surveys were conducted during representative periods of operation. During such surveys, the sliding screens and trash baskets were cleared of all accumulated debris at the start of the sampling period. At the end of the 24-hour period all accumulated material was processed using the same method as during heat treatment surveys.

Due to variation in daily operating patterns, all normal operation survey fish and macroinvertebrate data was standardized to circulated water flow rates to determine the rate of impingement by the following equation: Impingement Rate = Value/Circulated Water Volume in Million Gallons. Volume of water circulated was based on the water flow rate during the period surveyed. For each month, the mean monthly impingement rate was multiplied by the total monthly cooling water flow to derive an estimated monthly impinged abundance and biomass (kilogram [kg]) The estimated annual impinged abundance represents the summation of each estimated monthly abundance. No surveys occurred between December 2005 through February 2006 due to infrequent operation of the circulating water pumps. Estimated data for these months was derived by multiplying the mean impingement rate of November 2005 and March 2006, to represent the most seasonally relevant conditions available, by the sporadic reported cooling water flow volumes during the period of infrequent operations.

Data was recorded in the field on preprinted data sheets and entered into electronic format by Proteus Sea Farms. Field sheets and entered data were provided to MBC where in-house QA/QC measures were followed to ensure accurate transcription into digital format. Data were uploaded to the MBC fish impingement database for archiving. Length frequency distributions for those fishes examined were derived by rounding (1 to 4 = 0, 5 to 9 = 10) the recorded length to the nearest ten millimeters for each measurement type (SL, TL, or DW). Abundance per size class was plotted using MS Excel 2000. Those species that occurred in high enough abundance to result in more than 100 individuals being measured during the monitoring year were examined in further detail, including length frequency histograms. Data from both normal operation and heat treatment surveys were utilized for length frequency analysis.

## RESULTS

### Fish

One heat treatment and nineteen normal operation surveys were conducted during the 2006 monitoring year at Mandalay Generating Station. An estimated 112,164 individuals of 28 fish species with an estimated biomass of 1,502 kg were impinged during the 2006 monitoring year (Table 15 ). The most abundant species was shiner perch (*Cymatogaster aggregata*) with an estimated 48,209 individuals or 43% of the total abundance. Northern anchovy (*Engraulis mordax*), with 45,950

**Table 15 . Estimated abundance and biomass (kg) of fish species impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2006.**

| | Heat Treat. | | Observ. 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) |
| shiner perch | - | - | 1,552 | 11.939 | 48,209 | 386.046 | 48,209 | 386.046 | 43.0 | 25.7 |
| northern anchovy | - | - | 1,668 | 5.731 | 45,950 | 172.821 | 45,950 | 172.821 | 41.0 | 11.5 |
| topsmelt | 1 | 0.014 | 238 | 4.866 | 6,829 | 148.624 | 6,830 | 148.638 | 6.1 | 9.9 |
| silver surfperch | - | - | 1 | 0.025 | 3,664 | 91.611 | 3,664 | 91.611 | 3.3 | 6.1 |
| white seaperch | - | - | 88 | 8.307 | 3,369 | 296.740 | 3,369 | 296.740 | 3.0 | 19.8 |
| Pacific sardine | - | - | 19 | 0.363 | 1,173 | 14.987 | 1,173 | 14.987 | 1.0 | 1.0 |
| Pacific staghorn sculpin | - | - | 18 | 0.906 | 542 | 20.146 | 542 | 20.146 | 0.5 | 1.3 |
| Pacific herring | - | - | 12 | 0.566 | 481 | 20.509 | 481 | 20.509 | 0.4 | 1.4 |
| opaleye | 1 | 0.054 | 19 | 0.450 | 431 | 10.123 | 432 | 10.177 | 0.4 | 0.7 |
| white seabass | - | - | 5 | 4.650 | 261 | 208.811 | 261 | 208.811 | 0.2 | 13.9 |
| bat ray | - | - | 7 | 2.051 | 223 | 66.492 | 223 | 66.492 | 0.2 | 4.4 |
| bay pipefish | - | - | 5 | 0.013 | 207 | 0.559 | 207 | 0.559 | 0.2 | 0.0 |
| queenfish | - | - | 6 | 0.018 | 172 | 0.557 | 172 | 0.557 | 0.2 | 0.0 |
| diamond turbot | - | - | 3 | 0.201 | 108 | 4.655 | 108 | 4.655 | 0.1 | 0.3 |
| walleye surfperch | - | - | 1 | 0.006 | 94 | 0.561 | 94 | 0.561 | 0.1 | 0.0 |
| jacksmelt | - | - | 4 | 0.736 | 79 | 16.047 | 79 | 16.047 | 0.1 | 1.1 |
| deepbody anchovy | - | - | 4 | 0.041 | 76 | 0.878 | 76 | 0.878 | 0.1 | 0.1 |
| Pacific barracuda | - | - | 3 | 0.981 | 47 | 15.307 | 47 | 15.307 | 0.0 | 1.0 |
| striped mullet | - | - | 2 | 0.165 | 44 | 3.671 | 44 | 3.671 | 0.0 | 0.2 |
| jack mackerel | - | - | 2 | 0.106 | 35 | 1.848 | 35 | 1.848 | 0.0 | 0.1 |
| thornback | - | - | 1 | 0.523 | 34 | 17.665 | 34 | 17.665 | 0.0 | 1.2 |
| crevice kelpfish | - | - | 1 | 0.009 | 31 | 0.278 | 31 | 0.278 | 0.0 | 0.0 |
| rainbow seaperch | - | - | 1 | 0.007 | 30 | 0.207 | 30 | 0.207 | 0.0 | 0.0 |
| spotted kelpfish | - | - | 1 | 0.024 | 28 | 0.674 | 28 | 0.674 | 0.0 | 0.0 |
| yellowfin goby | - | - | 2 | 0.045 | 25 | 0.539 | 25 | 0.539 | 0.0 | 0.0 |
| California halibut | - | - | 1 | 0.036 | 19 | 0.668 | 19 | 0.668 | 0.0 | 0.0 |
| round stingray | 1 | 0.772 | - | - | - | - | 1 | 0.772 | 0.0 | 0.1 |
| Total | 3 | 0.840 | 3,664 | 42.765 | 112,161 | 1,501.024 | 112,164 | 1,501.864 | | |
| Number of Species | 3 | | 26 | | 26 | | 27 | | | |

individuals, was the second most abundant species contributing 41% to total abundance. The remaining 26 species together accounted for 16% of the total abundance, with a calculated total of 18,005 individuals. Of these 26 species, topsmelt (*Atherinops affinis*) was the most abundant with 6,830 individuals and round sting ray (*Urobatis halleri*) was the least abundant with one individual. In 2006, two individuals of the introduced fish species yellowfin goby (*Acanthogobius flavimanus*) were taken during normal operation surveys, for an estimated total of 25 for the survey year.

Shiner perch also contributed most to biomass, accounting for 26% of the estimated total biomass at 386 kg (Table 15 ). White seaperch (*Phanerodon furcatus*) was the second most abundant species with an estimated 297 kg or 20% of the total biomass. White seabass (*Atractoscion nobilis*), the third most abundant species, contributed 14% to biomass with 209 kg and northern anchovy with 173 kg or 11% of the total was fourth. Each of the remaining 24 species together made up less than 30% of the total biomass with an estimated weight of 437 kg. Of these 24 species topsmelt contributed most to biomass with an estimated 149 kg while rainbow seaperch (*Hypsurus caryi*) contributed the least at 0.2 kg.

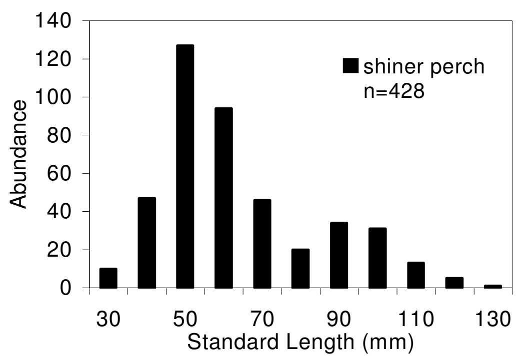



**Figure 29. Length frequency of shiner perch (*Cymatogaster aggregata*) impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2006.**

### Length Frequency Analysis

Three fish species were impinged in high enough abundances (>100 individuals) to be analyzed for length frequency to estimate the age structure of the impinged individuals. Shiner perch, the most abundant species, exhibited a unimodal distribution among impinged individuals, peaking at 50 mm SL (Figure 29). Topsmelt also exhibited a unimodal distribution among impinged individuals, peaking at 120 mm SL (Figure 30). Recorded lengths of northern anchovy indicate a unimodal distribution, dominated by the 70-mm SL size class (Figure 31).

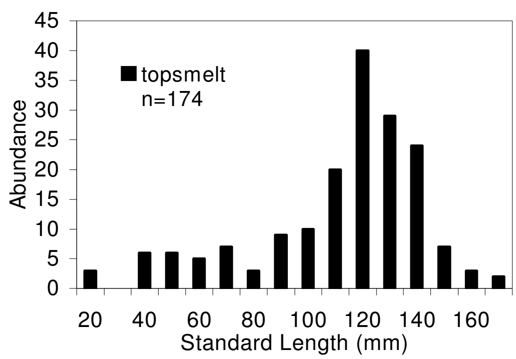



**Figure 30. Length frequency of topsmelt (*Atherinops affinis*) impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2006.**

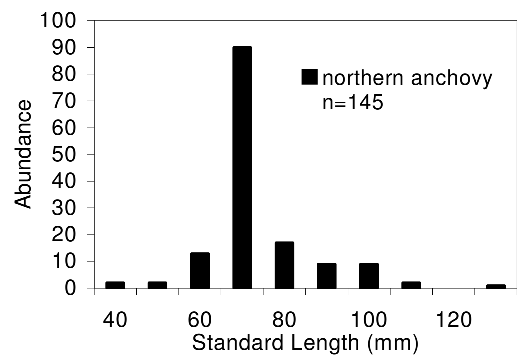



**Figure 31. Length frequency of northern anchovy (*Engraulis mordax*) impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2006.**

### Macroinvertebrates

A calculated 27,475 individuals of seven macroinvertebrates species with an estimated biomass of 67 kg were impinged during the 2006 monitoring year at Mandalay Generating Station (Tables 16 and 17). Pacific littleneck (*Protothaca staminea*), collected exclusively during a single heat treatment, dominated both abundance and biomass, with an estimated 27,020 individuals or 98% of the total abundance, and 52% of the estimated biomass, at 35 kg. Together, the remaining six species accounted for less than 2% of the total abundance, with an average of 76 individuals per species. California two-spot octopus (*Octopus bimaculatus/bimaculoides*) contributed the second most to macroinvertebrate weight with an estimated biomass of 14 kg. California spiny lobster with a biomass of 13 kg contributed the third most to total weight. Each of the remaining four species together contributed about 9% to the total, with an estimated biomass of 6 kg.

**Table 16. Estimated abundance of macroinvertebrate species impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2006.**

| Species | Heat Treat. | Observ. Norm. Op. | Est. Norm. Op. | Annual Total | Percent Total |
|---|---|---|---|---|---|
| Pacific littleneck | 27,020 | - | - | 27,020 | 98.3 |
| California aglaja | - | 3 | 153 | 153 | 0.6 |
| California two-spot octopus | 2 | 3 | 104 | 106 | 0.4 |
| California spiny lobster | - | 3 | 85 | 85 | 0.3 |
| striped shore crab | 3 | 2 | 73 | 76 | 0.3 |
| blackspotted bay shrimp | - | 1 | 19 | 19 | 0.1 |
| yellowleg shrimp | - | 1 | 16 | 16 | 0.1 |
| Total | 27,025 | 13 | 450 | 27,475 | |
| Number of Species | 3 | 6 | 6 | 7 | |

**Table 17. Estimated biomass (kg) of macroinvertebrate species impinged during heat treatment and normal operation surveys. Mandalay Generating Station NPDES, 2006.**

| Species | Heat Treat. | Observ. Norm. Op. | Est. Norm. Op. | Annual Total | Percent Total |
|---|---|---|---|---|---|
| Pacific littleneck | 34.74 | - | - | 34.740 | 51.7 |
| California two-spot octopus | 0.146 | 0.381 | 13.506 | 13.652 | 20.3 |
| California spiny lobster | - | 0.449 | 12.762 | 12.762 | 19.0 |
| California aglaja | - | 0.115 | 5.143 | 5.143 | 7.7 |
| striped shore crab | 0.036 | 0.026 | 0.799 | 0.835 | 1.2 |
| blackspotted bay shrimp | - | 0.002 | 0.037 | 0.037 | 0.1 |
| yellowleg shrimp | - | 0.001 | 0.016 | 0.016 | 0.0 |
| Total | 34.922 | 0.974 | 32.263 | 67.185 | |

## DISCUSSION

To evaluate fish loss at the Mandalay Generating Station, fish impingement was monitored during one heat treatment and nineteen normal operation surveys in 2006. Based on these surveys, a calculated total of 112,164 individuals representing 28 fish species and weighing 1,502 kg were impinged at the generating station. Overall impinged abundance estimates for the 2006 monitoring year were more than twice that reported for 2005, and represent the second highest since 2002 (Figure 32; MBC 2001a, 2002-2005a). In addition, a calculated 27,475 individuals representing seven macroinvertebrate species and weighing more than 67 kg were impinged, the highest total since impingement data was first reported in 2001. From 2001-2005 the average number of normal operation surveys per year was five. For the 2006 monitoring year, however, the number normal operation surveys performed was increased as part of a special study for 316(b) compliance. These additional surveys may account for the increase in fish abundance during the 2006 monitoring year compared to most previous years.

Estimates of impinged shiner perch abundance increased by 18% and biomass by 22% over the values reported for the 2005 monitoring year, and are the highest reported. Shiner perch have been reported as one of the top two most abundant fish species since the 2001 monitoring year (MBC 2001a, 2002-2005a). Still, the estimated 2006 total represented about one-half of the average annual number of 105,942 individuals impinged during two years of impingement surveys conducted at the Mandalay Generating Station from October 1978 to September 1980 (Herbinson 1981).

The size of the shiner perch impinged in 2006 (Figure 29) indicates multiple year classes were impinged, with most in the 50-mm and 60-mm size classes, representing young-of-the-year (YOY) (Love 1996). Shiner perch range from San Quintin Bay, Baja California to Port Wrangell, Alaska (Miller and Lea 1972). Shiner perch occur primarily in shallow-water marine, bay, and estuarine habitats, and is demersal on sandy and muddy bottoms (Emmett et al. 1991). Shiner perch have no larval stage. At birth, fully developed young are about 34 to 78 mm in length (Wilson and Millemann 1969, Hart 1973). Shiner perch live for about eight years and reach about 180 mm in length (Miller and Lea 1972, Hart 1973).

Shiner perch abundances declined in some impingement and trawl catches in southern California after the 1970s (MBC 2001b, Stull and Tang 1996). This decline could be related to a measurable shift in oceanic temperature regimes from a cool water to a warmer water offshore of California in the 1980s and 1990s (MBC 2001c). In southern California, zooplankton (a food source for shiner perch) decreased in biomass by about 80% between 1951 and 1993, with most of the decline occurring after the 1970s (Allen 1982, Roemmich and McGowan 1995).

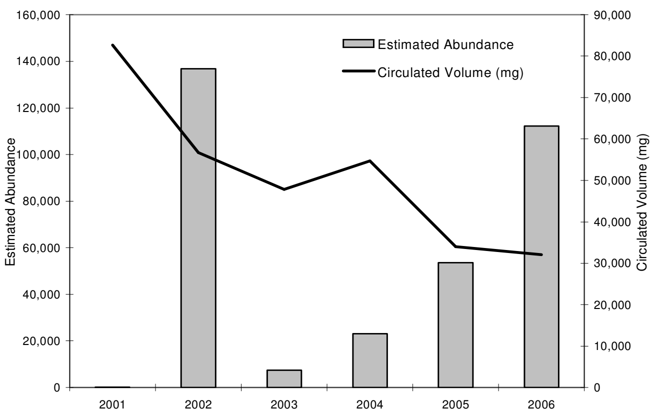



**Figure 32. Annual estimated abundance of fish impinged during heat treatment and normal operation surveys and annual reported circulating water volume (mg). Mandalay Generating Station NPDES, 2006.**

Northern anchovy was the second most abundant species in 2006. Lengths for northern anchovy were predominantly within the 70-mm SL size class representing YOY (Figure 30; Parrish et al. 1985). Northern anchovy range from Cape San Lucas, Baja California to Queen Charlotte Island, British Columbia and offshore to 480 km, primarily in association with soft substrate habitat (Hart 1973, Allen 1985). Juveniles are generally more common inshore and in estuaries and larvae are found from the surface to 75 m in epipelagic and neritic waters (Garrison and Miller 1982). The northern anchovy egg hatches in two to four days, and has a larval phase lasting approximately 70 days. Juvenile northern anchovy undergo transformation into a juvenile at about 35 to 40 mm, reaching 102 mm in their first year and 119 mm in their second (Hart 1973, Sakagawa and Kimura 1976, MBC 1987, Moser 1996). Live baitfish for the sportfishing community is the principle fishery for northern anchovy within southern California, with only a limited fishery currently operating (Bergen and Jacobson 2001). Adults offshore are preyed upon by marine fishes, mammals, and birds, especially California brown pelican (*Pelecanus occidentalis californicus*) (Bergen and Jacobson 2001). Links between breeding success of the endangered California brown pelican and northern anchovy abundance has been observed.

Topsmelt was the third most abundant fish species in 2006, although slightly more individuals of this species were measured than northern anchovy. Topsmelt are common in nearshore tidal waters, ranging from the Gulf of California to Vancouver Island, British Columbia (Miller and Lea 1972). Common around soft-bottom habitat, topsmelt are frequent residents of 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). Topsmelt can grow to lengths of 360 mm, attaining a length of 100 mm in the first year and 185 mm by its second year, growing proportionally less during each subsequent year (Hart 1973, Gregory 2001) Length frequency analysis of topsmelt impinged in 2006 indicate a principal distribution in the 120- to 140-mm SL size class or individuals almost two years old (Figure 31).

In 2006, two yellowfin goby were taken during normal operation surveys: one in February and one in May. Estimated total for yellowfin goby was 25 individuals impinged during the survey year. Previously, one yellowfin goby was taken in impingement sampling during 2002 for an estimated yearly total of 26 individuals (MBC 2002). Yellowfin goby were introduced from Asia, with the first recorded occurrence in California in San Francisco Bay in 1963 (Haaker 1979). The earliest record of the species in Los Angeles Harbor was a photograph taken in 1977, with a specimen first collected in 1978. The northern extent of the species is Tomales Bay, with the southern extent San Diego Bay, where in 2002 yellowfin goby was ranked as the 46th most abundant fish species in the bay (Miller and Lea 1972, Williams et al. 1998, Allen 2002). Yellowfin goby have wide thermal (11-28°C) and salinity tolerances, from freshwater (<5 psu) to marine (>25 psu) while the scattered occurrence of the species in California suggests multiple introductions. (Dill and Cordone 1997).

The most abundant macroinvertebrate species during the 2006 impingement survey was Pacific littleneck, with 27,020 individuals at 35 kg, all collected during a single heat treatment. This was the highest recorded abundance since 2001 (MBC 2001a, 2002-2005a). Only four individuals were observed during a single heat treatment during the 2003 monitoring year (MBC 2003). Pacific littleneck clam is most commonly found in coarse sand or sandy mud in bays or coves where it burrows 3 to 8 cm below the surface. Pacific littleneck clam ranges from the Aleutian Islands, Alaska to Cabo San Lucas, Baja California. This clam is one of the most abundant west coast species and supports a recreational fishery in southern California. Studies in Mugu Lagoon, Ventura Co. show that mortality rates are high in both young and old individuals, with the population primarily compromised of young adults (Morris et. al 1980).

California spiny lobster, a commercially important macroinvertebrate, was collected in low abundances exclusively during normal operation surveys. California spiny lobster has been a consistent member of the impinged macroinvertebrate community at Mandalay Generating Station since 2002, with three individuals collected in 2003, 2005, and 2006 (MBC 2003 and 2005a). 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 is commonly found within caves and crevices of rocky substrate throughout its range from Monterey Bay, California to Manzanillo, Mexico (Barsky 2001). Fishing, both recreational and commercial, within State of California waters is highly regulated by the California Department of Fish and Game, with a limited harvest season from early October to mid-March (Barsky 2001).

Fish abundance in 2006 was dominated by shiner perch and northern anchovy, the two most common species collected in normal operation surveys. Seven macroinvertebrate species were collected during impingement surveys, Pacific littleneck, striped shore crab, and California two-spot octopus being the three most abundant observed. Overall, fish and macroinvertebrate species impinged in 2006 were similar to those collected in previous survey and are common inhabitants of nearshore and bay and harbor environments.

## CONCLUSION

The estimated abundance and biomass of fish impinged in 2006 was higher than in 2005, but less than in 2002. Increased numbers in 2006 are likely a result of more intensive sampling conducted than in prior sampling years. All fish and macroinvertebrate species collected were typical of the bay and nearshore environments from which the generating station withdraws its cooling water. There was no indication that plant operations are adversely affecting the local marine macrofaunal community.

## 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., 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. 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, 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 201-202 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, 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.

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.

Bergen, D.R. and L.D. Jacobson. 2001. Northern anchovy. Pages 303-305 *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. 592 pp.

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.

Dill, W.A. and A.J. Cordone. 1997. History and status of introduced fished in California, 1871-1996. Calif. Dept. Fish Game Fish Bulletin 178: 414 p.

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

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.

Environmental Quality Analysts, Inc., and Marine Biological Consultants, Inc. 1975. Long Beach Generating Station marine monitoring studies - 1974 Annual Report. Prepared for Southern California Edison Company, June 1975. Vol. II. Appendices.

EPA. See United States Environmental Protection Agency.

EQA/MBC. See Environmental Quality Analysts and Marine Biological Consultants, Inc.

Eschmeyer, W.N., E.S. Herald, and H. Hammann. 1983. A field guide to Pacific Coast fishes of North America. Houghton-Mifflin Co., Boston, MA. 336 p.

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.

Garrison, K.J. and B.S. Miller. 1982. Review of the early life history of Puget Sound fishes. Fish. Res. Inst., Univ. Wash., Seattle, WA. FRI-UW-8216. 729 p.

Goldberg, S.R. 1976. Seasonal spawning cycles of the Sciaenid fishes *Genyonemus lineatus* and *Seriphus politus*. Fish. Bull., U.S. 74(4):983-984.

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

Haaker, P.L. 1979.Two Asiatic gobiid fishes, *Tridentiger trigoncephalus* and *Acanthogobius flavimanus*, in southern California. Bull. Southern California Acad. Sci. 78(1):56-61.

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

Herbinson, K.T. 1981. 316(b) Fish Impingement Inventory, Southern California Edison Company. April 1981.

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. 1996. Probably more than you want to know about the fishes of the Pacific Coast. Really Big Press, Santa Barbara, CA. Second edition. 381 p.

Love, M.S., G.E. McGowen, W. Westphal, R.J. Lavenberg, and L. Martin. 1984. Aspects of the life history and fishery of the white croaker, *Genyonemus lineatus* (Sciaenidae), off California. Fishery Bulletin 82:179-198

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. 1987. Ecology of important fisheries species offshore California. OCS Study 86-0093. Prepared for Minerals Management Service, Pacific OCS Region. 251 p.

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. 2005a. 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. 2005b. National Pollutant Discharge Elimination System 2006 receiving water monitoring report, Reliant Energy Ormond Beach Generating Station, Ventura County, California. Prepared for Reliant Energy. 53 p. plus appendices.

MBC Applied Environmental Sciences. 2005c. National Pollutant Discharge Elimination System, 2005 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. 78 p. plus appendices.

MBC Applied Environmental Sciences. 2005d. National Pollutant Discharge Elimination System, 2005 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. 62 p. plus appendices.

MBC Applied Environmental Sciences. 2005e. National Pollutant Discharge Elimination System, 2005 receiving water monitoring report, AES Redondo Beach Generating Station L.L.C., Los Angeles County, California. Prepared for AES Redondo Beach L.L.C. 70 p. plus appendices.

MBC Applied Environmental Sciences. 2006a. National Pollutant Discharge Elimination System 2006 receiving water monitoring report, Reliant Energy Ormond Beach Generating Station, Ventura County, California. Prepared for Reliant Energy. In prep.

MBC Applied Environmental Sciences. 2006b. National Pollutant Discharge Elimination System, 2006 receiving water monitoring report, Harbor Generating Station, Los Angeles County, California. Prepared for City of Los Angeles Department of Water and Power. In prep.

MBC Applied Environmental Sciences. 2006c. National Pollutant Discharge Elimination System, 2006 receiving water monitoring report, Haynes and AES Alamitos L.L.C. Generating Station, Los Angeles County, California. 2006 survey. Prepared for AES Alamitos L.L.C., and Los Angeles Department of Water and Power. In prep.

MBC Applied Environmental Sciences. 2006d. National Pollutant Discharge Elimination System, 2006 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. 2006e. National Pollutant Discharge Elimination System, 2006 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. 2006f. National Pollutant Discharge Elimination System, 2006 receiving water monitoring report, Long Beach Generating Station, Los Angeles County, California. Long Beach Generation L.L.C. In prep.

Merrill, R.J., and E.S. Hobson. 1970. Field observations of *Dendraster excentricus*, a sand dollar of western North America. Amer. Midl. Natur. 83:595-624.

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.

Moore, S. L. and P. W. Wild. 2001. White Croaker. *In*: Leet, W. S., C. M. Dewees, R. Klingbeil, E. J. Larson (eds.) California's Living Marine Resources: A Status Report. University of California Press, Agriculture and Natural Resources Publication SG01-11. 592 p.

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

Moser, H.G. (ed.). 1996. The early stages of fishes in the California Current Region. CalCOFI Atlas No. 33. Allen Press, Inc., Lawrence, KS. 1505 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.

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.

Parrish, R. H., D. L. Mallicoate, and K. F. Mais. 1985. Regional variations in the growth and age composition of northern anchovy, *Enraulis mordax*. Fish. Bull. 83(4):483-496.

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

Roemmich, D. and J. McGowan. 1995. Climatic warming and the decline of zooplankton in the California Current. Science 267:1324-1326.

Sakagawa, G.T. and M. Kimura. 1976. Growth of laboratory-reared northern anchovy, *Engraulis mordax*, from southern California. Fish. Bull. U.S. 74(2):271-279.

SCAMIT. See Southern California Association of Marine Invertebrate Taxonomists

SCCWRP. See Southern California Coastal Water Research Project.

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, A.L. 1981. Comparison of macrofaunal invertebrates in sand dollar (*Dendraster excentricus*) beds and adjacent areas free of sand dollars. Marine Biology 65:191-198.

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.

Sokal, R.R. and F.J. Rohlf. 1995. Biometry. The principles and practice of statistics in biological research. Third Edition. State University of New York at Stony Brook. 887 p.

Southern California Association of Marine Invertebrate Taxonomists. 2001. A Taxonomic Listing of Soft Bottom Macro- and Megainvertebrates from Infaunal and Epibenthic Programs in the Southern California Bight, Edition 4. Southern California Association of Marine Invertebrate Taxonomists. San Pedro, CA. 192 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.

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. 1986. California state mussel watch 1984-85. Water Qual. Mon. Rpt. 86-3WQ. 156 p. plus appendices.

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.

Stull, J.K. and C.L. Tang. 1996. Demersal fish trawls off Palos Verdes, southern California, 1973-1993. CalCOFI Rep. 37:211-240.

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.

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.

Williams, G.D., J.S. Desmond, and J.B. Zedler. 1998. Extension of 2 nonindigenous fishes, *Acanthogobius flavimanus* and *Poecilia latpinna*, into San Diego Bay marsh habitats. California Fish Game 84(1): 1-17.

Wilson, D.C. and R.E. Millemann. 1969. Relationships of female age and size embryo number and size in the shiner perch, *Cymatogaster aggregata*. J. Fish. Res. Board Can. 267:2339-2344.

**PERSONAL COMMUNICATION**

Norfolk, G. 2006. Reliant Energy Mandalay Generating Station.

Siekiel-Zdzienicki, B. J. 2006. 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 | impingement | 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

Dennis A. Dickinson
Executive Officer

Date: April 26, 2001

/COD

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

CA0001180

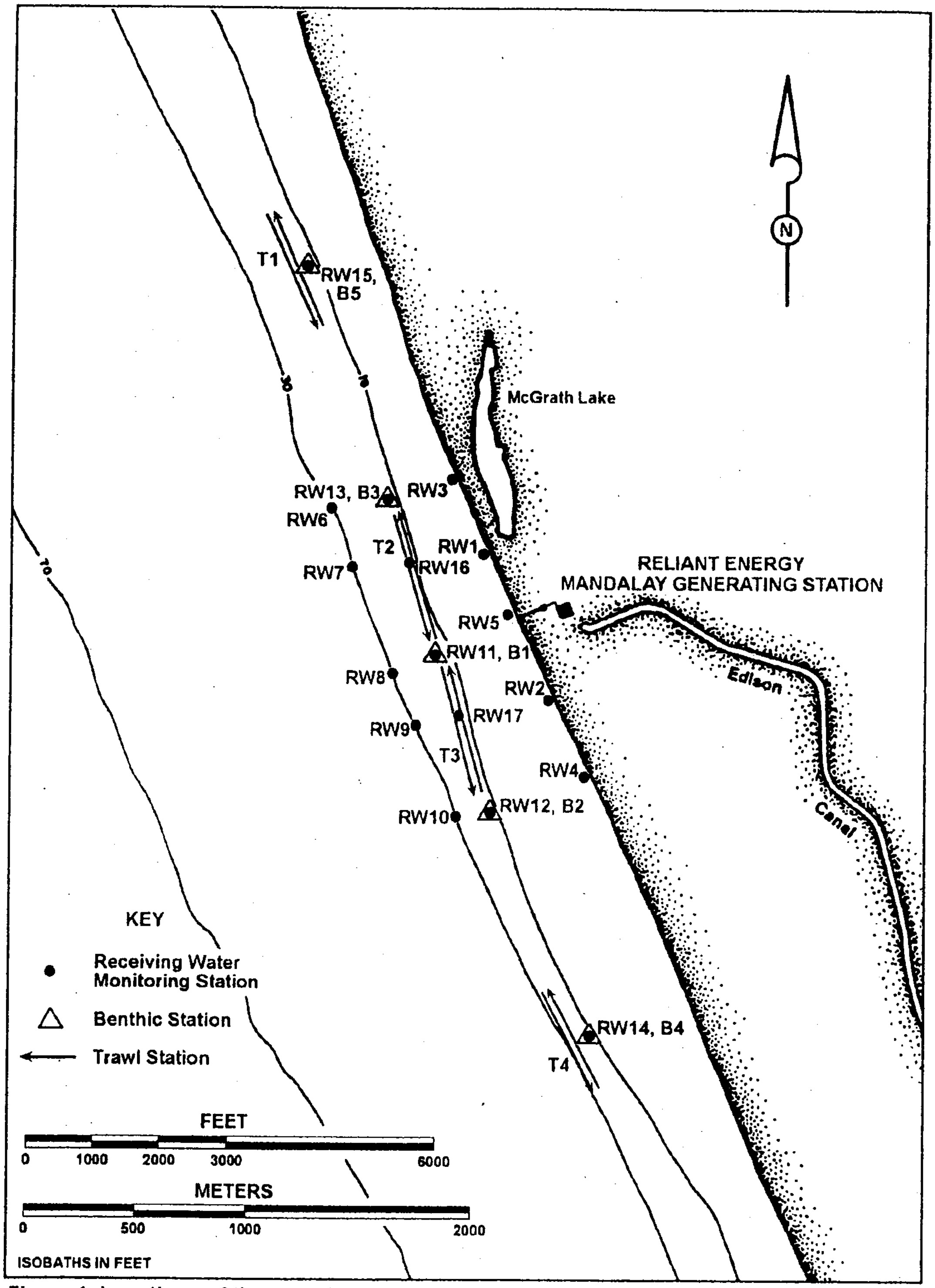



Figure 1. Locations of the sampling stations. Reliant Energy Mandalay Generating Station.

# APPENDIX B

## Receiving water quality parameters by station

**Appendix B-1. Water quality parameters at each receiving water monitoring station during flood and ebb tides. Mandalay Generating Station NPDES, winter 2006.**

| | | Temp. (°C) | | Oxygen (mg/l) | | pH | | Salinity (psu) | |
|---|---|---|---|---|---|---|---|---|---|
| | Depth (m) | FLOOD | EBB | FLOOD | EBB | FLOOD | EBB | FLOOD | EBB |
| **Surf Zone** | | | | | | | | | |
| RW1 | 0 | 13.33 | 16.06 | 8.48 | 9.34 | 8.08 | 8.41 | 33.05 | |
| RW2 | 0 | 13.41 | 15.87 | 8.42 | 9.50 | 7.99 | 8.30 | 33.38 | |
| RW3 | 0 | 13.34 | 16.00 | 8.54 | 9.24 | 8.10 | 8.44 | 33.18 | 33.97 |
| RW4 | 0 | 13.41 | 15.98 | 8.45 | 9.46 | 8.03 | 8.35 | 33.45 | 33.52 |
| RW5 | 0 | 13.38 | 16.25 | 8.45 | 9.00 | 7.94 | 8.42 | 32.97 | |
| **Offshore** | | | | | | | | | |
| RW6 | 0 | 13.82 | 15.47 | 8.67 | 12.88 | 8.03 | 8.26 | 32.37 | 32.13 |
| | 1 | 13.79 | 15.42 | 8.76 | 13.18 | 8.02 | 8.20 | 32.41 | 32.54 |
| | 2 | 13.37 | 14.57 | 8.73 | 12.32 | 7.97 | 8.26 | 33.25 | 33.26 |
| | 3 | 12.54 | 13.45 | 8.38 | 13.19 | 7.82 | 8.12 | 33.55 | 33.61 |
| | 4 | 11.81 | 12.41 | 6.31 | 11.83 | 7.63 | 7.88 | 33.65 | 33.81 |
| | 5 | 11.57 | 11.93 | 4.81 | 8.74 | 7.56 | 7.77 | 33.70 | 33.76 |
| | 6 | 11.49 | 11.74 | 4.57 | 7.13 | 7.56 | 7.74 | 33.67 | 33.72 |
| | 7 | 11.42 | 11.46 | 4.63 | 6.49 | 7.56 | 7.70 | 33.68 | 33.77 |
| | 8 | 11.38 | 11.35 | 4.65 | 5.98 | 7.57 | 7.68 | 33.68 | 33.74 |
| | 9 | 11.36 | 11.34 | 4.66 | 5.60 | 7.58 | 7.68 | 33.68 | 33.70 |
| | 10 | 11.36 | 11.34 | 4.63 | 5.46 | 7.57 | 7.67 | 33.68 | 33.69 |
| RW7 | 0 | 13.85 | 15.89 | 8.93 | 18.29 | 8.04 | 8.56 | 32.13 | 32.86 |
| | 1 | 13.83 | 14.64 | 8.96 | 19.23 | 8.04 | 8.41 | 32.24 | 33.53 |
| | 2 | 13.17 | 13.57 | 9.05 | 17.64 | 7.95 | 8.13 | 33.40 | 33.43 |
| | 3 | 12.54 | 12.54 | 8.20 | 13.25 | 7.75 | 7.90 | 33.58 | 33.78 |
| | 4 | 11.92 | 12.07 | 6.43 | 10.17 | 7.66 | 7.82 | 33.68 | 33.79 |
| | 5 | 11.58 | 11.83 | 5.56 | 8.29 | 7.60 | 7.75 | 33.68 | 33.75 |
| | 6 | 11.47 | 11.59 | 4.94 | 7.17 | 7.58 | 7.72 | 33.68 | 33.70 |
| | 7 | 11.44 | 11.38 | 4.77 | 6.49 | 7.58 | 7.69 | 33.67 | 33.73 |
| | 8 | 11.37 | 11.34 | 4.78 | 5.97 | 7.58 | 7.68 | 33.68 | 33.70 |
| | 9 | 11.33 | 11.34 | 4.75 | 5.70 | 7.58 | 7.68 | 33.69 | 33.70 |
| | 10 | 11.31 | 11.33 | 4.68 | 5.56 | 7.58 | 7.68 | 33.68 | 33.69 |
| | 11 | 11.31 | | 4.65 | | 7.58 | | 33.68 | |
| RW8 | 0 | 13.84 | 15.50 | 8.73 | 14.81 | 8.03 | 8.36 | 32.25 | 32.81 |
| | 1 | 13.81 | 14.95 | 8.78 | 14.98 | 8.02 | 8.34 | 32.07 | 33.04 |
| | 2 | 13.14 | 12.67 | 8.86 | 14.70 | 7.90 | 7.95 | 33.41 | 33.71 |
| | 3 | 12.49 | 12.06 | 8.03 | 10.03 | 7.74 | 7.83 | 33.72 | 33.83 |
| | 4 | 11.92 | 11.66 | 6.47 | 8.19 | 7.65 | 7.75 | 33.78 | 33.73 |
| | 5 | 11.51 | 11.56 | 5.57 | 7.07 | 7.60 | 7.71 | 33.79 | 33.69 |
| | 6 | 11.46 | 11.50 | 5.02 | 6.38 | 7.60 | 7.70 | 33.71 | 33.69 |
| | 7 | 11.40 | 11.47 | 4.93 | 6.00 | 7.59 | 7.70 | 33.70 | 33.68 |
| | 8 | 11.27 | 11.43 | 4.81 | 5.84 | 7.58 | 7.69 | 33.73 | 33.69 |
| | 9 | 11.22 | 11.38 | 4.72 | 5.67 | 7.57 | 7.68 | 33.70 | 33.69 |
| | 10 | 11.21 | 11.35 | 4.66 | 5.57 | 7.58 | 7.68 | 33.70 | 33.69 |

Appendix B-1. (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 | 13.78 | 15.48 | 8.70 | 15.62 | 7.99 | 8.38 | 32.13 | 32.73 |
| | 1 | 13.69 | 14.90 | 8.70 | 15.98 | 7.98 | 8.37 | 32.55 | 32.89 |
| | 2 | 13.36 | 12.71 | 8.71 | 15.03 | 7.94 | 8.06 | 33.33 | 33.52 |
| | 3 | 12.77 | 12.06 | 8.46 | 9.76 | 7.80 | 7.86 | 33.65 | 33.65 |
| | 4 | 12.05 | 11.57 | 7.03 | 7.72 | 7.67 | 7.75 | 33.81 | 33.65 |
| | 5 | 11.70 | 11.49 | 5.71 | 6.50 | 7.63 | 7.71 | 33.70 | 33.66 |
| | 6 | 11.51 | 11.48 | 5.24 | 5.96 | 7.61 | 7.70 | 33.70 | 33.66 |
| | 7 | 11.35 | 11.47 | 5.13 | 5.75 | 7.59 | 7.70 | 33.72 | 33.66 |
| | 8 | 11.23 | 11.47 | 4.88 | 5.64 | 7.58 | 7.70 | 33.73 | 33.67 |
| | 9 | 11.19 | 11.47 | 4.72 | 5.52 | 7.58 | 7.70 | 33.70 | 33.67 |
| | 10 | 11.18 | 11.47 | 4.67 | 5.47 | 7.58 | 7.70 | 33.70 | 33.67 |
| | 11 | 11.18 | | 4.64 | | 7.58 | | 33.70 | |
| RW10 | 0 | 13.92 | 14.04 | 8.81 | 11.93 | 8.01 | 8.14 | 31.86 | 33.04 |
| | 1 | 13.89 | 13.04 | 8.81 | 12.18 | 8.00 | 8.10 | 32.15 | 33.26 |
| | 2 | 13.29 | 11.98 | 8.89 | 10.40 | 7.93 | 7.90 | 33.48 | 33.60 |
| | 3 | 12.83 | 11.57 | 8.06 | 7.28 | 7.81 | 7.78 | 33.57 | 33.70 |
| | 4 | 12.41 | 11.50 | 6.73 | 6.36 | 7.74 | 7.74 | 33.64 | 33.65 |
| | 5 | 12.09 | 11.45 | 6.21 | 5.99 | 7.69 | 7.72 | 33.65 | 33.65 |
| | 6 | 11.64 | 11.44 | 5.71 | 5.78 | 7.64 | 7.72 | 33.67 | 33.65 |
| | 7 | 11.33 | 11.40 | 5.27 | 5.62 | 7.61 | 7.70 | 33.70 | 33.65 |
| | 8 | 11.24 | 11.37 | 4.92 | 5.50 | 7.60 | 7.70 | 33.70 | 33.66 |
| | 9 | 11.20 | 11.36 | 4.87 | 5.42 | 7.60 | 7.70 | 33.70 | 33.66 |
| | 10 | 11.20 | 11.34 | 4.82 | 5.36 | 7.60 | 7.70 | 33.70 | 33.66 |
| | 11 | 11.20 | | 4.84 | | 7.59 | | 33.70 | |
| RW11 | 0 | 13.71 | 15.45 | 8.71 | 13.72 | 8.01 | 8.35 | 32.18 | 32.69 |
| | 1 | 13.69 | 14.95 | 8.73 | 14.61 | 8.00 | 8.32 | 32.21 | 32.74 |
| | 2 | 13.09 | 13.32 | 8.77 | 12.68 | 7.94 | 8.04 | 33.12 | 33.39 |
| | 3 | 12.17 | 12.62 | 7.78 | 9.02 | 7.74 | 7.86 | 33.66 | 33.59 |
| | 4 | 11.94 | 12.08 | 5.88 | 7.61 | 7.66 | 7.78 | 33.65 | 33.66 |
| | 5 | 11.76 | | 5.25 | | 7.61 | | 33.66 | |
| RW12 | 0 | 13.59 | 14.50 | 8.68 | 10.59 | 8.01 | 8.11 | 32.40 | 32.71 |
| | 1 | 13.60 | 12.93 | 8.69 | 11.12 | 8.00 | 8.05 | 32.39 | 33.35 |
| | 2 | 12.99 | 11.96 | 8.80 | 9.16 | 7.89 | 7.87 | 33.27 | 33.59 |
| | 3 | 12.53 | 11.86 | 7.72 | 7.44 | 7.77 | 7.78 | 33.70 | 33.62 |
| | 4 | 12.37 | 11.68 | 6.78 | 6.44 | 7.74 | 7.73 | 33.69 | 33.67 |
| | 5 | 11.94 | 11.62 | 6.50 | 5.89 | 7.68 | 7.71 | 33.74 | 33.65 |
| | 6 | 11.82 | 11.60 | 5.74 | 5.70 | 7.63 | 7.70 | 33.69 | 33.65 |
| RW13 | 0 | 13.62 | 15.84 | 8.54 | 15.59 | 7.99 | 8.39 | 32.27 | 32.26 |
| | 1 | 13.56 | 15.45 | 8.51 | 14.93 | 7.98 | 8.38 | 32.49 | 32.67 |
| | 2 | 13.05 | 14.43 | 8.22 | 15.79 | 7.90 | 8.31 | 33.25 | 32.87 |
| | 3 | 11.98 | 13.38 | 7.34 | 13.15 | 7.76 | 8.06 | 33.63 | 33.23 |
| | 4 | 11.88 | 12.66 | 5.42 | 10.33 | 7.62 | 7.92 | 33.64 | 33.58 |
| | 5 | 11.87 | 12.29 | 4.94 | 8.71 | 7.60 | 7.79 | 33.65 | 33.64 |

Appendix B-1. (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 |
|---|---|---|---|---|---|---|---|---|---|
| RW14 | 0 | 13.78 | 14.20 | 9.43 | 10.00 | 8.05 | 8.06 | 32.69 | 32.96 |
| | 1 | 13.78 | 12.95 | 9.42 | 10.34 | 8.05 | 8.00 | 32.76 | 33.64 |
| | 2 | 13.30 | 11.81 | 9.52 | 9.62 | 7.97 | 7.81 | 33.35 | 33.68 |
| | 3 | 12.84 | 11.69 | 8.73 | 6.82 | 7.84 | 7.79 | 33.67 | 33.65 |
| | 4 | 12.45 | 11.50 | 7.59 | 6.56 | 7.79 | 7.76 | 33.72 | 33.67 |
| | 5 | 12.30 | 11.41 | 7.08 | 6.29 | 7.76 | 7.75 | 33.67 | 33.68 |
| | 6 | 12.29 | 11.39 | 6.72 | 6.11 | 7.75 | 7.74 | 33.65 | 33.69 |
| RW15 | 0 | 12.87 | 14.48 | 7.35 | 11.65 | 7.83 | 8.14 | 33.26 | 32.36 |
| | 1 | 12.86 | 14.19 | 7.36 | 11.73 | 7.83 | 8.15 | 33.27 | 32.85 |
| | 2 | 12.82 | 14.12 | 7.36 | 11.84 | 7.80 | 8.27 | 33.34 | 33.31 |
| | 3 | 12.59 | 13.31 | 7.25 | 12.77 | 7.74 | 8.09 | 33.50 | 33.52 |
| | 4 | 12.09 | 12.26 | 6.61 | 9.55 | 7.61 | 7.85 | 33.70 | 33.67 |
| | 5 | 11.79 | 12.00 | 5.37 | 7.49 | 7.55 | 7.75 | 33.73 | 33.66 |
| | 6 | 11.75 | | 4.71 | | 7.54 | | 33.69 | |
| RW16 | 0 | 13.69 | 15.23 | 8.55 | 15.12 | 8.00 | 8.37 | 32.08 | 32.68 |
| | 1 | 13.67 | 14.97 | 8.57 | 15.30 | 8.00 | 8.37 | 32.18 | 32.74 |
| | 2 | 13.15 | 13.32 | 8.59 | 15.31 | 7.95 | 8.15 | 33.16 | 33.36 |
| | 3 | 12.01 | 12.66 | 7.88 | 10.80 | 7.75 | 7.83 | 33.59 | 33.55 |
| | 4 | 11.60 | 12.41 | 5.41 | 7.91 | 7.60 | 7.81 | 33.68 | 33.64 |
| | 5 | 11.57 | 12.09 | 4.69 | 7.27 | 7.57 | 7.76 | 33.66 | 33.64 |
| | 6 | 11.56 | | 4.68 | | 7.56 | | 33.68 | |
| RW17 | 0 | 13.72 | 14.80 | 8.77 | 10.50 | 8.02 | 8.16 | 32.15 | 32.65 |
| | 1 | 13.71 | 13.13 | 8.76 | 11.68 | 8.02 | 8.05 | 32.16 | 33.46 |
| | 2 | 13.07 | 12.19 | 8.85 | 10.18 | 7.92 | 7.86 | 33.03 | 33.63 |
| | 3 | 12.40 | 12.01 | 8.21 | 7.75 | 7.76 | 7.79 | 33.65 | 33.64 |
| | 4 | 12.00 | 11.99 | 6.46 | 6.75 | 7.67 | 7.78 | 33.74 | 33.61 |
| | 5 | 11.77 | 12.00 | 5.95 | 6.54 | 7.62 | 7.78 | 33.69 | 33.60 |

**Appendix B-2. Water quality parameters at each receiving water monitoring station during flood and ebb tides. Mandalay Generating Station NPDES, summer 2006.**

| | | Temp. (°C) | | Oxygen (mg/l) | | pH | | Salinity (psu) | |
|---|---|---|---|---|---|---|---|---|---|
| | Depth (m) | FLOOD | EBB | FLOOD | EBB | FLOOD | EBB | FLOOD | EBB |
| **Surf Zone** | | | | | | | | | |
| RW1 | 0 | 17.25 | 19.36 | 8.55 | 8.35 | 8.10 | 8.17 | 33.56 | 33.65 |
| RW2 | 0 | 16.20 | 18.08 | 8.80 | 8.46 | 8.09 | 8.13 | 33.79 | 33.76 |
| RW3 | 0 | 16.91 | 18.64 | 8.68 | 8.58 | 8.14 | 8.21 | 33.74 | 33.62 |
| RW4 | 0 | 16.23 | 18.43 | 8.88 | 8.45 | 8.09 | 8.16 | 33.77 | 33.82 |
| RW5 | 0 | 18.48 | 24.85 | 8.30 | 7.31 | 7.92 | 8.01 | 33.27 | 33.45 |
| **Offshore** | | | | | | | | | |
| RW6 | 0 | 16.75 | 16.79 | 7.53 | 7.64 | 8.15 | 8.18 | 33.29 | 33.45 |
| | 1 | 16.71 | 16.78 | 7.53 | 7.64 | 8.16 | 8.18 | 33.32 | 33.46 |
| | 2 | 16.35 | 16.58 | 7.60 | 7.67 | 8.16 | 8.18 | 33.55 | 33.49 |
| | 3 | 15.97 | 16.04 | 7.57 | 7.70 | 8.16 | 8.18 | 33.59 | 33.55 |
| | 4 | 15.78 | 15.39 | 7.55 | 7.75 | 8.16 | 8.18 | 33.56 | 33.57 |
| | 5 | 15.71 | 14.61 | 7.54 | 7.82 | 8.16 | 8.18 | 33.53 | 33.63 |
| | 6 | 15.67 | 14.44 | 7.54 | 7.78 | 8.16 | 8.18 | 33.52 | 33.48 |
| | 7 | 15.63 | 14.43 | 7.49 | 7.76 | 8.16 | 8.17 | 33.51 | 33.47 |
| | 8 | 15.61 | 14.39 | 7.47 | 7.68 | 8.16 | 8.16 | 33.52 | 33.48 |
| | 9 | 15.61 | 14.37 | 7.48 | 7.54 | 8.15 | 8.15 | 33.51 | 33.46 |
| | 10 | 15.61 | 14.37 | 7.46 | 7.45 | 8.14 | 8.15 | 33.51 | 33.46 |
| RW7 | 0 | 16.87 | 16.68 | 7.54 | 7.64 | 8.16 | 8.18 | 33.17 | 33.45 |
| | 1 | 16.87 | 16.68 | 7.54 | 7.64 | 8.15 | 8.18 | 33.19 | 33.46 |
| | 2 | 16.79 | 16.57 | 7.56 | 7.66 | 8.17 | 8.18 | 33.30 | 33.48 |
| | 3 | 16.26 | 16.24 | 7.67 | 7.69 | 8.16 | 8.18 | 33.61 | 33.54 |
| | 4 | 15.88 | 15.68 | 7.59 | 7.77 | 8.15 | 8.18 | 33.57 | 33.51 |
| | 5 | 15.76 | 14.90 | 7.54 | 7.86 | 8.15 | 8.19 | 33.54 | 33.63 |
| | 6 | 15.70 | 14.54 | 7.52 | 7.98 | 8.16 | 8.18 | 33.54 | 33.55 |
| | 7 | 15.68 | 14.41 | 7.52 | 7.91 | 8.15 | 8.17 | 33.52 | 33.49 |
| | 8 | 15.65 | 14.37 | 7.49 | 7.71 | 8.15 | 8.16 | 33.52 | 33.47 |
| | 9 | 15.63 | 14.33 | 7.47 | 7.64 | 8.16 | 8.16 | 33.52 | 33.46 |
| | 10 | 15.63 | 14.25 | 7.46 | 7.55 | 8.16 | 8.15 | 33.51 | 33.47 |
| RW8 | 0 | 16.68 | 16.63 | 7.42 | 7.66 | 8.12 | 8.18 | 33.35 | 33.42 |
| | 1 | 16.67 | 16.62 | 7.42 | 7.67 | 8.12 | 8.18 | 33.36 | 33.43 |
| | 2 | 16.65 | 16.55 | 7.42 | 7.69 | 8.13 | 8.18 | 33.39 | 33.45 |
| | 3 | 16.46 | 16.03 | 7.50 | 7.77 | 8.14 | 8.18 | 33.46 | 33.57 |
| | 4 | 16.22 | 15.31 | 7.54 | 7.89 | 8.16 | 8.18 | 33.52 | 33.65 |
| | 5 | 16.00 | 14.74 | 7.56 | 7.91 | 8.16 | 8.18 | 33.57 | 33.60 |
| | 6 | 15.84 | 14.55 | 7.55 | 7.88 | 8.15 | 8.17 | 33.57 | 33.49 |
| | 7 | 15.75 | 14.41 | 7.54 | 7.79 | 8.15 | 8.16 | 33.53 | 33.50 |
| | 8 | 15.70 | 14.31 | 7.51 | 7.62 | 8.15 | 8.16 | 33.52 | 33.48 |
| | 9 | 15.70 | 14.29 | 7.48 | 7.54 | 8.14 | 8.15 | 33.52 | 33.46 |
| | 10 | 15.71 | 14.29 | 7.50 | 7.54 | 8.15 | 8.15 | 33.52 | 33.46 |

**Appendix B-2. (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 | 16.69 | 16.15 | 7.53 | 7.79 | 8.13 | 8.17 | 33.41 | 33.47 |
| | 1 | 16.49 | 16.09 | 7.54 | 7.77 | 8.14 | 8.18 | 33.48 | 33.49 |
| | 2 | 15.92 | 15.98 | 7.62 | 7.82 | 8.15 | 8.18 | 33.64 | 33.48 |
| | 3 | 15.79 | 15.87 | 7.56 | 7.90 | 8.14 | 8.19 | 33.55 | 33.47 |
| | 4 | 15.75 | 15.53 | 7.53 | 7.98 | 8.14 | 8.19 | 33.52 | 33.55 |
| | 5 | 15.71 | 14.64 | 7.49 | 8.11 | 8.14 | 8.18 | 33.53 | 33.58 |
| | 6 | 15.60 | 14.42 | 7.49 | 7.84 | 8.14 | 8.16 | 33.54 | 33.50 |
| | 7 | 15.48 | 14.38 | 7.40 | 7.70 | 8.13 | 8.16 | 33.55 | 33.46 |
| | 8 | 15.42 | 14.36 | 7.31 | 7.69 | 8.13 | 8.16 | 33.53 | 33.45 |
| | 9 | 15.36 | 14.31 | 7.26 | 7.67 | 8.13 | 8.16 | 33.52 | 33.46 |
| | 10 | 15.34 | 14.28 | 7.24 | 7.58 | 8.13 | 8.15 | 33.51 | 33.45 |
| RW10 | 0 | 16.96 | 16.05 | 7.62 | 8.12 | 8.14 | 8.20 | 33.41 | 33.44 |
| | 1 | 16.53 | 16.04 | 7.70 | 8.12 | 8.14 | 8.20 | 33.57 | 33.45 |
| | 2 | 15.84 | 15.85 | 7.73 | 8.17 | 8.14 | 8.20 | 33.63 | 33.45 |
| | 3 | 15.68 | 15.68 | 7.59 | 8.20 | 8.13 | 8.20 | 33.58 | 33.47 |
| | 4 | 15.52 | 14.94 | 7.48 | 8.34 | 8.13 | 8.20 | 33.56 | 33.64 |
| | 5 | 15.41 | 14.52 | 7.39 | 8.17 | 8.12 | 8.18 | 33.53 | 33.51 |
| | 6 | 15.32 | 14.41 | 7.33 | 7.98 | 8.12 | 8.17 | 33.52 | 33.47 |
| | 7 | 15.20 | 14.36 | 7.35 | 7.83 | 8.12 | 8.17 | 33.52 | 33.46 |
| | 8 | 15.02 | 14.32 | 7.34 | 7.75 | 8.12 | 8.16 | 33.52 | 33.45 |
| | 9 | 14.87 | 14.28 | 7.36 | 7.72 | 8.11 | 8.16 | 33.52 | 33.45 |
| | 10 | 14.69 | 14.27 | 7.41 | 7.71 | 8.11 | 8.16 | 33.55 | 33.45 |
| RW11 | 0 | 16.03 | 17.57 | 7.43 | 7.63 | 8.14 | 8.15 | 33.50 | 33.37 |
| | 1 | 15.99 | 17.45 | 7.42 | 7.67 | 8.14 | 8.15 | 33.51 | 33.38 |
| | 2 | 15.82 | 16.45 | 7.47 | 7.79 | 8.14 | 8.16 | 33.51 | 33.43 |
| | 3 | 15.76 | 15.91 | 7.42 | 7.90 | 8.15 | 8.17 | 33.50 | 33.47 |
| | 4 | 15.67 | 15.50 | 7.37 | 7.97 | 8.14 | 8.17 | 33.51 | 33.46 |
| | 5 | 15.63 | 15.33 | 7.26 | 7.84 | 8.13 | 8.16 | 33.50 | 33.47 |
| RW12 | 0 | 16.30 | 16.27 | 7.54 | 8.41 | 8.13 | 8.22 | 33.47 | 33.41 |
| | 1 | 16.27 | 16.28 | 7.52 | 8.41 | 8.13 | 8.21 | 33.47 | 33.41 |
| | 2 | 16.00 | 16.23 | 7.58 | 8.44 | 8.14 | 8.21 | 33.58 | 33.44 |
| | 3 | 15.69 | 15.87 | 7.53 | 8.52 | 8.13 | 8.21 | 33.58 | 33.54 |
| | 4 | 15.35 | 15.33 | 7.37 | 8.48 | 8.12 | 8.18 | 33.60 | 33.56 |
| | 5 | 15.24 | 14.85 | 7.20 | 8.05 | 8.11 | 8.17 | 33.51 | 33.60 |
| | 6 | | 14.62 | | 7.84 | | 8.16 | | 33.51 |
| RW13 | 0 | 16.31 | 17.59 | 7.47 | 7.68 | 8.16 | 8.15 | 33.47 | 33.38 |
| | 1 | 16.23 | 17.54 | 7.52 | 7.71 | 8.16 | 8.15 | 33.55 | 33.41 |
| | 2 | 16.02 | 17.42 | 7.53 | 7.70 | 8.16 | 8.15 | 33.53 | 33.40 |
| | 3 | 15.92 | 17.31 | 7.51 | 7.70 | 8.16 | 8.15 | 33.52 | 33.43 |
| | 4 | 15.90 | 16.51 | 7.49 | 7.85 | 8.15 | 8.15 | 33.52 | 33.67 |
| | 5 | 15.90 | 15.13 | 7.45 | 7.90 | 8.16 | 8.16 | 33.52 | 33.63 |

**Appendix B-2. (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 |
|---|---|---|---|---|---|---|---|---|---|
| RW14 | 0 | 16.22 | 16.35 | 7.51 | 8.80 | 8.12 | 8.24 | 33.58 | 33.39 |
| | 1 | 16.03 | 16.36 | 7.55 | 8.77 | 8.12 | 8.24 | 33.58 | 33.39 |
| | 2 | 15.39 | 16.27 | 7.56 | 8.82 | 8.10 | 8.24 | 33.63 | 33.41 |
| | 3 | 15.22 | 15.88 | 7.36 | 8.88 | 8.09 | 8.22 | 33.53 | 33.50 |
| | 4 | 15.09 | 14.87 | 7.39 | 8.68 | 8.10 | 8.19 | 33.52 | 33.56 |
| | 5 | 14.79 | 14.51 | 7.48 | 8.04 | 8.11 | 8.18 | 33.54 | 33.52 |
| | 6 | 14.54 | 14.44 | 7.54 | 7.83 | 8.10 | 8.17 | 33.53 | 33.45 |
| RW15 | 0 | 16.84 | 17.00 | 7.54 | 7.59 | 8.17 | 8.18 | 33.44 | 33.43 |
| | 1 | 16.80 | 17.00 | 7.58 | 7.63 | 8.17 | 8.18 | 33.46 | 33.43 |
| | 2 | 16.66 | 16.85 | 7.55 | 7.67 | 8.16 | 8.18 | 33.47 | 33.43 |
| | 3 | 16.62 | 15.65 | 7.49 | 7.76 | 8.16 | 8.17 | 33.47 | 33.51 |
| | 4 | 16.55 | 15.21 | 7.51 | 7.49 | 8.16 | 8.16 | 33.48 | 33.48 |
| | 5 | 16.43 | 15.03 | 7.49 | 7.38 | 8.16 | 8.16 | 33.49 | 33.48 |
| | 6 | 16.41 | 14.93 | 7.48 | 7.33 | 8.16 | 8.16 | 33.49 | 33.48 |
| RW16 | 0 | 16.97 | 17.52 | 7.41 | 7.68 | 8.11 | 8.15 | 33.35 | 33.37 |
| | 1 | 17.00 | 17.51 | 7.36 | 7.67 | 8.12 | 8.15 | 33.31 | 33.38 |
| | 2 | 16.19 | 17.08 | 7.53 | 7.76 | 8.15 | 8.15 | 33.59 | 33.50 |
| | 3 | 15.93 | 16.38 | 7.51 | 7.78 | 8.15 | 8.17 | 33.56 | 33.56 |
| | 4 | 15.92 | 15.74 | 7.47 | 7.74 | 8.14 | 8.17 | 33.53 | 33.68 |
| | 5 | 15.86 | 15.02 | 7.44 | 7.69 | 8.14 | 8.16 | 33.53 | 33.53 |
| | 6 | | 14.73 | | 7.47 | | 8.15 | | 33.54 |
| RW17 | 0 | 16.46 | 20.09 | 7.47 | 7.18 | 8.14 | 8.08 | 33.43 | 33.08 |
| | 1 | 16.16 | 18.76 | 7.56 | 7.37 | 8.14 | 8.11 | 33.54 | 33.60 |
| | 2 | 15.83 | 16.96 | 7.54 | 7.60 | 8.14 | 8.16 | 33.56 | 33.65 |
| | 3 | 15.78 | 16.23 | 7.51 | 7.86 | 8.14 | 8.18 | 33.54 | 33.51 |
| | 4 | 15.66 | 15.95 | 7.46 | 7.98 | 8.13 | 8.18 | 33.54 | 33.51 |
| | 5 | 15.64 | 15.69 | 7.31 | 7.94 | 8.13 | 8.18 | 33.52 | 33.51 |

# 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 ($M_\phi$) 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 ($\sigma_\phi$) measures the uniformity (or non-uniformity) of particle quantities in each size category of the sediment distribution. A $\sigma_\phi$ value under 0.35$\phi$ 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 4.0$\phi$ 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 ($\alpha_\phi$) 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, $\alpha_\phi$=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 ($\beta_\phi$) 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 ($\beta_\phi < 1$). $\beta_\phi$ = 1.00 for a normal curve. Curve category interpretations are based on Folk (1974).

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

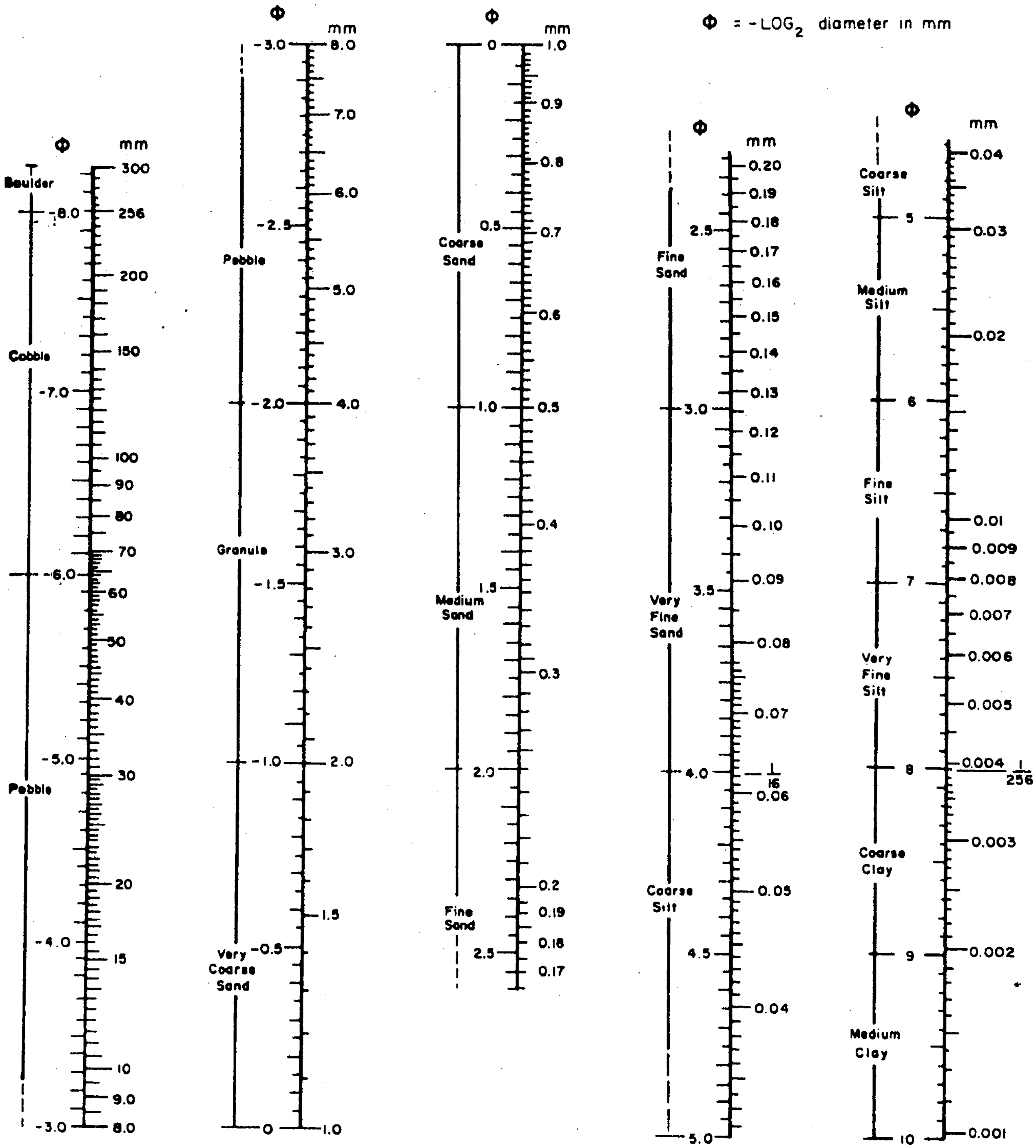
LITERATURE CITED

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:

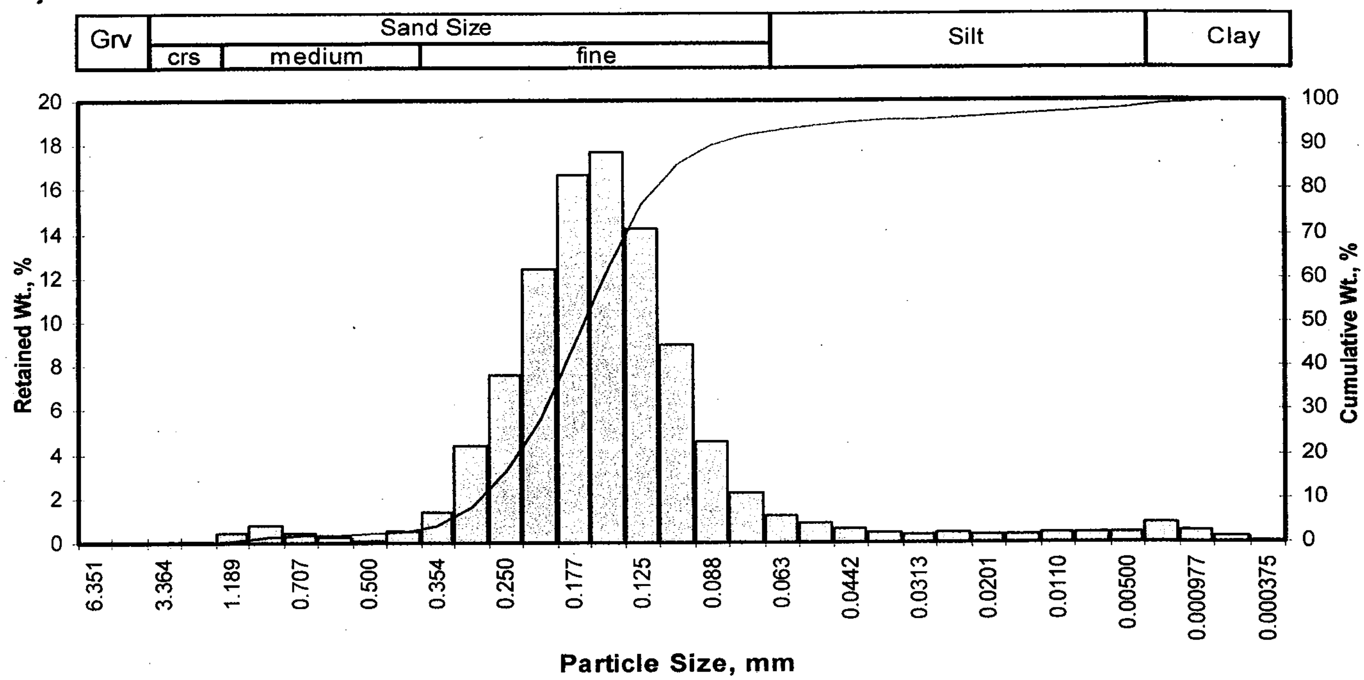
| | | | | |
|---|---|---|---|---|
| $\sigma_I$ under | .35 ϕ, | very well sorted | 1.0-2.0 ϕ, | poorly sorted |
| | .35-.50 ϕ, | well sorted | 2.0-4.0 ϕ, | very poorly sorted |
| | .50-.71 ϕ, | moderately well sorted | over 4.0 ϕ, | extremely poorly sorted |
| | .71-1.0 ϕ | moderately sorted | | |

Appendix C-2. Sediment grain size distribution and statistical parameters by station. Mandalay Generating Station NPDES, 2006.

**PTS** Laboratories, Inc.

**Particle Size Analysis - ASTM D4464M**

| | | | |
|---|---|---|---|
| **Client:** | Calscience | **PTS File No:** | 36827 |
| **Project:** | N/A | **Sample ID:** | MGS B1 |
| **Project No:** | 06-10-0033 | **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 | 0.39 | 0.39 | 0.39 |
| 0.0331 | 0.841 | 0.25 | 20 | 0.79 | 0.79 | 1.18 |
| 0.0278 | 0.707 | 0.50 | 25 | 0.46 | 0.46 | 1.64 |
| 0.0234 | 0.595 | 0.75 | 30 | 0.22 | 0.22 | 1.86 |
| 0.0197 | 0.500 | 1.00 | 35 | 0.10 | 0.10 | 1.96 |
| 0.0166 | 0.420 | 1.25 | 40 | 0.52 | 0.52 | 2.48 |
| 0.0139 | 0.354 | 1.50 | 45 | 1.34 | 1.34 | 3.82 |
| 0.0117 | 0.297 | 1.75 | 50 | 4.40 | 4.40 | 8.22 |
| 0.0098 | 0.250 | 2.00 | 60 | 7.58 | 7.58 | 15.80 |
| 0.0083 | 0.210 | 2.25 | 70 | 12.40 | 12.40 | 28.20 |
| 0.0070 | 0.177 | 2.50 | 80 | 16.60 | 16.60 | 44.80 |
| 0.0059 | 0.149 | 2.75 | 100 | 17.70 | 17.70 | 62.49 |
| 0.0049 | 0.125 | 3.00 | 120 | 14.20 | 14.20 | 76.69 |
| 0.0041 | 0.105 | 3.25 | 140 | 8.93 | 8.93 | 85.62 |
| 0.0035 | 0.088 | 3.50 | 170 | 4.57 | 4.57 | 90.19 |
| 0.0029 | 0.074 | 3.75 | 200 | 2.21 | 2.21 | 92.40 |
| 0.0025 | 0.063 | 4.00 | 230 | 1.24 | 1.24 | 93.64 |
| 0.0021 | 0.053 | 4.25 | 270 | 0.83 | 0.83 | 94.47 |
| 0.00174 | 0.0442 | 4.50 | 325 | 0.59 | 0.59 | 95.06 |
| 0.00146 | 0.0372 | 4.75 | 400 | 0.45 | 0.45 | 95.51 |
| 0.00123 | 0.0313 | 5.00 | 450 | 0.37 | 0.37 | 95.88 |
| 0.000986 | 0.0250 | 5.32 | 500 | 0.41 | 0.41 | 96.29 |
| 0.000790 | 0.0201 | 5.64 | 635 | 0.37 | 0.37 | 96.66 |
| 0.000615 | 0.0156 | 6.00 | | 0.37 | 0.37 | 97.03 |
| 0.000435 | 0.0110 | 6.50 | | 0.44 | 0.44 | 97.47 |
| 0.000308 | 0.00781 | 7.00 | | 0.39 | 0.39 | 97.86 |
| 0.000197 | 0.00500 | 7.65 | | 0.45 | 0.45 | 98.31 |
| 0.000077 | 0.00195 | 9.00 | | 0.85 | 0.85 | 99.16 |
| 0.000038 | 0.000977 | 10.00 | | 0.52 | 0.52 | 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 | 1.57 | 0.0133 | 0.337 |
| 10 | 1.81 | 0.0112 | 0.285 |
| 16 | 2.00 | 0.0098 | 0.249 |
| 25 | 2.19 | 0.0087 | 0.220 |
| 40 | 2.43 | 0.0073 | 0.186 |
| 50 | 2.57 | 0.0066 | 0.168 |
| 60 | 2.71 | 0.0060 | 0.152 |
| 75 | 2.97 | 0.0050 | 0.128 |
| 84 | 3.20 | 0.0043 | 0.108 |
| 90 | 3.49 | 0.0035 | 0.089 |
| 95 | 4.47 | 0.0018 | 0.045 |

| Measure | Trask | Inman | Folk-Ward |
|---|---|---|---|
| Median, phi | 2.57 | 2.57 | 2.57 |
| Median, in. | 0.0066 | 0.0066 | 0.0066 |
| Median, mm | 0.168 | 0.168 | 0.168 |
| Mean, phi | 2.53 | 2.60 | 2.59 |
| Mean, in. | 0.0068 | 0.0065 | 0.0065 |
| Mean, mm | 0.174 | 0.164 | 0.166 |
| Sorting | 1.312 | 0.600 | 0.740 |
| Skewness | 0.997 | 0.051 | 0.179 |
| Kurtosis | 0.235 | 1.421 | 1.518 |
| **Grain Size Description** (ASTM-USCS Scale) | | | Fine sand (based on Mean from Trask) |

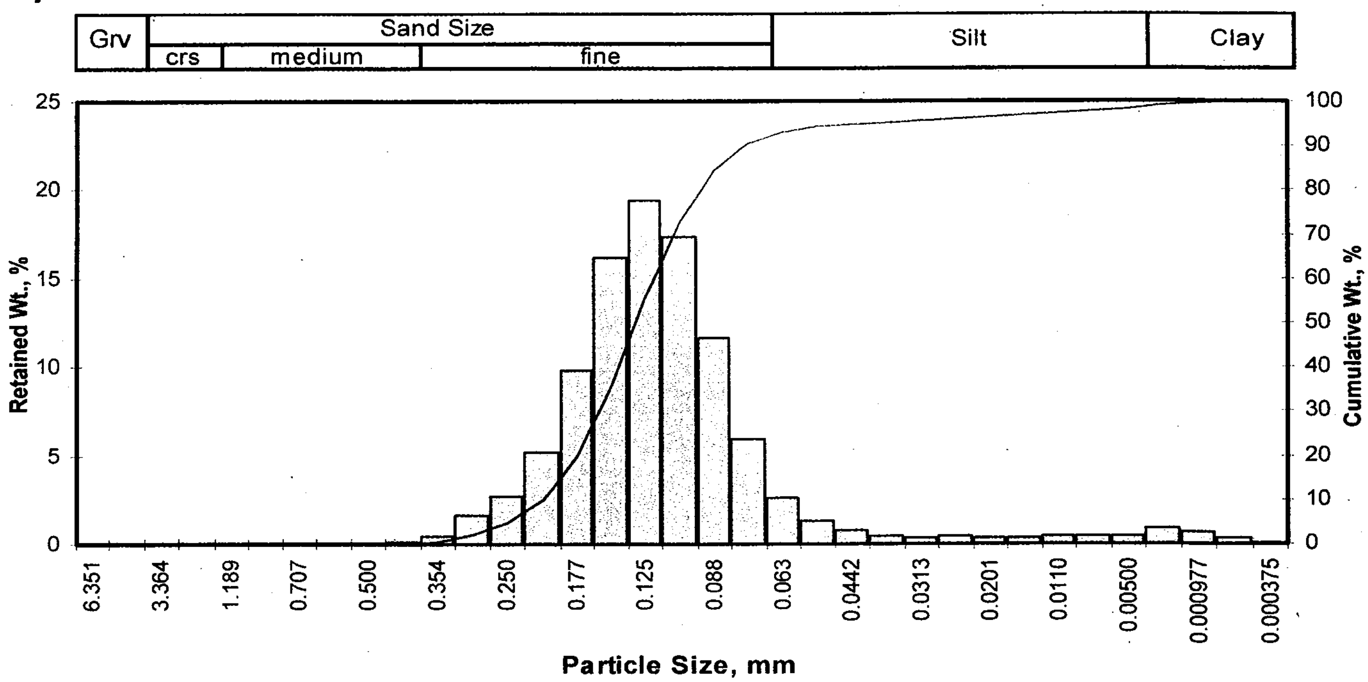
| Description | Retained on Sieve # | Weight Percent |
|---|---|---|
| Gravel | 4 | 0.00 |
| Coarse Sand | 10 | 0.00 |
| Medium Sand | 40 | 2.48 |
| Fine Sand | 200 | 89.93 |
| Silt | >0.005 mm | 5.91 |
| Clay | <0.005 mm | 1.69 |
| | **Total** | **100** |

Appendix C-2. (Cont.).

**PTS** Laboratories, Inc.

**Particle Size Analysis - ASTM D4464M**

| | | | |
|---|---|---|---|
| **Client:** | Calscience | **PTS File No:** | 36827 |
| **Project:** | N/A | **Sample ID:** | MGS B2 |
| **Project No:** | 06-10-0033 | **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 | 0.00 | 0.00 | 0.00 |
| 0.0331 | 0.841 | 0.25 | 20 | 0.00 | 0.00 | 0.00 |
| 0.0278 | 0.707 | 0.50 | 25 | 0.00 | 0.00 | 0.00 |
| 0.0234 | 0.595 | 0.75 | 30 | 0.00 | 0.00 | 0.00 |
| 0.0197 | 0.500 | 1.00 | 35 | 0.00 | 0.00 | 0.00 |
| 0.0166 | 0.420 | 1.25 | 40 | 0.07 | 0.07 | 0.07 |
| 0.0139 | 0.354 | 1.50 | 45 | 0.45 | 0.45 | 0.52 |
| 0.0117 | 0.297 | 1.75 | 50 | 1.60 | 1.60 | 2.12 |
| 0.0098 | 0.250 | 2.00 | 60 | 2.67 | 2.67 | 4.79 |
| 0.0083 | 0.210 | 2.25 | 70 | 5.20 | 5.20 | 9.99 |
| 0.0070 | 0.177 | 2.50 | 80 | 9.86 | 9.86 | 19.85 |
| 0.0059 | 0.149 | 2.75 | 100 | 16.20 | 16.19 | 36.04 |
| 0.0049 | 0.125 | 3.00 | 120 | 19.40 | 19.39 | 55.43 |
| 0.0041 | 0.105 | 3.25 | 140 | 17.40 | 17.39 | 72.82 |
| 0.0035 | 0.088 | 3.50 | 170 | 11.60 | 11.60 | 84.42 |
| 0.0029 | 0.074 | 3.75 | 200 | 5.95 | 5.95 | 90.37 |
| 0.0025 | 0.063 | 4.00 | 230 | 2.62 | 2.62 | 92.99 |
| 0.0021 | 0.053 | 4.25 | 270 | 1.25 | 1.25 | 94.24 |
| 0.00174 | 0.0442 | 4.50 | 325 | 0.71 | 0.71 | 94.95 |
| 0.00146 | 0.0372 | 4.75 | 400 | 0.47 | 0.47 | 95.42 |
| 0.00123 | 0.0313 | 5.00 | 450 | 0.36 | 0.36 | 95.78 |
| 0.000986 | 0.0250 | 5.32 | 500 | 0.40 | 0.40 | 96.18 |
| 0.000790 | 0.0201 | 5.64 | 635 | 0.35 | 0.35 | 96.53 |
| 0.000615 | 0.0156 | 6.00 | | 0.35 | 0.35 | 96.88 |
| 0.000435 | 0.0110 | 6.50 | | 0.44 | 0.44 | 97.32 |
| 0.000308 | 0.00781 | 7.00 | | 0.40 | 0.40 | 97.71 |
| 0.000197 | 0.00500 | 7.65 | | 0.45 | 0.45 | 98.16 |
| 0.000077 | 0.00195 | 9.00 | | 0.83 | 0.83 | 98.99 |
| 0.000038 | 0.000977 | 10.00 | | 0.60 | 0.60 | 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**

| Weight percent | Phi Value | Particle Size Inches | Particle Size Millimeters |
|---|---|---|---|
| 5 | 2.01 | 0.0098 | 0.248 |
| 10 | 2.25 | 0.0083 | 0.210 |
| 16 | 2.40 | 0.0074 | 0.189 |
| 25 | 2.58 | 0.0066 | 0.167 |
| 40 | 2.80 | 0.0056 | 0.143 |
| 50 | 2.93 | 0.0052 | 0.131 |
| 60 | 3.07 | 0.0047 | 0.119 |
| 75 | 3.30 | 0.0040 | 0.102 |
| 84 | 3.49 | 0.0035 | 0.089 |
| 90 | 3.73 | 0.0030 | 0.075 |
| 95 | 4.53 | 0.0017 | 0.043 |

| Measure | Trask | Inman | Folk-Ward |
|---|---|---|---|
| Median, phi | 2.93 | 2.93 | 2.93 |
| Median, in. | 0.0052 | 0.0052 | 0.0052 |
| Median, mm | 0.131 | 0.131 | 0.131 |
| Mean, phi | 2.89 | 2.95 | 2.94 |
| Mean, in. | 0.0053 | 0.0051 | 0.0051 |
| Mean, mm | 0.135 | 0.130 | 0.130 |
| Sorting | 1.282 | 0.544 | 0.654 |
| Skewness | 0.994 | 0.031 | 0.150 |
| Kurtosis | 0.243 | 1.314 | 1.439 |

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

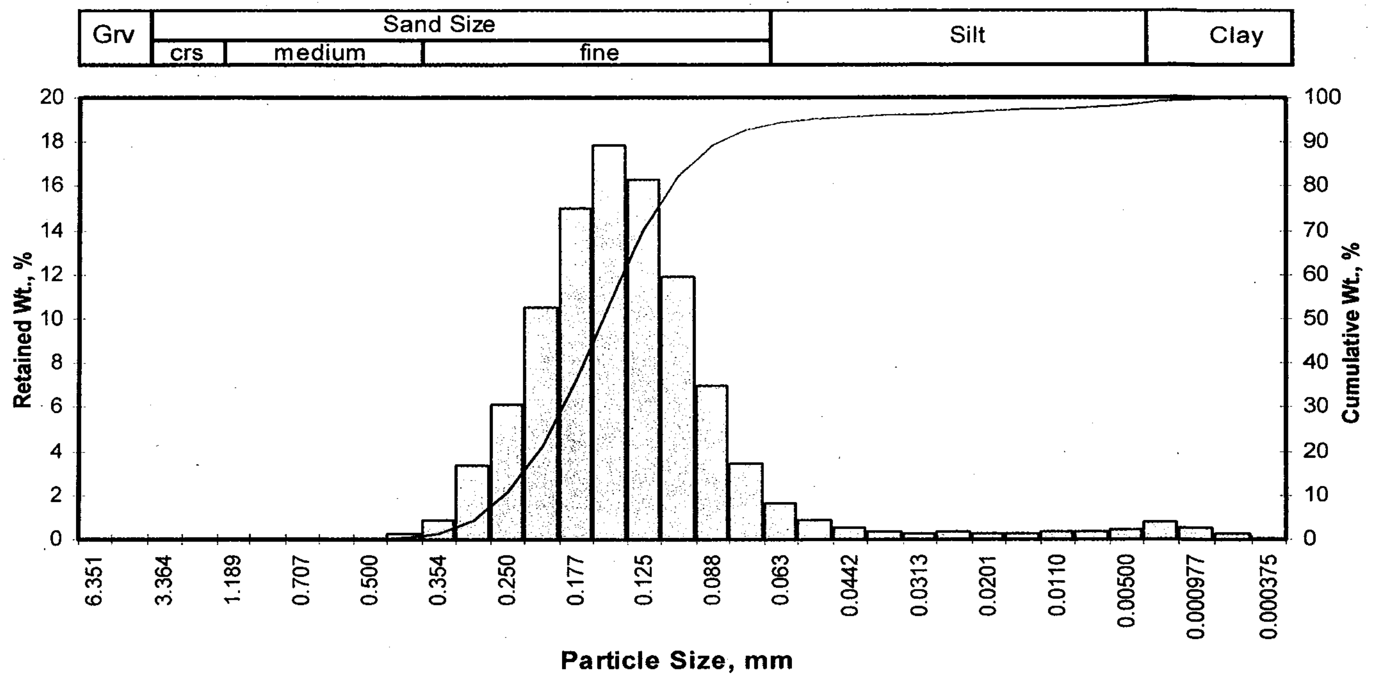
| Description | Retained on Sieve # | Weight Percent |
|---|---|---|
| Gravel | 4 | 0.00 |
| Coarse Sand | 10 | 0.00 |
| Medium Sand | 40 | 0.07 |
| Fine Sand | 200 | 90.29 |
| Silt | >0.005 mm | 7.80 |
| Clay | <0.005 mm | 1.84 |
| | Total | 100 |

Appendix C-2. (Cont.).

# PTS Laboratories, Inc.

**Particle Size Analysis - ASTM D4464M**

| | | | |
|---|---|---|---|
| **Client:** | Calscience | **PTS File No:** | 36827 |
| **Project:** | N/A | **Sample ID:** | MGS B3 |
| **Project No:** | 06-10-0033 | **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 | 0.00 | 0.00 | 0.00 |
| 0.0331 | 0.841 | 0.25 | 20 | 0.00 | 0.00 | 0.00 |
| 0.0278 | 0.707 | 0.50 | 25 | 0.00 | 0.00 | 0.00 |
| 0.0234 | 0.595 | 0.75 | 30 | 0.00 | 0.00 | 0.00 |
| 0.0197 | 0.500 | 1.00 | 35 | 0.00 | 0.00 | 0.00 |
| 0.0166 | 0.420 | 1.25 | 40 | 0.27 | 0.27 | 0.27 |
| 0.0139 | 0.354 | 1.50 | 45 | 0.90 | 0.90 | 1.18 |
| 0.0117 | 0.297 | 1.75 | 50 | 3.32 | 3.32 | 4.50 |
| 0.0098 | 0.250 | 2.00 | 60 | 6.12 | 6.13 | 10.63 |
| 0.0083 | 0.210 | 2.25 | 70 | 10.50 | 10.51 | 21.14 |
| 0.0070 | 0.177 | 2.50 | 80 | 15.00 | 15.02 | 36.15 |
| 0.0059 | 0.149 | 2.75 | 100 | 17.80 | 17.82 | 53.97 |
| 0.0049 | 0.125 | 3.00 | 120 | 16.30 | 16.32 | 70.29 |
| 0.0041 | 0.105 | 3.25 | 140 | 11.90 | 11.91 | 82.20 |
| 0.0035 | 0.088 | 3.50 | 170 | 6.98 | 6.99 | 89.19 |
| 0.0029 | 0.074 | 3.75 | 200 | 3.46 | 3.46 | 92.65 |
| 0.0025 | 0.063 | 4.00 | 230 | 1.64 | 1.64 | 94.30 |
| 0.0021 | 0.053 | 4.25 | 270 | 0.86 | 0.86 | 95.16 |
| 0.00174 | 0.0442 | 4.50 | 325 | 0.51 | 0.51 | 95.67 |
| 0.00146 | 0.0372 | 4.75 | 400 | 0.34 | 0.34 | 96.01 |
| 0.00123 | 0.0313 | 5.00 | 450 | 0.28 | 0.28 | 96.29 |
| 0.000986 | 0.0250 | 5.32 | 500 | 0.32 | 0.32 | 96.61 |
| 0.000790 | 0.0201 | 5.64 | 635 | 0.30 | 0.30 | 96.91 |
| 0.000615 | 0.0156 | 6.00 | | 0.30 | 0.30 | 97.21 |
| 0.000435 | 0.0110 | 6.50 | | 0.38 | 0.38 | 97.59 |
| 0.000308 | 0.00781 | 7.00 | | 0.36 | 0.36 | 97.95 |
| 0.000197 | 0.00500 | 7.65 | | 0.41 | 0.41 | 98.36 |
| 0.000077 | 0.00195 | 9.00 | | 0.79 | 0.79 | 99.15 |
| 0.000038 | 0.000977 | 10.00 | | 0.52 | 0.52 | 99.67 |
| 0.000019 | 0.000488 | 11.00 | | 0.30 | 0.30 | 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 | 1.77 | 0.0115 | 0.293 |
| 10 | 1.97 | 0.0100 | 0.254 |
| 16 | 2.13 | 0.0090 | 0.229 |
| 25 | 2.31 | 0.0079 | 0.201 |
| 40 | 2.55 | 0.0067 | 0.170 |
| 50 | 2.69 | 0.0061 | 0.155 |
| 60 | 2.84 | 0.0055 | 0.139 |
| 75 | 3.10 | 0.0046 | 0.117 |
| 84 | 3.31 | 0.0040 | 0.101 |
| 90 | 3.56 | 0.0033 | 0.085 |
| 95 | 4.20 | 0.0021 | 0.054 |

| Measure | Trask | Inman | Folk-Ward |
|---|---|---|---|
| Median, phi | 2.69 | 2.69 | 2.69 |
| Median, in. | 0.0061 | 0.0061 | 0.0061 |
| Median, mm | 0.155 | 0.155 | 0.155 |
| Mean, phi | 2.65 | 2.72 | 2.71 |
| Mean, in. | 0.0063 | 0.0060 | 0.0060 |
| Mean, mm | 0.159 | 0.152 | 0.153 |
| Sorting | 1.312 | 0.593 | 0.665 |
| Skewness | 0.992 | 0.045 | 0.143 |
| Kurtosis | 0.249 | 1.051 | 1.272 |

| 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 | 0.27 |
| Fine Sand | 200 | 92.38 |
| Silt | >0.005 mm | 5.71 |
| Clay | <0.005 mm | 1.64 |
| | Total | 100 |

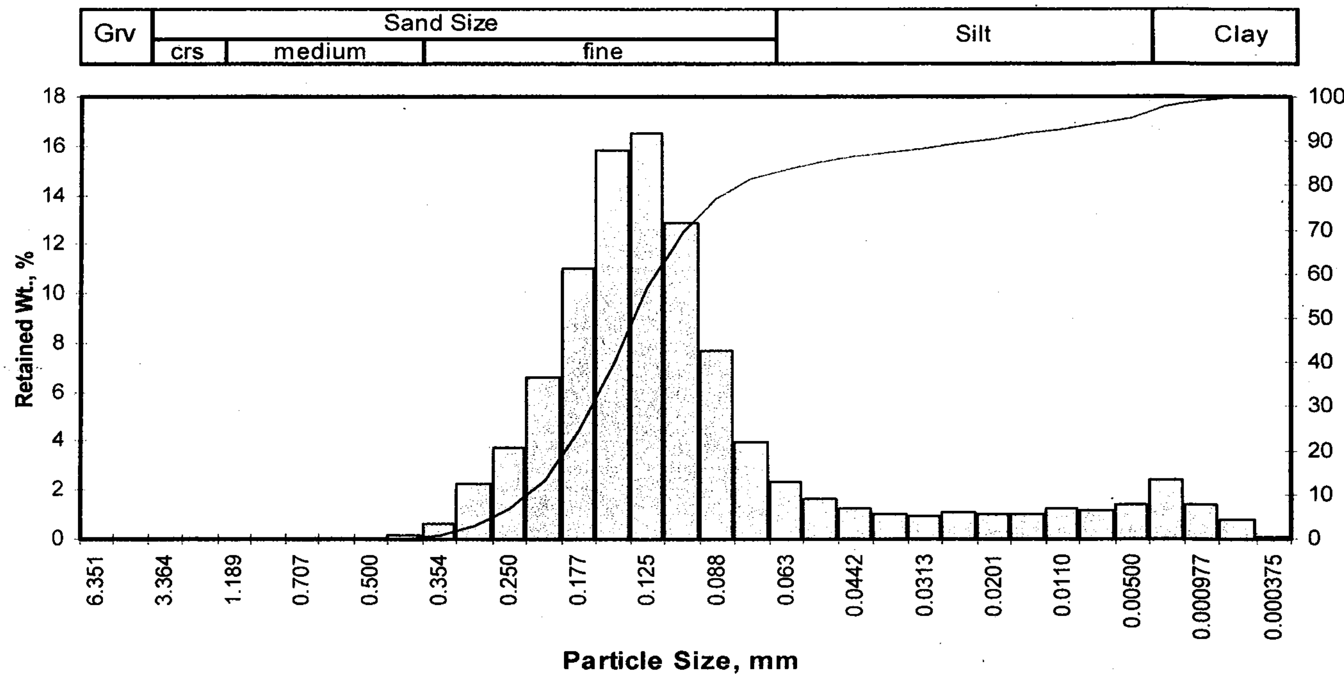

Phone: (562) 907-3607 Fax: (562) 907-3610

Appendix C-2. (Cont.).

**PTS** Laboratories, Inc.

**Particle Size Analysis - ASTM D4464M**

| | | | |
|---|---|---|---|
| **Client:** | Calscience | **PTS File No:** | 36827 |
| **Project:** | N/A | **Sample ID:** | MGS B4 |
| **Project No:** | 06-10-0033 | **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 | 0.00 | 0.00 | 0.00 |
| 0.0331 | 0.841 | 0.25 | 20 | 0.00 | 0.00 | 0.00 |
| 0.0278 | 0.707 | 0.50 | 25 | 0.00 | 0.00 | 0.00 |
| 0.0234 | 0.595 | 0.75 | 30 | 0.00 | 0.00 | 0.00 |
| 0.0197 | 0.500 | 1.00 | 35 | 0.00 | 0.00 | 0.00 |
| 0.0166 | 0.420 | 1.25 | 40 | 0.17 | 0.17 | 0.17 |
| 0.0139 | 0.354 | 1.50 | 45 | 0.65 | 0.65 | 0.82 |
| 0.0117 | 0.297 | 1.75 | 50 | 2.27 | 2.27 | 3.09 |
| 0.0098 | 0.250 | 2.00 | 60 | 3.70 | 3.70 | 6.80 |
| 0.0083 | 0.210 | 2.25 | 70 | 6.59 | 6.59 | 13.39 |
| 0.0070 | 0.177 | 2.50 | 80 | 11.00 | 11.00 | 24.39 |
| 0.0059 | 0.149 | 2.75 | 100 | 15.80 | 15.81 | 40.20 |
| 0.0049 | 0.125 | 3.00 | 120 | 16.50 | 16.51 | 56.71 |
| 0.0041 | 0.105 | 3.25 | 140 | 12.90 | 12.91 | 69.61 |
| 0.0035 | 0.088 | 3.50 | 170 | 7.68 | 7.68 | 77.29 |
| 0.0029 | 0.074 | 3.75 | 200 | 3.96 | 3.96 | 81.26 |
| 0.0025 | 0.063 | 4.00 | 230 | 2.32 | 2.32 | 83.58 |
| 0.0021 | 0.053 | 4.25 | 270 | 1.66 | 1.66 | 85.24 |
| 0.00174 | 0.0442 | 4.50 | 325 | 1.25 | 1.25 | 86.49 |
| 0.00146 | 0.0372 | 4.75 | 400 | 1.04 | 1.04 | 87.53 |
| 0.00123 | 0.0313 | 5.00 | 450 | 0.95 | 0.95 | 88.48 |
| 0.000986 | 0.0250 | 5.32 | 500 | 1.12 | 1.12 | 89.60 |
| 0.000790 | 0.0201 | 5.64 | 635 | 1.02 | 1.02 | 90.62 |
| 0.000615 | 0.0156 | 6.00 | | 1.00 | 1.00 | 91.62 |
| 0.000435 | 0.0110 | 6.50 | | 1.21 | 1.21 | 92.83 |
| 0.000308 | 0.00781 | 7.00 | | 1.15 | 1.15 | 93.98 |
| 0.000197 | 0.00500 | 7.65 | | 1.40 | 1.40 | 95.38 |
| 0.000077 | 0.00195 | 9.00 | | 2.39 | 2.39 | 97.77 |
| 0.000038 | 0.000977 | 10.00 | | 1.36 | 1.36 | 99.13 |
| 0.000019 | 0.000488 | 11.00 | | 0.79 | 0.79 | 99.92 |
| 0.000015 | 0.000375 | 11.38 | | 0.08 | 0.08 | 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 | 1.88 | 0.0107 | 0.272 |
| 10 | 2.12 | 0.0090 | 0.230 |
| 16 | 2.31 | 0.0079 | 0.202 |
| 25 | 2.51 | 0.0069 | 0.176 |
| 40 | 2.75 | 0.0059 | 0.149 |
| 50 | 2.90 | 0.0053 | 0.134 |
| 60 | 3.06 | 0.0047 | 0.120 |
| 75 | 3.43 | 0.0037 | 0.093 |
| 84 | 4.06 | 0.0024 | 0.060 |
| 90 | 5.45 | 0.0009 | 0.023 |
| 95 | 7.47 | 0.0002 | 0.006 |

| Measure | Trask | Inman | Folk-Ward |
|---|---|---|---|
| Median, phi | 2.90 | 2.90 | 2.90 |
| Median, in. | 0.0053 | 0.0053 | 0.0053 |
| Median, mm | 0.134 | 0.134 | 0.134 |
| Mean, phi | 2.90 | 3.19 | 3.09 |
| Mean, in. | 0.0053 | 0.0043 | 0.0046 |
| Mean, mm | 0.134 | 0.110 | 0.117 |
| Sorting | 1.374 | 0.877 | 1.286 |
| Skewness | 0.953 | 0.328 | 0.482 |
| Kurtosis | 0.199 | 2.187 | 2.502 |

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

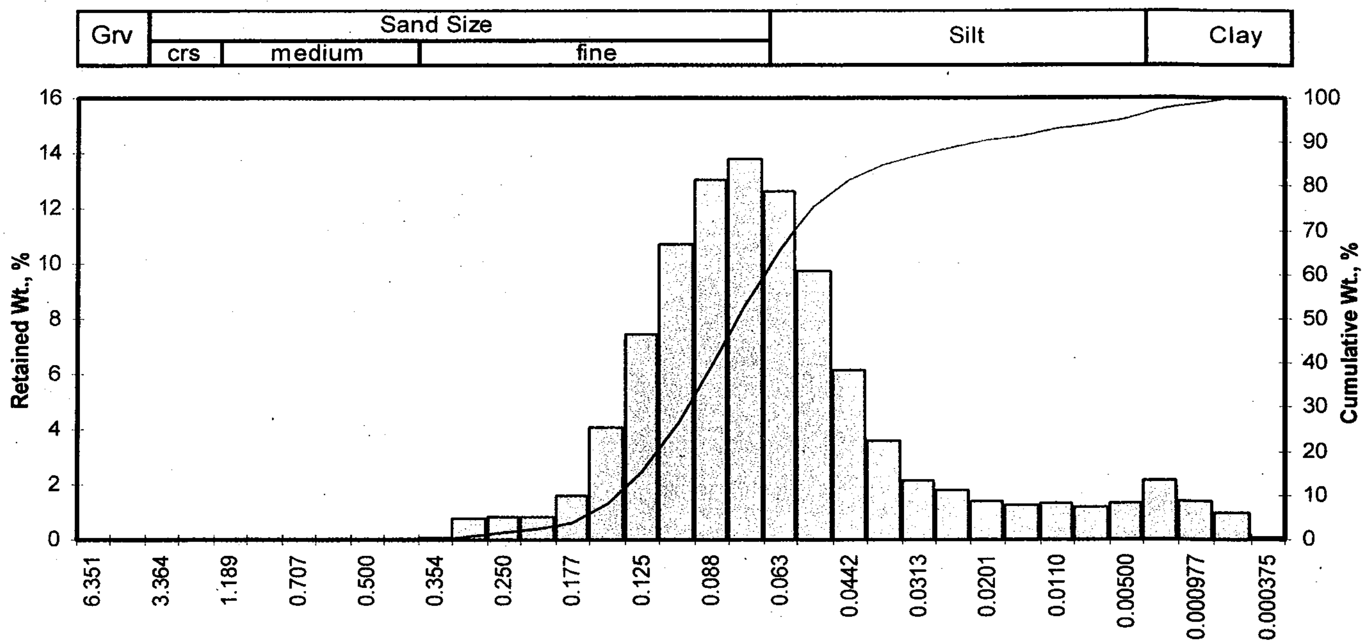
| Description | Retained on Sieve # | Weight Percent |
|---|---|---|
| Gravel | 4 | 0.00 |
| Coarse Sand | 10 | 0.00 |
| Medium Sand | 40 | 0.17 |
| Fine Sand | 200 | 81.08 |
| Silt | >0.005 mm | 14.13 |
| Clay | <0.005 mm | 4.62 |
| | Total | 100 |

Appendix C-2. (Cont.).

**PTS** Laboratories, Inc.

**Particle Size Analysis - ASTM D4464M**

| | | | |
|---|---|---|---|
| **Client:** | Calscience | **PTS File No:** | 36827 |
| **Project:** | N/A | **Sample ID:** | MGS B5 |
| **Project No:** | 06-10-0033 | **Depth, ft:** | N/A |




**Particle Size, mm**

| 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 | 0.00 | 0.00 | 0.00 |
| 0.0331 | 0.841 | 0.25 | 20 | 0.00 | 0.00 | 0.00 |
| 0.0278 | 0.707 | 0.50 | 25 | 0.00 | 0.00 | 0.00 |
| 0.0234 | 0.595 | 0.75 | 30 | 0.00 | 0.00 | 0.00 |
| 0.0197 | 0.500 | 1.00 | 35 | 0.00 | 0.00 | 0.00 |
| 0.0166 | 0.420 | 1.25 | 40 | 0.00 | 0.00 | 0.00 |
| 0.0139 | 0.354 | 1.50 | 45 | 0.06 | 0.06 | 0.06 |
| 0.0117 | 0.297 | 1.75 | 50 | 0.76 | 0.76 | 0.82 |
| 0.0098 | 0.250 | 2.00 | 60 | 0.84 | 0.84 | 1.66 |
| 0.0083 | 0.210 | 2.25 | 70 | 0.80 | 0.80 | 2.46 |
| 0.0070 | 0.177 | 2.50 | 80 | 1.59 | 1.59 | 4.05 |
| 0.0059 | 0.149 | 2.75 | 100 | 4.04 | 4.04 | 8.09 |
| 0.0049 | 0.125 | 3.00 | 120 | 7.44 | 7.44 | 15.53 |
| 0.0041 | 0.105 | 3.25 | 140 | 10.70 | 10.70 | 26.24 |
| 0.0035 | 0.088 | 3.50 | 170 | 13.00 | 13.00 | 39.24 |
| 0.0029 | 0.074 | 3.75 | 200 | 13.80 | 13.80 | 53.04 |
| 0.0025 | 0.063 | 4.00 | 230 | 12.60 | 12.60 | 65.64 |
| 0.0021 | 0.053 | 4.25 | 270 | 9.73 | 9.73 | 75.38 |
| 0.00174 | 0.0442 | 4.50 | 325 | 6.17 | 6.17 | 81.55 |
| 0.00146 | 0.0372 | 4.75 | 400 | 3.58 | 3.58 | 85.13 |
| 0.00123 | 0.0313 | 5.00 | 450 | 2.11 | 2.11 | 87.24 |
| 0.000986 | 0.0250 | 5.32 | 500 | 1.76 | 1.76 | 89.00 |
| 0.000790 | 0.0201 | 5.64 | 635 | 1.36 | 1.36 | 90.36 |
| 0.000615 | 0.0156 | 6.00 | | 1.23 | 1.23 | 91.59 |
| 0.000435 | 0.0110 | 6.50 | | 1.33 | 1.33 | 92.92 |
| 0.000308 | 0.00781 | 7.00 | | 1.14 | 1.14 | 94.06 |
| 0.000197 | 0.00500 | 7.65 | | 1.31 | 1.31 | 95.37 |
| 0.000077 | 0.00195 | 9.00 | | 2.14 | 2.14 | 97.51 |
| 0.000038 | 0.000977 | 10.00 | | 1.41 | 1.41 | 98.92 |
| 0.000019 | 0.000488 | 11.00 | | 0.98 | 0.98 | 99.90 |
| 0.000015 | 0.000375 | 11.38 | | 0.10 | 0.10 | 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 | 2.56 | 0.0067 | 0.170 |
| 10 | 2.81 | 0.0056 | 0.142 |
| 16 | 3.01 | 0.0049 | 0.124 |
| 25 | 3.22 | 0.0042 | 0.107 |
| 40 | 3.51 | 0.0034 | 0.088 |
| 50 | 3.69 | 0.0030 | 0.077 |
| 60 | 3.89 | 0.0027 | 0.068 |
| 75 | 4.24 | 0.0021 | 0.053 |
| 84 | 4.67 | 0.0015 | 0.039 |
| 90 | 5.56 | 0.0008 | 0.021 |
| 95 | 7.46 | 0.0002 | 0.006 |

| Measure | Trask | Inman | Folk-Ward |
|---|---|---|---|
| Median, phi | 3.69 | 3.69 | 3.69 |
| Median, in. | 0.0030 | 0.0030 | 0.0030 |
| Median, mm | 0.077 | 0.077 | 0.077 |
| Mean, phi | 3.64 | 3.84 | 3.79 |
| Mean, in. | 0.0032 | 0.0027 | 0.0028 |
| Mean, mm | 0.080 | 0.070 | 0.072 |
| Sorting | 1.424 | 0.830 | 1.158 |
| Skewness | 0.975 | 0.176 | 0.356 |
| Kurtosis | 0.225 | 1.954 | 1.972 |

| 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 | 0.00 |
| Fine Sand | 200 | 53.04 |
| Silt | >0.005 mm | 42.33 |
| Clay | <0.005 mm | 4.63 |
| | Total | 100 |

**Appendix C-3. Yearly grain size values, 1990 - 2006. Mandalay Generating Station NPDES, 2006.**

| | | | | | | Mean grain size | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Station | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | phi | μm | Sorting* | Skewness | Kurtosis |
| 2006 | B1 | 0.00 | 93.64 | 4.67 | 1.69 | 2.59 | 166 | 0.740 | 0.179 | 1.518 |
| | B2 | 0.00 | 92.99 | 5.17 | 1.84 | 2.94 | 130 | 0.654 | 0.150 | 1.439 |
| | B3 | 0.00 | 94.30 | 4.06 | 1.64 | 2.71 | 153 | 0.665 | 0.143 | 1.272 |
| | B4 | 0.00 | 83.58 | 11.8 | 4.62 | 3.09 | 117 | 1.286 | 0.482 | 2.502 |
| | B5 | 0.00 | 65.64 | 29.73 | 4.63 | 3.79 | 72 | 1.158 | 0.356 | 1.972 |
| 2005 | B1 | 0.00 | 88.15 | 10.27 | 1.58 | 3.24 | 106 | 0.651 | 0.130 | 1.166 |
| | B2 | 0.00 | 89.87 | 8.54 | 1.59 | 3.15 | 113 | 0.734 | -0.001 | 1.350 |
| | B3 | 0.00 | 91.09 | 7.04 | 1.87 | 3.06 | 120 | 0.714 | 0.112 | 1.371 |
| | B4 | 0.00 | 94.18 | 5.02 | 0.80 | 2.65 | 159 | 0.810 | 0.041 | 1.079 |
| | B5 | 0.00 | 83.27 | 14.12 | 2.61 | 3.40 | 94 | 0.754 | 0.237 | 1.555 |
| 2004 | B1 | 1.22 | 95.73 | 2.15 | 0.90 | 2.16 | 224 | 0.74 | -0.08 | 1.28 |
| | B2 | 0.00 | 97.09 | 2.16 | 0.75 | 2.27 | 207 | 0.59 | 0.08 | 1.06 |
| | B3 | 0.71 | 95.89 | 2.48 | 0.92 | 2.14 | 226 | 0.74 | 0.06 | 1.15 |
| | B4 | 1.48 | 94.91 | 2.61 | 1.00 | 2.18 | 221 | 0.80 | -0.12 | 1.51 |
| | B5 | 0.00 | 92.76 | 5.38 | 1.86 | 2.82 | 142 | 0.77 | 0.08 | 1.39 |
| 2003 | B1 | 0.00 | 95.01 | 3.53 | 1.46 | 2.28 | 207 | 0.81 | 0.09 | 1.32 |
| | B2 | 0.00 | 96.63 | 2.48 | 0.89 | 2.19 | 220 | 0.75 | 0.04 | 1.22 |
| | B3 | 0.00 | 93.67 | 4.66 | 1.67 | 2.58 | 168 | 0.84 | 0.10 | 1.28 |
| | B4 | 0.00 | 96.02 | 2.89 | 1.09 | 1.94 | 260 | 0.89 | 0.06 | 1.28 |
| | B5 | - | - | - | - | - | - | - | - | - |
| 2002 | B1 | 0.00 | 96.73 | 2.58 | 0.69 | 2.46 | 182 | 0.63 | -0.01 | 1.20 |
| | B2 | 0.00 | 94.97 | 4.08 | 0.95 | 2.64 | 161 | 0.71 | -0.02 | 1.33 |
| | B3 | 0.00 | 84.43 | 12.83 | 2.74 | 3.07 | 119 | 1.23 | 0.14 | 2.17 |
| | B4 | 0.00 | 94.60 | 4.40 | 1.00 | 2.62 | 162 | 0.76 | -0.03 | 1.35 |
| | B5 | 0.00 | 75.25 | 22.21 | 2.54 | 3.54 | 86 | 0.97 | 0.34 | 1.47 |
| 2001 | B1 | 0.00 | 94.78 | 4.52 | 0.70 | 2.47 | 180 | 0.71 | 0.18 | 1.23 |
| | B2 | 0.00 | 95.96 | 3.44 | 0.60 | 2.61 | 163 | 0.61 | 0.10 | 1.18 |
| | B3 | 0.00 | 96.21 | 2.90 | 0.89 | 2.64 | 161 | 0.61 | 0.00 | 1.13 |
| | B4 | 0.00 | 96.92 | 2.41 | 0.67 | 2.63 | 162 | 0.57 | 0.02 | 1.13 |
| | B5 | 0.00 | 85.18 | 13.15 | 1.67 | 3.28 | 103 | 0.79 | 0.11 | 1.46 |
| 2000 | B1 | 0.00 | 92.10 | 6.40 | 1.50 | 2.55 | 171 | 0.93 | 0.16 | 1.24 |
| | B2 | 0.00 | 93.42 | 4.97 | 1.61 | 2.71 | 153 | 0.73 | 0.16 | 1.36 |
| | B3 | 0.00 | 90.14 | 7.69 | 2.17 | 2.70 | 154 | 0.98 | 0.23 | 1.72 |
| | B4 | 0.00 | 94.23 | 4.09 | 1.68 | 2.65 | 160 | 0.65 | 0.23 | 1.26 |
| | B5 | 0.00 | 83.51 | 14.01 | 2.48 | 3.34 | 99 | 0.86 | 0.28 | 1.68 |
| 1999 | B1 | 0.00 | 94.55 | 4.41 | 1.04 | 2.67 | 158 | 0.72 | 0.01 | 1.31 |
| | B2 | 0.00 | 94.21 | 4.89 | 0.90 | 2.41 | 188 | 0.87 | 0.13 | 1.14 |
| | B3 | 0.00 | 95.60 | 3.57 | 0.83 | 2.56 | 169 | 0.75 | 0.00 | 1.06 |
| | B4 | 0.00 | 96.79 | 2.53 | 0.68 | 2.27 | 207 | 0.75 | 0.02 | 1.16 |
| | B5 | 0.00 | 76.32 | 21.05 | 2.63 | 3.55 | 85 | 0.84 | 0.28 | 1.48 |
| 1998 | B1 | 0.12 | 93.37 | 5.33 | 1.17 | 3.01 | 124 | 65.30 | 0.16 | 1.23 |
| | B2 | 0.01 | 98.14 | 1.82 | 0.02 | 2.59 | 166 | 71.18 | -0.12 | 1.09 |
| | B3 | 0.25 | 92.88 | 5.70 | 1.17 | 2.89 | 135 | 58.93 | 0.10 | 1.14 |
| | B4 | - | - | - | - | - | - | - | - | - |
| | B5 | - | - | - | - | - | - | - | - | - |
| 1997 | B1 | 2.14 | 85.05 | 10.34 | 2.47 | 3.31 | 101 | 60.14 | 0.10 | 1.30 |
| | B2 | 1.82 | 93.66 | 3.06 | 1.45 | 2.79 | 145 | 61.12 | -0.10 | 1.11 |
| | B3 | 0.16 | 69.54 | 28.49 | 1.82 | 3.80 | 72 | 60.25 | 0.14 | 1.15 |
| | B4 | 0.28 | 93.28 | 5.68 | 0.76 | 3.08 | 119 | 65.17 | 0.08 | 1.12 |
| | B5 | 0.12 | 96.07 | 3.34 | 0.47 | 2.62 | 163 | 59.24 | -0.03 | 0.98 |
| 1994 | B1 | 1.37 | 91.74 | 6.89 | 0.00 | 3.05 | 121 | 65.76 | -0.01 | 1.16 |
| | B2 | 48.53 | 46.64 | 4.45 | 0.38 | 0.12 | 920 | 39.76 | -0.37 | 0.50 |
| | B3 | 0.20 | 65.31 | 33.34 | 1.15 | 3.93 | 66 | 61.17 | 0.25 | 1.17 |
| | B4 | 5.04 | 89.57 | 5.40 | 0.00 | 2.61 | 164 | 55.63 | -0.25 | 1.96 |
| | B5 | 0.21 | 97.43 | 2.23 | 0.13 | 2.48 | 179 | 66.01 | 0.02 | 1.11 |
| 1993 | B1 | 20.44 | 78.30 | 0.84 | 0.42 | 1.07 | 480 | N.A. | N.A. | N.A. |
| | B2 | 0.23 | 98.66 | 0.74 | 0.37 | 2.47 | 180 | N.A. | N.A. | N.A. |
| | B3 | 0.80 | 93.69 | 5.09 | 0.42 | 2.48 | 179 | N.A. | N.A. | N.A. |
| | B4 | 0.59 | 98.95 | 0.00 | 0.46 | 2.23 | 213 | N.A. | N.A. | N.A. |
| | B5 | 0.05 | 90.83 | 8.72 | 0.40 | 2.50 | 177 | N.A. | N.A. | N.A. |

**Appendix C-3 (Cont.).**

| Year | Station | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | Mean grain size phi | Mean grain size µm | Sorting* | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|---|---|---|
| 1992 | B1 | 1.37 | 97.68 | 0.71 | 0.24 | 2.45 | 183 | N.A. | N.A. | N.A. |
| | B2 | 0.00 | 98.80 | 0.60 | 0.60 | 2.48 | 179 | N.A. | N.A. | N.A. |
| | B3 | 5.05 | 93.59 | 0.91 | 0.45 | 2.37 | 193 | N.A. | N.A. | N.A. |
| | B4 | 8.84 | 89.79 | 0.69 | 0.69 | 2.58 | 167 | N.A. | N.A. | N.A. |
| | B5 | 0.54 | 91.55 | 7.01 | 0.90 | 2.57 | 168 | N.A. | N.A. | N.A. |
| 1991 | B1 | 0.33 | 93.39 | 5.23 | 1.05 | 2.58 | 167 | N.A. | N.A. | N.A. |
| | B2 | 0.24 | 95.14 | 3.60 | 1.03 | 2.42 | 186 | N.A. | N.A. | N.A. |
| | B3 | 1.11 | 89.44 | 8.40 | 1.05 | 2.40 | 190 | N.A. | N.A. | N.A. |
| | B4 | 0.20 | 95.54 | 3.20 | 1.07 | 2.38 | 192 | N.A. | N.A. | N.A. |
| | B5 | 0.00 | 83.57 | 14.73 | 1.70 | 3.13 | 114 | N.A. | N.A. | N.A. |
| 1990 | B1 | 1.84 | 96.28 | 1.88 | 0.00 | 2.35 | 196 | 68.62 | -0.04 | 1.33 |
| | B2 | 0.60 | 98.86 | 2.53 | 0.01 | 2.68 | 156 | 72.52 | -0.07 | 1.48 |
| | B3 | 1.11 | 95.87 | 3.01 | 0.01 | 2.54 | 173 | 74.10 | -0.07 | 1.47 |
| | B4 | 4.88 | 92.48 | 2.64 | 0.01 | 2.37 | 193 | 66.20 | -0.31 | 2.95 |
| | B5 | 0.15 | 90.52 | 9.33 | 0.00 | 3.38 | 96 | 76.64 | 0.11 | 1.34 |
| 1988 | B1 | 4.56 | 87.93 | 6.86 | 0.64 | 2.57 | 168 | 58.77 | -0.18 | 2.22 |
| | B2 | 1.46 | 95.19 | 3.05 | 0.29 | 2.53 | 174 | 71.58 | 0.17 | 1.57 |
| | B3 | 3.50 | 92.18 | 4.16 | 0.16 | 2.32 | 200 | 66.75 | -0.09 | 2.44 |
| | B4 | 0.71 | 92.82 | 5.10 | 1.37 | 3.16 | 111 | 66.85 | 0.32 | 1.63 |
| | B5 | 4.34 | 90.91 | 2.95 | 1.81 | 2.80 | 144 | 64.47 | -0.13 | 2.05 |
| 1986 | B1 | 0.09 | 85.65 | 14.23 | 0.00 | 3.26 | 104 | 42.05 | 0.38 | 1.22 |
| | B2 | 0.00 | 94.40 | 4.94 | 0.66 | 3.16 | 111 | 58.88 | 0.31 | 1.57 |
| | B3 | 0.00 | 91.15 | 8.22 | 0.00 | 3.09 | 118 | 30.23 | 0.14 | 1.43 |
| | B4 | 0.11 | 89.76 | 9.88 | 0.26 | 3.18 | 110 | 49.68 | 0.38 | 1.55 |
| | B5 | 0.38 | 80.31 | 18.93 | 0.38 | 3.40 | 95 | 47.90 | 0.11 | 1.59 |
| 1980 | B1 | 0.00 | 67.77 | 25.78 | 6.03 | 3.77 | 73 | 0.80 | 0.37 | 3.32 |
| | B2 | 0.00 | 86.09 | 10.95 | 2.95 | 3.11 | 116 | 0.58 | 0.35 | 2.71 |
| | B3 | 0.00 | 74.46 | 22.80 | 2.74 | 3.61 | 82 | 0.60 | 0.40 | 2.00 |
| | B4 | 6.00 | 81.23 | 10.36 | 2.36 | 3.10 | 117 | 0.53 | 0.13 | 5.71 |
| | B5 | 0.00 | 68.28 | 29.51 | 2.18 | 3.69 | 78 | 0.73 | 0.42 | 1.32 |
| 1978 | B1 | 0.52 | 96.44 | 3.04 | 0.00 | 2.46 | 182 | 0.57 | 0.10 | NA |
| | B2 | 0.08 | 97.77 | 2.15 | 0.00 | 2.64 | 161 | 0.46 | -0.04 | NA |
| | B3 | 0.10 | 80.00 | 19.90 | 0.00 | 3.39 | 95 | 0.61 | 0.05 | NA |
| | B4 | 0.21 | 99.42 | 0.37 | 0.00 | 2.37 | 193 | 0.54 | -0.20 | NA |
| | B5 | 0.03 | 80.46 | 19.51 | 0.00 | 3.45 | 92 | 0.56 | 0.00 | NA |

N.A. = Not Available
- = not required
*Sorting values: % 1986-1998; phi 1978 & 1980, 1999-present

# APPENDIX D

## Sediment chemistry by station

Calscience Environmental Laboratories, Inc.

# Analytical Report

| | |
|---|---|
| MBC Applied Environmental Sciences | Date Received: 08/31/06 |
| 3000 Redhill Avenue | Work Order No: 06-08-1816 |
| Costa Mesa, CA 92626-4524 | Preparation: EPA 3050B |
| | Method: EPA 6020 |
| | Units: mg/kg |
| Project: MGS NPDES 05204A | Page 1 of 1 |

| Client Sample Number | Lab Sample Number | Date Collected | Matrix | Date Prepared | Date Analyzed | QC Batch ID |
|---|---|---|---|---|---|---|
| **MGS B1 (I,II,III)** | **06-08-1816-16** | **08/24/06** | **Solid** | **08/31/06** | **09/13/06** | **060831L03A** |

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

| Parameter | Result | RL | DF | Qual | Parameter | Result | RL | DF | Qual |
|---|---|---|---|---|---|---|---|---|---|
| Chromium | 2.06 | 0.04 | 0.434 | | Nickel | 2.23 | 0.04 | 0.434 | |
| Copper | 1.48 | 0.04 | 0.434 | | Zinc | 7.76 | 0.43 | 0.434 | |

| Client Sample Number | Lab Sample Number | Date Collected | Matrix | Date Prepared | Date Analyzed | QC Batch ID |
|---|---|---|---|---|---|---|
| **MGS B2 (I,II,III)** | **06-08-1816-17** | **08/24/06** | **Solid** | **08/31/06** | **09/13/06** | **060831L03A** |

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

| Parameter | Result | RL | DF | Qual | Parameter | Result | RL | DF | Qual |
|---|---|---|---|---|---|---|---|---|---|
| Chromium | 2.98 | 0.04 | 0.446 | | Nickel | 3.03 | 0.04 | 0.446 | |
| Copper | 2.18 | 0.04 | 0.446 | | Zinc | 10.1 | 0.4 | 0.446 | |

| Client Sample Number | Lab Sample Number | Date Collected | Matrix | Date Prepared | Date Analyzed | QC Batch ID |
|---|---|---|---|---|---|---|
| **MGS B3 (I,II,III)** | **06-08-1816-18** | **08/24/06** | **Solid** | **08/31/06** | **09/13/06** | **060831L03A** |

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

| Parameter | Result | RL | DF | Qual | Parameter | Result | RL | DF | Qual |
|---|---|---|---|---|---|---|---|---|---|
| Chromium | 2.25 | 0.04 | 0.434 | | Nickel | 2.21 | 0.04 | 0.434 | |
| Copper | 1.81 | 0.04 | 0.434 | | Zinc | 7.30 | 0.43 | 0.434 | |

| Client Sample Number | Lab Sample Number | Date Collected | Matrix | Date Prepared | Date Analyzed | QC Batch ID |
|---|---|---|---|---|---|---|
| **MGS B4 (I,II,III)** | **06-08-1816-19** | **08/24/06** | **Solid** | **08/31/06** | **09/13/06** | **060831L03A** |

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

| Parameter | Result | RL | DF | Qual | Parameter | Result | RL | DF | Qual |
|---|---|---|---|---|---|---|---|---|---|
| Chromium | 3.39 | 0.04 | 0.446 | | Nickel | 2.85 | 0.04 | 0.446 | |
| Copper | 1.73 | 0.04 | 0.446 | | Zinc | 9.30 | 0.45 | 0.446 | |

| Client Sample Number | Lab Sample Number | Date Collected | Matrix | Date Prepared | Date Analyzed | QC Batch ID |
|---|---|---|---|---|---|---|
| **MGS B5 (I,II,III)** | **06-08-1816-20** | **08/24/06** | **Solid** | **08/31/06** | **09/13/06** | **060831L03A** |

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

| Parameter | Result | RL | DF | Qual | Parameter | Result | RL | DF | Qual |
|---|---|---|---|---|---|---|---|---|---|
| Chromium | 3.25 | 0.05 | 0.452 | | Nickel | 3.16 | 0.05 | 0.452 | |
| Copper | 2.53 | 0.05 | 0.452 | | Zinc | 10.6 | 0.5 | 0.452 | |

| Client Sample Number | Lab Sample Number | Date Collected | Matrix | Date Prepared | Date Analyzed | QC Batch ID |
|---|---|---|---|---|---|---|
| **Method Blank** | **096-10-002-735** | **N/A** | **Solid** | **08/31/06** | **08/31/06** | **060831L03A** |

| 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

Calscience Environmental Laboratories, Inc.

# Analytical Report

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

| | |
|---|---|
| Date Received: | 08/31/06 |
| Work Order No: | 06-08-1816 |
| Preparation: | N/A |
| Method: | EPA 160.3 |

Project: MGS NPDES 05204A

Page 1 of 1

| Client Sample Number | Lab Sample Number | Date Collected | Matrix | Date Prepared | Date Analyzed | QC Batch ID |
|---|---|---|---|---|---|---|
| **MGS B1 (I,II,III)** | **06-08-1816-16** | **08/24/06** | **Solid** | **N/A** | **08/31/06** | **60831TSD1** |

| Parameter | Result | RL | DF | Qual | Units |
|---|---|---|---|---|---|
| Solids, Total | 77.3 | 0.1 | 1 | | % |

| Client Sample Number | Lab Sample Number | Date Collected | Matrix | Date Prepared | Date Analyzed | QC Batch ID |
|---|---|---|---|---|---|---|
| **MGS B2 (I,II,III)** | **06-08-1816-17** | **08/24/06** | **Solid** | **N/A** | **08/31/06** | **60831TSD1** |

| Parameter | Result | RL | DF | Qual | Units |
|---|---|---|---|---|---|
| Solids, Total | 74.9 | 0.1 | 1 | | % |

| Client Sample Number | Lab Sample Number | Date Collected | Matrix | Date Prepared | Date Analyzed | QC Batch ID |
|---|---|---|---|---|---|---|
| **MGS B3 (I,II,III)** | **06-08-1816-18** | **08/24/06** | **Solid** | **N/A** | **08/31/06** | **60831TSD1** |

| Parameter | Result | RL | DF | Qual | Units |
|---|---|---|---|---|---|
| Solids, Total | 77.1 | 0.1 | 1 | | % |

| Client Sample Number | Lab Sample Number | Date Collected | Matrix | Date Prepared | Date Analyzed | QC Batch ID |
|---|---|---|---|---|---|---|
| **MGS B4 (I,II,III)** | **06-08-1816-19** | **08/24/06** | **Solid** | **N/A** | **08/31/06** | **60831TSD1** |

| Parameter | Result | RL | DF | Qual | Units |
|---|---|---|---|---|---|
| Solids, Total | 76.2 | 0.1 | 1 | | % |

| Client Sample Number | Lab Sample Number | Date Collected | Matrix | Date Prepared | Date Analyzed | QC Batch ID |
|---|---|---|---|---|---|---|
| **MGS B5 (I,II,III)** | **06-08-1816-20** | **08/24/06** | **Solid** | **N/A** | **08/31/06** | **60831TSD1** |

| Parameter | Result | RL | DF | Qual | Units |
|---|---|---|---|---|---|
| Solids, Total | 73.9 | 0.1 | 1 | | % |

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

**Calscience Environmental Laboratories, Inc.**

## Quality Control - Spike/Spike Duplicate

| | | |
|---|---|---|
| MBC Applied Environmental Sciences | Date Received: | 08/31/06 |
| 3000 Redhill Avenue | Work Order No: | 06-08-1816 |
| Costa Mesa, CA 92626-4524 | Preparation: | EPA 3050B |
| | Method: | EPA 6020 |

Project MGS NPDES 05204A

| Quality Control Sample ID | Matrix | Instrument | Date Prepared | Date Analyzed | MS/MSD Batch Number |
|---|---|---|---|---|---|
| **06-08-1746-1** | **Solid** | **ICP/MS A** | **08/31/06** | **08/31/06** | **060831S03** |

| Parameter | MS %REC | MSD %REC | %REC CL | RPD | RPD CL | Qualifiers |
|---|---|---|---|---|---|---|
| Chromium | 119 | 113 | 80-120 | 3 | 0-20 | |
| Copper | 111 | 106 | 80-120 | 2 | 0-20 | |
| Nickel | 115 | 114 | 80-120 | 1 | 0-20 | |
| Zinc | 116 | 121 | 80-120 | 1 | 0-20 | 3 |

RPD - Relative Percent Difference , CL - Control Limit

Calscience Environmental Laboratories, Inc.

## Quality Control - Duplicate

| | | | |
|---|---|---|---|
| MBC Applied Environmental Sciences | | Date Received: | 08/31/06 |
| 3000 Redhill Avenue | | Work Order No: | 06-08-1816 |
| Costa Mesa, CA 92626-4524 | | Preparation: | N/A |
| | | Method: | EPA 160.3 |

Project: MGS NPDES 05204A

| Quality Control Sample ID | Matrix | Instrument | Date Prepared: | Date Analyzed: | Duplicate Batch Number |
|---|---|---|---|---|---|
| **MGS B1 (I,II,III)** | **Solid** | **N/A** | **N/A** | **08/31/06** | **60831TSD1** |

| Parameter | Sample Conc | DUP Conc | RPD | RPD CL | Qualifiers |
|---|---|---|---|---|---|
| Solids, Total | 77.3 | 77.1 | 0 | 0-25 | |

RPD - Relative Percent Difference , CL - Control Limit

Calscience Environmental Laboratories, Inc.

## Quality Control - LCS/LCS Duplicate

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

| | |
|---|---|
| Date Received: | N/A |
| Work Order No: | 06-08-1816 |
| Preparation: | EPA 3050B |
| Method: | EPA 6020 |

Project: MGS NPDES 05204A

| Quality Control Sample ID | Matrix | Instrument | Date Prepared | Date Analyzed | LCS/LCSD Batch Number |
|---|---|---|---|---|---|
| **096-10-002-735** | **Solid** | **ICP/MS A** | **08/31/06** | **08/31/06** | **060831L03A** |

| Parameter | LCS %REC | LCSD %REC | %REC CL | RPD | RPD CL | Qualifiers |
|---|---|---|---|---|---|---|
| Chromium | 106 | 109 | 80-120 | 2 | 0-20 | |
| Copper | 102 | 101 | 80-120 | 2 | 0-20 | |
| Nickel | 103 | 102 | 80-120 | 1 | 0-20 | |
| Zinc | 107 | 106 | 80-120 | 1 | 0-20 | |

RPD - Relative Percent Difference , CL - Control Limit

Calscience Environmental Laboratories, Inc.

## Glossary of Terms and Qualifiers

Work Order Number: 06-08-1816

| 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 or Matrix Spike Duplicate 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. |
| 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. |

**Appendix D-2. Yearly sediment metal concentrations, 1990 - 2006. Mandalay Generating Station NPDES, 2006.**

| | | Year | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Metal | Station | 1990 | 1991 | 1992 | 1993 | 1994 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Mean |
| Chromium | B1 | 9.7 | 25.3 | 7.2 | 8.9 | 9.6 | 8.8 | 7.0 | 11 | 11 | 11 | 12 | 8.7 | 8.3 | 7.23 | 2.06 | 10 |
| ERL = 81 | B2 | 15.6 | 37.2 | 7.8 | 7.4 | 9.6 | 8.7 | 7.2 | 7.5 | 10 | 8.9 | 12 | 9.6 | 8.6 | 6.31 | 2.98 | 11 |
| | B3 | 8.7 | 23.4 | 10.1 | 9.3 | 12 | 11 | 7.2 | 9.1 | 9.9 | 11 | 13 | 7.7 | 8.6 | 7.17 | 2.25 | 10 |
| | B4 | 9.3 | 14.3 | 10.0 | 8.1 | 12 | 9.2 | - | 7.9 | 9.6 | 13 | 11 | 7.0 | 7.5 | 7.78 | 3.39 | 9 |
| | B5 | 11.3 | 24.6 | 8.8 | 8.4 | 8.4 | 9.2 | - | 13 | 13 | 8.3 | 13 | - | 10 | 8.15 | 3.25 | 11 |
| Copper | B1 | 4.4 | 20.0 | 4.0 | 5.3 | 5.6 | 3.7 | 6.1 | 7.0 | 4.6 | 2.5 | 4.5 | 2.8 | 2.9 | 6.49 | 1.48 | 5.4 |
| ERL = 34 | B2 | 5.8 | 24.4 | 3.6 | 4.1 | 7.1 | 2.7 | 4.1 | 3.8 | 4.3 | 2.3 | 4.7 | 3.7 | 3.3 | 5.54 | 2.18 | 5.4 |
| | B3 | 2.6 | 14.8 | 5.1 | 9.0 | 8.4 | 5.3 | 4.2 | 5.3 | 5.3 | 2.6 | 5.5 | 3.1 | 2.9 | 6.91 | 1.81 | 5.5 |
| | B4 | 2.3 | 8.2 | 4.2 | 3.9 | 4.9 | 3.3 | - | 3.7 | 3.7 | 2.8 | 4.5 | ND | 2.8 | 5.31 | 1.73 | 3.7 |
| | B5 | 4.3 | 15.9 | 4.6 | 5.1 | 3.0 | 1.7 | - | 8.5 | 6.4 | 2.6 | 6.4 | - | 6.0 | 6.77 | 2.53 | 5.7 |
| Nickel | B1 | 6.6 | 14.7 | 6.0 | 7.9 | 7.1 | 7.8 | 4.3 | 9.7 | 8.5 | 6.7 | 8.9 | 6.2 | 6.5 | 8.53 | 2.23 | 7.4 |
| ERL = 20.9 | B2 | 10.3 | 16.7 | 6.2 | 5.9 | 8.2 | 6.6 | 4.2 | 6.3 | 7.8 | 6.3 | 9.0 | 6.2 | 6.8 | 7.32 | 3.03 | 7.4 |
| | B3 | 6.2 | 9.5 | 8.1 | 9.3 | 9.2 | 10 | 4.1 | 8.8 | 8.7 | 6.7 | 10.0 | 6.2 | 6.8 | 8.34 | 2.21 | 7.6 |
| | B4 | 6.3 | 9.1 | 6.7 | 6.3 | 6.5 | 7.1 | - | 6.5 | 7.0 | 8.0 | 8.9 | 5.1 | 6.3 | 7.53 | 2.85 | 6.7 |
| | B5 | 6.7 | 13.8 | 6.4 | 7.2 | 6.5 | 6.3 | - | 12.0 | 8.5 | 6.0 | 9.2 | - | 8.1 | 8.51 | 3.16 | 7.9 |
| Zinc | B1 | 17 | 14.7 | 15.4 | 18 | 22 | 27 | 19 | 6.4 | 23 | 21 | 21 | 15 | 14 | 24.6 | 7.76 | 18 |
| ERL = 150 | B2 | 27 | 15.4 | 16.2 | 16 | 25 | 23 | 14 | 16 | 22 | 18 | 19 | 15 | 16 | 22.0 | 10.1 | 18 |
| | B3 | 17 | 17.2 | 20.0 | 29 | 31 | 34 | 14 | 24 | 24 | 20 | 23 | 15 | 13 | 25.4 | 7.30 | 21 |
| | B4 | 17 | 16.4 | 19.0 | 18 | 20 | 24 | - | 17 | 20 | 23 | 19 | 13 | 13 | 21.1 | 9.30 | 18 |
| | B5 | 23 | 24.6 | 17.3 | 20 | 13 | 18 | - | 34 | 28 | 18 | 26 | - | 25 | 26.3 | 10.6 | 22 |
| Percent | B1 | 1.9 | 6.3 | 1.0 | 1.3 | 6.9 | 12.8 | 6.5 | 5.5 | 7.9 | 5.2 | 3.3 | 5.0 | 3.1 | 11.85 | 6.36 | 5.6 |
| Fines | B2 | 2.5 | 4.6 | 1.2 | 1.1 | 4.8 | 4.5 | 1.8 | 5.8 | 6.6 | 4.0 | 5.0 | 3.4 | 2.9 | 10.13 | 7.01 | 4.4 |
| | B3 | 3.0 | 9.5 | 1.4 | 5.5 | 34.5 | 30.3 | 6.9 | 4.4 | 9.9 | 3.8 | 15.6 | 6.3 | 3.4 | 8.91 | 5.70 | 9.9 |
| | B4 | 2.7 | 4.3 | 1.4 | 0.5 | 5.4 | 6.4 | - | 3.2 | 5.8 | 3.1 | 5.4 | 4.0 | 3.6 | 5.82 | 16.42 | 4.8 |
| | B5 | 9.3 | 16.4 | 7.9 | 9.1 | 2.4 | 3.8 | - | 23.7 | 16.5 | 14.8 | 24.8 | - | 7.2 | 16.73 | 34.36 | 14.4 |

ERL = Effects Range Low
- = not required
ND = below the detection limit (for calcuations ND = 0)

# APPENDIX E

## Mussel tissue chemistry by station

Appendix E-1. Mussel chemistry by station. Mandalay Generating Station NPDES, 2006.

# CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

## Trace Metals

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169d*

**CRG ID#:** *46657*
**Replicate #:** R1
**DILUTION FACTOR:** 1

**Sample Description:** MGS MT-I 06-11-0209
**Matrix:** Tissue

**Date Sampled:** 20-Oct-06
**Date Received:** 02-Nov-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 9.48 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Copper (Cu) | NA | EPA 6020m | 6.56 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Nickel (Ni) | NA | EPA 6020m | 1.459 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Zinc (Zn) | NA | EPA 6020m | 159.354 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**46657 R1**

Appendix E-1. (Cont.).


**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net


**Client:** ***Calscience Environmental Laboratories, Inc.*** **CRG Project ID:** ***26169d***

**CRG ID#:** *46657*
**Replicate #:** R2
**DILUTION FACTOR:** 1

**Sample Description:** MGS MT-I 06-11-0209
**Matrix:** Tissue

**Date Sampled:** 20-Oct-06
**Date Received:** 02-Nov-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 8.87 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Copper (Cu) | NA | EPA 6020m | 6.63 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Nickel (Ni) | NA | EPA 6020m | 1.461 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Zinc (Zn) | NA | EPA 6020m | 122.254 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**46657 R2**

Appendix E-1. (Cont.).


# CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net


## Trace Metals

**Client:** ***Calscience Environmental Laboratories, Inc.*** **CRG Project ID:** ***26169d***

**CRG ID#:** ***46658***
**Replicate #:** R1
**DILUTION FACTOR:** 1

**Sample Description:** MGS MT-II 06-11-0209
**Matrix:** Tissue

**Date Sampled:** 20-Oct-06
**Date Received:** 02-Nov-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 6.03 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Copper (Cu) | NA | EPA 6020m | 8.671 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Nickel (Ni) | NA | EPA 6020m | 2.322 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Zinc (Zn) | NA | EPA 6020m | 100.454 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**46658 R1**

Appendix E-1. (Cont.).

**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

**Client: Calscience Environmental Laboratories, Inc.** **CRG Project ID: 26169d**

CRG ID#: 46659
Replicate #: R1
DILUTION FACTOR: 1

Sample Description: MGS MT-III 06-11-0209
Matrix: Tissue

Date Sampled: 20-Oct-06
Date Received: 02-Nov-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 5.86 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Copper (Cu) | NA | EPA 6020m | 5.387 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Nickel (Ni) | NA | EPA 6020m | 1.216 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Zinc (Zn) | NA | EPA 6020m | 82.324 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |

MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance

California ELAP Certificate # 2261
46659 R1

Appendix E-1. (Cont.).


CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net


Conventional Chemistry

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169d*

**CRG ID#:** *46657*
**Replicate #:** R1
**DILUTION FACTOR:** 1

**Sample Description:** MGS MT-I 06-11-0209
**Matrix:** Tissue

**Date Sampled:** 20-Oct-06
**Date Received:** 02-Nov-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Percent Solids | NA | EPA 160.3 | 14.1 | Percent | 0.1 | 0.1 | 28-Nov-06 | 28-Nov-06 | 26169d-112806 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**46657 R1**

Appendix E-1. (Cont.).

**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

**Client:** ***Calscience Environmental Laboratories, Inc.*** **CRG Project ID:** ***26169d***

| | | | | | |
|---|---|---|---|---|---|
| **CRG ID#:** | ***46658*** | **Sample Description:** | MGS MT-II 06-11-0209 | **Date Sampled:** | 20-Oct-06 |
| **Replicate #:** | R1 | | | **Date Received:** | 02-Nov-06 |
| **DILUTION FACTOR:** | 1 | **Matrix:** | Tissue | | |

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Percent Solids | NA | EPA 160.3 | 14.7 | Percent | 0.1 | 0.1 | 28-Nov-06 | 28-Nov-06 | 26169d-112806 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**46658 R2**

Appendix E-1. (Cont.).

# CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

**Client:** ***Calscience Environmental Laboratories, Inc.*** **CRG Project ID:** ***26169d***

**CRG ID#:** ***46659*** **Sample Description:** MGS MT-III 06-11-0209 **Date Sampled:** 20-Oct-06

**Replicate #:** R1 **Date Received:** 02-Nov-06

**DILUTION FACTOR:** 1 **Matrix:** Tissue

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Percent Solids | NA | EPA 160.3 | 15.1 | Percent | 0.1 | 0.1 | 28-Nov-06 | 28-Nov-06 | 26169d-112806 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**46659 R1**

CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

## Trace Metals

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169d*

**CRG ID#:** *46656*
**Replicate #:** B1
**DILUTION FACTOR:** 1

**Sample Description:** QAQC 06-11-0209 Procedural Blank
**Matrix:** DI Water

**Date Sampled:**
**Date Received:**

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | ND | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Copper (Cu) | NA | EPA 6020m | ND | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Nickel (Ni) | NA | EPA 6020m | ND | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |
| Zinc (Zn) | NA | EPA 6020m | ND | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169d-15055 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**46656 B1**

Appendix E-1. (Cont.).

**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

## General Chemistry

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169d*

**CRG ID#:** *46656*
**Replicate #:** B1
**DILUTION FACTOR:** 1

**Sample Description:** QAQC 06-11-0209 Procedural Blank
**Matrix:** DI Water

**Date Sampled:**
**Date Received:**

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Percent Solids | NA | EPA 160.3 | ND | Percent | 0.1 | 0.1 | 28-Nov-06 | 28-Nov-06 | 26169d-112806 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**46656 B1**

Appendix E-1. (Cont.).

# CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

**Client:** ***Calscience Environmental Laboratories, Inc.*** **CRG Project ID:** ***26169d***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CRG ID#:** | ***48251*** | **Sample Description:** | QAQC 06-11-0209 | CRM (NRC DORM-2) | | **Date Sampled:** | |
| **Replicate #:** | CRM1 | | | | | **Date Received:** | |
| **Batch ID:** | 26169d-15055 | **Matrix:** | Tissue | | | **Date Processed:** | 28-Nov-06 |
| **Instrument:** | ICPMS #1 HP 4500 | **Analyst:** | P. Hershelman | | | **Date Analyzed:** | 30-Nov-06 |

| CONSTITUENT | METHOD | RESULT | UNITS | TRUE VALUE | ACCEPTANCE RANGE | COMMENT |
|---|---|---|---|---|---|---|
| Chromium (Cr) | EPA 6020m | 34.53 | µg/dry g | 34.7 | 26.0 - 43.4 | PASS |
| Copper (Cu) | EPA 6020m | 2.208 | µg/dry g | 2.34 | 1.75 - 2.92 | PASS |
| Nickel (Ni) | EPA 6020m | 18.37 | µg/dry g | 19.4 | 14.5 - 24.2 | PASS |
| Zinc (Zn) | EPA 6020m | 22.694 | µg/dry g | 25.6 | 19.2 - 32.0 | PASS |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Level; E= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable.**

**California ELAP Certificate # 2261**
**48251 CRM1**

Appendix E-1. (Cont.).


**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net


Trace Metals

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169d*

| | | | | | | |
|---|---|---|---|---|---|---|
| **CRG ID#:** | *48251* | **Sample Description:** | QAQC 06-11-0209 | CRM (NRC DORM-2) | **Date Sampled:** | |
| **Replicate #:** | CRM2 | | | | **Date Received:** | |
| **Batch ID:** | 26169d-15055 | **Matrix:** | Tissue | | **Date Processed:** | 28-Nov-06 |
| **Instrument:** | ICPMS #1 HP 4500 | **Analyst:** | P. Hershelman | | **Date Analyzed:** | 30-Nov-06 |

| CONSTITUENT | METHOD | RESULT | UNITS | TRUE VALUE | ACCEPTANCE RANGE | COMMENT |
|---|---|---|---|---|---|---|
| Chromium (Cr) | EPA 6020m | 35.67 | μg/dry g | 34.7 | 26.0 - 43.4 | PASS |
| Copper (Cu) | EPA 6020m | 2.361 | μg/dry g | 2.34 | 1.75 - 2.92 | PASS |
| Nickel (Ni) | EPA 6020m | 18.55 | μg/dry g | 19.4 | 14.5 - 24.2 | PASS |
| Zinc (Zn) | EPA 6020m | 24.894 | μg/dry g | 25.6 | 19.2 - 32.0 | PASS |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Level; E= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable.**

**California ELAP Certificate # 2261**
**48251 CRM2**

Appendix E-1. (Cont.).

***Sample ID:*** **46657-MS1/MS2** **MGS MT-I** ***Date Sampled:*** **10/20/2006**

| *Parameter* | *Non-Spiked Sample Concentration* | | | *Matrix Spike Results* | | | | | *Matrix Spike Duplicate Results* | | | | | *Acceptance Range* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Rep-1* | *Rep-2* | *Mean* | *Gross Conc.* | *Net Conc.* | *Spike Conc.* | *Percent Recovery* | *Comment* | *Gross Conc.* | *Net Conc.* | *Spike Conc.* | *Percent Recovery* | *Comment* | |
| **Trace Metals** | | | | ***Batch ID:*****26169d-15055** | | | | | | | | | | |
| Chromium (Cr) | 0.16 | 0.16 | 0.16 | 2.07 | 1.91 | 2 | **95** | PASS | 2.1 | 1.94 | 2 | **97** | PASS | 55 - 135% |
| Copper (Cu) | 0.135 | 0.135 | 0.135 | 2.082 | 1.947 | 2 | **97** | PASS | 2.097 | 1.962 | 2 | **98** | PASS | 65 - 125% |
| Nickel (Ni) | 0.03 | 0.03 | 0.03 | 2.045 | 2.015 | 2 | **101** | PASS | 2.057 | 2.027 | 2 | **101** | PASS | 70 - 130% |
| Zinc (Zn) | 3.293 | 3.293 | 3.293 | 5.079 | 1.786 | 2 | **89** | PASS | 5.178 | 1.885 | 2 | **94** | PASS | 60 - 120% |

Appendix E-1. (Cont.).

**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

## Trace Metals

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169d*

**CRG ID#:** *48251*
**Batch ID:** 26169d-15055
**Sample Description:** QAQC 06-11-0209 CRM (NRC DORM-2)
**Matrix:** Tissue
**Date Sampled:**
**Date Received:**
**Date Processed:** 28-Nov-06
**Date Analyzed:** 30-Nov-06

| CONSTITUENT | FRACTION | METHOD | CRM1 µg/dry g | CRM2 µg/dry g | % RPD | ACCEPTANCE RANGE | COMMENT |
|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 34.53 | 35.67 | 3 | 0 - 30% | PASS |
| Copper (Cu) | NA | EPA 6020m | 2.208 | 2.361 | 7 | 0 - 30% | PASS |
| Nickel (Ni) | NA | EPA 6020m | 18.37 | 18.55 | 1 | 0 - 30% | PASS |
| Zinc (Zn) | NA | EPA 6020m | 22.694 | 24.894 | 9 | 0 - 30% | PASS |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; E= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable.**

**California ELAP Certificate # 2261**
**48251**

Appendix E-1. (Cont.).

# CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

Trace Metals

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169d*

| | | | | | |
|---|---|---|---|---|---|
| **CRG ID#:** | *46657* | **Sample Description:** | MGS MT-I 06-11-0209 | **Date Sampled:** | 20-Oct-06 |
| | | | | **Date Received:** | 02-Nov-06 |
| **Batch ID:** | 26169d-15055 | **Matrix:** | Tissue | **Date Processed:** | 28-Nov-06 |
| | | | | **Date Analyzed:** | 30-Nov-06 |

| CONSTITUENT | FRACTION | METHOD | MS1 µg | MS2 µg | % RPD | ACCEPTANCE RANGE | COMMENT |
|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 2.07 | 2.1 | 1 | 0 - 30% | PASS |
| Copper (Cu) | NA | EPA 6020m | 2.082 | 2.097 | 1 | 0 - 30% | PASS |
| Nickel (Ni) | NA | EPA 6020m | 2.045 | 2.057 | 1 | 0 - 30% | PASS |
| Zinc (Zn) | NA | EPA 6020m | 5.079 | 5.178 | 2 | 0 - 30% | PASS |

MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; E= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable.

California ELAP Certificate # 2261

46657

Appendix E-1. (Cont.).

**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

## Trace Metals

**Client:** ***Calscience Environmental Laboratories, Inc.*** **CRG Project ID:** ***26169d***

| | | | | | |
|---|---|---|---|---|---|
| **CRG ID#:** | ***46657*** | **Sample Description:** | MGS MT-I 06-11-0209 | **Date Sampled:** | 20-Oct-06 |
| | | | | **Date Received:** | 02-Nov-06 |
| **Batch ID:** | 26169d-15055 | **Matrix:** | Tissue | **Date Processed:** | 28-Nov-06 |
| | | | | **Date Analyzed:** | 30-Nov-06 |

| CONSTITUENT | FRACTION | METHOD | R1 µg/dry g | R2 µg/dry g | % RPD | ACCEPTANCE RANGE | COMMENT |
|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 9.48 | 8.87 | 7 | 0 - 30% | PASS |
| Copper (Cu) | NA | EPA 6020m | 6.56 | 6.63 | 1 | 0 - 30% | PASS |
| Nickel (Ni) | NA | EPA 6020m | 1.459 | 1.461 | 0 | 0 - 30% | PASS |
| Zinc (Zn) | NA | EPA 6020m | 159.354 | 122.254 | 26 | 0 - 30% | PASS |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; E= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable.**

**California ELAP Certificate # 2261**
**46657**

Appendix E-1. (Cont.).

CRG Marine Laboratories, Inc.
2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

Trace Metals

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169c*

**CRG ID#:** *46653*
**Replicate #:** R1
**DILUTION FACTOR:** 1

**Sample Description:** Control MT-I 06-11-0208
**Matrix:** Tissue

**Date Sampled:** 18-Jul-06
**Date Received:** 02-Nov-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 5.31 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Copper (Cu) | NA | EPA 6020m | 4.686 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Nickel (Ni) | NA | EPA 6020m | 0.467 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Zinc (Zn) | NA | EPA 6020m | 89.134 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**46653 R1**

Appendix E-1. (Cont.).

CRG Marine Laboratories, Inc.
2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

## Trace Metals

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169c*

**CRG ID#:** *46653*
**Replicate #:** R2
**DILUTION FACTOR:** 1

**Sample Description:** Control MT-I 06-11-0208
**Matrix:** Tissue

**Date Sampled:** 18-Jul-06
**Date Received:** 02-Nov-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 6.47 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Copper (Cu) | NA | EPA 6020m | 4.374 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Nickel (Ni) | NA | EPA 6020m | 0.479 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Zinc (Zn) | NA | EPA 6020m | 90.194 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**46653 R2**

Appendix E-1. (Cont.).


**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net


Trace Metals

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169c*

**CRG ID#:** *46654*
**Replicate #:** R1
**DILUTION FACTOR:** 1

**Sample Description:** Control MT-II 06-11-0208
**Matrix:** Tissue

**Date Sampled:** 18-Jul-06
**Date Received:** 02-Nov-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 7.34 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Copper (Cu) | NA | EPA 6020m | 4.792 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Nickel (Ni) | NA | EPA 6020m | 0.503 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Zinc (Zn) | NA | EPA 6020m | 89.064 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**46654 R1**

Appendix E-1. (Cont.).

**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

Trace Metals

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169c*

**CRG ID#:** *46655*
**Replicate #:** R1
**DILUTION FACTOR:** 1

**Sample Description:** Control MT-III 06-11-0208
**Matrix:** Tissue

**Date Sampled:** 18-Jul-06
**Date Received:** 02-Nov-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 9.92 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Copper (Cu) | NA | EPA 6020m | 9.19 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Nickel (Ni) | NA | EPA 6020m | 0.861 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Zinc (Zn) | NA | EPA 6020m | 105.954 | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**46655 R1**

Appendix E-1. (Cont.).

**CRG Marine Laboratories, Inc.**
2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

General Chemistry

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169c*

**CRG ID#:** *46653*
**Replicate #:** R1
**DILUTION FACTOR:** 1

**Sample Description:** Control MT-I 06-11-0208
**Matrix:** Tissue

**Date Sampled:** 18-Jul-06
**Date Received:** 02-Nov-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Percent Solids | NA | EPA 160.3 | 19.6 | Percent | 0.1 | 0.1 | 28-Nov-06 | 28-Nov-06 | 26169c-112806 |

CONTROL SITE

MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance

California ELAP Certificate # 2261
46653 R1

Appendix E-1. (Cont.).

**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

General Chemistry

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169c*

**CRG ID#:** *46653*
**Replicate #:** R2
**DILUTION FACTOR:** 1

**Sample Description:** Control MT-I 06-11-0208
**Matrix:** Tissue

**Date Sampled:** 18-Jul-06
**Date Received:** 02-Nov-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Percent Solids | NA | EPA 160.3 | 19.7 | Percent | 0.1 | 0.1 | 28-Nov-06 | 28-Nov-06 | 26169c-112806 |

CONTROL SITE

MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance

California ELAP Certificate # 2261
46653 R2

Appendix E-1. (Cont.).


**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net


General Chemistry

**Client:** ***Calscience Environmental Laboratories, Inc.*** **CRG Project ID:** ***26169c***

**CRG ID#:** ***46654*** **Sample Description:** Control MT-II 06-11-0208 **Date Sampled:** 18-Jul-06

**Replicate #:** R1 **Matrix:** Tissue **Date Received:** 02-Nov-06

**DILUTION FACTOR:** 1

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Percent Solids | NA | EPA 160.3 | 18.8 | Percent | 0.1 | 0.1 | 28-Nov-06 | 28-Nov-06 | 26169c-112806 |

CONTROL SITE

MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance

California ELAP Certificate # 2261
46654 R1

Appendix E-1. (Cont.).


CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net


General Chemistry

**Client:** ***Calscience Environmental Laboratories, Inc.*** **CRG Project ID:** ***26169c***

**CRG ID#:** ***46655***
**Replicate #:** R1
**DILUTION FACTOR:** 1

**Sample Description:** Control MT-III 06-11-0208
**Matrix:** Tissue

**Date Sampled:** 18-Jul-06
**Date Received:** 02-Nov-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Percent Solids | NA | EPA 160.3 | 17.4 | Percent | 0.1 | 0.1 | 28-Nov-06 | 28-Nov-06 | 26169c-112806 |



**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**46655 R1**

Appendix E-1. (Cont.).

# CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

Trace Metals

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169c*

**CRG ID#:** *46652*
**Replicate #:** B1
**DILUTION FACTOR:** 1

**Sample Description:** QAQC 06-11-0208 Procedural Blank
**Matrix:** DI Water

**Date Sampled:**
**Date Received:**

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | ND | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Copper (Cu) | NA | EPA 6020m | ND | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Nickel (Ni) | NA | EPA 6020m | ND | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |
| Zinc (Zn) | NA | EPA 6020m | ND | µg/dry g | 0.025 | 0.05 | 28-Nov-06 | 30-Nov-06 | 26169c-15055 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**46652 B1**

CRG Marine Laboratories, Inc.
2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

Special Chemistry

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169c*

**CRG ID#:** *46652*
**Replicate #:** B1
**DILUTION FACTOR:** 1

**Sample Description:** QAQC 06-11-0208 Procedural Blank
**Matrix:** DI Water

**Date Sampled:**
**Date Received:**

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Percent Solids | NA | EPA 160.3 | ND | Percent | 0.1 | 0.1 | 28-Nov-06 | 28-Nov-06 | 26169c-112806 |

CONTROL SITE

MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance

California ELAP Certificate # 2261
46652 B1

Appendix E-1. (Cont.).

CRG Marine Laboratories, Inc.
2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

Trace Metals

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169c*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CRG ID#:** | *48250* | **Sample Description:** | QAQC | 06-11-0208 | CRM (NRC DORM-2) | **Date Sampled:** | |
| **Replicate #:** | CRM1 | | | | | **Date Received:** | |
| **Batch ID:** | 26169c-15055 | **Matrix:** | Tissue | | | **Date Processed:** | 28-Nov-06 |
| **Instrument:** | ICPMS #1 HP 4500 | **Analyst:** | P. Hershelman | | | **Date Analyzed:** | 30-Nov-06 |

| CONSTITUENT | METHOD | RESULT | UNITS | TRUE VALUE | ACCEPTANCE RANGE | COMMENT |
|---|---|---|---|---|---|---|
| Chromium (Cr) | EPA 6020m | 34.53 | µg/dry g | 34.7 | 26.0 - 43.4 | PASS |
| Copper (Cu) | EPA 6020m | 2.208 | µg/dry g | 2.34 | 1.75 - 2.92 | PASS |
| Nickel (Ni) | EPA 6020m | 18.37 | µg/dry g | 19.4 | 14.5 - 24.2 | PASS |
| Zinc (Zn) | EPA 6020m | 22.694 | µg/dry g | 25.6 | 19.2 - 32.0 | PASS |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Level; E= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable.**

**California ELAP Certificate # 2261**
**48250 CRM1**

CRG Marine Laboratories, Inc.
2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

Trace Metals

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169c*

**CRG ID#:** *48250*
**Replicate #:** CRM2
**Batch ID:** 26169c-15055
**Instrument:** ICPMS #1 HP 4500

**Sample Description:** QAQC 06-11-0208 CRM (NRC DORM-2)
**Matrix:** Tissue
**Analyst:** P. Hershelman

**Date Sampled:**
**Date Received:**
**Date Processed:** 28-Nov-06
**Date Analyzed:** 30-Nov-06

| CONSTITUENT | METHOD | RESULT | UNITS | TRUE VALUE | ACCEPTANCE RANGE | COMMENT |
|---|---|---|---|---|---|---|
| Chromium (Cr) | EPA 6020m | 35.67 | µg/dry g | 34.7 | 26.0 - 43.4 | PASS |
| Copper (Cu) | EPA 6020m | 2.361 | µg/dry g | 2.34 | 1.75 - 2.92 | PASS |
| Nickel (Ni) | EPA 6020m | 18.55 | µg/dry g | 19.4 | 14.5 - 24.2 | PASS |
| Zinc (Zn) | EPA 6020m | 24.894 | µg/dry g | 25.6 | 19.2 - 32.0 | PASS |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Level; E= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable.**

**California ELAP Certificate # 2261**
**48250 CRM2**

Appendix E-1. (Cont.).

# CRG Marine Laboratories, Inc.
# MATRIX SPIKE QAQC REPORT
## Project ID: 26169c

*Sample ID:* 46653-MS1/MS2 Control MT-I

*Date Sampled:* 7/18/2006

| Parameter | Non-Spiked Sample Concentration | | | Matrix Spike Results | | | | | Matrix Spike Duplicate Results | | | | | Acceptance Range |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rep-1 | Rep-2 | Mean | Gross Conc. | Net Conc. | Spike Conc. | Percent Recovery | Comment | Gross Conc. | Net Conc. | Spike Conc. | Percent Recovery | Comment | |
| **Trace Metals** | | | | *Batch ID:* 26169c-15055 | | | | | | | | | | |
| Chromium (Cr) | 0.17 | 0.17 | 0.17 | 1.98 | 1.81 | 2 | **91** | PASS | 2.03 | 1.86 | 2 | **93** | PASS | 55 - 135% |
| Copper (Cu) | 0.124 | 0.124 | 0.124 | 2 | 1.876 | 2 | **94** | PASS | 2.056 | 1.932 | 2 | **97** | PASS | 65 - 125% |
| Nickel (Ni) | 0.014 | 0.014 | 0.014 | 1.954 | 1.94 | 2 | **97** | PASS | 2.006 | 1.992 | 2 | **100** | PASS | 70 - 130% |
| Zinc (Zn) | 2.445 | 2.445 | 2.445 | 4.289 | 1.844 | 2 | **92** | PASS | 4.299 | 1.854 | 2 | **93** | PASS | 60 - 120% |

Appendix E-1. (Cont.).

# CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

## Trace Metals

**Client:** ***Calscience Environmental Laboratories, Inc.*** **CRG Project ID:** ***26169c***

| | | | | | | |
|---|---|---|---|---|---|---|
| **CRG ID#:** | ***48250*** | **Sample Description:** | QAQC 06-11-0208 | CRM (NRC DORM-2) | **Date Sampled:** | |
| | | | | | **Date Received:** | |
| **Batch ID:** | 26169c-15055 | **Matrix:** | Tissue | | **Date Processed:** | 28-Nov-06 |
| | | | | | **Date Analyzed:** | 30-Nov-06 |

| CONSTITUENT | FRACTION | METHOD | CRM1 µg/dry g | CRM2 µg/dry g | % RPD | ACCEPTANCE RANGE | COMMENT |
|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 34.53 | 35.67 | 3 | 0 - 30% | PASS |
| Copper (Cu) | NA | EPA 6020m | 2.208 | 2.361 | 7 | 0 - 30% | PASS |
| Nickel (Ni) | NA | EPA 6020m | 18.37 | 18.55 | 1 | 0 - 30% | PASS |
| Zinc (Zn) | NA | EPA 6020m | 22.694 | 24.894 | 9 | 0 - 30% | PASS |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; E= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable.**

**California ELAP Certificate # 2261**
**48250**

Appendix E-1. (Cont.).



# CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net


**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26169c*

| | | | | | |
|---|---|---|---|---|---|
| **CRG ID#:** | *46653* | **Sample Description:** | Control MT-I 06-11-0208 | **Date Sampled:** | 18-Jul-06 |
| | | | | **Date Received:** | 02-Nov-06 |
| **Batch ID:** | 26169c-15055 | **Matrix:** | Tissue | **Date Processed:** | 28-Nov-06 |
| | | | | **Date Analyzed:** | 30-Nov-06 |

| CONSTITUENT | FRACTION | METHOD | MS1 µg | MS2 µg | % RPD | ACCEPTANCE RANGE | COMMENT |
|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 1.98 | 2.03 | 2 | 0 - 30% | PASS |
| Copper (Cu) | NA | EPA 6020m | 2 | 2.056 | 3 | 0 - 30% | PASS |
| Nickel (Ni) | NA | EPA 6020m | 1.954 | 2.006 | 3 | 0 - 30% | PASS |
| Zinc (Zn) | NA | EPA 6020m | 4.289 | 4.299 | 0 | 0 - 30% | PASS |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; E= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable.**

**California ELAP Certificate # 2261**
**46653**

Appendix E-1. (Cont.).

**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

## Trace Metals

**Client: *Calscience Environmental Laboratories, Inc.*** **CRG Project ID: *26169c***

| | | | | | |
|---|---|---|---|---|---|
| **CRG ID#:** | ***46653*** | **Sample Description:** | Control MT-I 06-11-0208 | **Date Sampled:** | 18-Jul-06 |
| | | | | **Date Received:** | 02-Nov-06 |
| **Batch ID:** | 26169c-15055 | **Matrix:** | Tissue | **Date Processed:** | 28-Nov-06 |
| | | | | **Date Analyzed:** | 30-Nov-06 |

| CONSTITUENT | FRACTION | METHOD | R1 µg/dry g | R2 µg/dry g | % RPD | ACCEPTANCE RANGE | COMMENT |
|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 5.31 | 6.47 | 20 | 0 - 30% | PASS |
| Copper (Cu) | NA | EPA 6020m | 4.686 | 4.374 | 7 | 0 - 30% | PASS |
| Nickel (Ni) | NA | EPA 6020m | 0.467 | 0.479 | 3 | 0 - 30% | PASS |
| Zinc (Zn) | NA | EPA 6020m | 89.134 | 90.194 | 1 | 0 - 30% | PASS |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; E= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable.**

**California ELAP Certificate # 2261**
**46653**

Appendix E-1. (Cont.).


**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net


**Client:** ***Calscience Environmental Laboratories, Inc.*** **CRG Project ID:** ***26169c***

| | | | | | |
|---|---|---|---|---|---|
| **CRG ID#:** | *46653* | **Sample Description:** | Control MT-I 06-11-0208 | **Date Sampled:** | 18-Jul-06 |
| | | | | **Date Received:** | 02-Nov-06 |
| **Batch ID:** | 26169c-112806 | **Matrix:** | Tissue | **Date Processed:** | 28-Nov-06 |
| | | | | **Date Analyzed:** | 28-Nov-06 |

| CONSTITUENT | FRACTION | METHOD | R1 Percent | R2 Percent | % RPD | ACCEPTANCE RANGE | COMMENT |
|---|---|---|---|---|---|---|---|
| Percent Solids | NA | EPA 160.3 | 19.6 | 19.7 | 1 | 0 - 30% | PASS |

CONTROL SITE

MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; E= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable.

California ELAP Certificate # 2261
46653

**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

**Client:** ***Calscience Environmental Laboratories, Inc.*** **CRG Project ID:** ***26170***

**CRG ID#:** ***42296***
**Replicate #:** R1
**DILUTION FACTOR:** 1

**Sample Description:** RGS HBP-I mussel 06-08-0125
**Matrix:** Tissue

**Date Sampled:** 22-Jun-06 09:36
**Date Received:** 04-Aug-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 9.17 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Copper (Cu) | NA | EPA 6020m | 5.09 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Nickel (Ni) | NA | EPA 6020m | 0.48 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Zinc (Zn) | NA | EPA 6020m | 70.6 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**42296 R1**

Appendix E-1. (Cont.).

# CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26170*

**CRG ID#:** *42296*
**Replicate #:** R2
**DILUTION FACTOR:** 1

**Sample Description:** RGS HBP-I mussel 06-08-0125
**Matrix:** Tissue

**Date Sampled:** 22-Jun-06 09:36
**Date Received:** 04-Aug-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 8.43 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Copper (Cu) | NA | EPA 6020m | 4.9 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Nickel (Ni) | NA | EPA 6020m | 0.47 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Zinc (Zn) | NA | EPA 6020m | 70.1 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**42296 R2**

Appendix E-1. (Cont.).

CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26170*

**CRG ID#:** *42297*
**Replicate #:** R1
**DILUTION FACTOR:** 1

**Sample Description:** RGS HBP-II 06-08-0125 mussel
**Matrix:** Tissue

**Date Sampled:** 22-Jun-06 09:36
**Date Received:** 04-Aug-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 9.89 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Copper (Cu) | NA | EPA 6020m | 6.7 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Nickel (Ni) | NA | EPA 6020m | 0.56 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Zinc (Zn) | NA | EPA 6020m | 73.8 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**42297 R1**

Appendix E-1. (Cont.).

# CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26170*

**CRG ID#:** *42298*
**Replicate #:** R1
**DILUTION FACTOR:** 1

**Sample Description:** RGS HBP-III mussel 06-08-0125
**Matrix:** Tissue

**Date Sampled:** 22-Jun-06 09:36
**Date Received:** 04-Aug-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | 11.1 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Copper (Cu) | NA | EPA 6020m | 5.73 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Nickel (Ni) | NA | EPA 6020m | 0.65 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Zinc (Zn) | NA | EPA 6020m | 87.3 | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**42298 R1**

Appendix E-1. (Cont.).


CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net


**Client: Calscience Environmental Laboratories, Inc.** **CRG Project ID: 26170**

**CRG ID#:** 42296
**Replicate #:** R1
**DILUTION FACTOR:** 1

**Sample Description:** RGS HBP-I 06-08-0125 mussel
**Matrix:** Tissue

**Date Sampled:** 22-Jun-06 09:36
**Date Received:** 04-Aug-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Percent Solids | NA | EPA 160.3 | 17.5 | Percent | 0.1 | 0.1 | 15-Aug-06 | 15-Aug-06 | 26170-14054 |

REFERENCE SITE

MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance

California ELAP Certificate # 2261
42296 R1

# CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26170*

**CRG ID#:** *42297*
**Replicate #:** R1
**DILUTION FACTOR:** 1

**Sample Description:** RGS HBP-II mussel 06-08-0125
**Matrix:** Tissue

**Date Sampled:** 22-Jun-06 09:36
**Date Received:** 04-Aug-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Percent Solids | NA | EPA 160.3 | 15.3 | Percent | 0.1 | 0.1 | 15-Aug-06 | 15-Aug-06 | 26170-14054 |

REFERENCE SITE

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**42297 R1**

CRG Marine Laboratories, Inc.

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26170*

**CRG ID#:** *42298*
**Replicate #:** R1
**DILUTION FACTOR:** 1

**Sample Description:** RGS HBP-III mussel 06-08-0125
**Matrix:** Tissue

**Date Sampled:** 22-Jun-06 09:36
**Date Received:** 04-Aug-06

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Percent Solids | NA | EPA 160.3 | 14.4 | Percent | 0.1 | 0.1 | 15-Aug-06 | 15-Aug-06 | 26170-14054 |

REFERENCE SITE

MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance

California ELAP Certificate # 2261
42298 R1

Appendix E-1. (Cont.).

CRG Marine Laboratories, Inc.
2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26170*

**CRG ID#:** *42295*
**Replicate #:** B1
**DILUTION FACTOR:** 1

**Sample Description:** QAQC 06-08-0125 Procedural Blank
**Matrix:** DI Water

**Date Sampled:**
**Date Received:**

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Chromium (Cr) | NA | EPA 6020m | ND | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Copper (Cu) | NA | EPA 6020m | ND | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Nickel (Ni) | NA | EPA 6020m | ND | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |
| Zinc (Zn) | NA | EPA 6020m | ND | µg/dry g | 0.025 | 0.05 | 14-Aug-06 | 15-Aug-06 | 26170-14054 |

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**42295 B1**

Appendix E-1. (Cont.).

**CRG Marine Laboratories, Inc.**

2020 Del Amo Blvd., Suite 200, Torrance, CA 90501-1206 (310) 533-5190 FAX (310) 533-5003 crglabs@sbcglobal.net

**Client:** *Calscience Environmental Laboratories, Inc.* **CRG Project ID:** *26170*

**CRG ID#:** *42295*
**Replicate #:** B1
**DILUTION FACTOR:** 1

**Sample Description:** QAQC 06-08-0125 Procedural Blank
**Matrix:** DI Water

**Date Sampled:**
**Date Received:**

| CONSTITUENT | FRACTION | METHOD | RESULT | UNITS | MDL | RL | DATE PROCESSED | DATE ANALYZED | BATCH ID |
|---|---|---|---|---|---|---|---|---|---|
| Percent Solids | NA | EPA 160.3 | ND | Percent | 0.1 | 0.1 | 15-Aug-06 | 15-Aug-06 | 26170-14054 |

REFERENCE SITE

**MDL= Method Detection Limit (CFR 40 Part 136); RL= Reporting Limit; J= Estimated Value below the RL and above the MDL; ND= Not Detected; NA= Not Applicable; MI = Matrix Interferance**

**California ELAP Certificate # 2261**
**42295 B1**

**Appendix E-2. Yearly mussel tissue metal concentrations (mg/dry kg). Mandalay Generating Station NPDES, 2006.**

| | Chromium | | | | | Copper | | | | | Nickel | | | | | Zinc | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rep 1 | Rep 2 | Rep 3 | Mean | SD | Rep 1 | Rep 2 | Rep 3 | Mean | SD | Rep 1 | Rep 2 | Rep 3 | Mean | SD | Rep 1 | Rep 2 | Rep 3 | Mean | SD |
| **Mussel Mooring** | | | | | | | | | | | | | | | | | | | | |
| 2006[2] | 9.48 | 6.03 | 5.86 | 7.12 | 2.04 | 6.63 | 8.671 | 5.387 | 6.90 | 1.66 | 1.461 | 2.322 | 1.216 | 1.666 | 0.581 | 159.354 | 100.454 | 82.324 | 114.044 | 40.273 |
| 2005[2] | 4.6 | 2.91 | 2.46 | 3.3 | 1.1 | 13.6 | 6.02 | 4.93 | 8.2 | 4.7 | 2.98 | 1.39 | 0.93 | 1.77 | 1.08 | 83.1 | 64.8 | 37 | 62 | 23.2 |
| 2004[1] | ND | ND | ND | - | - | 4.9 | 6.3 | 6.0 | 5.7 | 0.7 | ND | ND | ND | - | - | 54 | 58 | 55 | 56 | 2.1 |
| 2003[2] | ND | ND | ND | - | - | 1.1 | 1.2 | 1.0 | 1.1 | 0.1 | ND | ND | ND | - | - | 13 | 18 | 13 | 15 | 2.9 |
| 2002[2] | ND | ND | ND | - | - | 6.6 | 6.4 | 7.1 | 6.7 | 0.4 | ND | ND | ND | - | - | 100 | 97 | 110 | 102 | 6.8 |
| 2001[2] | ND | ND | ND | - | - | 12 | 13 | 7.0 | 10.7 | 3.2 | ND | ND | ND | - | - | 130 | 260 | 140 | 177 | 72.3 |
| **Donor Site** | | | | | | | | | | | | | | | | | | | | |
| 2006[2] | 6.47 | 7.34 | 9.92 | 7.91 | 1.79 | 4.69 | 4.79 | 9.19 | 6.22 | 2.6 | 0.48 | 0.50 | 0.86 | 0.61 | 0.21 | 90.19 | 89.06 | 105.95 | 95.07 | 9.44 |
| 2005 | 3.23 | 3.23 | 5.06 | 3.8 | 1.1 | 8.54 | 12.8 | 12.4 | 11.2 | 2.4 | 7.55 | 3.49 | 10.6 | 7.2 | 3.6 | 65 | 95.6 | 86.1 | 82 | 15.7 |
| 2004* | NS | NS | NS | - | - | NS | NS | NS | - | - | NS | NS | NS | - | - | NS | NS | NS | - | - |
| 2003 | ND | ND | ND | - | - | 1.3 | 1.2 | 1.1 | 1.2 | 0.1 | ND | ND | ND | - | - | 11 | 11 | 10 | 11 | 0.6 |
| 2002 | ND | ND | ND | - | - | 16 | 20 | 40 | 25 | 12.9 | ND | ND | ND | - | - | 87 | 92 | 120 | 100 | 17.8 |
| 2001 | ND | ND | ND | - | - | 13 | 16 | 16 | 15 | 1.7 | ND | ND | ND | - | - | 270 | 170 | 250 | 230 | 52.9 |

ND = Below the detection limit (for calculations ND = 0)
NS = Not required
1 = Resident mussels
2 = Transplanated mussels
* = Transplant mussel source not required

# APPENDIX F

## Infauna data by station

## Appendix F-1. Infaunal master species list. Mandalay Generating Station NPDES, 2006.

PHYLUM (Phy)
- Subphylum or Class
  - Species

**CNIDARIA (CN)**
- Anthozoa
  - Actiniaria sp A Paquette 2005[1]

**PLATYHELMINTHES (PL)**
- Turbellaria
  - *Stylochoplana* sp[2]

**NEMERTEA (NE)**
- Anopla
  - *Carinoma mutabilis*
  - Lineidae
- Enopla
  - *Paranemertes californica*[3]
  - *Tetrastemma* sp

**NEMATODA (NT)**
- Nematoda

**MOLLUSCA (MO)**
- Gastropoda
  - *Nassarius perpinguis*
- Bivalvia
  - *Cooperella subdiaphana*
  - *Donax gouldii*
  - *Leptopecten latiauratus*
  - *Mactromeris catilliformis*[4]
  - *Siliqua lucida*
  - *Solen sicarius*
  - *Tellina modesta*

**ANNELIDA (AN)**
- Polychaeta
  - *Amaeana occidentalis*
  - *Ampharete labrops*
  - *Apoprionospio pygmaea*[5]
  - *Aricidea (Acmira) catherinae*[6]
  - *Armandia brevis*[7]
  - *Chone* sp SD1 Pt. Loma 1997
  - *Glycera macrobranchia*[8]
  - *Goniadia littorea*
  - *Hesionella mccullochae*
  - Maldanidae
  - *Mediomastus acutus*
  - *Mediomastus ambiseta*[9]

PHYLUM
- Subphylum or Class
  - Species

**ANNELIDA (AN) Cont.**
- Polychaeta (cont.).
  - *Nephtys caecoides*
  - *Nephtys cornuta*
  - *Onuphis* sp I Pt Loma 1983
  - *Owenia collaris*[10]
  - *Polydora cornuta*
  - *Scoletoma tetraura* Cmplx[11]
  - *Spiophanes bombyx*
  - *Syllis (Typosyllis) farallonensis*

**ARTHROPODA (AR)**
- Pycnogonida
  - *Anoropallene palpida*
- Ostracoda
  - *Euphilomedes longiseta*
- Malacostraca
  - *Americhelidium shoemakeri*[12]
  - *Anchicolurus occidentalis*
  - *Campylaspis* sp C Myers & Benedict 1974
  - *Caprella californica*
  - *Cyclaspis nubila*
  - *Diastylopsis tenuis*
  - *Edotia sublittoralis*
  - *Eohaustorius barnardi*[13]
  - *Gibberosus myersi*[14]
  - *Metamysidopsis elongata*
  - *Pacificanthomysis nephrophthalma*
  - *Photis macinerneyi*
  - *Photis* sp
  - *Rhepoxynius abronius*
  - *Rhepoxynius menziesi*[15]
  - *Rhepoxynius* sp A SCAMIT 1987

**ECHINODERMATA (EC)**
- Ophiuroidea
  - Amphiuridae
- Echinoidea
  - *Dendraster excentricus*
- Holothuroidea
  - *Molpadia arenicola*

**PHORONA (PR)**
  - *Phoronis* sp

The following footnotes indicate names used in previous surveys:

1 Limnactiniidae sp A SCAMIT 1989
2 Platyhelminthes sp A MBC
3 *Paranemertes* sp A of SCAMIT
4 *Spisula catilliformis*
5 *Apoprionospio pygmaeus*
6 *Acesta catherinae, Acmira catherinae*
7 *Armandia bioculata*
8 *Glycera convoluta*
9 *Mediomastus* spp (in part)
10 *Owenia fusiformis*
11 *Lumbrineris "tetraura", L. tetraura*
12 *Synchelidium shoemakeri*
13 *Eohaustorius washingtonianus*
14 *Megaluropus longimerus*
15 *Paraphoxus epistomus, Rhepoxynius epistomus*

## Appendix F-2. Infauna results by station. Mandalay Generating Station NPDES, 2006.

| Phylum | Species | B1 | B2 | B3 | B4 | B5 | Total | Percent Total |
|---|---|---|---|---|---|---|---|---|
| AN | *Chone* sp SD1 Pt. Loma 1997 | 1 | 154 | 4 | 55 | 28 | 242 | 28.71 |
| AN | *Apoprionospio pygmaea* | 4 | 35 | 2 | 4 | 68 | 113 | 13.40 |
| AR | *Diastylopsis tenuis* | 5 | 40 | 7 | 5 | 17 | 74 | 8.78 |
| NE | *Carinoma mutabilis* | 16 | 12 | 7 | 9 | 8 | 52 | 6.17 |
| AR | *Rhepoxynius menziesi* | 16 | 5 | 2 | 6 | 1 | 30 | 3.56 |
| AR | *Euphilomedes longiseta* | 9 | - | 1 | 16 | 2 | 28 | 3.32 |
| EC | *Dendraster excentricus* | 8 | 2 | 3 | 13 | 1 | 27 | 3.20 |
| MO | *Tellina modesta* | 2 | - | 2 | 1 | 20 | 25 | 2.97 |
| AN | *Mediomastus acutus* | 2 | 5 | 2 | 2 | 11 | 22 | 2.61 |
| AN | *Mediomastus ambiseta* | - | 5 | - | 1 | 14 | 20 | 2.37 |
| MO | *Solen sicarius* | 5 | 1 | 8 | 1 | 1 | 16 | 1.90 |
| AR | *Anchicolurus occidentalis* | 4 | 3 | 3 | 2 | 3 | 15 | 1.78 |
| NE | Lineidae | 1 | 7 | - | 1 | 5 | 14 | 1.66 |
| AN | *Goniada littorea* | - | 6 | - | 3 | 3 | 12 | 1.42 |
| MO | *Mactromeris catilliformis* | - | - | - | - | 12 | 12 | 1.42 |
| MO | *Siliqua lucida* | - | 5 | - | - | 7 | 12 | 1.42 |
| AN | *Onuphis* sp 1 Pt. Loma 1983 | 2 | 2 | 3 | - | 4 | 11 | 1.30 |
| AN | *Nephtys caecoides* | 7 | - | 2 | 1 | - | 10 | 1.19 |
| AN | *Owenia collaris* | - | 7 | 2 | - | 1 | 10 | 1.19 |
| AR | *Edotia sublittoralis* | 1 | - | - | - | 8 | 9 | 1.07 |
| AN | *Hesionella mccullochae* | - | 1 | - | 1 | 5 | 7 | 0.83 |
| AN | *Syllis (Typosyllis) farallonensis* | - | 5 | - | 2 | - | 7 | 0.83 |
| AN | *Glycera macrobranchia* | 1 | 1 | 1 | 2 | 1 | 6 | 0.71 |
| AN | *Spiophanes bombyx* | 2 | 2 | - | 1 | 1 | 6 | 0.71 |
| AR | *Americhelidium shoemakeri* | - | - | - | 5 | - | 5 | 0.59 |
| NE | *Paranemertes californica* | - | 4 | - | - | 1 | 5 | 0.59 |
| MO | *Cooperella subdiaphana* | - | - | - | - | 4 | 4 | 0.47 |
| AN | *Armandia brevis* | - | - | 1 | 1 | 1 | 3 | 0.36 |
| AR | *Anoropallene palpida* | - | - | - | - | 3 | 3 | 0.36 |
| AR | *Photis macinerneyi* | - | 1 | - | - | 2 | 3 | 0.36 |
| AR | *Rhepoxynius* sp A SCAMIT 1987 | - | 3 | - | - | - | 3 | 0.36 |
| CN | Actiniaria sp A Paquette 2005 | - | 2 | - | 1 | - | 3 | 0.36 |
| AN | *Amaeana occidentalis* | - | - | - | - | 2 | 2 | 0.24 |
| AN | *Aricidea (Acmira) catherinae* | - | 1 | - | 1 | - | 2 | 0.24 |
| AR | *Campylaspis* sp C Myers & Benedict 1974 | - | 2 | - | - | - | 2 | 0.24 |
| AR | *Caprella californica* | - | - | - | - | 2 | 2 | 0.24 |
| AR | *Gibberosus myersi* | 1 | 1 | - | - | - | 2 | 0.24 |
| AR | *Metamysidopsis elongata* | - | 1 | - | 1 | - | 2 | 0.24 |
| MO | *Leptopecten latiauratus* | - | - | - | - | 2 | 2 | 0.24 |
| NT | Nematoda | - | - | - | 2 | - | 2 | 0.24 |
| PL | *Stylochoplana* sp | - | 2 | - | - | - | 2 | 0.24 |
| AN | *Ampharete labrops* | - | - | - | 1 | - | 1 | 0.12 |
| AN | Maldanidae | - | 1 | - | - | - | 1 | 0.12 |
| AN | *Nephtys cornuta* | - | - | - | - | 1 | 1 | 0.12 |
| AN | *Polydora cornuta* | - | - | - | 1 | - | 1 | 0.12 |
| AN | *Scoletoma tetraura* Cmplx | - | - | 1 | - | - | 1 | 0.12 |
| AR | *Cyclaspis nubila* | - | 1 | - | - | - | 1 | 0.12 |
| AR | *Eohaustorius barnardi* | - | - | 1 | - | - | 1 | 0.12 |
| AR | *Pacifacanthomysis nephrophthalma* | - | - | - | - | 1 | 1 | 0.12 |
| AR | *Photis* sp | 1 | - | - | - | - | 1 | 0.12 |
| AR | *Rhepoxynius abronius* | - | 1 | - | - | - | 1 | 0.12 |
| EC | Amphiuridae | - | - | - | - | 1 | 1 | 0.12 |
| EC | *Molpadia arenicola* | 1 | - | - | - | - | 1 | 0.12 |
| MO | *Donax gouldii* | - | - | 1 | - | - | 1 | 0.12 |
| MO | *Nassarius perpinguis* | - | 1 | - | - | - | 1 | 0.12 |
| NE | *Tetrastemma* sp | - | 1 | - | - | - | 1 | 0.12 |
| PR | *Phoronis* sp | - | - | - | - | 1 | 1 | 0.12 |
| | Number of individuals | 89 | 320 | 53 | 139 | 242 | 843 | |
| | Number of species | 20 | 33 | 19 | 27 | 34 | 57 | |
| | Diversity (H') | 2.56 | 2.09 | 2.69 | 2.34 | 2.71 | 2.84 | |

**Appendix F-3. Infaunal data by station and replicate. Mandalay Generating Station NPDES, 2006.**

**Station B1**

| Phylum | Species | Replicate B1-I | B1-II | B1-III | B1-IV | Total | Percent Composition | Density No./m² |
|---|---|---|---|---|---|---|---|---|
| AR | *Rhepoxynius menziesi* | 4 | 3 | 2 | 7 | 16 | 17.98 | 400.0 |
| NE | *Carinoma mutabilis* | 4 | 2 | 5 | 5 | 16 | 17.98 | 400.0 |
| AR | *Euphilomedes longiseta* | 2 | - | 5 | 2 | 9 | 10.11 | 225.0 |
| EC | *Dendraster excentricus* | 3 | - | 5 | - | 8 | 8.99 | 200.0 |
| AN | *Nephtys caecoides* | 3 | - | 3 | 1 | 7 | 7.87 | 175.0 |
| AR | *Diastylopsis tenuis* | 2 | - | 1 | 2 | 5 | 5.62 | 125.0 |
| MO | *Solen sicarius* | 1 | - | 4 | - | 5 | 5.62 | 125.0 |
| AN | *Apoprionospio pygmaea* | 1 | 1 | 1 | 1 | 4 | 4.49 | 100.0 |
| AR | *Anchicolurus occidentalis* | 3 | - | 1 | - | 4 | 4.49 | 100.0 |
| AN | *Mediomastus acutus* | 1 | - | - | 1 | 2 | 2.25 | 50.0 |
| AN | *Onuphis* sp 1 Pt. Loma 1983 | - | - | - | 2 | 2 | 2.25 | 50.0 |
| AN | *Spiophanes bombyx* | 1 | - | - | 1 | 2 | 2.25 | 50.0 |
| MO | *Tellina modesta* | - | - | - | 2 | 2 | 2.25 | 50.0 |
| AN | *Chone* sp SD1 Pt. Loma 1997 | - | 1 | - | - | 1 | 1.12 | 25.0 |
| AN | *Glycera macrobranchia* | 1 | - | - | - | 1 | 1.12 | 25.0 |
| AR | *Edotia sublittoralis* | - | - | - | 1 | 1 | 1.12 | 25.0 |
| AR | *Gibberosus myersi* | 1 | - | - | - | 1 | 1.12 | 25.0 |
| AR | *Photis* sp | - | - | - | 1 | 1 | 1.12 | 25.0 |
| EC | *Molpadia arenicola* | - | - | 1 | - | 1 | 1.12 | 25.0 |
| NE | Lineidae | - | - | 1 | - | 1 | 1.12 | 25.0 |

**Summary**

| Parameter | Replicate B1-I | B1-II | B1-III | B1-IV | Station Total | Replicate Mean | S.D. |
|---|---|---|---|---|---|---|---|
| Number of individuals | 27 | 7 | 29 | 26 | 89 | 22.3 | 10.2 |
| Number of species | 13 | 4 | 11 | 12 | 20 | 10.0 | 4.1 |
| Diversity (H') | 2.42 | 1.28 | 2.18 | 2.21 | 2.56 | 2.02 | 0.51 |

**Appendix F-3. (Cont.).**

**Station B2**

| Phylum | Species | Replicate B2-I | B2-II | B2-III | B2-IV | Total | Percent Composition | Density No./m² |
|---|---|---|---|---|---|---|---|---|
| AN | *Chone* sp SD1 Pt. Loma 1997 | 15 | 48 | 52 | 39 | 154 | 48.13 | 3850.0 |
| AR | *Diastylopsis tenuis* | 26 | 8 | 6 | - | 40 | 12.50 | 1000.0 |
| AN | *Apoprionospio pygmaea* | 14 | 8 | 3 | 10 | 35 | 10.94 | 875.0 |
| NE | *Carinoma mutabilis* | 3 | 2 | 7 | - | 12 | 3.75 | 300.0 |
| AN | *Owenia collaris* | 1 | - | 4 | 2 | 7 | 2.19 | 175.0 |
| NE | Lineidae | 2 | - | 1 | 4 | 7 | 2.19 | 175.0 |
| AN | *Goniada littorea* | 2 | 2 | 1 | 1 | 6 | 1.88 | 150.0 |
| AN | *Mediomastus acutus* | - | - | 2 | 3 | 5 | 1.56 | 125.0 |
| AN | *Mediomastus ambiseta* | - | - | - | 5 | 5 | 1.56 | 125.0 |
| AN | *Syllis (Typosyllis) farallonensis* | 3 | 1 | 1 | - | 5 | 1.56 | 125.0 |
| AR | *Rhepoxynius menziesi* | 1 | - | - | 4 | 5 | 1.56 | 125.0 |
| MO | *Siliqua lucida* | - | 1 | 3 | 1 | 5 | 1.56 | 125.0 |
| NE | *Paranemertes californica* | 1 | - | 3 | - | 4 | 1.25 | 100.0 |
| AR | *Anchicolurus occidentalis* | 1 | 1 | - | 1 | 3 | 0.94 | 75.0 |
| AR | *Rhepoxynius* sp A SCAMIT 1987 | - | - | - | 3 | 3 | 0.94 | 75.0 |
| AN | *Onuphis* sp 1 Pt. Loma 1983 | 1 | - | - | 1 | 2 | 0.63 | 50.0 |
| AN | *Spiophanes bombyx* | 1 | 1 | - | - | 2 | 0.63 | 50.0 |
| AR | *Campylaspis* sp C Myers & Benedict 1974 | 1 | - | 1 | - | 2 | 0.63 | 50.0 |
| CN | Actiniaria sp A Paquette 2005 | - | 1 | - | 1 | 2 | 0.63 | 50.0 |
| EC | *Dendraster excentricus* | 1 | 1 | - | - | 2 | 0.63 | 50.0 |
| PL | *Stylochoplana* sp | - | 1 | 1 | - | 2 | 0.63 | 50.0 |
| AN | *Aricidea (Acmira) catherinae* | 1 | - | - | - | 1 | 0.31 | 25.0 |
| AN | *Glycera macrobranchia* | - | - | 1 | - | 1 | 0.31 | 25.0 |
| AN | *Hesionella mccullochae* | - | 1 | - | - | 1 | 0.31 | 25.0 |
| AN | Maldanidae | - | 1 | - | - | 1 | 0.31 | 25.0 |
| AR | *Cyclaspis nubila* | - | - | 1 | - | 1 | 0.31 | 25.0 |
| AR | *Gibberosus myersi* | 1 | - | - | - | 1 | 0.31 | 25.0 |
| AR | *Metamysidopsis elongata* | - | - | 1 | - | 1 | 0.31 | 25.0 |
| AR | *Photis macinerneyi* | - | 1 | - | - | 1 | 0.31 | 25.0 |
| AR | *Rhepoxynius abronius* | - | - | - | 1 | 1 | 0.31 | 25.0 |
| MO | *Nassarius perpinguis* | 1 | - | - | - | 1 | 0.31 | 25.0 |
| MO | *Solen sicarius* | - | - | - | 1 | 1 | 0.31 | 25.0 |
| NE | *Tetrastemma* sp | - | - | - | 1 | 1 | 0.31 | 25.0 |

**Summary**

| Parameter | Replicate B2-I | B2-II | B2-III | B2-IV | Station Total | Replicate Mean | S.D. |
|---|---|---|---|---|---|---|---|
| Number of individuals | 76 | 78 | 88 | 78 | 320 | 80.0 | 5.4 |
| Number of species | 18 | 15 | 16 | 16 | 33 | 16.3 | 1.3 |
| Diversity (H') | 2.07 | 1.51 | 1.67 | 1.88 | 2.09 | 1.79 | 0.24 |

**Appendix F-3. (Cont.).**

**Station B3**

| Phylum | Species | Replicate B3-I | B3-II | B3-III | B3-IV | Total | Percent Composition | Density No./m² |
|---|---|---|---|---|---|---|---|---|
| MO | *Solen sicarius* | 4 | 4 | - | - | 8 | 15.09 | 200.0 |
| AR | *Diastylopsis tenuis* | 1 | 2 | 3 | 1 | 7 | 13.21 | 175.0 |
| NE | *Carinoma mutabilis* | 2 | 2 | 3 | - | 7 | 13.21 | 175.0 |
| AN | *Chone* sp SD1 Pt. Loma 1997 | 1 | - | 1 | 2 | 4 | 7.55 | 100.0 |
| AN | *Onuphis* sp 1 Pt. Loma 1983 | - | - | 3 | - | 3 | 5.66 | 75.0 |
| AR | *Anchicolurus occidentalis* | - | - | 3 | - | 3 | 5.66 | 75.0 |
| EC | *Dendraster excentricus* | 2 | - | - | 1 | 3 | 5.66 | 75.0 |
| AN | *Apoprionospio pygmaea* | - | 1 | - | 1 | 2 | 3.77 | 50.0 |
| AN | *Mediomastus acutus* | - | - | - | 2 | 2 | 3.77 | 50.0 |
| AN | *Nephtys caecoides* | - | 1 | 1 | - | 2 | 3.77 | 50.0 |
| AN | *Owenia collaris* | 1 | - | 1 | - | 2 | 3.77 | 50.0 |
| AR | *Rhepoxynius menziesi* | 1 | - | 1 | - | 2 | 3.77 | 50.0 |
| MO | *Tellina modesta* | 1 | - | - | 1 | 2 | 3.77 | 50.0 |
| AN | *Armandia brevis* | - | 1 | - | - | 1 | 1.89 | 25.0 |
| AN | *Glycera macrobranchia* | 1 | - | - | - | 1 | 1.89 | 25.0 |
| AN | *Scoletoma tetraura* Cmplx | - | - | 1 | - | 1 | 1.89 | 25.0 |
| AR | *Eohaustorius barnardi* | 1 | - | - | - | 1 | 1.89 | 25.0 |
| AR | *Euphilomedes longiseta* | - | 1 | - | - | 1 | 1.89 | 25.0 |
| MO | *Donax gouldii* | - | 1 | - | - | 1 | 1.89 | 25.0 |

**Summary**

| Parameter | Replicate B3-I | B3-II | B3-III | B3-IV | Station Total | Replicate Mean | S.D. |
|---|---|---|---|---|---|---|---|
| Number of individuals | 15 | 13 | 17 | 8 | 53 | 13.3 | 3.9 |
| Number of species | 10 | 8 | 9 | 6 | 19 | 8.3 | 1.7 |
| Diversity (H') | 2.15 | 1.93 | 2.06 | 1.73 | 2.69 | 1.97 | 0.18 |

**Appendix F-3. (Cont.).**

**Station B4**

| Phylum | Species | Replicate B4-I | B4-II | B4-III | B4-IV | Total | Percent Composition | Density No./m² |
|---|---|---|---|---|---|---|---|---|
| AN | *Chone* sp SD1 Pt. Loma 1997 | 3 | 1 | - | 51 | 55 | 39.57 | 1375.0 |
| AR | *Euphilomedes longiseta* | 9 | - | 7 | - | 16 | 11.51 | 400.0 |
| EC | *Dendraster excentricus* | - | 6 | 6 | 1 | 13 | 9.35 | 325.0 |
| NE | *Carinoma mutabilis* | 4 | 2 | 3 | - | 9 | 6.47 | 225.0 |
| AR | *Rhepoxynius menziesi* | 2 | 3 | 1 | - | 6 | 4.32 | 150.0 |
| AR | *Americhelidium shoemakeri* | - | 1 | 4 | - | 5 | 3.60 | 125.0 |
| AR | *Diastylopsis tenuis* | - | 1 | 1 | 3 | 5 | 3.60 | 125.0 |
| AN | *Apoprionospio pygmaea* | - | - | - | 4 | 4 | 2.88 | 100.0 |
| AN | *Goniada littorea* | - | - | - | 3 | 3 | 2.16 | 75.0 |
| AN | *Glycera macrobranchia* | - | - | 1 | 1 | 2 | 1.44 | 50.0 |
| AN | *Mediomastus acutus* | 1 | 1 | - | - | 2 | 1.44 | 50.0 |
| AN | *Syllis (Typosyllis) farallonensis* | - | - | - | 2 | 2 | 1.44 | 50.0 |
| AR | *Anchicolurus occidentalis* | - | - | 1 | 1 | 2 | 1.44 | 50.0 |
| NT | Nematoda | - | 2 | - | - | 2 | 1.44 | 50.0 |
| AN | *Ampharete labrops* | - | - | - | 1 | 1 | 0.72 | 25.0 |
| AN | *Aricidea (Acmira) catherinae* | - | - | - | 1 | 1 | 0.72 | 25.0 |
| AN | *Armandia brevis* | - | - | - | 1 | 1 | 0.72 | 25.0 |
| AN | *Hesionella mccullochae* | - | - | - | 1 | 1 | 0.72 | 25.0 |
| AN | *Mediomastus ambiseta* | - | - | - | 1 | 1 | 0.72 | 25.0 |
| AN | *Nephtys caecoides* | - | 1 | - | - | 1 | 0.72 | 25.0 |
| AN | *Polydora cornuta* | - | - | 1 | - | 1 | 0.72 | 25.0 |
| AN | *Spiophanes bombyx* | - | 1 | - | - | 1 | 0.72 | 25.0 |
| AR | *Metamysidopsis elongata* | - | - | - | 1 | 1 | 0.72 | 25.0 |
| CN | Actiniaria sp A Paquette 2005 | 1 | - | - | - | 1 | 0.72 | 25.0 |
| MO | *Solen sicarius* | - | - | - | 1 | 1 | 0.72 | 25.0 |
| MO | *Tellina modesta* | 1 | - | - | - | 1 | 0.72 | 25.0 |
| NE | Lineidae | 1 | - | - | - | 1 | 0.72 | 25.0 |

**Summary**

| Parameter | Replicate B4-I | B4-II | B4-III | B4-IV | Station Total | Replicate Mean | S.D. |
|---|---|---|---|---|---|---|---|
| Number of individuals | 22 | 19 | 25 | 73 | 139 | 34.8 | 25.6 |
| Number of species | 8 | 10 | 9 | 15 | 27 | 10.5 | 3.1 |
| Diversity (H') | 1.73 | 2.06 | 1.89 | 1.36 | 2.34 | 1.76 | 0.30 |

**Appendix F-3. (Cont.).**

**Station B5**

| Phylum | Species | Replicate B5-I | B5-II | B5-III | B5-IV | Total | Percent Composition | Density No./m² |
|---|---|---|---|---|---|---|---|---|
| AN | *Apoprionospio pygmaea* | 10 | 17 | 27 | 14 | 68 | 28.10 | 1700.0 |
| AN | *Chone* sp SD1 Pt. Loma 1997 | 3 | 8 | 10 | 7 | 28 | 11.57 | 700.0 |
| MO | *Tellina modesta* | 6 | 6 | 3 | 5 | 20 | 8.26 | 500.0 |
| AR | *Diastylopsis tenuis* | 1 | 9 | 6 | 1 | 17 | 7.02 | 425.0 |
| AN | *Mediomastus ambiseta* | 1 | 7 | 5 | 1 | 14 | 5.79 | 350.0 |
| MO | *Mactromeris catilliformis* | 2 | 3 | 4 | 3 | 12 | 4.96 | 300.0 |
| AN | *Mediomastus acutus* | 1 | 2 | 3 | 5 | 11 | 4.55 | 275.0 |
| AR | *Edotia sublittoralis* | 1 | 1 | 5 | 1 | 8 | 3.31 | 200.0 |
| NE | *Carinoma mutabilis* | 1 | 3 | 3 | 1 | 8 | 3.31 | 200.0 |
| MO | *Siliqua lucida* | - | 3 | 2 | 2 | 7 | 2.89 | 175.0 |
| AN | *Hesionella mccullochae* | 3 | 1 | - | 1 | 5 | 2.07 | 125.0 |
| NE | Lineidae | - | 3 | - | 2 | 5 | 2.07 | 125.0 |
| AN | *Onuphis* sp 1 Pt. Loma 1983 | - | 1 | 2 | 1 | 4 | 1.65 | 100.0 |
| MO | *Cooperella subdiaphana* | 2 | 1 | 1 | - | 4 | 1.65 | 100.0 |
| AN | *Goniada littorea* | 1 | - | 2 | - | 3 | 1.24 | 75.0 |
| AR | *Anchicolurus occidentalis* | - | 1 | 2 | - | 3 | 1.24 | 75.0 |
| AR | *Anoropallene palpida* | 1 | - | 2 | - | 3 | 1.24 | 75.0 |
| AN | *Amaeana occidentalis* | - | 1 | - | 1 | 2 | 0.83 | 50.0 |
| AR | *Caprella californica* | - | - | 2 | - | 2 | 0.83 | 50.0 |
| AR | *Euphilomedes longiseta* | - | - | 1 | 1 | 2 | 0.83 | 50.0 |
| AR | *Photis macinerneyi* | 1 | 1 | - | - | 2 | 0.83 | 50.0 |
| MO | *Leptopecten latiauratus* | - | - | 2 | - | 2 | 0.83 | 50.0 |
| AN | *Armandia brevis* | - | - | 1 | - | 1 | 0.41 | 25.0 |
| AN | *Glycera macrobranchia* | 1 | - | - | - | 1 | 0.41 | 25.0 |
| AN | *Nephtys cornuta* | 1 | - | - | - | 1 | 0.41 | 25.0 |
| AN | *Owenia collaris* | 1 | - | - | - | 1 | 0.41 | 25.0 |
| AN | *Spiophanes bombyx* | 1 | - | - | - | 1 | 0.41 | 25.0 |
| AR | *Pacifacanthomysis nephrophthalma* | - | - | 1 | - | 1 | 0.41 | 25.0 |
| AR | *Rhepoxynius menziesi* | - | 1 | - | - | 1 | 0.41 | 25.0 |
| EC | Amphiuridae | 1 | - | - | - | 1 | 0.41 | 25.0 |
| EC | *Dendraster excentricus* | - | 1 | - | - | 1 | 0.41 | 25.0 |
| MO | *Solen sicarius* | 1 | - | - | - | 1 | 0.41 | 25.0 |
| NE | *Paranemertes californica* | - | 1 | - | - | 1 | 0.41 | 25.0 |
| PR | *Phoronis* sp | - | 1 | - | - | 1 | 0.41 | 25.0 |

**Summary**

| Parameter | Replicate B5-I | B5-II | B5-III | B5-IV | Station Total | Replicate Mean | S.D. |
|---|---|---|---|---|---|---|---|
| Number of individuals | 40 | 72 | 84 | 46 | 242 | 60.5 | 20.9 |
| Number of species | 20 | 21 | 20 | 15 | 34 | 19.0 | 2.7 |
| Diversity (H') | 2.61 | 2.56 | 2.48 | 2.25 | 2.71 | 2.47 | 0.16 |

**Appendix F-4. Infaunal wet weight biomass data (g). Mandalay Generating Station NPDES, 2006.**

| Sta-Rep | Annelida | Arthropoda | Mollusca | Echinodermata | Misc. | Total |
|---|---|---|---|---|---|---|
| B1-I | 0.171 | 0.042 | 0.055 | 0.038 | 0.023 | 0.329 |
| B1-II | <0.0001 | 0.005 | - | - | 0.026 | 0.030 |
| B1-III | <0.0001 | 0.093 | <0.0001 | 22.185[a] | 0.032 | 22.309 |
| B1-IV | 0.081 | 0.094 | <0.0001 | - | 0.016 | 0.191 |
| Total | 0.252 | 0.232 | 0.055 | 22.222 | 0.097 | 22.859 |
| | | | | | | |
| B2-I | 0.154 | 0.185 | 0.076 | <0.0001 | 0.100 | 0.516 |
| B2-II | 0.278 | 0.099 | 0.096 | 0.052 | 0.013 | 0.538 |
| B2-III | 0.169 | 0.046 | 0.131 | - | 0.014 | 0.360 |
| B2-IV | 0.355 | 0.028 | 0.040 | - | <0.0001 | 0.422 |
| Total | 0.956 | 0.358 | 0.343 | 0.052 | 0.127 | 1.836 |
| | | | | | | |
| B3-I | 0.061 | 0.033 | 0.054 | 3.140[b] | 0.058 | 3.346 |
| B3-II | 0.055 | 0.024 | 0.006 | - | 0.036 | 0.122 |
| B3-III | 0.085 | <0.0001 | - | - | 0.031 | 0.116 |
| B3-IV | 0.077 | <0.0001 | <0.0001 | <0.0001 | - | 0.077 |
| Total | 0.277 | 0.057 | 0.061 | 3.140 | 0.125 | 3.660 |
| | | | | | | |
| B4-I | 0.042 | <0.0001 | <0.0001 | - | 0.006 | 0.049 |
| B4-II | 0.027 | <0.0001 | - | 13.849[c] | 0.042 | 13.918 |
| B4-III | 0.046 | <0.0001 | - | 15.970[d] | 0.087 | 16.103 |
| B4-IV | 0.435 | <0.0001 | 0.072 | 0.069 | - | 0.576 |
| Total | 0.550 | - | 0.072 | 29.888 | 0.136 | 30.646 |
| | | | | | | |
| B5-I | 0.021 | 0.025 | <0.0001 | <0.0001 | 0.030 | 0.076 |
| B5-II | 0.067 | 0.015 | 0.092 | <0.0001 | 0.082 | 0.256 |
| B5-III | 0.166 | <0.0001 | 0.124 | - | 0.023 | 0.313 |
| B5-IV | 0.122 | <0.0001 | 0.087 | - | <0.0001 | 0.209 |
| Total | 0.376 | 0.040 | 0.304 | - | 0.135 | 0.855 |
| Grand Total | 2.412 | 0.688 | 0.835 | 55.302 | 0.620 | 59.855 |

Notes:
- = no animals
a = 4 medium sized *Dendraster excentricus* and 1 *Molpadia arenicola* at 22.1551
b = 2 medium sized *Dendraster excentricus* at 3.14
c = 6 medium sized *Dedraster excentricus* at 13.8487
d = 6 medium sized *Dendraster excentricus* at 15.9695

**Appendix F-5. Yearly infaunal abundance, 1978 - 2006. Mandalay Generating Station NPDES, 2006.**

| | | Year | | | | | | | | | | | | | | | | | | | | Percent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Phy | Species | 1978 | 1980 | 1986 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Total | Total |
| AN | *Apoprionospio pygmaea* | 86 | 213 | 17 | 175 | 52 | 490 | 170 | 128 | 203 | 100 | 658 | 28 | 143 | 569 | 354 | 719 | 86 | 744 | 113 | 5048 | 22.51 |
| MO | *Donax gouldii* | - | - | - | - | - | - | - | - | - | - | 3064 | - | 2 | - | - | 6 | - | 1 | 1 | 3074 | 13.71 |
| AN | *Mediomastus acutus* | 5 | 1 | - | - | - | - | - | 1 | 58 | 35 | 1026 | 28 | 12 | 103 | 83 | 3 | 40 | 6 | 22 | 1423 | 6.35 |
| AR | *Diastylopsis tenuis* | 123 | 163 | 75 | 33 | 12 | 9 | 5 | 11 | 88 | 45 | 2 | 51 | 56 | 7 | 19 | - | 4 | 424 | 74 | 1201 | 5.36 |
| AR | *Rhepoxynius menziesi* | 17 | 25 | 20 | 61 | 43 | 14 | 18 | 14 | 34 | - | 35 | 270 | 84 | 67 | 71 | 64 | 85 | 36 | 30 | 988 | 4.41 |
| AN | *Scoloplos armiger* Cmplx | 61 | 28 | 20 | 111 | 187 | 149 | 55 | 69 | 43 | 71 | 16 | 10 | 10 | 20 | 12 | 18 | 33 | 4 | - | 917 | 4.09 |
| AN | *Spiophanes bombyx* | 14 | 51 | 92 | 46 | 17 | 2 | 3 | 154 | 60 | 15 | 13 | 8 | 43 | 4 | 2 | - | 12 | 76 | 6 | 618 | 2.76 |
| AN | *Chone* sp SD1 Pt. Loma 1997 | - | - | - | - | - | - | - | - | - | - | 14 | 1 | 20 | 7 | 25 | 5 | 290 | 10 | 242 | 614 | 2.74 |
| EC | *Dendraster excentricus* | 12 | 1 | 43 | 17 | 87 | 14 | 14 | - | 10 | 103 | 52 | 75 | 34 | 41 | 15 | 7 | 4 | 3 | 27 | 559 | 2.49 |
| AN | *Owenia collaris* | 5 | 40 | - | 2 | 10 | 88 | 9 | 44 | 2 | 130 | 8 | 31 | 111 | 5 | 29 | 1 | 1 | - | 10 | 526 | 2.35 |
| NE | *Carinoma mutabilis* | - | 3 | 16 | 18 | 7 | 18 | 28 | 19 | 25 | 24 | 78 | 17 | 18 | 29 | 28 | 7 | 14 | 11 | 52 | 412 | 1.84 |
| MO | *Siliqua lucida* | - | 17 | 9 | 112 | - | 4 | - | - | 82 | 62 | 22 | 31 | 6 | 17 | 11 | - | 1 | 12 | 12 | 398 | 1.77 |
| AR | *Euphilomedes carcharodonta* | - | 1 | 1 | 3 | - | - | - | - | 47 | 333 | - | - | - | - | 2 | - | - | - | - | 387 | 1.73 |
| MO | *Tellina modesta* | 2 | 18 | 29 | 2 | 4 | - | - | 1 | 11 | 101 | 2 | 19 | 46 | 20 | 8 | 1 | 23 | 3 | 25 | 315 | 1.40 |
| AN | *Magelona pitelkai* | 9 | 131 | - | 38 | 13 | 21 | 14 | 24 | 20 | 5 | - | 1 | - | 8 | 6 | 5 | 1 | 3 | - | 299 | 1.33 |
| AN | *Goniada littorea* | 21 | 26 | 6 | - | 6 | 2 | - | 3 | 6 | 11 | 36 | 74 | 37 | 5 | 9 | - | 4 | 11 | 12 | 269 | 1.20 |
| AN | *Pectinaria californiensis* | - | 1 | 9 | 60 | 3 | - | - | - | 4 | 112 | - | 1 | 6 | - | 2 | - | 1 | - | - | 199 | 0.89 |
| AR | *Americhelidium shoemakeri* | 4 | - | - | 1 | 7 | - | - | - | 8 | 3 | - | 5 | 23 | 68 | 25 | 13 | 18 | 2 | 5 | 182 | 0.81 |
| AN | *Nephtys caecoides* | 6 | 4 | 8 | 5 | 9 | 24 | 8 | 11 | 14 | 3 | 3 | 6 | 11 | 9 | 19 | 21 | 8 | 2 | 10 | 181 | 0.81 |
| CN | *Zaolutus actius* | - | 4 | - | - | - | - | - | - | - | 99 | 4 | 7 | 40 | 4 | 17 | - | - | - | - | 175 | 0.78 |
| AR | *Rhepoxynius* sp A SCAMIT 1987 | 2 | 5 | 9 | 12 | 26 | 11 | - | - | 23 | 37 | - | 4 | 11 | 12 | 12 | - | 2 | 4 | 3 | 173 | 0.77 |
| AR | *Photis macinerneyi* | - | - | 13 | 45 | - | - | - | - | 4 | 20 | 2 | 5 | 10 | 6 | 1 | - | - | 58 | 3 | 167 | 0.74 |
| AN | *Mediomastus* spp | - | 9 | 16 | 17 | 12 | 7 | 4 | - | - | - | 91 | 2 | 1 | 2 | - | - | - | - | - | 161 | 0.72 |
| MO | *Mactromeris catilliformis* | - | - | - | - | - | - | - | - | - | 12 | - | - | - | 14 | 120 | - | 1 | 1 | 12 | 160 | 0.71 |
| AR | *Euphilomedes longiseta* | - | - | - | 2 | 10 | 22 | - | - | - | - | 3 | - | 3 | 5 | 54 | 12 | 12 | 6 | 28 | 157 | 0.70 |
| AN | *Magelona sacculata* | 2 | 23 | 47 | 22 | 16 | 4 | - | - | - | - | - | - | - | 2 | 6 | - | - | - | - | 122 | 0.54 |
| AN | *Spiophanes duplex* | 4 | 17 | - | 11 | - | - | - | 4 | 3 | 1 | 1 | - | 5 | 1 | - | - | - | 70 | - | 117 | 0.52 |
| AR | *Mandibulophoxus gilesi* | 14 | - | - | - | - | 36 | 15 | - | 4 | 15 | - | - | 3 | - | - | 4 | 23 | - | - | 114 | 0.51 |
| MO | *Solen sicarius* | 2 | - | 9 | 16 | 3 | 5 | 2 | 5 | 3 | 20 | 20 | 3 | 6 | - | - | 1 | - | - | 16 | 111 | 0.49 |
| AN | *Armandia brevis* | - | 7 | - | 5 | - | 1 | - | - | 7 | 3 | 6 | 9 | - | 6 | 3 | - | 11 | 46 | 3 | 107 | 0.48 |
| AN | *Onuphis eremita* | - | - | - | - | 11 | 9 | - | 45 | 1 | 1 | 17 | - | 1 | - | 1 | 19 | - | - | - | 105 | 0.47 |
| NE | Lineidae | - | - | - | 1 | - | - | - | - | - | 9 | 22 | 13 | 5 | 4 | 2 | 1 | 24 | 10 | 14 | 105 | 0.47 |
| AN | *Mediomastus ambiseta* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 13 | - | 61 | 5 | 20 | 99 | 0.44 |
| AN | *Chone albocincta* | - | - | - | - | 5 | 14 | - | 5 | 9 | 62 | - | - | - | - | 1 | - | - | - | - | 96 | 0.43 |
| AR | *Isocheles pilosus* | 12 | 1 | - | 75 | 1 | - | - | - | - | 1 | - | - | 2 | 1 | - | - | - | - | - | 93 | 0.41 |
| AR | *Anchicolurus occidentalis* | - | - | - | 2 | - | 3 | - | 1 | 2 | 4 | - | 19 | 4 | 1 | 1 | 1 | 4 | 35 | 15 | 92 | 0.41 |
| AN | *Dispio uncinata* | 9 | 20 | 10 | 6 | 2 | - | - | - | 1 | 4 | - | 4 | 9 | 7 | - | 1 | - | 12 | - | 85 | 0.38 |
| AR | *Edotia sublittoralis* | 1 | 7 | - | 1 | - | - | - | - | 1 | 35 | 1 | - | 2 | - | 3 | - | - | 18 | 9 | 78 | 0.35 |
| AR | *Eohaustorius barnardi* | 17 | 12 | 9 | 4 | 1 | - | - | - | 5 | 11 | 1 | 1 | 4 | 7 | 2 | - | - | - | 1 | 75 | 0.33 |
| AN | *Glycera macrobranchia* | 1 | 1 | - | 1 | 13 | 3 | 4 | 3 | 3 | 6 | 4 | 1 | 1 | 4 | 8 | 2 | 6 | 6 | 6 | 73 | 0.33 |
| AN | *Ampharete labrops* | 1 | - | 3 | 5 | - | 4 | - | - | 6 | - | 5 | 3 | 6 | 5 | 24 | - | 2 | 1 | 1 | 66 | 0.29 |
| NE | Nemertea | 3 | 4 | 3 | 4 | 4 | 1 | - | 10 | 2 | 4 | 16 | - | 1 | - | - | 3 | 2 | - | - | 57 | 0.25 |
| AN | *Spiochaetopterus costarum* | - | 1 | 1 | 5 | 7 | 2 | - | 12 | 7 | 4 | - | - | 10 | 5 | - | - | 1 | 1 | - | 56 | 0.25 |
| AR | *Uromunna ubiquita* | - | - | - | 1 | - | - | - | - | - | 33 | 2 | 4 | 1 | 3 | 6 | 1 | 3 | 1 | - | 55 | 0.25 |
| NE | *Paranemertes californica* | - | 4 | 1 | 6 | 2 | - | - | - | 4 | 11 | 1 | 1 | 3 | - | 1 | 2 | 1 | 10 | 5 | 52 | 0.23 |
| AR | *Photis* sp | 17 | 30 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 48 | 0.21 |
| AR | *Eohaustorius sawyeri* | - | - | - | - | 8 | - | - | - | - | - | - | 4 | - | - | 28 | 5 | 1 | - | - | 46 | 0.21 |
| AR | Calanoida | 6 | 39 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 45 | 0.20 |
| AN | *Onuphis* sp 1 Pt. Loma 1983 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 6 | - | 3 | 24 | 11 | 44 | 0.20 |
| AN | Onuphidae | 1 | - | - | - | 1 | - | 1 | - | 1 | 1 | - | - | 3 | - | 35 | - | - | - | - | 43 | 0.19 |
| AR | *Jassa slatteryi* | - | - | - | - | - | - | - | - | - | - | - | 38 | - | - | - | 3 | 2 | - | - | 43 | 0.19 |
| MO | *Macoma nasuta* | - | - | 8 | - | 35 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 43 | 0.19 |
| NT | Nematoda | - | - | - | - | 1 | - | 1 | - | 2 | 4 | - | 2 | - | 1 | - | 6 | 15 | 6 | 2 | 40 | 0.18 |
| AN | *Aricidea (Acmira) catherinae* | - | 7 | 9 | 1 | 5 | 2 | - | - | 3 | 2 | - | - | - | 1 | 3 | - | 3 | - | 2 | 38 | 0.17 |
| AR | *Leptocuma forsmani* | 1 | - | - | - | - | - | 14 | 3 | 1 | 5 | 1 | 2 | 2 | 2 | - | - | 4 | 2 | - | 37 | 0.16 |
| MO | *Cooperella subdiaphana* | - | 1 | 1 | 6 | - | - | - | - | - | 7 | 2 | 3 | 2 | 6 | 2 | 1 | 2 | - | 4 | 37 | 0.16 |
| AN | *Amastigos acutus* | - | 35 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 35 | 0.16 |
| AN | *Amaeana occidentalis* | 1 | - | - | - | - | - | 1 | - | - | - | 28 | 1 | - | - | - | - | - | - | 2 | 33 | 0.15 |
| AN | *Onuphis* sp | - | - | - | 1 | - | - | - | - | - | 11 | - | - | 15 | 5 | - | - | - | - | - | 32 | 0.14 |
| AN | *Syllis (Typosyllis) farallonensis* | - | - | 1 | - | - | - | - | - | 6 | - | - | - | - | - | - | - | - | 18 | 7 | 32 | 0.14 |
| AR | *Gibberosus myersi* | 2 | - | 1 | 1 | - | - | - | - | 2 | 8 | - | 3 | 4 | 5 | - | 2 | - | 2 | 2 | 32 | 0.14 |
| AR | *Campylaspis* sp C M & B 1974 | - | - | - | - | - | - | - | 1 | 1 | 1 | - | 8 | 12 | 1 | 2 | - | 1 | 1 | 2 | 30 | 0.13 |
| MO | *Mysella pedroana* | - | 1 | - | 27 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 28 | 0.12 |
| PR | Phoronidae | - | 2 | - | - | 1 | 1 | - | 2 | 3 | 7 | 1 | - | 5 | 2 | 1 | - | 3 | - | - | 28 | 0.12 |
| AN | *Neosabellaria cementarium* | - | - | - | - | - | - | - | - | - | - | - | 27 | - | - | - | - | - | - | - | 27 | 0.12 |
| MO | *Tellina bodegensis* | - | - | 1 | 2 | 2 | - | - | - | 13 | 1 | - | 3 | 1 | 2 | 2 | - | - | - | - | 27 | 0.12 |
| AN | *Polydora limicola* | - | - | - | - | - | - | - | - | 26 | - | - | - | - | - | - | - | - | - | - | 26 | 0.12 |
| AN | *Polydora* sp | 1 | 1 | 1 | 14 | 1 | 2 | - | 1 | - | - | - | - | - | 3 | - | - | - | - | - | 24 | 0.11 |
| AN | *Prionospio (Minuspio) lighti* | 1 | 1 | 1 | - | 4 | - | - | - | 5 | 7 | - | - | - | - | - | - | 3 | 1 | - | 23 | 0.10 |
| AN | *Syllis* spp | - | - | - | 3 | 13 | 5 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | 23 | 0.10 |

## Appendix F-5. (Cont.).

| Phy | Species | 1978 | 1980 | 1986 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Total | Percent Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AR | *Anoropallene palpida* | - | - | - | - | - | - | - | - | - | 17 | - | 3 | - | - | - | - | - | - | 3 | 23 | 0.10 |
| AR | Phoxocephalidae | - | - | - | - | - | 16 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | 23 | 0.10 |
| MO | *Macoma* sp | - | - | 6 | - | - | - | - | 1 | 2 | - | - | 2 | 7 | - | 1 | 2 | 1 | 1 | - | 23 | 0.10 |
| AN | *Hesionella mccullochae* | - | - | - | - | - | - | - | - | - | 1 | 3 | 1 | 5 | 1 | - | - | 1 | 3 | 7 | 22 | 0.10 |
| AR | *Lepidopa californica* | 2 | 1 | 5 | 3 | - | - | 4 | 3 | - | - | - | 1 | - | - | - | - | 3 | - | - | 22 | 0.10 |
| AR | *Photis macrotica* | 13 | 9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 22 | 0.10 |
| AN | *Notomastus tenuis* | - | - | - | 1 | - | - | - | - | 2 | - | 10 | 6 | 1 | - | - | - | - | - | - | 20 | 0.09 |
| MO | Mactridae | 1 | 5 | 14 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 20 | 0.09 |
| AR | *Hemilamprops californica* | - | - | - | - | - | - | - | - | - | 17 | - | 2 | - | - | - | - | - | - | - | 19 | 0.08 |
| AN | *Polydora cornuta* | - | - | 16 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 17 | 0.08 |
| AN | *Sthenelais verruculosa* | - | 1 | 2 | - | - | 1 | 1 | 2 | - | - | 2 | - | 5 | 2 | 1 | - | - | - | - | 17 | 0.08 |
| AR | *Lamprops carinatus* | - | - | - | - | - | - | - | - | - | - | - | - | 5 | - | 2 | - | 1 | 9 | - | 17 | 0.08 |
| PL | *Stylochoplana* sp | - | - | - | 3 | 2 | - | - | - | - | 7 | 2 | - | 1 | - | - | - | - | - | 2 | 17 | 0.08 |
| MO | *Macoma secta* | - | 2 | - | 1 | - | 3 | - | - | - | 1 | - | - | 1 | - | - | - | 8 | - | - | 16 | 0.07 |
| AR | *Cyclaspis nubila* | - | - | - | - | - | - | - | - | 5 | 7 | - | - | 1 | - | 1 | - | - | - | 1 | 15 | 0.07 |
| EC | Amphiuridae | - | - | - | - | 2 | - | - | - | 6 | - | - | 3 | - | 3 | - | - | - | - | 1 | 15 | 0.07 |
| MO | *Mactrotoma californica* | - | - | - | - | - | - | - | - | - | - | 1 | 1 | 13 | - | - | - | - | - | - | 15 | 0.07 |
| AN | *Chaetozone setosa* Cmplx | - | - | - | - | 13 | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | 14 | 0.06 |
| AN | *Nephtys cornuta* | - | 8 | - | - | - | - | - | - | - | - | 2 | - | - | 1 | - | - | 1 | 1 | 1 | 14 | 0.06 |
| AR | *Rhepoxynius* sp | 10 | - | - | - | - | - | 4 | - | - | - | - | - | - | - | - | - | - | - | - | 14 | 0.06 |
| PR | *Phoronis* sp | - | 3 | - | 8 | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 1 | 14 | 0.06 |
| MO | *Crepidula naticarum* | - | 4 | 9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 13 | 0.06 |
| AN | *Aricidea (Allia) hartleyi* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12 | - | - | 12 | 0.05 |
| AN | *Onuphis iridescens* | - | 5 | - | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12 | 0.05 |
| AN | *Spiophanes berkeleyorum* | 2 | - | - | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | - | 12 | 0.05 |
| AN | *Sthenelais tertiaglabra* | - | - | - | - | - | - | - | - | 2 | 6 | - | 4 | - | - | - | - | - | - | - | 12 | 0.05 |
| AR | *Balanus pacificus* | - | 4 | 2 | - | - | - | - | - | - | - | - | 2 | - | 4 | - | - | - | - | - | 12 | 0.05 |
| MO | *Cyclostremella dalli* | - | - | - | - | - | - | - | - | - | 12 | - | - | - | - | - | - | - | - | - | 12 | 0.05 |
| MO | *Olivella baetica* | 1 | 1 | 1 | 2 | - | - | - | - | - | - | 1 | 1 | - | 2 | 2 | - | 1 | - | - | 12 | 0.05 |
| NE | *Tetrastemma* sp | - | - | - | - | - | - | - | - | 3 | 4 | - | 2 | - | - | 2 | - | - | - | 1 | 12 | 0.05 |
| NE | *Tubulanus polymorphus* | - | - | 2 | - | - | - | - | - | 4 | - | 1 | - | 1 | 2 | 1 | - | 1 | - | - | 12 | 0.05 |
| AN | *Carraziella* sp A SCAMIT 1995 | - | - | - | - | - | - | - | - | - | - | - | - | - | 11 | - | - | - | - | - | 11 | 0.05 |
| AN | *Cirriformia spirabrancha* | - | - | 2 | - | - | - | - | - | 1 | 5 | - | 2 | - | 1 | - | - | - | - | - | 11 | 0.05 |
| AN | *Dipolydora socialis* | - | - | - | - | - | - | - | - | 11 | - | - | - | - | - | - | - | - | - | - | 11 | 0.05 |
| AN | *Scolelepis squamata* | - | - | - | - | - | 4 | - | 6 | - | 1 | - | - | - | - | - | - | - | - | - | 11 | 0.05 |
| AR | *Aoroides* sp | - | - | - | - | - | - | - | - | 4 | - | 1 | 1 | 2 | - | 3 | - | - | - | - | 11 | 0.05 |
| AR | *Neotrypaea* sp | 1 | 1 | 7 | 1 | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 11 | 0.05 |
| CN | Actiniaria | - | - | - | - | 6 | - | - | - | 5 | - | - | - | - | - | - | - | - | - | - | 11 | 0.05 |
| MO | *Mysella* sp A SCAMIT 1988 | - | - | - | - | - | - | - | - | - | 11 | - | - | - | - | - | - | - | - | - | 11 | 0.05 |
| MO | *Rictaxis punctocaelatus* | - | - | 4 | - | - | - | - | - | - | - | 2 | - | 4 | 1 | - | - | - | - | - | 11 | 0.05 |
| AN | *Glycinde armigera* | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | 1 | 2 | - | 10 | 0.04 |
| AN | *Phyllodoce hartmanae* | - | - | 3 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 3 | - | 10 | 0.04 |
| AR | *Ogyrides* sp A Roney 1978 | 1 | - | 3 | 1 | - | - | - | - | 1 | 1 | - | 2 | 1 | - | - | - | - | - | - | 10 | 0.04 |
| CN | Anthozoa | - | 2 | 2 | 1 | - | 3 | - | 2 | - | - | - | - | - | - | - | - | - | - | - | 10 | 0.04 |
| AN | *Aricidea (Aedicira) pacifica* | - | - | - | 1 | - | - | - | - | - | - | 7 | - | - | - | - | - | - | 1 | - | 9 | 0.04 |
| AN | *Mooreonuphis stigmatis* | - | - | - | - | - | - | - | - | - | - | - | 9 | - | - | - | - | - | - | - | 9 | 0.04 |
| AN | *Sigalion spinosus* | - | - | 2 | 2 | - | 1 | - | - | 3 | - | - | - | - | 1 | - | - | - | - | - | 9 | 0.04 |
| CN | Limnactiniidae sp A SCAMIT 1989 | - | - | - | - | 5 | - | - | - | - | 1 | 1 | 1 | - | - | 1 | - | - | - | - | 9 | 0.04 |
| MO | *Macoma indentata* | - | - | - | - | - | - | - | - | 3 | 2 | - | - | - | 2 | 2 | - | - | - | - | 9 | 0.04 |
| AN | *Glycinde polygnatha* | - | 8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 8 | 0.04 |
| AN | *Polydora cirrosa* | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 7 | - | - | - | - | 8 | 0.04 |
| AR | *Aoroides inermis* | - | - | - | - | - | - | - | - | - | - | - | 3 | - | 5 | - | - | - | - | - | 8 | 0.04 |
| AR | *Metamysidopsis elongata* | 1 | - | 1 | - | 2 | - | - | - | 1 | - | - | - | - | - | - | - | 1 | - | 2 | 8 | 0.04 |
| EC | *Leptosynapta* sp | - | 1 | 1 | 2 | - | 1 | - | 3 | - | - | - | - | - | - | - | - | - | - | - | 8 | 0.04 |
| MO | *Nassarius perpinguis* | - | 1 | - | - | - | - | - | - | 1 | 2 | - | - | - | 1 | 1 | 1 | - | - | 1 | 8 | 0.04 |
| PL | *Pseudoceros* sp | - | - | - | - | - | - | - | - | 1 | 2 | 1 | - | 1 | - | - | 3 | - | - | - | 8 | 0.04 |
| NE | *Cerebratulus californiensis* | - | 2 | - | 1 | 1 | 1 | 2 | - | - | - | - | - | - | - | - | - | - | - | - | 7 | 0.03 |
| AN | *Chone* sp | 1 | - | 1 | 1 | - | - | - | - | - | - | - | - | - | - | 2 | - | - | 1 | - | 6 | 0.03 |
| AN | *Lumbrineris californiensis* | - | - | 1 | - | - | - | - | - | 1 | - | - | 2 | 2 | - | - | - | - | - | - | 6 | 0.03 |
| AN | *Magelona californica* | - | - | - | - | - | - | - | - | - | - | - | - | 6 | - | - | - | - | - | - | 6 | 0.03 |
| AN | *Scoletoma tetraura* Cmplx | - | - | - | - | 1 | - | - | - | 2 | 1 | - | - | - | - | - | - | 1 | - | 1 | 6 | 0.03 |
| AR | *Eohaustorius sencillus* | - | - | - | - | - | 5 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 6 | 0.03 |
| AR | *Pollicipes polymerus* | - | - | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 6 | 0.03 |
| AR | *Rhepoxynius abronius* | - | - | - | - | - | - | - | - | 1 | - | - | - | 3 | - | - | - | - | 1 | 1 | 6 | 0.03 |
| CO | Enteropneusta | 1 | - | - | - | - | - | - | - | - | 1 | - | 1 | - | - | - | - | 3 | - | - | 6 | 0.03 |
| EC | *Amphiodia urtica* | - | - | - | - | 1 | 1 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | 6 | 0.03 |
| NE | *Tetrastemma candidum* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | 4 | - | 6 | 0.03 |
| NE | *Zygonemertes virescens* | - | - | - | - | - | - | - | - | - | - | - | - | - | 5 | - | - | - | 1 | - | 6 | 0.03 |
| AN | *Heteromastus* sp | - | - | 5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5 | 0.02 |
| AN | *Nephtys* sp | - | - | - | 2 | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 5 | 0.02 |

## Appendix F-5. (Cont.).

| Phy | Species | 1978 | 1980 | 1986 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Total | Percent Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AN | *Spiophanes* sp | - | 1 | - | - | - | - | 1 | 3 | - | - | - | - | - | - | - | - | - | - | - | 5 | 0.02 |
| AN | *Syllis (Typosyllis)* sp | - | - | - | - | - | - | - | - | - | 5 | - | - | - | - | - | - | - | - | - | 5 | 0.02 |
| AR | *Blepharipoda occidentalis* | - | - | - | - | - | - | 2 | 2 | 1 | - | - | - | - | - | - | - | - | - | - | 5 | 0.02 |
| AR | *Cumella californica* | - | 1 | - | - | 1 | - | - | - | - | 3 | - | - | - | - | - | - | - | - | - | 5 | 0.02 |
| AR | *Cyclaspis* sp C SCAMIT 1986 | - | - | - | - | - | 5 | - | - | - | - | - | - | - | - | - | - | - | - | - | 5 | 0.02 |
| AR | Gammaridea | 1 | 1 | - | - | - | - | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | - | 5 | 0.02 |
| AR | Harpacticoida | - | - | - | - | - | - | - | - | - | - | 3 | - | 1 | - | - | - | - | 1 | - | 5 | 0.02 |
| AR | *Jassa marmorata* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5 | - | - | - | 5 | 0.02 |
| CN | *Renilla kollikeri* | - | - | 1 | 1 | - | - | - | - | - | - | - | 1 | - | - | - | 2 | - | - | - | 5 | 0.02 |
| EC | *Amphiodia* sp | - | - | - | - | - | - | - | - | - | 3 | - | 1 | - | - | - | - | 1 | - | - | 5 | 0.02 |
| MO | *Modiolus* sp | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | 1 | 2 | - | - | - | - | 5 | 0.02 |
| MO | *Rochefortia tumida* | - | - | - | - | - | - | - | - | - | 1 | - | 1 | - | - | 1 | - | 2 | - | - | 5 | 0.02 |
| NE | *Monostylifera* sp C SCAMIT 1995 | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | 2 | - | - | - | - | 5 | 0.02 |
| NE | *Tetrastemma* sp A SCAMIT 1995 | - | - | - | - | - | - | - | - | - | - | 3 | 1 | - | - | - | - | 1 | - | - | 5 | 0.02 |
| AN | *Onuphis eremita parva* | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 2 | 1 | - | - | - | - | 4 | 0.02 |
| AN | Phyllodocidae | - | - | - | - | - | - | - | - | - | 4 | - | - | - | - | - | - | - | - | - | 4 | 0.02 |
| AN | *Podarkeopsis glabra* | - | - | - | 1 | 1 | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 | 0.02 |
| AN | *Typosyllis aciculata* | 1 | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 | 0.02 |
| AR | *Balanus* sp | - | - | - | - | - | - | - | - | 4 | - | - | - | - | - | - | - | - | - | - | 4 | 0.02 |
| AR | *Cancer gracilis* | - | 2 | 1 | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 4 | 0.02 |
| AR | *Hartmanodes hartmanae* | - | - | 1 | - | 1 | - | 1 | - | - | - | - | - | - | 1 | - | - | - | - | - | 4 | 0.02 |
| AR | *Lamprops quadriplicatus* | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 3 | - | - | 4 | 0.02 |
| AR | Mysidacea | 1 | 2 | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 | 0.02 |
| AR | *Zeuxo normani* | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | 4 | 0.02 |
| EC | Ophiuroidea | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | 1 | 1 | - | 4 | 0.02 |
| MO | *Chione* sp | - | - | 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 | 0.02 |
| MO | *Crepidula norrisiarum* | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 3 | - | - | - | - | 4 | 0.02 |
| MO | *Macoma yoldiformis* | - | - | 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 | 0.02 |
| MO | *Modiolus neglectus* | - | 2 | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | 4 | 0.02 |
| MO | *Pandora bilirata* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 3 | - | - | 4 | 0.02 |
| MO | *Rochefortia* sp A SCAMIT 1988 | - | - | - | - | - | - | - | - | - | - | - | - | 4 | - | - | - | - | - | - | 4 | 0.02 |
| MO | *Yoldia seminuda* | - | - | 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 | 0.02 |
| NE | *Tetrastemma nigrifrons* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 | - | - | 4 | 0.02 |
| AN | *Anaitides* sp | - | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | 0.01 |
| AN | *Diopatra ornata* | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - | - | - | 3 | 0.01 |
| AN | *Eteone fauchaldi* | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 1 | 1 | - | - | - | - | 3 | 0.01 |
| AN | *Goniada maculata* | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | 1 | - | 3 | 0.01 |
| AN | Lumbrineridae | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 2 | - | - | - | - | - | 3 | 0.01 |
| AN | *Nereis procera* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | 2 | - | - | 3 | 0.01 |
| AN | *Notomastus* sp A SCAMIT 2001 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | 3 | 0.01 |
| AN | *Phyllodoce* sp | - | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | 0.01 |
| AN | *Polycirrus* sp A SCAMIT 1995 | - | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - | - | - | - | 3 | 0.01 |
| AN | *Sabellaria nanella* | - | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | 0.01 |
| AN | *Syllides* sp | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - | - | - | - | - | - | 3 | 0.01 |
| AR | *Anoplodactylus oculospinus* | - | - | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | 0.01 |
| AR | *Cancer* sp | - | - | - | 1 | - | - | - | - | 1 | - | - | - | - | - | 1 | - | - | - | - | 3 | 0.01 |
| AR | *Caprella californica* | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 3 | 0.01 |
| AR | *Ischyrocerus anguipes* | - | - | - | - | - | - | - | - | - | - | - | 2 | - | 1 | - | - | - | - | - | 3 | 0.01 |
| AR | *Ischyrocerus pelagops* | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - | - | - | - | - | - | 3 | 0.01 |
| AR | *Parasterope hulingsi* | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | - | 1 | - | - | 3 | 0.01 |
| AR | *Photis brevipes* | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - | 3 | 0.01 |
| CN | Actiniaria sp A Paquette 2005 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | 3 | 0.01 |
| MO | *Leptopecten latiauratus* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | 2 | 3 | 0.01 |
| MO | *Neverita reclusiana* | - | - | - | 1 | 1 | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 3 | 0.01 |
| MO | *Nuculana taphria* | - | - | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | 0.01 |
| MO | *Odostomia* sp D MBC 1975 | - | - | 1 | 1 | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 3 | 0.01 |
| MO | *Protothaca staminea* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 1 | - | 1 | - | - | 3 | 0.01 |
| NE | *Carinomella lactea* | - | 1 | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | 0.01 |
| NE | *Enopla* sp A SCAMIT 1995 | - | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - | - | - | - | 3 | 0.01 |
| NE | Nemertea sp B MBC 2004 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | 3 | 0.01 |
| PL | Platyhelminthes | 1 | - | - | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | 0.01 |
| AN | *Aricidea (Acmira) horikoshii* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | - | - | - | 2 | 0.01 |
| AN | *Eteone cf. alba* | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| AN | *Glycera nana* | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| AN | *Heteropodarke heteromorpha* | - | - | - | - | - | - | - | - | 1 | 1 | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| AN | *Leitoscoloplos pugettensis* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | 1 | - | - | 2 | 0.01 |
| AN | *Lumbrineris* sp | - | - | 1 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| AN | *Magelona* sp | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| AN | *Phloides asperus* | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | 2 | 0.01 |
| AN | *Phyllochaetopterus prolifica* | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | 2 | 0.01 |

**Appendix F-5. (Cont.).**

| Phy | Species | Year 1978 | 1980 | 1986 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Total | Percent Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AN | *Phyllodoce pettiboneae* | - | - | - | - | - | - | - | - | 1 | 1 | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| AN | Spionidae | - | 1 | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| AN | *Tenonia priops* | - | 1 | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| AR | *Americhelidium* sp | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| AR | *Cerapus tubularis* Cmplx | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 1 | - | - | - | - | - | 2 | 0.01 |
| AR | *Monocorophium acherusicum* | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | - | - | - | 2 | 0.01 |
| AR | Paguridae | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | - | - | - | - | - | 2 | 0.01 |
| AR | *Parasterope baresi* | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| AR | *Pinnixa franciscana* | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| AR | *Pinnixa* sp | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| AR | *Rhepoxynius stenodes* | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| AR | *Rhepoxynius variatus* | - | - | - | - | 1 | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 2 | 0.01 |
| EC | Holothuroidea | - | - | - | - | - | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| MO | *Crepidula* sp | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| MO | Gastropoda | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | - | - | - | - | - | 2 | 0.01 |
| MO | *Nassarius fossatus* | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| MO | Pelecypoda | - | - | - | - | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| MO | *Polygireulima rutila* | - | - | - | - | 1 | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| NE | *Micrura alaskensis* | - | 1 | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.01 |
| NE | *Micrura* sp | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | 2 | 0.01 |
| PR | *Phoronopsis* sp | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | 2 | 0.01 |
| AN | *Aricidea* sp | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | 1 | 0.00 |
| AN | *Axiothella rubrocincta* | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | Capitellidae | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | *Chaetozone* sp | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | *Chone* sp C (Harris 1984) | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | *Cirriformia moorei* | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | *Cirriformia* sp | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | 1 | 0.00 |
| AN | *Cirriformia tentaculata* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 0.00 |
| AN | *Diopatra* sp | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 0.00 |
| AN | *Diopatra spendidissima* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 1 | 0.00 |
| AN | *Eteone brigitteae* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | Euclymeninae sp A SCAMIT 1987 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 1 | 0.00 |
| AN | *Exogone lourei* | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | 1 | 0.00 |
| AN | *Glycera* sp | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | *Harmothoe hirsuta* | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | 1 | 0.00 |
| AN | *Lumbrineris japonica* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 0.00 |
| AN | Maldanidae | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | 0.00 |
| AN | *Malmgreniella* sp | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | Oligochaeta | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 1 | 0.00 |
| AN | *Parandalia ocularis* | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | *Paraprionospio pinnata* | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | *Pholoe glabra* | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | *Phylo felix* | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | *Pista disjuncta* | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | *Polyophthalmus pictus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 1 | 0.00 |
| AN | Sigalionidae | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | *Sphaerephesia similisetis* | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AN | Syllidae | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | 0.00 |
| AN | *Timarete luxuriosa* | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Alienacanthomysis macropsis* | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Amphideutopus oculatus* | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Cancer antennarius* | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | 1 | 0.00 |
| AR | *Caprella* sp | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Caprella verrucosa* | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | Crustacea (zoea) | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | Cumacea | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Cyclaspis* sp B SCAMIT 1989 | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Cyprideis stewarti* | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Eochelidium* sp A SCAMIT 1996 | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Foxiphalus obtusidens* | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Gitanopsis vilordes* | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Holmesimysis costata* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 0.00 |
| AR | Ischyroceridae | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Listriella melanica* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | 0.00 |
| AR | *Monocorophium* sp | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Monoculodes hartmanae* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Munnogonium tillerae* | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Mysidopsis intii* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Neomysis kadiakensis* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | 0.00 |

**Appendix F-5. (Cont.).**

| Phy | Species | 1978 | 1980 | 1986 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Total | Percent Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AR | *Opisthopus transversus* | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Pachycheles rudis* | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Pacifacanthomysis nephrophthalma* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | 0.00 |
| AR | *Paraonella platybranchia* | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Photis* sp A SCAMIT 1995 | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Postasterope barnesi* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | Pycnogonida | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Pyromaia tuberculata* | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Rhepoxynius lucubrans* | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| AR | *Rhepoxynius tridentatus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 1 | 0.00 |
| AR | *Stenothoe estacola* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 0.00 |
| AR | *Tiron biocellata* | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| CN | *Hydractinia* sp | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | 0.00 |
| EC | *Amphiodia digitata* | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 | 0.00 |
| EC | *Amphiura acrystata* | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| EC | *Caudina arenicola* | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| EC | *Molpadia arenicola* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | 0.00 |
| EN | Entoprocta | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| EP | *Cryptoarachnidium argillum* | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| EP | *Triticella elongata* | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | 0.00 |
| MO | *Acteocina* sp | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | 1 | 0.00 |
| MO | *Amiantis callosa* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 0.00 |
| MO | *Crepidula onyx* | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | 0.00 |
| MO | *Ennucula tenuis* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| MO | *Kurtziella plumbea* | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| MO | *Lyonsia californica* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 0.00 |
| MO | *Macoma carlottensis* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | 1 | 0.00 |
| MO | *Mysella* sp | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| MO | Mytilidae | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| MO | *Nitidiscala sawinae* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| MO | *Odostomia* sp | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| MO | *Rochefortia compressa* | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | 0.00 |
| MO | *Sulcoretusa xystrum* | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| MO | *Yoldia cooperii* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 1 | 0.00 |
| NE | *Amphiporus* sp | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | 0.00 |
| NE | *Cerebratulus* sp | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| PL | Platyhelminthes sp A of MBC | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| PL | *Stylochus exiguus* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | 0.00 |
| SI | Sipuncula | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | 1 | 0.00 |
| | Number of individuals | 511 | 1049 | 612 | 1041 | 699 | 1021 | 399 | 599 | 946 | 1737 | 5311 | 896 | 915 | 1161 | 1123 | 952 | 885 | 1726 | 843 | 22426 | |
| | Number of species | 54 | 79 | 68 | 72 | 70 | 53 | 35 | 38 | 81 | 92 | 59 | 82 | 79 | 75 | 75 | 38 | 75 | 60 | 57 | 319 | |
| | 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 | |
| | Diversity (H') | 2.85 | 3.05 | 3.38 | 3.13 | 3.03 | 2.15 | 2.28 | 2.45 | 3.20 | 3.30 | 1.46 | 2.97 | 3.26 | 2.38 | 2.87 | 1.25 | 2.82 | 2.82 | 2.84 | 3.41 | |

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 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, 2006.**

| Phylum | Class | Family | Species | Common name |
|---|---|---|---|---|
| Annelida | | | | |
| | Polychaeta | | | |
| | | Aphroditidae | | |
| Arthropoda | | | | |
| | | | *Aphrodita* sp | sea mouse unid |
| | Malacostraca | | | |
| | | Cancridae | | |
| | | | *Cancer anthonyi* | yellow crab |
| | | | *Cancer gracilis* | graceful crab |
| | | Crangonidae | | |
| | | | *Crangon nigromaculata* | blackspotted bay shrimp |
| | | Cymothoidae | | |
| | | | *Elthusa vulgaris* | sea louse |
| | | Hippolytidae | | |
| | | | *Heptacarpus stimpsoni* | Stimpson coastal shrimp |
| | | Leucosiidae | | |
| | | | *Randallia ornata* | globose sand crab |
| | | Majidae | | |
| | | | *Loxorhynchus grandis* | sheep crab |
| | | | *Pyromaia tuberculata* | tuberculate pear crab |
| | | Palinuridae | | |
| | | | *Panulirus interruptus* | California spiny lobster |
| | | Pinnotheridae | | |
| | | | *Opisthopus transversus* | mottled pea crab |
| | | Portunidae | | |
| | | | *Portunus xantusii* | Xantus swimming crab |
| Cnidaria | | | | |
| | Hydrozoa | | | |
| | | Polyorchidae | | |
| | | | *Polyorchis penicillatus* | red jellyfish |
| Echinodermata | | | | |
| | Echinoidea | | | |
| | | Dendrasteridae | | |
| | | | *Dendraster excentricus* | Pacific sand dollar |
| | Holothuroidea | | | |
| | | Caudinidae | | |
| | | | *Caudina arenicola* | sweet potatoe sea cucumber |
| Mollusca | | | | |
| | Cephalopoda | | | |
| | | Octopodidae | | |
| | | | *Octopus bimaculatus/bimaculoides* | California two-spot octopus |
| | Gastropoda | | | |
| | | Nassariidae | | |
| | | | *Nassarius perpinguis* | fat western nassa |
| Chordata | | | | |
| | Actinopterygii | | | |
| | | Agonidae | | |
| | | | *Stellerina xyosterna* | pricklebreast poacher |
| | | Cottidae | | |
| | | | *Leptocottus armatus* | Pacific staghorn sculpin |
| | | Cynoglossidae | | |
| | | | *Symphurus atricaudus* | California tonguefish |
| | | Embiotocidae | | |
| | | | *Amphistichus argenteus* | barred surfperch |
| | | | *Cymatogaster aggregata* | shiner perch |
| | | | *Hyperprosopon argenteum* | walleye surfperch |
| | | | *Phanerodon furcatus* | white seaperch |
| | | Engraulidae | | |
| | | | *Engraulis mordax* | northern anchovy |
| | | Gobiidae | | |
| | | | *Lepidogobius lepidus* | bay goby |
| | | Paralichthyidae | | |
| | | | *Citharichthys stigmaeus* | speckled sanddab |
| | | | *Paralichthys californicus* | California halibut |
| | | Pleuronectidae | | |
| | | | *Parophrys vetulus* | English sole |
| | | Sciaenidae | | |
| | | | *Pleuronichthys verticalis* | hornyhead turbot |
| | | | *Atractoscion nobilis* | white seabass |
| | | | *Genyonemus lineatus* | white croaker |
| | | | *Menticirrhus undulatus* | California corbina |
| | | | *Seriphus politus* | queenfish |
| | | Scorpaenidae | | |
| | | | *Sebastes miniatus* | vermillion rockfish |
| | | Stromateidae | | |
| | | | *Peprilus simillimus* | Pacific pompano |
| | | Syngnathidae | | |
| | | | *Syngnathus californiensis* | kelp pipefish |
| | Chondrichthyes | | | |
| | | Myliobatidae | | |
| | | | *Myliobatis californica* | bat ray |
| | | Platyrhinidae | | |
| | | | *Platyrhinoidis triseriata* | thornback |
| | | Rhinobatidae | | |
| | | | *Rhinobatos productus* | shovelnose guitarfish |
| | | Squalidae | | |
| | | | *Squalus acanthias* | spiny dogfish |
| | | Squatinidae | | |
| | | | *Squatina californica* | Pacific angel shark |

**Appendix G-2. Abundance of fish species in trawl replicates, winter and summer. Mandalay Generating Station NPDES, 2006.**

| | Winter | | | | | | | | | Summer | | | | | | | | | Annual | Percent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T1 | | T2 | | T3 | | T4 | | | T1 | | T2 | | T3 | | T4 | | | | |
| Species | I | II | I | II | I | II | I | II | Total | I | II | I | II | I | II | I | II | Total | Total | Total |
| *Genyonemus lineatus* | - | 1 | - | - | 1 | 1 | - | - | 3 | 490 | 224 | 131 | 35 | 1,233 | 315 | 705 | 520 | 3,653 | 3,656 | 62.3 |
| *Citharichthys stigmaeus* | 30 | 29 | 13 | 6 | 14 | 35 | 80 | 99 | 306 | 109 | 70 | 71 | 116 | 61 | 59 | 197 | 159 | 842 | 1,148 | 19.6 |
| *Cymatogaster aggregata* | - | - | - | - | - | - | 1 | - | 1 | 8 | 1 | 82 | 39 | 20 | 8 | 114 | 57 | 329 | 330 | 5.6 |
| *Syngnathus californiensis* | 3 | 4 | 3 | 4 | 5 | 4 | 8 | 9 | 40 | 14 | 25 | 56 | 22 | 35 | 27 | 16 | 10 | 205 | 245 | 4.2 |
| *Engraulis mordax* | 11 | 1 | 1 | - | 15 | 1 | - | - | 29 | 9 | 25 | 112 | 27 | 10 | 7 | 9 | 3 | 202 | 231 | 3.9 |
| *Hyperprosopon argenteum* | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 7 | 17 | 41 | 67 | 67 | 1.1 |
| *Phanerodon furcatus* | - | - | - | - | - | - | - | - | - | - | - | 6 | - | 5 | 8 | 15 | 5 | 39 | 39 | 0.7 |
| *Seriphus politus* | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | - | 1 | 2 | 29 | 34 | 34 | 0.6 |
| *Stellerina xyosterna* | - | - | 1 | 1 | - | - | - | - | 2 | 7 | 1 | 5 | 5 | 1 | 1 | 1 | 2 | 23 | 25 | 0.4 |
| *Leptocottus armatus* | - | - | - | - | - | - | - | - | - | 1 | 1 | - | 1 | 1 | 9 | 1 | 1 | 15 | 15 | 0.3 |
| *Platyrhinoidis triseriata* | 1 | 1 | - | - | - | - | - | - | 2 | - | - | - | 2 | 4 | 4 | 1 | 2 | 13 | 15 | 0.3 |
| *Squalus acanthias* | - | - | - | - | - | - | - | - | - | 3 | 1 | 1 | - | 1 | 6 | - | - | 12 | 12 | 0.2 |
| *Parophrys vetulus* | 1 | - | - | 2 | 1 | - | 1 | - | 5 | - | - | - | - | - | 1 | 3 | 1 | 5 | 10 | 0.2 |
| *Lepidogobius lepidus* | 1 | - | - | - | - | - | 3 | 2 | 6 | - | - | - | - | - | - | - | - | - | 6 | 0.1 |
| *Paralichthys californicus* | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 2 | 1 | 2 | 6 | 6 | 0.1 |
| *Amphistichus argenteus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 2 | 4 | 4 | 0.1 |
| *Atractoscion nobilis* | - | - | - | - | - | - | - | - | - | 1 | - | 2 | - | - | - | 1 | - | 4 | 4 | 0.1 |
| *Rhinobatos productus* | - | - | - | - | 1 | - | - | - | 1 | 1 | - | - | - | - | 1 | 1 | - | 3 | 4 | 0.1 |
| *Myliobatis californica* | 1 | - | - | - | - | - | - | - | 1 | - | 1 | - | - | - | - | - | 2 | 3 | 4 | 0.1 |
| *Menticirrhus undulatus* | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | - | - | 1 | - | 3 | 3 | 0.1 |
| *Sebastes miniatus* | - | - | - | - | - | - | 1 | 2 | 3 | - | - | - | - | - | - | - | - | - | 3 | 0.1 |
| *Squatina californica* | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | - | - | - | - | 2 | 2 | 0.0 |
| *Pleuronichthys verticalis* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | 1 | 0.0 |
| *Symphurus atricaudus* | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | 1 | 1 | 0.0 |
| *Peprilus simillimus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 1 | 0.0 |
| Total abundance | 48 | 36 | 18 | 13 | 37 | 41 | 94 | 112 | 399 | 644 | 351 | 467 | 250 | 1,374 | 457 | 1,087 | 837 | 5,467 | 5,866 | |
| Species | 7 | 5 | 4 | 4 | 6 | 4 | 6 | 4 | 12 | 11 | 11 | 10 | 11 | 13 | 16 | 17 | 16 | 23 | 25 | |
| Diversity (H') | 1.13 | 0.72 | 0.85 | 1.20 | 1.30 | 0.54 | 0.60 | 0.46 | 0.91 | 0.82 | 1.10 | 1.70 | 1.58 | 0.50 | 1.22 | 1.14 | 1.26 | 1.20 | 1.28 | |
| Area Trawled ($m^2$) | 4,852.7 | 4,881.3 | 4,635.0 | 4,489.3 | 4,870.8 | 4,758.5 | 4,821.9 | 4,882.7 | | 4,603.1 | 4,625.9 | 4,656.8 | 4,662.9 | 4,533.9 | 4,632.3 | 4,207.7 | 4,635.5 | | | |
| Abundance less than 30 mm SL. | | | | | | | | | | | | | | | | | | | | |
| *Engraulis mordax* | 2 | 1 | - | - | - | - | - | - | 3 | - | - | - | - | - | - | - | - | - | 3 | |
| *Genyonemus lineatus* | 8 | 2 | 1 | - | - | - | - | - | 11 | - | - | - | - | - | - | - | - | - | 11 | |
| Total Abundance < 30 mm SL | 10 | 3 | 1 | - | - | - | - | - | 14 | - | - | - | - | - | - | - | - | - | 14 | |

**Appendix G-3. Biomass (kg) of fish species in trawl replicates. Mandalay Generating Station NPDES, 2006.**

| | Winter | | | | | | | | | Summer | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T1 | | T2 | | T3 | | T4 | | | T1 | | T2 | | T3 | | T4 | | | Annual | Percent |
| Species | I | II | I | II | I | II | I | II | Total | I | II | I | II | I | II | I | II | Total | Total | Total |
| *Genyonemus lineatus* | - | 0.00 | - | - | 0.00 | 0.00 | - | - | 0.01 | 1.03 | 0.43 | 0.28 | 0.05 | 3.70 | 0.96 | 2.99 | 2.60 | 12.04 | 12.05 | 20.41 |
| *Squatina californica* | - | - | - | - | - | - | - | - | - | - | 0.70 | - | 11.00 | - | - | - | - | 11.70 | 11.70 | 19.82 |
| *Citharichthys stigmaeus* | 0.20 | 0.24 | 0.08 | 0.04 | 0.15 | 0.31 | 0.70 | 0.92 | 2.64 | 0.95 | 0.65 | 0.64 | 1.00 | 0.65 | 0.73 | 2.20 | 1.50 | 8.32 | 10.96 | 18.56 |
| *Myliobatis californica* | 0.40 | - | - | - | - | - | - | - | 0.40 | - | 0.51 | - | - | - | - | - | 6.20 | 6.71 | 7.11 | 12.04 |
| *Platyrhinoidis triseriata* | 0.44 | 0.48 | - | - | - | - | - | - | 0.92 | - | - | - | 0.80 | 1.30 | 2.20 | 0.11 | 0.64 | 5.05 | 5.97 | 10.11 |
| *Squalus acanthias* | - | - | - | - | - | - | - | - | - | 0.62 | 0.10 | 0.25 | - | 0.25 | 1.31 | - | - | 2.53 | 2.53 | 4.28 |
| *Cymatogaster aggregata* | - | - | - | - | - | - | 0.02 | - | 0.02 | 0.04 | 0.00 | 0.20 | 0.06 | 0.04 | 0.01 | 1.40 | 0.58 | 2.33 | 2.36 | 3.99 |
| *Paralichthys californicus* | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.22 | 0.43 | 0.37 | 0.65 | 1.67 | 1.67 | 2.83 |
| *Seriphus politus* | - | - | - | - | - | - | - | - | - | - | - | 0.00 | 0.00 | - | 0.03 | 0.03 | 0.63 | 0.70 | 0.70 | 1.18 |
| *Hyperprosopon argenteun* | - | - | - | - | - | - | - | - | - | - | 0.01 | - | - | 0.01 | 0.06 | 0.17 | 0.39 | 0.63 | 0.63 | 1.07 |
| *Leptocottus armatus* | - | - | - | - | - | - | - | - | - | 0.03 | 0.04 | - | 0.04 | 0.13 | 0.32 | 0.03 | 0.01 | 0.60 | 0.60 | 1.01 |
| *Menticirrhus undulatus* | - | - | - | - | - | - | - | - | - | 0.24 | - | - | 0.11 | - | - | 0.19 | - | 0.54 | 0.54 | 0.91 |
| *Syngnathus californiensis* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.02 | 0.06 | 0.02 | 0.04 | 0.10 | 0.03 | 0.06 | 0.08 | 0.04 | 0.02 | 0.38 | 0.44 | 0.75 |
| *Engraulis mordax* | 0.02 | 0.00 | 0.00 | - | 0.07 | 0.01 | - | - | 0.10 | 0.00 | 0.06 | 0.09 | 0.06 | 0.04 | 0.03 | 0.05 | 0.01 | 0.33 | 0.43 | 0.73 |
| *Phanerodon furcatus* | - | - | - | - | - | - | - | - | - | - | - | 0.05 | - | 0.07 | 0.08 | 0.16 | 0.06 | 0.41 | 0.41 | 0.70 |
| *Rhinobatos productus* | - | - | - | - | 0.11 | - | - | - | 0.11 | 0.06 | - | - | - | - | 0.06 | 0.13 | - | 0.25 | 0.36 | 0.61 |
| *Parophrys vetulus* | 0.04 | - | - | 0.10 | 0.04 | - | 0.03 | - | 0.21 | - | - | - | - | - | 0.03 | 0.04 | 0.03 | 0.10 | 0.30 | 0.51 |
| *Pleuronichthys verticalis* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.10 | 0.10 | 0.10 | 0.17 |
| *Stellerina xyosterna* | - | - | 0.00 | 0.00 | - | - | - | - | 0.00 | 0.02 | 0.00 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.08 | 0.09 | 0.14 |
| *Amphistichus argenteus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.03 | 0.03 | 0.06 | 0.06 | 0.10 |
| *Symphurus atricaudus* | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.03 | - | - | - | 0.03 | 0.03 | 0.04 |
| *Peprilus simillimus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.01 | - | - | 0.01 | 0.01 | 0.01 |
| *Sebastes miniatus* | - | - | - | - | - | - | 0.00 | 0.00 | 0.01 | - | - | - | - | - | - | - | - | - | 0.01 | 0.01 |
| *Atractoscion nobilis* | - | - | - | - | - | - | - | - | - | 0.00 | - | 0.00 | - | - | - | 0.00 | - | 0.00 | 0.00 | 0.01 |
| *Lepidogobius lepidus* | 0.00 | - | - | - | - | - | 0.00 | 0.00 | 0.00 | - | - | - | - | - | - | - | - | - | 0.00 | 0.01 |
| Total Biomass (kg) | 1.10 | 0.73 | 0.09 | 0.15 | 0.37 | 0.33 | 0.78 | 0.94 | 4.48 | 3.01 | 2.53 | 1.62 | 13.18 | 6.49 | 6.34 | 7.94 | 13.46 | 54.57 | 59.04 | |
| Area Trawled ($m^2$) | 4,852.7 | 4,881.3 | 4,635.0 | 4,489.3 | 4,870.8 | 4,758.5 | 4,821.9 | 4,882.7 | | 4,603.1 | 4,625.9 | 4,656.8 | 4,662.9 | 4,533.9 | 4,632.3 | 4,207.7 | 4,635.5 | | | |

| Biomass (kg) less than 30 mm SL. | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Engraulis mordax* | 0.00 | 0.00 | - | - | - | - | - | - | 0.00 | - | - | - | - | - | - | - | - | 0.00 |
| *Genyonemus lineatus* | 0.00 | 0.00 | 0.00 | - | - | - | - | - | 0.00 | - | - | - | - | - | - | - | - | 0.00 |
| Total Biomass | 0.00 | 0.00 | 0.00 | - | - | - | - | - | 0.01 | - | - | - | - | - | - | - | - | 0.01 |

Note: 0.00 = <0.005

**Appendix G-4. Length of fish species in trawl replicates. Manalay Generating Station NPDES, Winter 2006.**

| MGS T1-I | Length (cm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 14 | 16 | 18 | 31 | 43 |
| *Citharichthys stigmaeus* | 2 | 5 | 3 | 1 | 4 | 13 | 2 | - | - | - | - | - |
| *Engraulis mordax* | - | - | 2 | 8 | 1 | - | - | - | - | - | - | - |
| *Lepidogobius lepidus* | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Myliobatis californica** | - | - | - | - | - | - | - | - | - | - | 1 | - |
| *Parophrys vetulus* | - | - | - | - | - | - | - | 1 | - | - | - | - |
| *Platyrhinoidis triseriata* | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Syngnathus californiensis* | - | - | - | - | - | - | - | 1 | 1 | 1 | - | - |

| MGS T1-II | Length (cm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 14 | 17 | 20 | 44 |
| *Citharichthys stigmaeus* | 2 | 3 | 2 | 1 | 2 | 9 | 8 | 2 | - | - | - | - |
| *Engraulis mordax* | - | - | - | - | - | 1 | - | - | - | - | - | - |
| *Genyonemus lineatus* | - | - | 1 | - | - | - | - | - | - | - | - | - |
| *Platyrhinoidis triseriata* | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Syngnathus californiensis* | - | - | - | - | - | - | - | - | 2 | 1 | 1 | - |

| MGS T2-I | Length (cm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Species | 3 | 4 | 7 | 8 | 9 | 15 | 16 | 19 |
| *Citharichthys stigmaeus* | 4 | 1 | - | 7 | 1 | - | - | - |
| *Engraulis mordax* | - | - | 1 | - | - | - | - | - |
| *Stellerina xyosterna* | 1 | - | - | - | - | - | - | - |
| *Syngnathus californiensis* | - | - | - | - | - | 1 | 1 | 1 |

| MGS T2-II | Length (cm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Species | 3 | 5 | 8 | 14 | 16 | 17 | 18 | 19 |
| *Citharichthys stigmaeus* | 1 | 1 | 4 | - | - | - | - | - |
| *Parophrys vetulus* | - | - | - | 1 | 1 | - | - | - |
| *Stellerina xyosterna* | 1 | - | - | - | - | - | - | - |
| *Syngnathus californiensis* | - | - | - | 1 | - | 1 | 1 | 1 |

| MGS T3-I | Length (cm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 13 | 14 | 16 | 18 | 29 |
| *Citharichthys stigmaeus* | - | - | 4 | 7 | 2 | - | 1 | - | - | - | - | - |
| *Engraulis mordax* | - | 1 | 7 | 4 | 2 | 1 | - | - | - | - | - | - |
| *Genyonemus lineatus* | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Parophrys vetulus* | - | - | - | - | - | - | - | 1 | - | - | - | - |
| *Rhinobatos productus* | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Syngnathus californiensis* | - | - | - | - | - | - | - | - | 2 | 2 | 1 | - |

| MGS T3-II | Length (cm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 3 | 4 | 5 | 7 | 8 | 9 | 10 | 16 | 17 | 20 | 21 |
| *Citharichthys stigmaeus* | 1 | 1 | - | 4 | 22 | 6 | 1 | - | - | - | - |
| *Engraulis mordax* | - | - | - | - | - | 1 | - | - | - | - | - |
| *Genyonemus lineatus* | - | - | 1 | - | - | - | - | - | - | - | - |
| *Syngnathus californiensis* | - | - | - | - | - | - | - | 1 | 1 | 1 | 1 |

| MGS T4-I | Length (cm) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 2 | 3 | 7 | 8 | 9 | 10 | 13 | 14 | 16 | 17 | 19 | 21 | 22 |
| *Citharichthys stigmaeus* | 1 | 2 | 5 | 46 | 19 | 6 | - | - | - | 1 | - | - | - |
| *Cymatogaster aggregata* | - | - | - | - | - | 1 | - | - | - | - | - | - | - |
| *Lepidogobius lepidus* | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| *Parophrys vetulus* | - | - | - | - | - | - | - | 1 | - | - | - | - | - |
| *Sebastes miniatus* | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Syngnathus californiensis* | - | - | - | - | - | - | 1 | - | 1 | 1 | 2 | 1 | 2 |

| MGS T4-I | Length (cm) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 3 | 4 | 7 | 8 | 9 | 10 | 12 | 15 | 16 | 17 | 19 | 20 | 21 | 22 |
| *Citharichthys stigmaeus* | 3 | - | 7 | 62 | 22 | 5 | - | - | - | - | - | - | - | - |
| *Lepidogobius lepidus* | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Sebastes miniatus* | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Syngnathus californiensis* | - | - | - | - | - | - | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |

"*" = Disc Width

Fish measuring less than 30 mm (not included above):

| | T1 | | T2 | | T3 | | T4 | |
|---|---|---|---|---|---|---|---|---|
| | I | II | I | II | I | II | I | II |
| None | | | | | | | | |

Fish diseases, abnormalities, and paratism

| Species | Sta-Rep | Length | Note |
|---|---|---|---|
| None | | | |

**Appendix G-5. Length of fish species in trawl replicates. Mandalay Generating Station NPDES, Summer 2006.**

MGS T1-I

| | Length (cm) | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 25 | 40 |
| *Atractoscion nobilis* | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Citharichthys stigmaeus* | - | - | 8 | 7 | 14 | 16 | 47 | 15 | 1 | 1 | - | - | - | - | - | - | - | - | - | - |
| *Cymatogaster aggregata* | - | - | 6 | - | - | - | 1 | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Engraulis mordax* | - | 2 | 4 | 2 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Genyonemus lineatus* | - | 7 | 68 | 103 | 22 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Leptocottus armatus* | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - |
| *Menticirrhus undulatus* | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - |
| *Rhinobatos productus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - |
| *Squalus acanthias* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| *Stellerina xyosterna* | - | - | - | - | 1 | 5 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Syngnathus californiensis* | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 3 | 3 | 1 | 1 | 5 | - | - |

MGS T1-II

| | Length (cm) | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 25 | 33 | 43 |
| *Citharichthys stigmaeus* | 2 | 1 | 3 | 14 | 9 | 16 | 21 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Cymatogaster aggregata* | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Engraulis mordax* | - | 7 | 3 | - | - | 4 | 10 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Genyonemus lineatus* | 8 | 77 | 105 | 10 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Hyperprosopon argenteum* | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Leptocottus armatus* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Myliobatis californica** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - |
| *Squalus acanthias* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - |
| *Squatina californica* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Stellerina xyosterna* | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Syngnathus californiensis* | - | - | - | - | - | - | - | - | - | - | 1 | 1 | 2 | 3 | 6 | 4 | 5 | 2 | 1 | - | - |

MGS T2-I

| | Length (cm) | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 45 |
| *Atractoscion nobilis* | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Citharichthys stigmaeus* | - | 2 | 6 | 7 | 8 | 9 | 25 | 12 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Cymatogaster aggregata* | - | 2 | 60 | 16 | 1 | - | - | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - | - |
| *Engraulis mordax* | - | 8 | 68 | 34 | 1 | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Genyonemus lineatus* | - | 2 | 47 | 75 | 4 | 2 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Phanerodon furcatus* | - | - | - | - | 2 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Seriphus politus* | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Squalus acanthias* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Stellerina xyosterna* | - | - | - | - | - | 2 | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Syngnathus californiensis* | - | - | - | - | - | - | - | - | - | - | 1 | 4 | 10 | 16 | 13 | 5 | 4 | 1 | 2 | - |

MGS T2-II

| | Length (cm) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 16 | 17 | 18 | 19 | 21 | 32 | 49 | 104 |
| *Citharichthys stigmaeus* | 4 | 11 | 12 | 16 | 15 | 36 | 13 | 7 | 2 | - | - | - | - | - | - | - | - | - |
| *Cymatogaster aggregata* | 1 | 35 | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Engraulis mordax* | 4 | 8 | 5 | 1 | 1 | 6 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *Genyonemus lineatus* | - | 21 | 12 | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Leptocottus armatus* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - |
| *Menticirrhus undulatus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| *Platyrhinoidis triseriata* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | - |
| *Seriphus politus* | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Squatina californica* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Stellerina xyosterna* | - | - | - | - | 2 | 2 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Syngnathus californiensis* | - | - | - | - | - | - | - | - | - | - | 1 | 5 | 11 | 4 | 1 | - | - | - |

MGS T3-I

| | Length (cm) | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 14 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 31 | 38 | 39 | 45 |
| *Citharichthys stigmaeus* | 1 | 3 | 10 | 7 | 2 | 8 | 11 | 17 | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Cymatogaster aggregata* | 1 | 15 | 3 | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Engraulis mordax* | - | - | 2 | - | 1 | 3 | 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Genyonemus lineatus* | - | 12 | 133 | 42 | 7 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Hyperprosopon argenteum* | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Leptocottus armatus* | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - |
| *Paralichthys californicus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - |
| *Phanerodon furcatus* | - | - | - | - | 3 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Platyrhinoidis triseriata* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | 1 | 1 |
| *Squalus acanthias* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Stellerina xyosterna* | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Symphurus atricaudus* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Syngnathus californiensis* | - | - | - | - | - | - | - | - | - | - | 6 | 6 | 7 | 4 | 2 | 2 | 5 | 2 | 1 | - | - | - | - |

"*" = Disc Width

**Appendix G-5. (Cont.)**

| MGS T3-II | | | | | | | | | | | | Length (cm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 33 |
| *Citharichthys stigmaeus* | 1 | 3 | 5 | 7 | 3 | 11 | 9 | 16 | 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Cymatogaster aggregata* | - | 4 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Engraulis mordax* | - | 1 | - | 1 | - | 1 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Genyonemus lineatus* | - | 14 | 140 | 33 | 7 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Hyperprosopon argenteum* | - | - | - | 2 | 4 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Leptocottus armatus* | - | - | - | - | - | - | 1 | 1 | - | 3 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Paralichthys californicus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | - |
| *Parophrys vetulus* | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Peprilus simillimus* | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Phanerodon furcatus* | - | - | - | 2 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Rhinobatos productus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - |
| *Seriphus politus* | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Squalus acanthias* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Stellerina xyostema* | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Syngnathus californiensis* | - | - | - | - | - | - | - | - | 1 | 1 | - | 1 | 2 | 4 | 3 | 2 | 3 | 4 | 2 | - | 3 | 1 | - |

| MGS T3-II (Cont.) | | | Length (cm) | | | | |
|---|---|---|---|---|---|---|---|
| Species | 38 | 39 | 40 | 41 | 42 | 44 | 51 |
| *Platyrhinoidis triseriata* | - | - | 1 | - | 1 | 1 | 1 |
| *Squalus acanthias* | 1 | 1 | 1 | 1 | - | 1 | - |

| MGS T4-I | | | | | | | | | | | | Length (cm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 14 | 16 | 17 | 18 | 19 | 22 | 23 | 24 | 25 | 28 | 34 |
| *Amphistichus argenteus* | - | - | - | - | - | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Atractoscion nobilis* | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Citharichthys stigmaeus* | - | 4 | 19 | 25 | 24 | 17 | 27 | 36 | 36 | 8 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Cymatogaster aggregata* | - | 2 | 18 | 34 | 5 | 1 | 4 | 18 | 28 | 4 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Engraulis mordax* | - | - | - | 1 | - | - | - | 7 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Genyonemus lineatus* | - | - | - | 75 | 87 | 23 | 9 | 4 | - | - | 1 | 1 | - | - | - | - | - | - | - | - | - | - |
| *Hyperprosopon argenteum* | - | - | - | - | 1 | 10 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Leptocottus armatus* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Menticirrhus undulatus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| *Paralichthys californicus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - |
| *Parophrys vetulus* | - | - | - | 2 | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - |
| *Phanerodon furcatus* | - | - | - | - | 3 | 3 | 6 | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Platyrhinoidis triseriata* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - |
| *Rhinobatos productus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Seriphus politus* | - | - | - | - | - | - | - | - | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| *Stellerina xyostema* | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Syngnathus californiensis* | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 3 | 5 | 3 | 2 | - | 1 | - | - |

| MGS T4-II | | | | | | | | | | | | | Length (cm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 23 | 25 | 29 | 38 |
| *Amphistichus argenteus* | - | - | - | - | 1 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Citharichthys stigmaeus* | 8 | 23 | 18 | 17 | 11 | 24 | 27 | 25 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Cymatogaster aggregata* | - | 16 | 14 | 3 | - | 2 | 11 | 10 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Engraulis mordax* | - | - | 1 | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Genyonemus lineatus* | - | 3 | 73 | 82 | 24 | 11 | 1 | 1 | 1 | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| *Hyperprosopon argenteum* | - | - | - | 2 | 32 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Leptocottus armatus* | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Paralichthys californicus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | - |
| *Parophrys vetulus* | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Phanerodon furcatus* | - | - | - | - | 2 | 2 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Platyrhinoidis triseriata* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Pleuronichthys verticalis* | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - |
| *Seriphus politus* | - | - | 1 | - | - | - | - | 7 | 13 | 5 | 2 | - | - | 1 | - | - | - | - | - | - | - | - | - |
| *Stellerina xyostema* | - | - | - | - | 1 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Syngnathus californiensis* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 1 | 1 | 2 | 2 | 2 | - | - | - |

| MGS T4-II (Cont.) | Length (cm) | | |
|---|---|---|---|
| Species | 39 | 44 | 68 |
| *Myliobatis californica** | - | 1 | 1 |
| *Platyrhinoidis triseriata* | 1 | - | - |

"*" = Disc Width

Fish measuring less than 30 mm (not included above):

| | T1 | | T2 | | T3 | | T4 | |
|---|---|---|---|---|---|---|---|---|
| | I | II | I | II | I | II | I | II |
| None | | | | | | | | |

Fish diseases, abnormalities, and paratism

| Species | Sta-Rep | Length | Note |
|---|---|---|---|
| None | | | |

**Appendix G-6. Abundance of macroinvertebrate species in trawl replicates, winter and summer. Mandalay Generating Station NPDES, 2006.**

| | Winter | | | | | | | | | Summer | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T1 | | T2 | | T3 | | T4 | | | T1 | | T2 | | T3 | | T4 | | | Annual | Percent |
| Species | I | II | I | II | I | II | I | II | Total | I | II | I | II | I | II | I | II | Total | Total | Total |
| *Crangon nigromaculata* | 127 | 164 | 160 | 200 | 364 | 509 | 582 | 473 | 2,579 | 960 | 1,488 | 384 | 528 | 432 | 538 | 192 | 269 | 4,791 | 7,370 | 51.8 |
| *Dendraster excentricus* | - | - | 93 | 120 | - | 4 | 1,289 | 3,133 | 4,639 | - | - | 1 | 1 | - | - | 385 | 976 | 1,363 | 6,002 | 42.2 |
| *Cancer gracilis* | - | 1 | 8 | 9 | 14 | 16 | 138 | 209 | 395 | 7 | 10 | 17 | 18 | 28 | 41 | 151 | 70 | 342 | 737 | 5.2 |
| *Pyromaia tuberculata* | - | - | 1 | - | 2 | - | 15 | 26 | 44 | - | - | 3 | 1 | 2 | 1 | - | 2 | 9 | 53 | 0.4 |
| *Caudina arenicola* | - | - | - | 1 | 4 | 5 | - | - | 10 | - | - | - | - | 1 | 1 | 1 | - | 3 | 13 | 0.1 |
| *Heptacarpus stimpsoni* | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | 1 | 4 | - | 8 | 8 | 0.1 |
| *Nassarius perpinguis* | 2 | - | 1 | 2 | - | - | - | 2 | 7 | - | - | - | - | - | - | - | - | - | 7 | 0.0 |
| *Cancer anthonyi* | - | - | - | - | - | - | - | 1 | 1 | 1 | 1 | 3 | - | 1 | - | - | - | 6 | 7 | 0.0 |
| *Polyorchis penicillatus* | - | - | - | 1 | - | 1 | 1 | - | 3 | - | - | - | - | 1 | 1 | 1 | - | 3 | 6 | 0.0 |
| *Loxorhynchus grandis* | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - | - | 1 | 4 | 4 | 0.0 |
| *Aphrodita* sp | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | 2 | 2 | 0.0 |
| *Panulirus interruptus* | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | 2 | 2 | 0.0 |
| *Randallia ornata* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 1 | 0.0 |
| *Octopus bimaculatus/bimaculoides* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | 1 | 0.0 |
| *Portunus xantusii* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 1 | 0.0 |
| *Opisthopus transversus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 1 | 0.0 |
| Total Abundance | 129 | 165 | 263 | 333 | 384 | 535 | 2,025 | 3,844 | 7,678 | 971 | 1,499 | 411 | 552 | 465 | 586 | 735 | 1,318 | 6,537 | 14,215 | |
| Species | 2 | 2 | 5 | 6 | 4 | 5 | 5 | 6 | 8 | 4 | 3 | 6 | 6 | 6 | 9 | 7 | 5 | 15 | 16 | |
| Diversity (H') | 0.08 | 0.04 | 0.82 | 0.84 | 0.25 | 0.24 | 0.87 | 0.62 | 0.87 | 0.07 | 0.05 | 0.32 | 0.22 | 0.30 | 0.34 | 1.07 | 0.72 | 0.75 | 0.91 | |
| Evenness (J') | 0.12 | 0.05 | 0.51 | 0.47 | 0.18 | 0.15 | 0.54 | 0.35 | 0.42 | 0.05 | 0.04 | 0.18 | 0.12 | 0.17 | 0.16 | 0.55 | 0.45 | 0.28 | 0.33 | |
| Area Trawled ($m^2$) | 4,852.7 | 4,881.3 | 4,635.0 | 4,489.3 | 4,870.8 | 4,758.5 | 4,821.9 | 4,882.7 | | 4,603.1 | 4,625.9 | 4,656.8 | 4,662.9 | 4,533.9 | 4,632.3 | 4,207.7 | 4,635.5 | | | |
| Fish Parasites Not Included Above | | | | | | | | | | | | | | | | | | | | |
| *Elthusa vulgaris* | 1 | 2 | - | - | - | 3 | 13 | 12 | 31 | 5 | 3 | 10 | 5 | - | 4 | 30 | 7 | 64 | 95 | |

**Appendix G-7. Biomass (kg) of macroinvertebrates species in trawl replicates, winter and summer. Mandalay Generating Station NPDES, 2006.**

| | Winter | | | | | | | | | Summer | | | | | | | | | Annual | Percent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T1 | | T2 | | T3 | | T4 | | | T1 | | T2 | | T3 | | T4 | | | | |
| Species | I | II | I | II | I | II | I | II | Total | I | II | I | II | I | II | I | II | Total | Total | Total |
| *Dendraster excentricus* | - | - | 0.21 | 0.27 | - | 0.01 | 2.90 | 7.05 | 10.44 | - | - | 0.00 | 0.00 | - | - | 0.79 | 2.00 | 2.79 | 13.23 | 34.7 |
| *Crangon nigromaculata* | 0.35 | 0.45 | 0.44 | 0.55 | 1.00 | 1.40 | 1.60 | 1.30 | 7.09 | 1.00 | 1.55 | 0.40 | 0.55 | 0.45 | 0.56 | 0.20 | 0.28 | 4.99 | 12.08 | 31.7 |
| *Cancer gracilis* | - | 0.10 | 0.32 | 0.20 | 0.28 | 0.11 | 1.10 | 1.80 | 3.91 | 0.32 | 0.31 | 0.26 | 0.60 | 0.88 | 1.40 | 2.80 | 1.30 | 7.87 | 11.78 | 30.9 |
| *Panulirus interruptus* | - | - | - | - | - | - | - | - | - | - | - | - | 0.46 | - | - | - | - | 0.46 | 0.46 | 1.2 |
| *Loxorhynchus grandis* | - | - | - | - | - | - | - | - | - | 0.25 | - | - | - | - | - | - | 0.04 | 0.29 | 0.29 | 0.7 |
| *Caudina arenicola* | - | - | - | 0.00 | 0.01 | 0.01 | - | - | 0.02 | - | - | - | - | 0.00 | 0.07 | 0.00 | - | 0.07 | 0.09 | 0.2 |
| *Pyromaia tuberculata* | - | - | 0.00 | - | 0.00 | - | 0.02 | 0.03 | 0.05 | - | - | 0.01 | 0.00 | 0.00 | 0.00 | - | 0.00 | 0.01 | 0.06 | 0.2 |
| *Aphrodita* sp | - | - | - | - | - | - | - | - | - | - | - | - | 0.04 | - | - | - | - | 0.04 | 0.04 | 0.1 |
| *Octopus bimaculatus/bimaculoides* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.04 | - | 0.04 | 0.04 | 0.1 |
| *Polyorchis penicillatus* | - | - | - | 0.00 | - | 0.00 | 0.00 | - | 0.01 | - | - | - | - | 0.00 | 0.00 | 0.00 | - | 0.01 | 0.01 | 0.0 |
| *Cancer anthonyi* | - | - | - | - | - | - | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | - | 0.00 | - | - | - | 0.01 | 0.01 | 0.0 |
| *Nassarius perpinguis* | 0.00 | - | 0.00 | 0.00 | - | - | - | 0.00 | 0.01 | - | - | - | - | - | - | - | - | - | 0.01 | 0.0 |
| *Randallia ornata* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.00 | - | - | 0.00 | 0.00 | 0.0 |
| *Heptacarpus stimpsoni* | - | - | - | - | - | - | - | - | - | - | - | 0.00 | - | - | 0.00 | 0.00 | - | 0.00 | 0.00 | 0.0 |
| *Opisthopus transversus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.00 | - | - | 0.00 | 0.00 | 0.0 |
| *Portunus xantusii* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.00 | - | - | 0.00 | 0.00 | 0.0 |
| Total Biomass (kg) | 0.35 | 0.55 | 0.97 | 1.02 | 1.29 | 1.53 | 5.62 | 10.18 | 21.52 | 1.57 | 1.86 | 0.67 | 1.65 | 1.34 | 2.04 | 3.84 | 3.62 | 16.59 | 38.11 | |
| Species | 2 | 2 | 5 | 6 | 4 | 5 | 5 | 6 | 8 | 4 | 3 | 6 | 6 | 6 | 9 | 7 | 5 | 15 | 16 | |
| Diversity (H') | 0.04 | 0.47 | 1.07 | 1.03 | 0.57 | 0.35 | 1.04 | 0.84 | 1.05 | 0.91 | 0.46 | 0.77 | 1.19 | 0.67 | 0.77 | 0.77 | 0.94 | 1.26 | 1.23 | |
| Evenness (J') | 0.05 | 0.68 | 0.66 | 0.57 | 0.41 | 0.22 | 0.64 | 0.47 | 0.51 | 0.66 | 0.42 | 0.43 | 0.66 | 0.37 | 0.35 | 0.39 | 0.59 | 0.46 | 0.44 | |
| Area Trawled ($m^2$) | 4852.7 | 4881.3 | 4635.0 | 4489.3 | 4870.8 | 4758.5 | 4821.9 | 4882.7 | | 4603.1 | 4625.9 | 4656.8 | 4662.9 | 4533.9 | 4632.3 | 4207.7 | 4635.5 | | | |
| Fish parasites not included above | | | | | | | | | | | | | | | | | | | | |
| *Elthusa vulgaris* | 0.00 | 0.00 | - | - | - | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | - | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.03 | |

Note: 0.00 = < 0.005

## Appendix G-8. Abundance of fish species in trawl replicates, 1978 - 2006. Mandalay Generating Station NPDES, 2006.

| Species | 1978 | 1980 | 1986 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994 | 1997 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Total | Percent Total | F.O. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Genyonemus lineatus* | 6713 | 8446 | 1464 | 1150 | 1592 | 2291 | 2756 | 3043 | 7237 | 20 | 363 | 5363 | 1033 | 9342 | - | 16 | 4632 | 3656 | 59117 | 50.5 | 17 |
| *Seriphus politus* | 966 | 4889 | 830 | 195 | 957 | 1341 | 6049 | 3009 | 5483 | - | 76 | 1352 | 4630 | 3971 | 8 | 138 | 1106 | 34 | 35034 | 29.9 | 17 |
| *Engraulis mordax* | 1476 | 494 | 2 | 52 | 88 | 359 | 1469 | 159 | 115 | - | 640 | 256 | 383 | 1216 | 9 | 3322 | 202 | 231 | 10473 | 8.9 | 17 |
| *Citharichthys stigmaeus* | 36 | 8 | 40 | 64 | 76 | 217 | 4 | 75 | 16 | 7 | 143 | 219 | 38 | 224 | 51 | 476 | 325 | 1148 | 3167 | 2.7 | 18 |
| *Cymatogaster aggregata* | 107 | 24 | - | 4 | 33 | 63 | 4 | 58 | 88 | 17 | 190 | 42 | 11 | 529 | 18 | 118 | 135 | 330 | 1771 | 1.5 | 17 |
| *Syngnathus californiensis* | - | - | - | - | - | - | - | - | - | - | 80 | 149 | 104 | 179 | 3 | 118 | 346 | 245 | 1224 | 1.0 | 8 |
| *Amphistichus argenteus* | 210 | 172 | 46 | 223 | 38 | 95 | 29 | 115 | 41 | 18 | 1 | 33 | 9 | 42 | - | 45 | 67 | 4 | 1188 | 1.0 | 17 |
| *Phanerodon furcatus* | 245 | 321 | 2 | 17 | 18 | 26 | 5 | 5 | 80 | 12 | 25 | - | 1 | 225 | - | - | 23 | 39 | 1044 | 0.9 | 15 |
| *Hyperprosopon argenteum* | 335 | 340 | 8 | 18 | - | 50 | 5 | 26 | 28 | 1 | 1 | 16 | 37 | 28 | 1 | 9 | 53 | 67 | 1023 | 0.9 | 17 |
| *Platyrhinoidis triseriata* | 27 | 21 | 12 | 16 | 6 | 56 | 4 | 167 | 2 | 3 | 13 | 14 | 6 | 52 | - | 2 | 24 | 15 | 440 | 0.4 | 17 |
| *Paralichthys californicus* | 25 | 54 | 66 | 58 | 21 | 27 | 1 | 8 | 11 | - | 2 | 5 | 1 | 4 | - | - | 1 | 6 | 290 | 0.2 | 15 |
| *Menticirrhus undulatus* | 15 | 3 | 79 | - | - | 3 | 2 | 33 | 19 | - | 2 | 73 | 24 | 9 | - | 8 | 6 | 3 | 279 | 0.2 | 14 |
| *Synodus lucioceps* | 17 | 5 | - | - | 8 | - | 1 | 2 | 4 | - | 1 | 1 | 26 | 115 | - | 1 | 9 | - | 190 | 0.2 | 12 |
| *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 | 143 | 0.1 | 13 |
| *Syngnathus exilis* | 3 | - | - | 77 | 5 | - | - | - | 58 | - | - | - | - | - | - | - | - | - | 143 | 0.1 | 4 |
| *Xystreurys liolepis* | - | 10 | 17 | 10 | 1 | 3 | 1 | 1 | 5 | 1 | 39 | 27 | 1 | 16 | - | - | 1 | - | 133 | 0.1 | 14 |
| *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 | 107 | 0.1 | 13 |
| *Squalus acanthias* | 6 | 37 | 3 | - | - | 5 | - | - | - | - | - | - | 1 | - | - | - | 41 | 12 | 105 | 0.1 | 7 |
| *Peprilus simillimus* | 2 | 23 | - | 6 | - | 1 | 7 | - | 3 | - | - | 30 | 2 | 20 | - | 1 | 2 | 1 | 98 | 0.1 | 12 |
| *Syngnathus spp* | - | 6 | 17 | - | - | 18 | 11 | 25 | - | - | - | - | - | - | - | - | - | - | 77 | 0.1 | 5 |
| *Pleuronichthys verticalis* | 8 | 17 | - | - | - | 31 | - | - | 3 | - | 1 | 9 | 2 | - | - | - | 3 | 1 | 75 | 0.1 | 9 |
| *Leptocottus armatus* | - | 2 | 7 | 19 | 3 | 6 | - | 8 | 1 | - | 1 | - | - | 5 | - | 3 | 1 | 15 | 71 | 0.1 | 12 |
| *Myliobatis californica* | 4 | 4 | - | - | 5 | 2 | 4 | 2 | 2 | - | 5 | 3 | 5 | 2 | - | 17 | 9 | 4 | 68 | 0.1 | 14 |
| *Pleuronichthys guttulatus* | 9 | 15 | 3 | 6 | 8 | 3 | - | 5 | - | - | 1 | - | - | 2 | 1 | - | 1 | - | 54 | 0.0 | 11 |
| *Embiotoca jacksoni* | 2 | 3 | - | - | - | - | 3 | - | 3 | - | - | - | - | 30 | - | 2 | 4 | - | 47 | 0.0 | 7 |
| *Pleuronichthys ritteri* | 5 | - | 3 | - | 3 | 1 | - | 5 | 23 | - | - | - | 3 | 1 | - | - | 1 | - | 45 | 0.0 | 9 |
| *Sardinops sagax* | - | - | 2 | - | 1 | 1 | 15 | 2 | 1 | - | - | 9 | 1 | - | - | 7 | 3 | - | 42 | 0.0 | 10 |
| *Stellerina xyosterna* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 15 | - | 25 | 40 | 0.0 | 2 |
| *Hyperprosopon anale* | 17 | 17 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 34 | 0.0 | 2 |
| *Porichthys myriaster* | 2 | 2 | - | - | - | - | - | - | - | - | 1 | - | - | 1 | - | - | 27 | - | 33 | 0.0 | 5 |
| *Brachyistius frenatus* | 2 | 27 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 29 | 0.0 | 2 |
| *Atractoscion nobilis* | 4 | - | - | - | - | 2 | 4 | 12 | - | - | - | - | - | - | - | - | 2 | 4 | 28 | 0.0 | 6 |
| *Atherinopsis californiensis* | - | - | - | 12 | 1 | - | - | 1 | 1 | 9 | - | - | - | 1 | - | 1 | - | - | 26 | 0.0 | 7 |
| *Rhacochilus toxotes* | - | - | 1 | - | - | - | - | - | 3 | - | - | - | - | 18 | - | - | 1 | - | 23 | 0.0 | 4 |
| *Mustelus californicus* | 1 | 3 | 8 | - | - | - | - | 2 | 2 | - | - | 1 | - | 2 | - | - | - | - | 19 | 0.0 | 7 |
| *Rhacochilus vacca* | 11 | 5 | - | 1 | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | 19 | 0.0 | 4 |
| *Atherinops affinis* | - | 1 | - | - | - | - | 16 | - | - | - | - | - | - | - | - | - | - | - | 17 | 0.0 | 2 |
| *Squatina californica* | 1 | - | 1 | - | - | - | - | - | - | - | - | 6 | 1 | 5 | - | - | 1 | 2 | 17 | 0.0 | 7 |
| *Sebastes auriculatus* | 1 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 1 | 3 | 13 | 0.0 | 5 |
| *Triakis semifasciata* | - | - | 1 | 4 | - | 1 | - | 1 | 1 | - | - | - | - | - | - | - | 2 | - | 10 | 0.0 | 6 |
| *Sphyraena argentea* | - | - | - | - | - | - | 9 | - | - | - | - | - | - | - | - | - | - | - | 9 | 0.0 | 1 |
| *Mustelus henlei* | 1 | - | - | 2 | - | 3 | - | - | 1 | - | - | - | - | - | - | - | - | - | 7 | 0.0 | 4 |
| *Zalembius rosaceus* | 5 | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 1 | - | - | 7 | 0.0 | 3 |

**Appendix G-8. (cont.).**

| Species | 1978 | 1980 | 1986 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994 | 1997 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Total | Percent Total | F.O. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Lepidogobius lepidus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 6 | 6 | 0.0 | 1 |
| *Raja inornata* | - | - | 1 | 2 | 1 | 2 | - | - | - | - | - | - | - | - | - | - | - | - | 6 | 0.0 | 4 |
| *Symphurus atricauda* | 5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 6 | 0.0 | 2 |
| *Anchoa compressa* | - | - | - | - | 3 | - | - | 1 | - | - | - | - | - | - | - | - | - | - | 4 | 0.0 | 2 |
| *Paralabrax nebulifer* | - | - | 2 | - | - | 1 | - | - | 1 | - | - | - | - | - | - | - | - | - | 4 | 0.0 | 3 |
| *Porichthys notatus* | - | 3 | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | 4 | 0.0 | 2 |
| *Roncador stearnsii* | - | 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 | 0.0 | 1 |
| *Raja binoculata* | 2 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | 0.0 | 2 |
| *Urolophus halleri* | - | - | 1 | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | 3 | 0.0 | 2 |
| *Heterostichus rostratus* | 1 | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.0 | 2 |
| *Platichthys stellatus* | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.0 | 2 |
| *Sebastes carnatus* | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.0 | 1 |
| *Aulorhynchus flavidus* | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | 1 | 0.0 | 1 |
| *Chilara taylori* | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.0 | 1 |
| *Clupea pallasii* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 0.0 | 1 |
| *Odontophyxis trispinosa* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | 0.0 | 1 |
| *Raja kincaidii* | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.0 | 1 |
| *Sebastes miniatus* | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | 0.0 | 1 |
| *Sebastes paucispinis* | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | 1 | 0.0 | 1 |
| *Sebastes serranoides* | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.0 | 1 |
| *Torpedo californica* | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.0 | 1 |
| *Trichiurus nitens* | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | 0.0 | 1 |
| Number of individuals | 10299 | 14986 | 2648 | 2009 | 2896 | 4674 | 10399 | 6892 | 13296 | 89 | 1597 | 7616 | 6324 | 16056 | 91 | 4304 | 7062 | 5866 | 117104 | | |
| Number of species | 41 | 35 | 29 | 24 | 23 | 30 | 21 | 28 | 33 | 10 | 25 | 22 | 24 | 27 | 7 | 22 | 33 | 25 | 67 | | |
| 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 | 3269.8 | | |

Appendix G-9. Abundance of macroinvertebrates in trawl replicates, 1978 - 2006. Mandalay Generating Station NPDES, 2006.

| Species | 1978 | 1980 | 1986 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994 | 1997 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 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 | 58,627 | 66.6 |
| *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 | 27,432 | 31.2 |
| *Cancer gracilis* | 3 | 3 | 3 | 1 | 141 | 7 | - | 4 | 5 | - | 12 | 19 | 103 | 59 | 16 | 93 | 76 | 737 | 1,282 | 1.5 |
| *Pyromaia tuberculata* | 1 | - | - | - | - | - | - | - | 1 | - | 46 | 2 | 3 | 1 | 1 | 1 | 6 | 53 | 115 | 0.1 |
| *Astropecten verrilli* | 95 | - | - | - | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | 98 | 0.1 |
| *Pleurobranchia bachei* | - | - | - | - | - | 45 | - | - | - | - | - | - | - | - | - | - | - | - | 45 | 0.1 |
| *Portunus xantusii* | 12 | - | - | - | - | 5 | - | 4 | 5 | - | 6 | 1 | 1 | - | - | 3 | 3 | 1 | 41 | 0.0 |
| *Penaeus californiensis* | - | 38 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 39 | 0.0 |
| *Polyorchis pencillata* | - | - | 1 | 1 | - | - | - | - | - | - | 23 | 5 | - | 3 | - | - | - | 6 | 39 | 0.0 |
| *Panulirus interruptus* | 3 | 2 | 2 | - | 2 | 1 | 2 | 2 | 1 | - | 1 | 11 | 3 | 4 | - | - | - | 2 | 36 | 0.0 |
| *Cancer anthonyi* | - | - | 9 | 6 | 2 | 1 | - | - | 2 | - | - | 1 | 1 | - | - | 3 | - | 7 | 32 | 0.0 |
| *Heptacarpus* sp A of MBC | - | - | - | - | 4 | - | - | - | 26 | - | - | - | - | - | - | - | - | - | 30 | 0.0 |
| *Heptacarpus stimpsoni* | - | - | - | - | 4 | - | - | - | 12 | - | - | - | - | - | - | - | - | 8 | 24 | 0.0 |
| *Loxorhynchus grandis* | 1 | 2 | - | - | 2 | 4 | - | 2 | - | 2 | - | - | - | 2 | - | - | 1 | 4 | 20 | 0.0 |
| *Caudina arenicola* | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | - | - | 2 | - | 13 | 17 | 0.0 |
| *Nassarius perpinguis* | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | 4 | - | 1 | - | 7 | 14 | 0.0 |
| *Opisthopus transversus* | 5 | 4 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | 12 | 0.0 |
| *Randallia ornata* | 10 | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | 1 | 12 | 0.0 |
| *Astropecten armatus* | - | - | - | - | 5 | 1 | - | 1 | 1 | - | - | - | - | - | - | - | - | - | 8 | 0.0 |
| *Cancer antennarius* | 3 | - | - | - | - | 1 | - | 4 | - | - | - | - | - | - | - | - | - | - | 8 | 0.0 |
| *Nassarius fossatus* | - | - | - | - | 1 | 4 | - | - | 1 | - | - | - | - | 1 | - | 1 | - | - | 8 | 0.0 |
| *Renilla kollikeri* | - | - | - | - | - | - | - | - | - | - | 6 | - | 1 | 1 | - | - | - | - | 8 | 0.0 |
| *Farfantepenaeus californicus* | - | - | - | - | - | - | - | - | - | - | - | 7 | - | - | - | - | - | - | 7 | 0.0 |
| *Pugettia producta* | 5 | - | 1 | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 7 | 0.0 |
| *Heterocrypta occidentalis* | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 6 | 0.0 |
| *Thetys vagina* | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 | - | - | - | - | 4 | 0.0 |
| *Cancer* spp | - | - | 1 | - | - | 1 | - | 1 | - | - | - | - | - | - | - | - | - | - | 3 | 0.0 |
| *Heptacarpus palpator* | - | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - | 3 | 0.0 |
| *Isocheles pilosus* | - | - | - | 1 | - | 1 | - | - | - | - | - | 1 | - | - | - | - | - | - | 3 | 0.0 |
| *Loxorhynchus crispatus* | - | - | - | - | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | - | - | 3 | 0.0 |
| *Aphrodita* sp | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 2 | 0.0 |
| *Blepharipoda occidentalis* | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.0 |
| *Calliostoma* sp | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | 2 | 0.0 |
| *Nassarius* sp | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | 2 | 0.0 |
| *Pisaster brevispinis* | 1 | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.0 |
| *Pisaster ochraceus* | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.0 |
| *Polinices* sp | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.0 |
| *Astropecten* sp | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.0 |
| *Hippolytes californiensis* | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.0 |
| *Idotea* sp | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.0 |

**Appendix G-9. (Cont.).**

| Species | 1978 | 1980 | 1986 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994 | 1997 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Total | Percent Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Muricea californica* | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.0 |
| *Octopus bimaculatus/bimaculoides* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | 0.0 |
| Paguridae | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.0 |
| *Pagurus spilocarpus* | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.0 |
| *Pelagia noctiluca* | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.0 |
| Penaeid shrimp | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | 1 | 0.0 |
| *Rossia pacifica* | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | 0.0 |
| *Salpa* sp | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.0 |
| *Solen* sp | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.0 |
| *Synidotea harfordi* | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 1 | 0.0 |
| *Triopha maculata* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 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 | 88,011 | |
| Number of species | 17 | 6 | 15 | 8 | 14 | 15 | 3 | 10 | 12 | 3 | 12 | 11 | 12 | 12 | 4 | 11 | 7 | 16 | 51 | |
| 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 | 272.85 | |
| Parasitic species (not included above): | | | | | | | | | | | | | | | | | | | | |
| *Elthusa vulgaris* | 9 | - | 1 | 2 | - | 19 | 31 | 11 | 34 | - | 2 | 2 | - | 31 | 15 | 4 | 4 | 95 | 157 | |
| *Elthusa* sp | - | - | - | - | 6 | - | - | - | - | - | - | 3 | 5 | - | - | 52 | 52 | - | 14 | |
| *Ethusa californica* | - | - | - | - | - | - | - | - | - | - | - | - | 4 | - | - | - | - | - | 4 | |
| *Nerocila* sp | - | - | - | - | - | - | - | - | - | - | - | 2 | 1 | - | - | - | - | - | 3 | |
| Copepoda | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | |
| Bopyridae, unid. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | - | 2 | |

Notes: N/A = not available; 0.0 = <0.005

# APPENDIX H

**Fish and macroinvertebrate heat treatment and normal operation data**

**Appendix H-1. Species list of impinged fish and macroinvertebrate species. Mandalay Generating Station NPDES, 2006.**

| Phylum / Class / Family / Taxa | Common name |
|---|---|
| Arthropoda | |
| Malacostraca | |
| Penaeidae | |
| *Farfantepenaeus californiensis* | yellowleg shrimp |
| Crangonidae | |
| *Crangon nigromaculata* | blackspotted bay shrimp |
| Grapsidae | |
| *Pachygrapsus crassipes* | striped shore crab |
| Palinuridae | |
| *Panulirus interruptus* | California spiny lobster |
| Mollusca | |
| Bivalvia | |
| Veneridae | |
| *Protothaca staminea* | Pacific littleneck |
| Cephalopoda | |
| Octopodidae | |
| *Octopus bimaculatus/bimaculoides* | California two-spot octopus |
| Gastropoda | |
| Aglajidae | |
| *Navanax inermis* | California aglaja |
| Chordata | |
| Actinopterygii | |
| Atherinopsidae | |
| *Atherinops affinis* | topsmelt |
| *Atherinopsis californiensis* | jacksmelt |
| Carangidae | |
| *Trachurus symmetricus* | jack mackerel |
| Clinidae | |
| *Gibbonsia elegans* | spotted kelpfish |
| *Gibbonsia montereyensis* | crevice kelpfish |
| Clupeidae | |
| *Clupea pallasii* | Pacific herring |
| *Sardinops sagax* | Pacific sardine |
| Cottidae | |
| *Leptocottus armatus* | Pacific staghorn sculpin |
| Chordata (Cont.). | |
| Actinopterygii (Cont.). | |
| Embiotocidae | |
| *Cymatogaster aggregata* | shiner perch |
| *Hyperprosopon argenteum* | walleye surfperch |
| *Hyperprosopon ellipticum* | silver surfperch |
| *Hypsurus caryi* | rainbow seaperch |
| *Phanerodon furcatus* | white seaperch |
| Engraulidae | |
| *Anchoa compressa* | deepbody anchovy |
| *Engraulis mordax* | northern anchovy |
| Gobiidae | |
| *Acanthogobius flavimanus* | yellowfin goby |
| Kyphosidae | |
| *Girella nigricans* | opaleye |
| Mugilidae | |
| *Mugil cephalus* | striped mullet |
| Paralichthyidae | |
| *Paralichthys californicus* | California halibut |
| Pleuronectidae | |
| *Pleuronichthys guttulatus* | diamond turbot |
| Sciaenidae | |
| *Atractoscion nobilis* | white seabass |
| *Seriphus politus* | queenfish |
| Sphyraenidae | |
| *Sphyraena argentea* | Pacific barracuda |
| Syngnathidae | |
| *Syngnathus leptorhynchus* | bay pipefish |
| Chondrichthyes | |
| Myliobatidae | |
| *Myliobatis californica* | bat ray |
| Platyrhinidae | |
| *Platyrhinoidis triseriata* | thornback |
| Urolophidae | |
| *Urobatis halleri* | round stingray |

**Appendix H-2. Abundance and biomass for each fish species recorded during heat treatment surveys at Mandalay Generating Station. Mandalay Generating Station NPDES, 2006.**

| | 13-Jul-06 | |
|---|---|---|
| Species | Abundance | Biomass (kg) |
| *Urobatis halleri* | 1 | 0.772 |
| *Girella nigricans* | 1 | 0.054 |
| *Atherinops affinis* | 1 | 0.014 |
| Total | 3 | 0.840 |
| Number of Species | 3 | |

**Appendix H-3. Abundance of fish impinged during normal operations by survey date at Mandalay Generating Station. Mandalay Generating Station NPDES, 2006.**

| | 2005 | | | 2006 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | | Mar | | Apr | May | | Jun | | Jul | | Aug | | Sep | | Total |
| Species | 6 | 1 | 2 | 29 | 8 | 9 | 9 | 23 | 7 | 3 | 17 | 16 | 21 | 6 | 13 | 16 | 24 | 7 | 27 | Abundance |
| *Engraulis mordax* | - | 12 | 33 | 1,600 | - | - | - | - | - | - | 13 | - | 1 | 2 | - | - | 3 | 4 | - | 1,668 |
| *Cymatogaster aggregata* | - | 34 | 575 | 649 | - | - | - | - | - | - | 28 | - | 1 | 104 | 26 | 32 | 84 | 19 | - | 1,552 |
| *Atherinops affinis* | - | 2 | 44 | 86 | - | - | 1 | - | 47 | 4 | 10 | 1 | 2 | 12 | 9 | 1 | 10 | 7 | 2 | 238 |
| *Phanerodon furcatus* | - | - | - | 88 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 88 |
| *Girella nigricans* | - | - | - | 13 | 4 | - | - | 1 | - | 1 | - | - | - | - | - | - | - | - | - | 19 |
| *Sardinops sagax* | 2 | 4 | 1 | 11 | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | 19 |
| *Leptocottus armatus* | - | - | - | 3 | - | - | - | - | - | - | 10 | 2 | - | - | 1 | - | 1 | 1 | - | 18 |
| *Clupea pallasii* | - | - | - | 12 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12 |
| *Myliobatis californica* | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | 1 | 3 | 1 | - | 7 |
| *Seriphus politus* | 2 | - | 1 | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | 1 | 6 |
| *Atractoscion nobilis* | - | - | - | 3 | - | - | - | - | - | - | - | - | 1 | - | 1 | - | - | - | - | 5 |
| *Syngnathus leptorhynchus* | - | - | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | - | 5 |
| *Anchoa compressa* | - | - | - | - | - | - | - | - | - | - | 4 | - | - | - | - | - | - | - | - | 4 |
| *Atherinopsis californiensis* | 2 | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 |
| *Pleuronichthys guttulatus* | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 1 | - | 3 |
| *Sphyraena argentea* | - | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - | - | - | - | 3 |
| *Mugil cephalus* | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| *Trachurus symmetricus* | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| *Acanthogobius flavimanus* | - | - | - | - | 1 | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | 2 |
| *Gibbonsia elegans* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 |
| *Gibbonsia montereyensis* | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 |
| *Hyperprosopon argenteum* | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Hyperprosopon ellipticum* | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 |
| *Hypsurus caryi* | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 |
| *Paralichthys californicus* | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Platyrhinoidis triseriata* | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | 1 |
| Total Abundance | 8 | 52 | 656 | 2,472 | 5 | - | 1 | 1 | 47 | 5 | 75 | 4 | 7 | 119 | 37 | 37 | 101 | 34 | 3 | 3,664 |
| Number of Species | 4 | 4 | 7 | 14 | 2 | - | 1 | 1 | 1 | 2 | 11 | 3 | 6 | 4 | 4 | 4 | 5 | 7 | 2 | 26 |

**Appendix H-4. Biomass (kg) of fish impinged during normal operations by survey date at Mandalay Generating Station. Mandalay Generating Station NPDES, 2006.**

| | 2005 | | | 2006 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | | Mar | | Apr | May | | Jun | | Jul | | Aug | | Sep | | Total |
| Species | 6 | 1 | 2 | 29 | 8 | 9 | 9 | 23 | 7 | 3 | 17 | 16 | 21 | 6 | 13 | 16 | 24 | 7 | 27 | Biomass (kg) |
| *Cymatogaster aggregata* | - | 0.080 | 3.595 | 5.469 | - | - | - | - | - | - | 0.654 | - | 0.034 | 1.125 | 0.365 | 0.177 | 0.333 | 0.107 | - | 11.939 |
| *Phanerodon furcatus* | - | - | - | 8.307 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 8.307 |
| *Engraulis mordax* | - | 0.014 | 0.200 | 5.344 | - | - | - | - | - | - | 0.097 | - | 0.024 | 0.013 | - | - | 0.025 | 0.014 | - | 5.731 |
| *Atherinops affinis* | - | 0.004 | 0.530 | 2.402 | - | - | 0.027 | - | 0.864 | 0.035 | 0.142 | 0.029 | 0.007 | 0.150 | 0.457 | 0.012 | 0.119 | 0.048 | 0.040 | 4.866 |
| *Atractoscion nobilis* | - | - | - | 3.929 | - | - | - | - | - | - | - | - | 0.592 | - | 0.129 | - | - | - | - | 4.650 |
| *Myliobatis californica* | - | - | - | - | - | - | - | - | - | - | 0.657 | - | - | - | - | 0.217 | 1.053 | 0.124 | - | 2.051 |
| *Sphyraena argentea* | - | - | - | - | - | - | - | - | - | - | 0.981 | - | - | - | - | - | - | - | - | 0.981 |
| *Leptocottus armatus* | - | - | - | 0.207 | - | - | - | - | - | - | 0.592 | 0.050 | - | - | 0.016 | - | 0.020 | 0.021 | - | 0.906 |
| *Atherinopsis californiensis* | 0.068 | - | - | 0.668 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.736 |
| *Clupea pallasii* | - | - | - | 0.566 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.566 |
| *Platyrhinoidis triseriata* | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.523 | - | - | - | - | - | 0.523 |
| *Girella nigricans* | - | - | - | 0.311 | 0.084 | - | - | 0.037 | - | 0.018 | - | - | - | - | - | - | - | - | - | 0.450 |
| *Sardinops sagax* | 0.106 | 0.120 | 0.010 | 0.106 | - | - | - | - | - | - | - | - | 0.021 | - | - | - | - | - | - | 0.363 |
| *Pleuronichthys guttulatus* | - | - | - | 0.180 | - | - | - | - | - | - | - | - | 0.002 | - | - | - | - | 0.019 | - | 0.201 |
| *Mugil cephalus* | - | - | - | 0.165 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.165 |
| *Trachurus symmetricus* | 0.106 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.106 |
| *Anchoa compressa* | - | - | - | - | - | - | - | - | - | - | 0.041 | - | - | - | - | - | - | - | - | 0.041 |
| *Paralichthys californicus* | - | - | 0.036 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.036 |
| *Hyperprosopon ellipticum* | - | - | - | - | - | - | - | - | - | - | - | 0.025 | - | - | - | - | - | - | - | 0.025 |
| *Gibbonsia elegans* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.024 | - | 0.024 |
| *Acanthogobius flavimanus* | - | - | - | - | 0.026 | - | - | - | - | - | 0.019 | - | - | - | - | - | - | - | - | 0.045 |
| *Seriphus politus* | 0.002 | - | 0.001 | - | - | - | - | - | - | - | 0.013 | - | - | - | - | - | - | - | 0.002 | 0.018 |
| *Syngnathus leptorhynchus* | - | - | 0.002 | 0.003 | - | - | - | - | - | - | - | - | - | - | - | 0.008 | - | - | - | 0.013 |
| *Gibbonsia montereyensis* | - | - | - | - | - | - | - | - | - | - | 0.009 | - | - | - | - | - | - | - | - | 0.009 |
| *Hypsurus caryi* | - | - | - | - | - | - | - | - | - | - | 0.007 | - | - | - | - | - | - | - | - | 0.007 |
| *Hyperprosopon argenteum* | - | - | - | 0.006 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.006 |
| Total Biomass (kg) | 0.282 | 0.218 | 4.374 | 27.663 | 0.110 | - | 0.027 | 0.037 | 0.864 | 0.053 | 3.212 | 0.104 | 0.680 | 1.811 | 0.967 | 0.414 | 1.550 | 0.357 | 0.042 | 42.765 |
| Number of Species | 4 | 4 | 7 | 14 | 2 | - | 1 | 1 | 1 | 2 | 11 | 3 | 6 | 4 | 4 | 4 | 5 | 7 | 2 | 26 |

**Appendix H-5. Estimated monthly abundance of fish impinged during normal operations at Mandalay Generating Station. Mandalay Generating Station NPDES, 2006.**

| | 2005 | | | 2006 | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Abundance |
| *Cymatogaster aggregata* | - | 670 | 10,672 | 23,961 | - | - | - | 606 | 58 | 7,673 | 3,984 | 585 | 48,209 |
| *Engraulis mordax* | - | 237 | 612 | 44,349 | - | - | - | 319 | 60 | 137 | 116 | 120 | 45,950 |
| *Atherinops affinis* | - | 39 | 817 | 3,228 | - | 20 | 187 | 440 | 171 | 1,256 | 301 | 370 | 6,829 |
| *Hyperprosopon ellipticum* | - | - | - | - | - | - | - | - | 3,664 | - | - | - | 3,664 |
| *Phanerodon furcatus* | - | - | - | 3,369 | - | - | - | - | - | - | - | - | 3,369 |
| *Sardinops sagax* | 35 | 79 | 19 | 984 | - | - | - | - | 56 | - | - | - | 1,173 |
| *Leptocottus armatus* | - | - | - | 67 | - | - | - | 230 | 110 | 65 | 42 | 28 | 542 |
| *Clupea pallasii* | - | - | - | 481 | - | - | - | - | - | - | - | - | 481 |
| *Girella nigricans* | - | - | - | 289 | 65 | 19 | - | 58 | - | - | - | - | 431 |
| *Atractoscion nobilis* | - | - | - | 138 | - | - | - | - | 58 | 65 | - | - | 261 |
| *Myliobatis californica* | - | - | - | - | - | - | - | 63 | - | - | 129 | 31 | 223 |
| *Syngnathus leptorhynchus* | - | - | 19 | 94 | - | - | - | - | - | - | 94 | - | 207 |
| *Seriphus politus* | 35 | - | 19 | - | - | - | - | 59 | - | - | - | 59 | 172 |
| *Pleuronichthys guttulatus* | - | - | - | 22 | - | - | - | - | 58 | - | - | 28 | 108 |
| *Hyperprosopon argenteum* | - | - | - | 94 | - | - | - | - | - | - | - | - | 94 |
| *Atherinopsis californiensis* | 35 | - | - | 44 | - | - | - | - | - | - | - | - | 79 |
| *Anchoa compressa* | - | - | - | - | - | - | - | 76 | - | - | - | - | 76 |
| *Sphyraena argentea* | - | - | - | - | - | - | - | 47 | - | - | - | - | 47 |
| *Mugil cephalus* | - | - | - | 44 | - | - | - | - | - | - | - | - | 44 |
| *Trachurus symmetricus* | 35 | - | - | - | - | - | - | - | - | - | - | - | 35 |
| *Platyrhinoidis triseriata* | - | - | - | - | - | - | - | - | - | 34 | - | - | 34 |
| *Gibbonsia montereyensis* | - | - | - | - | - | - | - | 31 | - | - | - | - | 31 |
| *Hypsurus caryi* | - | - | - | - | - | - | - | 30 | - | - | - | - | 30 |
| *Gibbonsia elegans* | - | - | - | - | - | - | - | - | - | - | - | 28 | 28 |
| *Acanthogobius flavimanus* | - | - | - | - | 9 | - | - | 16 | - | - | - | - | 25 |
| *Paralichthys californicus* | - | - | 19 | - | - | - | - | - | - | - | - | - | 19 |
| Total Abundance | 146 | 1,026 | 12,179 | 77,193 | 74 | 39 | 187 | 1,975 | 4,235 | 9,230 | 4,666 | 1,249 | 112,199 |
| Number of Species | 4 | 4 | 7 | 14 | 2 | 2 | 1 | 12 | 8 | 6 | 6 | 8 | 26 |
| Total Flow (mg) | 2,200 | 4,218 | 2,342 | 590 | 586 | 592 | 521 | 3,333 | 3,664 | 6,938 | 3,810 | 3,247 | 32,041 |

**Appendix H-6. Estimated monthly biomass (kg) of fish impinged during normal operations at Mandalay Generating Station. Mandalay Generating Station NPDES, 2006.**

| | 2005 | | | 2006 | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Biomass (kg) |
| *Cymatogaster aggregata* | - | 1.577 | 66.720 | 196.709 | - | - | - | 14.493 | 1.984 | 83.378 | 17.645 | 3.540 | 386.046 |
| *Phanerodon furcatus* | - | - | - | 296.740 | - | - | - | - | - | - | - | - | 296.740 |
| *Atractoscion nobilis* | - | - | - | 165.872 | - | - | - | - | 34.544 | 8.395 | - | - | 208.811 |
| *Engraulis mordax* | - | 0.276 | 3.712 | 162.696 | - | - | - | 2.455 | 1.446 | 0.893 | 0.924 | 0.419 | 172.821 |
| *Atherinops affinis* | - | 0.079 | 9.836 | 81.459 | - | 0.547 | 3.296 | 5.190 | 2.054 | 38.289 | 3.778 | 4.096 | 148.624 |
| *Hyperprosopon ellipticum* | - | - | - | - | - | - | - | - | 91.611 | - | - | - | 91.611 |
| *Myliobatis californica* | - | - | - | - | - | - | - | 20.685 | - | - | 42.023 | 3.784 | 66.492 |
| *Clupea pallasii* | - | - | - | 20.509 | - | - | - | - | - | - | - | - | 20.509 |
| *Leptocottus armatus* | - | - | - | 4.605 | - | - | - | 10.290 | 2.773 | 1.041 | 0.847 | 0.590 | 20.146 |
| *Platyrhinoidis triseriata* | - | - | - | - | - | - | - | - | - | 17.665 | - | - | 17.665 |
| *Atherinopsis californiensis* | 1.186 | - | - | 14.861 | - | - | - | - | - | - | - | - | 16.047 |
| *Sphyraena argentea* | - | - | - | - | - | - | - | 15.307 | - | - | - | - | 15.307 |
| *Sardinops sagax* | 1.848 | 2.365 | 0.186 | 9.415 | - | - | - | - | 1.173 | - | - | - | 14.987 |
| *Girella nigricans* | - | - | - | 6.895 | 1.493 | 0.693 | - | 1.042 | - | - | - | - | 10.123 |
| *Pleuronichthys guttulatus* | - | - | - | 4.004 | - | - | - | - | 0.117 | - | - | 0.534 | 4.655 |
| *Mugil cephalus* | - | - | - | 3.671 | - | - | - | - | - | - | - | - | 3.671 |
| *Trachurus symmetricus* | 1.848 | - | - | - | - | - | - | - | - | - | - | - | 1.848 |
| *Anchoa compressa* | - | - | - | - | - | - | - | 0.878 | - | - | - | - | 0.878 |
| *Gibbonsia elegans* | - | - | - | - | - | - | - | - | - | - | - | 0.674 | 0.674 |
| *Paralichthys californicus* | - | - | 0.668 | - | - | - | - | - | - | - | - | - | 0.668 |
| *Hyperprosopon argenteum* | - | - | - | 0.561 | - | - | - | - | - | - | - | - | 0.561 |
| *Syngnathus leptorhynchus* | - | - | 0.037 | 0.281 | - | - | - | - | - | - | 0.241 | - | 0.559 |
| *Seriphus politus* | 0.035 | - | 0.019 | - | - | - | - | 0.385 | - | - | - | 0.118 | 0.557 |
| *Acanthogobius flavimanus* | - | - | - | - | 0.243 | - | - | 0.296 | - | - | - | - | 0.539 |
| *Gibbonsia montereyensis* | - | - | - | - | - | - | - | 0.278 | - | - | - | - | 0.278 |
| *Hypsurus caryi* | - | - | - | - | - | - | - | 0.207 | - | - | - | - | 0.207 |
| Total Biomass (kg) | 4.917 | 4.297 | 81.178 | 968.278 | 1.736 | 1.240 | 3.296 | 71.506 | 135.702 | 149.661 | 65.458 | 13.755 | 1,501.024 |
| Number of Species | 4 | 4 | 7 | 14 | 2 | 2 | 1 | 12 | 8 | 6 | 6 | 8 | 26 |
| Total Flow (mg) | 2,200 | 4,218 | 2,342 | 590 | 586 | 592 | 521 | 3,333 | 3,664 | 6,938 | 3,810 | 3,247 | |

**Appendix H-7. Length frequency of impinged fish measured during heat treatment and normal operation surveys at Mandalay Generating Station. Mandalay Generating Station NPDES, 2006.**

| | Size Class (cm) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 25 | 27 | 28 | 29 | 32 | 33 | 34 | 37 | 39 | 41 | 42 | 47 | 52 | Measured |
| *Acanthogobius flavimanus* | - | - | - | - | - | - | - | 1 | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| *Anchoa compressa* | - | - | - | - | - | - | - | 3 | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 |
| *Atherinops affinis* | 3 | - | 6 | 6 | 5 | 7 | 3 | 9 | 10 | 20 | 40 | 29 | 24 | 7 | 3 | 2 | - | - | - | - | - | - | - | - | 1 | - | 1 | 1 | - | - | - | - | - | - | 177 |
| *Atherinopsis californiensis* | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Atractoscion nobilis* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | - | 1 | 1 | - | 1 | 5 |
| *Clupea pallasii* | - | - | - | - | - | - | - | - | - | 2 | - | - | - | 8 | - | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 12 |
| *Cymatogaster aggregata* | - | 10 | 47 | 127 | 94 | 46 | 20 | 34 | 31 | 13 | 5 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 428 |
| *Engraulis mordax* | - | - | 2 | 2 | 13 | 90 | 17 | 9 | 9 | 2 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 145 |
| *Gibbonsia elegans* | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Gibbonsia montereyensis* | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Girella nigricans* | - | - | - | - | - | - | 9 | 4 | 6 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 20 |
| *Hyperprosopon argenteum* | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Hyperprosopon ellipticum* | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Hypsurus caryi* | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Leptocottus armatus* | - | - | - | - | - | 2 | 3 | 5 | 4 | 1 | - | - | 1 | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 18 |
| *Mugil cephalus* | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| *Myliobatis californica** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 | 2 | - | 1 | - | - | - | - | - | - | - | - | 7 |
| *Phanerodon furcatus* | - | - | - | - | - | 1 | - | - | - | 1 | - | - | 8 | 21 | 17 | 10 | 6 | 2 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 68 |
| *Platyrhinoidis triseriata*** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 |
| *Pleuronichthys guttulatus* | - | - | 1 | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| *Sardinops sagax* | - | - | - | - | - | 1 | - | 1 | 6 | 4 | - | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 15 |
| *Seriphus politus* | - | - | 1 | 2 | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 |
| *Sphyraena argentea* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 2 | - | - | - | - | 3 |
| *Syngnathus leptorhynchus* | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | - | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 |
| *Trachurus symmetricus* | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Urobatis halleri** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |

Note: * = Disc Width and ** = Total Length

**Appendix H-8. Abundance and biomass for each macroinvertebrate species recorded during heat treatment surveys at Mandalay Generating Station. Mandalay Generating Station NPDES, 2006.**

| | 13-Jul-06 | |
|---|---|---|
| Species | Abundance | Biomass (kg) |
| *Protothaca staminea* | 27,020 | 34.74 |
| *Octopus bimaculatus/bimaculoides* | 2 | 0.146 |
| *Pachygrapsus crassipes* | 3 | 0.036 |
| Total | 27,025 | 34.922 |
| Number of Species | 3 | |

**Appendix H-9. Abundance of macroinvertebrates impinged during normal operations by survey date at Mandalay Generating Station. Mandalay Generating Station NPDES, 2006.**

| | 2005 | | | 2006 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | | Mar | | Apr | May | | Jun | | Jul | | Aug | | Sep | | Total |
| Species | 6 | 1 | 2 | 29 | 8 | 9 | 9 | 23 | 7 | 3 | 17 | 16 | 21 | 6 | 13 | 16 | 24 | 7 | 27 | Abundance |
| *Navanax inermis* | - | - | - | 1 | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | 3 |
| *Octopus bimaculatus/bimaculoides* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | 1 | - | 3 |
| *Panulirus interruptus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | 1 | - | 3 |
| *Pachygrapsus crassipes* | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 2 |
| *Crangon nigromaculata* | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| *Farfantepenaeus californiensis* | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 |
| Total Abundance | - | - | 2 | 1 | - | - | - | - | - | - | 2 | - | - | - | - | 3 | 2 | 2 | 1 | 13 |
| Number of Taxa | - | - | 2 | 1 | - | - | - | - | - | - | 2 | - | - | - | - | 2 | 2 | 2 | 1 | 6 |

**Appendix H-10. Biomass (kg) of macroinvertebrates impinged during normal operations by survey date at Mandalay Generating Station. Mandalay Generating Station NPDES, 2006.**

| | 2005 | | | 2006 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | | Mar | | Apr | May | | Jun | | Jul | | Aug | | Sep | | Total |
| Species | 6 | 1 | 2 | 29 | 8 | 9 | 9 | 23 | 7 | 3 | 17 | 16 | 21 | 6 | 13 | 16 | 24 | 7 | 27 | Biomass (kg) |
| *Panulirus interruptus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.428 | - | 0.021 | - | 0.449 |
| *Octopus bimaculatus/bimaculoides* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.144 | 0.143 | 0.094 | - | 0.381 |
| *Navanax inermis* | - | - | - | 0.011 | - | - | - | - | - | - | 0.014 | - | - | - | - | - | - | - | 0.090 | 0.115 |
| *Pachygrapsus crassipes* | - | - | 0.017 | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.009 | - | - | 0.026 |
| *Crangon nigromaculata* | - | - | 0.002 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.002 |
| *Farfantepenaeus californiensis* | - | - | - | - | - | - | - | - | - | - | 0.001 | - | - | - | - | - | - | - | - | 0.001 |
| Total Biomass (kg) | - | - | 0.019 | 0.011 | - | - | - | - | - | - | 0.015 | - | - | - | - | 0.572 | 0.152 | 0.115 | 0.090 | 0.974 |
| Number of Taxa | - | - | 2 | 1 | - | - | - | - | - | - | 2 | - | - | - | - | 2 | 2 | 2 | 1 | 6 |

**Appendix H-11. Estimated monthly abundance of macroinvertebrates impinged during normal operations at Mandalay Generating Station. Mandalay Generating Station NPDES, 2006.**

| | 2005 | | | 2006 | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Abundance |
| *Navanax inermis* | - | - | - | 94 | - | - | - | 16 | - | - | - | 43 | 153 |
| *Octopus bimaculatus/bimaculoides* | - | - | - | - | - | - | - | - | - | - | 76 | 28 | 104 |
| *Panulirus interruptus* | - | - | - | - | - | - | - | - | - | - | 57 | 28 | 85 |
| *Pachygrapsus crassipes* | - | - | 19 | - | - | - | - | - | - | - | 54 | - | 73 |
| *Crangon nigromaculata* | - | - | 19 | - | - | - | - | - | - | - | - | - | 19 |
| *Farfantepenaeus californiensis* | - | - | - | - | - | - | - | 16 | - | - | - | - | 16 |
| Total Abundance | - | - | 38 | 94 | - | - | - | 32 | - | - | 187 | 99 | 450 |
| Number of Taxa | - | - | 2 | 1 | - | - | - | 2 | - | - | 3 | 3 | 6 |
| Total Flow | 2,200 | 4,218 | 2,342 | 590 | 586 | 592 | 521 | 3,333 | 3,664 | 6,938 | 3,810 | 3,247 | |

**Appendix H-12. Estimated monthly biomass (kg) of macroinvertebrates impinged during normal operations at Mandalay Generating Station. Mandalay Generating Station NPDES, 2006.**

| | 2005 | | | 2006 | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Biomass (kg) |
| *Octopus bimaculatus/bimaculoides* | - | - | - | - | - | - | - | - | - | - | 10.866 | 2.640 | 13.506 |
| *Panulirus interruptus* | - | - | - | - | - | - | - | - | - | - | 12.161 | 0.601 | 12.762 |
| *Navanax inermis* | - | - | - | 1.029 | - | - | - | 0.218 | - | - | - | 3.896 | 5.143 |
| *Pachygrapsus crassipes* | - | - | 0.316 | - | - | - | - | - | - | - | 0.483 | - | 0.799 |
| *Crangon nigromaculata* | - | - | 0.037 | - | - | - | - | - | - | - | - | - | 0.037 |
| *Farfantepenaeus californiensis* | - | - | - | - | - | - | - | 0.016 | - | - | - | - | 0.016 |
| Total Biomass (kg) | - | - | 0.353 | 1.029 | - | - | - | 0.234 | - | - | 23.510 | 7.137 | 32.263 |
| Number of Taxa | - | - | 2 | 1 | - | - | - | 2 | - | - | 3 | 3 | 6 |
| Total Flow | 2,200 | 4,218 | 2,342 | 590 | 586 | 592 | 521 | 3,333 | 3,664 | 6,938 | 3,810 | 3,247 | |

**Appendix H-13. Total abundance of fish impinged during heat treatments and extrapolated normal operations, 2001 - 2006. Mandalay Generating Station NPDES, 2006.**

| Species | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Total | Percent Total | Mean |
|---|---|---|---|---|---|---|---|---|---|
| *Leuresthes tenuis* | - | 114883 | 6502 | 4273 | 39910 | - | 165568 | 49.15 | 27594.7 |
| *Cymatogaster aggregata* | 27 | 14305 | 563 | 14709 | 8883 | 48209 | 86696 | 25.74 | 14449.3 |
| *Engraulis mordax* | 3 | 101 | 1 | 1607 | 3137 | 45950 | 50799 | 15.08 | 8466.5 |
| *Atherinops affinis* | - | 6232 | - | - | - | 6830 | 13062 | 3.88 | 2177.0 |
| *Lepidogobius lepidus* | - | - | - | - | 79 | 3665 | 3744 | 1.11 | 624.0 |
| *Hyperprosopon ellipticum* | - | - | - | - | - | 3664 | 3664 | 1.09 | 610.7 |
| *Phanerodon furcatus* | - | 1 | - | 45 | 20 | 3369 | 3435 | 1.02 | 572.5 |
| *Sardinops sagax* | - | 246 | 92 | 1224 | 260 | 1173 | 2995 | 0.89 | 499.2 |
| *Leptocottus armatus* | 81 | 605 | 98 | 402 | 113 | 542 | 1841 | 0.55 | 306.8 |
| *Pleuronichthys guttulatus* | - | - | - | 156 | 444 | 108 | 708 | 0.21 | 118.0 |
| *Syngnathus leptorhynchus* | - | - | 50 | 334 | 26 | 207 | 617 | 0.18 | 102.8 |
| *Clupea pallasii* | - | - | - | - | - | 481 | 481 | 0.14 | 80.2 |
| *Myliobatis californica* | - | - | 26 | 43 | 179 | 223 | 471 | 0.14 | 78.5 |
| *Girella nigricans* | - | - | - | - | - | 432 | 432 | 0.13 | 72.0 |
| *Paralichthys californicus* | 27 | 1 | 36 | 43 | 174 | 19 | 300 | 0.09 | 50.0 |
| *Hypsopsetta guttulata* | - | 236 | 53 | - | - | - | 289 | 0.09 | 48.2 |
| *Atractoscion nobilis* | - | - | - | - | 22 | 261 | 283 | 0.08 | 47.2 |
| *Seriphus politus* | - | 2 | - | - | 44 | 172 | 218 | 0.06 | 36.3 |
| *Anchoa compressa* | - | - | - | - | 127 | 76 | 203 | 0.06 | 33.8 |
| *Trachurus symmetricus* | - | 28 | - | 87 | 19 | 35 | 169 | 0.05 | 28.2 |
| *Peprilus simillimus* | - | 33 | - | 129 | 1 | - | 163 | 0.05 | 27.2 |
| *Hyperprosopon argenteum* | - | - | - | - | - | 94 | 94 | 0.03 | 15.7 |
| *Atherinopsis californiensis* | - | - | - | - | - | 79 | 79 | 0.02 | 13.2 |
| *Embiotoca jacksoni* | - | - | - | - | 77 | - | 77 | 0.02 | 12.8 |
| *Gibbonsia elegans* | - | 4 | 1 | - | 41 | 28 | 74 | 0.02 | 12.3 |
| *Gibbonsia montereyensis* | - | 28 | - | - | - | 31 | 59 | 0.02 | 9.8 |
| *Platyrhinoidis triseriata* | - | - | - | - | 23 | 34 | 57 | 0.02 | 9.5 |
| *Acanthogobius flavimanus* | - | 26 | - | - | - | 25 | 51 | 0.02 | 8.5 |
| *Sphyraena argentea* | - | - | - | - | - | 47 | 47 | 0.01 | 7.8 |
| *Mugil cephalus* | - | - | - | - | - | 44 | 44 | 0.01 | 7.3 |
| *Hypsurus caryi* | - | - | - | - | - | 30 | 30 | 0.01 | 5.0 |
| *Urobatis halleri* | 24 | - | - | - | - | 1 | 25 | 0.01 | 4.2 |
| *Syngnathus* sp | 24 | - | - | - | - | - | 24 | 0.01 | 4.0 |
| *Xystreurys liolepis* | - | - | - | - | 19 | - | 19 | 0.01 | 3.2 |
| *Porichthys myriaster* | - | 12 | - | - | - | - | 12 | 0.00 | 2.0 |
| *Umbrina roncador* | - | 3 | - | - | - | - | 3 | 0.00 | 0.5 |
| *Paralabrax nebulifer* | - | - | 2 | - | - | - | 2 | 0.00 | 0.3 |
| *Cheilotrema saturnum* | - | 1 | - | - | - | - | 1 | 0.00 | 0.2 |
| *Heterostichus rostratus* | - | 1 | - | - | - | - | 1 | 0.00 | 0.2 |
| *Hexagrammos decagrammus* | - | - | - | 1 | - | - | 1 | 0.00 | 0.2 |
| *Paralabrax clathratus* | - | 1 | - | - | - | - | 1 | 0.00 | 0.2 |
| Number of individuals | 186 | 136749 | 7424 | 23053 | 53598 | 115829 | 336839 | | 56139.8 |
| Number of species | 6 | 20 | 11 | 13 | 20 | 28 | 41 | | 16.3 |

Note: 0.00 = <0.005.

**Appendix H-14. Total abundance of macroinvertebrates impinged during heat treatments and extrapolated normal operations, 2001 - 2006. Mandalay Generating Station NPDES, 2006.**

| Species | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Total | Percent Total | Mean |
|---|---|---|---|---|---|---|---|---|---|
| *Protothaca staminea* | - | - | 4 | - | - | 27020 | 27024 | 96.35 | 4504.0 |
| *Pachygrapsus crassipes* | 27 | - | 1 | 4 | 156 | 76 | 264 | 0.94 | 44.0 |
| *Navanax inermis* | - | - | - | 48 | - | 153 | 201 | 0.72 | 33.5 |
| *Octopus bimaculoides* | 1 | 41 | 12 | - | - | 106 | 160 | 0.57 | 26.7 |
| *Hemigrapsu nudus* | - | - | - | 129 | - | - | 129 | 0.46 | 21.5 |
| *Loligo opalescens* | 124 | - | - | - | - | - | 124 | 0.44 | 20.7 |
| *Panulirus interruptus* | - | 3 | 3 | 1 | 3 | 85 | 95 | 0.34 | 15.8 |
| *Crangon nigromaculata* | - | - | - | - | - | 19 | 19 | 0.07 | 3.2 |
| *Farfantepenaeus californiensis* | - | - | - | - | - | 16 | 16 | 0.06 | 2.7 |
| *Aplysia californica* | - | 2 | - | - | 4 | - | 6 | 0.02 | 1.0 |
| Polchaeta, unid | - | - | - | 3 | - | - | 3 | 0.01 | 0.5 |
| *Cancer antennarius* | 1 | - | - | 2 | - | - | 3 | 0.01 | 0.5 |
| *Macoma* sp | - | - | - | 2 | - | - | 2 | 0.01 | 0.3 |
| *Pugettia producta* | - | - | - | 1 | - | - | 1 | 0.00 | 0.2 |
| *Aplysia* sp | 1 | - | - | - | - | - | 1 | 0.00 | 0.2 |
| Number of individuals | 154 | 46 | 20 | 190 | 163 | 27475 | 28048 | | 4674.7 |
| Number of species | 5 | 3 | 4 | 8 | 3 | 7 | 15 | | 5.0 |

Note: 0.00 = <0.005.