Appendix H.

Ports of Long Beach and Los Angeles Year 2000 Biological Baseline Study of San Pedro Bay

PORTS OF LONG BEACH and LOS ANGELES Year 2000 BIOLOGICAL BASELINE STUDY OF SAN PEDRO BAY

Prepared for:

THE PORT OF LONG BEACH

THE PORT OF LOS ANGELES

Prepared by:

MEC ANALYTICAL SYSTEMS, INC.

<u>In Association With:</u>

Science Applications International Corporation
Merkel & Associates, Inc.
Keane Biological Consulting
Everest International Consultants

PORTS OF LONG BEACH AND LOS ANGELES
YEAR 2000 BIOLOGICAL BASELINE STUDY
OF SAN PEDRO BAY

Submitted to:

Port of Long Beach
Planning Division
925 Harbor Plaza
Long Beach, California 90802

Submitted by:

MEC Analytical Systems, Inc.
2433 Impala Drive
Carlsbad, California 92008

In Association With:

Science Applications International Corporation
Merkel & Associates, Inc.
Keane Biological Consulting
Everest International Consultants

June 2002

FORWARD

The prevailing thinking until recent times was that the ocean is large and can accept an infinite amount of waste discharges from human activity. It had been documented decades earlier that streams, rivers, and lakes can be affected by waste discharges leading to polluted conditions. Environmental conditions had been documented for some estuaries, especially the brackish–fresh water sections, in Europe, notably United Kingdom prior to World War II. No such studies had been undertaken in United States at that time. The State of California played an important role in the realization that the marine environment can be affected by waste discharges. The establishment of the then California Water Pollution Control Board provided the impetus to study conditions in protected waters and later offshore waters. With EPA arriving on the scene in 1970 and later the establishment of research laboratories in Narragansett, Rhode Island, Gulf Breeze, Florida and Newport, Oregon gave further impetus to determine the causes, effects and control of marine pollution. The Food and Agriculture Organization of the United Nations convened a world wide conference on marine pollution in Rome, Italy, in 1970. The problems caused by marine pollution were now investigated on a world-wide scale.

Los Angeles–Long Beach Harbors played an important role in alerting the public to pollution in the marine environment. Concurrent with the initial studies in the harbors was a survey of some parts of San Francisco Bay. Because of the vastness of the San Francisco Bay, it was not possible to get a picture of the entire system. Since a much smaller area was covered, it was possible to obtain an overview of the entire ecosystem of Los Angeles–Long Beach Harbors. Publication of the results of the different studies in the harbors, especially the raw data, not only called attention to marine pollution, but also permitted others to evaluate the data themselves.

Because of the interest and importance of the harbors by public officials and environmental groups, we have a detailed picture of the environmental conditions in the harbors for the past 50 years. No other marine region of the world can boast of such a record. From the studies of Los Angeles-Long Beach Harbors, we have seen first the realization that marine pollution does occur, and later the first realization that pollution abatement can improve the environment.

Donald J. Reish
May 2001

EXECUTIVE SUMMARY

The marine biological environment of Long Beach and Los Angeles Harbors has been periodically studied since the 1950s. Early studies documented severe pollution in several of the basins in the harbors. Comprehensive studies in the 1970s reported a dramatic improvement in marine habitat quality relative to the 1950s, although areas of pollution were still evident in inner harbor and blind-end slip areas.

In the last three decades, the Ports of Long Beach and Los Angeles (Ports) have undertaken long-range development efforts to increase the shipping and commercial capacity of the harbors. During the 1980s and 1990s several separate biological studies were conducted that were limited to either one port or the other in support of these anticipated harbor modifications.

Considerable changes have occurred in the harbors since the comprehensive surveys of the 1970s and more focused surveys of the 1980s and 1990s. Some of these changes included deepening of navigational channels and basins, constructing substantial landfills at Piers 300 and 400 in Los Angeles Harbor, constructing a transportation corridor out to Pier 400, expanding Pier J in Long Beach Harbor, and constructing the west basin of the Cabrillo Marina complex. As part of mitigation for construction and channel deepening, shallow water habitats were created in formerly deepwater areas near Pier 300, the San Pedro Breakwater, and on the east side of Pier 400. Thus, several areas that were previously aquatic habitat are now land, some previous areas that were deep water are now shallow, and circulation patterns within the harbors have been altered.

The Ports retained MEC Analytical Systems, Inc. (MEC) and its subcontractors to conduct environmental studies in Long Beach and Los Angeles Harbors in the year 2000. The goal of this study was to provide an update of quantitative information on physical/chemical and biological conditions within the different marine habitats of the harbors.
The specific objectives of the study were to:

- Measure water quality and sediment grain size to provide physical/chemical characterization of environmental conditions during biological surveys,
- Provide an updated quantitative baseline of the benthic invertebrate community,
- Provide an updated quantitative baseline of larval, juvenile, and adult fish populations,
- Provide an updated description of biological communities attached to rocky riprap habitats,
- Map kelp distribution and describe macroalgae communities,
- Map eelgrass distribution,
- Provide an updated quantitative baseline of bird use patterns,
- Identify relative occurrence of non-indigenous (exotic) species among native populations,
- Compare year 2000 study findings with previous baseline studies.

The Year 2000 Baseline Study is the first comprehensive examination of the status of biological communities within both inner and outer harbor areas of both Ports since the 1970s. It is the first study to map kelp and eelgrass distribution throughout both Ports.

Major findings of the Year 2000 Baseline Study are summarized according to the survey element below.

Physical/Chemical Conditions

Oceanographic conditions at the onset of the Year 2000 Baseline Study were characterized by the dissipation of a weak to moderate La Niña event, which had followed the strong El Niño of 1997-1998. Water quality measurements conducted quarterly for the 2000 study were generally consistent with expected values for near-coastal and harbor environments, and indicated minimal spatial and temporal trends within the harbor complex. Slightly reduced salinities in surface waters at a subset of the monitoring sites reflected freshwater inputs; however, the magnitude of this effect was spatially and temporally limited. Results indicate a continued trend of water quality improvement since the 1970s, with most dissolved oxygen concentrations in excess of 5 milligrams/liter. Episodic and localized changes in some parameters, such as low dissolved oxygen concentrations coinciding with low transmissivity, suggested minor effects possibly associated with sediment resuspension events. Water clarity (transmissivity) decreased with increasing depth and was relatively lower in bottom waters at stations with fine sediments and/or in the vicinity of dredging and/or disposal.

Water circulation in the harbors has been modified by some of the construction activities that have occurred since the 1980s. Review of modeling studies indicate that changes to tidal circulation as a result of construction of Pier 400 mainly involve a blocking of north to south flow through Angel's Gate, which reduces flow velocity into the harbor. The flow under flood current is forced to go around the structure to the east and west. Model studies indicate that reduced flushing does not have significant impacts on dissolved oxygen concentrations. Results of the Year 2000 Baseline Study did not observe any depressions in dissolved oxygen near Pier 400 or within the adjacent Pier 300 Shallow Water Habitat outside the range observed elsewhere in the harbor.

Adult and Juvenile Fish

Studies of adult and juvenile fish were conducted quarterly and employed three different sampling methods including use of large lampara nets to sample pelagic fish throughout the water column, otter trawl to sample bottom-associated (demersal) species, and beach seines to sample shallow nearshore waters. A total of 76 taxa representing 74 unique species of fish were collected with the different sampling nets over all stations and sampling periods. Fish appeared healthy, with a very low incidence (< 0.01%) of obvious abnormalities or external parasites. Northern anchovy (*Engraulis mordax*) and white croaker (*Genyonemous lineatus*) were the abundant species collected in 2000. White croaker was top ranked in terms of biomass. Other species caught in very high abundance were queenfish (*Seriphus politus*), topsmelt (*Atherinops affinis*), and specklefin midshipman (*Porichthys myriaster*). California tonguefish (*Symphurus atricauda*), speckled sanddab (*Citharichthys stigmaeus*), Pacific sardine (*Sardinops sagax*), shiner surfperch (*Cymatogaster aggregata*), salema (*Xenistius californiensis*), and white surfperch (*Phanerodon furcatus*) also had high abundances.

Commercially and/or recreationally important species, including California halibut (*Paralichthys californica*) and barred sand bass (*Paralabrax nebulifer*) had moderate abundance. California halibut was collected primarily with otter trawl nets, and ranked seventh in total abundance and second in total biomass for that sampling gear. California halibut were found at all stations, but more juveniles were found in shallow waters, particularly the created shallow water habitats, which were constructed as part of mitigation for Port development projects. Barred sand bass also were caught primarily by trawls, and ranked tenth in total abundance with that gear.

Fish abundance showed seasonal trends with significantly higher catch during the summer. Similar to previous studies in which day and night samples were collected, a greater variety and more fish were collected at night in the present study. Day/night differences in catch are believed to result from a combination of fish behaviors at night related to decreased visual avoidance of sampling gear, increased dispersal of schooling species, and increased foraging activity at night by several species (Horn and Allen 1981).

More species of fish were collected in shallow water, including all three of the created shallow water mitigation sites (Cabrillo, Pier 300, Long Beach Shallow Water Habitats), than at deepwater stations in open water, channel, basin, and slip habitats. The greater diversity may be explained in part to the greater habitat heterogeneity associated with the shallow water habitats, which were adjacent to rock riprap and/or vegetated areas (e.g., eelgrass beds, kelp bed). For instance, the Cabrillo Shallow Water Habitat is located alongside the San Pedro Breakwater, which supports giant kelp and other macroalgae; the Long Beach Shallow Water Habitat is located adjacent to riprap shoreline along Pier 400 that supports giant kelp and other macroalgae, and extensive eelgrass beds occur within the Pier 300 Shallow Water Habitat.

Little difference was observed in lampara fish catch between inner and outer harbor areas, indicating that pelagic schooling species range in high abundances throughout the harbor complex. In contrast, deepwater habitats in outer to middle harbor areas generally had a greater number, biomass, and variety of trawl-caught fish than inner harbor areas. Benthic invertebrates, which represent an important food source for demersal fish, also exhibited a trend of decreasing habitat quality from outer to inner harbor areas.

Fish catch using lampara nets in 2000 was similar to studies in 1986-1987 in Los Angeles Harbor. On the Long Beach side of the harbor complex, catch values were within the range previously reported in 1994 and 1996; however, basins of the middle and outer Long Beach Harbor had higher abundance in 2000, primarily due to large catches of northern anchovy. Numbers of collected species were similar between 2000 and previous studies.

Evaluation of long-term trends in trawl catch is confounded by smaller sized nets used in previous studies. This is particularly problematic for comparing abundance, since the net size comparison study conducted in the present study indicates considerable catch variability with different sized nets. Nevertheless, trawl catch values appeared to be higher in Long Beach Harbor in 2000 than recorded in 1994 and 1996. The City of Los Angeles has reported shifts in trawl catch abundance in Los Angeles Harbor each year since 1996 that they have attributed to the ongoing construction of Pier 400. Although there was some indication that dredging and/or disposal activities may have resulted in lower lampara fish catch near Pier 400, there was little correspondence between otter trawl fish catch and locations near or away from dredging or disposal in 2000.

An estimate of harbor-wide fish abundance based on 2000 catch data standardized to area and adjusted by net efficiency totaled about 44 million fish. An estimate for only outer Los Angeles

Harbor in 1986-1987 was 15 million fish for that harbor. The higher estimated value for 2000 reflects consideration of the area throughout both inner and outer areas of Long Beach and Los Angeles Harbors. The top five species (northern anchovy, white croaker, queenfish, Pacific sardine, and topsmelt) account for nearly 92% of the total fish populations.

Ichthyoplankton

Forty-nine taxa representing 44 unique species of fish larvae and 13 categories of fish eggs were identified. The most abundant fish larvae were Goby type A (arrow goby, cheekspot goby, and shadow goby) (33%), bay goby (16%), northern anchovy (14%), California clingfish (13%), queenfish (10%), blennies (5%), and white croaker (5%). Dominant egg taxa were unidentified eggs (likely including high numbers of California halibut eggs) (57%) and sciaenid eggs (35%). Although not as abundant, eggs of speckled sanddab, California tonguefish, and spotted turbot together comprised nearly 7% of the collected eggs.

With the exception of the Pier 300 Shallow Water Habitat, which had high larval abundance, and the Long Beach West Basin, which had low larval abundance, the abundances of larvae were generally higher on the Long Beach side of the harbor complex. This bears some similarity to the abundance pattern indicated for adult fish caught by lampara, which generally showed higher abundance in deepwater channel, basins, and slips in Long Beach Harbor. The very high larval abundance noted in the Pier 300 Shallow Water Habitat did not correspond to adult fish distribution, which showed moderate abundance in both the lampara and otter trawl catches at that location. The larval catch was dominated by benthic associated gobies (arrow goby, cheekspot goby, shadow goby), which inhabit burrows and were undersampled by the lampara and trawl nets used to capture adult fish.

Species composition varied among different areas and habitats in the harbor. Larvae of pelagic or demersal species found over sand and/or mud bottoms as adults (e.g., croakers, gobies, anchovies) generally had a wide dispersal pattern within the harbor complex. Some of the species were more strongly associated with deep or shallow water habitats. For example, Goby type A larvae (arrow goby, cheekspot goby, shadow goby) were strongly associated with shallow water habitats, whereas bay goby larvae were more abundant at the deepwater stations. White croakers were substantially more abundant at deepwater habitats, whereas queenfish had localized high abundance in either shallow or deep water. Larvae of flatfish such as California halibut, diamond turbot, speckled sanddab, horneyhead and spotted turbot generally had higher abundances in deepwater habitats in the outer harbor, basins, and channels. Fish associated with vegetation and/or rocky substrate during some part of their life stage (eggs and/or juvenile-adults) (e.g., atherinids, kelpfish, pipefish, reef finspot) had a more localized larval distribution at locations near rirprap or macroalgae beds.

Larval abundance was significantly higher in spring and summer and a secondary peak occurred in the fall. A primary peak in egg abundance during the winter and a secondary peak in summer preceded the periods of higher larval abundance. During the past 30 years, the dominant larval fish and egg species in Long Beach and Los Angeles Harbors have remained relatively consistent although there have been shifts in dominance. Dominant larval fish species in the current study are similar to those caught in the past, but they differ in ranked abundance. The Year 2000 Baseline Study differs from past studies in surveying both inner and outer harbor and shallow and deepwater habitats nearly equally in both harbors. Earlier studies focused more on outer harbor areas. The increased number of shallow water habitats surveyed in 2000 study probably accounts for the higher ranked abundance of gobies and clingfish over northern anchovy in the present study.

The ichthyoplankton survey provided a good measure of the importance of species inhabiting burrows or associated with rocky and/or vegetated habitats in the Long Beach-Los Angeles harbor complex. These species were poorly represented in the adult fish surveys, yet are an important part of the overall ecology of the diverse marine habitats in the harbors. The ichthyoplankton results also demonstrate that a wide variety of fish spawn and develop within Long Beach and Los Angeles Harbors.

Benthic Invertebrates

Over 400 species of benthic infauna (small organisms that live on and within the sediment) and larger macroinvertebrates were collected during the Year 2000 Baseline Study. Both the small infaunal and larger macroinvertebrates exhibited significant declines in abundance between the winter (January-February) and remaining surveys, which may have been related to the dissipation of the La Niña period, which followed the strong 1997-1998 El Niño.

Small infaunal organisms, which tend to be less motile than larger macroinvertebrates, exhibited spatial variability in species composition that appeared to be tied to a combination of factors including water depth, years since dredging/disposal, and habitat quality. Assemblages in the outer harbor differed between shallow and deepwater habitats, and differences were apparent between assemblages from areas that have or have not experienced recent dredging. Areas of recent dredging had fewer species and lower abundance than non-dredged areas, indicating that the recently dredged areas were still in the colonization phase. In general, habitat quality was highest at the created Cabrillo, Pier 300, and Long Beach Shallow Water Habitats and the deep open waters of both harbors. A gradient of decreasing habitat quality was observed in basin and slip habitats and the back channels of the inner harbor.

Larger macroinvertebrates exhibited spatial variability, some of which appeared to relate to water depth and some of which may have been related to habitat and/or dredging/disposal. Assemblages generally differed between shallow and deepwater habitats. Similar to fish, catch abundance was higher in basin habitats in Long Beach Harbor than in the open waters of the outer harbor. The lowest catch was obtained in the inner harbor.

Similar benthic invertebrate species have been collected in the harbors over the past 30 years, but the relative abundances of the species have varied and there has been a shift in the dominance of several species. There has been a steady improvement in benthic habitat quality as demonstrated by increased diversity and less dominance by pollution tolerant benthic infauna species over the past half century. Many areas in the harbors were severely polluted in the 1950s with depauperate faunal assemblages. Polluted and "semi-healthy" areas still exist in the harbors; however, the spatial extent of these areas of relatively poorer habitat quality is not as widespread today. The most polluted area is the Consolidated Slip of Los Angeles Harbor; "semi-healthy" areas exist in the Cerritos Channel of the inner harbor and in confined basins and slips in both harbors. There were different species assemblages in the basins and slips of Los Angeles and Long Beach Harbors, with those in Los Angeles Harbor appearing to have a somewhat lower habitat quality. The quality of these "semi-healthy" areas has improved over the conditions reported in the 1950s and 1970s.

Riprap Associated Organisms

A total of 265 species of invertebrates and algae was identified within the riprap community. Distinct tidal zonation was observed with increasing numbers of species with increasing depth. However, abundances were similar throughout the upper and lower intertidal and subtidal zones.

The riprap community during the Year 2000 Baseline Study exhibited similar spatial patterns and dominant species as reported in the 1980s. Similar to historical studies, more species occurred on riprap in the outer than inner harbor areas. Barnacles dominated the upper intertidal and were conspicuous in the middle to lower intertidal strata. The non-indigenous Mediterranean mussel *Mytilus galloprovincialis* was a dominant in the lower intertidal and shallow subtidal. Tanaid and amphipod crustaceans also were dominant species in the shallow subtidal. Other commonly observed fauna included crabs, sea anemones, sea urchins, and starfish in lower intertidal and shallow subtidal zones. Giant kelp and/or feather boa kelp were overstory species in the subtidal zone of riprap stations in the outer harbor, and sargassum and to a lesser extent feather boa kelp were observed in the inner harbor.

Kelp and Macroalgae

Kelp and macroalgal communities are narrowly distributed within the harbor areas, being principally restricted to the shallow hard bottom environments associated with riprap shorelines, breakwaters, and pier structures, as well as harbor debris (e.g., rubble, mussel shells, calcareous tubes). The true kelp communities were restricted to the outermost portions of the harbor where giant kelp forms a principal component of macroalgal assemblages. While nowhere within the Ports is algal diversity high, there is a general cline of lessening algal diversity from the outermost portions of the harbors to the innermost channel environments.

Giant kelp (*Macrocystis pyrifera*) communities within Long Beach and Los Angeles Harbors are not abundant totaling only about 25 acres in the spring of 2000 and declining to about 14 acres in the fall of 2000. While algal communities within the Ports exhibit year-round presence, there is substantial seasonality to the communities. All of the algal communities appear to exhibit relatively vigorous growth during the spring months. During the summer months, warm temperatures, lack of nutrients and poor water circulation are all likely contributors to a decline in *Macrocystis* dominated communities. Other dominant alga such as *Sargassum muticum* in the inner harbor also likely decline for these same reasons.

The occurrence of giant kelp within the harbors is relatively recent according to reports of prior investigations. *Macrocystis* was established within the Ports as transplants to the San Pedro Breakwater in 1977. The distribution of kelp has expanded within outer Los Angeles Harbor since that time. During the present study, giant kelp also was found along the Middle Breakwater, submerged dike at the Cabrillo Shallow Water Habitat, riprap edges of Pier 400, other localized riprap shorelines, and on cobbles offshore Cabrillo Beach.

Eelgrass

Eelgrass habitat occurs in shallow waters offshore Cabrillo Beach and within the Pier 300 Shallow Water Habitat in Los Angeles Harbor. These beds, while consistent in their occurrence from year to year, exhibit relatively strong seasonal variation in overall area. Eelgrass beds within the Port of Los Angeles ranged from approximately 50 acres in the spring to approximately 100 acres at their peak in the fall. This pattern of expansion and contraction of eelgrass habitat is not atypical of what is regularly observed in other areas where eelgrass occurs in marginal habitat areas that are typically on the deeper fringes of normal depth distribution ranges.

Within the Cabrillo Beach and Pier 300 sites, eelgrass distributions were influenced by light restrictions, seasonality, and extrinsic biotic factors. Large areas that were devoid of eelgrass in March 2000 were dominated by a dense growth of a filamentous brown alga and urchin barrens were also observed within the eelgrass beds.

In addition to the two eelgrass beds located within the Port of Los Angeles, there was a single plant located in Long Beach Harbor within the Cerritos Channel along the north shoreline of Pier A at Berth A88. An eelgrass leaf from a broad-leaved form of eelgrass also was found floating around the Arco Terminal during March 2000. This broad-leaved eelgrass is not at all similar to the eelgrass found within the larger beds found in the Port of Los Angeles and has been noted to occur in deeper waters than the more typical form of eelgrass. These observations suggest that other limited eelgrass beds may exist in the harbors.

Birds

A total of 99 species, representing 31 families, were observed within the Ports of Long Beach and Los Angeles during the 2000-2001 monitoring year. Of that total, 69 species are considered to be dependent on marine habitats. The greatest number of individuals was observed during the July 2000 survey and the first survey in August 2000, primarily due to large numbers of Elegant Terns nesting at Pier 400 that were foraging in the harbor waters. Despite the high abundances observed during July and August, the June through September surveys yielded the lowest numbers of species (36 to 41), and fall and winter surveys yielded the highest numbers of species (43 to 60 species).

The most abundant birds were gulls (44.1% of mean observations during the survey year), and the Western Gull was the most numerous gull species. Diving birds that feed on fish (Aerial Fish Foragers) were second in abundance (22.4% of mean observations); this bird guild was dominated by Elegant Terns and Brown Pelicans. The third most abundant bird guild was waterfowl (21.4% of mean observations), represented largely by Western Grebe, Brant's Cormorant, and Surf Scoter. Upland birds, dominated by large numbers of Rock Doves roosting under docks and pilings, accounted for 5.9% of mean observations. Small shorebirds, large shorebirds, and wading/marshbirds accounted for 2.7%, 1.4%, and 1.5% of mean observations, respectively. Commonly observed species included Surfbirds, Black-bellied Plovers, and Western Sandpipers (small shorebirds); Willets and Black Oystercatchers (large shorebirds); and Great-blue Herons and Black-crowned Night Herons (wading/marshbirds). Raptors accounted for $< 0.05\%$ of the mean number of individuals observed. As during previous surveys, birds were not equally distributed among survey zones and habitats; survey zones along the breakwaters supported the highest densities of birds.

Due to variations in total area surveyed, duration and timing of surveys, and survey methods, as well as a reduction in available open water habitat, data collected during the 2000-2001 and previous surveys are not always comparable, particularly raw abundances. However, the total number of species and average number of species (species per survey) during 2000-2001 surveys increased from that of previous surveys. Average number of individuals (number per survey) during 2000-2001 also increased from previous surveys (however, these data were not available for 1986-1987 surveys).

Several sensitive species were observed during the 2000-2001 surveys. The California Brown Pelican accounted for 9.5% of the total observations, which was a substantial increase from the 3.8% of the total observations recorded during the 1973-1974 studies. Peregrine Falcons were observed during 12 of the 20 survey dates; several pairs of Peregrine Falcons are known to nest within the Ports and vicinity. California Least Terns nest in the Port of Los Angeles. There were over 500 nesting pairs in 2000, which was substantially higher than the approximately 100 nesting pairs during the 1986-1987 study. Other sensitive terns nesting within the Port of Los Angeles and observed in high numbers during the 2000 summer surveys were Caspian Tern and Elegant Tern, as well as the related Black Skimmer. Other sensitive species observed during surveys included Black-crowned Night Herons (nesting sites on the Navy Mole of Long Beach West Basin), Black Oystercatcher, Burrowing Owl, and Loggerhead Shrike.

Dredging and Disposal Activities

Lower water clarity (transmissivity) was measured in waters near locations of dredging and disposal activities. Lower water clarity also was measured at stations with finer sediments due to sediment resuspension. With the exception of depth and possibly temperature, physical/chemical parameters such as dissolved oxygen, pH, and salinity provided little insight to species composition of adult fish and ichthyoplankton in different areas of the harbors. Species composition differed between shallow and deepwater habitats, which appeared to be related more to broad dispersal patterns associated with widely distributed pelagic or soft-bottom associated demersal species, or to localized distribution patterns of species associated with rock and/or vegetated habitats.

It is not known to what extent fish and ichthyoplankton abundance may have been affected by dredging and/or disposal activities. An indication that these perturbations may have been influential was the lower abundance of adult fish caught by lampara in outer Los Angeles Harbor near Pier 400; however, lampara catch was high in Long Beach West Basin where dredging also occurred. Larval abundance was lower than expected in Long Beach West Basin, where dredging occurred, and relatively lower in outer Los Angeles Harbor near Pier 400 as compared to outer Long Beach Harbor. On the other hand, there was little correspondence between the abundance of adult fish caught by otter trawl and locations near or away from dredging and disposal activities.

Benthic invertebrate assemblages differed between areas that have or have not experienced recent dredging. Areas of recent dredging had a similar species assemblage as non-dredged areas, but there were fewer species and lower abundance indicating that the recently dredged areas were still in the colonization phase.

Exotic Species

The only exotic (non-indigenous) fish species collected in the 2000 sampling surveys was the yellowfin goby (*Acanthogobius flavimanus*). This species, which was introduced from Japan, has been reported in previous studies of the harbors, but its relative abundance appears to be higher in 2000 as compared to earlier studies.

Non-indigenous fauna potentially comprise about 15% of the invertebrate species that inhabit the harbors. A few of the species are dominant in abundance. The polychaete *Pseudopolydora paucibranchiata* and clam *Theora lubrica* comprised 26% of the total infaunal abundance and the New Zealand bubble snail *Philine auriformis* accounted for 4.5% of the macroinvertebrate abundance in 2000. The relative abundance of these species has increased in the harbors since the 1970s.

Approximately 11% of the species associated with rocky riprap were potentially non-indigenous. Conspicuous were the Mediterranean mussel (*Mytilus galloprovincialis*) and Pacific oyster (*Crassostrea gigas*). While the Mediterranean mussel has been a common inhabitant of the harbors for many years, the occurrence of the Pacific oyster is fairly recent and is localized mainly in Los Angeles Harbor. Its occurrence was not reported during comprehensive studies of Los Angeles Harbor in 1986-1987, and apparently has established since then.

Known occurrences of invasive exotic algae within the harbors include the ubiquitous *Sargassum muticum* and the first discovery of *Undaria pinnatifida* on the eastern Pacific coastline. While *Sargassum* has become a naturalized element of the algal flora and no substantial changes in this species distribution pattern within the Ports are expected, this is not the case with *Undaria*. The relatively recent introduction of *Undaria*, probably as a result of hull fouling or ballast water transport, and its recent identification at a number of other locations along the coast suggest that this species may become much more widespread within Long Beach and Los Angeles Harbors over time.