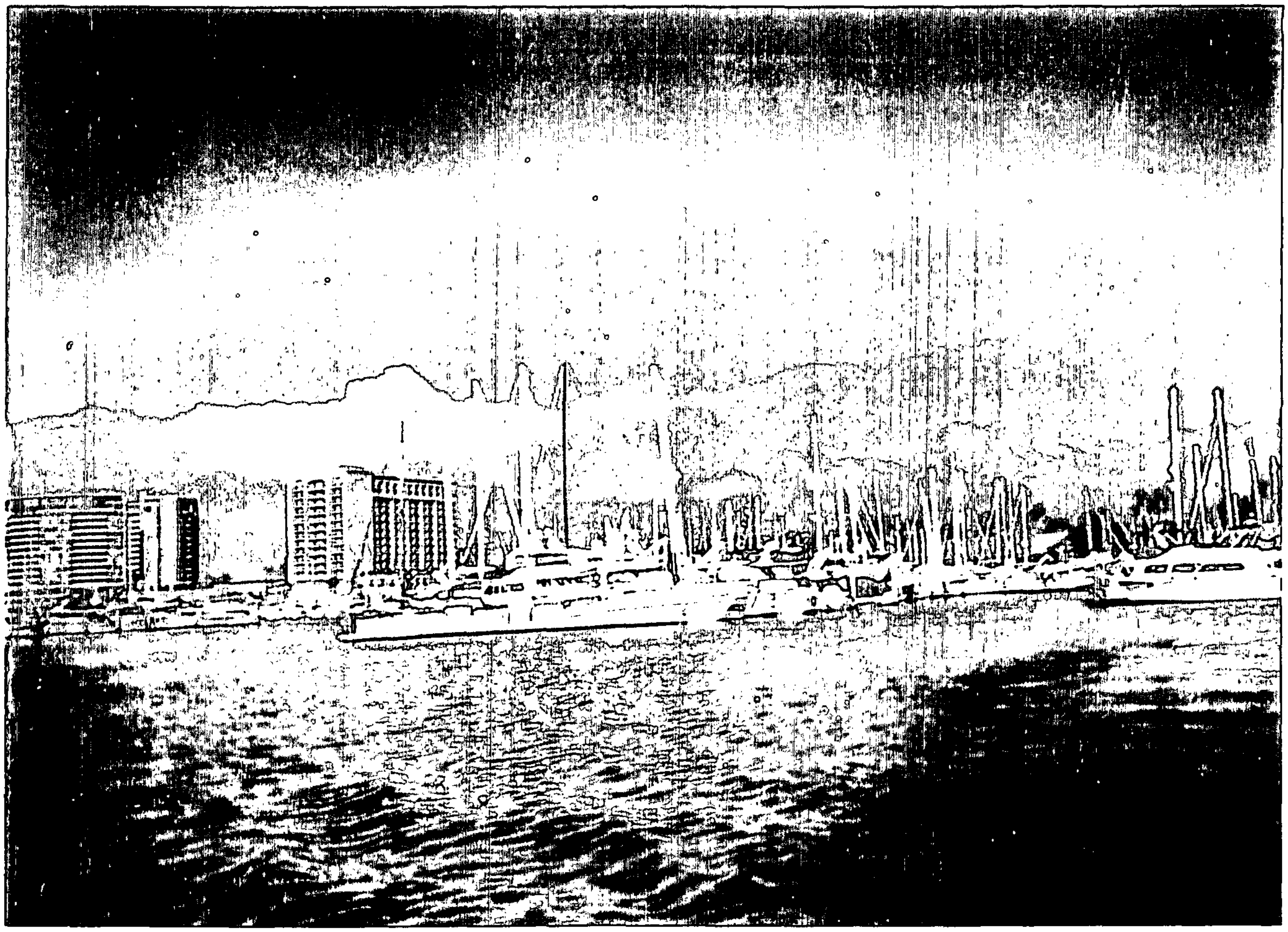
MARINE STUDIES OF SAN PEDRO BAY, CALIFORNIA PART 23

The Marine Environment of Marina del Rey

July 1995 - June 1996



A Report to the Department of Beaches and Harbors
County of Los Angeles

by

Dorothy F. Soule, Mikihiko Oguri and Richard E. Pieper

Harbors Environmental Projects
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EXECUTIVE SUMMARY

Contract Performance

This report to the County of Los Angeles Department of Beaches and Harbors details the results of the monitoring program in Marina del Rey conducted by the Harbors Environmental Projects (HEP) of the University of Southern California. **The period covered in the present report emphasizes the field surveys and data collected from July 1995 through June 1996.** The report discusses the data from this contract period and compares it with the extensive data base derived from previous studies of the marina. Previous studies conducted in the marina by HEP include data taken from 1976-1979 in cooperation with the federally funded USC Sea Grant Program and from 1984 to June 1996 from Los Angeles County contracts.

1995-1996 Results

Physical Water Quality (Chapter II) data continued to emphasize the semi-enclosed, estuarine nature of the marina. Waters nearest the entrance were influenced by oceanic waters from Santa Monica Bay, while waters in the inner basins showed minimal mixing, long residence time, and land-derived influences. Water near the entrance were generally cooler, had higher dissolved oxygen concentrations, were bluer in color (less phytoplankton and particulates), had greater light penetration, and showed lower ammonia-nitrogen concentrations. Conversely, the waters of the inner basins were warmer in temperature, had lower dissolved oxygen concentrations, were greener in color (more phytoplankton), had lower water transparency, and higher ammonia-nitrogen concentrations. **Ammonia-nitrogen concentrations were always above 2 ug-at/l and averaged 6.2 ug-at/l over this sampling year. These data emphasize the eutrophic nature of this estuarine system.**

The major perturbations and impacts to the marina continue to be from rainfall runoff from the flood control system. Runoff from the Ballona Creek channel drains water from much of metropolitan Los Angeles, carries the largest volume of water, and most of it flows directly into Santa Monica Bay. Only a portion of this water enters the marina, however, and its impacts appear to be usually limited to the entrance channel. **Although of lower volume, runoff north of the marina from the area around Washington Boulevard and Washington Street enters Marina del Rey at Basin E, at the innermost location in the marina. Most of this water flows and is pumped into Oxford Street Flood Control Basin before entering Basin E. The waters of Oxford Street Basin also impact the marina, particularly Basin E, during dry weather periods.**

The total rainfall recorded in the foothills of 21 inches during the 1995-1996 season was about half of that recorded for the 1994-1995 season. Monthly sampling was after major rains in December 1995, February 1996 and March 1996. The major impacts were observed from the December and February runoff. Ammonia-nitrogen from the runoff was maximal in Oxford Street Basin with values of 13.2 ug-at/l in December and 12.5 ug-at/l in February. Similarly, pH values were the lowest in the basin for these two months with recorded pH values of 7.2 in both months. **Runoff after the March storm was more towards the average, emphasizing the importance of the earlier rainfalls for washing accumulated terrestrial wastes from the land into the sea.**

Dissolved oxygen (DO) levels were slightly better this sampling year. There were only eighteen instances where DO levels were below 5.0 ppm for the 1995-1996 season as compared to 78 instances of DO below 5.0 ppm for the 1994-1995 season. **All cases of DO below 5.0 ppm for 1995-1996 were either in Oxford Street Basin or in Basin E.** The lowest DO's were in July and November 1995 where values were 1.0 ppm and 1.9 ppm, and both minima were in Oxford Street Basin. Low DO values were also seen throughout the water column in November in Basin E. Lowered pH values were also observed throughout much of the marina in November.

Physical water quality in Basin D which has the swimming beach showed no abnormal physical values in 1995-1996 with all measurements consistent with the marina as a whole. Physical water quality measurements in Basin F were often similar to those in Basin E, yet with no obvious large terrestrial input as in Basin E. There may be additional nutrient input into this basin from local runoff.

Sediment Grain Size (Chapter III) was sampled on October 26, 1995, before the winter rainy season began, yet after a record rainfall in for the 1994-1995 season. In low rainfall years and during low flow summer periods, fine sediments accumulate at the mouth of Ballona Creek and in the basins and decrease according to the increase in flushing during high rainfall winter seasons. As is usual after a wet year, in 1995 there was a decrease in the finest sediments and an increase in the coarser fractions in the Ballona Creek impact areas (Stations 12 and 1).

The finest grained sediments carry the most contaminants complexed or adsorbed on their surfaces due to their high surface to volume ratio. In addition, storm drains dumping into the marina carry terrestrial sediment and contamination in the runoff water. In low energy periods, tidal circulation alone will redistribute sediments throughout the marina, causing them to settle in the lowest energy environments. These include shallow sites with low mixing, areas where channels widen out reducing velocities, or sites where there is slack wat due to converging currents or eddies. The marina as a whole is a low energy environment and areas have a high percentage of fine sediments. Those areas with the lowest mixing, wit percentage of finest sediments consistently over 80 percent, include the area near the fishin (Station 25), the center of the main channel (Station 5), the end of the main channel (Stat and the end of Basin F (Station 9).

Sediments accumulate at the end of Ballona Creek, behind the br and north of the breakwater as a result of natural currents and sand and oceanic storms cause the deposition of new sand in the entranc sandbars act as a cork in a bottle, decreasing flushing and resulting contaminated sediments settling out in the marina so that dredging is nec both physical and ecological grounds.

Sediment Contamination (Chapter IV) continues to be a proble marina. Stations were ranked for levels of metallic contaminants and nonmetallic con (e.g., immediate oxygen demand (IOD), chemical oxygen demand (COD), oil and grease, organic nitrogen and phosphorus). **Station 25, at the administration docks, was the station highest ranked for contamination in the marina in 1995.** In individual metals it ranked highest only in silver, but it had highest scores in chemical oxygen demand and organic nitrogen, and was high in other contaminants. **Stations 9 (Basin F), 10 (Basin E), and 11 (end of the main channel) were consistently among the most contaminated, with Station 10 appearing in the highest category in all of the past surveys. These stations are the most interior in the marina where mixing with oceanic waters is minimal.** Station 10 in Basin E also receives input from Oxford Basin and directly from a Washington Street storm collector system. Station 9 ranked highest of all stations in chromium, copper, iron, potassium and organic nitrogen, and second highest in manganese, mercury and nickel. Station 10 was the highest in arsenic, cadmium, zinc, IOD, and phosphorus, and second highest in lead, mercury and organic nitrogen. Station 11 was highest in manganese, mercury, nickel and oil and grease, and second highest in arsenic, chromium, copper, potassium, IOD and COD.

Station 8 in Basin D is of concern because of its swimming beach (Mother's Beach). It was ranked in the medium high category in 1995. Station 8 was the third highest in copper, iron and nickel, and fourth highest in manganese, mercury, potassium, tributyl tin and organic nitrogen, concomitant with the large increase in the finest sediments in 1995. **Station 1, at the terminus of Ballona Creek with the most oceanic mixing, was the cleanest in 1995.**

Mean values of tributyl tin (TBT), highly toxic in the parts per trillion range, declined since measurements in the marina began, but the maxima seem to be rising since April 1994. **While Station 6 (Basin B) is generally the cleanest of the basins, in 1995 it ranked highest by an order of magnitude in tributyl tin, indicating new and extensive usage in the area.** All of the TBT values are highly toxic.

The pesticides Chlordane and the p.p' forms of DDT, including degradation products p.p'DDD and p.p'DDE, continue to occur in the marina in concentrations

sufficient to inhibit reproduction and growth of some species of fish and invertebrates. Although there has been a general decline in maximum total pesticides and chlorinated hydrocarbons (Arclors) since 1989, their levels still provide the potential for ecological harm. **Recent evidence has shown that many of these pesticides and chlorinated hydrocarbons act as "endocrine disrupters". These simulated estrogens include numerous pesticides, industrial chemicals (PCBs, dioxins), pharmaceuticals and plasticizers. The chemicals mimic or block natural hormones which result in males having female parts or female behavior so that they cannot reproduce. In addition, the combination of two of these chemicals acting together are up to one thousand times more powerful than either individual chemical acting alone.**

Chlordane has been banned for most uses but is obviously still reaching marina waters. Ballona Creek seems to be the collection point for Chlordane (Station 12 ranked first in 1995), with the second highest Chlordane in 1995 at Station 2. All of the survey stations exceeded the ER-L and ER-M for Chlordane, except where it was below the limits of detection in the inner marina basins and at the end of the main channel.

Maxima for total DDTs occurred in 1989 and 1992. The long term trend for the means shows a stable pattern, with a possible trend downward since 1992. In 1995, the ER-L for p.p'DDT was exceeded at Stations 2, 4, 5, 12, 13 and 22, and the ER-M was exceeded at Stations 4, 5, 13 and 22. For p.p'DDD, the ER-L was exceeded at all stations, except Stations 6 and 9 where DDD was below the detection limits. Only Stations 8 and 12 exceeded the ER-M. All stations except Stations 9 and 13 exceeded the ER-L for p.p'DDE, and all but Stations 1, 8, 9, 23 and 22 exceeded the ER-M. **Considering the DDTs as a whole, all stations exceeded the ER-L except for Stations 6, 9 and 13.**

Aroclors (PCBs) first appeared in marina surveys in the 1970s, declined, then reappeared in substantial amounts in 1989 and 1990. In 1994, Aroclor 1254 was found at all stations except Stations 3, 6, 8, 11 and 22. **Aroclor 1254 was found only at Station 12 in Ballona Creek in 1995.**

A pilot study was conducted to investigate **Terrestrial Contamination In or Near Oxford Basin (Chapter V)** before and after the winter rains. On November 15, 1995, soil and water samples were taken at 12 sites near the Oxford Street flood control Basin and Basin E of the marina. Soil samples were taken above the highest high tide line when near water and from the terrestrial areas of the watershed around Oxford Basin. On December 13, 1995, immediately after the first rain of the season, water was sampled at 5 of these sites where water was flowing. Samples were analyzed for trace metals, pesticides, PAHs and PCBs.

Soils at most stations sampled around Oxford Basin were heavily contaminated by the heavy metals lead and zinc at levels far in excess of the Effects Range-Low (ER-L) and in some cases far exceeded the Effects Range-Medium (ER-M), established for toxicity in marine sediments. Fewer sites were contaminated by copper, mercury or nickel. Comparisons with prior marina data indicates that **terrestrial concentrations of lead, zinc, cadmium, and barium are likely sources for contamination in the marina.** Conversely, concentrations of copper, mercury and boron were lower in the terrestrial soils than marina sediments. Immediately after the 0.5" of rain in December, all of the water sampled had levels of copper, iron, lead, and zinc in excess of the SWRCB Daily Limits for effluent discharge. Tributyl tin was found in one sample of water flowing into Oxford Basin and must have come from terrestrial origin.

The Chlorinated Hydrocarbons, Chlordane, p.p'DDT, p.p'DDD and p.p'DDE, appeared in the soil at almost all of the sites during dry weather, at levels exceeding the ER-L and, in some cases, exceeding the ER-M. The mean concentrations of Chlordane in the soils was almost four times higher than for marina sediments, indicating widespread terrestrial contamination. The p.p'DDT concentrations exceeded the ER-M at most sites and represents relatively new contamination, as yet undegraded. The degradation product p.p'DDD occurred at scattered stations and, when present, exceeded the ER-L. The degradation product p.p'DDE occurred at all stations; all concentrations were above the ER-L and concentrations at five stations were above the ER-M. **Widespread terrestrial contamination**

of these pesticides were at levels capable of inhibiting marine life in both the marina and the surrounding runoff areas. Dieldrin was only found at one terrestrial site, and pesticides were not detected in any water sample. No PCB's were detected in soils or water.

Polynuclear Aromatic Hydrocarbons (PAHs) were measured for the first time. Levels were high in the soil (dry weather) at two sites sampled. **Soil from station F, above the entry to Oxford Basin to the east, was contaminated with 22 times the ER-L of naphthalene and almost 10 times the ER-L of phenanthrene.** Levels of fluoranthene and pyrene were also above the ER-L. **The most contaminated site, surprisingly, was from soil collected from a flower bed adjacent to the parking lot at the western end of Basin E (station M).** Naphthalene measured over 18 times the ER-L and 3 times the ER-M, phenanthrene was 12 times the ER-L and twice the ER-M, while fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(a)fluoranthene, benzo(k)fluoranthene, and benzo(a)pyrene all exceeded the ER-L. **If the source of this contamination was from the parking lot, the possibility exists that the larger parking lots in the marina area are a major source of contaminant PAHs.** Small amount of PAHs, below the ER-L, were detected in other sites in dry weather soils. No PAHs were detected in water after the rainfall.

Microbiology (Chapter VI) discusses both bacterial contamination and Biological Oxygen Demand. As has been the case in prior surveys, **the incidence of coliform and enterococcus bacterial contamination in violation of public health standards is primarily associated with rainfall runoff, and as such occurs in the storm water channels of Ballona Creek and Oxford Basin, or in the marina in Basin E connected to Oxford Basin by the tide gate.**

The substantial increase in enterococcus contamination may be associated with the amount of rainfall in the storm season or the intensity of a storm period. The extreme rains (23.9 inches) in January 1995 may have flushed away localized contamination, whereas the less severe rains of 1995-1996 caused material to be flushed into the local area but not flushed out to sea.

The question of sources of coliform and enterococcus contamination at Mother's Beach in Basin D continues to confound efforts to assure the public that the beach area is safe for body contact recreation. Violations were few in the dry season, but ideally there should be none, especially for enterococcus. Coliform contamination may be due to the many birds that rest or feed, particularly between the lifeguard tower and the boat dock. Monofilament line deployed between poles seems to be more effective in deterring seagulls than thicker, more visible lines, which can be easily seen by the birds and do not then intimidate them.

Some of the contamination may be due to the many dogs and cats, and sometimes vagrants, that frequent the area. [Following the HEP contract period, DHS found fecal coliform violations at the beach in three of five weeks in July, one in August and twice in September, but only one station had an enterococcus violation in September, suggesting that most of the contamination may not have been of human origin. The jet ski launch ramp had high coliforms once in August.]

We do not subscribe to the arbitrary grading system given by some environmental action groups to characterize various beaches because we have been unable to determine what criteria are used in 'failing' a given beach. Certainly a beach in a low energy marine area such as Mother's Beach would flush more slowly than an open coastal beach; the tradeoff, however, is that open coastal beaches have far rougher waters that are potentially dangerous to small children. **Beach closures by DHS should be strictly observed, and even in the absence of beach posting, water should be avoided for at least 72 hours after a rainfall or when drainage into the area can be observed.**

The five day **Biochemical Oxygen Demand (BOD)** data indicate the amount of organic debris or waste by determining the amount of dissolved oxygen utilized in microbiological degradation of those chemicals. **Levels in the marina proper are generally low, less than 1.0 mg/l, except during and after seasonal rainstorms. This indicates that oxygen reduction or stress due to organic load is not normally a problem in the marina, as it might be if vessel wastes were commonly dumped.** Dissolved oxygen could be depleted during rainfall episodes when BOD_5 levels are high. **Ballona Creek and Oxford Basin provide almost all of the maximum BOD_5 values, and although the volume of Oxford Basin flow does not compare with that of Ballona Creek, the high BODs indicate impacts on the marina, at least in Basin E.**

The quantity of BOD in Ballona Creek is probably trivial as far as impacts on the receiving waters of Santa Monica Bay are concerned and would quickly be assimilated as necessary nutrients in the ecosystem. Toxic organic materials are not measured as BOD_5, however, because they would inhibit or destroy the normal microbials that would potentially digest the organic matter.

Benthic Faunal (Chapter VII) numbers and species composition present seem to be most influenced by the physical conditions in the marina associated with high or low rainfall runoff, accumulations of very fine sediments due to decreased circulation, and flushing and disturbances such as storm waves with associated sand deposition. The absence of species that might be expected may well be due to toxic levels of some trace metals and pesticides or chlorinated hydrocarbons.

Altogether, 157 benthic species occurred in the marina in 1995, as compared to 162 species in 1994. In both years most of the species occurred in small numbers at one or a few stations. The most common polychaetes, such as *Mediomastus* spp. and *Pseudpolydora paucibranchiata*, occur at all, or almost all, stations in large numbers, while species like *Aphelochaeta* sp. (formerly identified as *Tharyx parvus* locally) and *Leitoscoloplos pugettensis* occur at almost all stations but in fewer numbers. Such species seem to be able to cope with a variety of sediment grain sizes, chemical contamination, varying salinities and manmade or natural disturbances, perhaps due in part to rapid reproduction. Other species are delicately balanced in regard to one or more of these factors and may appear in limited numbers or may appear in limited distribution patterns. The nematodes and oligochaetes are examples of those that appear in very large numbers but distribution is limited to a few stations.

The generally very fine sediments may select against crustaceans other than a few species of gammarids, caprellids and mysids, and against some large molluscan species. Depth in the marina is associated with the amount of water circulation in the marina, with the shallowest waters being located in the areas of poor circulation or flushing. These areas also generally show the siltiest sediments that have the greatest capability for complexing with trace metals.

Levels of many trace metals, nonmetallic contaminants, pesticides and sometimes chlorinated hydrocarbons exceed threshold toxicities (Chapter IV) in organisms typical of the benthic community, but it is not known how many of these chemicals are actually bioavailable when complexed to sediments. This is an area of information being pursued at laboratories around the country and in Europe, but the task is exceedingly difficult just from sheer numbers of species and chemicals involved. Many of the benthic species are still undescribed (unidentifiable) in the scientific literature, let alone having been tested for toxicity levels of single compounds or complexes of compounds. Species that have been considered "typical", or indicators, may in fact not be.

There are natural fluctuations in populations, regardless of manmade impacts. The system appears to be relatively stable and resilient, within the range of fluctuations. **It is clear from the information gathered, however, that study of the benthic fauna in the marina points out the areas of severe stress, in particular in 1995, the drastic decline at Station 8, near Mother's Beach in Basin D.**

Benthic studies, coupled with sediment and other investigations, also demonstrated the "cork in the bottle" effect of the sandbars in the entrance channel and the mouth of Ballona Creek. The effects of heavy and light seasonal rainfall runoff are not as consistent, possibly because each station may be affected differently. Decreases in the species diversity index, however, coincided with areas receiving possibly contaminated runoff or physically disruptive impacts. Such sites include Stations 12 and 1 in Ballona Creek, Station 3 which receives the Ballona Lagoon-Venice Canal flow, Stations 7 and 8 in the inner basins, and Station 5 in the center of the main channel.

Dredging apparently had beneficial effects, as seen at Stations 2 in the entrance channel and Station 10 in Basin E.

Fish Fauna (Chapter VIII) were sampled in the fall and spring of this reporting period. **The fall 1995 survey showed the lowest number of species in comparison to fall surveys over the previous twelve years.** There is also some indication that there has been a gradual decline in numbers of species during the fall surveys over these years. The low values in 1995, however, may have resulted from the disappearance of rocky habitat near the entrance which had been covered by sediment. Subsequent dredging in March and April 1996 transported 230,000 cy of sand and sediment from the entrance area to the southern beach. In contrast to the fall surveys, **the spring survey in May 1996 indicated an increase in numbers species from 1995 results, which was the highest since 1991.** The sediment removal and uncovering of rocky habitat may have led to the increase in fish species. The sand removal may have also led to increased circulation of oceanic water into the marina which benefited the fishes.

The marina continues to provide significant habitats for nearshore and wetland species of fishes. Rocky reef and estuarine fishes are persistent inhabitants and many epipelagic schooling fishes swim in and out of the marina. The eutrophic nature of this semi-enclosed estuary provides for important habitats for shelter and feeding, as well as being an important nursery ground. While some species live entirely within the marina, others enter to shed their eggs, and yet others shed eggs outside and the eggs are carried into the marina by the tides. The eggs hatch, feed and develop in the productive waters and are hidden from predators by the low water visibility.

The fishes are vulnerable to natural climate variability and manmade impacts. The reported warming trend over the last decade and the existence of ENSO events tend to result in lower productivity and more warmer-water species. The presence of the round stingray, *Urolophus halleri*, is an indication that 1995-1996 was again a warm water period. Some manmade impacts can be controlled, but others cannot. The terrestrial sediments around the marina are in some cases quite contaminated and could influence the fish populations.

The seagrass beds of *Ruppia maritima*, the last remains of the earlier wetlands of the natural Ballona Creek estuary, have regrown in Basin D (Chapter IX). These seagrass beds were mapped from 1979 to 1981, and again in 1990. They were absent from Basin D in 1991. The present beds of *R. maritima* were mapped in the spring of 1996. They were approximately the same in location and shape, but were not as large and blade length was shorter than in the previous studies.

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I. INTRODUCTION

SCOPE AND PERIOD OF PERFORMANCE

The present report covers the period of field and laboratory efforts from 1 July 1995 through 30 June 1996, supported by the County of Los Angeles, Department of Beaches and Harbors. The first months of the period were dry summer and fall following a year of low rainfall, conditions in effect when the benthic sediment and faunal surveys were conducted on 26 October 1995. The remaining monthly water quality surveys were conducted during winter and spring rains, storm swells, and sand deposition. Major dredging at the entrance occurred during March and April 1996 when 230,000 cy were removed and deposited for beach replenishment. The fall fish surveys were performed in November 1995 and the spring fish surveys were conducted in May 1996, after the dredging was completed.

HISTORY OF THE PROJECT

Harbors Environmental Projects of the University of Southern California (HEP, USC) initiated baseline studies in Marina del Rey, the largest manmade marina in the world, in 1976, with partial funding from the Federal Sea Grant Program and the County. Survey techniques were examined and stations established for ecological evaluation of the marina. There was a hiatus until 1984, when surveys were resumed. Although there have been some lapses in periods covered due to funding constraints, the survey constitutes a unique, long term record of the ecology of the area (Soule and Oguri, 1977, 1980, 1985, 1986, 1987, 1988, 1990, 1994; Soule, Oguri and Jones, 1991, 1992a, 1992b, 1993; Soule, Oguri and Pieper, 1996).

HISTORY OF THE SITE

Marina del Rey was developed in the early 1960s on degraded wetlands that formed part of the estuary of Ballona Creek. Wetlands once extended through the communities of La Ballona, Port Ballona and what is now Venice on the north, to the Baldwin Hills and the San Diego Freeway on the east and to the Westchester bluffs on the south. Present street drainage extends east to the USC area at Exposition Park, based on early drainage patterns. In earlier years, Ballona

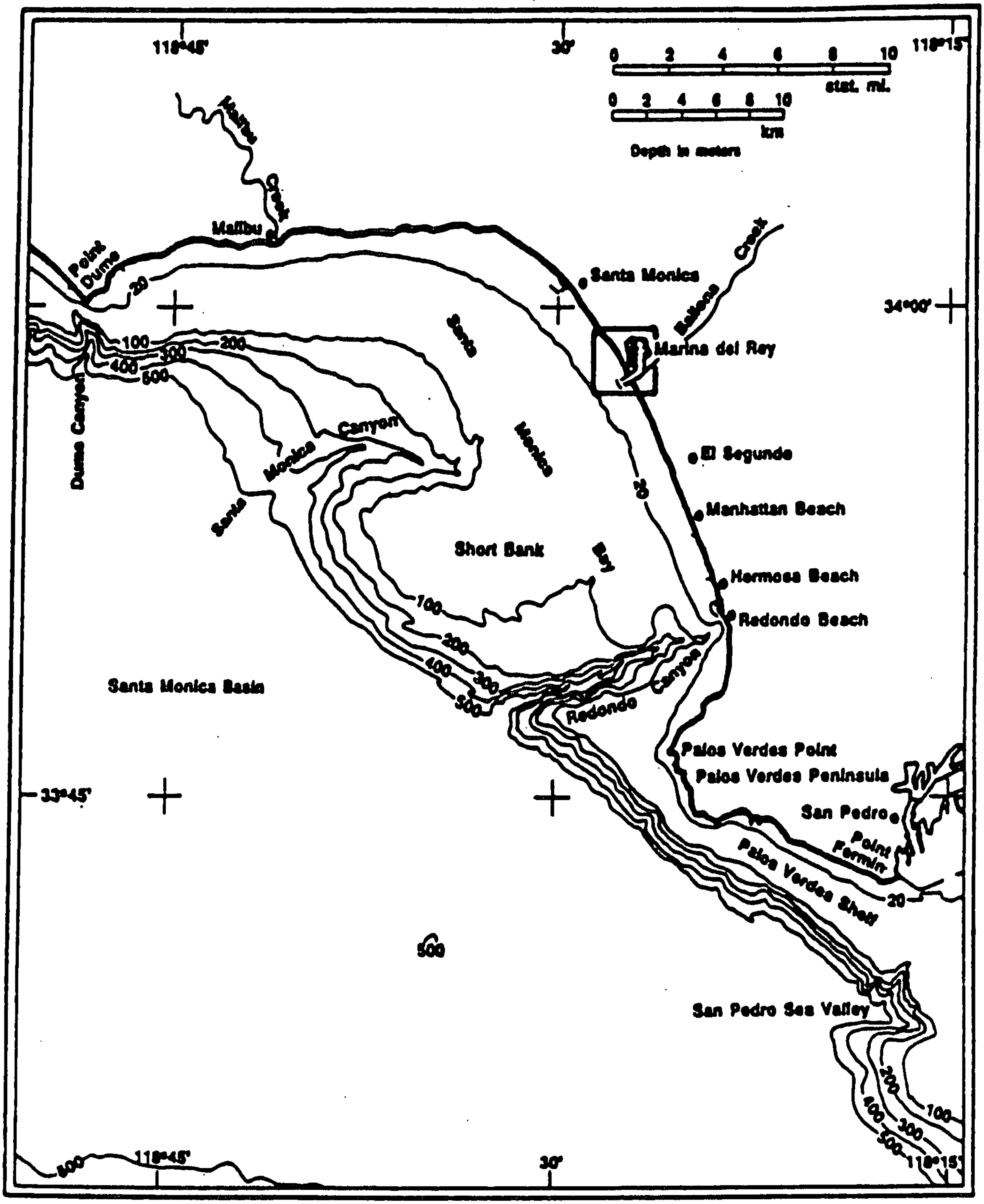


Figure I.1. Location of Marina del Rey within Santa Monica Bay.

Wetlands joined wetlands leading to the Los Angeles River, to the north and east of the Baldwin Hills and Palos Verdes Peninsula. At one time creation of a navigable channel from Ballona Creek to Dominguez Channel and the Los Angeles River was considered. The San Pedro area and the little port of Ballona were competing sites for development of the large port, with railroad magnates engaging in political battles for control. Ultimately San Pedro was selected because it was more sheltered from southwest swells during storms. The history has been reviewed in our previous reports, based in part on Bancroft (1884) and Beecher (1915).

Until Ballona Creek was channelized in the 1920s, a number of streams meandered through the wetlands, forming a large pond that drained into what are now Ballona Lagoon and Del Rey Lagoon, behind a barrier beach. The estuary opened into Santa Monica Bay, cutting the submerged Santa Monica Canyon at the margin of the alluvial shelf of the bay (Figure I.1). In the mud flats, birds, molluscans and crustaceans abounded, along with mosquitoes and midges in the standing freshwater pools.

Urbanization overtook the wetlands, with development of oil and gas fields, truck farms and industrial sites, which resulted in piecemeal dumping and filling. These activities deprived the wetlands of the normal cycles of renewal, including sedimentation and nutrient flow during heavy winter storms. Natural flooding was controlled by channelizing for the benefit of development to control urban flooding. During World War II, industrial activity increased extensively, with no controls on fills or dumping of toxic materials, causing contamination problems today when sites are re-graded or excavated for new construction.

Postwar residential development expanded urbanization to the margins of the reduced wetlands (Figure I.2). Wartime experience with boats was new to many people and fostered developments in recreational boating, while postwar affluence increased pressure to create marinas to accommodate that interest. The Corps of Engineers designed several configurations and created a physical model for the marina at their laboratory in Vicksburg, Mississippi to test them. Construction began in 1960 with building concrete walls on dry land and then excavating the basins and channels.

Figure I.2. Study Site, Marina del Rey, California.

(base map courtesy of Automobile Club of Southern California)

The present configuration was believed to be adequate to protect boats without a breakwater, but this was disproved not long after the marina opened, when southwest swells from a winter storm damaged docks and vessels. Thus the present breakwater was added several years later. This protected vessels but also reduced flushing, which in turn reduced ecological conditions within the marina but added a rocky reef structure as a habitat.

LONG TERM RESULTS OF STUDIES

Soule et al. (1993), reviewed the reasons for undertaking baseline studies in the marina, based on inquiries from the County about the productivity of the waters. Results of monitoring and research studies in Marina del Rey from 1976-1979 and 1984-1992 were discussed. Some of the findings are summarized below.

The effects of natural events such as droughts and flooding have an overriding impact on the marina ecology. El Nino episodes characterized by incursion of warmer water from the tropics, and usually linked to increased rainfall, strongly affect the occurrence of fish species and numbers.

Sediment distribution is affected by low energy flow in the dry season and low rainfall years, by the intensity and frequency of storms in wet years, and by the extent of sand barriers at the entrance. Fine sediments accumulate in basins and channels under low flow conditions. Dry weather flow and low rainfall runoff conditions may move sediments to the main channel and entrance channel where they accumulate, while heavy runoff will move them seaward. If sandbars are present at the entrance, contaminated fine sediments may accumulate behind them.

Copper, lead, mercury, nickel and zinc are present in levels sufficient to inhibit reproductive stages of sensitive species. Lead particularly seems to be associated with runoff. Distribution patterns of chromium, nickel, manganese and iron are associated with, or complexed to, the finest grained sediments and follow their distribution patterns.

Pesticides occur in concentrations that are inhibitory to some organisms, especially reproductive stages. The levels of pesticides have been declining, however.

Polychlorinated biphenyls (PCBs) have appeared episodically at toxic levels. Some terrestrial soils in areas to the north of the marina are known to contain high levels of PCBs that can enter drainage channels during grading or excavation.

Nutrients are primarily of terrestrial origin and are largely uncoupled from those in Santa Monica Bay. Nutrients are inversely related to salinity, indicating their freshwater origin.

When excessive coliform and enterococcus bacterial contamination is found throughout the marina it is largely due to runoff, as evidenced by the high levels that occur at Ballona Creek and Oxford Basin immediately after storms in the winter. However, prolonged rainfall periods tend to reduce bacterial counts. Lower levels were usually found during the summer, when marina usage is at its highest but runoff the lowest. High coliform counts at Mother's Beach in Basin D in past years were largely due to birds resting on the sands; this was controlled by stringing monofilament or polypropylene lines across flight patterns. High counts in the water at the docks where the Life Guard, Sheriff's Patrol and Coast Guard vessels tie up are probably due to seagulls and pelicans resting, and to the practice of hosing bird guano off the docks each morning, before samples were taken.

Benthic organisms are disrupted physically by natural events such as flooding, or manmade events such as dredging or pollution. Opportunistic species, particularly nematodes, which tolerate lower salinities and reproduce more rapidly with very large numbers, often recolonize disturbed areas. They are, in turn, replaced by more normal fauna through succession if conditions stabilize. The soft, unconsolidated sediments and sometimes inhibitory levels of contamination favor populations of tolerant polychaete worms. They provide an important food for bottom feeding fish, but tend to select against molluscan and macrocrustacean species. Microcrustaceans are less nutritious by weight than polychaetes because of their indigestible exoskeletons.

About 90 species or larval taxa of fishes have been reported in the marina, more than for any other wetlands in the area. The fish species represent the remains of the wetlands fauna that has been largely shut off from the wetlands south of Ballona Creek. The rocky breakwater and jetties are important to species that would otherwise not find a habitat in the marina.

The seagrass beds in sandy Basin D are very important to development of larval and juvenile fish, which also provide forage for larger fish.

Oxford Basin drainage is a significant source of pollutants in spite of the relatively low volume of runoff into the basin, as evidenced by the relatively high levels of coliforms, organic nitrogen and lead, for example.

Ballona Creek is a significant source of contaminants, as indicated by levels of coliforms, volatile solids, chemical oxygen demand, oil and grease, sulfide, organic nitrogen, lead and silver. Levels of non-metals have been reduced, some by orders of magnitude, during the period of the surveys. Its flow pattern is often marked by floating trash flushed from storm drains that accumulates at the breakwater and south jetty after rains. Debris such as grass clippings and plastic food containers may move up into the main channel on the tides.

The screen in Ballona Creek is not very effective at catching debris; it becomes filled and overflows, and is not deployed during rainstorms. A small boat with a hand held skimmer could easily remove floating trash such as grocery sacks, soccer balls and fast food containers that accumulate along the breakwater and jetties but this is apparently not being done.

Adding slips and vessels acts to damp the limited circulation. As slips were added it become more critical to guard against pollution to preserve esthetic and marine environmental quality. Addition of vessels at the inner end of the main channel strongly affected the area. The present configuration of slips is illustrated in Figure I.3.

Monthly survey data do not indicate a serious or widespread problem with sewage release from vessels. However, the increase in the number of persons living aboard vessels that are not equipped with adequate holding tanks or capable of going to sea increases the possibility of contamination of persons exposed to waters in the marina while doing routine maintenance.

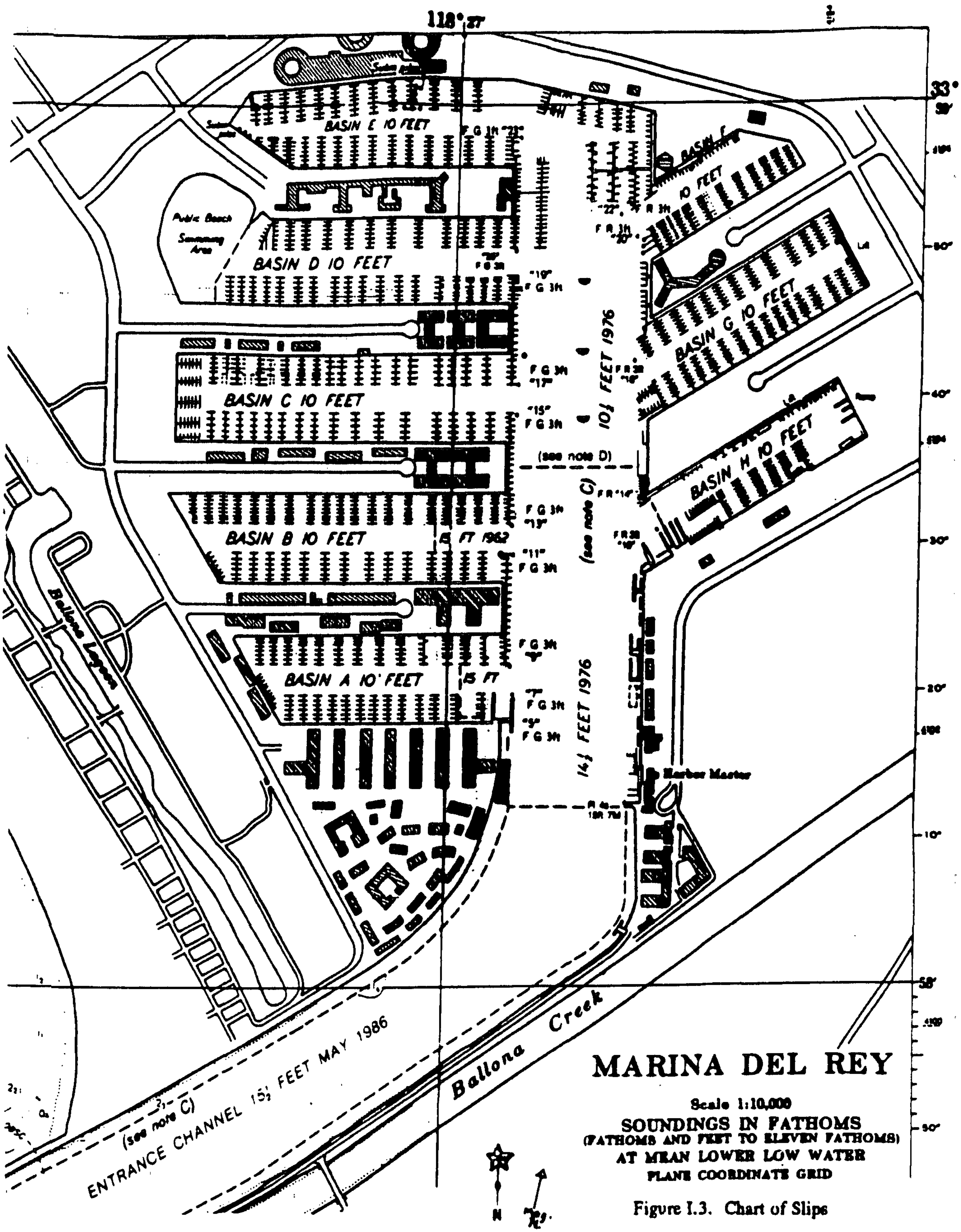


Figure I.3. Chart of Slips

STATION LOCATIONS AND DESCRIPTIONS

Figure I.4 illustrates the survey stations for the marina, Ballona Creek and Oxford Basin. Stations were numbered 1 to 13 for the original studies. A number of others were added for special studies, but not all of those were retained for routine monitoring, resulting in numbers out of sequence with the original stations.

Stations 1-13: designated in 1976

MDR-1. Located midway between the breakwater and the southern jetty at the mouth of Ballona Creek Flood Control Channel. The area is subjected to discharges from the creek, to severe impacts from storm water flow and deposition or erosion from storm wave action. Depth irregular, 2-6 meters.

MDR-2. At the entrance to the marina, midway between the two marina jetties. The area is protected from most storm waves and swells. Influenced by tidal action, winds, and weak longshore currents. Sediment and debris is carried tidally into the marina from the creek, and sand from the northern beach blows into the channel, covering jetty rocks, creating sandbars which reduce navigable areas. The areas nearby were dredged in February 1987, a "knockdown" was attempted in October 1992; dredging also was done in October-November 1994. Depth 4-6 meters.

MDR-3. On the northwest side of the entrance channel, in front of the tide gate to Ballona Lagoon and the Venice Canal system. Protected from all but severe storm waves, but subjected to sediment and contaminated drainage from the lagoon. In the 1970s, mussel mounds were present which have since disappeared, replaced by fine sediment and sand.

MDR-4. Seaward of the Administration docks, where there is heavy vessel use; sometimes a depositional area, at the junction of the entrance channel with the main channel. Depth 3-6 meters.

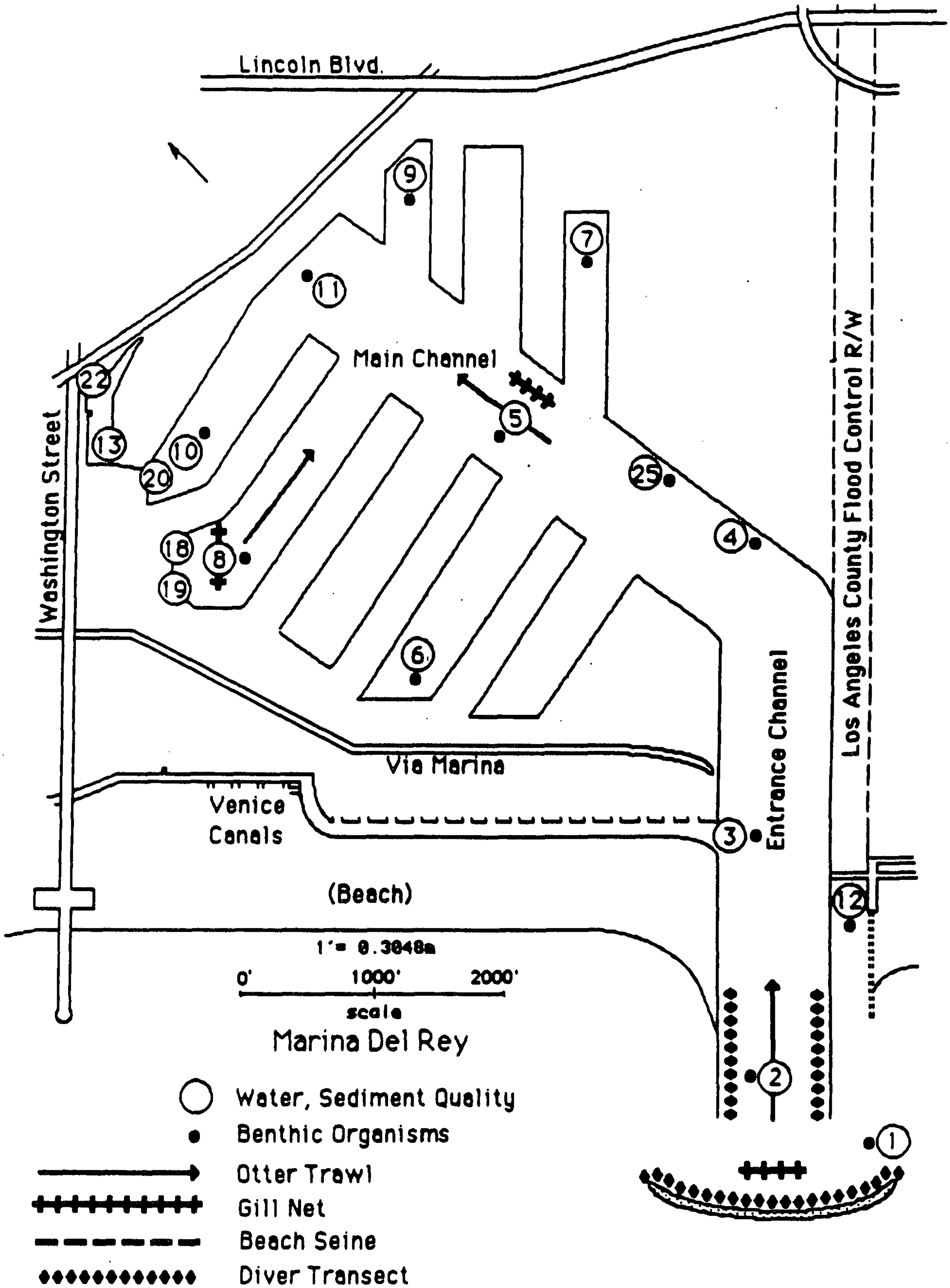


Figure I.4. Survey Stations for Marina del Rey

MDR-5. In the center of the main channel opposite Burton Chace Park. Sediment accumulates there when flushed from the basins. Marks the end of the area originally dredged to greater depth in the outer marina. Depth 4-5 meters.

MDR-6. At the innermost end of Basin B, protected from westerly winds by seawall, circulation reduced, pollution levels usually medium low to moderate. Depth 3-4 meters.

MDR-7. At the end of Basin H near the work yard dock. Exposed to westerly winds. Depth 2-3 meters.

MDR-8. Off the swimming beach (Mother's Beach) in Basin D near first slips outside floats. Depth 3-4 meters.

MDR-9. At the innermost end of Basin F, circulation low. Depth 2-3 meters.

MDR-10. Innermost end of Basin E; subjected to flow from Oxford Flood Control Basin and major street drainage. Deposition of highly contaminated sediments beneath docks, which broke up due to accretion. In 1995, docks removed and sediment taken with clamshell for land disposal in 1995, dragged to level, larger slips constructed. Depth 4 meters.

MDR-11. At end of main channel, subjected to storm drain flow and influx from Station 10. Impacted by reduced circulation, pollution increase, when slips were built for large boats. Depth 2-3 meters.

MDR-12. In Ballona Creek at the Pacific Avenue footbridge. Subject to tidal flushing, freshwater discharge year round and heavy rainfall runoff from storm drains. Also subjected to illegal dumping of trash upstream, and formerly to sewage overflows. Depth 1-4 meters.

MDR-13. Inside tidegate in Oxford Basin, subjected to reduced tidal flushing, stormwater runoff, street drainage. Surface only sampled, inaccessible at times through locked gate.

<u>Stations 18-22: added in Fall 1988 for water quality and bacteriology.</u>

MDR-18. Twenty meters off wheelchair ramp in Basin D at perimeter of swimming rope. Depth 1-2 meters.

MDR-19. At end of wheel chair ramp; accessible only from shore on foot.

MDR-20. At innermost end of Basin E where Oxford Basin flows through tidegate into marina. Flow obstructed by large vessels there. Depth 2-3 meters.

MDR-22. Inner Oxford Basin at bend where Washington Blvd. culvert empties into basin. Accessible only on foot; at very low tides only a mudflat.

<u>Station 25: added in Fall 1989 for water quality, bacteriology and benthic sampling.</u>

MDR-25. Between the Administration docks and the public fishing docks. The area is subjected to intensive vessel use by Life Guards, Sheriff's patrol and Coast Guard. Popular bird roost as well. Fishing docks attract birds to fishermen's catch, offal; dogs on docks. Depth 3-6 m. Storm surge heavily damaged administration docks in 1983; they were rebuilt in 1985.

II. PHYSICAL WATER QUALITY

INTRODUCTION

Marina del Rey is a coastal estuary, linked to the open ocean through tidal exchange at the entrance of the marina, where freshwater input occurs mainly during the rainy season through the flood control system. Thus, the properties and characteristics of the waters of the marina are a function of oceanic variability, local climatic conditions including rainfall and materials carried in the runoff, and the nature of this semi-closed estuary system with its' local runoff.

Oceanic variability in the Southern California Bight controls the overall conditions for the waters of Marina del Rey. These oceanic effects are not well predicted by present day ocean science, but they can be measured. The largest scale events have over-riding control over all smaller-scale processes. Sea surface temperature is a good indicator of this variability. During cold-water periods California Current waters dominate and this water is high in nutrients. Conversely, during warm-water periods California Current flow is reduced, and the warm, nutrient-poor waters from the south dominate.

The waters off southern California appear to be in a decade long warming trend since 1977 (Smith 1995). Water temperatures briefly decreased back to normal values in 1987 and have been increasing since then. Inter-annual variability is dominated by the El Niño Southern Oscillation (ENSO) events which impact the coastal waters. The El Niño Watch (Coast Watch, NMFS, NOAA) program monitors sea surface temperatures from Baja California to Vancouver Island, Canada, and compares these data to the long-term mean in water temperatures. Coast Watch data show that 1992 and 1993 were particularly warm-water years with water temperatures one to six degrees above the long-term mean off of the Los Angeles area. The 1994-1995 season showed temperatures close to normal in November and December 1994, and temperatures above normal during the first half of 1995. The period covered in the present report, 1995-1996, showed oceanic temperatures slightly higher than the 1994-1995 period, with the highest deviations from the long-term mean averaging three degrees above normal during February through May of 1996 and temperatures one to two degrees above normal for the rest of the months. This oceanic warming trend and the interannual variability is reflected in the Marina del Rey data.

Oceanic variability which occurs at shorter temporal scales, both inside and outside of Marina del Rey, include seasonal heating (summer) and cooling (winter), seasonal rainfall, periods of high or low winds, and tidal variations. These shorter-term events are superimposed on the base line set by the long-period events. Coastal water is transported into the marina from Santa Monica Bay with the daily tidal changes. The amount of water transported is a function of tide height and, therefore, volume flow. Maximum flow and water exchange occurs during the spring tides (times of full and new moons) and minimal exchange occurs during neap tides (first and third quarters of the moon). Marina del Rey encompases a large area with numerous narrow basins. Exchange of oceanic water occurs through a long, narrow entrance channnel. Thus, mixing and exchange is greatest near the entrance and minimal at the ends of the farthest basins. Localized offshore events which could impact the waters of the marina include local phytoplankton blooms, including red tides. Depending on the direction of current flow, a sewage spill or failure in the Hyperion treatment plant could result in the transport of sewage water towards, and into, the marina.

Seasonal and aperiodic variations in climate have influences in the marina of varying strength and duration. The summer period of warm temperature, low winds and high light levels allow for both high productivity, and water stratification which reduces vertical mixing. Winter periods of low light and high winds mix the water column and usually result in lower productivity. Winter and spring rains add freshwater runoff to the marina waters. More important than the freshwater itself, these waters often carry high nutrient loads as well as possible pollutants.

The major modifications of Marina del Rey waters occurs largely through wet and dry weather flow through the Ballona Creek Flood Control Channel, the run-off into Basin E from both the Oxford Street Flood Control Basin and local flood-control pumping, plus numerous storm drains and other channels that drain into the marina basins themselves. By far the largest in volume flow and potential impact, the runoff from Ballona Creek is mixed back into the marina by both tidal action and reflection off the breakwater into the entrance. While the Ballona Creek runoff may have a major influence on the marina entrance, only a portion of the Ballona Creek water enters the marina. The effect of this runoff is easily seen after a storm, however, by observing the accumulation of trash (styrofoam cups, plastic bottles, plastic bags, tennis and basket balls, etc.) at the outer breakwater and in the outer channel itself. Conversely, the runoff that flows or is pumped into Oxford Street Basin flows directly into the marina at Basin E. Additional runoff water is pumped directly into Basin E. Runoff water from these sources go nowhere else. In addition, the point of entry of this water into basin E is at the farthest location in the marina from the entrance, with the lowest flushing rate.

The period of this report is from July 1995 through June 1996. Rainfall was about half of that reported during the 1994-1995 season. Monthly sampling occurred immediately after the first major rain of the year in December (0.8 inches of rain on December 13-14, 1995; sampling on December 14). Rain also occurred in January through March 1996, and traces of rain fell in April and May. Monthly sampling was also immediately after major rainfalls in February (2.0 inches of rain on January 31, sampling on February 1) and March (1.8 inches of rain on March 13-14, sampling on March 14). The January 4 sampling was after three weeks of dry weather.

In addition to these marina-wide events, local changes at any particular site are of major interest. Properties may change at certain sites due to localized runoff bringing nutrients or pollutants into areas of minimal mixing, dredging effects, and the existence of fishing piers or swimming beaches.

PROCEDURES

Sampling and data collection for water quality assessment was conducted monthly at the stations described in Chapter 1. The monthly dates were selected, insofar as possible, to permit access to the shallow waters of Ballona Creek at or near high tide, with succeeding stations sampled on a falling tide. Samples were collected on falling tides when feasible to obtain samples of marina water rather than sampling mostly tidally introduced water. Water quality sampling was performed from the County Life Guard *Bay Watch* vessels, whose operators have cooperated with the University research team most effectively since surveys were reinstituted in 1984.

Temperature, conductivity (later converted to salinity), dissolved oxygen (D.O.) and pH were measured at one meter intervals through the water column using a Martek Mark XVII sensing device. Light transparency was measured by beam transmittance at one meter intervals using a modified HydroProducts transmissometer with a 0.1 meter light path. Both instruments were calibrated immediately prior to each field excursion, and if any data were questionable, immediately after the instruments were returned to the laboratory. Measurements of light transparency were compared with light-penetration observations made with a Secchi disk, and water color was measured by comparing the Forel-Ule scale vials using the white Secchi disk as background.

Water samples for nutrient analysis (ammonia-nitrogen), and Biochemical Oxygen Demand (BOD) were obtained at all stations with a Naumann sampler, a PVC, self-closing sampler, at two meter intervals beginning at the surface. The sample for ammonia-nitrogen was immediately acidified in the field with concentrated hydrochloric acid and later analyzed in the laboratory with an Orion ammonia electrode. BOD samples were stored on ice and returned to the laboratory for analysis (see Chapter VI).

All figures for this section are found at the end of the chapter. The field log is presented in Appendix A. The complete water quality data tables are contained in Appendix B.

TEMPERATURE

Water temperatures in Marina del Rey for the 1995-1996 period were consistently one to two degrees higher than those in the 1994-1995 sampling year (Table II.1). Temperature ranges in 1995-1996 were generally cooler than in the 1993-1994 season. These observation closely agree with the El Niño Coast Watch data for the Southern California area for these years. This emphasizes the close link between the oceanic system and the waters of Marina del Rey relative to basic water properties (in this case seawater temperature). The Coast watch data also shows that water temperatures during February and March have been similar between 1992 and 1996, and all values have been around three degrees above the long-term mean water temperature. For the other

Table II.1 Temperature ranges (degrees C) for all depths and stations by season and year (stations 18, 19, 20, 22 added in 1988-89; station 25 added in 1989-90)

Year	Spring Mar,Apr,May	Summer Jun,Jul,Aug	Autumn Sep,Oct,Nov	Winter Dec,Jan,Feb
1976		18.0-23.3[1]	18.3-21.9	14.0-18.8
1977	15.7-20.7	17.9-22.6	17.5-21.8	14.4-16.4
1978	15.3-21.8	16.1-23.3	16.0-22.3	12.2-14.4
1979	13.7-20.2			
1984	17.7-20.2[1]	19.4-23.3[2]	16.8-25.6	
1985			18.0-21.8[2]	12.4-14.3[1]
1986			16.5-20.8[2]	14.5-16.5[1]
1987			17.2-21.4[2]	15.3-16.6[1]
1988			15.9-21.4[2]	11.2-14.3
1989	14.1-22.9	15.6-24.0	15.4-23.4	11.8-16.2
1990	14.0-20.8	17.4-25.3	14.0-23.6	11.8-16.8
1991	13.3-18.3	17.0-22.1	16.5-22.3	11.0-14.8
1992	15.9-22.7	16.8-26.0	17.0-22.8	13.5-15.8
1993	15.2-22.6	17.8-28.2	18.4-26.6[2]	13.1-15.3[2]
1994	14.8-21.2	18.0-24.6[2]	13.6-23.4	12.8-17.0
1995	15.0-20.1	17.3-23.7	17.3-24.7	13.8-17.3
1996	13.9-22.6	18.0-23.9[1]		

1 one month only
2 two months only

months the Coast Watch data indicates that the 1995-1996 season was warmer than 1994-1995, but cooler than the 1992-1993 and 1993-1994 seasons.

Plots of temperature from all months and all stations are found at the end of this chapter. After beginning at the station in Ballona Creek, data are plotted relative to the distance from the breakwater. This station order, therefore, reflects the degree of mixing of the marina water with that of the open ocean. Water in Marina del Rey near the channel entrance is similar to the oceanic water of coastal Santa Monica Bay. The marina water least mixed with oceanic water are farthest from the entrance, those of Oxford Street Basin. Figures II.1 through II.12 show the monthly data for all stations at 0-2 m and near the bottom. Averages of these data are shown in Figures II.13 through II.15.

Water temperature in Marina del Rey followed a typical seasonal trend (Table II.2, Figure II.15). Temperatures peaked in September 1995 (mean of 21.8°C). The late summer - early autumn period (September) is typically warm, has minimal winds, and little upwelling to cool the water. Temperatures then decreased to a minimum in February 1996 (mean of 14.4°C), a result of increased wind mixing and reduced solar heating. Temperatures then slowly increased through June (mean of 20.9°C). Temperature increases after February are probably due to both solar heating and the increased volume transport of warmer water from the south. The northerly flowing southern California Undercurrent often surfaces during the late winter months and joins with the countercurrent to bring Equatorial waters to the north.

The overall pattern of temperature in Marina del Rey reflects the decreased mixing from the entrance to the most interior locations. Average temperatures for the year were lowest near the entrance and slowly increased with distance from the entrance, being the highest in Oxford Street Basin (Figure II.13). This would be expected as a result of solar heating in the shallow, interior waters and decreased mixing with cool oceanic water. Warming would be increased in Oxford Street Basin which, in addition to being the farthest location in the marina, has only limited access to the marina waters through a tidegate at the inner-most part of basin E. This pattern was more evident during the spring, summer, and early autumn months (March through September). During the late autumn and winter months (October through February) water temperatures were about the same at all stations. The main deviation from this pattern was in December 1995 when the waters of Oxford Street Basin were cooler than the rest of the marina. Sampling in December was immediately after a storm and these low values resulted from the runoff and pumping of storm water from the flood control system into the basin (salinity data supports this observation).

While tidal currents and distance into the marina's interior waters determine the horizontal mixing of oceanic water into the marina, water-column density structure determines the degree of vertical mixing at any one location. Except in surface waters immediately after a rain storm when a

Table II.2 Monthly Temperature: minimum, maximum and mean (in degrees C), 1995-1996.

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
July	17.3	2 (b)	23.4	13	20.8	falling/rising
August	20.2	3 (t,m,b)	23.7	22	21.1	rising/falling
September	20.2	4 (b)	24.7	22	21.8	rising/falling
October	20.4	25 (b)	22.4	13, 22	21.3	falling
November	17.3	1 (b)	19.1	9(m),10(b), 20 (b), 22	18.6	falling
December [1]	14.1	13	17.3	10 (m,b)	16.8	falling
January	14.6	8 (t,m,b), 18 (b)	15.9	1 (m,b), 12 (b)	15.2	falling
February [1]	13.8	1 (b), 2 (b)	17.0	13	14.4	falling
March [1]	14.1	12 (t)	17.9	13	15.8	falling
April	13.9	3 (b)	21.4	22	17.4	rising/falling
May	18.9	1 (b)	22.6	22	20.2	rising/falling
June	18.0	1 (b), 2 (b)	23.9	22	20.9	rising/falling

[1] Rain in preceeding few days

t = top, m = middle, b = bottom of water column

fresh-water layer of water is at the surface, water temperature controls the density structure in the water column. The more similar the water temperatures between surface and bottom, the greater the vertical mixing. Conversely, as the difference in water temperature between surface and bottom increase, vertical mixing is reduced.

As observed last year, water temperatures were well mixed during the autumn and winter periods. Temperature differences were one degree or less between surface and bottom from

October 1995 through March 1996 (Figures II.4 through II.9). Similarly, some stratification was observed during the spring and summer months. The greatest temperature differential between surface and bottom was observed in July 1995 and April 1996 mainly in the main channel (Figures II.1 and II.10). Temperature differentials, indicating stratification, were observed in the inner basins in September 1995 and May 1996 (Figures II.3 and II.11). When stratification is the greatest vertical mixing of oxygen to the bottom of the water column may be reduced.

SALINITY

The baseline for salinity patterns will, as with temperature, be determined by the oceanic waters of Santa Monica Bay. Because it is a semi-enclosed estuary, the salinities in Marina del Rey are heavily modified by freshwater input, including both wet and dry weather runoff, from the flood control system as well as local runoff. The largest amount of flood control runoff is from Ballona Creek. While a major portion of this flow goes directly offshore, a portion may be reflected off the outer breakwater and returned to the marina with the incoming tide into the main channel. The freshwater runoff from the drainage area around Washington Boulevard and Washington Street flows into Oxford Street Basin, is pumped into Oxford Street Basin, or is pumped directly into Basin E. The runoff that goes into Oxford Street Basin flows directly into Basin E. Localized rainfall and runoff draining directly into the marina also modifies surface salinities. Conversely, evaporation in the inner basins during the summer months will raise salinities in these areas over the oceanic levels.

The oceanic salinity off of southern California varies seasonally, interannually, and over decade-length time scales. The major changes result from the relative mix of lower-salinity, modified-subarctic water carried down the coast by the California current and the higher salinity waters moving northward by the California undercurrent or California countercurrent. Seasonally, the California current is strongest during the spring and summer, bringing in low-salinity cool water. This is also the cause of the coastal fog during this period. During the winter months the southerly flow of the California current slows and the California undercurrent moves to the surface. Warmer, more saline water from the south enters the area from both the California undercurrent and countercurrent. These seasonal trends are modified by interannual variations resulting from ENSO (El Niño Southern Oscillations) events. During major warm water (El Niño) years waters are warmer and saltier than normal, influenced by both the Equatorial and Central Pacific waters masses. Conversely, during cold water years (non El Niño or La Niña), salinities are lower and closer resemble those of California current waters.

Sampling in the marina is typically conducted on falling tides to both standardize sampling and minimize the impact of incoming oceanic water. Oceanic water entering the main channel may slowly "move" existing water back towards the inner basins, may mix with marina water when flow is at higher velocities, or may move as a wedge under, in between, or on top of marina water when there is density stratification in the marina.

The overall salinity pattern is shown in Figure II.16 and is summarized in Table II.3. Minimum salinity values, not surprisingly, were always either in Ballona Creek (Station 12) or Oxford Street Basin (Stations 13 or 22). Minimum salinities were lowest at these two locations both during the rainy period (wet weather runoff) and during the dry months (dry weather flow).

The lowest salinity values reported occurred when the monthly sampling was immediately after a major rainfall. These were in December 1995, and February and March 1996 (Figures II.17 and II.18; Table II.3). Sampling on December 14 was after 0.8 inches of rain on December 13-14, sampling on February 1 was after 2.0 inches of rain on January 31, and sampling on March 14 was after 1.8 inches of rain on March 13-14. Salinity minima for these months were all from Oxford Street Basin (Figures II.19 through II.21; Table II.3). The data from December 1995 and March 1996 show that the freshwater input at the time of sampling was almost completely restricted to Ballona Creek (Stations 12 and 1) and Oxford Street Basin (Stations 13 and 22). In these months, minimal amounts of low salinity water in the rest of the marina (Figures II.19 and II.21). After the February storm, however, salinities were also lower throughout the marina (Figure II.20). Since water temperatures in February were isothermal (Figure II.8), the salinity structure in February would, at least temporarily, create density stratification which might reduce vertical mixing.

Table II.3 Monthly Salinity: minimum, maximum and mean (in parts per thousand), 1995-1996 (values converted from conductivity and temperature).

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
July	20.7	22	34.8	2(b),3(b),4(b), 5(b),7(b),8(t), 25(m,b)	34.1	falling/rising
August	33.9	22	34.5	3(b),7(t,m,b)	34.3	rising/falling
September	33.3	12 (t)	34.5	7(t,m,b),8(b), 9(b),10(b), 11(b),18(b)	34.3	rising/falling
October	31.9	12 (t)	34.8	25 (m,b)	34.5	falling
November	21.1	12 (t)	34.6	7 (t,m,b)	34.1	falling
December [1]	1.4	13, 22	34.4	2 (t)	31.6	falling
January	30.0	12 (t)	34.2	1(b),2(t,m,b), 3(b),4(t,m,b), 5(t,m,b),7(t, m,b),9(t,m,b), 25(t,m,b)	34.0	falling
February [1]	5.2	22	34.0	5 (b)	30.0	falling
March [1]	11.1	13	34.3	2 (b)	31.7	falling
April	31.3	12 (t)	34.4	5 (b)	33.9	rising/falling
May	31.8	12 (t)	34.5	5 (b), 7 (t,m)	34.2	rising/falling
June	18.7	12 (t)	34.0	2 (m)	33.5	rising/falling

[1] Rain in preceeding few days
t = top, m = middle, b = bottom of water column

The major impact of freshwater input during the dry months (especially July 1995 and June 1996) from the flood control system is also evident by comparing the monthly averages with and without the data from Ballona Creek and Oxford Street Basin (Figures II.17 and II.18). When these flood control stations are removed from the averages (Figure II.18) salinity averages throughout the marina were similar.

Salinity maxima were consistently in the entrance channel and main channel of the marina (Table II.3). These data indicate that oceanic salinities produced these maxima. Any potential high salinities due to increased evaporation in the inner basins appears to have been negated by freshwater input.

RAINFALL

Los Angeles is a temperate region with abundant winter rainfall and dry summers. Although it varies from year to year, rains may begin in October and last through May, with the majority of rain falling between January and March. The major effect of rainfall on marine estuaries is to bring nutrients and pollutants into the estuary through freshwater runoff. Both nutrients and pollutants accumulate on the land during the dry season and are flushed off the land during the rainy season. Thus, interest in rainfall is more due to the anthropogenic input of nutrients and pollutants into the estuary, rather than the freshwater itself.

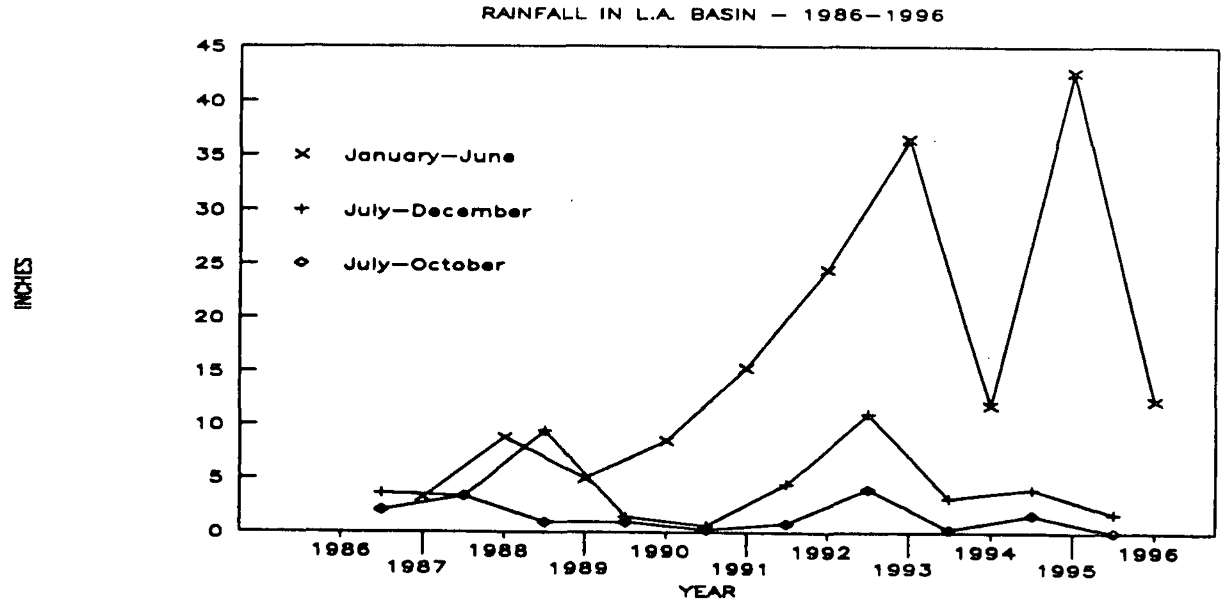
The impact of runoff in Marina del Rey varies as a function of the amount of runoff, its nutrient and pollutant load, and the degree of mixing with oceanic water (i.e., distance from the entrance). Two major and one minor sources of runoff enter the marina. Ballona Creek collects water from the largest flood plain in this area. The area ranges from the Santa Monica mountains on the north to Westchester and Inglewood on the south, and is roughly bounded by the San Diego and Harbor freeways on the east and west. Freshwater runoff from Ballona Creek enters the marina via the entrance channel by reflection off of the breakwater and with an incoming tide (flood tide). While the drainage area for Ballona Creek is large, only a portion of this runoff enters the interior waters of the marina. Its major impact is, therefore, near the entrance and in the main channel. A combination of heavy rain, high tides and/or heavy storm swell from the south or southwest can raft debris into the main channel until it fills the water surface of slips on the east side of the main channel.

The second major freshwater input through both wet and dry weather flow is from flood control runoff north of the marina. This low lying area (an earlier wetlands) drains runoff, and water is pumped, into Oxford Street Flood Control Basin from parts of Washington Boulevard and Washington Street, Glencoe Avenue on the east and Penmar on the west, and Carleton Way on the north to part of Maxella Avenue on the south. Waters from Oxford Street Basin then enter the marina at the end of Basin E. Additional flood-control runoff is pumped into the end of Basin E from the area between Washington Street and Washington Boulevard, and between McKinley and Cloy Avenue. All of this runoff enters Marina del Rey at Basin E, the most interior basin in the marina.

The third source of runoff is from the local areas of the marina itself. This includes runoff and "wash water" from the parking lots, local businesses and residences, and the boats themselves. In total area, this is comparable to the drainage area which goes into Oxford Street Basin, but this region has very little land and is mainly the water which makes up Marina del Rey.

Observable impacts of runoff and its nutrient and pollutant load are mainly a function of the when the sampling is done relative to the storm and runoff. This is particularly true for water column measurements. The longer the interval between storm runoff and sampling, the less likely is the chance to observe any impact. This would be due to mixing and flushing from the marina, biological accumulation and utilization, and settling or adsorption to benthic sediments. In addition, the first and strongest storms of the season would wash the greatest percentage of accumulated nutrients and pollutants from the land, buildings and plants.

The average rainfall in Los Angeles is around 12" near the coast and 20" near the foothills, with annual variations from one-third to three times the average (Ruffner, J.A. and F.E. Blair, The Weather Almanac, 1981). The rainfall data used in these reports, compiled since 1980, are unofficial data (courtesy of Dr. John D. Soule) compiled north of downtown Los Angeles near the foothills. The complete listing of rainfall data is found in Appendix E. A summary of these data from 1986 to the present are plotted on the next page. The range in rainfall near the foothills went from a low of 6.8" for the 1986-1987 season to a high of 46.7" for the 1994-1995 season



(Appendix E), with significant variability from year to year. As expected, most of the rainfall was from January through March, and very little during the summer season. The plot also shows a relatively consistent increase in rainfall since 1986. This appears to correlate to the decadal increase in surface water temperature in the Southern California Bight (Smith 1995).

A total of 20.8 inches of rain was reported in the foothills for this reporting period (Table II.4), about one-half of the 39" reported for the 1994-1995 reporting period (Soule et al., 1996). Rainfall for this reporting period began on November 1 with 0.2" of rain reported in the foothills and no rain reported in the south bay. This light rain probably had negligible effects on the marina. The first major storm was recorded December 13-14, 1995. Monthly water sampling was on December 14, immediately after the storm. Rainfall of 0.8" was recorded in the foothills and 0.52" recorded in the south bay. Although much of this rain may have stayed in the ground, runoff from solid features and vegetation would be expected to wash nutrients and pollutants into the flood control basins and channels. Sampling on February 1 and March 14 were also immediately after storm runoff. Sampling in the other rainy months was far enough after the rain to measure the runoff effects. The major storm of the season was on February 19-21 where 7.5" of rain were recorded in the foothills and 2.17" of rain recorded in the south bay. Sampling had been earlier in the month on February 1, and the next sampling was on March 14.

Table II.4 Rainfall in Los Angeles Basin (in inches): comparison of unofficial records taken near the foothills and in the South Bay, July 1995 through June 1996.

	Foothills daily	Foothills monthly		South Bay daily	South Bay monthly
Nov 1	0.2	0.2	Nov 1	-	-
Dec 13	0.5		Dec 13	0.52	
14	0.3		14	-	
23	0.7	1.5	23	0.95	1.5
Jan 16	0.7		Jan 16	0.06	
19	0.2		19	0.10	
21	0.3		21	0.15	
27	-		27	0.29	
31	2.0	3.2	31	1.20	1.8
Feb 3	0.2		Feb 3	0.30	
19	4.0		19	0.15	
20	1.2		20	1.95	
21	2.3		21	0.87	
22	0.5		22	-	
25	0.3		25	0.20	
27	0.5	9.0	27	0.50	4.0
Mar 4	0.7		Mar 4	0.70	
5	0.5		5	0.05	
12	2.0		12	0.15	
13	1.4		13	0.08	
14	0.4		14	-	
28	0.1	5.1	28	0.03	1.0
Apr 1	0.4		Apr 1	0.06	
16	1.0		16	-	
18	0.3	1.7	18	0.39	0.4
May 16	0.1	0.1	May 16	-	-
TOTAL:					
Foothills:		**20.8**	**South Bay:**		**8.7**

The rainfall total from the foothills (20.8", unofficial records by J. Soule) was over twice as high (Table II.4) as that measured in the south bay (8.7", unofficial records by R. Pieper). This is surprisingly similar to the averages listed in the Weather Almanac of 12" near the coast and 20" near the foothills. In comparing these two data sets, rainfall in December was the same at the coast and in the foothills, and two to five times higher in the foothills from January through May.

DISSOLVED OXYGEN

Dissolved oxygen (DO) is one of the best indicators of water quality and may be reduced to low values in eutrophic estuaries. Oxygen enters the ocean primarily at the sea surface, and in the open ocean DO concentrations at the surface are in equilibrium with air concentrations. DO values may be increased due to photosynthesis by phytoplankton (single celled diatoms, dinoflagellates and other unicellular organisms), the macro-algae in the sub-tidal zone, and marine grasses in some locations. Turbulence at the ocean surface due to winds and waves mixes more oxygen into the water and mixes it to a deeper depth. In coastal regions mechanical mixing and aeration in surf zones off of beaches, jetties, and breakwaters can supersaturate the water with oxygen.

DO utilization, resulting in low ambient concentrations, is mainly through the respiration of living organisms (the herbivores, carnivores and decomposers). Bacterial respiration is probably the major use of oxygen during the decomposition of both living and dead organic matter. Oxygen levels can be further reduced by the chemical oxidation of organic matter.

DO concentrations typically decrease in value below the surface due to oxygen utilization by respiration and lack of replenishment from the surface. In shallow, well mixed waters, DO will be relatively constant with depth. Wind mixing or turbulence may mix oxygen to deeper depths, but no deeper than the pycnocline (in southern California this is usually the thermocline). Density stratification due to temperature and/or salinity structure is an indicator of reduced vertical mixing. Depending on the strength of the stratification, DO at depth may not be replenished with oxygenated surface waters and could be reduced to levels harmful to marine organisms.

In Marina del Rey two different types of mixing can replenish DO in the water column. Horizontal exchange of oceanic water through tidal mixing brings oxygenated waters into the marina. Those areas closest to the entrance will have the greatest amount of exchange, and those areas farthest from the entrance will have the least amount of exchange. In addition, the greater the tidal difference (spring tides) the greater the mixing. Secondly, increased winds will mix the water column (vertically) and oxygenate the deeper depths.

Reduced horizontal mixing of DO occurs the during the periods of neap tides (minimal tidal difference), with the interior basins having minimal exchange. Sunlight and warm air temperatures increase water temperature at the surface, and create a warm surface layer above the cooler, more oceanic water below. Winds in the spring often mix this water to the bottom and oxygenate the water column. In the summer and fall, reduced winds leave the water column stratified and oxygen replenishment to sub-surface waters is reduced.

While the respiration of all living organisms consistently utilizes DO, major changes in DO result from bacterial degradation of large, aperiodic amounts of particulate or dissolved organic material. Phytoplankton blooms, including red tides (blooms of dinoflagellates), often occur in the marina and in the offshore waters of Santa Monica Bay. When the nutrients run out that sustained the bloom, the algal cells die off and bacterial aerobic respiration can rapidly deplete DO in the water during decomposition. When mixing is minimal DO can rapidly go to zero, especially near the bottom. When bacterial decomposition continues anaerobically near the bottom or in the bottom sediments hydrogen sulfide is produced. In addition to the nutrients which may initiate a bloom, rainfall runoff also brings organic detritus and organics into the marina which may result in significant oxygen utilization. This utilization would include both bacterial breakdown or the organics and oxidation of chemicals in the runoff.

Seasonal variations in DO since 1976 are shown in Table II.5. Values are generally within the same ranges as the past ten years, which were generally higher than the low ranges observed during 1976. Two exceptions stand out for the summer and autumn periods where lower than normal values were recorded. This is also shown in the monthly means, minima and maxima for the 1995 - 1996 sampling period (Table II.6). The low value for the summer season was in July 1995 when a DO of 1.0 ppm was recorded at Station 13 in Oxford Street Basin. This value was the lowest recorded for the summer period since our sampling began (Tables II.5 and II.6). Although this was a period of water stratification in the marina as a whole which would have reduced vertical mixing of oxygen (see temperature plot, Figure II.1), only this station in the flood

Table II.5 Dissolved Oxygen ranges (ppm), for all depths and stations by season and year (stations 18, 19, 20, 22 added in 1988-89; station 25 added in 1989-90).

Year	Spring Mar,Apr,May	Summer Jun,Jul,Aug	Autumn Sep,Oct,Nov	Winter Dec,Jan,Feb
1976		5.6-10.9[1]	0.2-11.9	0.0-7.0
1977	6.5-12.9	2.4-11.3	4.4-13.2	5.6-14.8
1978	3.9-14.0	3.2-16.4	1.4-7.6	1.1-12.3
1979	2.5-12.3			
1984	4.1-9.1[1]	5.0-10.1[2]	2.1-10.8	
1985			3.8-15.7[2]	3.9-8.9[1]
1986			3.9-9.1[2]	5.3-8.9[1]
1987			5.3-9.4[2]	
1988			4.4-9.1[2]	4.8-9.0
1989	4.6-13.8	3.3-10.9	2.5-12.0	3.9-9.9
1990	1.4-11.9	1.6-10.1	4.2-10.1	2.0-13.1
1991	5.6-12.9	3.0-11.0	4.7-10.2	5.5-10.1
1992	2.0-8.8	2.0-8.8	2.5-8.2	2.0-8.9
1993	3.3-11.1	4.0-9.2[2]		
1994		2.5-8.1	3.3-9.4	2.7-9.7
1995	4.4-10.2	1.0-8.3	1.9-8.1	4.6-12.1
1996	4.6-9.2	3.4-9.1[1]		

[1] one month only
[2] two months only

control basin had a very low value. In addition to water stratification, however, July 6, 1995 (the sampling date) was preceded by a period of minimal tidal variation which would also reduce the horizontal mixing of oxygenated water into this semi-isolated basin. Bacterial decomposition, using oxygen in the eutrophic waters of this isolated basin, were the likely cause of this low DO value.

The low DO value during the autumn period (Table II.5) was from Station 22, this time at the far side of Oxford Street Basin (Table II.6). This low value of DO of 1.9 ppm was in November 1995, and was the lowest DO recorded in the autumn since 1978 (Table II.6). While the water column appeared well mixed in November , the November 16 sampling date was also

Table II.6 Monthly Dissolved Oxygen: minimum, maximum and mean (ppm), 1995-1996.

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
July	1.0	13	8.3	22	6.68	falling/rising
August	5.1	13	7.9	3 (m)	7.12	rising/falling
September	5.2	22	8.1	2 (t)	7.00	rising/falling
October	4.2	22	7.6	1 (m)	6.63	falling
November	1.9	22	7.4	1 (b), 2 (b)	5.92	falling
December [1]	4.6	10 (b)	8.8	2 (m)	6.44	falling
January	7.4	13, 22	10.3	1 (b)	8.45	falling
February [1]	7.0	10 (b)	12.1	6 (t)	8.99	falling
March [1]	4.6	22	9.1	8 (t)	7.78	falling
April	5.9	10 (b)	8.8	22	6.98	rising/falling
May	5.0	8 (b)	9.2	1 (m,b)	7.80	rising/falling
June	3.4	10 (b)	9.1	1 (m)	7.26	rising/falling

[1] Rain in preceding few days

t = top, m = middle, b = bottom of water column

preceded by five days of minimal tidal variations, emphasizing the lack of horizontal exchange with the outer waters of the marina and the isolated nature of the basin.

The summary data also show that the minimum DO levels during most of the year were in Oxford Street Basin (Stations 13 or 22) or in Basin E (Station 10) which is immediately adjacent to the basin (Table II.6). The eutrophic nature of Oxford Street Basin, subsequent oxygen utilization, and lack of horizontal mixing and exchange with the outer waters is emphasized. The only exception to this pattern was in May 1996 where the minimum DO value of 5.0 ppm was near the bottom in Basin D (Station 8). DO maxima were generally in the surface waters and occurred during the winter months when the water temperatures were the lowest. This was expected as oxygen enters the water at the sea-surface and oxygen saturation increases with decreasing temperature.

Monthly plots for all stations of DO means, minima and maxima are in Figures II.22 through II.33, and the seasonal and station averages are in Figures II.34 through II.36. In the plots the stations are ordered relative to distance from the breakwater. All figures show the decrease in DO with increasing distance into the marina. This reflects the high DO utilization in this eutrophic estuary and the reduced mixing with oceanic waters in the interior basins. The lowest DO values were in Oxford Street Basin which is both the furthest from the entrance and this large basin is only connected to the marina through a pipe under Admiralty Way into Basin E.

Regulatory agencies consider that DO values less than 5.0 ppm are not acceptable for marine life, and the 5.0 ppm value is marked on the DO plots. Depths where DO values were less than 5.0 ppm for each month are also listed in Table II.7. While the 5.0 ppm value of DO is based on long term fish survival, fish can survive temporarily on lower levels and invertebrates can survive on much lower DO levels. There were only 18 instances of DO less than 5.0 ppm in the 1995 - 1996 monitoring period (Table II.7), as compared to 78 instances during the 1994 - 1995 period (Soule et al. 1996). Although DO values were generally better in the marina during this present reporting period, monthly sampling may have missed instances where DO values were below 5.0 ppm.

All of the instances during this reporting period with DO less than 5.0 ppm were in Oxford Street Basin or in the adjacent waters at the end of Basin E (Table II.7). The extremely low DO reading in July 1995 was at Station 13 in Oxford Street Basin, and oxygen utilization in the flood-control basin was the probable cause of the lower value at the adjacent stations in Basin E (Figure II.22). While the lowest value in October 1995 was in Oxford Street Basin, this reading was only moderately low (Table II.6) and DO values near the bottom were lower than surface values in most of the marina (Figure DO.4). Thus, vertical mixing and exchange was minimal throughout the

Table II.7 Depths are listed (in m) where Dissolved Oxygen values were less than 5.0 ppm, tabulated as a function of month and station, 1995-1996

Station Number (Ordered relative to distance from the breakwater)

	12	1	2	3	4	25	5	7	6	11	9	8	18	10	20	13	22
Jul	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	-
Aug	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sep	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oct	-	-	-	-	-	-	-	-	-	-	-	-	-	4	*	-	0
Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	0,1, 2,3	0,1, 2,3	0	0
Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	-	-
Jan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-

* station 20 not occupied - large crane working in area

marina during this month. The low DO at Station 10 in Basin E may have been augmented by construction and dredging work on the slips in this area (no sample was taken at Station 20 due to a large crane blocking the sampling site). November 1995 showed the lowest DO values throughout the water column in Basin E for this reporting period, with even lower DO in Oxford Street Basin (Table II.7, II.26). Values were below 5.0 ppm for all depths at both stations in Basin E (Stations 10 and 20). The December 1995 sampling was the first sampling after a major rainfall. Oxygenated runoff raised the DO in Oxford Street Basin, while low values remained in Basin E, especially near the bottom (Table II.6, Table II.7, II.27).

DO values in 1996 were only below the 5.0 ppm cutoff on two occasions (Table II.7). The low value in March 1996 was again in Oxford Street Basin, yet it should also be noted that DO values in much of the interior waters near the bottom were lower than surface values (Figure II.30). This pattern of lower values near the bottom than the surface were also evident in May and

June of 1996 (Figures II.32 and II.33). Reduced vertical mixing and exchange is indicated in all three months. The low DO in June was near the bottom in Basin E. It should also be noted that DO values in Oxford Street Basin for April through June 1996 were about the same as (May) or higher than (April and June) the interior waters of the marina. High wind mixing, possibly along with high rates of photosynthesis, especially in April and June, exceeded decomposition rates of oxygen utilization in Oxford Street Basin. There were dangerously low values in Oxford Street Basin in July and November 1995, but no incidence of anoxia were detected.

HYDROGEN ION CONCENTRATION (pH)

The pH of the marina, in general, is in good condition and does not indicate any problem. The impact of storm-water runoff into Oxford Street Basin does result in lowered pH values which probably have minimal effects on the marina's water quality. Values would probably have to be consistently below 6.5 to cause biological impacts. For the health and safety of swimmers, the pH in freshwater swimming pools is maintained at values between 7.2 and 7.8.

The hydrogen ion (pH) scale is based on the negative logarithm of the hydrogen ion concentration in gram-atoms per liter, measured with a hydrogen ion (pH) electrode. A pH of 7.0 is neutral, values below 7.0 are acidic, and those above 7.0 are basic. The pH values in surface waters in the open ocean usually vary between 8.1 and 8.3, depending on temperature, salinity and the partial pressure of carbon dioxide in the atmosphere. Sub-surface and surface pH values vary with biological activity. When photosynthesis is greater than respiration, more CO_2 is taken up than used and pH may increase to higher values in the euphotic zone. When respiration is greater than photosynthesis, more CO_2 is released than used and pH may decrease, especially when mixing is minimal (in the oxygen minimum zone) and towards the bottom. The buffering capacity of sea water rarely allows for extremes in values of pH.

Variations in semi-enclosed eutrophic estuaries and isolated tide pools may range from highs of 9.9 during the day and lows of 7.3 during the night. Monthly means of pH for the 1995-1996 season ranged from 8.0 to 8.3 for Marina del Rey as a whole, emphasizing the importance of sea water buffering and adequate mixing with offshore seawater (Table II.8). The pH range,

Table II.8 Monthly Hydrogen Ion concentration (pH): minimum, maximum and mean , 1995-1996.

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
July	7.8	13	8.2	1,2,3,12,22	8.08	falling/rising
August	7.8	13	8.2	1,2,3,4,12,25	8.09	rising/falling
September	7.6	22	8.3	1,2,12	8.10	rising/falling
October	7.5	13	8.2	1,2,3,4,5,25	8.10	falling
November	7.5	22	8.0	1,2,3,4,5,7,12	7.92	falling
December [1]	7.2	13, 22	8.2	2	7.99	falling
January	7.7	13	8.2	1, 2	8.02	falling
February [1]	7.2	13, 22	8.1	1,2,3,4,5,12	7.96	falling
March [1]	7.4	22	8.3	6, 18	8.10	falling
April	7.5	13	8.3	1, 2	8.03	rising/falling
May	7.9	8,9,10, 13,20,22	8.2	1,2,3	8.07	rising/falling
June	7.8	10	8.4	12	8.09	rising/falling

[1] Rain in preceding few days

however, varied between 7.2 and 8.4, emphasizing the eutrophic nature of this estuary and a lack of vertical or horizontal mixing at some sites under some localized conditions. This range is slightly smaller than the 1994-1995 season which had a pH range from 7.1 to 8.7.

As reported in earlier studies on Marina del Rey, the lowest pH values were in Oxford Street Basin at Stations 13 or 22 (Table II.8, Figure II.37). When data from Oxford Street Basin and Ballona Creek are removed from the monthly means, the monthly means, maxima and minima were relatively constant over the year (Figures II.38 and II.39). The two lowest pH values were in

December 1995 and February 1996, both with a pH of 7.2. These low values were from stations in Oxford Street Basin (Stations 13 and 22), and sampling dates for these two months were immediately after a rainfall (Table II.8). The lowest pH for the 1994-1995 sampling season was also from Oxford Street Basin (pH of 7.1), at both stations in the basin, and immediately after a rainfall in February 1995 (Soule *et al.* 1996). The effects of rain water runoff is unclear since pH values from Ballona Creek for these months were 8.0 or greater. Possibly the pH of the runoff into Oxford Street Basin was lower than that coming down the Ballona Creek flood control channel, or the seawater mixing into the Ballona Creek sampling location had the effect of raising the pH at that site (Station 12). Alternatively, the high organic load from the runoff, coupled with long residence time and minimal mixing, resulted in greater bacterial respiration in Oxford Street Basin.

The pH values in Oxford Street Basin at one or both stations were always less than 8.0 (Table II.9) indicating that, for our sampling times, biological respiration was greater than photosynthesis. It should be noted that sampling was always in the morning and that the effects of photosynthesis to reverse this trend in pH might occur later in the afternoon. Values of pH below 8.0 were often recorded in Basin E and one or both stations. Station 10 is more towards the center of the channel in Basin E and more often had lower pH values, especially near the bottom. Increased bacterial decomposition of organics from Oxford Street Basin may explain this observation.

Other depths where pH values were less than 8.0 are also shown in Table II.9. November 1995 showed the most consistent marina-wide pH values below 8.0. During November low values were in all of the interior basins, extended down the main channel to Station 3 (near the Ballona Lagoon - Venice Canal outfall), and were throughout the water column. Off southern California, November may represent the start of the winter low productivity period. Thus, November may represent the first month where there is a die off of organisms and increased bacterial decomposition. While this would not be noticed as a pH change in the open ocean, it is more evident in this enclosed estuary where mixing is reduced. Values were not low in the

Table II.9 Depths are listed (in m) where pH values were less than 8.0 , tabulated as a function of month and station, 1995-1996

	Station Number (Ordered relative to distance from the breakwater)																
	12	1	2	3	4	25	5	7	6	11	9	8	18	10	20	13	22
Jul	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-
Aug	-	-	-	-	-	-	-	-	-	-	-	-	-	4	2,3	0	-
Sep	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0
Oct	-	-	-	-	-	-	-	-	-	-	-	-	-	4	*	0	0
Nov	-	-	-	0.1, 2,3	0,1	0,1, 2,3, 4	0,1, 2	0,1, 2	0,1, 2,3	0,1, 2,3	0,1, 2,3	0,1, 2,3	0,1, 2	0,1, 2,3	0,1, 2,3	0	0
Dec	-	-	-	-	-	-	-	-	-	-	0	-	-	0,1, 2,4	0,1, 2	0	0
Jan	-	-	-	-	-	-	-	0,1, 2,3, 4	-	-	-	-	-	-	-	0	0
Feb	-	-	-	-	-	-	5	1,2, 3	2,3, 4	0,3	0,1, 2,3	1,2, 3,4	1,2, 3	0,1, 2,3, 4	0,1	0	0
Mar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0
Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	3,4	-	0	0
May	-	-	-	-	-	-	-	-	-	-	4	4	-	3,4	2	0	0
Jun	-	-	-	-	-	-	-	-	-	-	2,3	4	-	4	-	0	-

* station 20 not occupied - large crane working in area

December runoff period, but there were lower pH values after the storm in February 1996 in all of the interior basins and throughout the water column.

During May and June 1976, Station 9 in Basin F and Station 8 in Basin D also had pH values of 7.9 near the bottom. These two locations, as at Station 10 in Basin E, are far from the entrance and experience less exchange with oceanic waters. Although in general the trends in pH values are consistent within the marina, there are a few exceptions. The pH values from Station 7 in Basin H in January 1996 were all 7.9 throughout the water column, while the rest of the marina proper had values of 8.0 or greater. While these values are not significantly lower, they represent an anomaly in the pattern. This location off of the boat launching ramp may have experienced some unique impact.

The pH maxima generally occur near the marina entrance (Table II.8) and represent oceanic conditions. The highest pH was at the Ballona Creek station in June 1996 (pH of 8.4). This high pH value at the surface of Station 12 may represent the impact of some dry-weather runoff from the flood control channel.

WATER COLOR (Forel Ule Scale)

Water color is influenced by a number of physical, chemical and biological factors. The observed color is determined by light scattering due to particulates in the water, the actual color of the particles present, or sometimes to dissolved materials in the water. Pure freshwater appears black in color as no light is scattered (reflected) back to the observer. Pure sea water appears blue to the observer due to scattering at the short wave lengths (blue end of the spectrum). With increasing phytoplankton numbers, the water will appear to be blue-green, then green with increased light scattering at longer wavelengths. If phytoplankton numbers are extremely high, that of a phytoplankton bloom, the water may take on the color of the particular algal species. Water color will appear green with a bloom of a green algae, yellow-green to yellow to brown with a diatom bloom, and brown to red with a dinoflagellate bloom. A dinoflagellate bloom may be called a "red tide" due to the color of water. Increased sediment in the water due to freshwater runoff or mixing with bottom sediments may turn the water brown or black in color.

The Forel-Ule (FU) scale is a standard set of vials filled with various shades of colors that might be expected in the marine environment. These are compared to the color of sea water when viewed above a white Secchi disk suspended beneath the water surface. Number on the color vials start at 1, the blue color of the purest ocean water (numbers 1-3 represent the deep-sea blue colors). Numbers slowly increase as the colors change to the blue greens (numbers 4-6), greens (numbers 7-9), yellow-greens (numbers 10-12), yellow-green-browns (numbers 14-16), yellow-browns (numbers 17-18), and brown-reds (numbers 19-21). The FU scale does not include colors applicable to sediment mixing or colored water such as might come from peat. Thus, it is not appropriate to use the Forel-Ule scale in the shallow, often muddy waters of Oxford Street Basin. Color estimates using the Forel-Ule scale are very subjective and it is important to have the same person perform the observations in all surveys. With this condition, the FU color estimate provides a useful indication of events occurring in the water.

The monthly means, minima, and maxima FU values are summarized in Table II.10 and the data are plotted in Figures II.40 to II.42. Since Marina del Rey is a coastal estuary, water colors for most of the year are indicative of relatively high levels of production (high particle density and therefore scattering of the longer wavelengths). Mean values for most of the year range from 11 to 14 (yellow-green to yellow-green-brown). It is relatively rare to find low-production, blue water colors inside of the marina. The lowest FU values (FU 4) were near the entrance in August and September 1995 when the colors were in the blue-green range (Table II.10). The lowest FU maximum value (FU 8) was in September 1996, and FU values ranged from 4 to 8 throughout the marina. Thus, September represented a low production period with water colors always in the blue-green to green range. Colors in the blue-green to green range (FU 6 and 8) were also observed near the entrance in October 1995 and May 1996, again indicating the presence of lower production oceanic waters.

The darkest water noted was after the major rainfall runoff in the months of December 1995, January 1996 and February 1996. In all three cases the water was the darkest in Ballona Creek (Station 12), and in two months (December and February) this color was also noted at Station 1 which is further down the Ballona Creek channel. The color range (FU 17 and 18) was noted as being in the yellow-browns, but the color was darker and more due to sediment load than an algal-based red tide. As noted earlier, no measurements were made in the shallow, sediment laden Oxford Street Basin.

Stations where Forel-Ule values were greater than 12 are shown in Table II.11. The effect of runoff after the February storm runoff is particularly evident as values are high throughout the marina. High values after the December and March storms are more restricted to the Ballona Creek channel and Basin E which receives the major runoff from Oxford Street Basin. High FU values

Table II.10 Monthly Water Color (Forel-Ule scale): minimum, maximum and mean (FU units), 1995-1996, excluding stations 13 and 22 in Oxford Street Basin.

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
July	10	8, 18	14	12	11.2	falling/rising
August	4	1,2,12	12	20	6.3	rising/falling
September	4	1,2,8,12	8	9, 20	5.9	rising/falling
October	6	2, 3	14	10	9.4	falling
November	10	1,2,3,4, 5,11,25	13	12	11.0	falling
December [1]	11	5,6,25	18	1, 12	13.2	falling
January	10	1,2,3,4,5,6, 10,11	12	7,8,9,12, 18,20,25	10.9	falling
February [1]	13	25	17	1, 12	14.9	falling
March [1]	10	3	17	12	13.2	falling
April	10	1	13	3,4,9,12	12.1	rising/falling
May	8	1	14	20	11.7	rising/falling
June	12	2,4,5,6,11, 12,13,25	14	20	12.5	rising/falling

[1] Rain in preceding few days

in Basin E (Station 10) in October 1995 was either due to sediment re-suspension by the work in the area or from input from Oxford Street Basin, or both. April through June 1996 showed periodic high productivity (high FU values) at a variety of stations. The higher values at Station 3 may indicate an influence from the Ballona Lagoon - Venice Canal outfall, and high values at Stations 10 and 20 in Basin E, again, are the likely result of influence from Oxford Street Basin and the minimal amount of mixing and long residence time of water in this area. High productivity

Table II.11 Values are shown where Forel Ule values were greater than 12, tabulated as a function of month and station, 1995-1996; no measurements were taken at stations 13 and 22 in Oxford Basin.

	Station Number (Ordered relative to distance from the breakwater)																
	12	1	2	3	4	25	5	7	6	11	9	8	18	10	20	13	22
Jul	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Aug	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Sep	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Oct	-	-	-	-	-	-	-	-	-	-	-	-	-	14	*	+	+
Nov	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Dec	18	18	14	-	-	-	-	13	-	13	13	-	-	14	14	+	+
Jan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Feb	17	17	14	14	14	13	14	15	14	16	16	14	15	15	15	+	+
Mar	17	15	-	-	-	-	14	-	14	-	-	14	14	14	14	+	+
Apr	13	-	-	13	13	-	-	-	-	-	13	-	-	-	-	+	+
May	-	-	-	-	-	-	-	-	-	13	13	-	-	13	14	+	+
Jun	-	13	-	13	-	-	-	13	-	-	13	13	-	13	14	+	+

* station 20 not occupied - large crane working in area
+ no measurements taken; stations not appropriate for FU measurement

at Station 9 in Basin F during these months (April through June) may similarly be due to enrichment, this time from local runoff, and the fact that it too is one of the more interior basins in the marina. There were no particularly high values noted in Basin D, the area near Mother's Beach (Stations 8 and 18). Station 18 was always below FU 13 except during the major runoff months of February and March. A similar pattern is seen at Station 8 except for June 1996 where the FU color value was 13. This value of 13 was not different from most of the interior channels during this month.

There were no red tides observed in Marina del Rey during the 1995-1996 season. A green tide (bloom of a unicellular green alga), which was evident in coastal waters from Redondo Beach to Santa Monica during mid-August 1995, was not noted in marina waters. Monthly sampling in the marina, however, was on August 10; the green tide was evident primarily during the week of August 15-18, and we may have missed its development.

WATER TRANSPARENCY

Water transparency is the greatest when there is the least amount of particulate material in the water. Conversely, transparency decreases with an increase in particulates. Suspended particulates may include bottom sediment, terrestrial runoff and debris, microbes, or phytoplankton. Water transparency is usually indirectly related to water color. The higher the Forel-Ule color index, the lower the transparency and the lower the FU color index the greater the light transmission.

Water transparency in this study is evaluated in two ways. Electronic measurements are made with a transmissometer attached to the Martek sensor package. It has a self contained light source which measures transmitted light over a fixed light path to a light sensor. Water transparency determined by the transmissometer is measured as a function of depth at two meter intervals. A more qualitative estimate of water transparency is made with the Secchi disk. A single measurement is made at each station by observing the depth to which an observer can no longer see the Secchi disk. This measurement provides an estimate for the water column as a whole and is a good indicator of the extinction coefficient of the light profile. Low Secchi depths indicate low water transparency, usually as a result of high particulate concentrations.

Data on water transparency is summarized in Table II.12 as percent light transmission from the transmissometer and Table II.13 summarizes the information from the Secchi disk. Summary plots of these data are shown in Figures II.43 through II.48. Data were not taken in Oxford Street Basin due to its shallow water depths and muddy bottom.

Oceanic water is the bluest due to low particulate concentrations. This type of water also has the greatest water transparency (high percent of light transmission and the largest Secchi depth). Under non-runoff conditions, maximum water transparency was generally observed at those stations nearest to the entrance to the marina (Stations 1, 2, and 12). When Station 12 in Ballona Creek had high water transparency (Tables II.12 and II.13), it was generally due to oceanic water below the water surface (Table II.12). After major storms when rainwater runoff was high (December 1995, February and March 1996), maximum water transparency was at

Table II.12 Monthly Percent Light Transmission: minimum, maximum and mean (%T), 1995-1996, excluding stations 13 and 22 in Oxford Street basin.

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
July	49	10 (b)	88	12 (b)	69.5	falling/rising
August	47	11 (b)	84	12 (m,b)	71.5	rising/falling
September	38	10 (b)	79	12 (m,b)	63.7	rising/falling
October	48	25 (b)	92	1 (t),12 (t,m)	75.9	falling
November	57	20 (b)	93	1 (m)	78.1	falling
December [1]	4	12 (t)	93	25 (m)	76.3	falling
January	32	9 (t)	90	1 (t)	78.5	falling
February [1]	11	12 (t)	76	5 (m)	61.9	falling
March [1]	15	12 (t)	78	3 (t)	69.4	falling
April	51	9 (b)	77	12 (t)	69.7	rising/falling
May	46	9 (m)	84	1 (m,b)	65.2	rising/falling
June	43	9 (b)	81	2 (m,b)	66.4	rising/falling

[1] Rain in preceeding few days

t = top, m = middle, b = bottom of water column

various locations within the Marina del Rey, often mid-way between the two major raimwater (flood control) inputs. Station 25, near the Harbor Master's Office, and Station 5, in the main channel, had the highest percent light transmission in both December and February (Table II.12). Similarly, Station 25 had the greatest Secchi depth for both months (Table II.13).

Low water transparency usually occurs as a result of high particulate load, due either to high phytoplankton biomass or particulates and chemicals in freshwater runoff. Minimum water transparency for the 1995-1996 season was during the three high-runoff months in Ballona Creek

Table II.13 Monthly Secchi Disk depth: minimum, maximum and mean (in meters), 1995-1996, excluding stations 13 and 22 in Oxford Street Basin.

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
July	1.5	8,9,10,18	2.5	1, 12	1.9	falling/rising
August	1.5	10, 20	3.7	2, 12	2.5	rising/falling
September	1.7	10	6.5	2	3.0	rising/falling
October	2.0	7,9,10	4.0	2, 12	2.8	falling
November	1.5	10, 20	4.2	1	2.6	falling
December [1]	0.1	12	2.7	25	2.5	falling
January	1.5	8, 20	3.5	1, 12	2.5	falling
February [1]	0.2	12	1.5	20, 25	1.0	falling
March [1]	0.3	12	2.9	7	2.0	falling
April	1.3	8, 18	2.7	1	2.3	rising/falling
May	1.4	20	4.4	1	2.3	rising/falling
June	1.3	9	2.0	6	1.6	rising/falling

[1] Rain in preceeding few days

near the surface. Values from the transmissometer ranged from 4 to 15 percent light transmission during December, February and March (Table II.12). Secchi depth values for these months ranged from 0.1 to 0.3 m (Table II.13). No water transparency measurements were made in Oxford Street Basin due to its shallow depth and muddy bottom.

Depths where water transparency measurements were less than 50 percent are tabulated in Table II.14. The impact of freshwater runoff is particularly evident in the December 1995 values where transparency was low through out the water column in Ballona Creek (Station 12) and at the

Table II.14 Depths are listed (in m) where water transparency values were less than 50 %, tabulated as a function of month and station, 1995-1996; no measurements were taken at stations 13 an 22 in Oxford Basin.

	Station Number (Ordered relative to distance from the breakwater)																
	12	1	2	3	4	25	5	7	6	11	9	8	18	10	20	13	22
Jul	-	-	-	-	-	-	-	-	-	-	3	-	-	3	-	+	+
Aug	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	+	+
Sep	-	-	-	-	-	-	-	-	4,5	-	4	3,4	-	2,3,4	1,2	+	+
Oct	-	-	-	-	-	6	-	-	-	-	-	-	-	-	*	+	+
Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Dec	0,1,2	0,1,2,3,4,5	3,4	-	-	-	-	-	-	-	-	-	-	4	0	+	+
Jan	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	+	+
Feb	0	0	-	0	-	-	0	-	0	-	-	0	-	-	-	+	+
Mar	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
May	-	-	-	-	-	-	-	-	-	-	2,3,4	-	-	3,4	-	+	+
Jun	-	-	-	-	-	-	-	-	-	-	3,4	-	-	4	-	+	+

* station 20 not occupied - large crane working in area
\+ no measurements taken

end of the Ballona Creek channel (Station 1). The impact of Ballona Creek runoff is evident at Station 2 at the entrance of the main channel, but transparency was over 50 percent inside the marina from that station. Water transparency again was below 50 percent at Stations 10 and 20 in Basin E. No measurements were taken in Oxford Street Basin, but it is assumed that the low values in Basin E were due to runoff and pumping which went into Basin E. Transparency after the February storm is less evident and values less than 50 percent only occurred at 6 stations and only in surface waters. Only one low value was measured after the March storm. These data illustrate the impact of runoff from the first major storm of the season, especially with respect to runoff from the major water shed leading into Ballona Creek and the particulate matter which had accumulated on the land over the previous dry months. To a lesser extent, this is also seen at Station 20 in Basin E which receives runoff water directly from Oxford Street Basin.

In the nine, non-runoff months minimum transparency was in mid-water or near the bottom (Tables II.12 and II.14). This could be due to turbidity from bottom sediments, from phytoplankton or bacterial growth just above the bottom, and/or from sub-surface living or dead particulates (including phytoplankton). When the minima were in the water column it is unlikely that the effect was from resuspended bottom sediments. In different months lowered transparency was observed in a number of the interior basins. In September 1995 transparency below 50 percent was seen in all of the interior basins. This may reflect an increase in bacterial action due to a die off in primary production at the end of summer. As with the other water measurements, Basins E and F, the most interior basins, had the lowest values. Basin E was likely impacted by Oxford Street Basin. The stations in Basin E and F showed lower values during May and June of 1996 (Tables II.12 and II.14)., and stations in both basins also had consistently high Forel-Ule values during this spring period (Table II.11). These two measures combine to indicate higher production leading to low water transparency, in addition to minimal mixing with oceanic waters. Data from Basin D (Stations 8 and 18), which includes the Mother's Beach area, only had a few low transparency and high FU values.

Water transparency measurements were similar to those reported for the 1994-1995 season. Highest values were from oceanic waters and lowest values were from the Ballona Creek flood control channel after a major rainfall. Similarly, low values during non-runoff months, probably resulting from high production, were observed in both Basins E and F. These are the most interior basins and have minimal mixing with oceanic water. While Basin E is directly impacted by Oxford Street Basin, it is unclear whether or not there is a local input of nutrients which increase the eutrophic nature of Basin F. The waters of Basin D for this reporting period were rarely the lowest and had higher transparencies than reported for the 1994-1995 season.

AMMONIA-NITROGEN

As on land, inorganic nutrients are needed for plant growth in the sea. Lack of one or more of these nutrients may limit growth. Estuaries are semi-enclosed coastal ecosystems where seawater mixes with nutrient-rich freshwater drained from the land and mixing with more oligotrophic oceanic waters is reduced. The combination of nutrient addition, shallow depths which confine microorganisms within the euphotic zone, and minimal exchange with oceanic waters (long residence time) results in extremely productive waters. The eutrophic (high nutrient) nature of estuaries makes them an important nursery area for many fishes and invertebrates. Although manmade, Marina del Rey has all of the characteristics of a typical, eutrophic estuary.

Eutrophic systems are rarely stable since nutrient input, biological populations (such as predators) and water conditions vary over time. When one or more of the limiting nutrients become high, a major phytoplankton bloom may develop. Initial growth of this bloom may both oxygenate the water and provide additional food for many organisms. When one (or more) of the nutrients becomes limiting to growth, a major die off will occur. Nutrient and water characteristics sometimes lead to a bloom of dinoflagellates which are red or brown in color. High concentrations of the dinoflagellates appear to turn the water red or brown, resulting in a "red tide". In addition to nutrient availability, water stability is usually required for a bloom to develop. With extensive mixing, low-nutrient oceanic water both reduces nutrient concentrations and mixes phytoplankton cells below the euphotic zone.

The two macronutrients usually limiting growth in aquatic systems are phosphorus and nitrogen. Phosphorus is usually the limiting nutrient in freshwater systems and nitrogen is usually the limiting nutrient in marine systems. Plants can take up nitrogen in the form of nitrates, nitrites, and ammonia. In the open ocean all forms of nitrogen are close to zero in the euphotic zone due to rapid utilization and rapid recycling. Bacterial breakdown of organic matter results of nitrate accumulation deeper in the water column, below the upper mixed layer. When these waters are brought to the surface through mixing or upwelling, nitrogen in the form of nitrates is provided for growth. In the surface waters of the open ocean ammonia is produced through bacterial recycling, but is rapidly taken up by the phytoplankton. Most oceanic concentrations, therefore, are very low, usually less than 1 ug-at/l. Ammonia, if available, is the preferred nitrogen source because it can be metabolized more directly than nitrates.

In estuarine systems, ammonia concentrations are much higher due to increased levels of bacterial recycling and by input from anthropogenic sources. In these eutrophic waters, light penetration is often limited to the surface waters. When mixing is minimal bacterial breakdown producing ammonia occurs below the euphotic zone. Ammonia levels are often significantly increased by freshwater inputs containing high ammonia concentrations. These might include ocean outfalls from treated sewage, rainwater runoff, and direct input from boats. Rainwater runoff into Marina del Rey is significantly augmented by direct flow from major flood control systems. One flood control source, as discussed earlier, sends water direct into Oxford Street Basin and Basin E. The Ballona Creek runoff enters the marina through tidal mixing at the entrance. Local and aperiodic ammonia inputs may also occur at various locations within the marina. These may include the discharge of human wastes from boats, dog and cat wastes, bird droppings, and wash-down products from local docks, walkways, and businesses. Bacterial breakdown of organic material, plant or animal, in runoff will produce ammonia.

Ammonia concentrations were always above 2.0 ug-at/l at all stations and depths in the marina for the 1995-1996 season (Table II.15). Even at its lowest concentrations, ammonia-nitrogen was never absent and always above typical oceanic values. The mean ammonia concentration for the marina during the nine dry months was 4.9 ug-at/l. When the three runoff months are added in, the mean for the 1995-1996 sampling period increases to 6.19 ug-at/l. Ammonia concentrations ranged from a low of 2.1 ug-at/l in June 1996 at Station 6 in Basin B to a high of 47.4 ug-at/l from runoff water after the first major storm of the season in December 1995 at Station 22 in Oxford Street Basin. These values are similar to values and patterns noted in previous years. [Note: Table II.12 on Ammonia concentrations in the 1994-1995 report is incorrect. In that report, Table II.12 is a repeat of the Secchi depth data and ammonia values

Table II.15 Monthly Ammonia-Nitrogen: minimum, maximum and mean (ug-at/l), 1995-1996.

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
July	2.9	2 (t)	9.6	3 (t)	5.64	falling/rising
August	4.5	12 (t)	12.7	13	6.58	rising/falling
September	2.2	9 (m)	15.0	13	3.91	rising/falling
October	2.2	4 (t)	8.8	22	3.17	falling
November	3.9	1 (m)	18.3	22	7.33	falling
December [1]	3.2	2 (m)	47.4	22	13.19	falling
January	3.6	1 (t,m,b)	8.3	7 (m)	5.78	falling
February [1]	5.4	1 (b)	42.7	22	12.50	falling
March [1]	2.5	4 (m)	12.0	13	4.59	falling
April	2.7	2 (t)	5.7	13	3.76	rising/falling
May	3.0	6 (m)	8.9	20 (t)	4.15	rising/falling
June	2.1	6 (t)	10.1	13	3.69	rising/falling

[1] Rain in preceding few days

t = top, m = middle, b = bottom of water column

should be read from the text, figures or appendix.]

Monthly ammonia plots for all stations are shown in Figures II.49 through II.60. Lowest ammonia values were nearest to the entrance, usually at Stations 1 and 2, and represent coastal or oceanic water (Table II.15). During the three runoff months minimal values were also in these locations, but were in the sub-surface oceanic waters which moved in under the surface runoff. In months where minima were at other stations (September, October, March, May and June), ammonia concentrations were low throughout most of the marina.

Maximum ammonia concentrations occurred during the three months where sampling was immediately after a major rainfall. All readings for these months were the highest in Oxford Street Basin, with the highest value (47.4 ug-at/l) in December 1995 (Table II.15, Figure II.54). Ammonia concentrations in Oxford Street Basin were again high from the February storm runoff (42.7 ug-at/l), but were not significantly higher than other month readings from Oxford Street Basin after the March storm runoff (12.0 ug-at/l). This pattern of high ammonia concentrations in the runoff water is also seen in the data from Ballona Creek for these months (Figures II.54, II-56 and II.57). Ballona Creek water also had high ammonia levels in December and February, and lower values in the March runoff, probably because most of the organic debris had already been flushed from the channels.

Oxford Street Basin also had high, usually the highest, ammonia values during the dry months. This is most likely due to bacterial regeneration of organic matter. Stations 10 and 20 in Basin E usually had elevated values, probably due to input from Oxford Street Basin. In contrast to Oxford Street Basin, Ballona Creek ammonia levels are close to those of the other stations in the marina for the dry months. Slightly elevated ammonia values were measured at various stations in different months. In July 1995, elevated levels at Station 3 may show the effects of the Ballona Lagoon - Venice Canal outfall (Figure II.49). Higher levels at Station 4 in August 1995 and February 1996 may be due to local runoff or accumulation in the eddy that sometimes forms seaward of the Coast Guard dock (Figures II.50 and II.56). Elevated levels at Station 5 in December 1995 are puzzling as this station is in the center of the main channel (Figure II.54). The location is midway between the entrance and the inner basins, however, and may be a depositional area for materials washed from the basins. There were also slightly elevated levels at Station 25 in March, May and June 1996 (Figures II.57, II.59, and II.60). This station is near the fishing dock which may result in higher ammonia concentrations due to bait tanks, bird droppings and wash-down from both the docks and local walkways.

The high levels of ammonia in storm water runoff and consistently high levels in Oxford Street Basin are shown in Table II.16. Depths and stations where ammonia concentrations were

Table II.16 Depths are listed (in m) where Ammonia values were greater than 10.0 ug-at/l, tabulated as a function of month and station, 1995-1996; ammonia samples were collected every 2 m.

	Station Number (Ordered relative to distance from the breakwater)																	
	12	1	2	3	4	25	5	7	6	11	9	8	18	19	10	20	13	22
Jul	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aug	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-
Sep	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-
Oct	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-
Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0	0
Dec	0,2	0	-	-	-	-	0	0,2	0,2	0,2	0,2	0,2	-	0	0,2, 4	0,2	0	0
Jan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Feb	0,2	0	-	-	-	0,2	0,2	0,2	0,2	0	0,2	0,2	0,2	-	0,2	-	0	0
Mar	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-
Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jun	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-

* station 20 not occupied - large crane working in area

greater than 10 ug-at/l indicate that runoff from Ballona Creek probably had minimal impact on the waters of the interior of Marina del Rey. Conversely, runoff from Oxford Street Basin definitely affected Basin E (Stations 10 and 20). High ammonia concentrations after the December and February storms were found in most of the marina's interior waters. This may have been due to local runoff, stranding of organic material in low energy water or may have resulted from the runoff flowing into Basin E from Oxford Street Basin or direct pumping of storm water into Basin E. Ammonia levels above 10 ug-at/l were also found in Oxford Street Basin waters during five of the nine dry months.

Ammonia values greater than 5 ug-at/l were observed throughout the marina during both dry and wet weather months (Table II.17). October and November 1995 values greater than 5 ug-at/l were probably due to both runoff and bacterial decomposition. Stations 10 and 20 in Basin E

Table II.17 Depths are listed (in m) where Ammonia values were greater than 5.0 ug-at/l, tabulated as a function of month and station, 1995-1996; ammonia samples were collected every 2 m.

	Station Number (Ordered relative to distance from the breakwater)																	
	12	1	2	3	4	25	5	7	6	11	9	8	18	19	10	20	13	22
Jul	0,2,4	2	2	0,2,4	-	4	2	-	-	0,2	0	-	-	-	0,2	0,2	0	0
Aug	-	-	0,2,3	0,2	0,2,4	0,2,4	0,2,4	0,2,4	0,2,4	0,2,4	0,2,4	0,2,4	0,2	0	0,2,4	0,2	0	0
Sep	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,2	0	0
Oct	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	*	0	0
Nov	0,2	0	2,4	0,2,4,6	0,2,4,6	0,2,4	0,2,4	0,2	0,2	0,2	0,2	0,2	0,2	-	0,2	0,2	0	0
Dec	0,2	0,2,4	-	0,2,4	0,2,4	0,2,4	00,2,4	0,2	0,2	0,2	0,2	0,2	0	0	0,2,4	0,2	0	0
Jan	0,2,4	-	0	-	0,2	0,2,4,6	0,2,4	0,2,4	0,2,4	0,2,4	0,2,4	0,2,4	0,2	0	0,2,4	0,2,4	0	0
Feb	0,2,4	0,2,4	0.2.4	0,2,4	0,2,4	0,2,4	0,2,4	0,2	0,2,4	0,2,4	0,2	0,2,4	0,2	0	0,2,4	0,2	0	0
Mar	0,2	0	-	-	-	2,4	-	-	-	-	0	-	-	-	0,2	0	0	0
Apr	-	-	-	0	-	-	4	-	-	-	-	-	-	-	-	-	0	0
May	0,2	-	4	-	-	4	-	-	-	-	-	-	-	-	-	0,2,4	0	0
Jun	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	0	0

* station 20 not occupied - large crane working in area

consistently showed the higher ammonia concentrations. The data also indicates that waters in the marina runoff after the March storm had relatively low ammonia values. Most of the ammonia had been washed off of the land by the previous storms, and biological uptake may have been higher by March.

Ammonia-nitrogen data show the eutrophic nature of the waters of Marina del Rey. Major inputs occur from storm water runoff, especially that water that goes into Oxford Street Basin and then into Basin E and the rest of the marina. Conversely, it appears that the high ammonia levels from Ballona Creek water may not enter very far into the interior of the marina. During dry weather, major ammonia levels are found in Oxford Street Basin and enter the marina's waters via Basin E.

CONCLUSIONS

Although man-made, Marina del Rey has the characteristics of, and behaves as, a typical coastal, eutrophic estuary. Nutrient input from freshwater sources, relatively shallow bottom depths, and minimal mixing with oceanic waters make it highly productive and, therefore, an important nursery for both fishes and invertebrates.

In addition to its importance for marine organisms, the marina is also used by boaters and swimmers. Major modifications of the waters can occur through anthropogenic inputs which can upset the balance in the estuary. Marina del Rey consists of the main channel and eight interior basins. As with other marinas and estuaries, waters near the main entrance are heavily influenced and mixed with oceanic water, while mixing is less with increasing distance into the interior basins.

The major sources of anthropogenic inputs are from the flood-control system. Ballona Creek drains runoff from a large portion of metropolitan Los Angeles and this water enters the marina from the entrance channel, mainly by tidal movement. The majority of this flow, however, continues into Santa Monica Bay. Impacts of this water are mainly in the entrance channel.

Conversely, the runoff collected from the area off of Washington Boulevard and Washington Street enter directly into Oxford Street Basin or into Basin E, the most interior location in the marina. Water from Oxford Street Basin goes directly into Basin E. Mixing with oceanic waters is minimal and residence time is long in this basin. In both wet and dry months, Oxford Street Basin continues to be the major source of perturbation in those water properties studied. High nutrients due to both runoff and bacterial degradation increase productivity, decrease water transparency, decrease pH, and decrease oxygen levels.

During this reporting period DO levels below 5.0 ppm were only recorded in Oxford Street Basin and in Basin E. There were fewer instances of low DO during this 1995-1996 season than reported in the previous 1994-1995 study. Levels of pH were within safe levels within the marina, the only low values (pH of 7.2) occurring in Oxford Street Basin in the runoff from the December and February storms.

Other Basins of concern include Basin D with its swimming beach. This basin appeared to have good physical water quality during this reporting period. No DO values below 5.0 were recorded and all other measures were consistent with values in the other waters of the marina. Data from Station 9 in Basin F continue to show that this area is comparable in many instances with Basin E, yet with no large input sources such as Oxford Street Basin. There may be additional nutrient input into this basin from boats or local runoff.

Of greater concern, however, is the possibility of toxins, bacteria and pollutants in runoff waters. These are not discussed in this section, are generally aperiodic in nature, and have the potential to have major impacts on the health of the water.

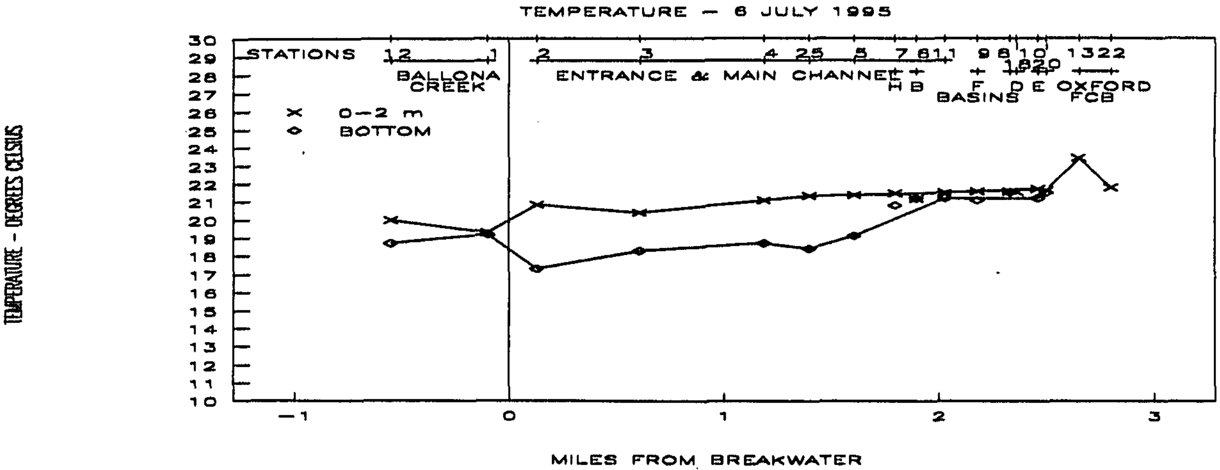


Figure II.1. Average water temperature (°C), surface to 2m, and bottom, 6 July 1995.

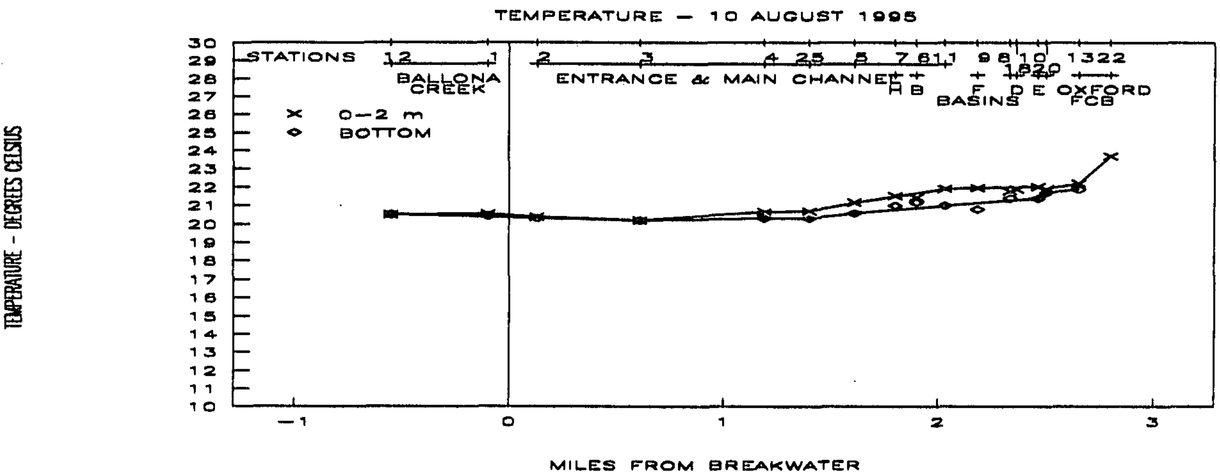


Figure II.2. Average water temperature (°C), surface to 2m, and bottom, 10 August 1995.

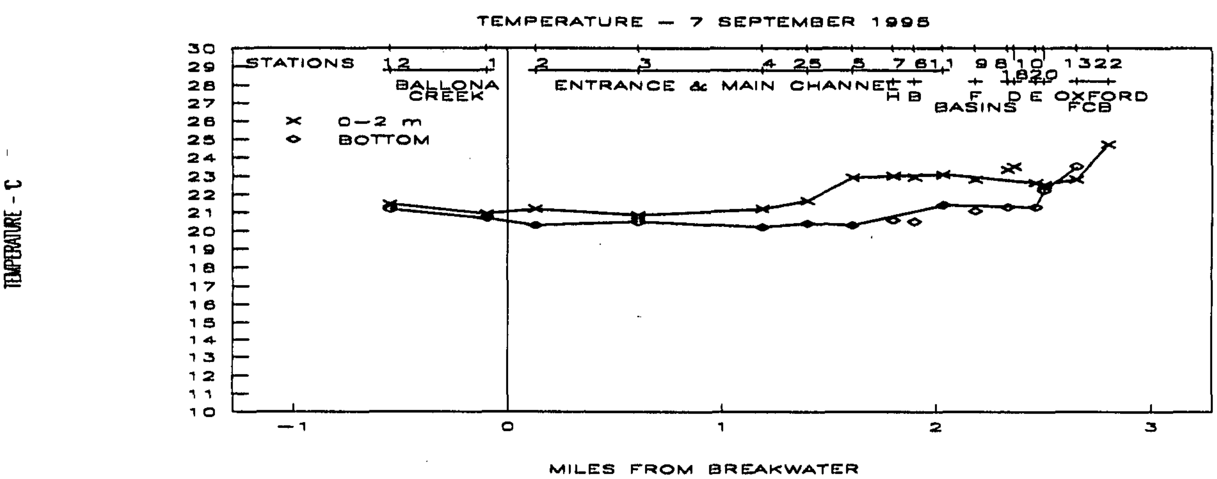


Figure II.3. Average water temperature (°C), surface to 2m, and bottom, 7 September 1995.

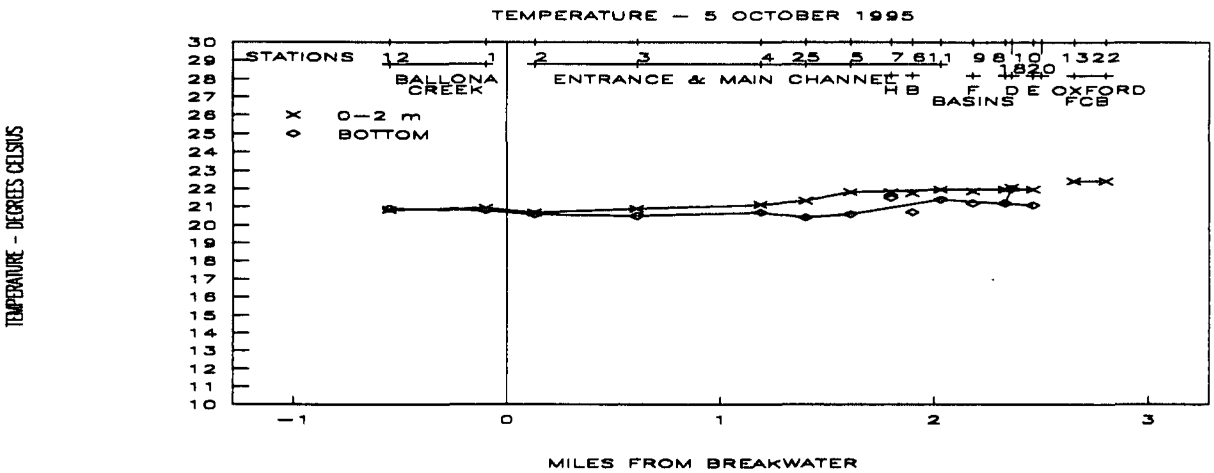


Figure II.4. Average water temperature (°C), surface to 2m, and bottom, 5 October 1995.

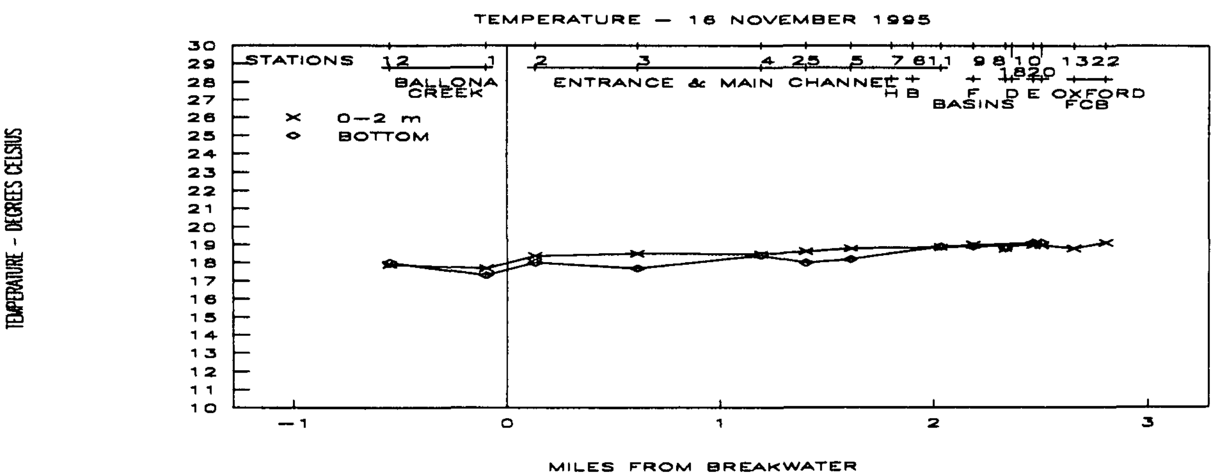


Figure II.5. Average water temperature (°C), surface to 2m, and bottom, 16 November 1995.

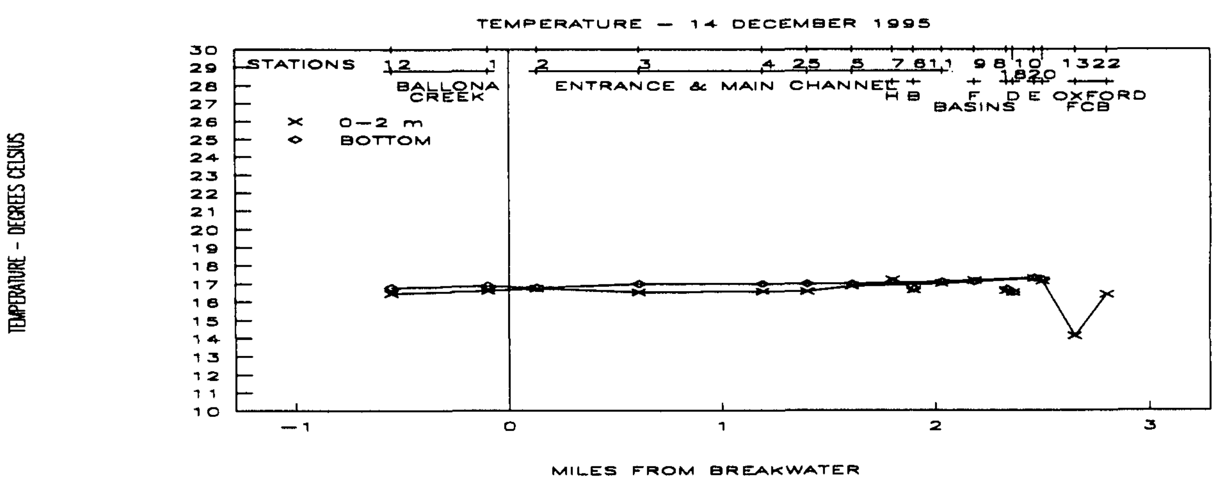


Figure II.6. Average water temperature (°C), surface to 2m, and bottom, 14 December 1995.

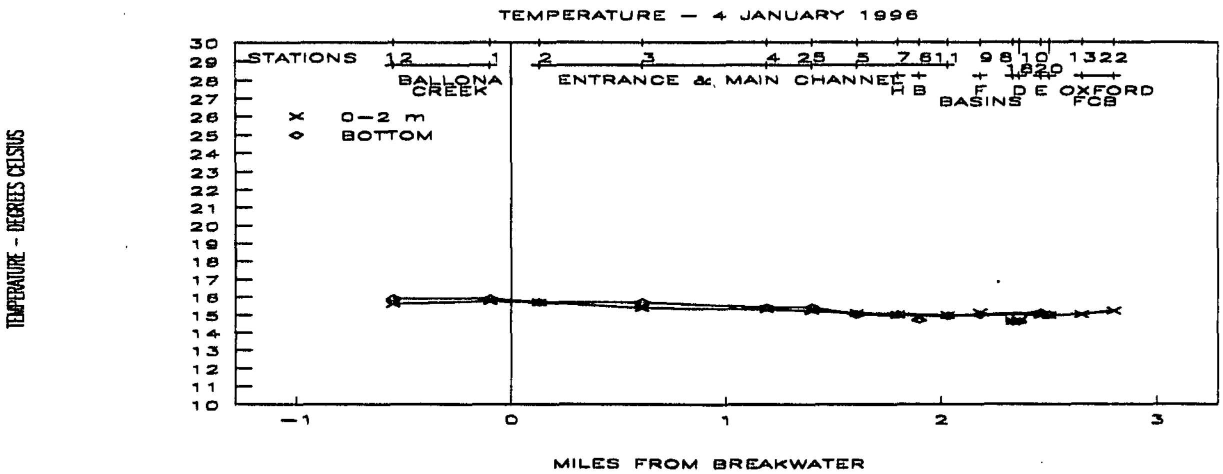


Figure II.7. Average water temperature (°C), surface to 2m, and bottom, 4 January 1996.

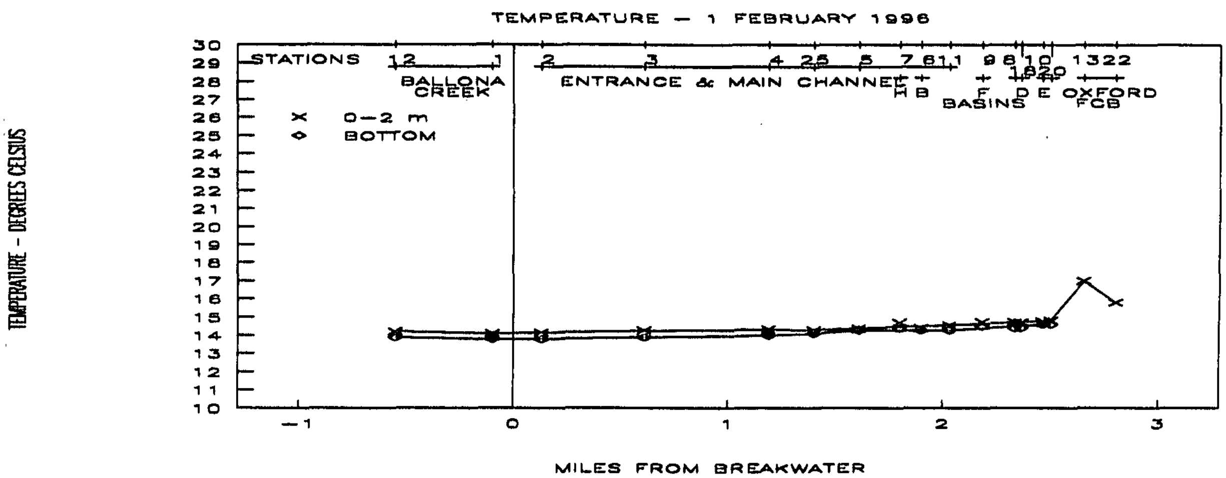


Figure II.8. Average water temperature (°C), surface to 2m, and bottom, 1 February 1996.

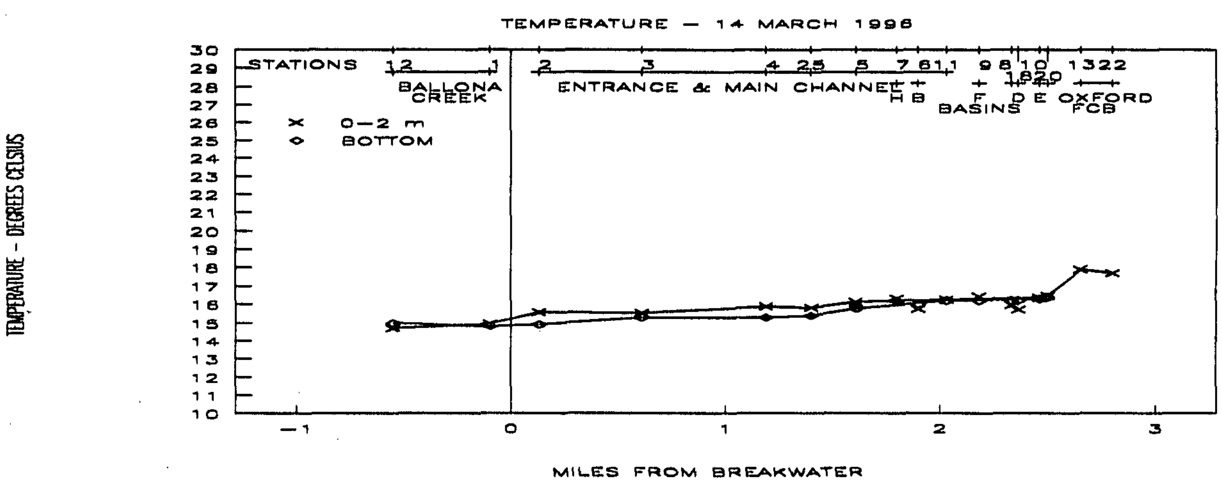


Figure II.9. Average water temperature (°C), surface to 2m, and bottom, 14 March 1996.

1.

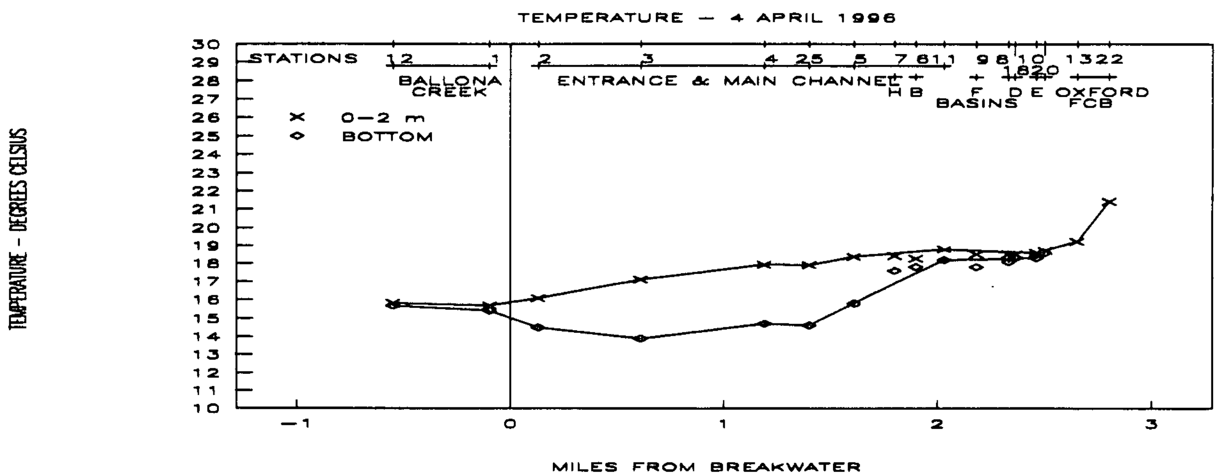


Figure II.10. Average water temperature (°C), surface to 2m, and bottom, 4 April 1996.

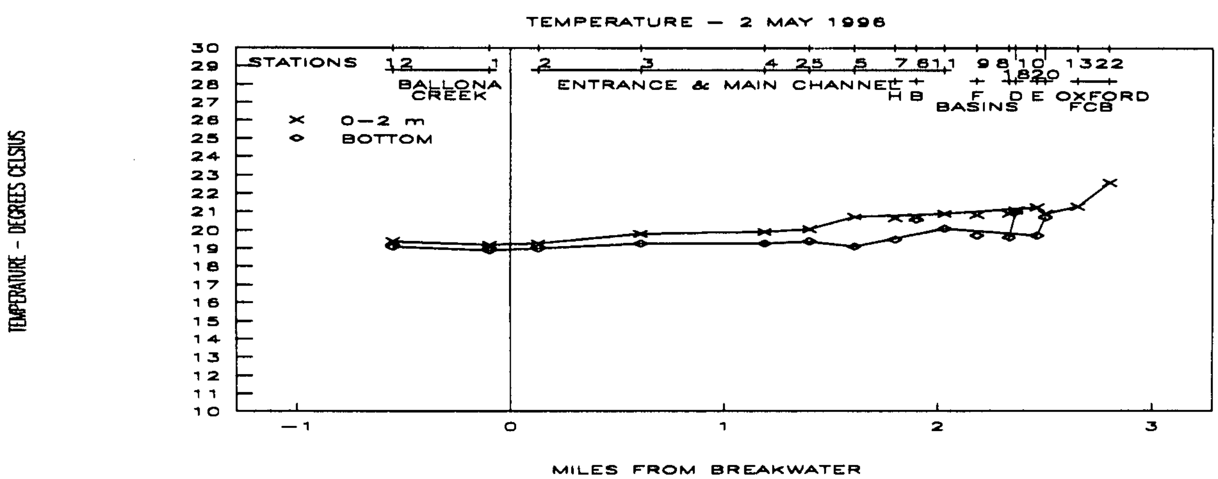


Figure II.11. Average water temperature (°C), surface to 2m, and bottom, 2 May 1996.

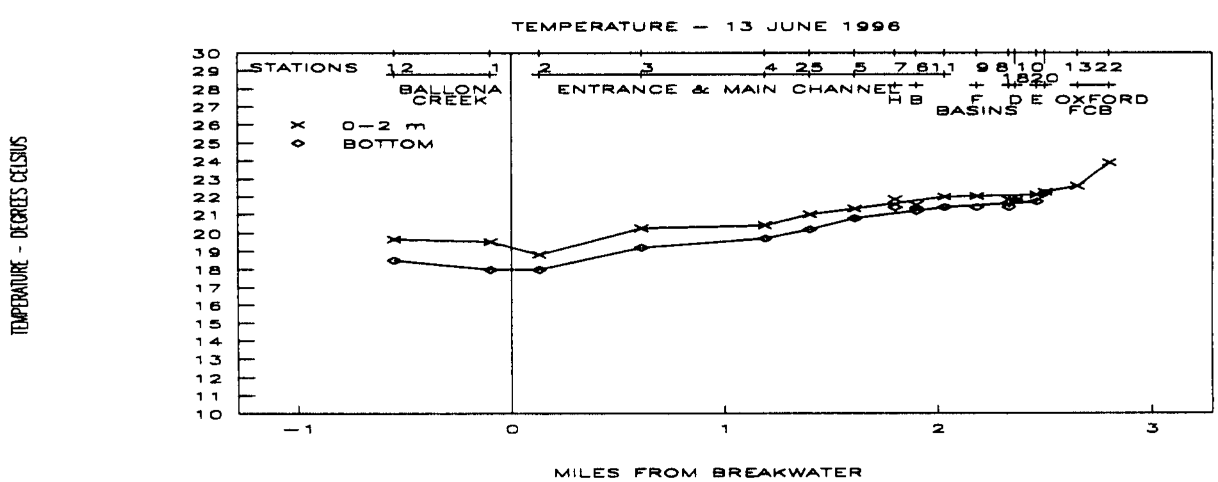


Figure II.12. Average water temperature (°C), surface to 2m, and bottom, 13 June 1996.

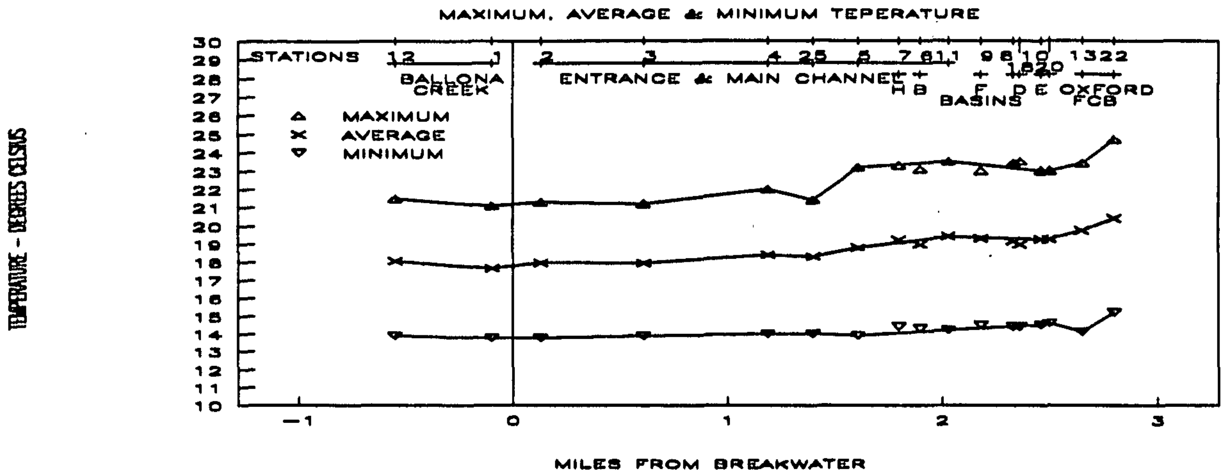


Figure II.13. Maximum, average and minimum temperature (°C) for all depths by station during July 1995 through June 1966.

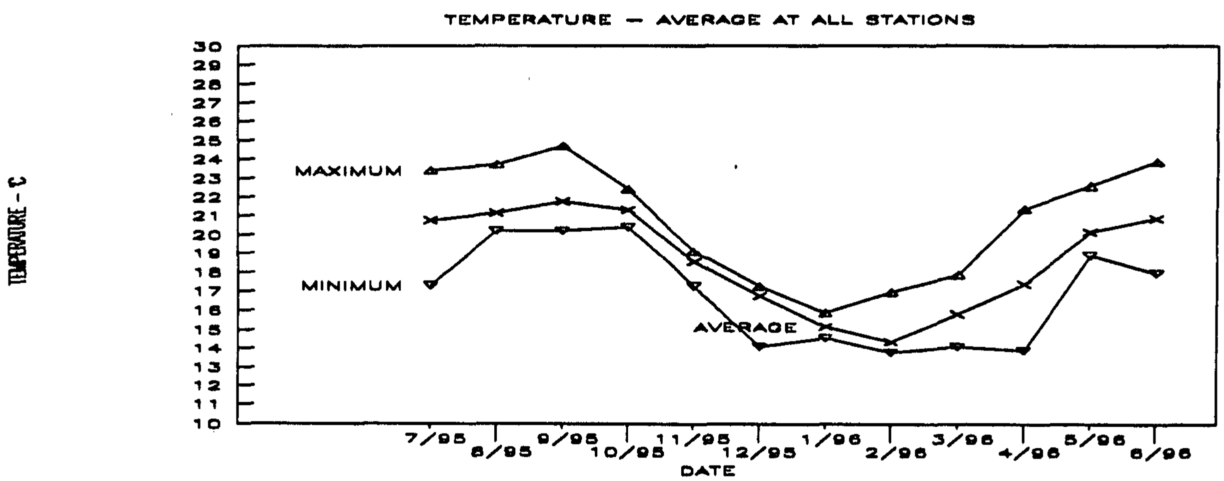


Figure II.14. Maximum, average and minimum temperature (°C) for all stations including Ballona Creek and Oxford Basin, July 1995–June 1966.

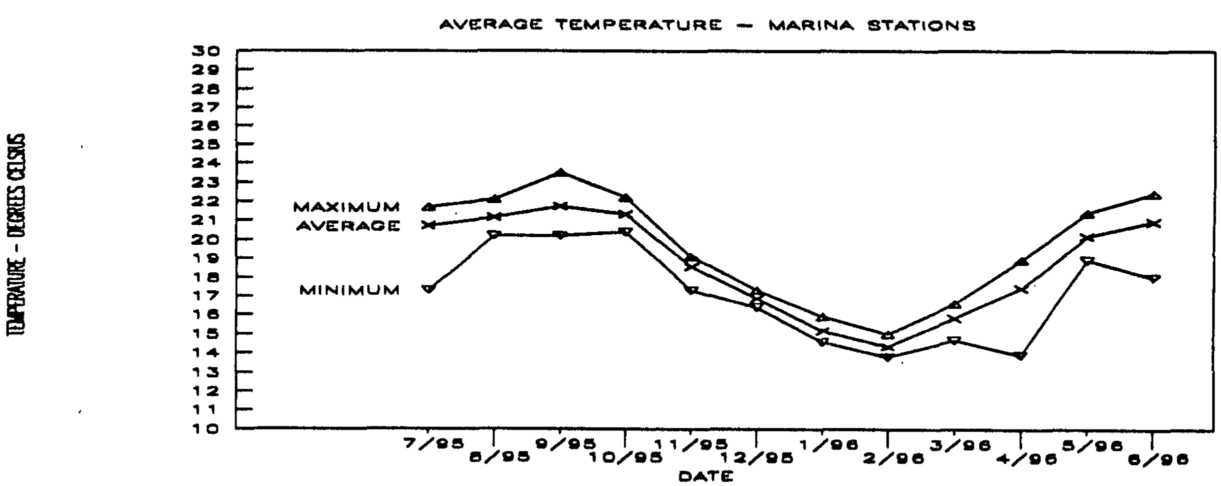


Figure II.15. Maximum, average and minimum temperature (°C) for all stations excluding Ballona Creek and Oxford Basin, July 1995–June 1966.

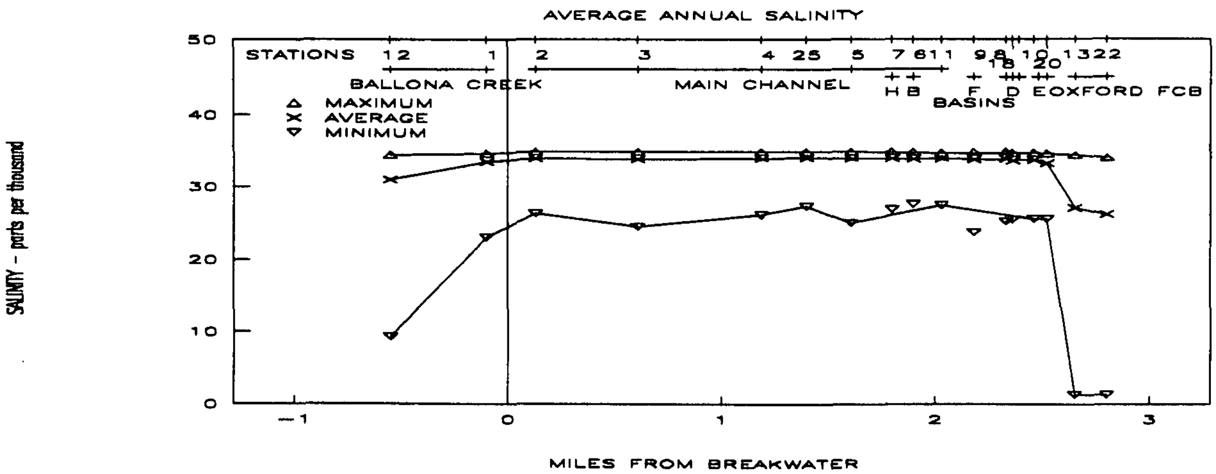


Figure II.16. Maximum, average and minimum salinity (°/oo) for all depths by station during July 1995 through June 1996.

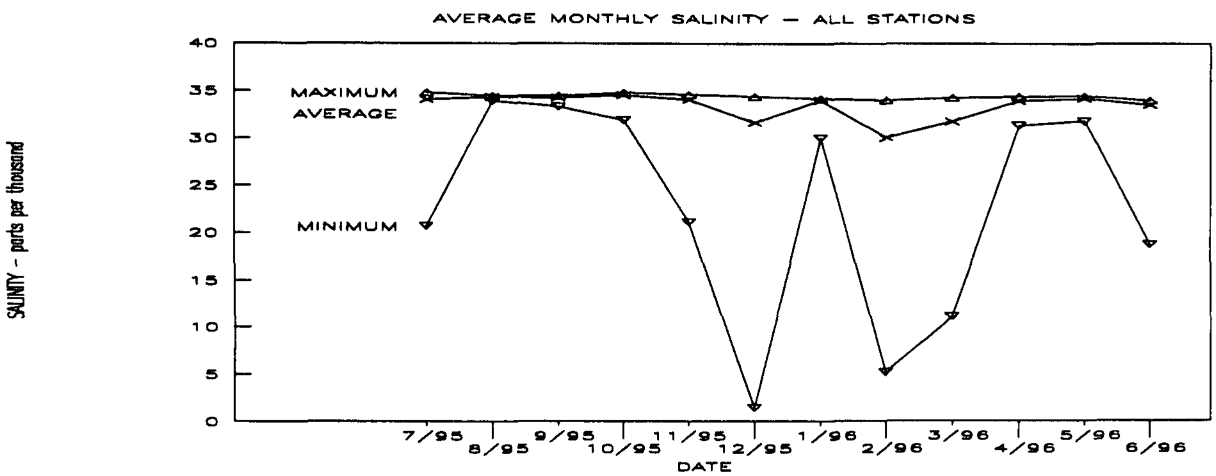


Figure II.17. Maximum, average and minimum monthly salinity (°/oo) for all stations and depths including Ballona Creek and Oxford Basin, July 1995–June 1996.

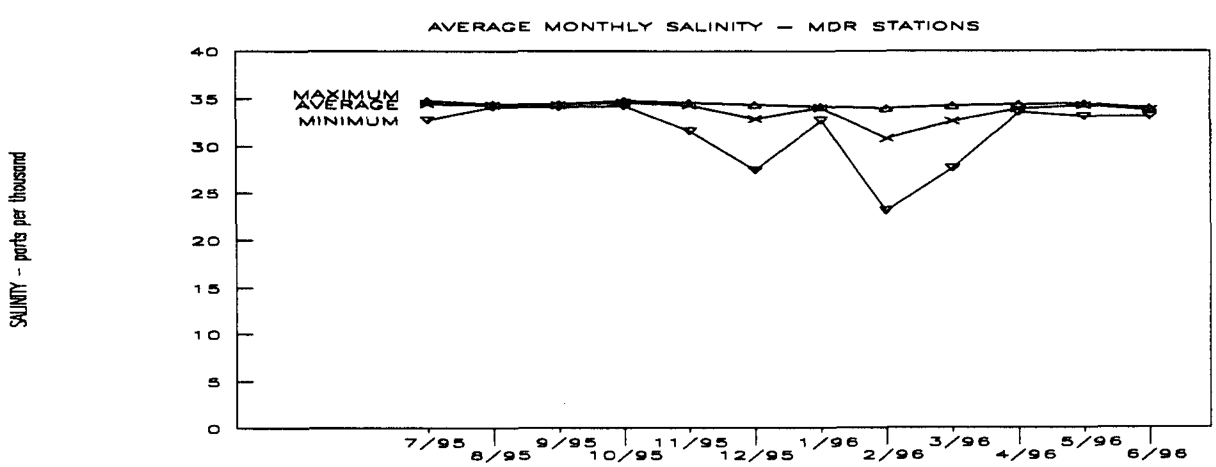


Figure II.18. Maximum, average and minimum monthly salinity (°/oo) for all stations and depths excluding Ballona Creek and Oxford Basin, July 1995–June 1996.

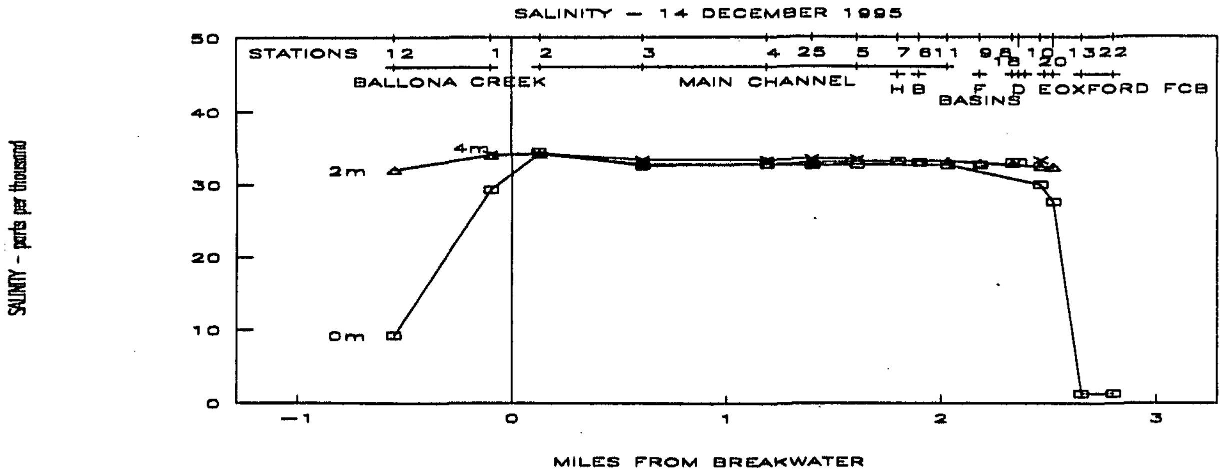


Figure II.19. Salinity (°/oo), 14 December 1995.

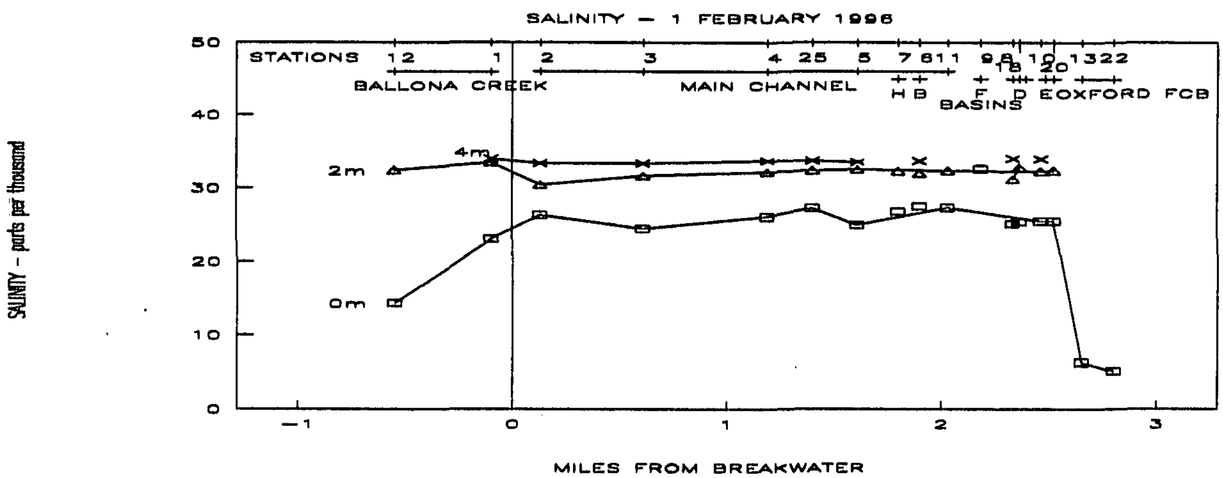


Figure II.20. Salinity (°/oo), 1 Febuary 1996.

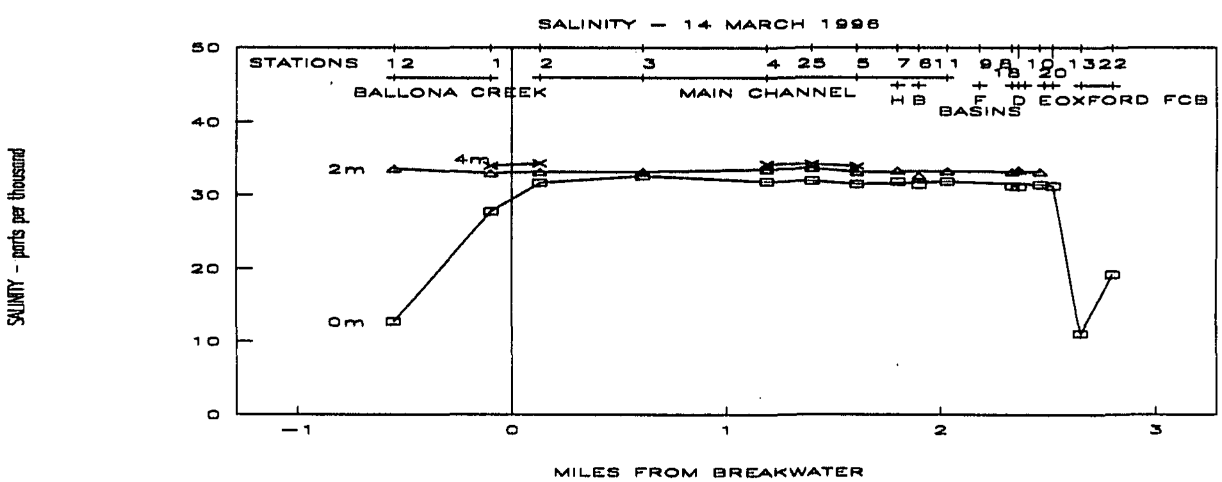


Figure II.21. Salinity (°/oo), 14 March 1996.

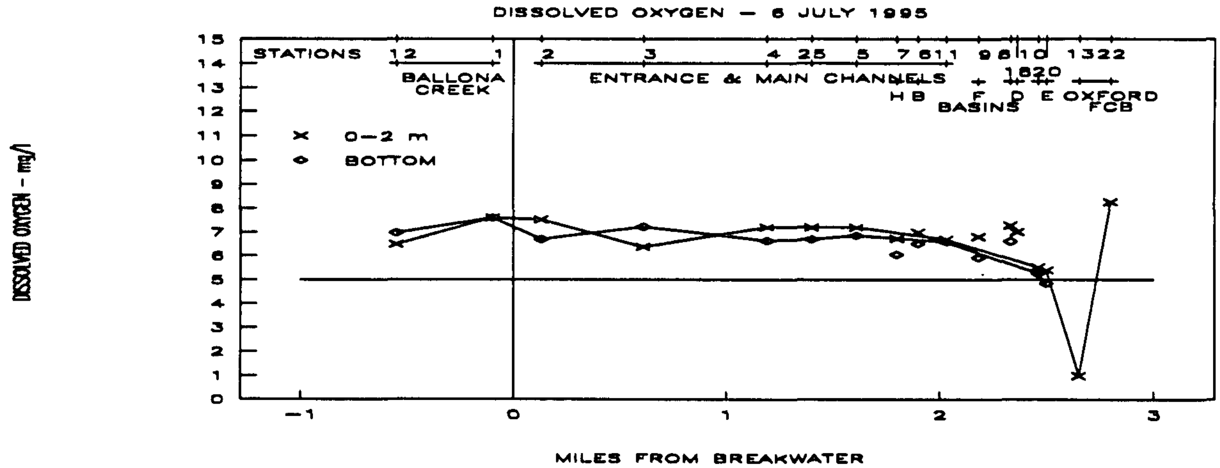


Figure II.22. Average dissolved oxygen (ppm), surface to 2m and bottom, 6 July 1995

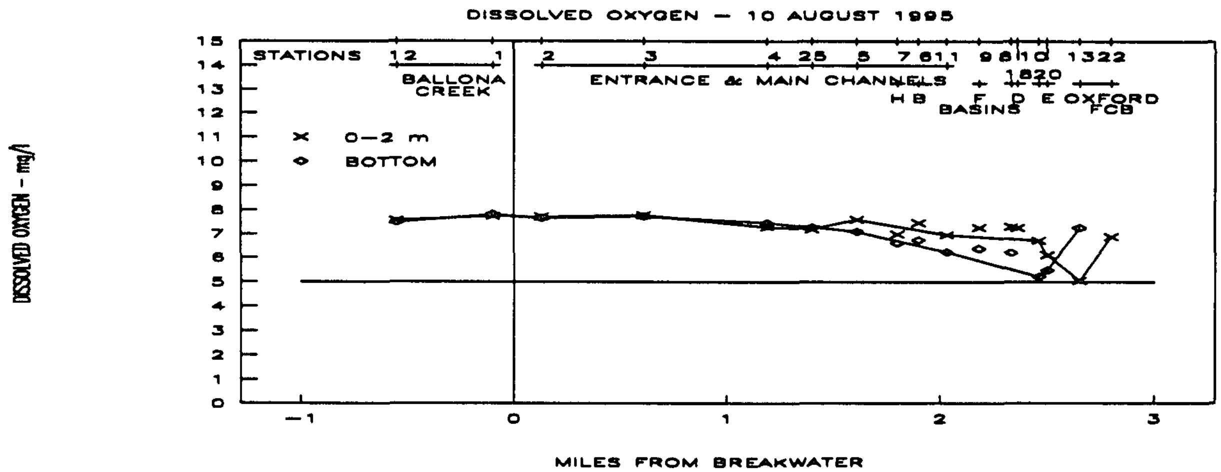


Figure II.23. Average dissolved oxygen (ppm), surface to 2m and bottom, 10 August 1995.

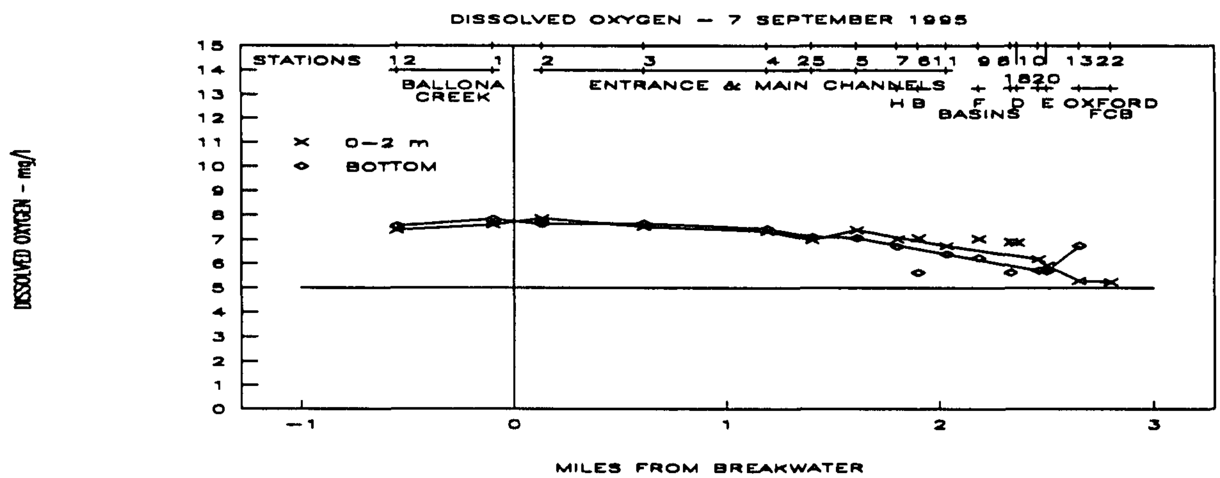


Figure II.24. Average dissolved oxygen (ppm), surface to 2m and bottom, 7 September 1995.

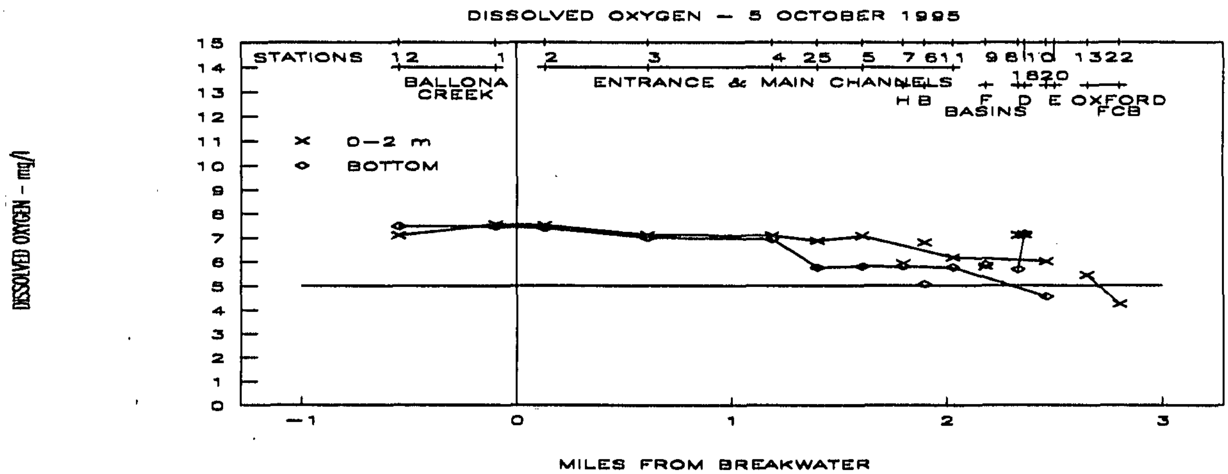


Figure II.25. Average dissolved oxygen (ppm), surface to 2m and bottom, 5 October 1995.

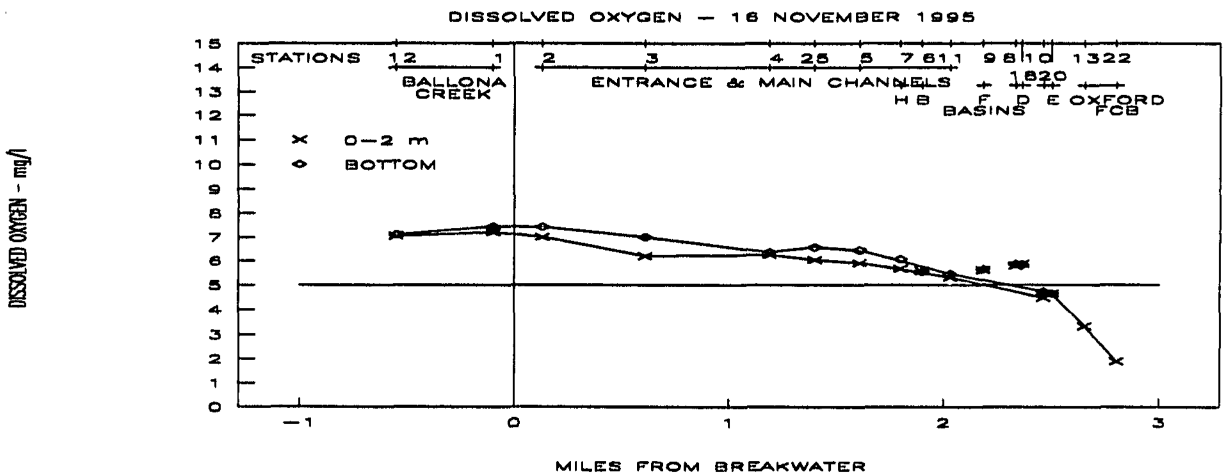


Figure II.26. Average dissolved oxygen (ppm), surface to 2m and bottom, 16 November 1995.

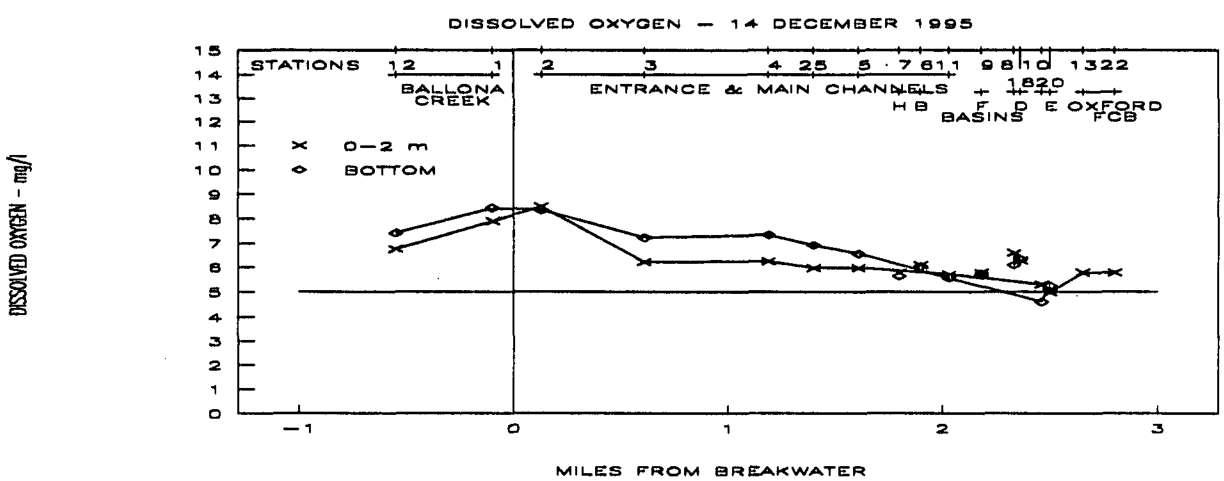


Figure II.27. Average dissolved oxygen (ppm), surface to 2m and bottom, 14 December 1995.

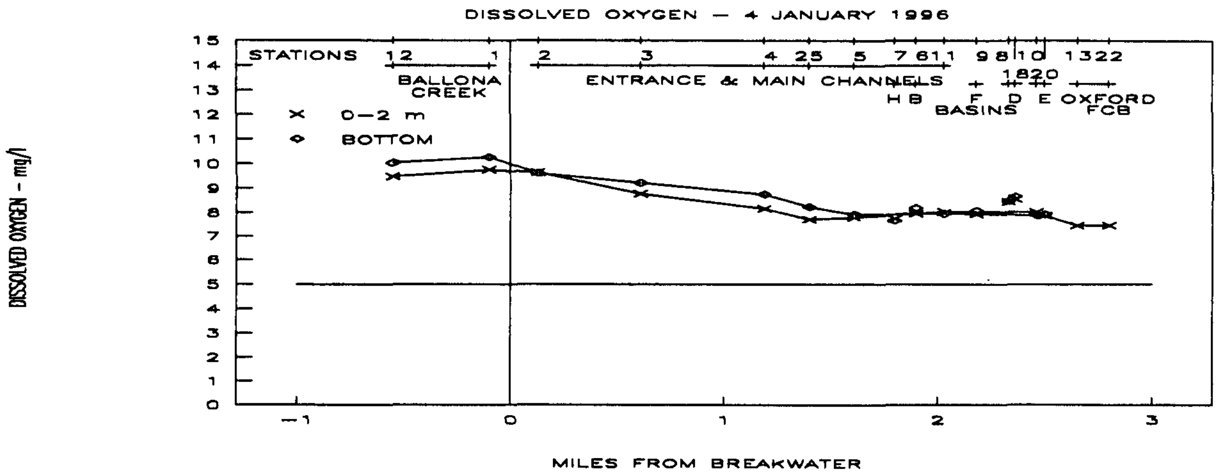


Figure II.28. Average dissolved oxygen (ppm), surface to 2m and bottom, 4 January 1996.

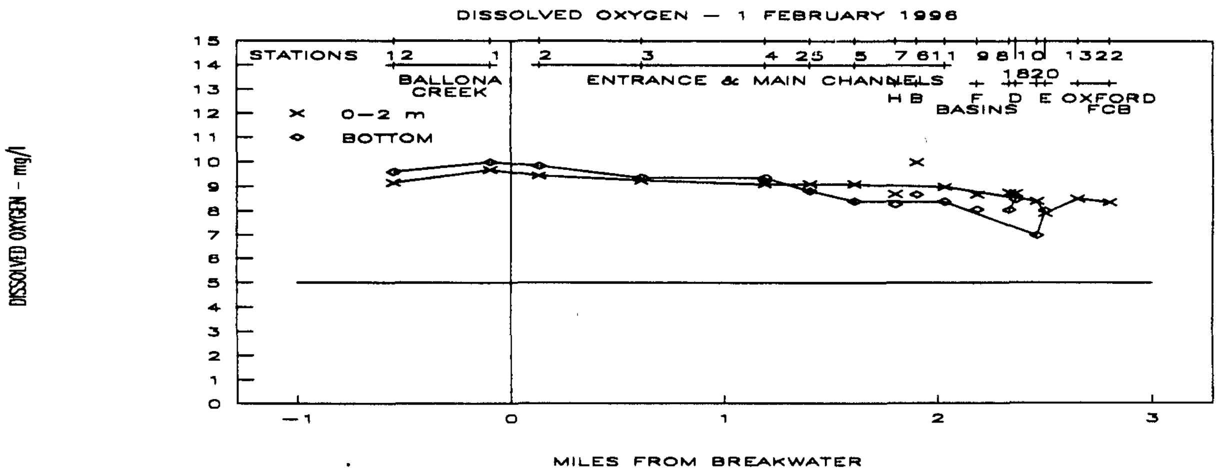


Figure II.29. Average dissolved oxygen (ppm), surface to 2m and bottom, 1 February 1996.

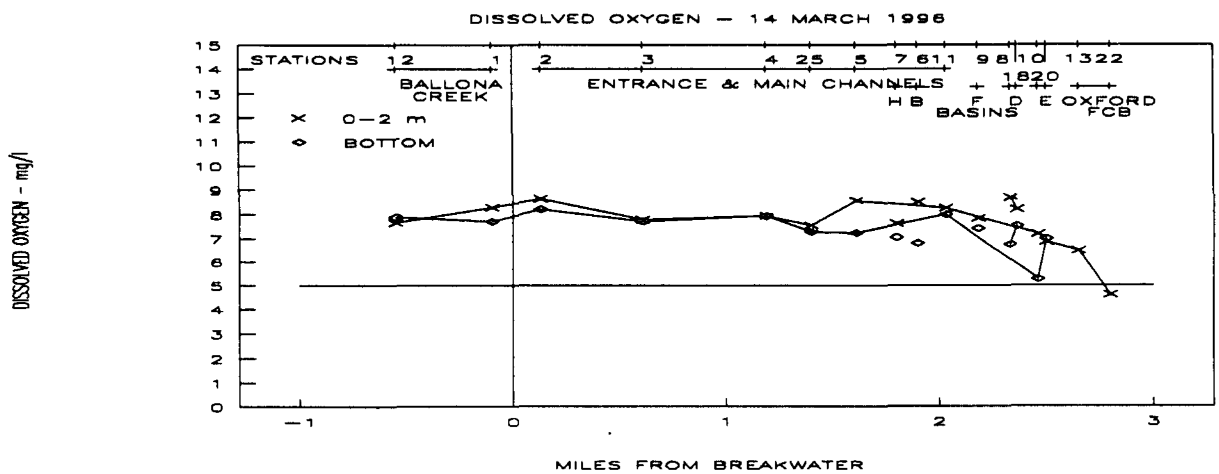


Figure II.30. Average dissolved oxygen (ppm), surface to 2m and bottom, 14 March 1996.

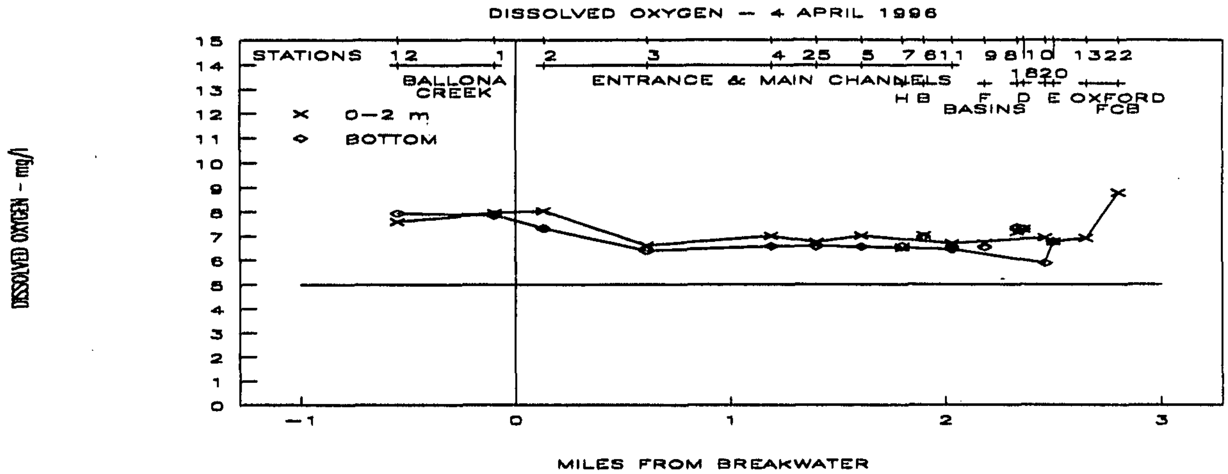


Figure II.31. Average dissolved oxygen (ppm), surface to 2m and bottom, 4 April 1996.

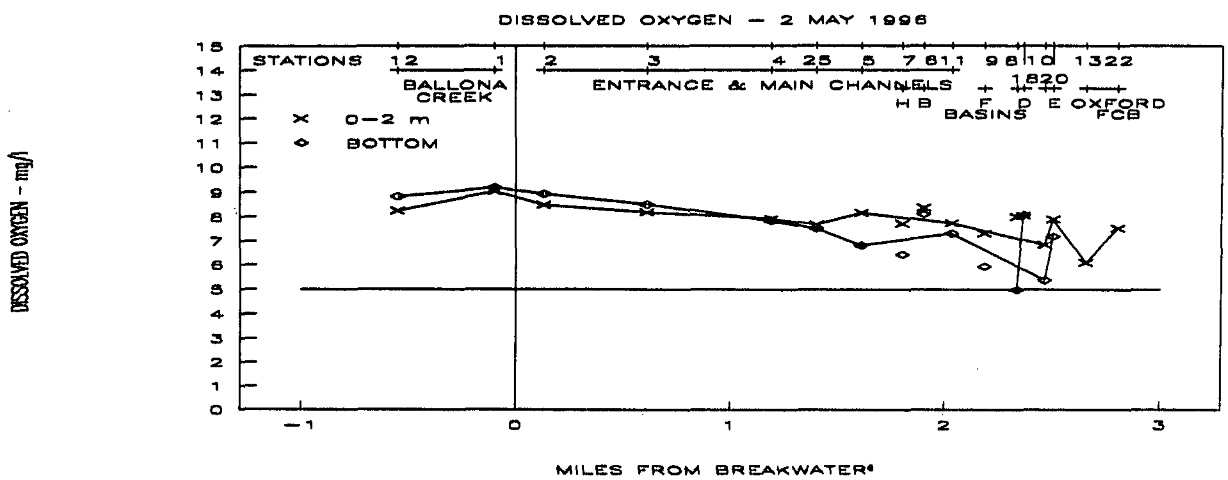


Figure II.32. Average dissolved oxygen (ppm), surface to 2m and bottom, 2 May 1996.

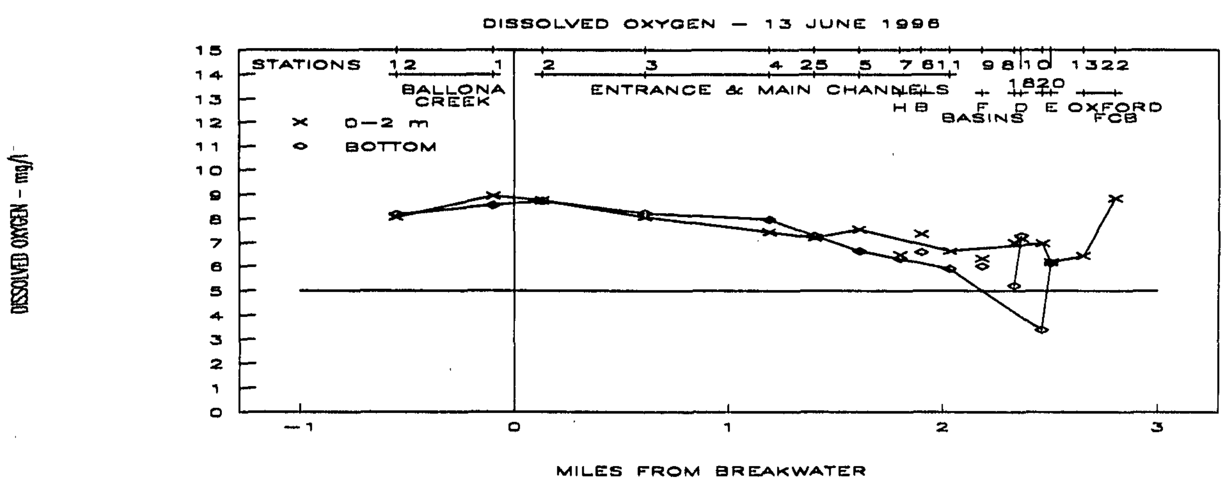


Figure II.33. Average dissolved oxygen (ppm), surface to 2m and bottom, 13 June 1996.

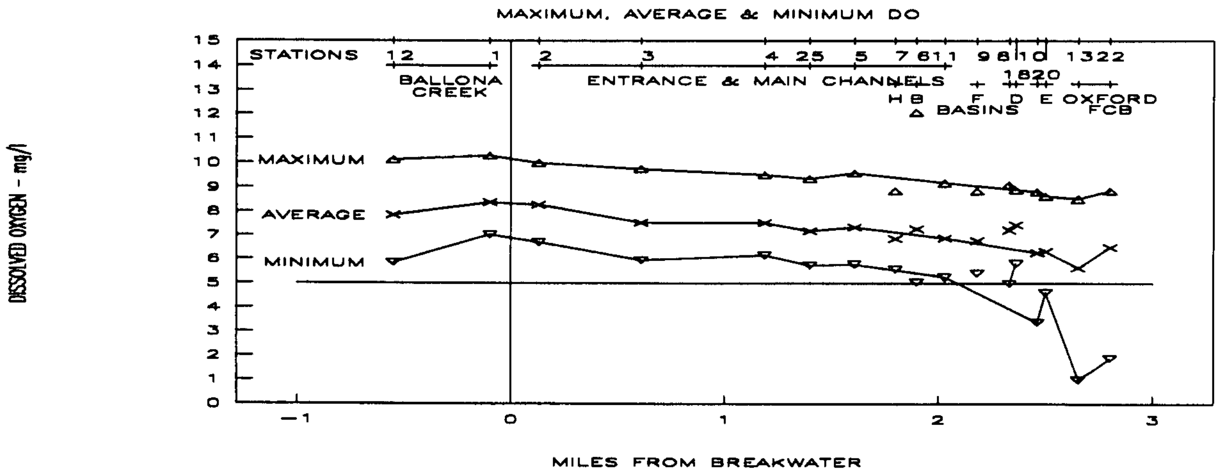


Figure II.34. Maximum, average and minimum dissolved oxygen (ppm) for all depths by station during July 1995 through June 1996.

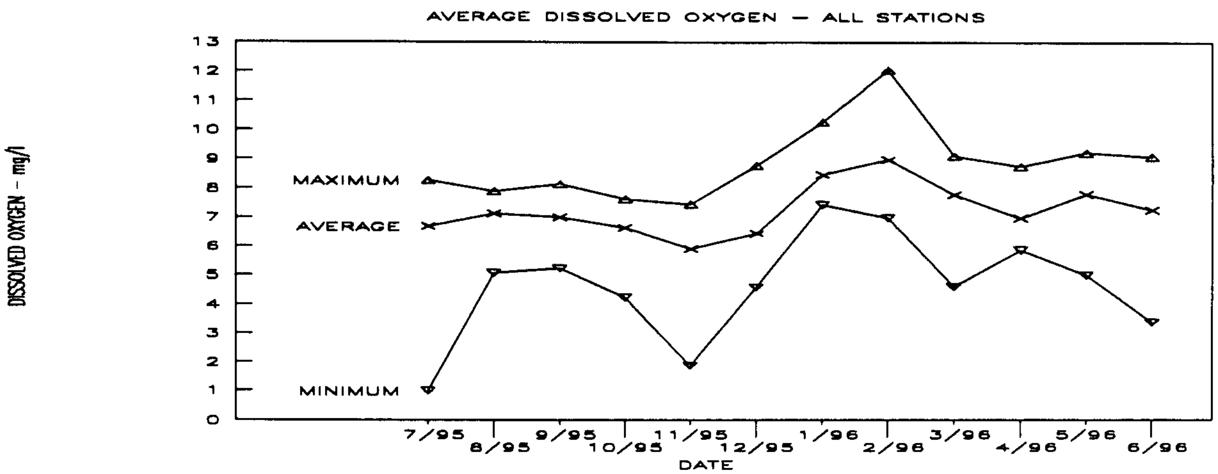


Figure II.35. Maximum, average and minimum dissolved oxygen (ppm) for all stations and depths including Ballona Creek and Oxford Basin by month, July 1995–June 1996.

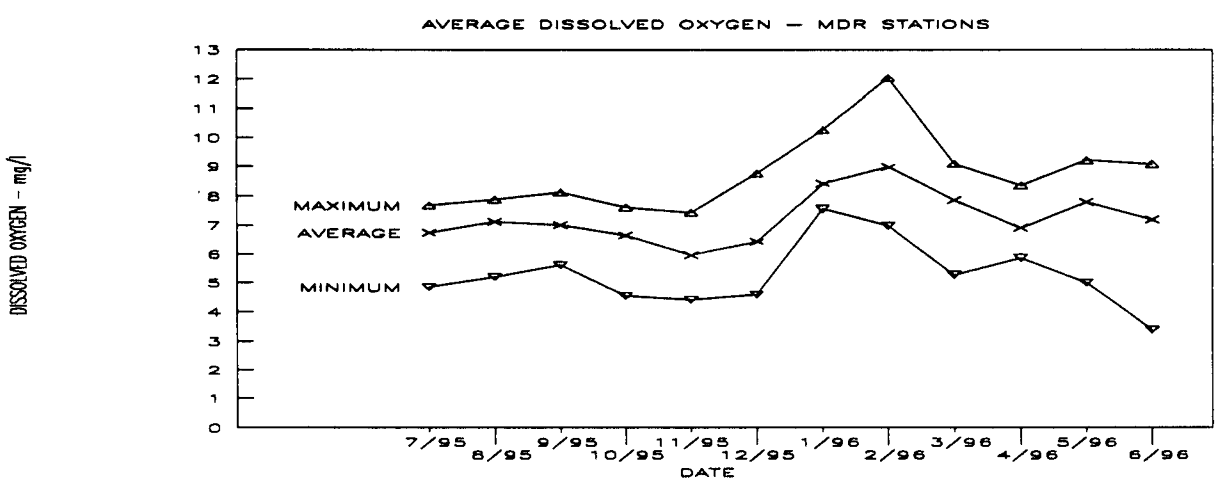


Figure II.36. Maximum, average and minimum dissolved oxygen (ppm) for all stations and depths excluding Ballona Creek and Oxford Basin by month, July 1995–June 1996.

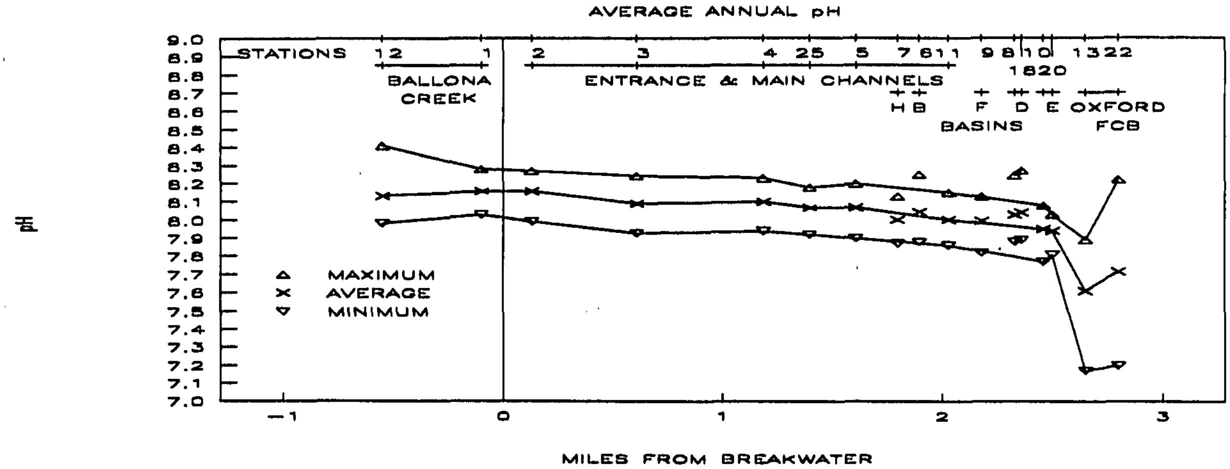


Figure II.37. Maximum, average and minimum pH for all depths by station during July 1995 through June 1996.

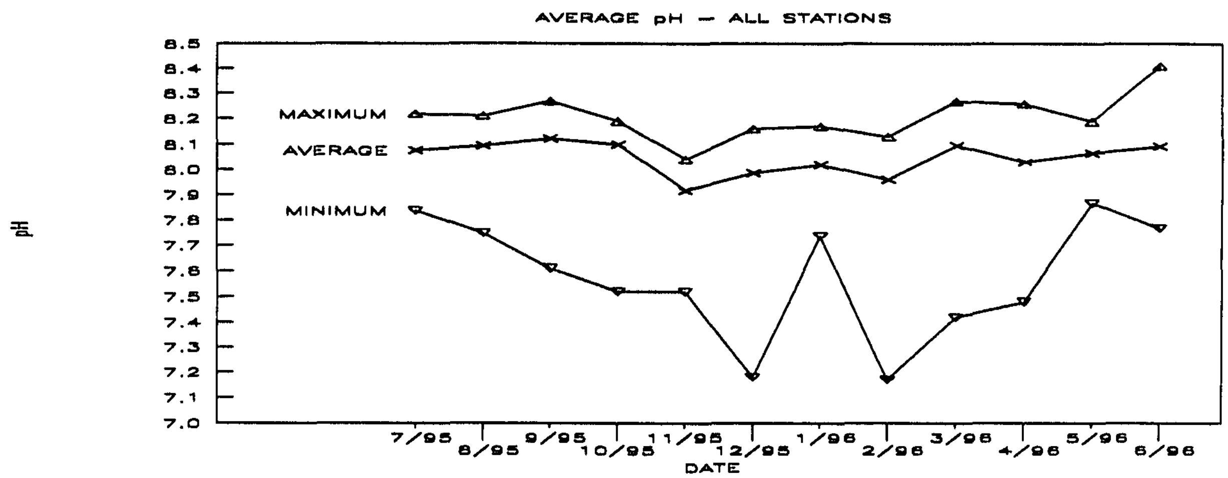


Figure II.38. Maximum, average and minimum monthly Ph for all stations AND depths including Ballona Creek and Oxford Basin, July 1995-June 1996.

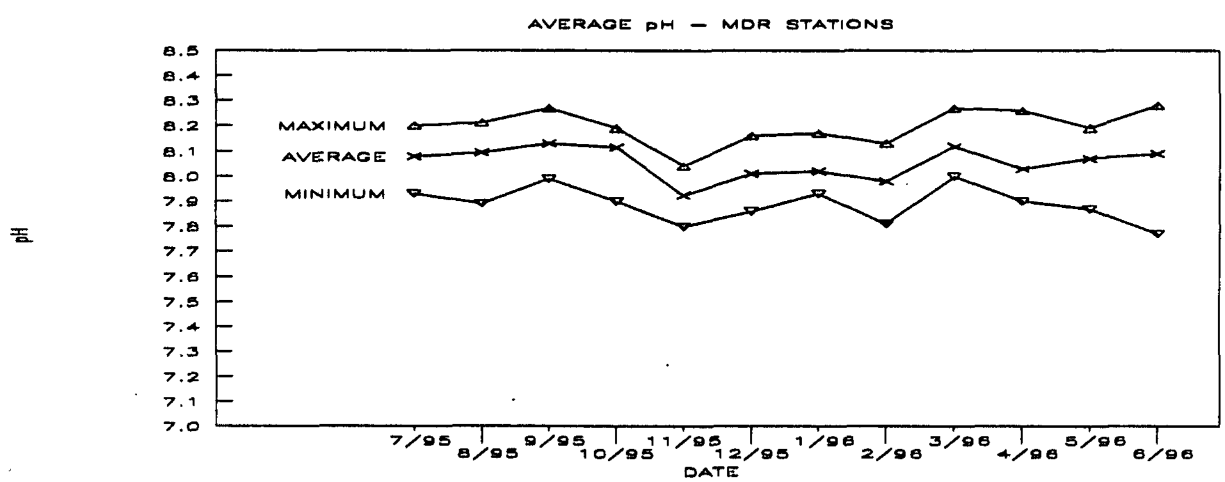


Figure II.39. Maximum, average and minimum monthly pH for all stations AND depths excluding Ballona Creek and Oxford Basin, July 1995-June 1996.

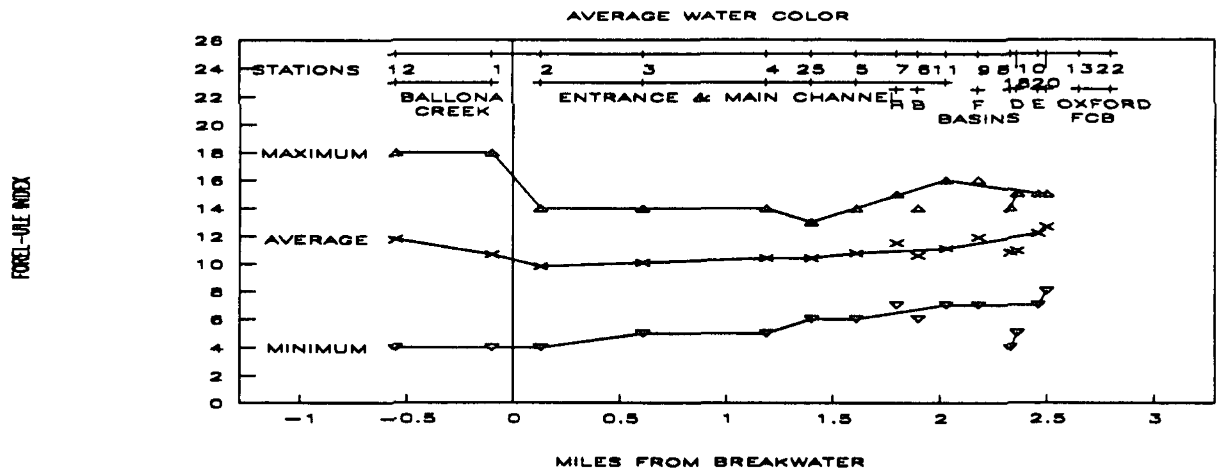


Figure II.40. Maximum, average and minimum Forel-Ule color values by station during July 1995 through June 1996.

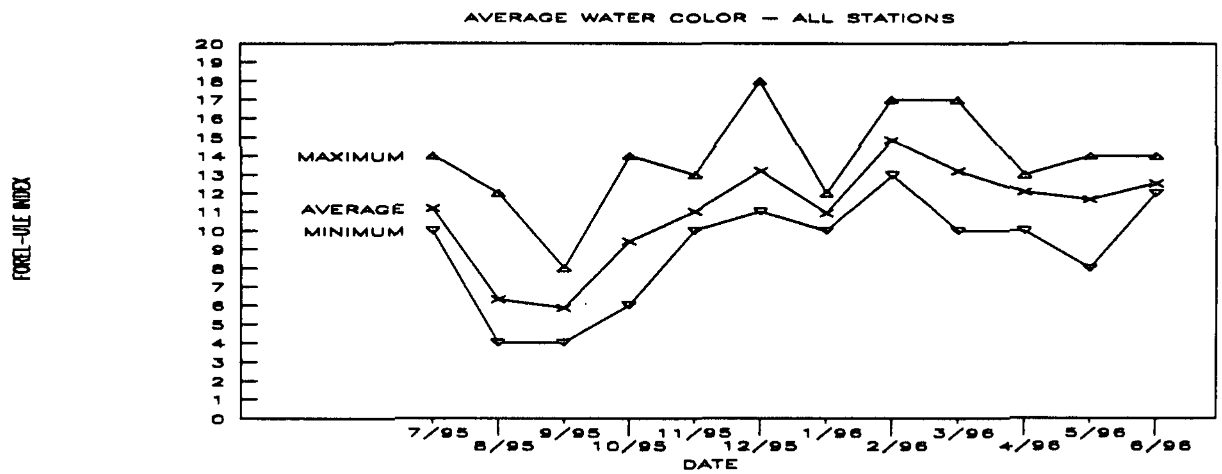


Figure II.41. Maximum, average and minimum Forel-Ule color values for marina stations including Ballona Creek during July 1995 through June 1996.

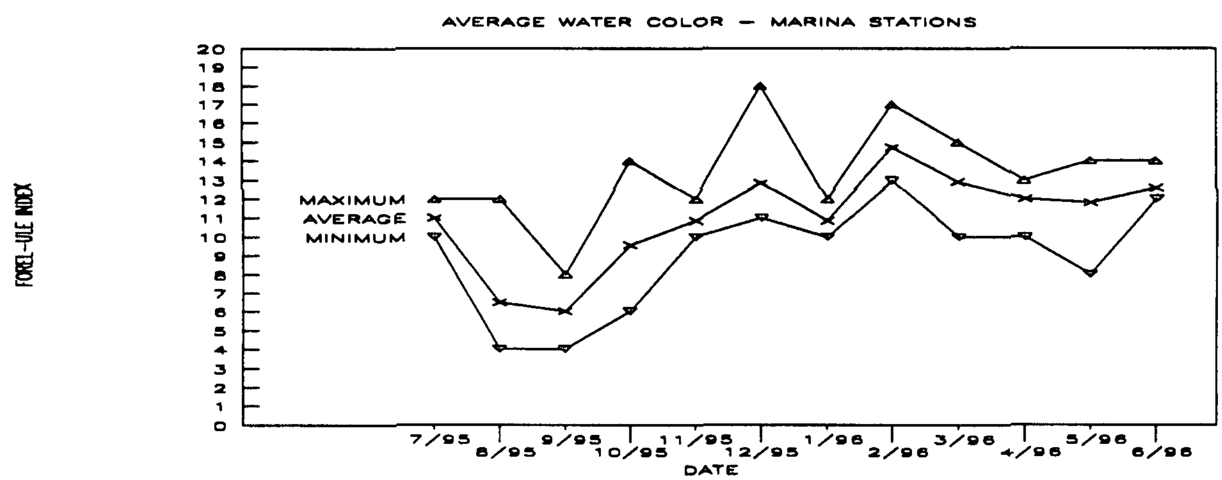


Figure II.42. Maximum, average and minimum Forel-Ule color values for marina stations excluding Ballona Creek during July 1995 through June 1996.

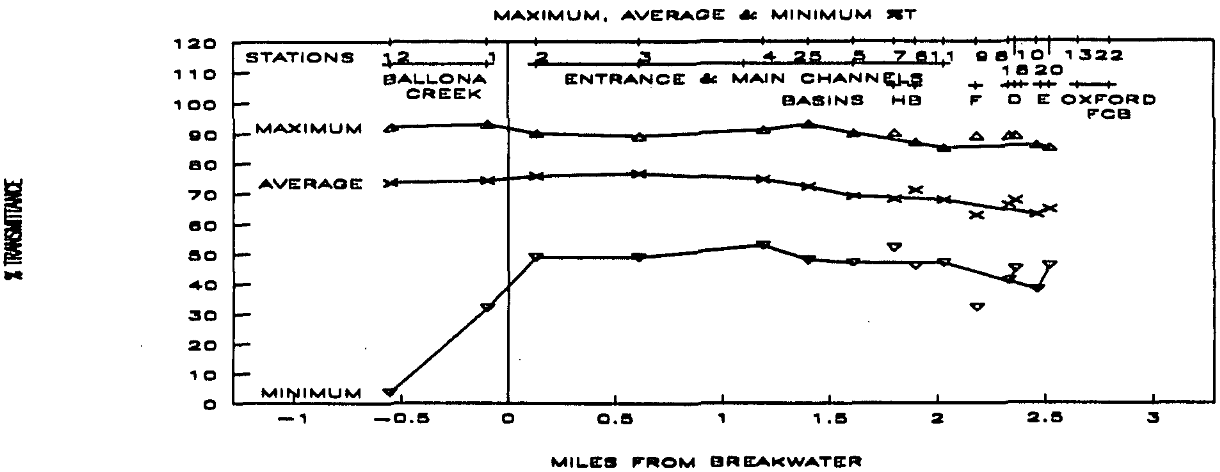


Figure II.43. Maximum, average and minimum percent transmittance by station during July 1995 through June 1996.

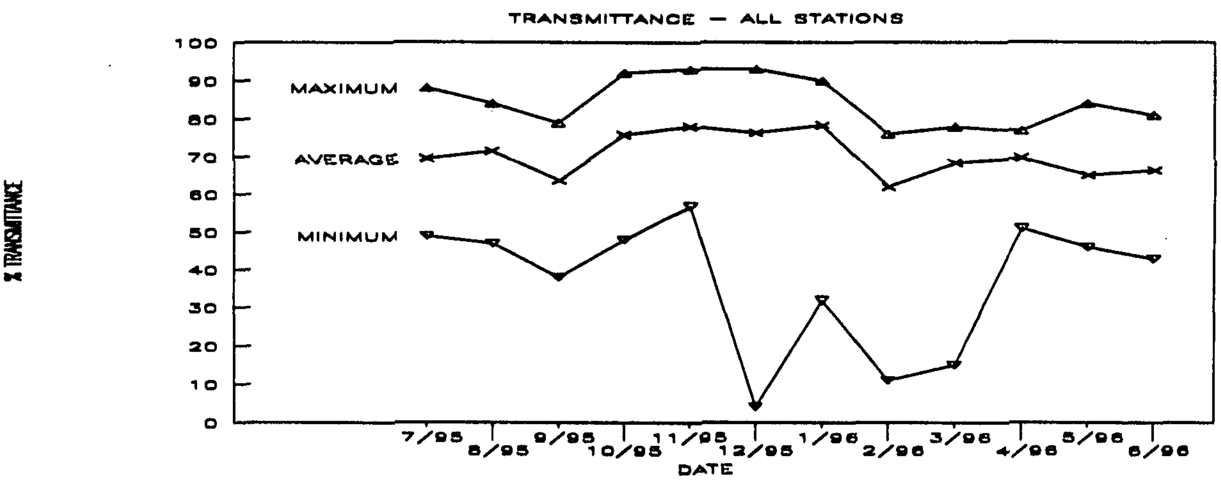


Figure II.44. Maximum, average and minimum percent transmittance for marina stations including Ballona Creek during July 1995 through June 1996.

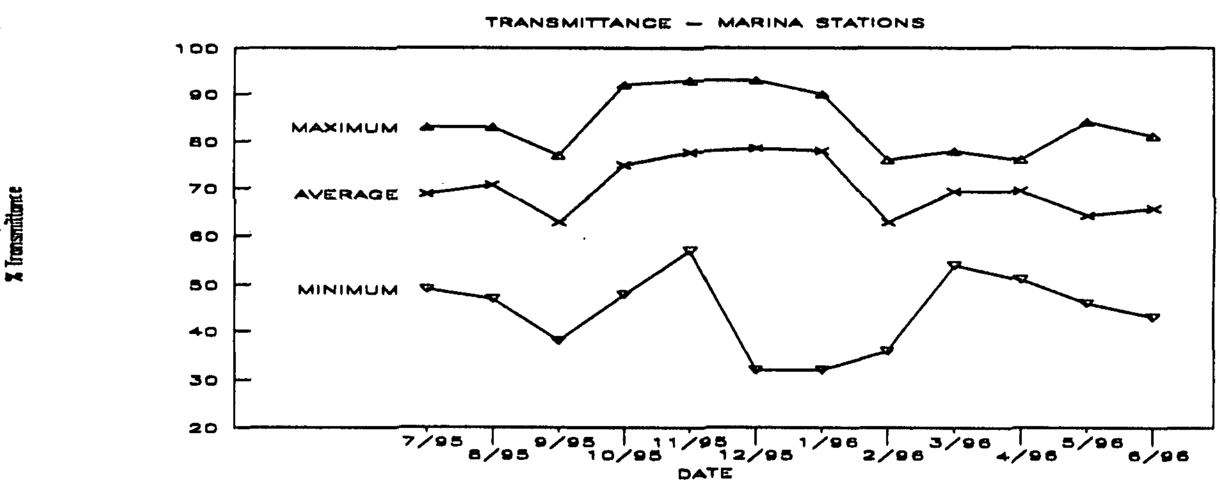


Figure II.45. Maximum, average and minimum percent transmittance for marina stations excluding Ballona Creek during July 1995 through June 1996.

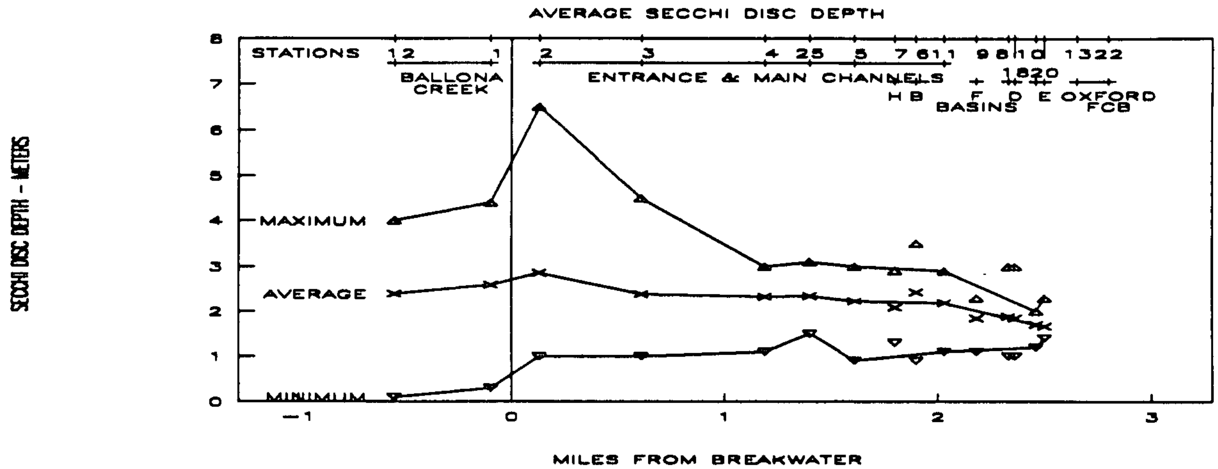


Figure II.46. Maximum, average and minimum Secchi disc depth (m) by station during July 1995 through June 1996.

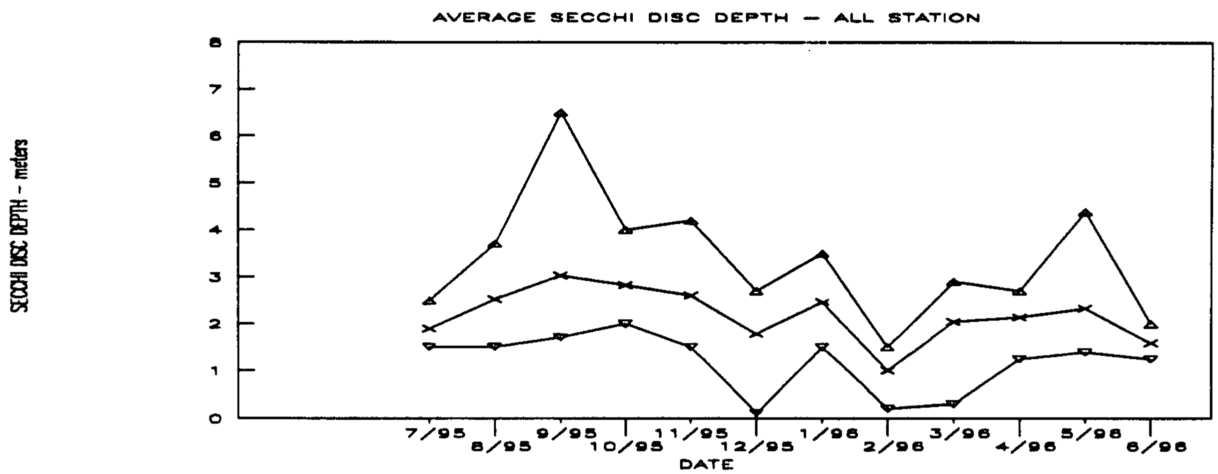


Figure II.47. Maximum, average and minimum Secchi disc depth (m) for marina stations including Ballona Creek during July 1995 through June 1996.

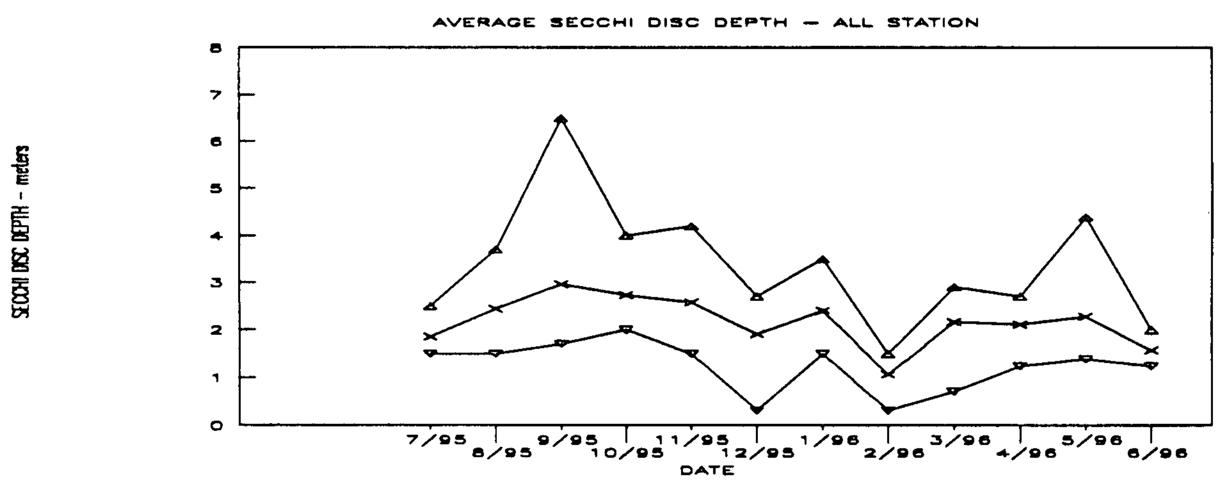


Figure II.48. Maximum, average and minimum Secchi disc depth (m) for marina stations excluding Ballona Creek during July 1995 through June 1996.

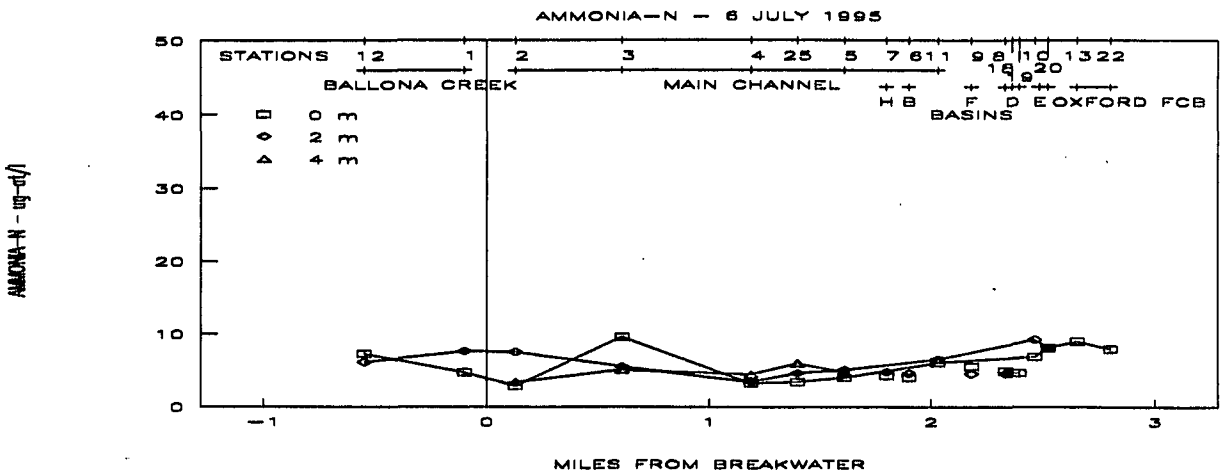


Figure II.49. Ammonia-N (ug-at/l), 6 July 1995.

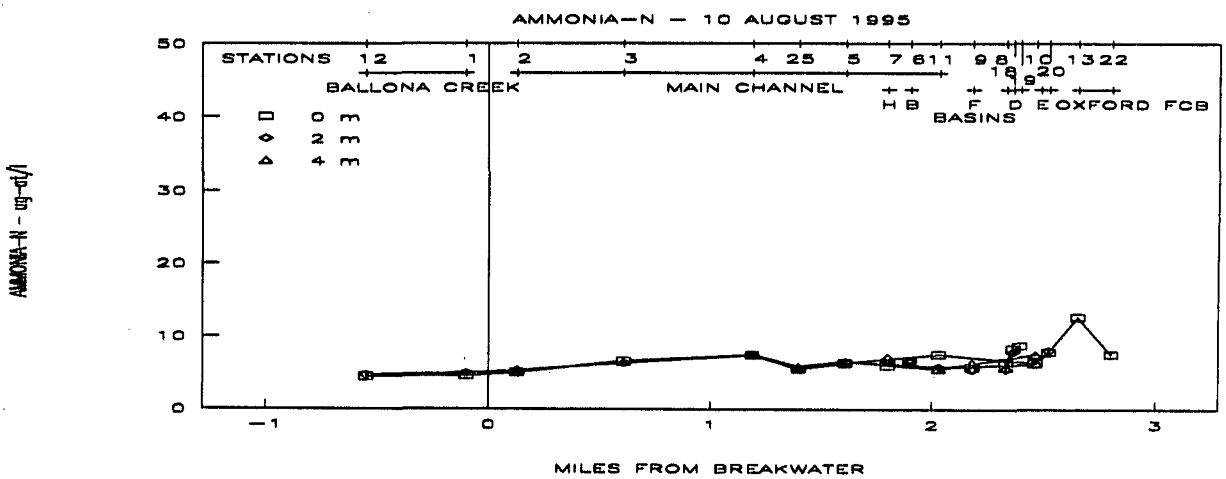


Figure II.50. Ammonia-N (ug-at/l), 10 August 1995.

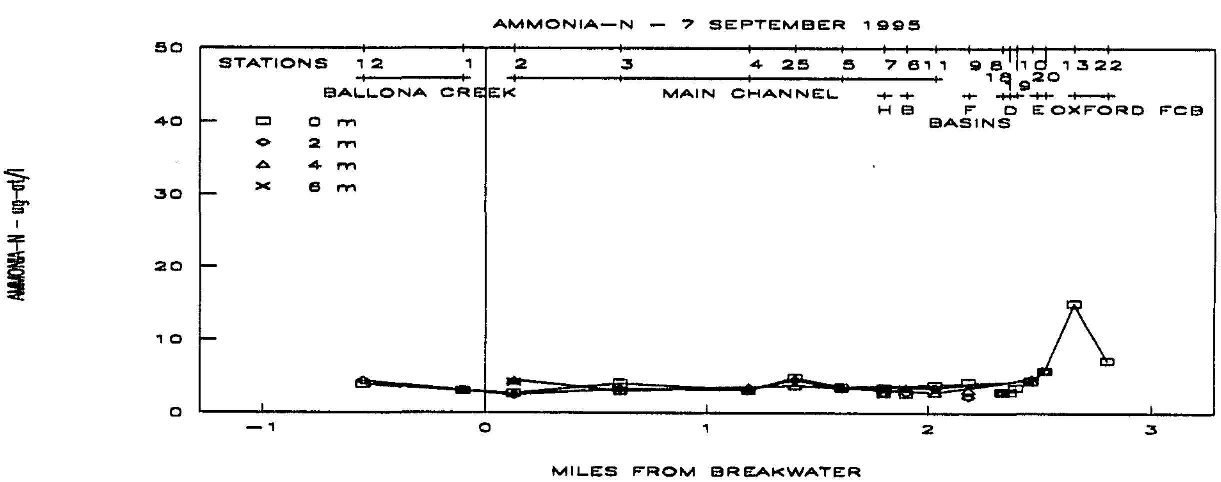


Figure II.51. Ammonia-N (ug-at/l), 7 September 1995.

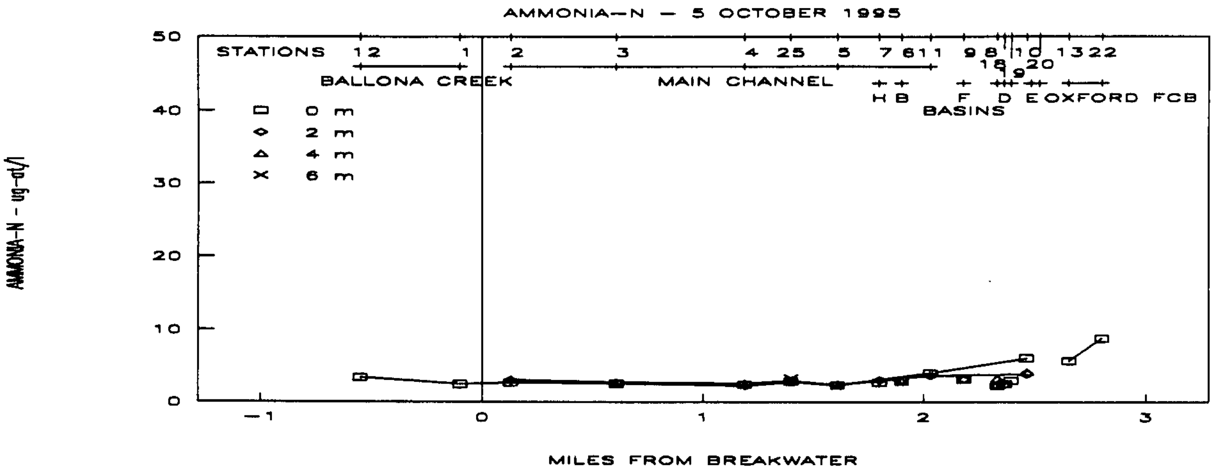


Figure II.52. Ammonia-N (ug-at/l), 5 October 1995.

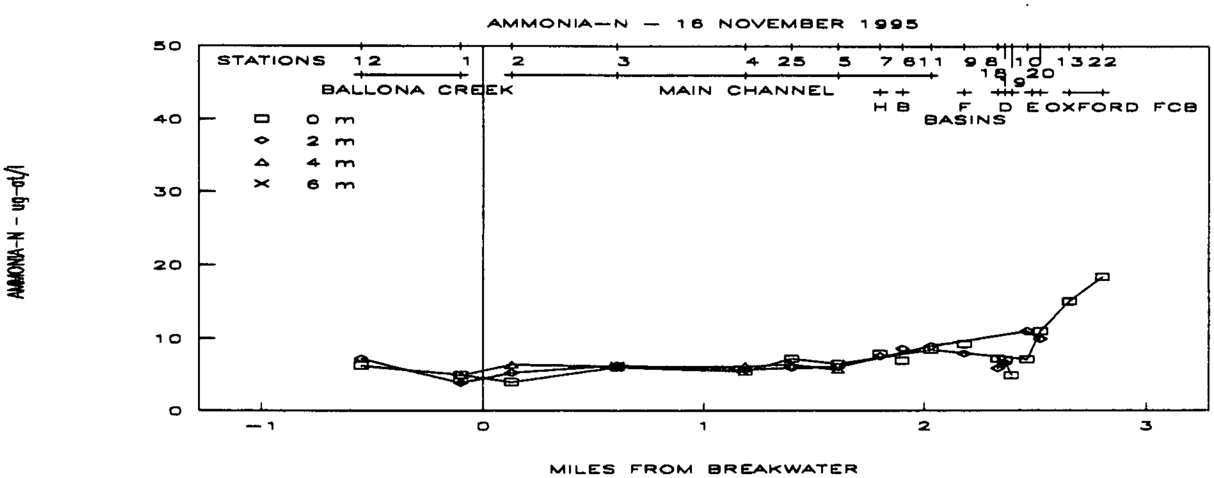


Figure II.53. Ammonia-N (ug-at/l), 16 November 1995.

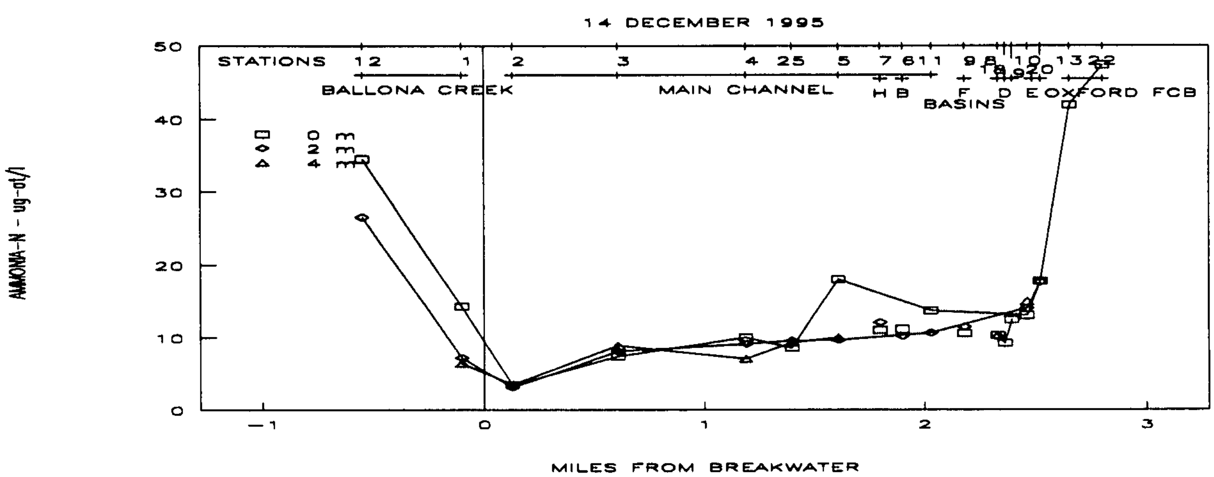


Figure II.54. Ammonia-N (ug-at/l), 14 December 1995.

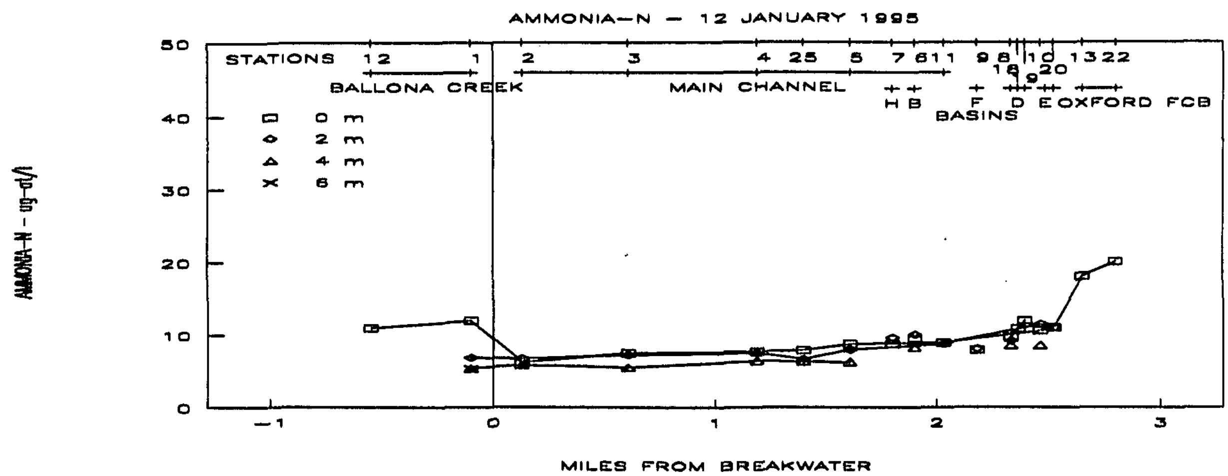


Figure II.55. Ammonia-N (ug-at/l), 4 January 1996.

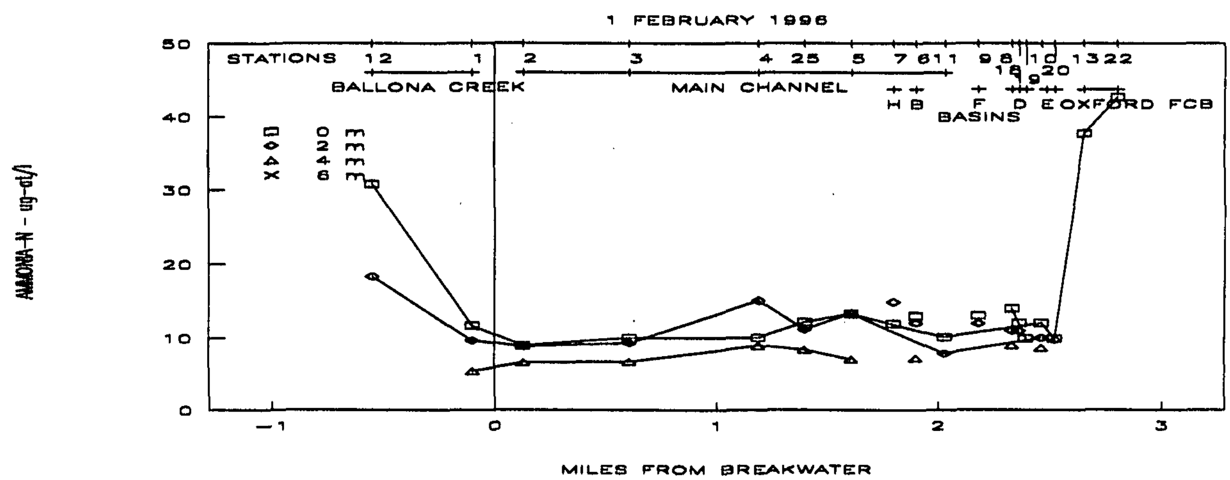


Figure II.56. Ammonia-N (ug-at/l), 1 February 1996.

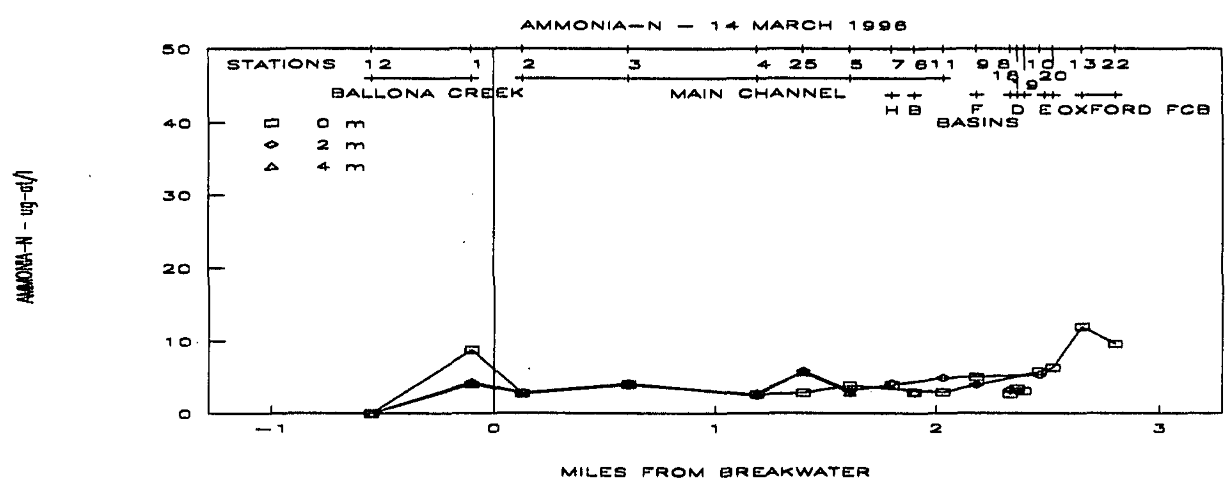


Figure II.57. Ammonia-N (ug-at/l), 14 March 1996.

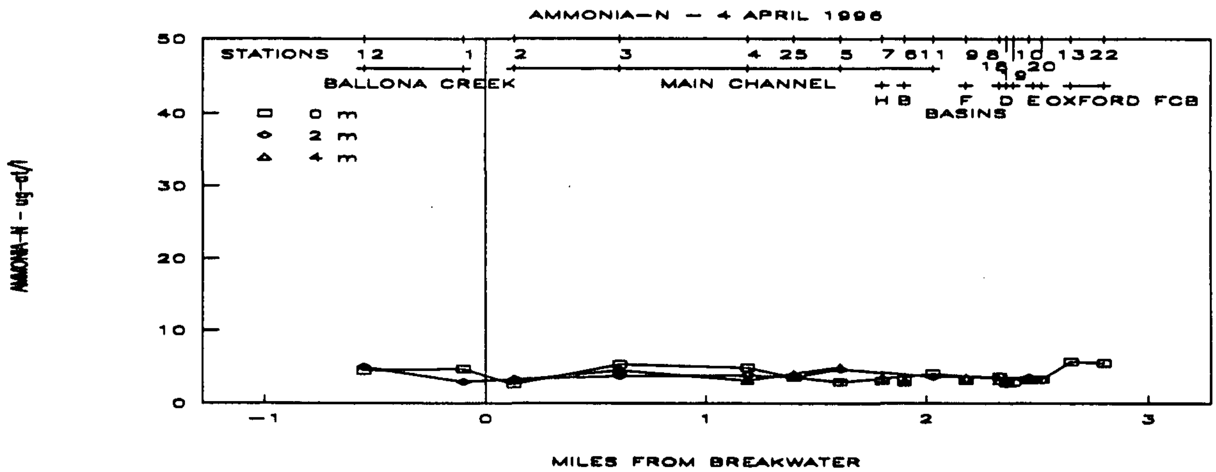


Figure II.58. Ammonia-N (ug-at/l), 4 April 1996.

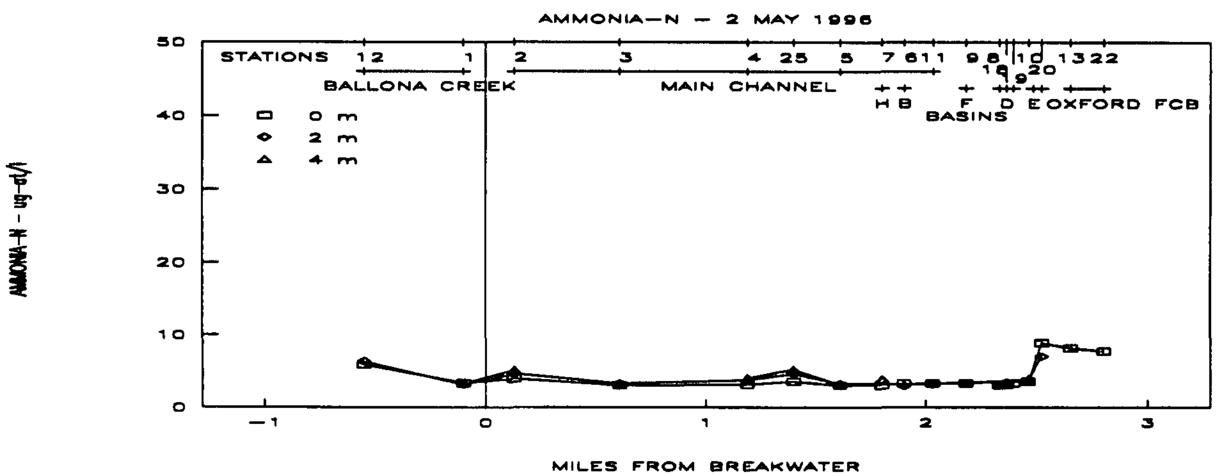


Figure II.59. Ammonia-N (ug-at/l), 2 May 1996.

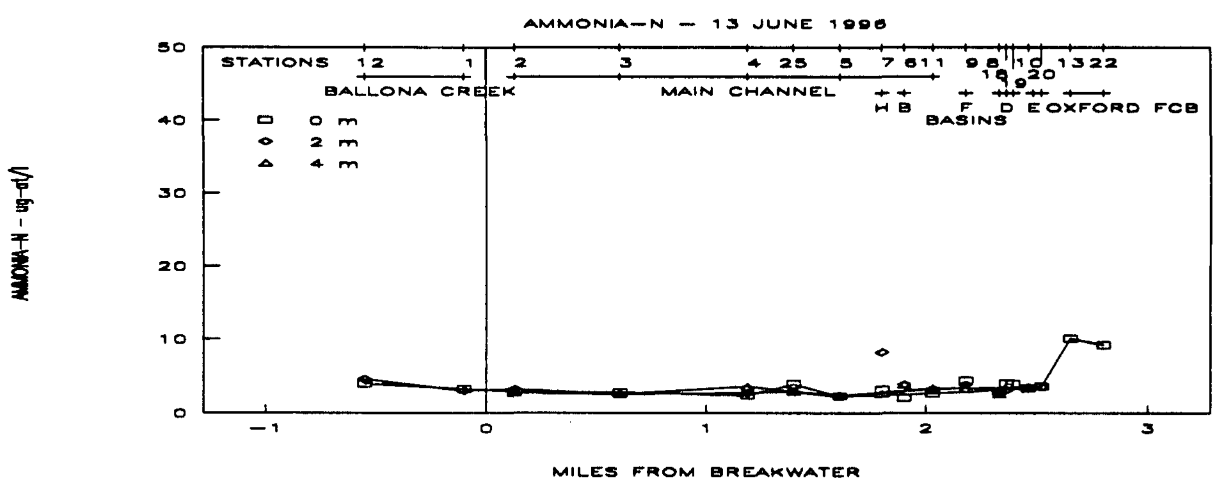


Figure II.60. Ammonia-N (ug-at/l), 13 June 1996.

III. SEDIMENT GRAIN SIZES

INTRODUCTION

The marina is a low energy environment due in part to its origin from a portion of historic wetlands, a large natural depositional area, and also to its configuration, constructed to protect vessels and installations from the ocean environment. The exceptions to the low energy regime occur in those periods of high rainfall runoff, extreme tides and/or to oceanic storm waves and surf originating from the south or southwest. The bottom (benthos) of the marina is largely composed of fine and very fine grained sediments that are replenished through stormwater runoff, local storm drains and tidal flux.

Sorting of sediments occurs in stormwater flows, with coarser grained materials settling out when velocity decreases, as at the mouth of Ballona Creek when the suspended contents of the narrow channel are released to spread into a wider area, either behind the breakwater or beyond it. Finer grained sediments are carried farther seaward into Santa Monica Bay in a spreading, muddy plume, to be gradually deposited over a large area as the plume is mixed with ocean waters by turbulence. Where tidal energy or runoff velocities are low and/or when sediment runoff is less, as it is in dry weather or low rainfall periods, fine sediments are deposited near small storm drains, in the inner basins and in the center of the main channel. In dry or low rainfall seasons, the finest grained sediments sometimes comprise more than ninety percent of the surface deposits in areas of the lowest tidal action.

Depositional Areas

Although the design depth of the basins has not generally been compromised by extensive deposition, in the inner Basin E area where Oxford Basin and the Washington Street drain are located, accumulation was so severe that it broke up docks by elevating them. The sediments deposited there from the large drains and from tidal flux in the marina were so contaminated that land disposal was required before the docks could be reconstructed during the summer of 1995.

The inner end of Basin D near Mothers' Beach is another site for deposition, where runoff from the beach carries fine grained sediments, to be met by tidal flow, which tends to cause deposition in the confined swimming area and near Station 8.

In low energy periods in summer or in low rainfall years, deposition also occurs at Station 5, in the middle of the main channel because the basins are only weakly flushed by storm drains, and sediments are deposited when basin flows meet the tidal flow in the center of the main channel. In years of heavier rainfall, this depositional area may move seaward toward the entrance channel. When sandbars have accumulated inside the breakwater and along the entrance channel jetties, a depositional area will occur in the entrance channel near Station 2, sometimes extending almost to Station 3. If the sandbars are not periodically removed, fine sediments, with their burden of complexed or adsorbed contaminants, will continue to settle out there regardless of the velocity and volume of stormwater flow.

Sand accretion along the jetty on the northerly side of the entrance channel, to some extent due to northwest winds that carry beach sand over and through the jetty, has been at least partly controlled. Littoral drift in nearshore waters in spring and summer brings sand from the north to the area as well. This jetty is a valuable underwater habitat for rocky shallow water fish species and can be entirely lost when a beach builds up in the channel so extensively that dogs play there at low tide.

Along the jetty on the southerly side of the entrance channel, flow from Ballona Creek is partly reflected off the breakwater, causing a decrease in velocity and consequent deposition behind the breakwater. In winter, the undercurrent that flows from the south and extreme tides and storms may also decrease flow velocity seaward. Storm winds and very large wave sets from the south can cause sand to be carried seaward or, more often, to be deposited in large amounts inside the breakwater and around the end of the southern entrance channel jetty.

Shifting sands between the jetties and the breakwater, especially during storms, can make entering and exiting the marina hazardous to vessels, particularly since the County Lifeguards, Sheriff and U.S. Coast Guard may be called out during storms. The south entrance is avoided by many vessels on that account, although the most recent dredging in spring 1996 greatly improved both the north and south entrances.

The Breakwater and the Need for Dredging

Originally, research on a physical model of the planned marina at the Corps of Engineers facility in Vicksburg, Mississippi indicated that no breakwater was necessary, although there was no test wave machine at that time. The first year after facilities were opened in Basin A, winter storms from the south sent waves up the entrance channel to reflect off the seawall where the administration docks are now and across the main channel, damaging boats and facilities in Basin A. Construction of the breakwater greatly reduced energy flow into the marina but cannot control it entirely, as evidenced in 1985 when storm swells damaged the administration dock, requiring its reconstruction and improvement.

The reduced energy created by the breakwater, which causes deposition behind it and along the jetties, necessitates dredging to maintain entrances into the marina. Unfortunately, no schedule of routine maintenance dredging for the marina, such as that used in commercial ports, is maintained by the Corps of Engineers, which is responsible for the navigable channel.

In recent years dredging has been sporadic and subject to lengthy negotiating over permits to dredge and dispose of sediments. If dredging is done as needed, sediments are much more likely to be of acceptable quality to use for badly needed beach replenishment, but if dredging is delayed for years, contaminated fine sediments will have accumulated on and behind the sandbars to the point where they cannot be deposited on beaches or disposed of at sea. Natural beach replenishment has been greatly diminished in southern California by construction of dams and concreting of river channels, which deprives the coast of the rock and gravel that becomes sand as it is ground down in rivers or during transport at sea.

In 1987, 131,000 cubic yards (cy) of sediment were removed from the tips of the jetties and the mouth of Ballona Creek; in 1992, a so-called knockdown removed only 17,000 cy from the south jetty of the entrance channel, and in November-December 1994, 57,000 cy were removed from the ends of the jetties and Ballona Creek mouth. The record rainfall, which flushed the creek mouth and an influx of ocean sediments in storms in 1994-1995, plus the moderate amount of sediment removal in late 1994, made the sand suitable for beach replenishment in March and April 1996 when 230,000 cy were dredged.

Although dredging is temporarily very disruptive to fish species that normally inhabit the rocky breakwater and jetties, the impact of sedimentation in those areas is severe; sediment irritates gill and mucus membranes of fish and covers the algae and small invertebrates that normally provide their food. When sandbars act like a cork in a bottle, decreased circulation in the marina inhibits the influx of fish eggs and larvae and forage fish throughout the marina, as can be seen in the fall 1995 surveys (Chapter VIII). As soon as dredging was completed in the spring of 1996, the fish diversity and numbers increased dramatically at the breakwater and jetties. Invertebrates are also affected by sedimentation and turbidity at the breakwater and jetties, although the common soft bottom benthic organisms from adjacent areas generally reproduce rapidly enough to reoccupy that habitat, sometimes within weeks; however, scarce species may disappear.

METHODS

Sediment samples were taken from the same benthic grabs that were sampled for sediment chemistry and screened for benthic organisms. Grain sizes are determined by sieving samples through a series of screens having various mesh sizes, with the lowest number, 25, representing the largest sized sand particles, increasing through 35, 60 100 and 200 up to the <200 screen mesh size for the smallest grained sediments. Screen number is thus inversely proportional to the size of sediment grains. During the period covered by this report, sediments were sampled on 26 October 1995 in conjunction with sampling for benthic chemistry and fauna.

RESULTS AND DISCUSSION

The 1995 survey followed the July 1994-June 1995 rainfall year of record rainfall, with 46.7 inches (") in the northeast Los Angeles basin, even higher than the 46.5 " during the July 1992-June 1993 season. In contrast, sampling on 29 September 1994 followed the July 1993 - June 1994 year of low rainfall, totaling 14.95" and a dry summer.

Ballona Creek and the Entrance Channel

Soule et al. (1996) discussed the differences in the amounts of the finest sediments, particularly in Ballona Creek and the entrance channel, between low rainfall and high rainfall years. Fine sediments accumulate in low rainfall years and to a lesser extent during the dry summers. Comparison of the surveys in April and September 1994 (Tables III.1, 2) illustrate the increase in deposition in Ballona Creek during the dry season when summer flows are low.

In wet years, there is a large decrease in the finest sediments and an increase in the coarser fractions in the creek bed at Station 12 and 1. Sediment grain size in the October 1995 survey (Table III.3) was influenced greatly by the record high rainfall year of 1994-1995, and presumably by dredging in November and December 1994. In Ballona Creek, the coarser grained sediments (screens 25 and 35 mesh) increased at Station 12 from a total of 19.7 percent in fall 1994 to 42.1 percent in fall 1995, and at Station 1 from a total of 0.6 percent to 25 percent.

On the other hand, the percent finest sediments (<200 mesh screen) at Station 12 increased from 34.79 percent in the spring of 1994 to 46.5 percent in the fall of 1994, representing accumulation in the channel over the summer. The fines decreased to 22.7 percent in fall 1995 following the record rainfall season, an approximately 50 percent reduction. At Station 1, the decrease was from 34.5 percent in fall 1994 to 7.7 percent in fall 1995, or almost 80 percent reduction, which illustrates the greater flushing at the mouth of Ballona Creek and the greater accretion in the creek bed upstream but still well within the tidal reach at Station 12.

Station 2 has a lower level of flushing than Ballona Creek, and the larger two grain sizes actually decreased between 1994 and 1995. The finest sediments decreased somewhat from 34.8 percent to 27.3 percent, with small increases in the intermediate sediment sizes.

The finest grained sediments almost doubled between 1994 and 1995 at Station 3, which receives the outflow from Ballona Lagoon and the Venice Canal system, whereas

Table III.1. Percent grain size in Marina Del Rey, 21 April 1994 (particle size decreases with increasing screen mesh size), following spring storms, low rainfall year.

Mesh size Station	25	35	60	100	200	<200
1	5.44	12.80	50.59	19.99	10.04	1.16
2	1.59	1.20	2.22	8.11	48.08	38.98
3	2.69	14.86	61.56	11.52	1.34	8.03
4	0.66	0.36	0.99	6.31	38.47	53.21
5	0.21	0.22	0.34	0.82	3.58	94.83
6	0.26	0.24	2.50	11.52	36.38	49.10
7	0.14	0.03	0.26	1.72	15.57	82.28
8	31.06	3.50	4.55	5.09	8.75	47.05
9	0.52	0.16	0.30	0.48	1.28	97.26
10	1.66	1.12	2.68	2.95	4.64	86.95
11	0.00	0.03	0.04	0.07	0.21	99.65
12	7.00	10.76	25.81	12.48	9.16	34.79
13	58.42	6.83	14.24	10.58	8.17	1.76
22	44.77	4.13	8.53	8.11	9.77	24.69
25	0.14	0.10	0.44	1.50	11.77	86.05

Table III.2. Percent grain size in Marina Del Rey, 29 September 1994 (particle size decreases with increasing screen mesh size), following low rainfall year, dry summer.

Mesh size Station	25	35	60	100	200	<200
1	0.30	0.30	2.40	10.20	52.40	34.50
2	1.40	0.80	1.80	8.70	52.60	34.80
3	6.20	16.30	50.70	8.10	1.00	17.70
4	0.30	0.20	1.00	5.00	36.70	56.90
5	0.20	0.10	0.20	0.70	3.00	95.80
6	0.10	0.10	1.30	9.90	33.00	55.60
7	0.10	0.10	0.60	2.60	20.50	76.10
8	0.10	0.70	4.50	14.80	28.10	51.90
9	1.90	0.70	1.00	1.20	2.80	92.40
10	0.30	0.20	0.80	1.90	4.30	92.40
11	0.50	0.20	0.30	0.30	0.40	98.40
12	12.50	7.20	13.90	10.00	9.90	46.50
13	49.90	7.20	10.60	6.70	5.60	20.00
22	30.30	6.30	10.80	7.90	8.70	35.90
25	0.30	0.20	0.60	1.90	9.40	87.40

Table III.3. Percent grain size in Marina Del Rey, 26 October 1995 (particle size decreases with increasing screen mesh size), following a record rainfall year and a dry summer.

Mesh size Station	25	35	60	100	200	<200
1	11.0	14.0	43.5	16.2	7.6	7.7
2	0.4	1.0	2.3	12.3	56.7	27.3
3	2.1	8.9	46.2	9.8	1.9	31.0
4	0.2	0.1	0.1	4.3	39.4	55.9
5	0.1	0.1	0.3	2.0	10.0	87.6
6	0.1	0.3	3.5	20.8	30.4	45.0
7	0.1	0.2	1.1	5.9	31.6	61.1
8	0.1	0.2	0.9	2.7	9.2	86.9
9	0.1	0.1	0.2	0.5	3.0	96.2
10	2.0	1.7	4.6	5.4	9.0	77.3
11	2.8	2.3	2.9	0.5	2.3	89.3
12	15.8	26.3	27.3	4.3	3.5	22.7
13	30.1	7.3	13.3	11.6	11.5	26.2
22	25.1	5.7	11.0	9.8	12.1	36.3
25	0.1	0.3	0.7	1.7	11.2	86.1

there was almost no change in the characteristics at Station 4, a calm area just seaward of the Coast Guard docks. **Figures III.1, 2, 3 and 4 indicate that the greatest diversity and variability of grain sizes occurs in the areas most influenced by Ballona Creek storm water runoff and oceanic waters. The 1991 survey showed the highest levels of very fine sediments, following several years with low rainfall and a minimal fall rains prior to the fall 1991 sampling.** Rainfall records in northern Los Angeles basin (Appendix E) indicate the potential stormwater runoff which will enter flood control channels like Ballona Creek, although amounts are generally higher in the foothills than those along the coast (Chapter II). The total in 1986-86 was only 6.8", 1987-88 totaled 12.1", 1988-1989 totaled 13.45, 1989-90 had 9.9" and 1990-91 15.9"; years of low rainfall apparently caused an accumulation of fine sediments that were not carried seaward by the low runoff but settled out in the marina. In contrast, 1992-93 rainfall totaled a then-record 46.54", and 1994-95 totaled 46.7".

Station 3 is affected by both oceanic waters and Ballona Creek, but also is subjected to considerable sedimentation from the Ballona Lagoon-Venice Canals system. Following earlier excavations in the lagoon, waters were heavily muddied, but conditions were improved by the removal of contaminated sediment..

The Main Channel

Station 4, located seaward of the Coast Guard docks, is in a relatively quiet area at the confluence of the entrance channel and the main channel. It contains chiefly sediments of 200 mesh or <200 mesh, which have at times been inversely proportional to each other. There are only small amounts of more coarsely grained materials; this is also true at Station 25, between the Life Guard docks and the public fishing pier (Figures III.5 and III.6).

Station 5, in the center of the main channel, has a very high percentage of the <200 screen fine sediments. It too showed an alltime peak in fines in 1991, followed by small decreases until 1995 (Figure III.7), which indicated the increase in flushing after the record rainfall years in 1992-93 and 1994-95.

The Basins and Inner Marina

The basin stations on the westerly side of the marina have more variation in sediments than those on the easterly side where there is more terrestrial and street drainage. Station 6, in Basin B on the westerly side, is generally the cleanest of the basins and has a more diverse sediment structure, having lesser percentages of the <200 fraction, although it is usually dominant, and higher percentages of medium grained sediments. Station 7, about the same distance from the entrance but on the easterly side, has less diversity and variability and a higher percentage of the <200 fraction sediments (Figures III.8 and III.9).

Stations 8 and 9 are about the same distance from the entrance, but differ markedly (Figures III.10 and III.11). Station 8 in Basin D is near the beach area at the inner end and consequently has a more diverse grain size structure, but it shows distinct incidences of influxes of the finest sediments. Peak years for the <200 fraction were 1991 and 1995 but probably for different reasons; the 1991 peak may have represented the accumulation during the dry years, followed by a large decrease. However, the large increase in fall 1995 following the record rainfall year may represent unusually severe runoff which carried sediments washed from the beach into the slip area, where the station is. In contrast, Station 9 shows little variation from year to year, and is always dominated by the <200 grain size fraction, to the extent that the other fractions were almost indistinguishable.

Station 11, at the end of the main channel, is more typical of a basin than of the channel since closely quartered docks were placed there several years ago. As seen in Figure III.12, the <200 screen fraction dominates, although it decreased from 98.4 percent in fall 1994 to 89.3 percent in fall 1995, with small increases in the coarser fractions.

Station 10, near the inner end of Basin E, has shown more variation (Figure III.13) than Station 11, due to variation in flow from Oxford Basin and the Washington Street drain, and to excavation at the docks. Page A.16 in Soule et al. (1996) showed photos of the transition at Station 10 from disrupted docks to reconstruction and, finally, to docking of much larger vessels in 1995.

Oxford Basin

Station 13, just inside Oxford Basin beyond the tidegate from Basin E, showed great variation in the amounts of the finest fraction, peaking in 1991 and decreasing to the lowest percentage of the finest fraction in April 1994, after which the fines increased slowly. There is much more diversity in the grain size structure, since the basin is essentially a terrestrial basin that is tidally flushed to varying degrees. Station 13 is flushed with higher velocity because of the narrowing of the channel through the tidegate to Basin E, moving the finest fraction on into the marina or tidally depositing fines at the inner end of Oxford Basin. The coarsest fraction of 25 screen size is well represented there (Figure III.14).

Station 22, at the inner end of Oxford Basin, was not sampled until 1990 for grain size. Figure III.15 shows that the peak period for the finest grained fraction was in 1991, after which that fraction decreased greatly to April 1994; subsequently the percent rose somewhat in fall 1994. Conversely, the coarsest fraction rose to a peak in April 1994, after which it declined. Reconstruction of drainage and installation of a pumping station above the inner end of Oxford Basin after severe flooding in adjacent streets in recent years may have been at least partly responsible for the decrease in fines after 1991.

Average Grain Size

A plot of the average grain size for all stations on an annual basis from 1988 to 1995 clearly shows the dominance of the finest grained sediments of <200 screen mesh size, with the 200 mesh size second but at much lower levels. **The peak year for the finest silt was 1991 by far, at the end of a period of five years of low annual rainfall. This indicates the accretion of the finest sediments during low energy periods.**

CONCLUSIONS

No area of the marina can be considered decoupled from the interactions of tidal flux, oceanic storms and rainfall runoff in storm drains and flood control channels. In low rainfall years and during low flow summer periods, fine sediments accumulate at the mouth of Ballona Creek and in the basins and decrease according to the increase in flushing during high rainfall winter seasons. The coarsest sediments increase in wet seasons as new sediments are carried in runoff or are uncovered by flushing away of the finest grained sediments, depending on the location of the site considered.

The finest grained sediments (200 or <200 screen mesh size) carry the most contaminants complexed or adsorbed on their surfaces due to their high surface to volume ratio. In low energy periods, tidal circulation alone will redistribute sediments throughout the marina, causing them to settle in the lowest energy areas: the shallowest sites, areas where narrow channels widen out reducing velocities, or sites where flows from two or more directions meet, creating a slack area. When the marina was constructed, routing storm drains into the basins was economical and was perceived as helping to assist in flushing, without understanding that high levels of contaminated sediments might be introduced as well. No environmental studies were performed before or after construction.

Sediments accumulate at the end of Ballona Creek and behind the breakwater as a consequence of natural phenomena. The sandbars act as a cork in a bottle, causing more contaminated sediments to settle out in the marina and decreasing flushing so that dredging is necessary on both physical and ecological grounds.

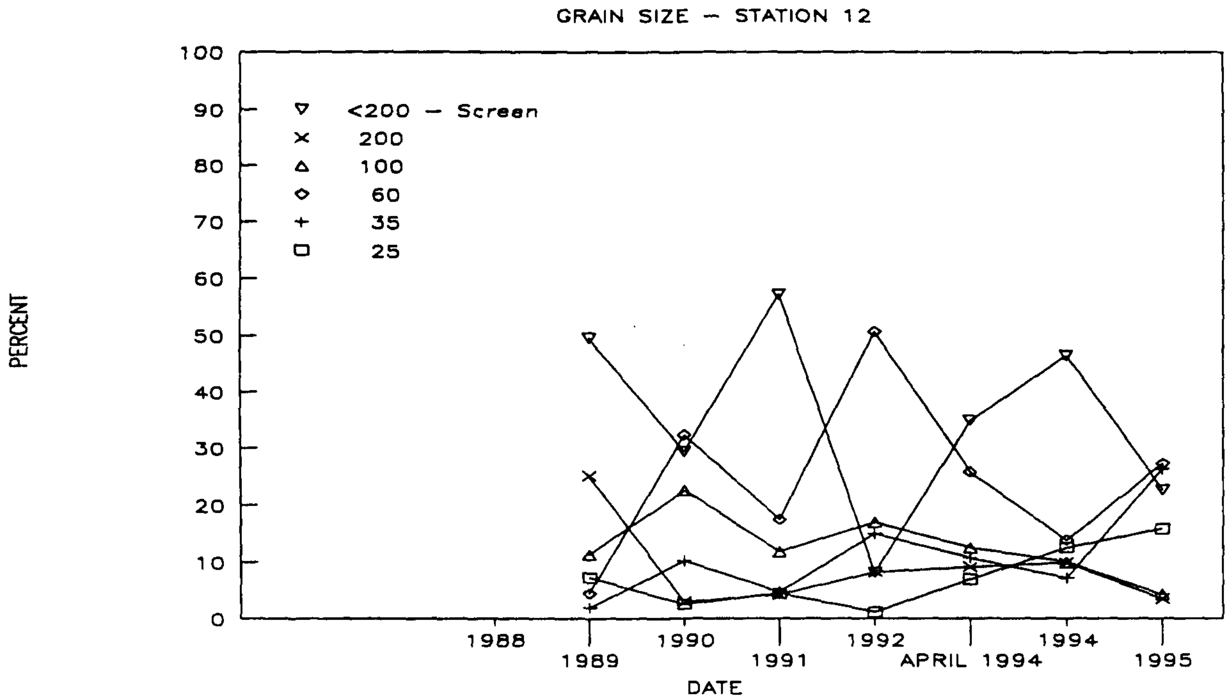


Figure III.1. Grain size distribution in sediments from Station 12, 1988–1995. All samples were collected in fall months except for April of 1994.

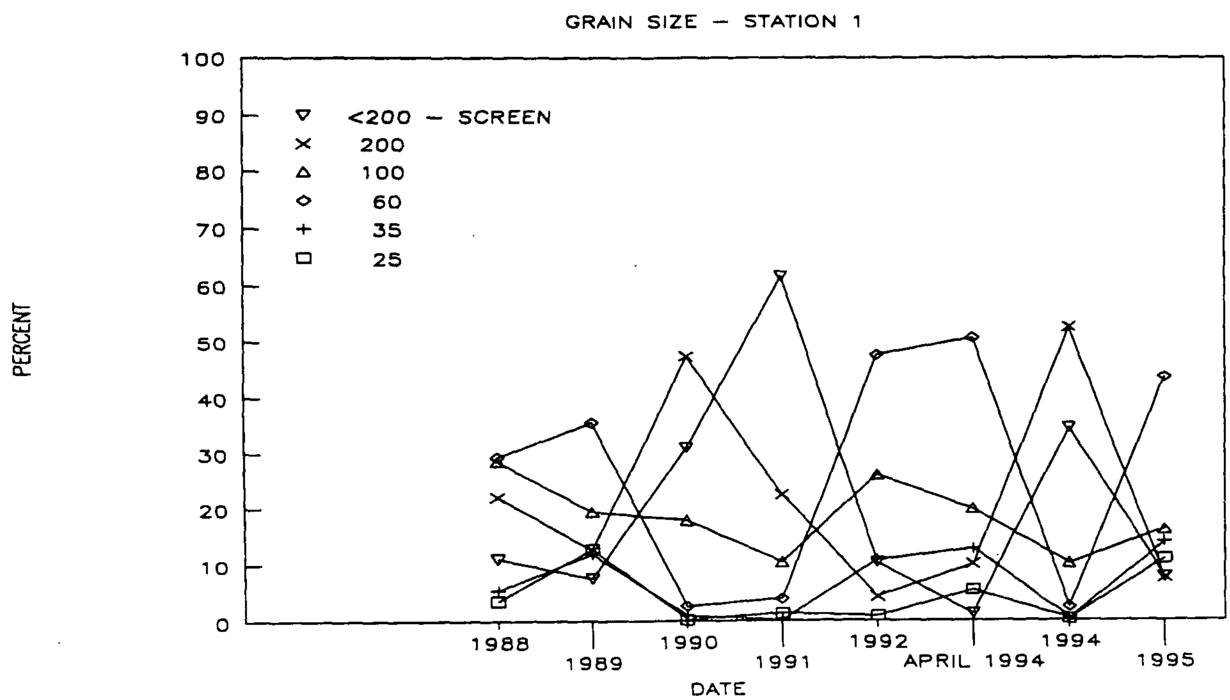


Figure III.2. Grain size distribution in sediments from Station 1, 1988–1995. All samples were collected in fall months except for April of 1994.

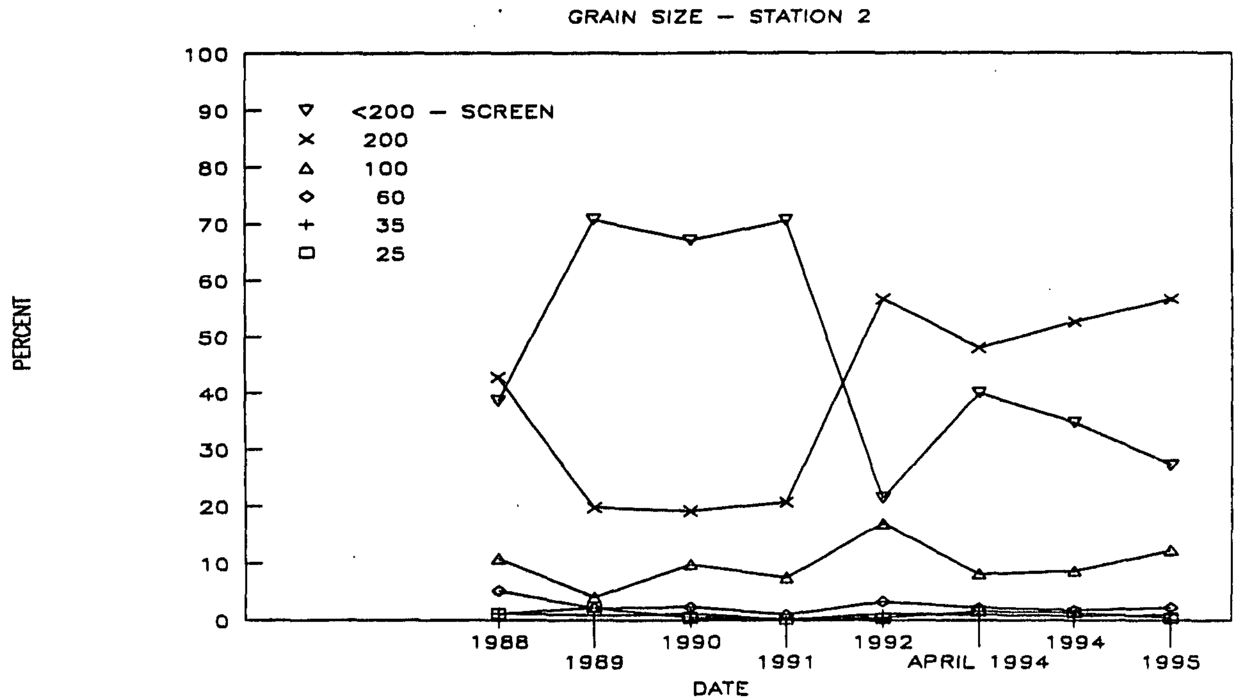


Figure III.3. Grain size distribution in sediments from Station 2, 1988–1995. All samples were collected in fall months except for April of 1994.

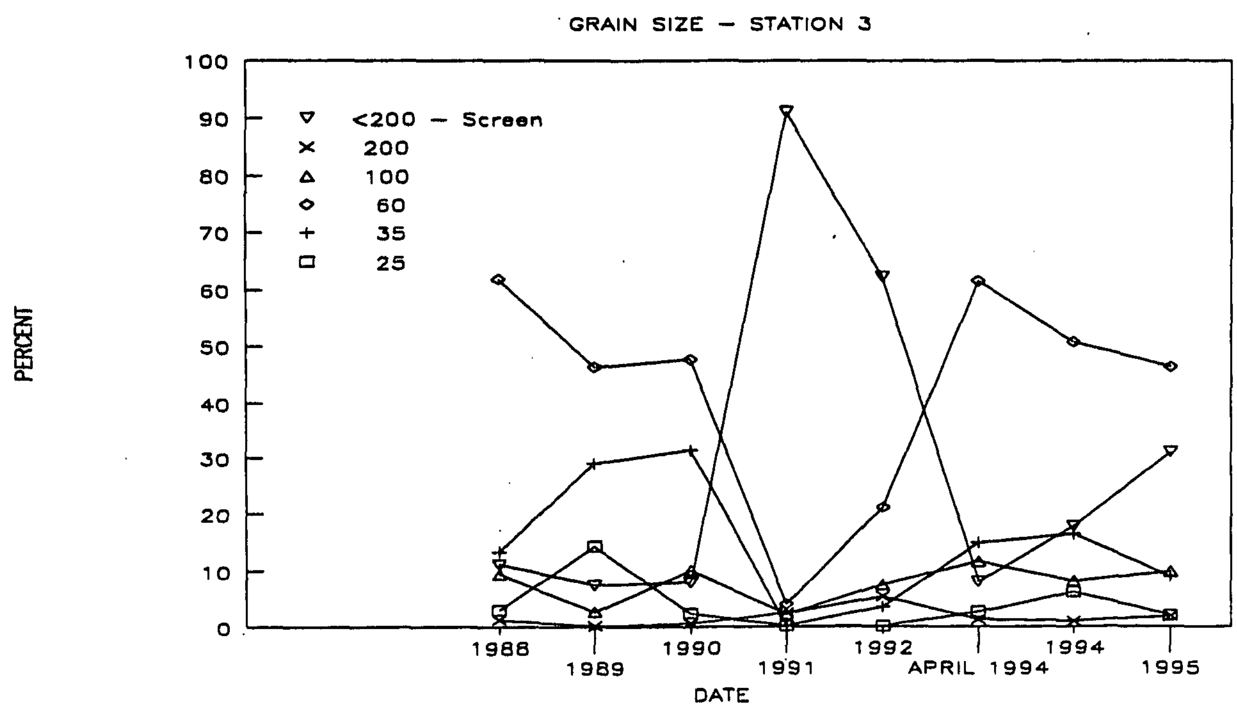


Figure III.4. Grain size distribution in sediments from Station 3, 1988–1995. All samples were collected in fall months except for April of 1994.

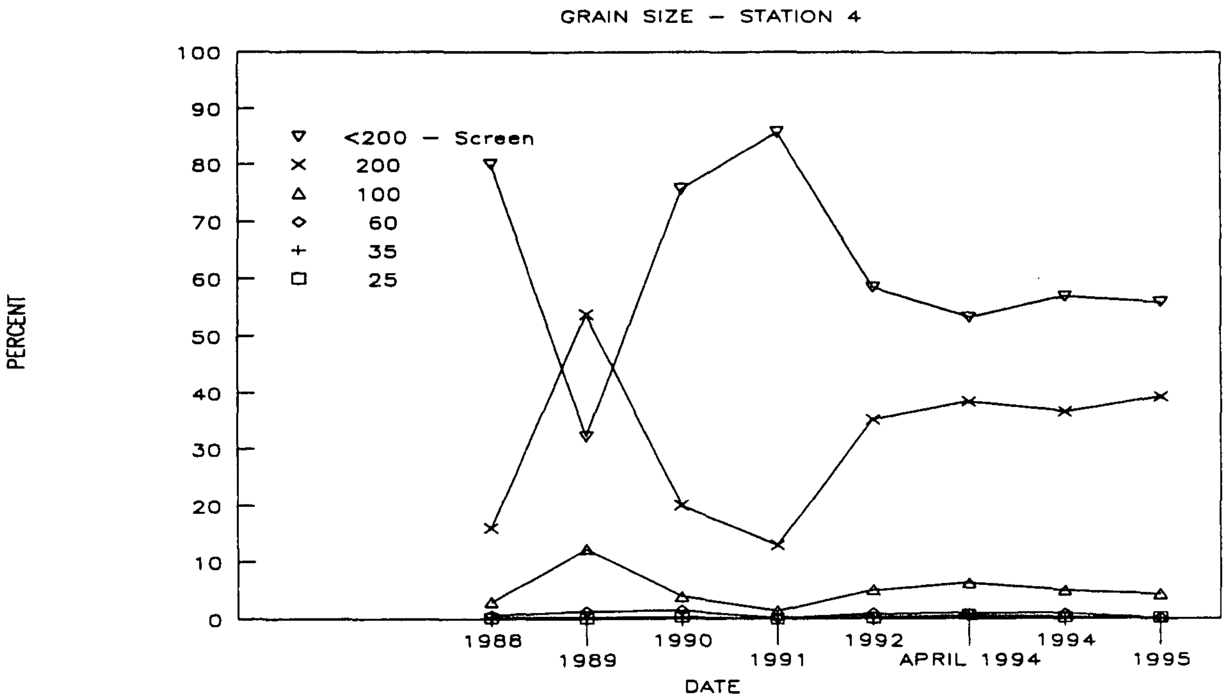


Figure III.5. Grain size distribution in sediments from Station 4, 1988–1995. All samples were collected in fall months except for April of 1994.

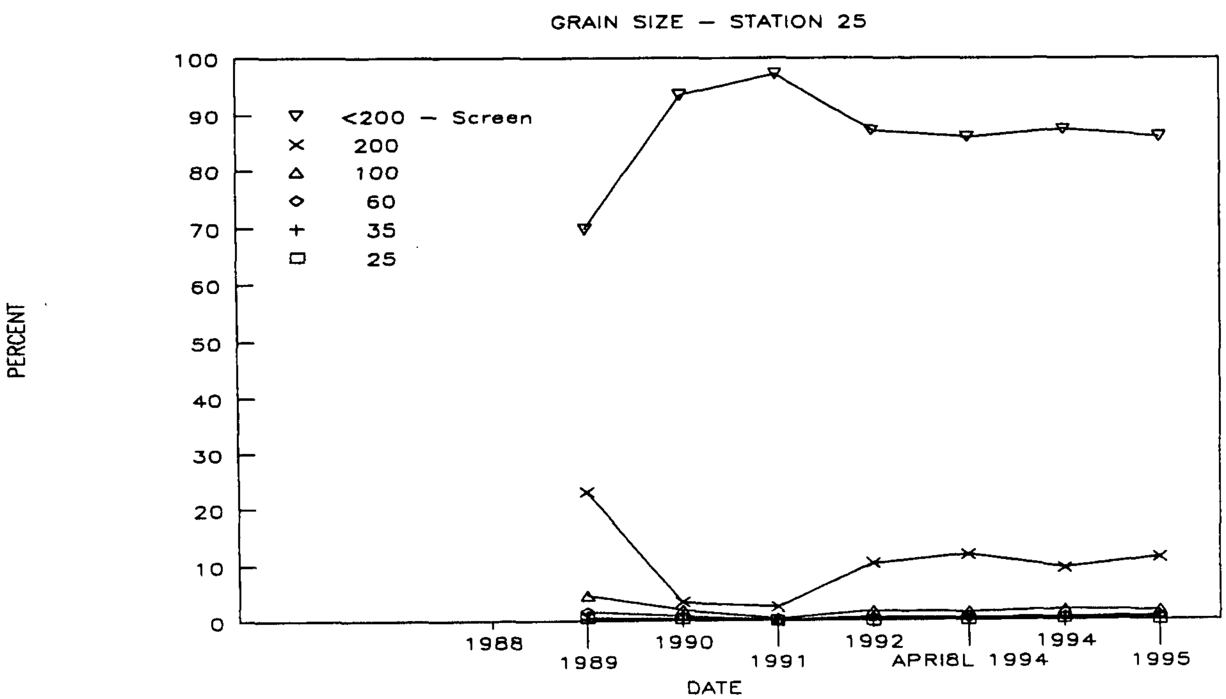


Figure III.6. Grain size distribution in sediments from Station 25, 1988–1995. All samples were collected in fall months except for April of 1994.

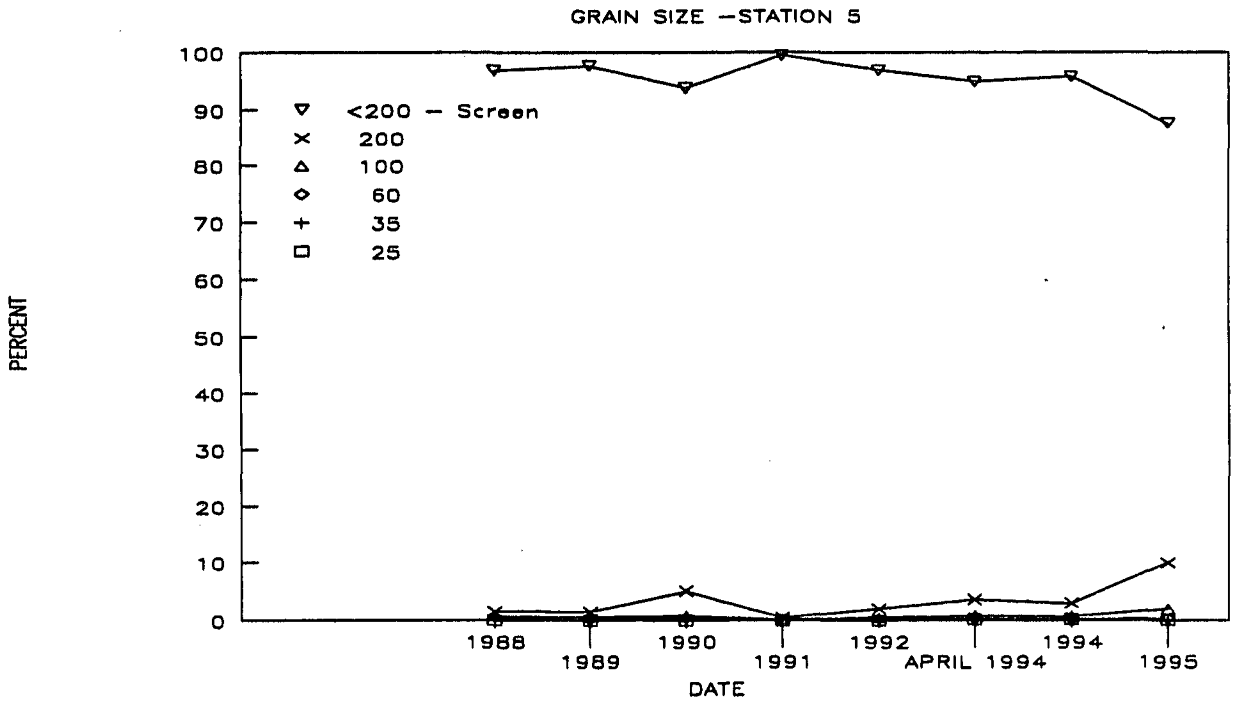


Figure III.7. Grain size distribution in sediments from Station 5, 1988–1995. All samples were collected in fall months except for April of 1994.

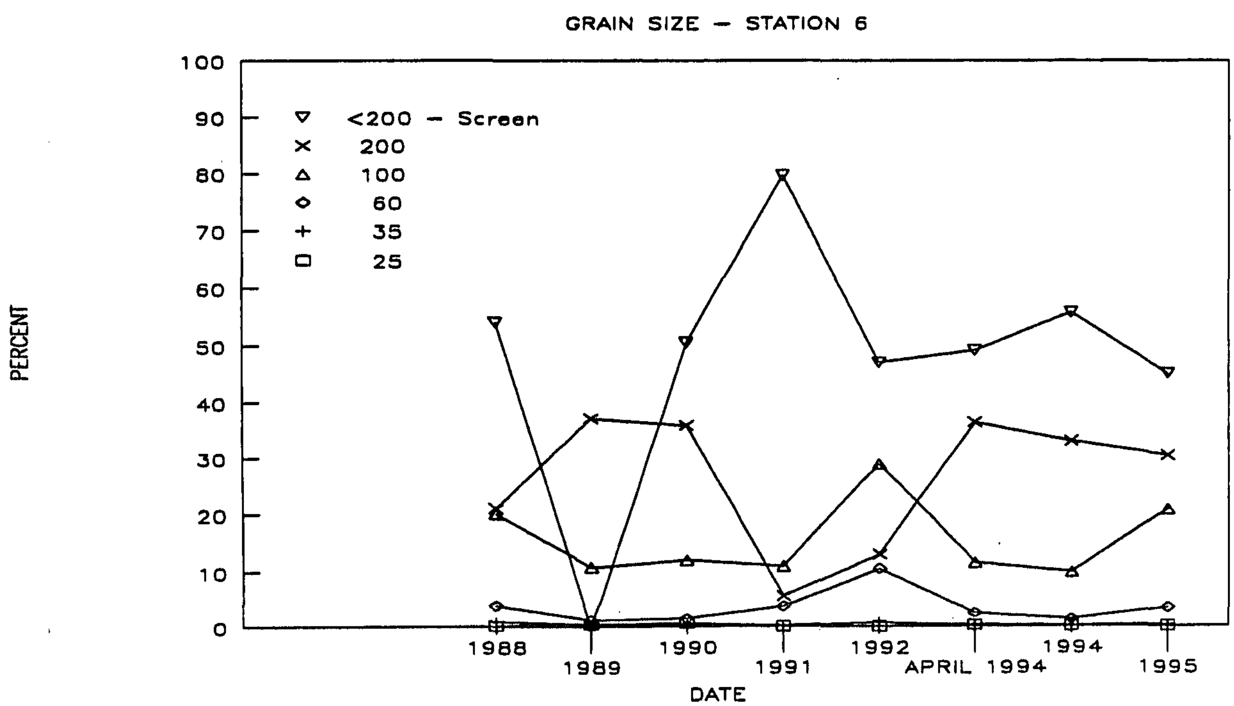


Figure III.8. Grain size distribution in sediments from Station 6, 1988–1995. All samples were collected in fall months except for April of 1994.

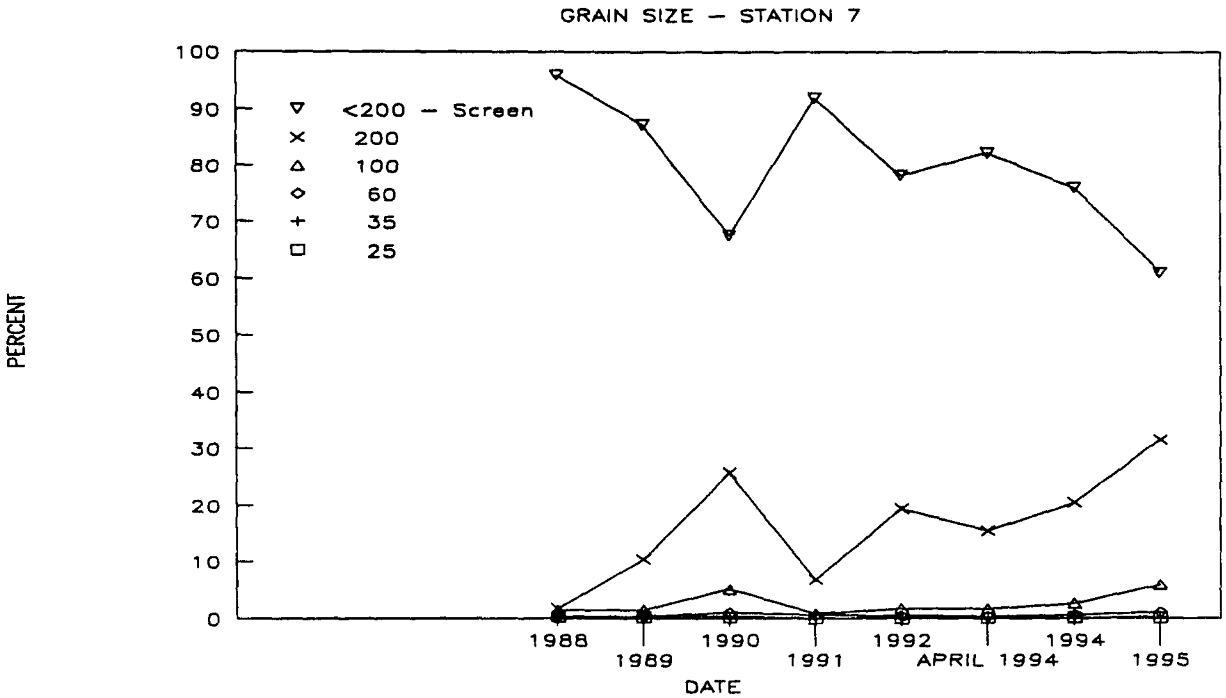


Figure III.9. Grain size distribution in sediments from Station 7, 1988–1995. All samples were collected in fall months except for April of 1994.

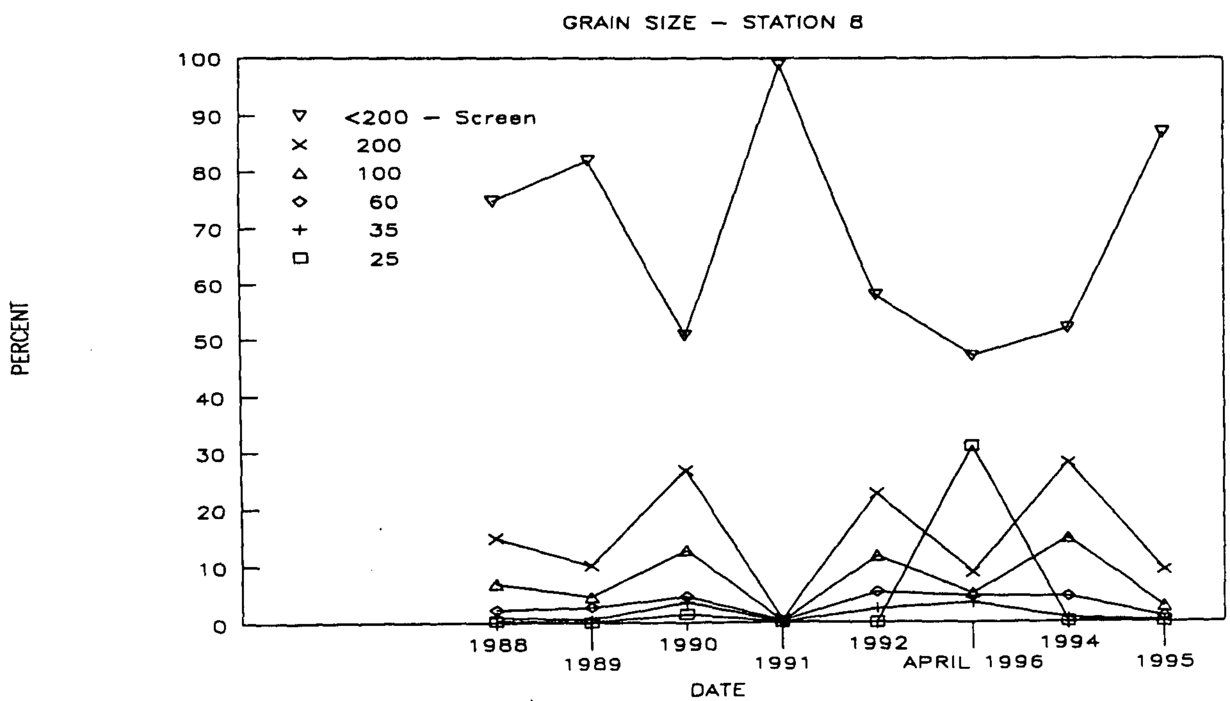


Figure III.10. Grain size distribution in sediments from Station 8, 1988–1995. All samples were collected in fall months except for April of 1994.

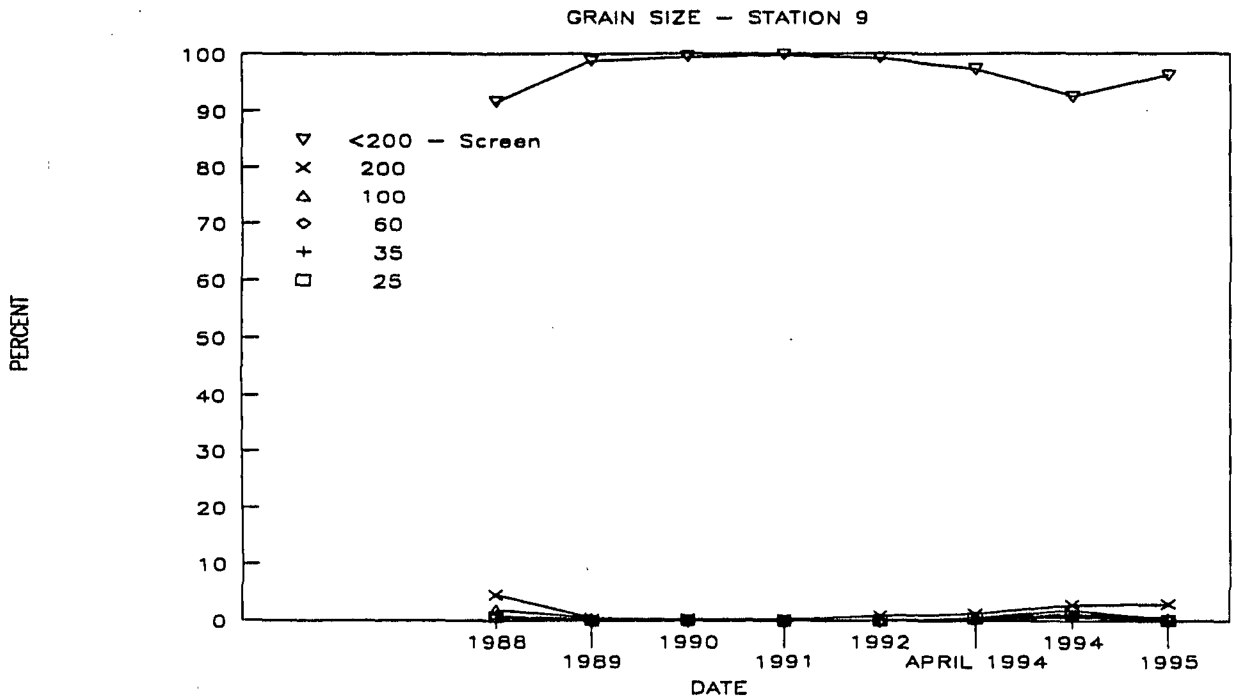


Figure III.11. Grain size distribution in sediments from Station 9, 1988–1995. All samples were collected in fall months except for April of 1994.

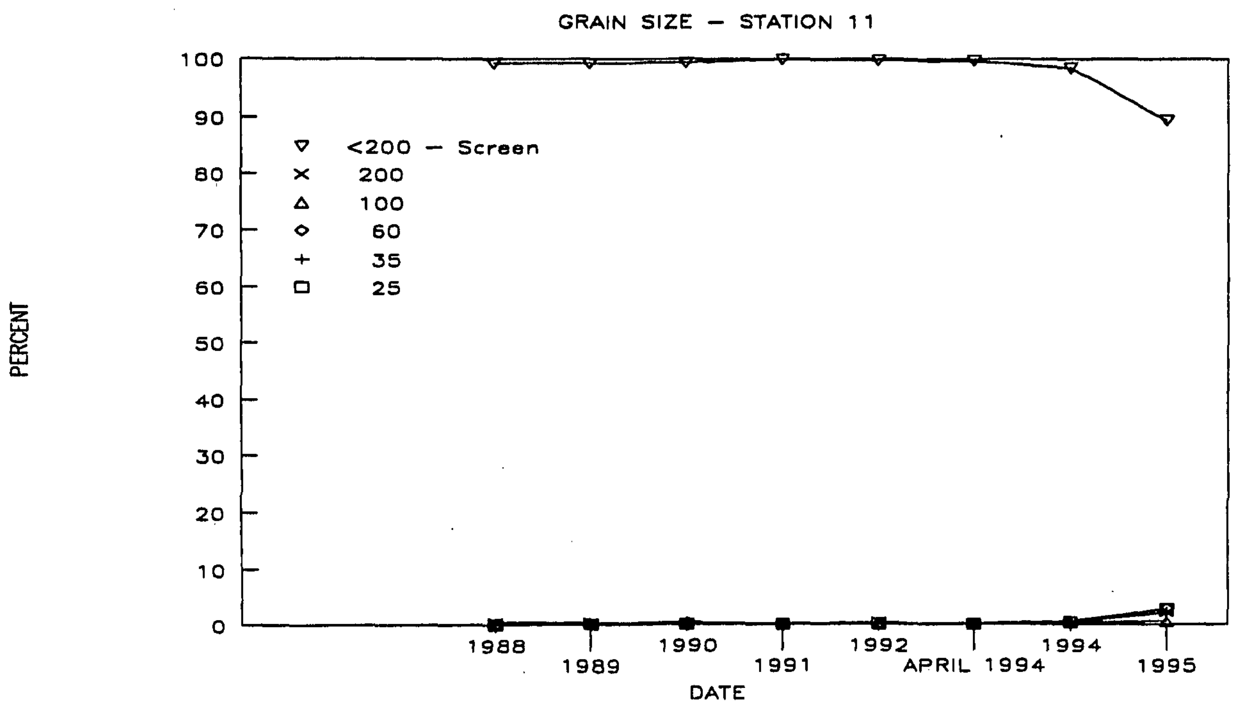


Figure III.12. Grain size distribution in sediments from Station 11, 1988–1995. All samples were collected in fall months except for April of 1994.

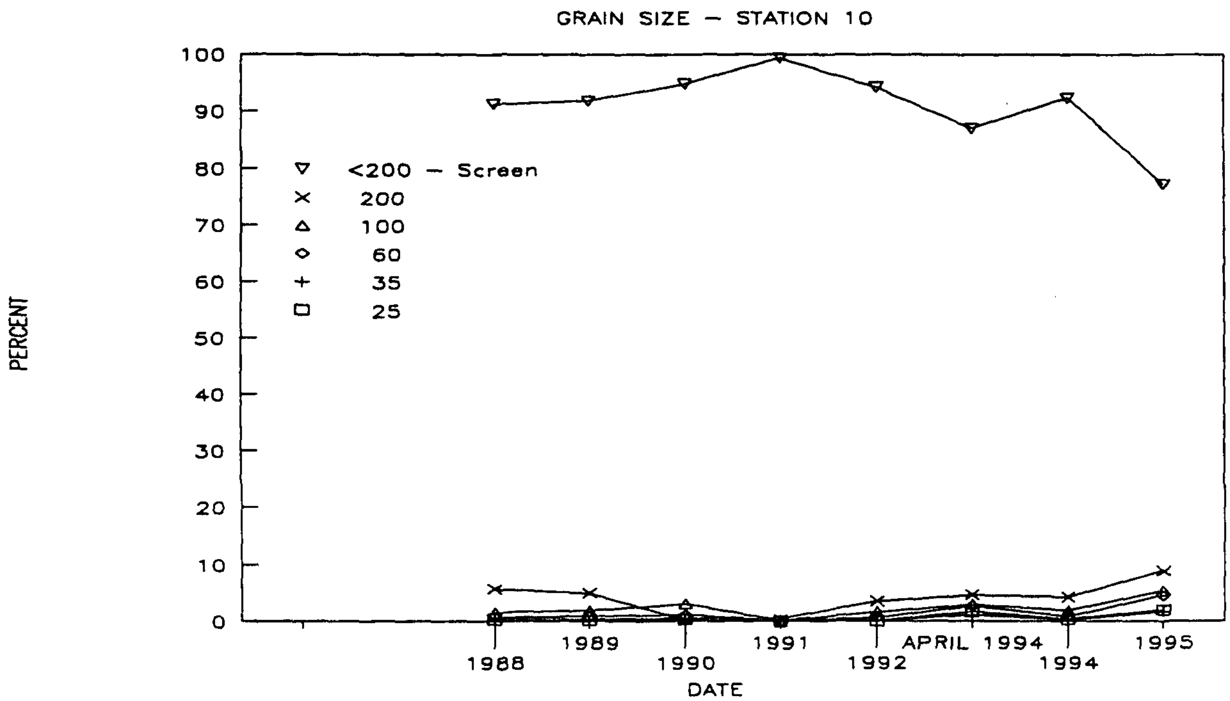


Figure III.13. Grain size distribution in sediments from Station 10, 1988–1995. All samples were collected in fall months except for April of 1994.

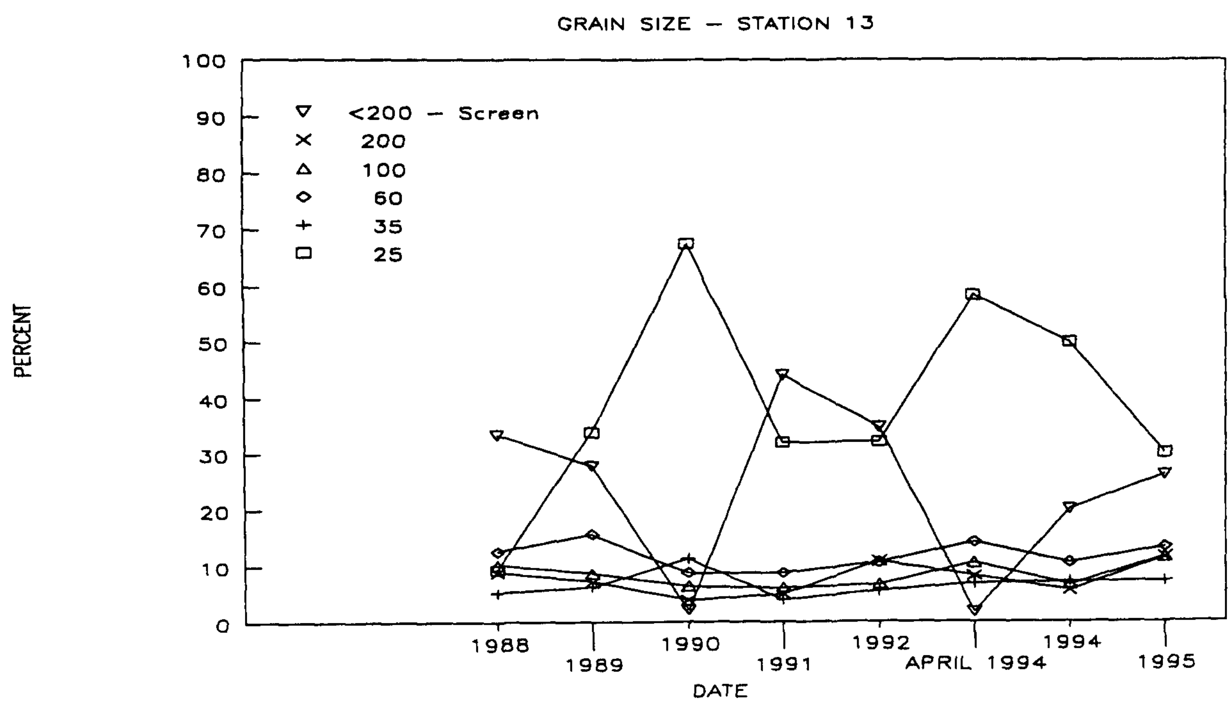


Figure III.14. Grain size distribution in sediments from Station 13, 1988–1995. All samples were collected in fall months except for April of 1994.

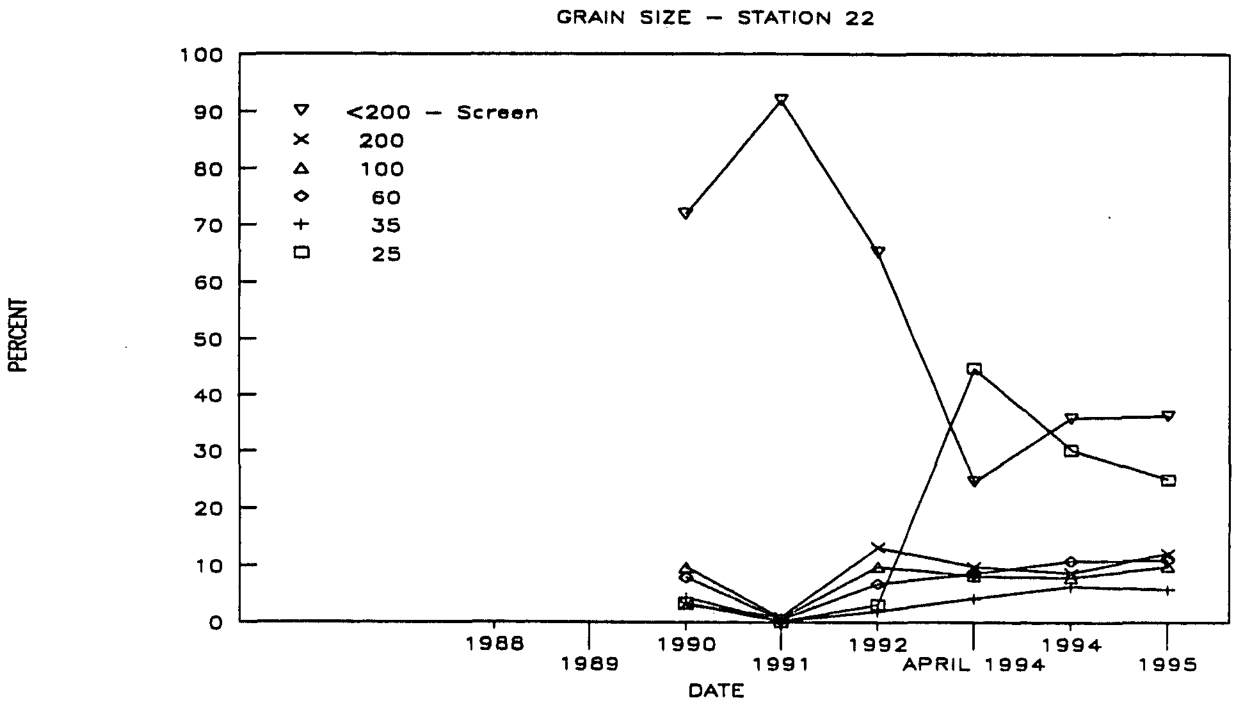


Figure III.15. Grain size distribution in sediments from Station 22, 1988–1995. All samples were collected in fall months except for April of 1994.

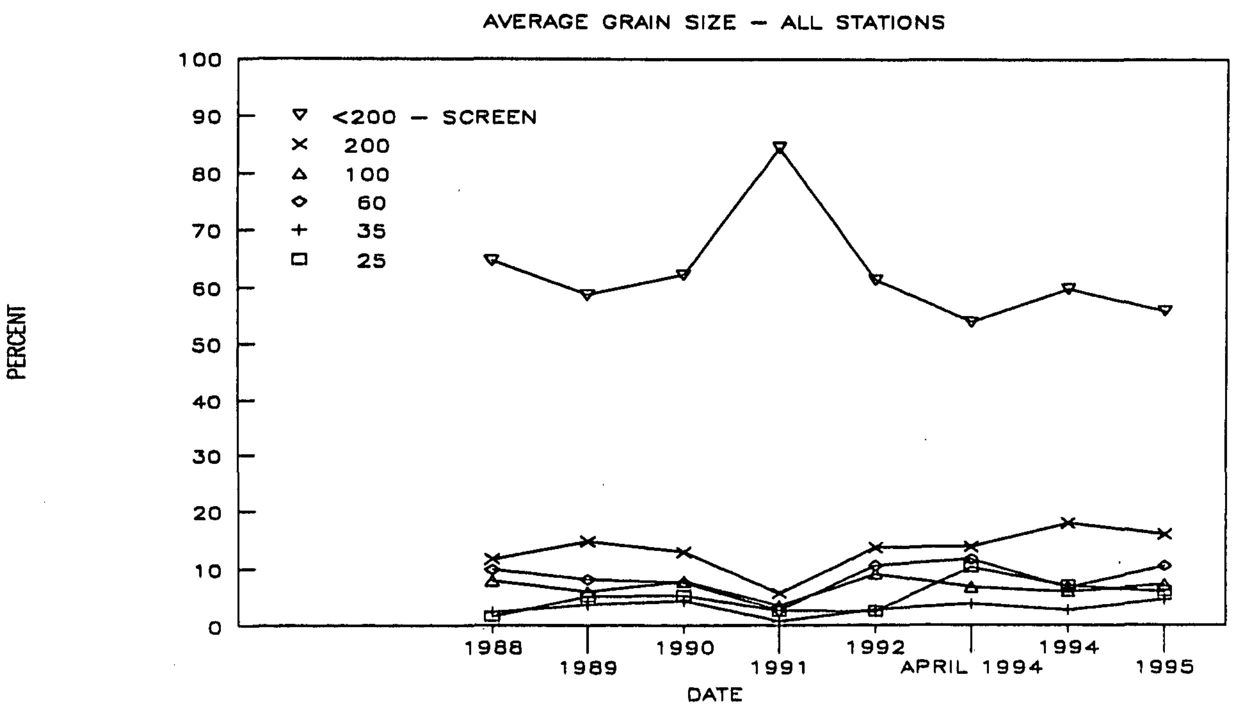


Figure III.16. Average grain size distribution in sediments from all stations, 1988–1995. All samples were collected in fall months except for April, 1994.

IV. SEDIMENT CONTAMINATION

INTRODUCTION

The Marina

There are, and have been, many opportunities for contamination of benthic sediments in the Marina del Rey area. The obvious uses of the marina may engender petroleum product slicks and spills, the presence of metal ions from antifouling compounds in paints, detergents and other cleaning compounds, and the possible illegal release of sewage from vessel holds. Boat yards and in-situ boat maintenance have in the past been important sources of contamination, but enforcement of controls has hopefully reduced that source of contamination.

The Wetlands

The wetlands from which the marina was developed were badly degraded long before the marina was designed. Small streams and ponds were confined to the main channel, which was then concretized to form the present Ballona Creek Flood Control Channel, with its numerous storm drain connections and provision for emergency diversion of sewage treatment plant overflows into it. The wetlands were filled in a patchwork of truck farms, trash dumps, fill for the Hughes aircraft runway and plants, oil and gas field development and, during World War II, industrial plants. As a result, some of the terrestrial soils in the surrounding area to the north and east are contaminated with trace metals and pesticides, which can enter storm drains or flow into the marina during heavy runoff such as the very wet rainy seasons in 1992-1993 and 1994-1995. These sources are very difficult to control, because flood control takes precedence for those low-lying areas that must be protected from inundation, and the storm drains are designed to move the rainfall runoff into the marina as quickly as possible.

Ballona Creek

Ballona Creek Flood Control Channel is a major storm drain delivery system for lands extending in places to downtown Los Angeles and the basin. The long, dry summers allow accumulations of debris in local storm drains, and the first significant rains in the fall carry large amounts of debris, particularly plastic fast food containers, grocery sacks, milk bottles, beverage and motor oil cans, and balls ranging from ping pong size to soccer and basketballs. Efforts to contain the debris are made, but nets cannot be deployed in the channel during the storms for fear of backing waters up into residential and commercial areas if the net fills up. Operation of a skimmer boat is intermittent and relatively ineffective when faced with barrels and barrels of trash, such as can accumulate during a storm. The mouth of Ballona Creek is flushed by tidal exchange and by wind and waves.

During dry weather there is always some flow into Ballona Creek, and the low velocity flow tends to deposit sediment near the mouth, while waters may be deflected off the breakwater and carried back into the marina by incoming tides. During heavy rains, runoff tends to move out to sea, forming a wide plume that dissipates rapidly, with sediments sinking according to their particle sizes and weights. During oceanic storms, with heavy surf and high winds or extremely high tides, the plume may be pushed up the entrance channel, stranding floating debris in slips, especially at the administration docks where it sometimes looks as though one could walk between boats and docks on solid masses. Kelp fronds broken off from outside the breakwater may end up on the beach in Basins D and E.

Garden debris that is dumped into the flood control channel or comes through the storm drain system is theoretically beneficial to nutrient flow into the open sea where it can biodegrade and be recycled through microbial action into the food web. The problem comes when the organic material is stranded in the marina, where there may already be an excess of more readily available nutrients. Breakdown of the debris may create a high oxygen demand on the waters, causing them to become anoxic and toxic sulfide to form, or degradation may be too slow and the debris may become noxious and/or unsightly.

<u>Marina Channels and Basins</u>

The farther away from the opening into the bay, the lower the flushing or exchange in the marina becomes, causing deposition of fine sediments in the inner ends of the basins and the end of the main channel, and with it, the potential for associated contaminants.

These stations include those in Basin E and F and at the inner end of the main channel, which are low circulation areas.

The outer entrance channel is well flushed when sandbars have not created a barrier; when sandbars or shoals are present, the flushing of the marina becomes much reduced, and contaminated sediments and debris can accumulate behind them. Circulation is then impaired throughout the marina, which may increase summer stratification, with elevated water temperatures and decreases in the dissolved oxygen content of the water, potentially to the extent of impacting fish populations. Some fish species will simply leave the marina for the bay, but others that do not have that capability may die. Benthic populations are much more tolerant of low dissolved oxygen unless anoxia is persistent and toxic sulfide begins to accumulate in bottom sediments, giving off hydrogen sulfide gas.

Oxford Basin

Oxford Basin is a flood control basin that collects drainage from the residential and commercial/industrial community north and east of the marina. It is connected to the marina through a tidegate at the northwest end of Basin E, while another collector system from above Washington Street enters that basin just a few hundred feet away at the west corner. Our special study of contamination in land drained into Oxford Basin, reported herein in Chapter V, demonstrates the higher content of some contaminants in the terrestrial soils which can be eroded and carried into the marina. Although the volume of drainage is much smaller than that of Ballona Creek, Oxford Basin sediments sometimes carry a substantial burden of contaminants. Sediments from the marina may also be carried into Oxford basin on high tides, stranding contaminants as well.

PROCEDURES

Sediment samples were taken on 26 October 1995 with a Campbell grab, a modified Van Veen, from the University of Southern California R.V. *Golden West*. Two stations in Ballona Creek and eleven stations in the marina were sampled with the grab; small subsamples were taken from each station for grain size determination and chemical analysis, and the remains of each sample were sieved through screens to obtain benthic organisms.

Two stations in Oxford Basin were sampled by hand with plastic cups for grain size and chemical analysis only, because the bottom area is intermittently exposed. Chemical samples were chilled in the field and frozen until analyzed at Associated Laboratories in Orange, California. Percentages of moisture, volatile solids, total dissolved solids and total organic carbon were determined, along with specific conductance in *u*mhos/cm; 31 metallic and nonmetallic contaminants are measured in mg/kg dry wt (ppm), and analyses for 20 pesticides and chlorinated hydrocarbons performed, measured in *u*g/kg (ppb).

RESULTS AND DISCUSSION

METALLIC AND NONMETALLIC CONTAMINANTS

Station Rankings

As in past reports, stations were ranked from 1 to 15, for the 15 stations, for each of 13 metallic parameters selected to make the surveys comparable from year to year; these were arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, tributyl tin and zinc. For the nonmetallic parameters, immediate oxygen demand, chemical oxygen demand, oil and grease, organic nitrogen and phosphorus amounts were used.

Soule et al., (1993, 1996) summarized the incidence of trace metals in the southern California Bight (Mearns et al., 1991), and the terrestrial incidence (USEPA, 1983), and indicated the various uses of the substances that might lead to their occurrences in the marina.

There is insufficient information to insert some toxicity factor that would determine the actual activity/toxicity of each of the parameters in context of the physical factors present at each station. Much of the literature on toxicity that has been developed in the laboratory concerns a relatively few parameters, mostly for freshwater organisms and based on testing single species. Thus our ranking is strictly limited to comparing stations in the survey.

It is unfortunate that there has sometimes not been funding to perform the sediment/benthic surveys at least twice a year because the Spring survey represents conditions immediately after the rainy season while the Fall survey adds the impact of the dry weather, low runoff period.

Table IV.1 presents the comparative scores for survey stations from 1989 to 1995. Tables IV. 2 and 3 contain the data for metals and nonmetallic contaminants respectively, on which the ranking scores were based. Some parameters have not been included in the rankings because there is not enough information to determine what their significance might be to marina ecology, or the data have not been taken until the last two years when the County expanded the list to include parameters they use to evaluate water quality in freshwater watershed measurements. Distribution of metallic parameters at the stations are mapped in Figures IV.1-35, at the end of this chapter.

Station 25, at the administration docks, was the station highest ranked for contamination in the marina in 1995. It has been in the highest category every year since it was added in 1989, except in the 1989, 1991 and Spring 1994 surveys. In individual metals it ranked highest only in silver, but it had highest scores in chemical oxygen demand (COD) and organic nitrogen, and was high in others.

Stations 9, 10 and 11, in the inner marina, are consistently among the most contaminated, with Station 10 appearing in the highest category in every survey. The removal of contaminated sediments and reconstruction of docks adjacent to Station 10 resulted in some improvement in benthic diversity and numbers (Chapter VII.4), but the contamination score remained high. Station 9 has dropped into medium high position only twice, in 1989 and Fall 1994, and Station 11 has declined to medium high in only in 1989, 1992 and Fall 1994.

In Ballona Creek, **Station 1 has consistently been among the cleanest, except when it ranked medium high in 1990 and moderate in Fall 1994,** but was the cleanest in 1995. The pattern for Station 1 differs from that at Station 12 upstream; they are not strongly coupled. The only substance in which it ranked high was selenium, where it was second to Station 2. Interestingly, it had middle level rank in tributyl tin, showing that once contaminated marina sediments reach the area.

Table IV.1. Ranking of stations according to scores* for 18 sediment trace metals and non-metallic contaminants.

	Oct Sta	1989+ Score	Oct Sta	1990 Score	May Sta	1991 Score	Oct Sta	1991 Score	Oct Sta	1992 Score	Apr Sta	1994 Score	Sep Sta	1994 Score	Oct Sta	1995 Score
HIGH			10	259	10	249	10	266	9	230						
above 200			9	243	9	232	9	217	10	226	9	223	10	221	25	222
			25	219	11	212	11	209	25	217	11	215			10	217
	10	208	11	217	25	203	8	205	22	204	22	211			11	216
			22	214							10	209	25	202	9	202
MED HIGH	9	180	5	185	22	188	22	198	11	198	25	198	11	197		
140-199	11	172			3	178	5	196	5	179			5	191		
	12	165			8	178	25	193			5	187	9	181		
	2	158	1	147	5	168	3	164			12	164	12	171	8	160
	5	148	2	147	2	150					7	144	13	149	4	152
	25	146									2	141			13	145
	7	143													5	144
MODERATE			8	137	7	140	7	129	3	135	4	133				
100-139			7	128			4	125	4	133	13	129				
			4	123					8	126			4	124		
									6	122					12	122
									7	121						
									13	120						
	8	116									8	117	2	116	6	111
	13	116											6	103	7	111
			12	108	4	109	6	106	2	106			1	100		
									12	106						
MED LOW			13	93	12	97	2	96			6	96			22	97
70-99					6	95	13	93					7	97	2	93
			6	84	13	85	12	87					8	96		
	6	72														
LOW	4	50	3	46	1	64	1	55			1	41	22	64	3	69
0-69	1	33									3	30			1	41
	3	28							1	25			3	25		

+ Station 22 not sampled

*Scores are determined by ranking the stations from 1 to 15 (lowest to highest) for each parameter and totaling the scores.

Parameters included: arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, tributyltin, zinc, immediate oxygen demand (IOD), chemical oxygen demand (COD), oil and grease, organic nitrogen and phosphate phosphorus.

Table IV.2. Trace metal sediment contaminants, 26 October 1995, in mg/kg dry weight (ppm).

Stations / Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	22	25	Mean
Arsenic	3.56	5.24	5.15	8.54	9.61	7.38	7.52	9.99	10.70	11.80	11.70	5.53	5.55	5.18	11.00	7.90
Barium	30.8	51.0	49.0	83.1	115.0	57.7	85.4	103.0	134.0	126.0	141.0	64.9	154.0	145.0	124.0	97.59
Cadmium	0.51	0.52	0.58	1.10	<0.36	<0.32	<0.31	<0.45	<0.46	1.23	0.68	0.92	0.62	1.00	1.22	0.56
Chromium	15.0	25.2	25.1	46.3	57.9	39.6	38.8	63.5	83.3	67.5	78.2	22.9	27.2	24.3	74.5	45.95
Copper	37.5	29.4	49.1	87.8	174	203	158	367	380	299	373	36	72	31.7	223	168.03
Iron	7,340	14,100	12,600	23,500	35,300	24,100	26,300	42,300	49,600	41,700	48,860	13,300	20,800	18,800	39,500	27,873
Lead	61.1	70.6	54.3	91.2	84.0	60.1	56.7	81.0	115.0	177.0	95.1	127.0	295.0	101.0	145.0	107.61
Manganese	74.6	133.0	89.2	185.0	263.0	163.0	211.0	276.0	314.0	251.0	315.0	121.0	197.0	259.0	279.0	208.72
Mercury	<0.1	0.12	0.11	0.27	0.43	0.82	0.45	0.86	0.87	0.87	0.92	0.69	0.21	<0.10	0.46	0.47
Nickel	7.54	15.70	12.50	24.30	26.50	24.60	24.00	36.90	40.30	36.20	41.10	14.40	18.80	18.10	35.40	25.09
Potassium	970	2,430	1,906	3,745	6,220	3,716	4,530	7,120	8,335	7,530	7,810	1,869	2,200	3,280	5,680	4,489
Selenium	0.63	0.66	0.50	0.47	<0.41	0.47	0.36	<0.51	<0.51	0.48	<0.48	0.37	<0.28	<0.28	<0.42	0.26
Silver	<0.47	<0.61	<0.57	0.96	<0.74	<0.65	<0.63	<0.91	<0.93	<0.87	<0.86	<0.52	<0.50	<0.50	0.99	0.14
Tributyltin	0.28	0.08	0.20	0.34	0.31	3.04	0.47	0.32	0.15	0.19	0.18	0.10	0.15	0.09	0.30	0.41
Zinc	87.9	143.0	140.0	230.0	269.0	221.0	219.0	387.0	419.0	455.0	423.0	426.0	324.0	174.0	397.0	287.66

Table IV.3. Non metallic sediment contaminants. 26 October 1995.

Station Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	22	25	Mean
UNITS - %																
Moisture	23.99	41.07	36.32	44.61	51.05	44.86	42.50	60.52	61.16	58.55	58.10	30.61	27.84	27.57	51.81	44.04
Volatile solids	1.47	6.24	4.22	4.82	6.13	4.37	4.87	7.65	7.70	7.79	7.87	3.86	2.90	4.11	8.26	5.48
Total Dissolved Solids	0.95	2.14	2.15	2.60	3.38	2.39	2.45	4.84	4.32	4.56	4.32	1.56	1.35	1.63	3.20	2.79
Total Organic Carbon	0.6	2.5	1.7	1.9	2.4	1.7	1.9	3.1	3.1	3.1	3.2	1.5	1.2	1.6	3.3	2.19
UNITS - umhos/cm																
Specific Conductance	2,560	4,330	3,990	4,780	4,900	4,460	4,730	5,890	5,640	6,040	5,850	3,190	3,340	3,740	5,290	4,582
UNITS - mg/kg on a dry weight basis																
Immediate Oxygen Demand	11	141	69	116	112	153	134	111	294	360	338	263	17	17	270	160.4
Chemical Oxygen Demand	20,400	75,600	35,200	54,200	51,700	33,100	32,100	58,500	64,200	64,200	78,700	53,100	20,800	34,600	79,800	50,413
Oil & Grease	1,130	2,530	1,480	1,650	1,440	520	828	590	1,790	1,790	2,840	1,460	1,410	1,100	2,420	1,532
Alkalinity (as CaCO3)	14,100	28,400	24,000	29,800	32,200	24,800	25,000	38,000	40,500	34,600	36,500	20,100	18,100	11,400	41,000	27,900
Total Hardness (as CaCO3)	29,500	52,000	41,300	59,600	71,200	48,900	58,700	76,800	75,000	66,900	73,600	32,300	22,200	37,200	84,100	55,287
Boron	5.7	20.9	15.50	20.6	22.0	20.8	17.6	34.7	37.5	33.5	33.2	13.1	12.9	14.4	30.6	22.20
Calcium	7,304	9,590	9,190	9,644	9,027	5,450	9,050	8,253	6,410	5,863	7,260	6,070	3,940	5,720	11,360	7,609
Chloride	5,300	11,800	10,300	14,100	18,800	13,200	13,700	25,700	24,800	24,100	24,200	7,960	7,170	7,870	19,300	15,220
Fluoride	2.78	6.72	4.51	6.14	8.74	6.49	6.83	11.45	11.56	13.03	11.48	6.14	5.40	6.06	9.17	7.77
Nitrogen	1.8	ND<1	2.2	1.4	1.8	1.6	ND<1	ND<1	ND<1	2.2	ND<1	1.2	1.2	1.87	ND<1	1.02
Nitrate	8	ND<5	9	6	8	7	ND<5	ND<5	ND<5	9	ND<5	5	5	6	ND<5	4.20
Organic Nitrogen	370	1,260	890	1,140	1,180	856	835	1,580	1,600	1,762	1,500	910	692	971	1,940	1,165.7
Total Phosphorus	288	546	391	836	1,010	703	963	851	1,260	1,260	908	1,020	623	823	1,020	833.5
Sodium	3,270	9,280	6,475	9,963	13,260	9,935	9358	18,100	17,270	16,930	16,300	5,244	5,120	6,510	13,560	10,705
Sulfides	27	1,322	101	98	44	31	17	108	92	92	165	12	1	1	191	153.5
Sulfate	684	1,650	1,010	2,230	2,190	1,880	1,640	4,030	3,140	3,570	2,720	1,460	790	1,020	2,460	2,031.6

Rankings at Station 12 fluctuated from medium high in Fall 1989, to moderate in 1990, to medium low in Spring and Fall 1991, and back up to moderate in Fall 1992. The score rose to medium high in Spring and Fall 1994 and declined to moderate in 1995. Station 12 had the second highest zinc level, the third highest phosphorus and the fourth highest lead level.

The creek is vulnerable to so many possible insults upstream, such as spills and dumping, which might appear at Station 12, in addition to carrying large amounts of rainfall runoff. While Station 1 is also subjected to such flows, it is cleansed more than is Station 12 by tidal flushing, currents and storm waves.

The contaminant burden at Station 2, in the center of the entrance channel between the ends of the jetty, has fluctuated widely, in contrast to that at Station 1. Station 2 ranked medium high in Fall 1989, Fall 1990 and May 1991, but dropped to medium low by October 1991. The ranking then rose to medium high by April 1994, but declined to medium low by Fall 1995. The highest selenium in the survey elevated its score, as did the second highest oil and grease and the third highest COD in 1995.

The decline in ranking preceded the small knockdown dredging in 1992 so that was not responsible for the change. Similarly, the decline by Fall 1994 preceded the dredging in winter 1994. The record rains in 1992-1993 may have flushed contaminants seaward in the marina, only to be deposited to some extent at Station 2 by the spring. Over the summer of 1994 some of the contaminants were carried seaward. The further lowering of contamination by 1995 may have been influenced by the 1994 dredging, but probably is also linked to the heavy rains of 1994-1995.

Station 3 would normally be considered a clean, low scoring station because of the flushing effect of the tidegate to Ballona Lagoon and the Venice Canals. In 1995 it was high only in selenium. Past surveys have shown the effects of disruptions in the lagoon. During shoreline construction the score jumped to medium high in Spring and Fall 1991, declined to moderate in 1992 and returned to low by Spring 1994, where it has remained. **Efforts currently being made to clean the lagoon and restore the native**

plants will undoubtedly be temporarily damaging to Station 3, but presumably the disturbance will subside as it did before. Some extensive disruptions occurred in March 1997 when a bulldozer attempting to clear out non-native plant species, instead tore out the plot where attempts were being made to restore native plants such as pickle weed.

Station 4, seaward of the Coast Guard docks, has moved up from low ranking in 1989, to moderate from 1990 to 1994, rising to medium high in 1995. This depositional area has relatively quiet water except under southern storm wave conditions. The increased activity at the administration docks may contribute contaminants, as may sediments moving down channel from Station 5 and the basins or up channel from Station 2. The station was second highest in silver, and third highest in cadmium and tributyl tin.

Station 5 has been consistently contaminated at the medium high level during all surveys. It is a shoaling area, where sediments, moving under low flow conditions from the basins meet and settle out in the center of the main channel. While not having the highest amount of any of the parameters, it ranked tenth or eleventh highest in arsenic, chromium, manganese, nickel, potassium, tributyl tin and phosphorus, indicating that this is a collecting area for contaminants.

Station 6, at the end of Basin B, is the cleanest of the basins, due to several factors; it is closer to the entrance and it has relatively little street and parking lot drainage into it. Relative to the other stations, it has ranked medium low in Fall 1989, Fall 1990, May 1991 and April 1994, and moderate in Fall 1991, Fall 1994 and Fall 1995. The changes are small and probably insignificant. **In 1995, Station 6 ranked highest by an order of magnitude in tributyl tin, indicating new and extensive usage in the area.**

Station 7, in Basin H on the landward side of the marina but slightly nearer the entrance, has much more potential for contamination, with large parking lots, storm drains and boat maintenance yards. It had much higher scores, medium high and moderate, than did Station 6 from 1989 until Fall 1992, when they were almost the same. Then Station 7 rose to medium high in April 1994 while Station 6 scores decreased to medium low; scores of the two stations were close in Fall 1994, and were identical ranks in

1995, in the low end of the moderate category. Their benthic faunal diversity and numbers were similar in 1995 as well. The station had midlevel rankings in most parameters, but was second highest in tributyl tin.

Stations 8 and 9, in Basins D and F, are similar distances from the entrance in the inner marina, but are quite different, in part because Basin D has a beach at the inner end while Basin F is crowded with vessels. Both have street and parking lot runoff, but Basin F is closer to adjacent urban usage.

The ranking of Station 8 rose from moderate in 1989 to medium high in May 1991, and to high in October 1991, after which it declined in each survey to medium low in Fall 1994. The Station 8 ranking jumped back to medium high in 1995, concomitant with the lowest benthic faunal numbers of species and individuals by far in the marina surveys. Coincidentally, the second lowest benthic faunal counts in the marina were in October 1991, when the metallic and nonmetallic ranking was the highest. **In 1995 Station 8 was third highest in copper, iron, and nickel and fourth highest in manganese, mercury, potassium, tributyl tin and organic nitrogen, concomitant with the large increase in the finest sediments.** It is possible that when runoff into Basin E is heavy, giving a positive pressure to flow outward, as during and after a storm, tidal flow and runoff may both be diverted into Basin D, where shoaling toward the beach provides opportunity for the fine grained sediments to settle out and remain deposited.

Station 9 has consistently been in the high category of rankings, except in 1989 and Fall 1994, when its ranking was medium high. Benthic faunal numbers were much better in the 1970s through 1985, before more slips were constructed at Station 11, than they have been since (Chapter VII). The area is poorly flushed, and may receive sediments from Oxford Basin runoff and deposition from the slowly moving tidal flow. Station 9 ranks highest of all stations in chromium, copper, iron, potassium and organic nitrogen, and second highest in manganese, mercury and nickel; it also ranks third in IOD and organic nitrogen and fourth highest in arsenic, barium, zinc, COD and oil and grease.

Station 10 was highest in arsenic, cadmium, zinc, IOD and phosphorus, and second highest in lead, mercury, and organic nitrogen. There was little rainfall between the time that the dock area adjacent to Station 10 was cleaned by clam shell dredge and the fall survey. Whether the station will be improved or no remains to be seen.

Station 11 was highest in manganese, mercury, nickel and oil and grease, and second highest in arsenic, chromium, copper, potassium, IOD and COD.

Stations 13 and 22 are in Oxford Flood Control Basin, once euphemistically called a bird sanctuary. It would make a good small migratory stopover if it were not sadly so contaminated. So many Easter ducks and bunnies were dumped over the fence in years past that the banks were torn up and eroded and coliform counts from feces high. The populations had to be removed and prohibited. Station 13 is just inside the tidegate from Basin E, and is almost always under seawater except at extreme low tides or if the tidegate is closed, while Station 22 lies at the Washington Street drain into Oxford Basin is sometimes exposed at low tide. At the inner end of the basin, storm drains from adjacent streets funnel in street runoff.

Scores at Stations 13 and 22 have almost opposite trends; in the 1989 to 1992 period the rankings at Station 13 were in the medium low to moderate categories, but rose in Fall 1994 to medium high and remained there in 1995. Conversely, scores at Station 22 were high or medium high through April 1994, after which they dropped suddenly to low and medium low. Flushing from the record rains of 1992-1993 may have moved some polluted sediments toward the tidegate and into the marina. Brush and trash clearance by the County and a new pumping station at the inner end of Oxford Basin may also have helped to flush sediments away from Station 22.

<u>Nonmetallic Parameters</u>

Among the nonmetallic parameters not included in the rankings, values for chloride, sodium, fluoride and organic nitrogen were all highest at Stations 8, 9, 10 and 11, (Table IV.3), indicating deposition and retention of salts and organic matter in the shallow areas of low flushing and high evaporation.

The problems of accumulation at Station 2 due to the sandbars and shoaling were indicated by high COD, oil and grease, and in particular, high sulfide, much higher than elsewhere in the marina. This suggests a lengthy residence time there for organic detritus due to the shoaling. The highest COD was at Station 25, but Station 2 was third highest, another indication of poorer flushing than should occur in the entrance channel.

Station Rankings and NOAA Effects Range Ratings

In 1990 the National Oceanographic and Atmospheric Administration (NOAA) published results of intensive data analysis by Long and Morgan (1990) to provide some evaluation of the many disparate reports from field and laboratory investigations on the effects of various metals and pesticides. **The NOAA report is the best compendium on effects available, and they established ranges for Effects Range-Low (ER-L), Effects Range Median (ER-M) (not 'medium', as it has sometimes mistakenly been written), and Apparent Effects Threshold (AET), the point at which effects are visible.**

We have used the NOAA information since Long sent us a draft copy to work with, because we had provided him with Marina del Rey data for the NOAA investigations. The data for metals ranges and the ER-L, ER-M and AET values is presented in Table IV.4.

Because some of the marina levels of metallic parameters fall below the ER-L or ER-M, we have reevaluated the ranking of marina stations for only those parameters which do reach the ER-L at some stations in the marina survey. **The metals of concern are chromium, copper, lead, mercury, nickel, silver and zinc.**

Arsenic has not appeared at ER-L levels in any survey, and cadmium has only been reported once at ER-L level, at Station 13 in May 1991. Chromium did not appear at ER-L levels until September 1994 at Station 11, and in October 1995 at Station 9. These must continue to be checked in case they increase with some change in runoff burden, in metals processing nearby, or change in usage around vessels. Both those sites are near runoff drains and in areas of heavy vessel usage, and could easily change with some frequency. We do not recommend dropping any parameters from the survey, because new ER-L levels might be recognized in the future, based on new research.

Table IV.4. Concentrations (mg/kg, ppm) in metals in sediments producing biological effects.*

Parameter		ER-L	ER-M	AET	NRC	MDR Range	Stations Equal/Exceeding ER-L	ER-M	AET
Arsenic		33	85	50	33				
Oct	90					2.99 - 13.80	...	...	...
May	91					2.62 - 10.54	...	...	...
Oct	91					2.22 - 2.51	...	...	...
Oct	92					1.81 - 12.60	...	...	...
Apr	94					2.44 - 19.80	...	...	...
Sep	94					2.86 - 11.20	...	...	...
Oct	95					3.56 - 11.80	...	...	...
Cadmium		5	9	5	31				
Oct	90					0.32 - 2.13	...	...	...
May	91					0.43 - 5.54	13	...	13
Oct	91					<0.63 - 3.00	...	...	...
Oct	92					0.13 - 2.22	...	...	...
Apr	94					<0.20 - 2.95	...	...	...
Sep	94					<0.21 - 1.14	...	...	...
Oct	95					<0.31 - 1.23			
Chromium		80	145	...	...				
Oct	90					6.78 - 69.8	...	...	...
May	91					16.50 - 67.8	...	...	...
Oct	91					12.50 - 57.9	...	...	...
Oct	92					8.73 - 72.6	...	...	...
Apr	94					5.74 - 67.9	...	...	...
Sep	94					11.90 - 81.7	11	...	...
Oct	95					15.00 - 83.3	9	...	...
Copper		70	310	300	136				
Oct	90					10.40 - 399	all but 12,1,2,3,4,13	10	10
May	91					22.60 - 348	all but 12,1,2,22	8,10 ...	8,10 ...
Oct	91					13.80 - 410	all but 12,1,2	... 8,9,10,11	... 8,9,10,11
Oct	92					5.50 - 322	all but 1,2,5,11,13	9	9
Apr	94					6.55 - 339	all but 12,1,2,3	9,11	9,11
Sep	94					25.0 - 402	all but 1,2,3,22	10,11	10,11
Oct	95					29.4 - 380	all but 1,2,3,12,22	8,9,11	...

* Units are in Effects Range-Low (ER-L), Effects Range-Median (ER-M), Apparent Effects Threshold (AET), (Long and Morgan, 1990 for NOAA); NCR = National Research Council EPA (1989) Threshold Toxic Levels. In ppm (mg/kg dry wt).

Table IV.4. (continued)

Parameter		ER-L	ER-M	AET	NRC	MDR Range	Stations ER-L	Equal/Exceeding ER-M	AET
Lead		35	110	300	132				
Oct	90					7.95 - 325	all but 2,3,13	12,25,6, 9,10,22	12
May	91					41.30 - 575	all stations	all but 1,4,6,7,22	13
Oct	91					62.20 - 487	all stations	1,2,6,7	...
Oct	92					22.90 - 372	all but 1	13,22,10, 12,25,9	... 13,22
Apr	94					12.50 - 427	all but 3	5,9,10,11, 12,13,22,25	12,13
Sep	94					32.30 - 413	all but 3	5,9,10,11, 12,13,25	13
Oct	95					54.3 - 295	all	9,10,12,13,25	10,13,25
Mercury		0.15	1.0	1.0	0.8				
Oct	90					<.12 - 1.08	all but 12,2,3	9	9
May	91					<.07 - 1.2	all but 12,3,22	8	8
Oct	91					<0.09 - 0.94	all but 1,2,12,13	...	...
Oct	92					0.10 - 2.80	all but 1,13	all but 1,2,3,4, 7,12,13	all but 1,2,3,4, 7,12,13
Apr	94					<0.09 - 1.01	all but 13	10	10
Sep	94					0.11 - 0.97	all but 22	...	...
Oct	95					<0.1 - 0.92	all but 1,2,3,22		
Nickel		30	50	NSD	20				
Oct	90					4.18 - 41.2	25,5,9,10,11	...	...
May	91					12.00 - 43.2	5,8,9,10	...	
Oct	91					8.02 - 32.0	9,10	...	...
Oct	92					4.91 - 37.3	9,10,11	...	...
Apr	94					3.67 - 39.4	5,9,10,11, 22,25	...	...
Sep	94					7.14 - 58.1	5,9,10,11,25	11	...
Oct	95					7.54 - 41.1	8,9,10,11,25	...	...

* Units are in Effects Range-Low (ER-L), Effects Range-Median (ER-M), Apparent Effects Threshold (AET), (Long and Morgan, 1990 for NOAA); NCR = National Research Council EPA (1989) Threshold Toxic Levels. In ppm (mg/kg dry wt).

Table IV.4. (continued)

Parameter		ER-L	ER-M	AET	NRC	MDR Range	Stations Equal/Exceeding ER-L	ER-M	AET
Silver		1.0	2.2	2.2					
Sep	94					<0.141 - 2.35	4,12,25	12	12
Oct	95					<0.47 - 0.99			
Zinc		120	270	260	760				
Oct	90					28 - 491	all but 3,6	25,9,10 11,22	25,9,10, 11,22
May	91					102 - 640	all but 22	25,8,9, 10,11,13	25,8,9, 10,11,13
Oct	91					55.80 - 624	all but 1	8,9,10,11, 22,25	8,9,10,11 22,25
Oct	92					27.00 - 532	all but 1	9,10,11,13, 22,25	9,10,11,13, 22,25
Apr	94					20.3 - 647	all but 1,3,12	9,11,13, 22,25	5,9,11,13, 22,25
Sep	94					55.3 - 446	all but 3	9,10,11,13, 25	9,10,11,13, 25
Oct	95					81.9 455	all but 1	8,9,10,11, 12,13,25	5,8,9,10,11, 12,13,25

* Units are in Effects Range-Low (ER-L), Effects Range-Median (ER-M), Apparent Effects Threshold (AET), (Long and Morgan, 1990 for NOAA); NCR = National Research Council EPA (1989) Threshold Toxic Levels. In ppm (mg/kg dry wt).

It is important to note that the rankings in which we used only metals, listed above, that had levels above the ER-L were very similar to those produced by ranking the 18 parameters discussed earlier (Table IV.1). The special ranking is as follows:

Rank	Station	Score
High	25	83
	9	82
	11	81
	10	80
Medium High	8	66
	4	59
	5	52
Moderate	6	48
	13	48
	12	46
	7	38
Medium Low	22	26
	2	21
Low	3	19
	1	15

Neither of the ranking methods explains the very low benthic faunal numbers found in 1995. Other factors, such as sediment and freshwater influx during the extreme rains must be involved. Since no benthic faunal survey was performed in October 1993 or April 1994, after the record rainfall of the winter of 1992-1993, it is not possible to compare the two record or near record rainfall periods.

Trends in Metallic Contaminants

Analysis of metals data since 1984 indicates that the long term levels are relatively stable, although there are certainly deviations in concentrations at individual stations. Table IV.4 compares the ranges in metals data with the ER-L, ER-M and AET values established by NOAA.

Arsenic had its lowest range in Fall 1991 and its maximum in April 1994, but the mean since 1984 is slightly increasing, although concentrations remain below the ER-L. The highest **cadmium** was in May 1991 at Station 13, the only time it reached the ER-L;

the trend is slightly down since then. The mean for **chromium** changed little in 13 surveys, but the maximum increased in the 1994 and 1995 surveys, making one station exceed the ER-L in each of the two surveys. The trend line indicates no significant difference.

Copper also shows no significant change, probably because it is so widely involved in antifouling compounds. It is quite toxic to marine life. For this reason, it is above the ER-L in all marina stations, but is below that in Ballona Creek and the entrance channel, and usually in Oxford Basin. Copper also exceeds the ER-M in the inner marina, usually at Stations 8, 9, 10, and 11.

Iron has no ER-L or ER-M values, but it is a strong stimulant to phytoplankton growth. Iron levels appear to be quite stable, although there was a substantially elevated maximum in 1989.

Mean lead has been stable in the marina, although there was a decrease in maxima since May 1991. Highest maxima were in 1987 and 1991, while the lowest maximum was in 1988. The elimination of lead in gasoline has not had an appreciable effect, and the mean seems to be trending slightly upward since 1992, perhaps as urban sediments are carried toward the coast. The ER-L is usually exceeded at all stations, excepting at times Station 1, or 3. The more serious impact is that it exceeds the ER-M often, at Station 12 and 22 in the flood control channels, and at the heavily contaminated marina stations 9, 10, 11 and 25.

Mean **manganese** is also stable at survey stations, with the maxima seen in 1987 and 1991, Fall 1994 and 1995. There is no ER-L or ER-M for manganese.

Mercury has a stable mean, trending slightly downward except in 1988 and 1992.. The highest maximum by far was in 1992, when it was unusually high at Station 10. Mercury exceeded the ER-L at all stations except at Station 1, 2, ,3 and 22. In 1990, 1991 and 1992 Station 12 was below the ER-L, and Station 13 was below the limit in 1992 and April 1994.

Nickel also has a stable mean, varying little from year to year. The highest maxima were in 1987 and Fall 1994. Nickel exceeds the ER-L at the inner marina stations, usually at Stations 9, 10, 11, and sometimes at 5, 8 or 25. Occasionally nickel exceeds the ER-M as well at an inner marina station.

Tributyl tin (TBT) was not measured until 1987, and was found in highly toxic levels in the marina at that time, the highest at Station 6. It is highly toxic in the parts per trillion range, at much more dilute concentrations than those of other metals, which are toxic in the parts per billion range. The Department of Beaches and Harbors instituted a ban on TBT containing paints for before the Federal or State bans were instituted for vessels under 25 m or on aluminum hulls and some portable boats. The mean has been relatively stable since, but the maxima seem to be rising since April 1994. The peak in 1995 was again at Station 6, where it was much higher at 3.04 ppm, than the next highest of 0.47 at Station 7. **All of the TBT values are highly toxic.**

Recent information on butyl tins, the breakdown products of tributyl tin, indicates that they are strong immune system suppressants. Dead dolphins in Japan in were found with high concentrations in liver tissue. Massive die-offs of stranded dophins have occurred on the Atlantic and Gulf Coasts and in the Mediterranean in the last decade. In Florida, research showed higher concentrations in coastal animals than those taken farther out to sea. While not proving that the butyl tins killed the animals, a reduced immune system could well cause dolphins to be susceptable to bacterial or viral disease (Miot, 1997). As long as TBT is allowed on large vessels and aluminum hulls, butyl tins will accumulate in coastal sediments.

Silver has only been measured in Fall 1994 and 1995. In 1994, stations 4, 12 and 25 exceeded the ER-L and Station 12 exceeded the ER-M. No station exceeded the ER-L or ER-M in 1995.

Zinc has had a very stable mean since 1984. The highest maxima were in 1987, May 1991and April 1994. All stations have levels exceeding the ER-l with few exceptions, mostly at Station 1. Five to seven stations usually exceed the ER-M as well.

The ranges in concentrations for metals and selected nonmetallic contaminants from 1985 to 1995 are presented in Table IV.5, along with the station numbers of the maximum concentrations.

Table IV.5. Ranges of non-metallic contaminants and trace metals in sediments in Marina del Rey surveys and highest stations by years.

Parameter*	Oct 85		Feb 87[1]		Oct 87		Oct 88[2]	
Vol. Solids%	1.69-16.84	1,2	1.07-7.87	1,2	3.6-9.7	10,13	0.88-7.19	11,9
TOC%	1.01-10.10	1,2	0.6-4.7	1,2	2.1-5 .6	10,13	0.51-4.17	11,9
IOD	75-850	1,9	ND<1-220	10,11	38-315	10,11	18-330	10,9
COD**	3.4-194.6	1,2	3.75-131.5	1,2	25.3-96.8	2,10	8.3-87.6	10,9
O&G**	0.10-16.7	1,2	1.0-20.7	1,2	0.8-2.8	2,3	0.50-3.5	11,8,9
PO_4	12400-47700	5,9	6200-45000	9,10	1900-5300	6,5	ND<1-3100	9,4
Org-N	650-5900	1,10	216-3900	1,10	1200-3000	10,13	135-1840	10,8
S	0.09-16.9	1,5	0.3-18.9	1,9	0.5-4.7	3,1	0.2-12.1	2,13
As	<2.0-5.8	2,1	<2.0-7.9	1,8	3.3-9.6	4,10	1.86-12.0	10,9
Cd	<1.0		<1.0-5.8	11,1	<1.0-34	13	0.19-1.10	10,4
Cr	5.9-72	11,10	6.5-70.4	9,11	27.9-89.1	12,5	7.2-70.5	10,11
Cu	11.8-245.6	10,11	10.3-359	10,9	24.8-383.0	10.6	6.8-342	10,8
Fe**	15.15-45.6	11,10	4.8-49.5	8,10	12.5-40.9	11,10	4.16-50.1	10,11
Pb	18.1-376.6	10,9	11.0-537	1,12	6.0-563	13	25.4-206	10,9
Mn	30.8-294.4	11,5	46-285	11,9	118-340	13,12	36-276	11,5
Hg	0.09-1.26	10,9	<0.1-1.47	9,10	<0.1-1.1.8	10,6	0.11-1.70	11,5
Ni	<1.0-39.3	10,9	4.4-41.6	11,9	14.6-59.6	12,10	4.0-37.4	11,5
TBT	NA		NA		<8.0-1070	6,10	<.01-5.57	10,11
Zn	42-490	1,10	25-660	1,10	74-587	13,10	42.6-435	10,8

* In mg/kg dry wt unless otherwise indicated. < = Below limits of detection; NA = not analyzed. IOD = Immediate Oxygen Demand: TOC = Total Organic Carbon; COD = Chemical Oxygen Demand.

AS = Arsenic; Cd = Cadmium; Cr = Chromium; Fe = Iron; Pb = lead; Mn == Manganese; Hg = Mercury; Ni = Nickel; S = Sulfide; TBT = Tributyltin; Zn = Zinc.

** COD; Oil & Grease; Iron in 1000s.
[1] Stations 12,13 added in February 1987. [2] No sample possible at Station 12 in October 1988.
[3] Station 25 added in 1989. [4] Station 22 added in 1990.

Table IV.5. continued, ranges of non-metalic contaminants and trace metals and highest stations.

Parameter*	Oct 89[3]		Oct 90[4]		May 91		Oct 91	
Vol. Solids%	0.48-13.91	12,2,10	1.3-11.78	22,10	2.96-11.45	13,10	2.22-16.12	22,10,9
TOC%	0.28-8.07	12,2,10	0.52-4.71	22,10	1.18-4.58	13,10	0.88-6.45	22,10,5
IOD	12-461	12,10	12-374	11,10	15-432	10,9	26-557	10,8,9
COD**	2.44-215.6	12,2,10	6.77-153.1	22,10	34.4-120	2,13	15.5-188.3	22,10,3
O&G**	0.39-11.07	12,2,10	0.36-4.86	22,2	1.28-7.3	2,10	1.08-8.7	22,10,8
PO_4	1900-13300	9,5,11	1.51-179	22,11	3.24-101.1	12,9	<1-43.50	6,10
Org-N	380-4770	12,2,10	235-4125	22,25	1060-3125	13,2	334-4910	22,10,25
S	<0.1-40.7	12,9	<0.2-3.22	1,22	0.13-14.44	7,4	<0.1-6.33	5,6,7
As	1.13-11.3	9,11	2.99-13.80	10,9	2.62-10.54	11,9	2.22-5.51	4,25,3
Cd	<.26-2.12	13,12,2	0.32-2.13	22.10	0.43-5.54	13,3	<0.63-3.0	22,3,10
Cr	4.68-65.2	11,10	6.78-69.80	9,11	16.5-67.8	9,11	12.5-57.9	11,9,10
Cu	8.19-333	10,9	10.4-399	10,9	24-348	10,8	13.8-455	10,8,9
Fe**	3.21-47.1	11,10	3.84-71.5	7,9	14.4-62.8	11,9	8.27-63.2	11,9,10
Pb	17.0-305	13,2,10	7.95-325	12,10	41.3-575	13,10	62.2-487	22,10,13
Mn	27.5-283	11,9	30.3-273	9,11	147-315	11,9	86.3-263	11,9,5
Hg	<0.12-0.92	8,9	<0.10-1.08	9,1	<0.07-1.2	8,9	<0.09-0.94	8,10,9
Ni	3.88-36.4	11,10	4.18-41.20	10,9	12-43.2	13,9	8.02-32.0	9,10,11
TBT	<0.1-0.4	10,9	<0.03-0.52	10,25	<0.01-0.44	3,10	<0.02-0.53	11,10,9
Zn	20.3-444	10,13,2	28-491	22,10	102-640	13,10	55.8-624	22,10,8,9

* In mg/kg dry wt unless otherwise indicated. < = Below limits of detection; NA = not analyzed.
IOD = Immediate Oxygen Demand: TOC = Total Organic Carbon; COD = Chemical Oxygen Demand.

AS = Arsenic; Cd = Cadmium; Cr = Chromium; Fe = Iron; Pb = lead; Mn == Manganese; Hg = Mercury; Ni = Nickel; S = Sulfide; TBT = Tributyltin; Zn = Zinc.

** COD; Oil & Grease; Iron in 1000s.
[1] Stations 12,13 added in February 1987. [2] No sample possible at Station 12 in October 1988.
[3] Station 25 added in 1989. [4] Station 22 added in 1990.

Table IV.5. continued, ranges of non-metallic contaminants and trace metals and highest stations.

Parameter*	Oct 92		Apr 94		Sept 94		Oct 95	
Vol. Solids%	1.13-13.58	22,10,9	1.20-12.20	22,12	2.94-11.72	12,13	1.47-8.26	25,11
TOC%	0.46-5.43	22,10,9	0.50-4.9	22,12,11	1.2-4.7	12,13	0.6-3.3	25,11
IOD	<1.0-383	10,25,9	4.00-290	22,9,11	31-460	10,11	11-360	10,11
COD**	3.14-165.0	22,10,25	2.68-154.0	22,12,2	8.6-171.0	12,13	20.4-79.8	25,11
O&G**	0.227-4.16	22,2,3	0.508-9.2	22,12	0.8-6.76	12,13	0.52-2.84	11,2
PO_4	0.53-15.10	9,25,4	290-1640	25,9,11	280-2220	13,11	288-1260	9,10
Org-N	105-4010	22,10,25	110-3180	22,10,12	452-2960	13,12	692-1940	25,10
S	0.4-13.8	3,4,9	0.60-1350	22,2,12	1.5-2310	12,1	1.0-1322	2
As	1.81-12.60	9,11,10	2.44-19.8	9,10,11	2.86-11.2	10,25	3.56-11.80	10,11
Cd	0.13-2.22	22,13,25	<0.2-2.93	22,13	<2.8-1.14	12,1	<0.31-1.23	10,25
Cr	8.73-72.6	9,10,11	5.74-67.5	11,9,10	11.9-81.7	11,25	15-83.3	9,11
Cu	5.50-322	9,8	6.55-339	11.9,8	25.3-402	10,11	29.4-380	9,11
Fe**	5.7-49.6	10,11,9	3.36-51.80	11,9	6.40-49.8	11,5	7.3-49.6	9,11
Pb	22.90-372	13,22,1	12.50-427	12,13,22	32.3-413	13,12	54.3-295	13,10
Mn	63.1-279	9,5,11	26.20-292	11,5,9	52.2-328	11,5	74.6-315	11,9
Hg	<0.10-2.8	10,9	<0.09-1.01	10,9,11	0.11-0.97	9,10	<.09-0.92	11,10
Ni	4.91-37.3	9,10,11	3.67-39.40	11,9,10	7.14-58.1	11,5	7.54-41.1	11,9
TBT	<0.003-2.2	10,25,11	<0.04-0.34	9,5	0.05-0.88	10,6	0.08-3.04	6
Zn	27.0-523	22,10	20.30-647	22,13,11	55.3-446	10,11	87.9-455	10,12

* In mg/kg dry wt unless otherwise indicated. < = Below limits of detection; NA = not analyzed.
IOD = Immediate Oxygen Demand: TOC = Total Organic Carbon; COD = Chemical Oxygen Demand.

AS = Arsenic; Cd = Cadmium; Cr = Chromium; Fe = Iron; Pb = lead; Mn == Manganese; Hg = Mercury; Ni = Nickel; S = Sulfide; TBT = Tributyltin; Zn = Zinc.

** COD; Oil & Grease; Iron in 1000s.
[1] Stations 12,13 added in February 1987. [2] No sample possible at Station 12 in October 1988.
[3] Station 25 added in 1989. [4] Station 22 added in 1990.

Some metals enter the food web by first being taken up by phytoplankton; these include selenium and lead, according to tests on *Mytilus*, which are strong bioaccumulators. Cadmium was absorbed mostly from the water, and uptake of other metals such as zinc and silver was dependent on water conditions (Adler, 1997).

Sulfide, a nonmetallic parameter, was very low every year in the marina and flood control channels from 1984 until Spring 1994, when it soared to 2310 ppm in Ballona Creek at Station 12, 1,670 ppm at Station 1 and 1,580 ppm at Station 2; these were unexpectedly high, because the next highest in the marina was 613 ppm at Station 10. This could well be interpreted as due to the flushing of storm drains by the record rains of the winter of 1992-1993 of 47.5 inches in the Los Angeles Basin, following years of much lower rainfall ranging from a low of 6.8 inches in 1986-1987 to a high of 29.0 in 1991-1992.

In 1995, possibly demonstrating the effects of deposition from Ballona Creek flood control channel of sediments in the marina, the sulfide was 1,322 ppm at Station 2, while the range elsewhere was 191 ppm at Station 25 down to 1.0 ppm at Stations 13 and 22. Soule et al., 1996 stated that sulfide was several orders of magnitude lower than it had been in the 1977-1978 surveys. This is still true even though the maxima increased by an order of magnitude in April 1994 at Station 22 and nearly doubled that at Station 12 by September 1994, following a low rainfall year in 1993-1994 and the dry summer; the 1995 maximum declined to slightly less that the April 1994 value, but this time it was at Station 2 after heavy rains in 1994-1995.

Sulfate, another nonmetallic parameter, was highest in Fall 1994 at Stations 25, 5 and 11 on the main channel and at Stations 9 and 10 in Basins F and D, ranging from 2,100 ppm to 2,640 ppm In 1995, sulfate was higher, with the highest at Station 8, at 4,030 ppm, and was above 2,40 ppm at Stations 9, 10 and 11. The sulfides had apparently reacted to form metallic sulfates and been deposited in the lowest flushing areas.

In our sediment conclusions in 1995, Soule et al., 1996 stated that there had been a number of reductions in some nonmetallic pollutants, excluding pesticides and chlorinated hydrocarbons, over the period of the USC surveys:

Volatile Solids declined from a maximum in 1985 of 16.84 percent to a maximum of 7.19 percent in 1988, but rose to a peak of 13.58 percent in 1992 after which it declined to 8.26 percent in 1995;

Total Organic Carbon declined from a maximum of 10.1 percent in 1985 to 4.71 percent in 1990, after which it rose slightly to a maximum of 5.43 in 1992 and declined to a maximum of 3.3 percent in 1995;

Immediate Oxygen Demand has decreased by an order of magnitude or more since 1977 and 1978;

Chemical Oxygen Demand maxima, which were usually at Station 12, have declined since 1989, concomitant with efforts to control sewage overflows into the creek and the maximum shifted to Station 25 in 1995;

Organic Nitrogen maxima have declined from a peak of 5900 ppm in 1985, to a low of 1840 ppm in 1988, rose to 4910 in 1991 and decreased to 1940 ppm in 1995, being only about 33 percent of the 1985 level, but the decline may not be stable; and

Phosphorus maxima have declined by more than an order of magnitude from 47,700 ppm in 1985 to 15.1 ppm in 1992; there were increases in April and September 1994 to 2220 ppm, but declined to 1260 in 1995.

It is possible that the long sequence of relatively low, or very low rainfall in the 1980s affected flushing in quite different ways, in turn changing the levels of parameters. However, not all changes are consistent in following the relatively wet rainfall year of 1991-1992, nor the very wet years of 1992-1993 and 1994-1995 (see rainfall figures in Los Angeles Basin in Appendix E). Peaks may represent episodes of dumping violations, accidental spills or erosion as well.

PESTICIDES AND CHLORINATED HYDROCARBONS

The pesticides Chlordane and the p.p' forms of DDT, including degradation products p.p' DDD and p.p'DDE, continue to occur in the marina in concentrations sufficient to inhibit reproduction and growth of some species of fish and invertebrates. Table IV.6 contains the data for pesticides and chlorinated hydrocarbons.

Table IV.6. Sediment pesticides and chlorinated hydrocarbons, 26 October 1995, in ug/kg (ppb).

Stations / Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	22	25	Mean°
Chlordane	140.0	230.0	160.0	180.0	60.0	ND<20	ND<20	ND<20	ND<20	110.0	ND<20	380.0	100.0	110.0	160.0	163.00
p.p' DDT	ND<4.0	5.0	ND<4.0	60.0	9.0	ND<4.0	ND<4.0	ND<4.0	ND<4.0	ND<4.0	ND<4.0	6.0	14.0	7.0	ND<4.0	16.83
p.p' DDD	6.0	16.0	10.0	16.0	14.0	ND<4.0	10.0	70.0	ND<4.0	9.0	13.0	20.0	5.0	7.0	14.0	16.15
p.p' DDE	7.0	15.0	15.0	22.0	16.0	60.0	19.0	14.0	ND<4.0	31.0	25.0	24.0	ND<4.	7.0	25.0	21.54
Total pesticides	153.0	266.0	185.0	278.0	99.0	60.0	29.0	84.0	ND	150.0	38.0	430.0	119.0	131.0	199.0	158.64
Aroclor 1254	ND<50	ND<50	ND<50	ND<50	ND<50	ND<50	ND<50	ND<50	ND<50	ND<50	ND<50	90.0	ND<50	ND<50	ND<50	90.00
Total pesticides & chlorinated hydrocarbons	153.0	266.0	185.0	278.0	99.0	60.0	29.0	84.0	ND	150.0	38.0	520.0	119.0	131.0	199.0	165.07

° Mean of stations where detected

ND< = none detected at detection level indicated

Parameters below limits of detection at all stations:

ND<1.0 - Aldrin, Lindane, Dieldrin, Heptaclor, Heptaclor epoxide
ND<2.0 - Alpha BHC, Beta BHC, Endrin
ND<10.0 - Toxaphene
ND<50.0 - Aroclor 1016, 1221, 1232, 1242, 1248, 1260

Table IV.7. Chlorinated hydrocarbon ranges in sediment and highest stations by years in 1985-1995.

Date Parameter ug/kg(ppb)	October	'87[1]	October	'88[2]	October	'89[3]	October	'90[4]	May	'91
Chlordane	ND-290	2,1	13.5-283	2,4	ND-630	2,12	10-410	22;2	ND-360	2,3
Dieldrin	ND		ND		ND		ND		ND	
p.p'DDT	6-57	2,10	ND-29.1	8,11	4-200	12,9	ND-29	2,9	ND-14	2,22
p.p'DDD	2-34	9,2	ND-66.7	9,4	2-40	12,2	4-100	22,25	ND-15	11,10
p.p'DDE	10-105	9,10	ND-189	9,10	ND-77	11,10	ND-104	25,22	3.5-110	13,11
Aroclor										
1254	ND		ND		ND-330	2,10	ND-153	2,6	ND	
1260	ND		ND		ND-200	25,12	ND-172	11,1	ND-300	11,1

Date Parameter ug/kg(ppb)	October	'91	October	'92	April	'94	Sept	'94	Oct	'95
Chlordane	31-436	2,22	ND-270	3,10	ND-167	12,2	ND-109	12,4	ND-380	12,2
Dieldrin	ND		ND		ND-30	12	ND		ND	
p.p'DDT	ND-48	3,2	ND-56	12,22	ND-86	11,9	ND-49	10,7	ND-60	4,13
p.p'DDD	ND-23	2,3	ND-36	5,22	ND-40	9,11	8-47	4,9	ND-70	8,12
p.p'DDE	3-67	3,2	ND-169	10,9	ND-94	9,10	11-63	9,10	ND-60	6,10
Aroclor										
1254	ND		ND		ND-110	22,12	ND-231	10,9	ND-90	12
1260	ND		ND-90	25,22	ND		ND		ND	

[1]Station 12,13 added in February 1981
[2]Station 12 not sampled in 1988
[3]Station 25 added in 1989
[4]Station 22 added in 1990
ND = <limits of detection, documented in respective annual reports

Concentrations of the pesticides and chlorinated hydrocarbons that occurred in the marina in the 1995 are mapped in Figures IV.36-41, appended at the end of this chapter. The data on ranges for each of the parameters and the stations with the highest levels in the surveys of 1987 through 1995 are presented in Table IV. 7 (opposite page).

During the marina surveys a number of pesticides have not been found in the marina; these include Aldrin, Heptaclor, Heptaclor epoxide, Alpha BHC, Beta BHC, Endrin and Toxaphene. Lindane was last found in October 1987. Dieldrin was absent after 1985, until it occurred at Station 12 in April 1994; production of Dieldrin was halted in the USA in the early 1970s but it continued to be imported until 1985.

Station Rankings based on Total Concentrations of Pesticides and Aroclors

Total pesticides are more important than the separate levels of the various forms of DDT. With Chlordane added to the DDTs, Station 12 had the highest pesticides, 430 ppb. Station 4 was second, with 278 ppb, followed by Station 2, with 266 ppb in 1995.

When the all the pesticides plus the chlorinated hydrocarbons (Aroclors) are considered as a total, a clearer picture of the potential for ecological harm is gained. Table IV.8 ranks the stations according to total pesticide and chlorinated hydrocarbons in ppb from 1989 to 1995 since these are comparable parameters and need not be ranked according to station for each parameter as are the trace metal scores, which do not have comparable levels of impact or magnitude of concentrations.

Station 2 holds the record for the highest total score accumulated of 1121 ppb in 1989 (scores were not determined prior to that). Its total moved to high in 1990 and back to the highest, although with much lower total s of 569 ppb and 5441 ppb in May and October 1991. The total dropped to moderate in 1992 and remained there through 1995.

The Station 12 score declined from 809 ppb in 1989 to 303 ppb in May 1991 but increased in each subsequent period to reach 520 ppb in 1995. Station 2, which held the record high in 1989 of 1121 ppb, declined to 541 ppb in October 1991, and to 266 ppb in 1995.

The next highest total in 1995 was at Station 4, which had climbed from medium low

Table IV.8. Ranking of stations by total pesticides and chlorinated hydrocarbons In ppb (ug/kg).

	Oct Sta	1989+ Score	Oct Sta	1990 Score	May Sta	1991 Score	Oct Sta	1991 Score	Oct Sta	1992 Score	Apr Sta	1994 Score	Sep Sta	1994 Score	Oct Sta	1995 Score
HIGHEST	2	1121														
above-500	12	809														
			22	731												
					2	569	2	541							12	520
HIGH	10	419	10	494	11	496										
400-499			2	473	10	487			10	486						
			11	443	1	429			22	459			10	450		
					3	401	3	409			12	400				
MED HIGH	11	380							12	398			4	376		
300-399	25	354					22	345			9	341				
	5	324	9	334					5	338						
	7	324	25	327	13	324			25	337			9	313		
	9	306			12	303			9	315			12	300		
									3	315						
MODERATE											11	289				
200-299									2	274	22	280	22	280		
											25	278	25	269	4	278
			5	262							5	261	5	266	2	266
					25	248					2	252	2	241		
											7	240	13	225		
	13	236			8	232					10	230				
			4	206	4	218			4	220			7	220		
			1	205	5	218							1	210		
MED LOW															25	199
100-199			6	178			25	173			4	185			3	185
			7	166												
			8	150			12	152							1	153
	4	147	12	135	7	141	4	141							10	150
	6	120											11	111	22	131
							5	130							13	119
							6	130	11	104	13	104	22	100		
LOW	8	86					7	92	6	87					5	99
0-99	1	85					10	91	7	83					8	84
							11	91								
							9	71								
					22	54	1	57							6	60
							8	55	8	50	8	39	6	38		
					6	35	13	34			1	28	8	34	11	38
			13	22							6	27	3	18	7	29
	3	17	3	21					1	ND						
									13	ND	3	ND			9	ND

+ Station 22 not sampled

in 1989 to moderate. Station 3, which was in the low category in 1989 and 1990, jumped to high with 409 ppb in October 1991, then dropped to low in April and September 1994, and then rose to medium low in 1995.

There was a readily apparent general decline in maximum total pesticides and chlorinated hydrocarbons from 1121 ppb in 1989, to 400 ppb in April 1994, after which the maxima rose somewhat to 520 ppb in 1995. Within the marina, no stations were in the high and medium high categories in 1995. There has been about a 50 percent decline in the median since 1989. The inner marina stations and Oxford Basin joined the downward trend in maxima and thus in total scores. There is considerable variability, however.

<u>NOAA Effects Ranges for Pesticides and Chlorinated Hydrocarbons</u>

The Effects Range Low (ER-L), Effects Range Median (ER-M) and Apparent Effects Threshold (AET) for the principle pesticides and Aroclors found in the marina were among those evaluated by NOAA (1990). The data are presented in Table IV.9.

<u>Chlordane</u>

Chlordane has been banned for most uses but is obviously still reaching marina waters. Chlordane was used for termite control, and the soil in older areas with wooden houses is probably saturated with it. Soule et al., (1996 and previous reports) reviewed the incidence of chlordane and its effects. Chlordane decreased during the dry period of summer in 1994, but increased in 1995 sediments. **In Fall 1994, Chlordane was below the limits of detection at Stations 3, 6 and 8, and the mean concentration was 66.08 ppb (Soule et al., 1996), while in 1995 it was below the limits of detection at Stations 6, 7, 8, 9, and 11, but the mean, at stations where detected, was 163 ppb.** The 1995 maximum for Chlordane was at Station 12, with 380 ppb. In contrast, in 1994, the maximum was only 109 ppb at Station 12. Ballona Creek seems to be a major collection point for Chlordane. **The second highest Chlordane in 1995 was Station 2, followed by Stations 4, with 180 ppb, and Stations 3, and 25, with 160 ppb.**

The ER-L for Chlordane is 0.5 ppb and the ER-M is 6 ppb. **All the survey stations**

exceeded both in 1995, except where it was below the limits of detection, in the inner marina basins and the end of the main channel. The AET was also exceeded.

The DDTs

Although p.p'DDT has been banned since the early 1970s, fresh (or non-degraded) DDT and its breakdown products, p.p'DDD and p.p'DDE, continue to be found in the marina and flood control channels. **Maxima for total DDTs occurred in 1989 and 1992, while minima occurred in 1987 and 1991 (Table IV.7). Obviously, input, or exposure of contaminated sediments, is irregular.** The long term trend for the mean of total DDTs shows a stable pattern, without significant change, although the trend is downward since 1992.

The mean for DDT decreased from 17.29 ppb in Fall 1994 to 6.73 ppb in 1995, being below the limits of detection at nine of the 15 stations in 1995, as compared to being undetected at only one, Station 3, in 1994. The maximum, however was 60 ppb at Station 4, compared to last year's maximum of 49 ppb at Station 10. The absence in detection at Station 1, 3, 6, 7, 8, 9, 10 and 11 suggests both flushing from the basins and new sand deposition at Station 1 due to the heavy rainfalls in the winter of 1994-1995.

The ER-L for p.p'DDT is 1.0 ppb, which was exceeded at Stations 2, 4, 5, 12, 13 and 22 but was undetected at the other basin stations in 1995. The ER-M is 7.0 ppb, which was exceeded at Stations 4, 5, 13 and 22.

The ER-L for p.p'DDD is 2.0 ppb and the ER-M is 20 ppb, although recent research suggests that this should be lower. **All survey stations exceeded the ER-L except Stations 6 and 9, where DDD was below the limits of detection. Only Stations 8 and 12 exceeded the ER-M.** This may be one of the substances impacting the biota in Basin D.

The ER-L for p.p'DDE is 2.0 ppb and the ER-M is 15 ppb, which also should probably be lowered. **All stations except Stations 9 and 13 exceeded the ER-L and all but Stations 1, 8, 9, 23 and 22 exceeded the present ER-M.**

The ER-L for total DDTs is 3.0 ppb, because of the importance of the additive effects of the various forms. The NOAA ER-M is 350 ppb, but recent research suggests that this

Table IV.9. Concentrations (ug/kg, ppb) of pesticides and chlorinated hydrocarbons producing biological effects.

Parameter		ER-L	ER-M	AET	NRC	MDR Range	Stations ER-L	Equal/Exceeding ER-M	AET
Chlordane		0.5	6	27	20				
Oct	90					10 - 410	all stations	all stations	all stations
May	91					<10 - 360	all but 6?(ND)	same	same
Oct	91					31 - 436	all stations	all stations	all stations
Oct	92					<50 - 270	all but 1,6,7,8,11,13	same	same
Apr	94					<20 - 167	all but 3,6,8 (ND)	same	same
Sep	94					<20 - 109	all but 2,6,8 (ND)	same	same
Oct	95					<20 * 380	all but 6,7,8,9,11(ND)	same	same
p.p'DDT		1	7	6?	6				
Oct	90					<4 - 29	all but 3,12,13,22, 25 (ND)	same	same
May	91					<4 - 14	all stations	all but 3,4,6,7,25	same
Oct	91					<4 - 48	all but 1,13 (ND)	same	same
Oct	92					<4 - 56	all but 1,13 (ND)	all but 1,13,2	same same
Apr	94					<4 - 86	all but 1,3,6 (ND)	same	...
Sep	94					<4 - 49	all but 3 (ND)	all but 3,6,8	same
Oct	95					<4 - 60	2,4,5,12,13,22	4,5,13,22	same
p.p'DDD		2	20	?	13000				
Oct	90					<4 - 100	all but 3,6,7,12,13(ND	2,9,11,22, 25	?
May	91					<4 - 15	all but 22 (ND)	...	?
Oct	91					<4 - 23	all but 6,8,10,13	2,3	?
Oct	92					<1 - 36	all but 1,8,13 (ND)	4,5,6,9, 10,12,22	?
Apr	94					<4 - 40	all but 1,3 (ND)	4,5,7,9 10,11,12,25	?
Sep	94					8 - 47	all stations	all but 3,6,8	?
Oct	95					<4 - 70	all but 6,9 (ND)	8,12	

< = below the limits of detection; ND = none detected
Units are in Effects Range-Low (ER-L), Effect Range-Median (ER-M), Apparent Effects Threshold (AET) (NOAA: Long and Morgan, 1990); National Research Council (NRC) EPA Threshold Levels. In ppb (ug/kg).
[1]ER-L, ER-M, AGT established only for Total Aroclors.
* No station had both Aroclor 1254 and 1260 at the same time

Table IV.9. (continued)

Parameter	ER-L	ER-M	AET	NRC	MDR Range	Stations Equal/Exceeding ER-L	ER-M	AET
p,p'DDE	2	15	2?	28000				
Oct 90					<4 - 104	all but 3 (ND)	all but 3,12,13	all but 3 (ND)
May 91					3.5 - 110	all stations	all but 22,9	all stations
Oct 91					3.0 - 67	all stations	all but 1,8,12,13	all stations
Oct 92					<4 - 169	all but 1,13 (ND)	same	same
Apr 94					<4 - 94	all but 1,3 (ND)	all but 1,3,6,8	...
Sep 94					8 - 63	all stations	all but 1,3	...
Oct 95					<4 - 60	all but 9,13 (ND)	all but 1,8,9,13,22	...
Total DDTs	3	350	...	...				
Oct 90					<4 - 199	all but 3 (ND)	...	...
May 91					33 - 134	all stations	...	...
Oct 91					3.0 - 136	all stations	...	...
Oct 92					<1 - 236	all but 1,13 (ND)	...	...
Apr 94					<4 - 204	all but 1,3 (ND)	...	...
Sep 94					22 - 141	all stations	...	...
Oct 95					<4 - 190	all but 6,9,13 (ND)		
Total Aroclor[1]	50	400	3?	280				
Aroclor 1254*								
Oct 90					<1 - 153	all but 2,4,5,6,7,8	...	all but 2,4,5,6,7,8
May 91					<10	...	...	...
Oct 91					<10	...	...	...
Oct 92					<50	...	...	...
Apr 94					<50 - 110	5,7,9,11, 12,22,25	...	...
Sep 94					<50 - 231	all but 3,6,8,11,22	...	...
Oct 95					<50 - 90	12	...	...
Aroclor 1260*								
Oct 90					<1 - 172	all but 9,10,11,22,25	...	all but 9,10,11,22,25
May 91					<10 - 300	all but 6,13,22 (ND)	...	all but 6,13,22
Oct 91					<10	...	...	?
Oct 92					<50 - 90	12,5,9, 22,25	12,5,9, 22,25	?
Apr 94					<50	ND	...	?
Sept 94					<50	ND	...	...
Oct 95						ND	...	...

should be lower. **All stations exceeded the ER-L except Stations 6, 9 and 13. where they were below the limits of detection.** None of the stations exceeded the present ER-M.

Chlorinated Hydrocarbons; the Aroclors (PCBs)

There are many types of Aroclor; our analyses determine types numbered 1016, 1221, 1232, 1248, 1254 and 1260, with the end numbers indicating the amount of chlorine in the compound. They supposedly increase in toxicity with the increasing numbers.

Aroclors first appeared in marina surveys in the 1970s, when a peak of 1,247 ppb was found. They reappeared in October 1989 at highly toxic levels, so unexpectedly that a second survey for PCBs was conducted in January 1990 (Soule et al., 1991). Aroclor 1254 was highest at Stations 2, with 330 ppb, and 10, with 150 ppb, but was detected at all sites except Station 3. Aroclor 1260 appeared only at Stations 25, with 200 ppb, and 12, with 130 ppb, suggesting that sources were nearby if Aroclor 1254 is a degradation product. **The two forms were never found together at any station.** By January 1990, Aroclor 1260 was even higher at Station 25 and occurred at all stations except Stations 3, 4, and 13. The Aroclors may have reflected drainage from developing the formerly industrial site northeast of the marina on Lincoln Boulevard. It was known that **terrestrial soil north the marina had a level of Aroclor 1260 as high as 22,200 ppb at about that time**, but no Aroclors were found near the excavation site for the new hotel.

No Aroclor 1260 was found in the April and September 1994 surveys nor in 1995. Aroclor 1254 was found at all stations except Stations 3, 6, 8, 11 and 22 in September 1994, but occurred only at Station 12 in 1995. Old transformers usually contained PCBs as lubricants, which makes them dangerous if they leak or are not properly disposed of.

The ER-L given by NOAA (Long and Morgan, 1990) is for total Aroclor, of 50 ppb, and the ER-M is 400 ppb. **The potential for serious impact is great with contaminated soils nearby and the general presence of PCBs as lubricants in old equipment.**

"Endocrine Disrupters"

Research in the last four years has shown that DDT breakdown products, PCBs, dioxins, some plasticizers, sealants and detergents, and the synthetic hormones taken by human females that get into the waste water, are classed as "endocrine disrupters" that can mimic or block the action of natural hormones. This effect, so recently recognized, may be responsible for disrupting reproduction by causing, for example, some male fish to look and act like females, with resultant reproductive failure that could influence fish populations in fresh and coastal marine waters. The substances can cause limb abnormalities in animals and neurological aberrations (summarized by Raloff, 1997).

CONCLUSIONS

Metallic parameters have not declined in the marina in recent years, but seem relatively stable within a fairly large range of variation. Among the metals measured, Effects Range data published by NOAA indicate that the metals for which levels hazardous to marine life have been established are arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver and zinc. Of these, copper, lead, mercury, nickel and zinc are found in the marina in concentrations that can inhibit the biota, especially sensitive larvae and juveniles and the reproductive capacities of adults. These contaminants influence the ecology of the marina by inhibiting or eliminating some of the species such as some molluscan and large crustacean species. Tributyl tin (TBT) is highly toxic, but no sediment tolerances have been established. When present, even in the smallest quantities of the parts per trillion concentration, TBT is extremely toxic to larvae.

Most of the toxic metals tend to complex with the finest grained sediments (Soule et al., 1996), resulting in the high concentrations in the areas of poorest circulation. Some mixtures, however, are not as toxic as the sum of their contaminants would indicated, suggesting that some chemical reactions result in sequestering the metallic ions and rendering them inert until conditions change.

Benthic organisms, particularly the worms, work the sediment by burrowing (bioturbation), helping to disperse contaminants into the bottom. Some species are able to consume contaminated sediment without passing it up the food web, but other bottom dwellers bioaccumulate metals.

Station 25 ranked highest in metallic and non-metallic contaminants as it has almost every year. Stations 9, 10 and 11 in the inner marina are consistently among the most contaminated. Station 8, which had the poorest benthic fauna, increased its burden of fine sediments and metals. **Storm runoff from Oxford Basin may flow into Basin D when it meets a rising tide; flow can only rise against the bulkheads in other basins, but the excess water can flow unopposed up onto the beach, where sediments will be stranded. This should be an area rich in biota, but is too often impacted.**

Non-metallic contaminants including Volatile Solids, Total Organic Carbon, Immediate Oxygen Demand, Chemical Oxygen Demand, Organic Nitrogen and Phosphorus have all declined in recent years, which represents a positive improvement in the marina ecology. **High concentrations of chloride, sodium, fluoride and organic nitrogen at Stations 8, 9, 10 and 11 further indicate the deposition in those poorly flushed sites.**

Although the pesticides Chlordane and the DDTs including DDT, DDD and DDE and the chlorinated hydrocarbons (PCBs) have declined in recent years, concentrations continue to occur in the marina in quantities that are inhibitory to reproduction of some species of invertebrates and fish. **New DDT and Chlordane seem to enter the marina, and existing DDTs and Chlordane are moved about by tidal circulation.**

The PCB Aroclors 1254 and 1260, which are highly toxic, have appeared sporadically, with the likely sources being erosion and runoff from the adjacent urban and industrial area.

Most serious is the recent research that shows that the class of compounds including Chlordane, the DDTs and the PCBs, plus synthetic female hormones that enter waste water, detergents, sealants, plasticizers and dioxin act as "endocrine disrupters" in invertebrates and fish. Males become feminized and are unable to mate or reproduce. This problem may account, in part, for the decrease in many coastal and freshwater species.

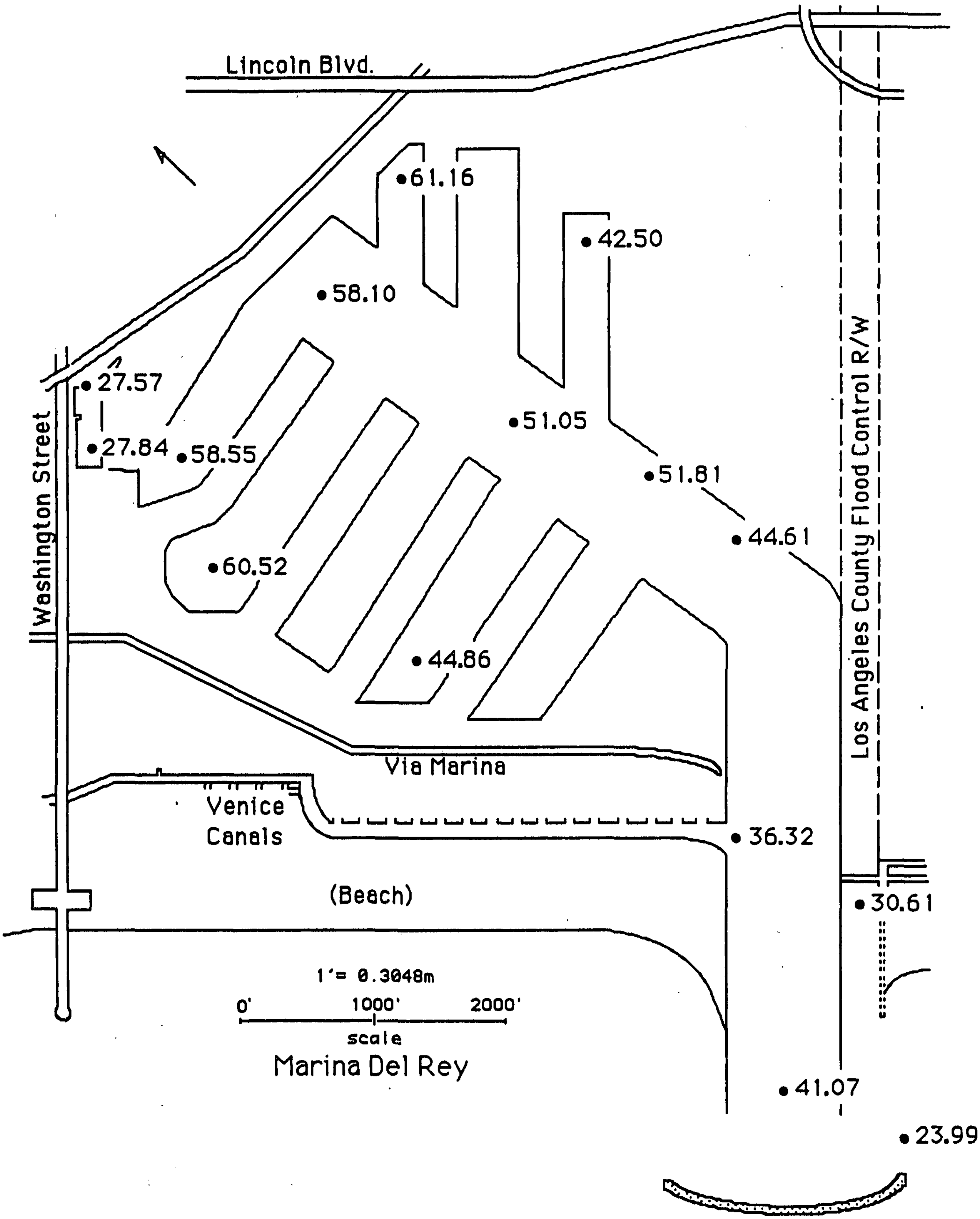


Figure IV.1. Percent moisture in sediment, 27 October 1995.

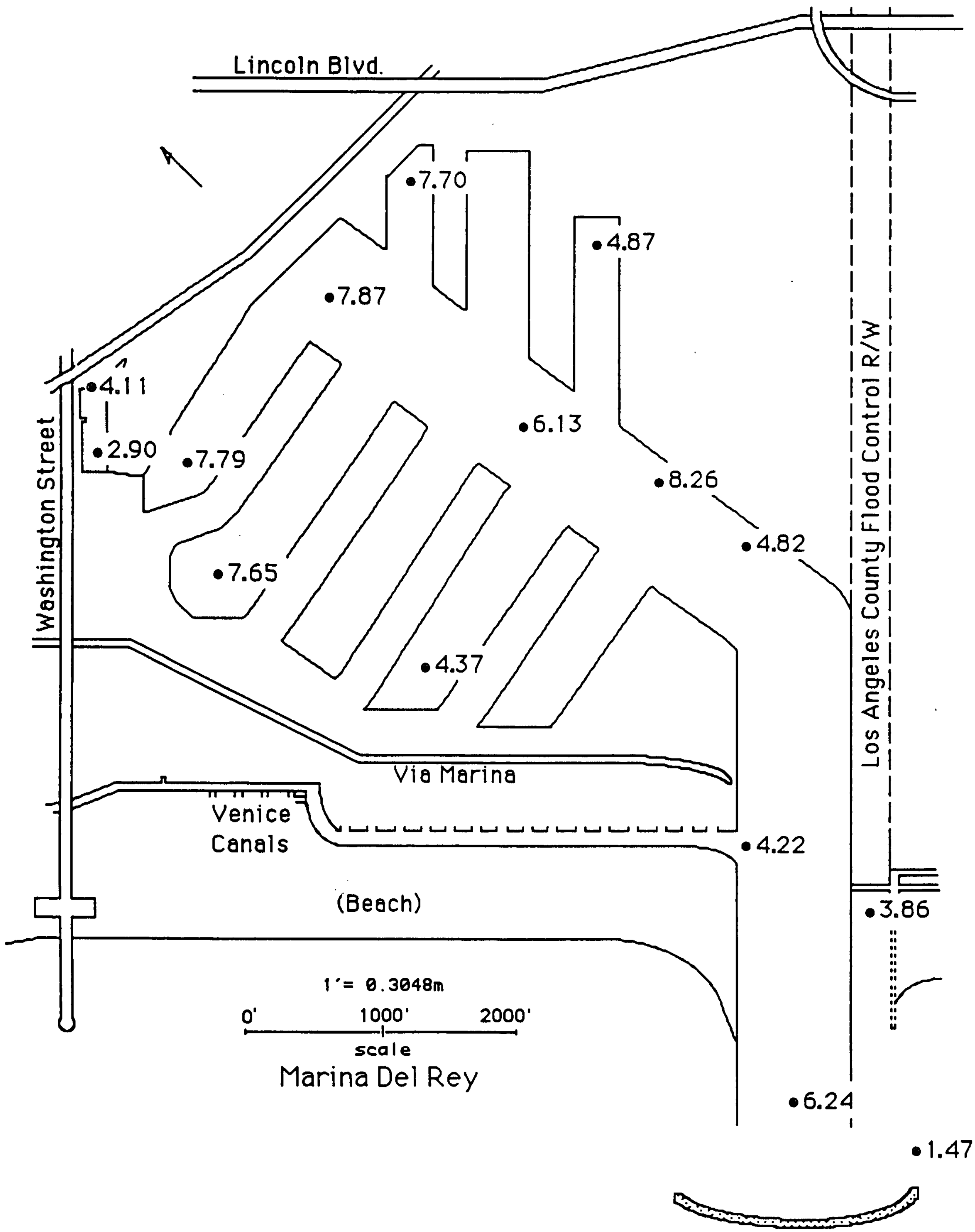


Figure IV.2. Percent volatile solids in sediment, 27 October 1995.

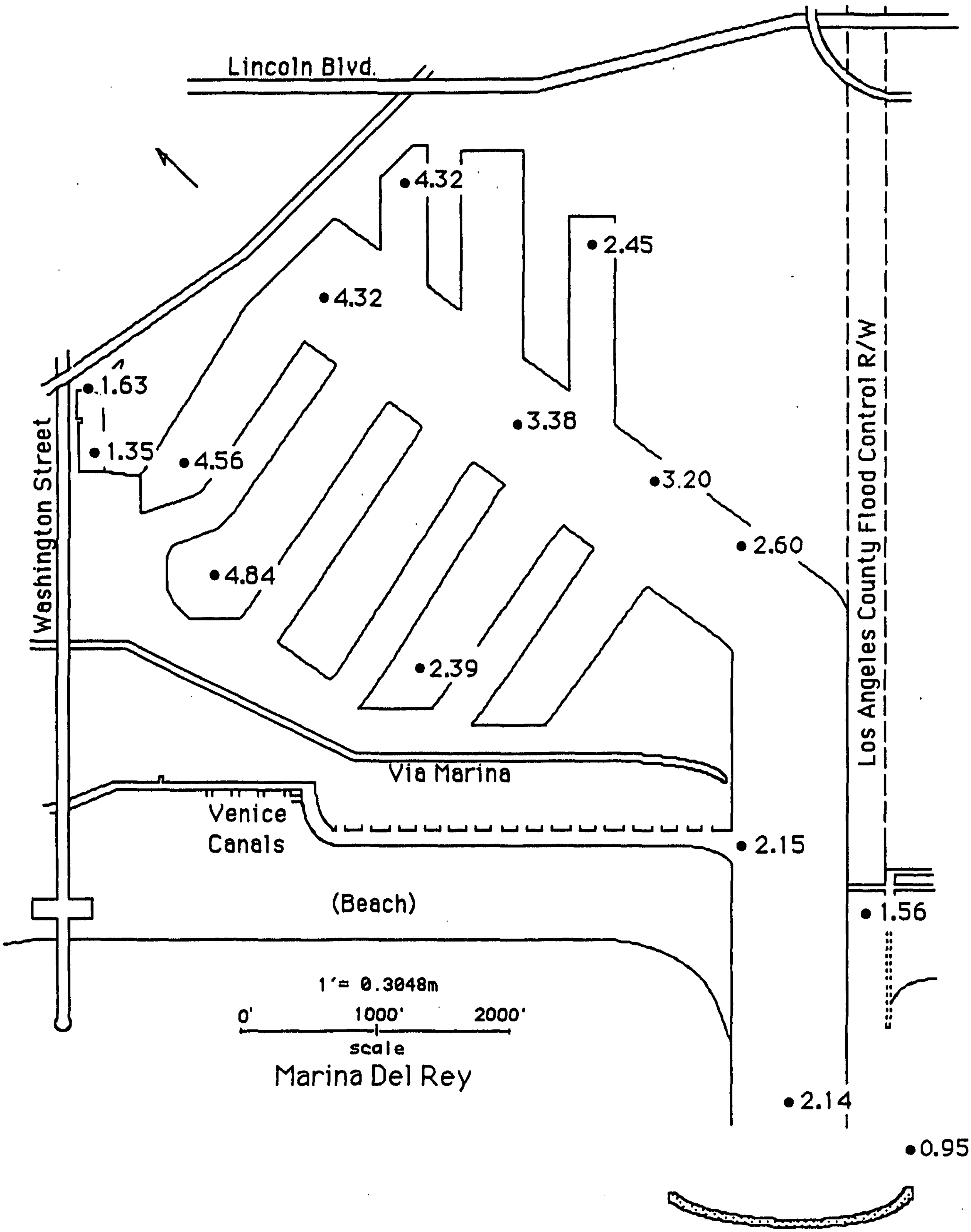


Figure IV.3. Percent total dissolved solids in sediment, 27 October 1995.

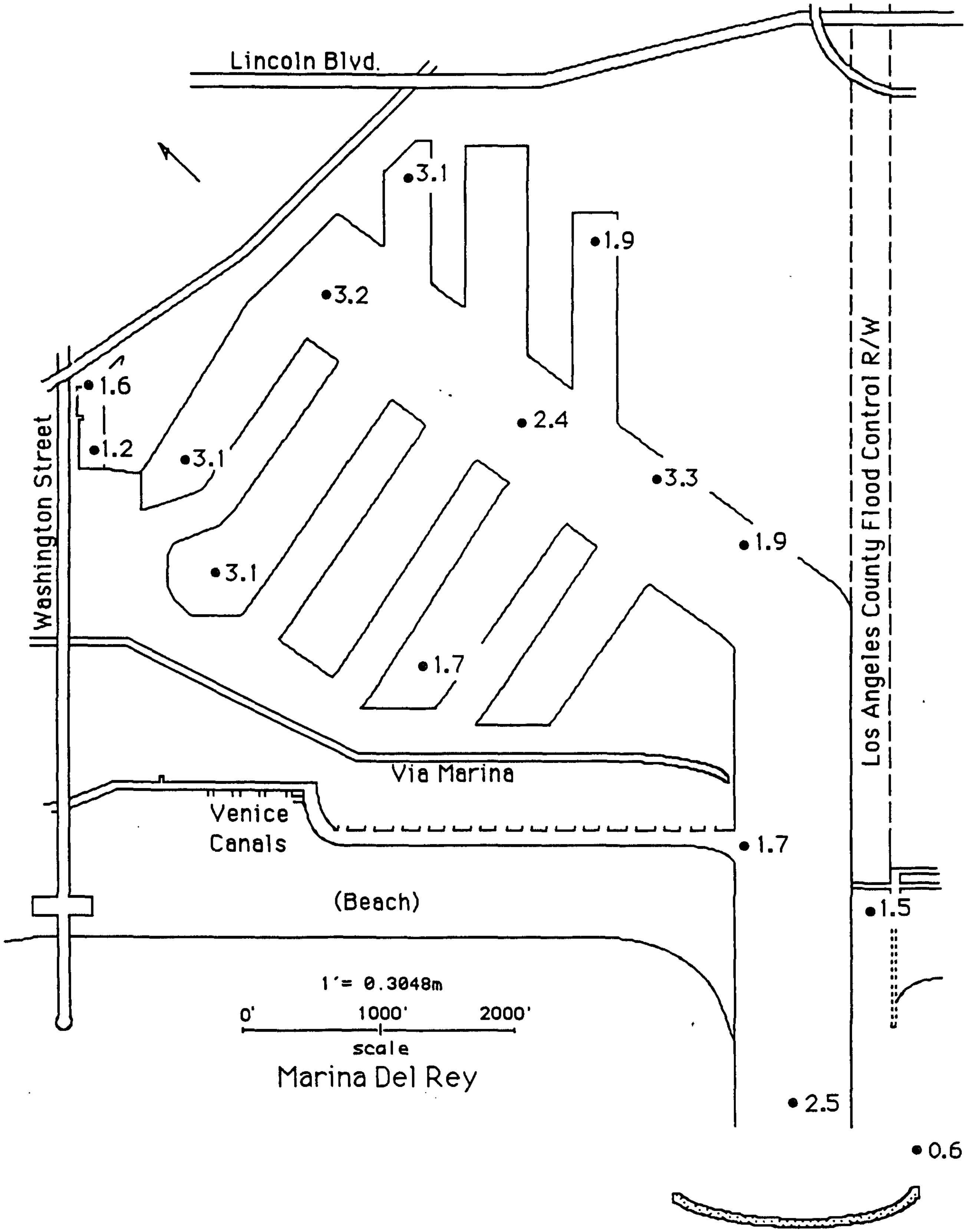


Figure IV.4. Percent total organic carbon, 27 October 1995

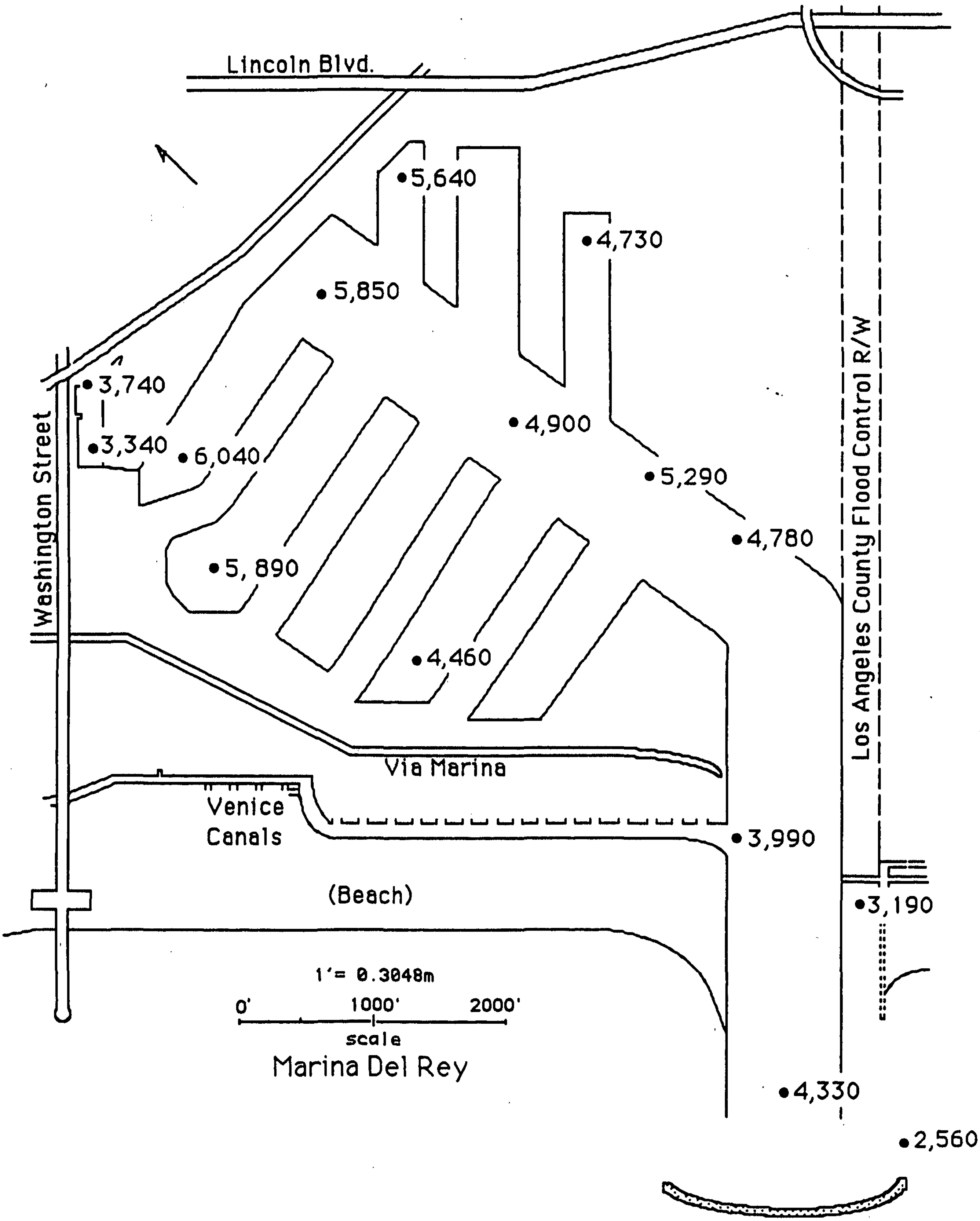


Figure IV.5. Specific conductance in μmhos/cm, 27 October 1995

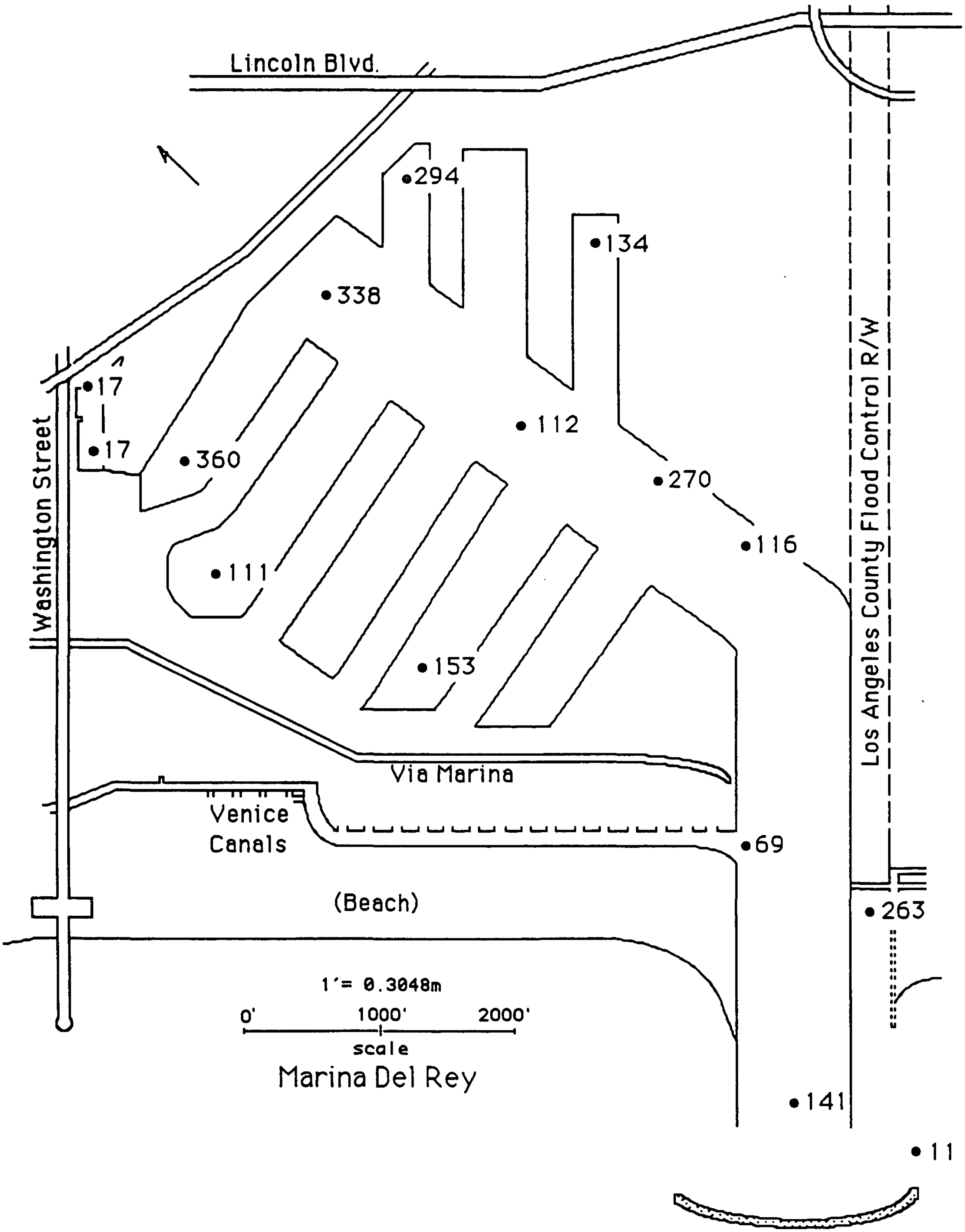


Figure IV.6. Immediate oxygen demand in mg/kg dry wt (ppm), 27 October 1995.

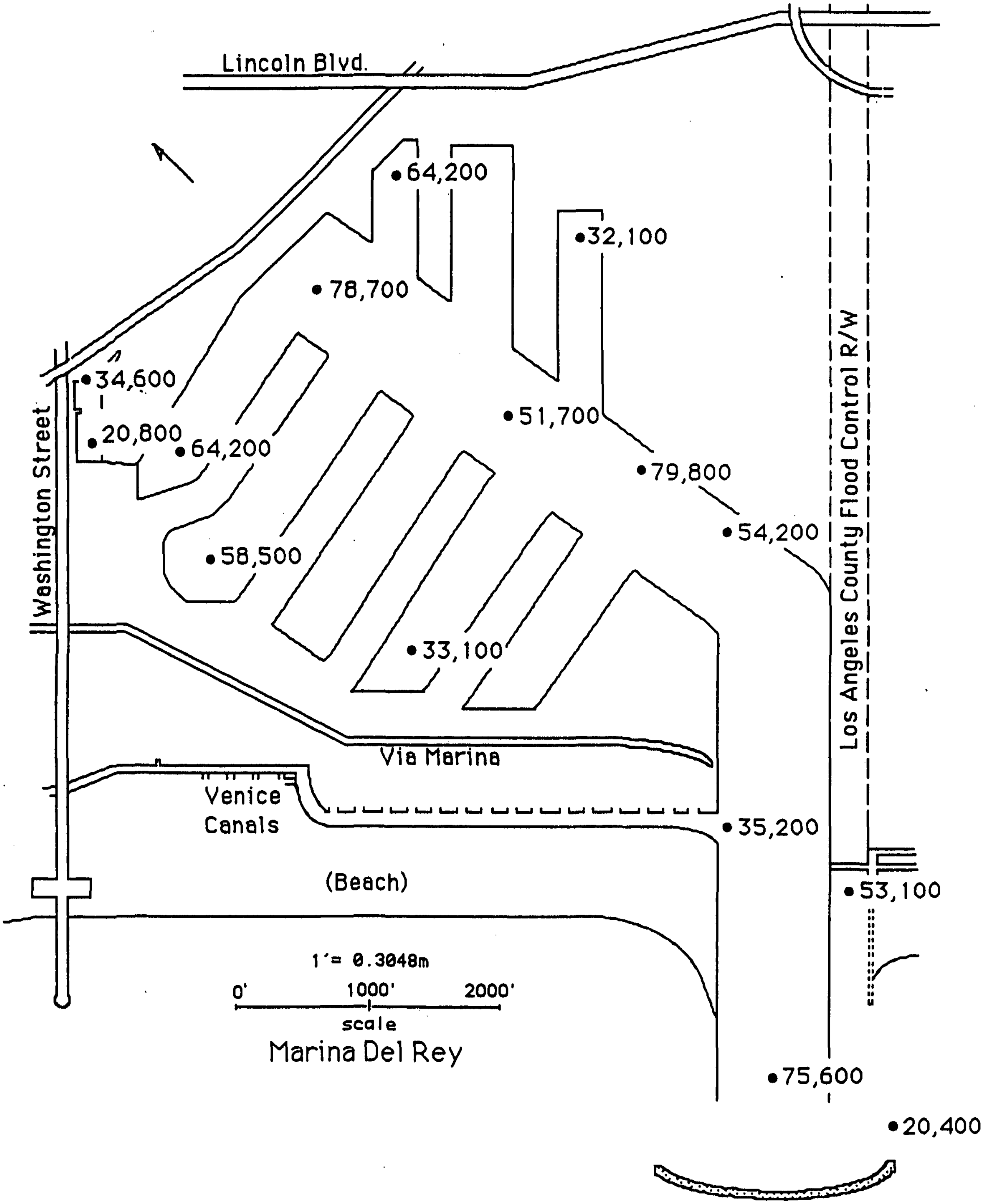


Figure IV.7. Chemical oxygen demand in mg/kg dry wt. (ppm), 27 October 1995.

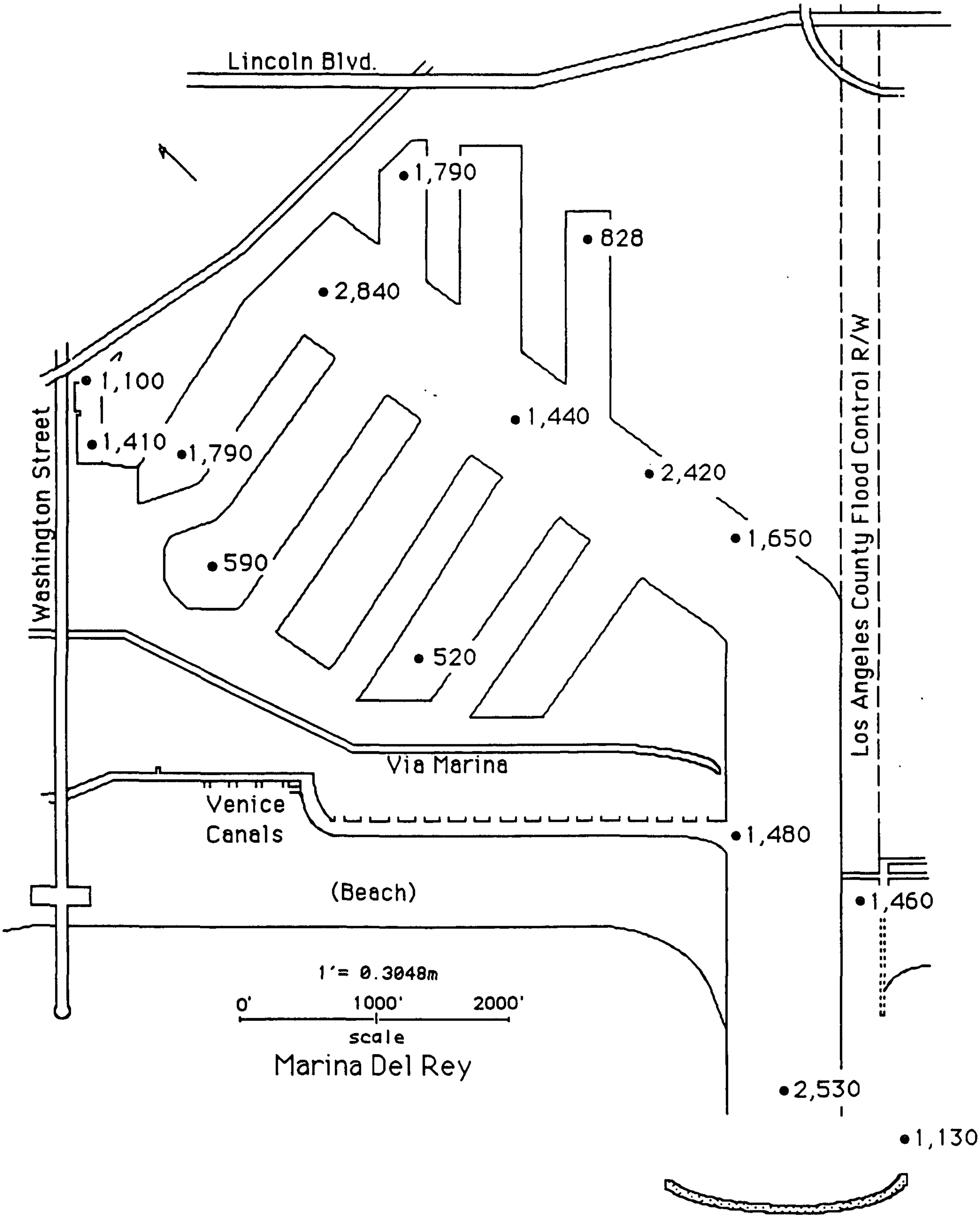


Figure IV.8. Oil and Grease in mg/kg, dry wt., 27 October 1995.

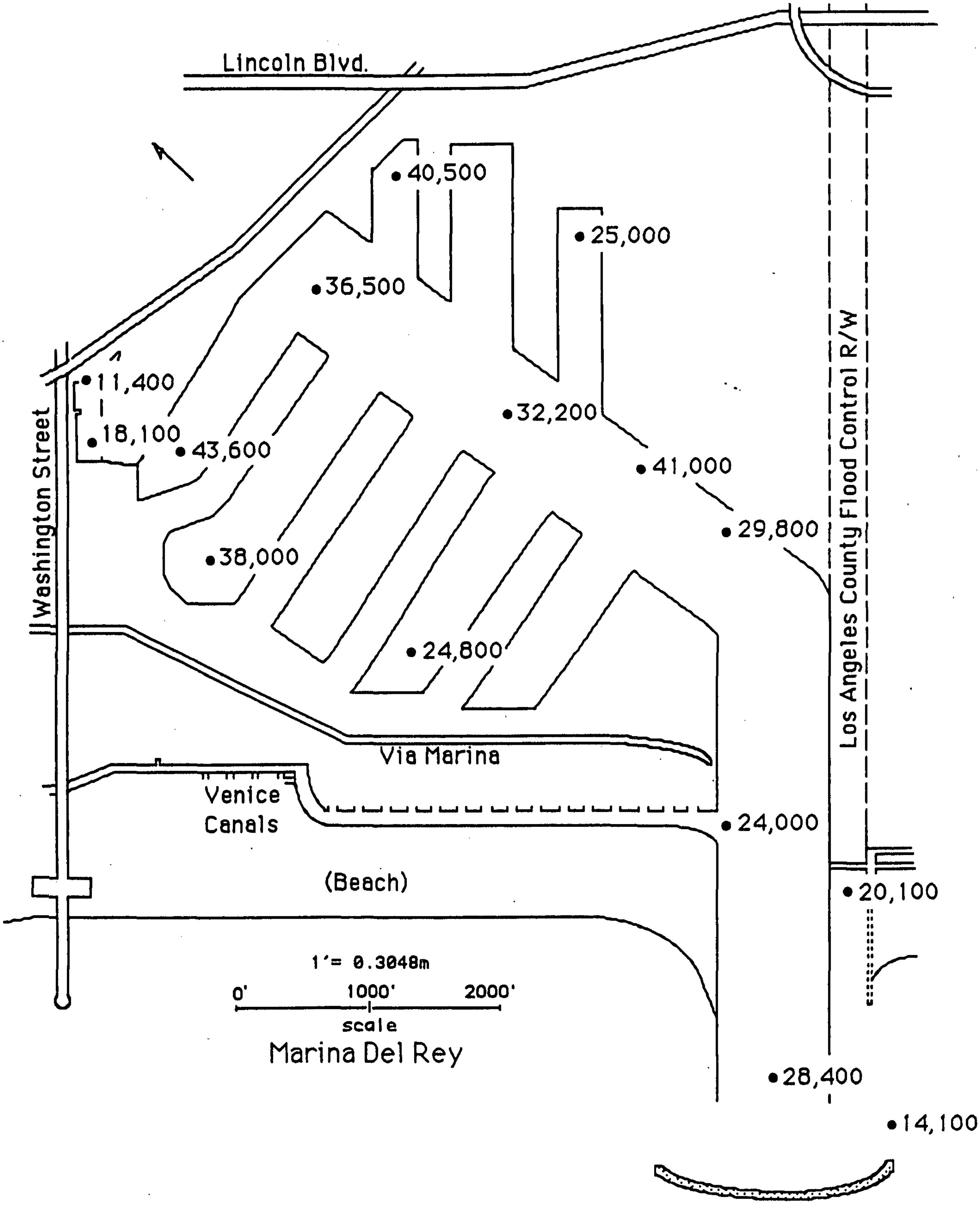


Figure IV.9. Alkalinity (as $CaCO_3$) in mg/kg dry wt., 27 October 1995.

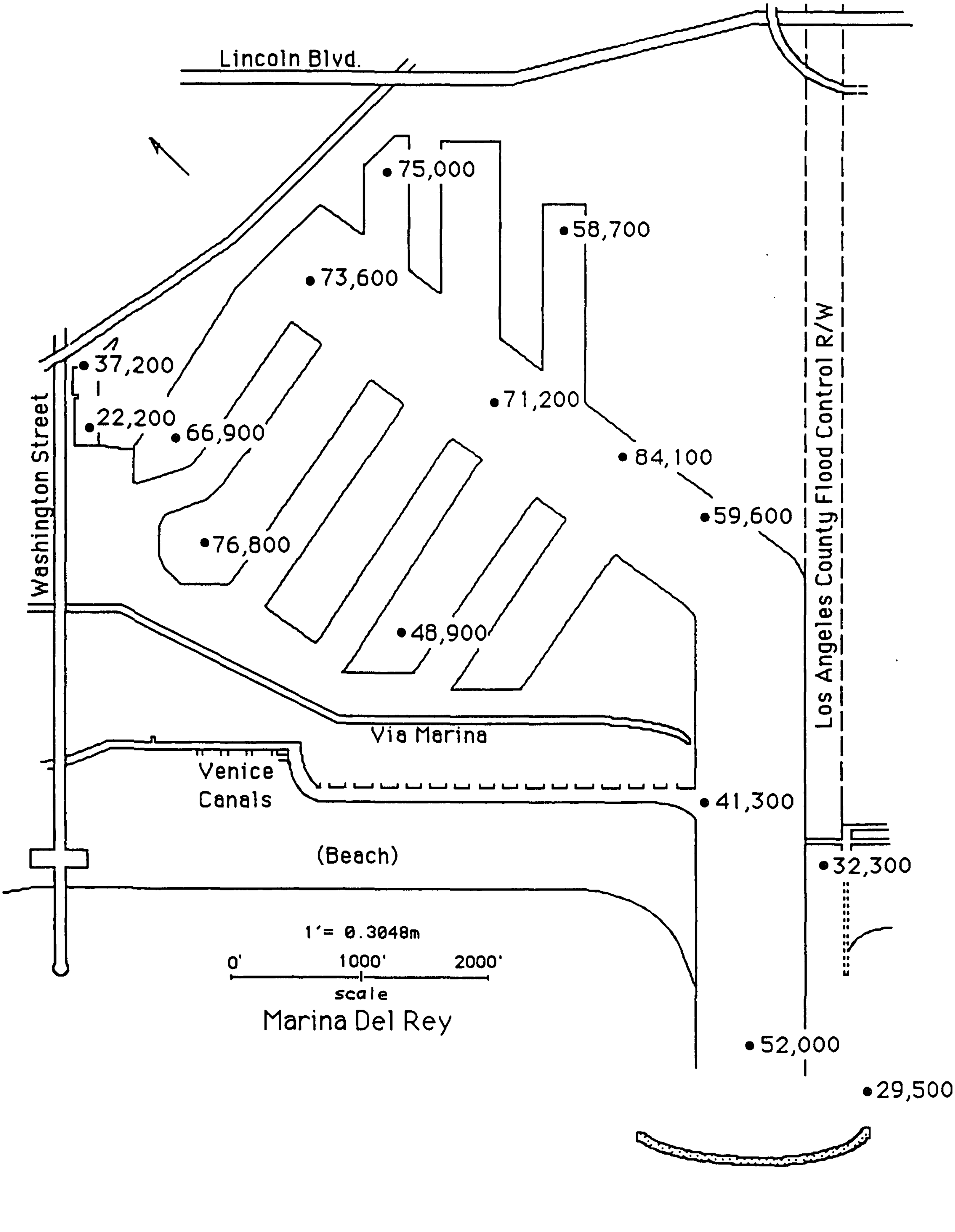


Figure IV.10. Total hardness (as $CaCO_3$) in mg/kg dry wt., 27 October 1995.

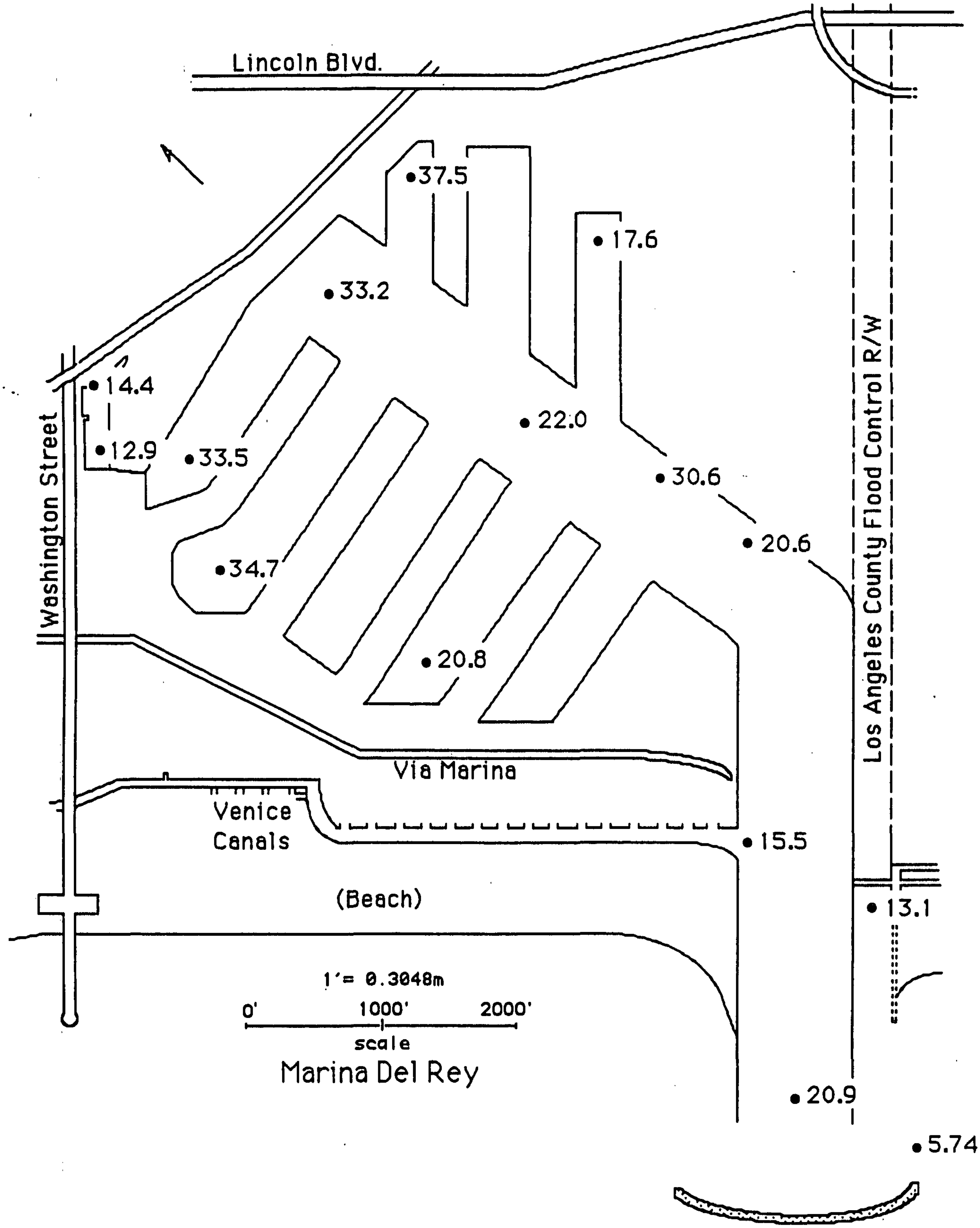


Figure IV.11. Boron in mg/kg dry wt., 27 October 1995.

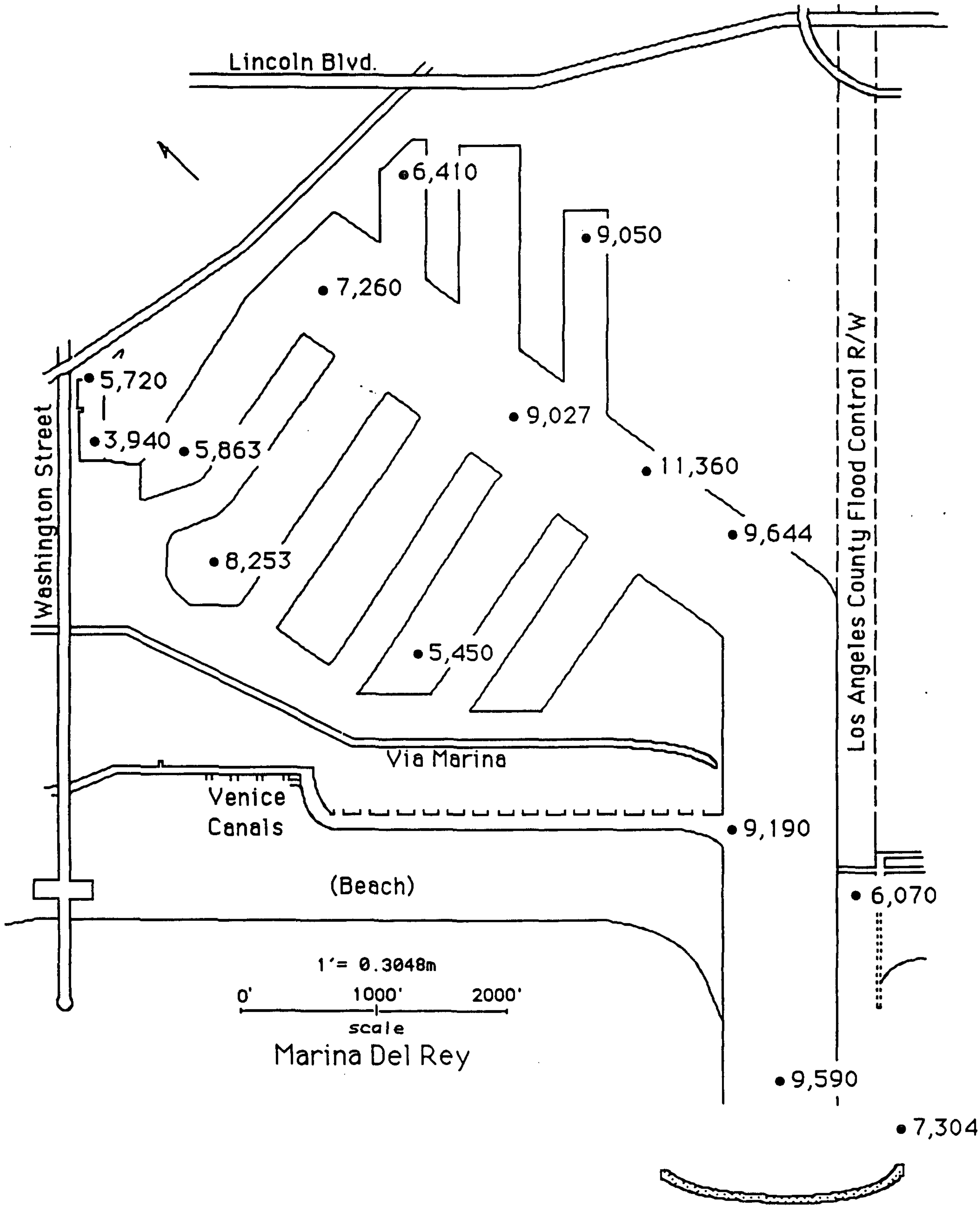


Figure IV.12. Calcium in mg/kg dry wt., 27 October 1995.

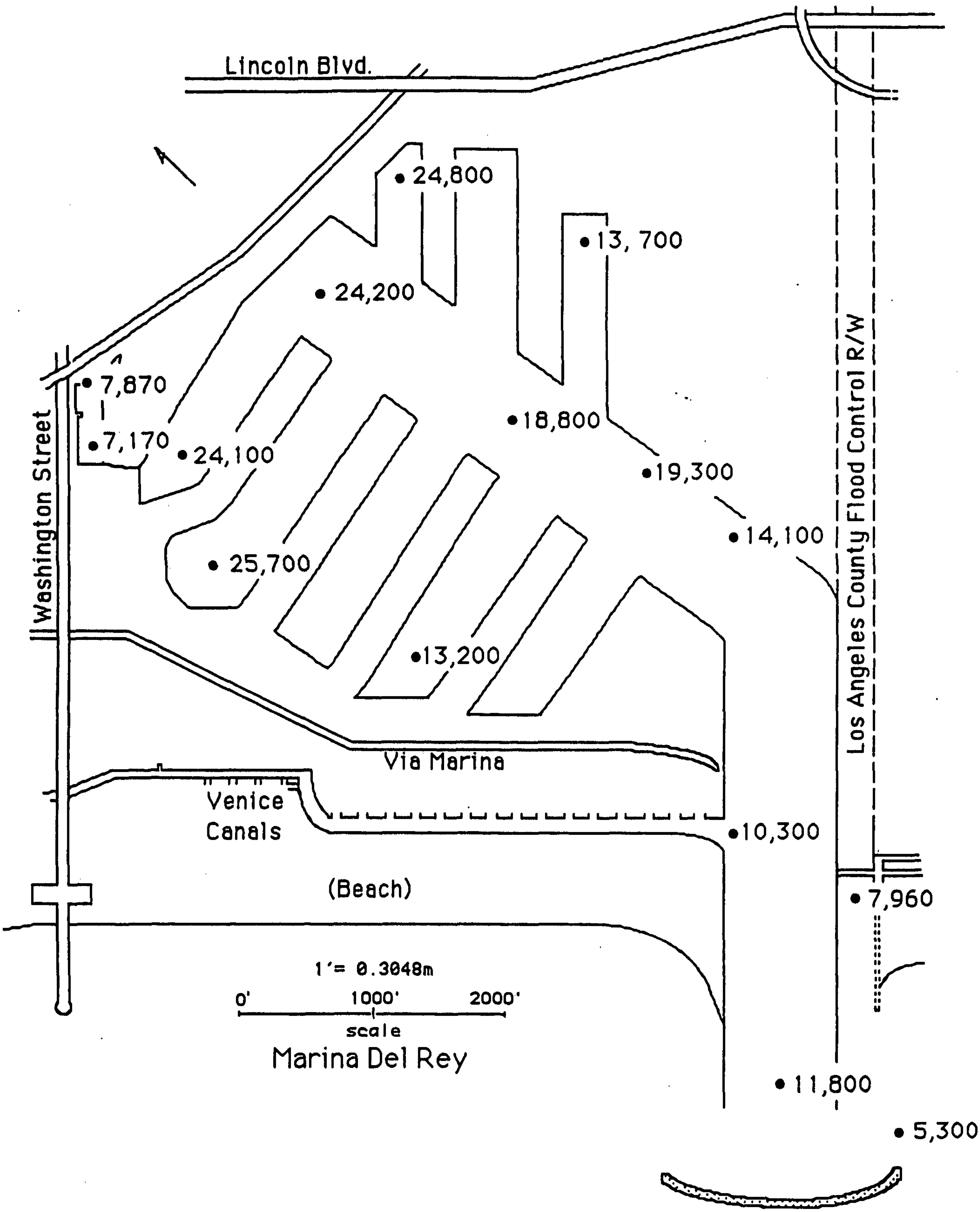


Figure IV. 13. Chloride in mg/kg dry wt., 27 October 1995.

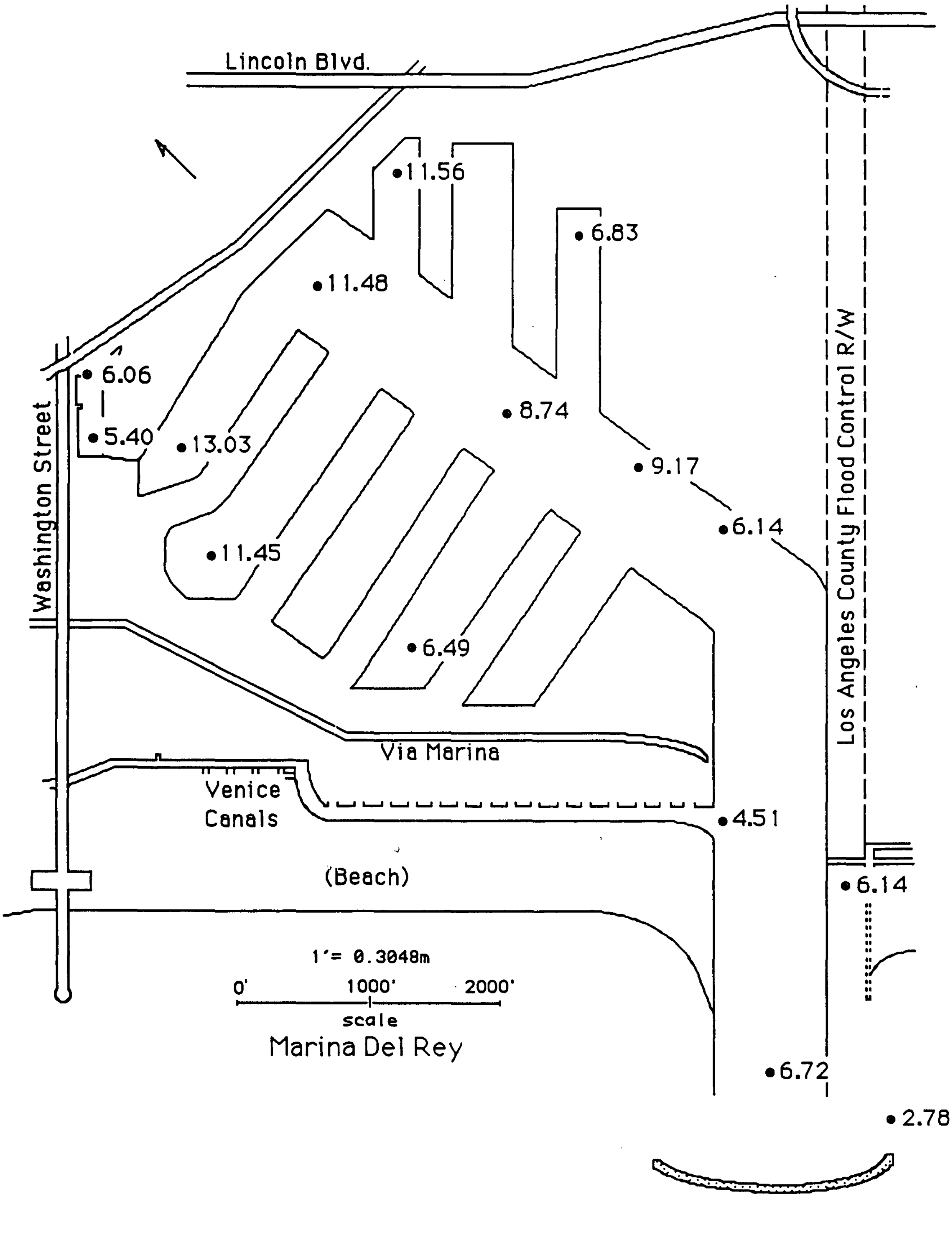


Figure IV.14. Fluoride in mg/kg dry wt., 27 October 1995

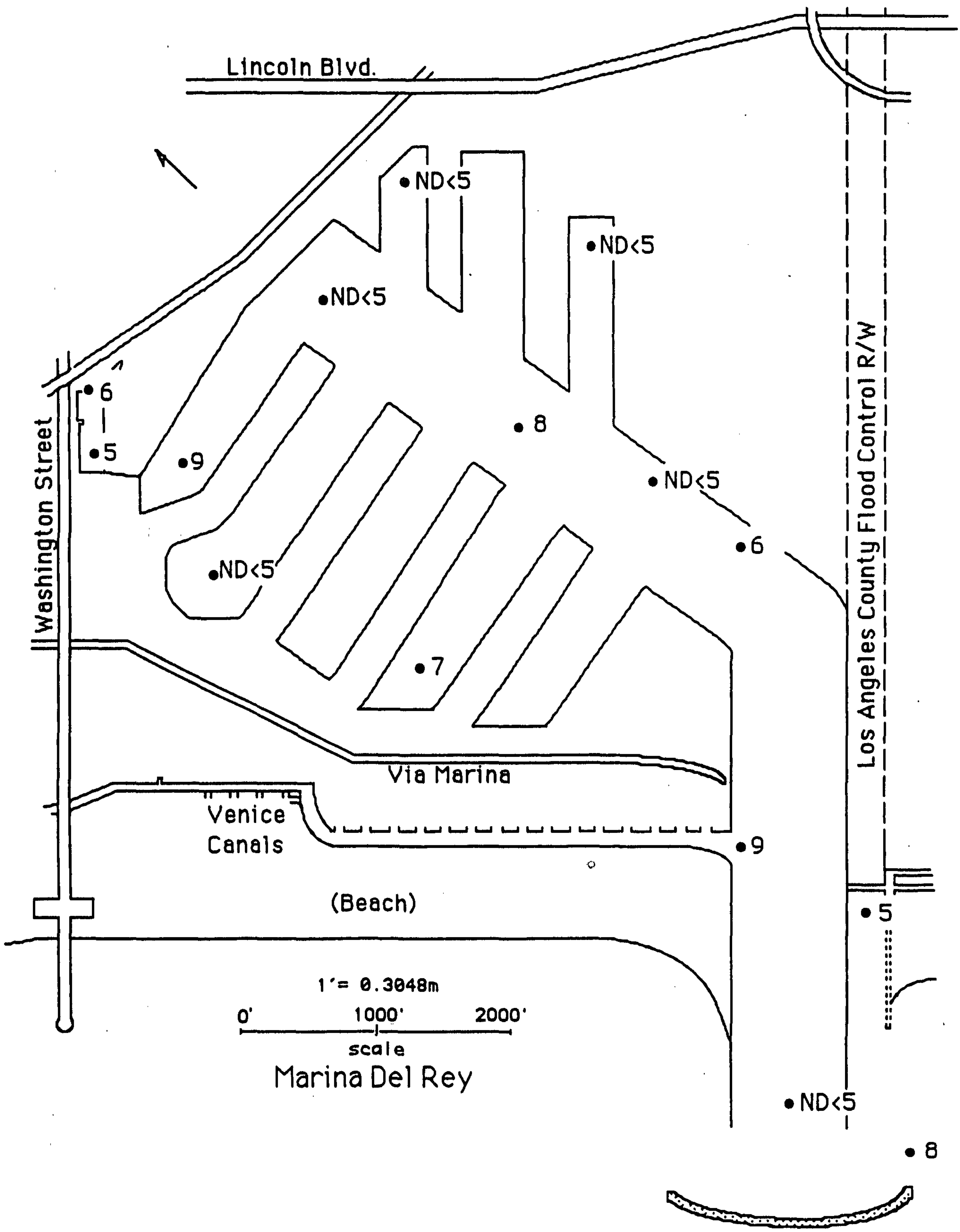


Figure IV.15. Nitrate in mg/kg dry wt., 27 October 1995.

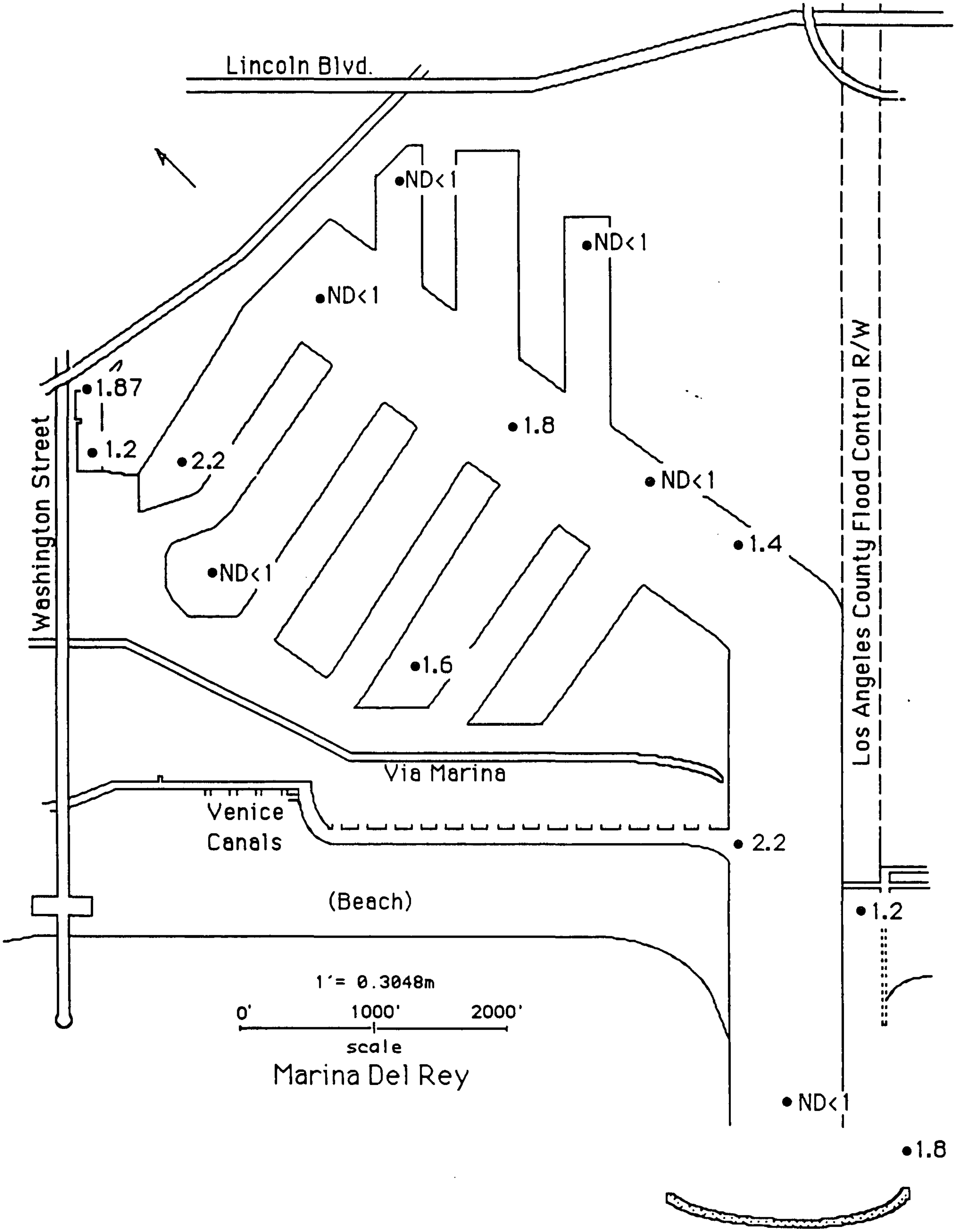


Figure IV.16. Nitrogen (NO_2 - NO_3 - N) in mg/kg dry wt., 27 October 1995.

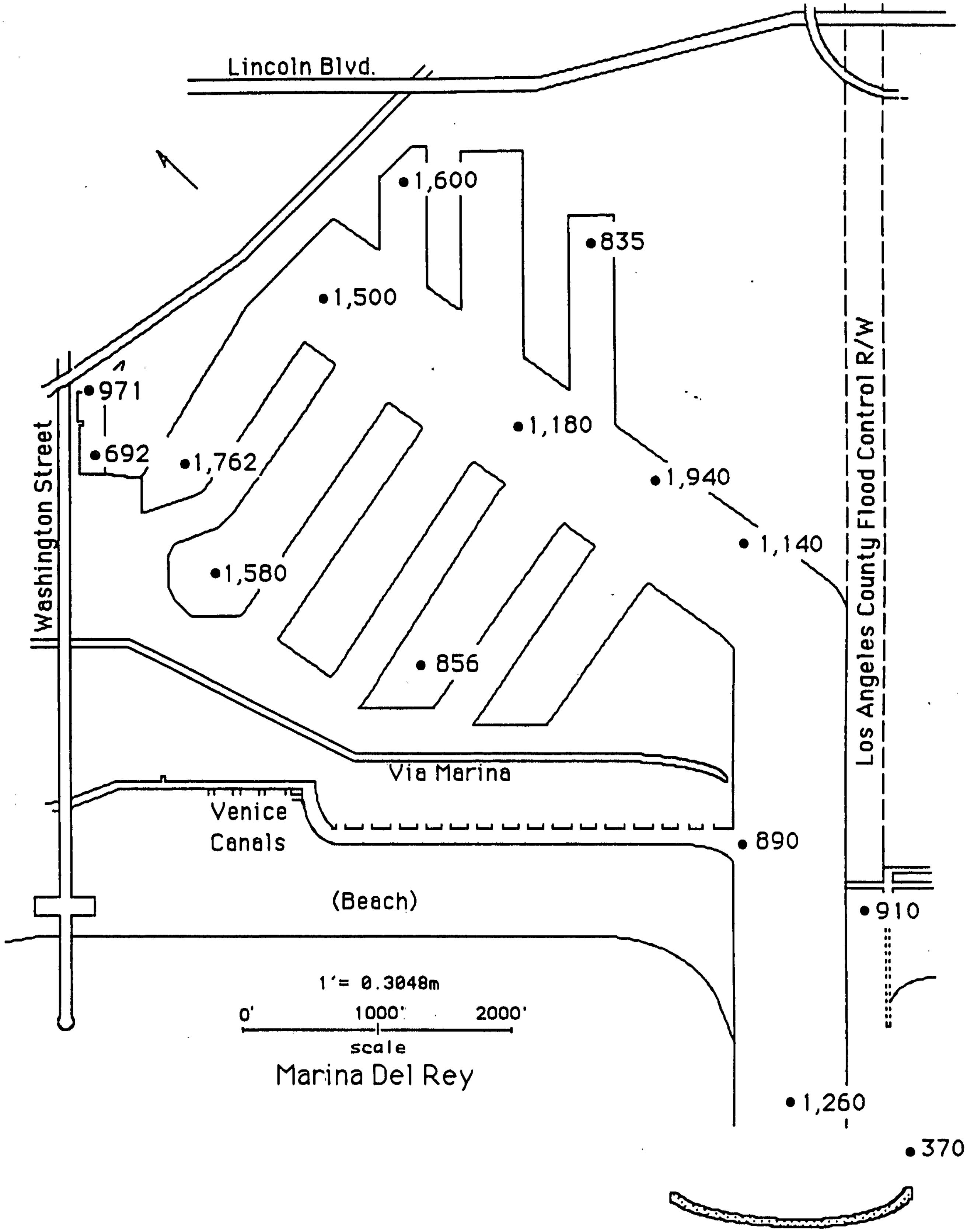


Figure IV.17. Oganic nitrogen in mg/kg dry wt., 27 October 1995.

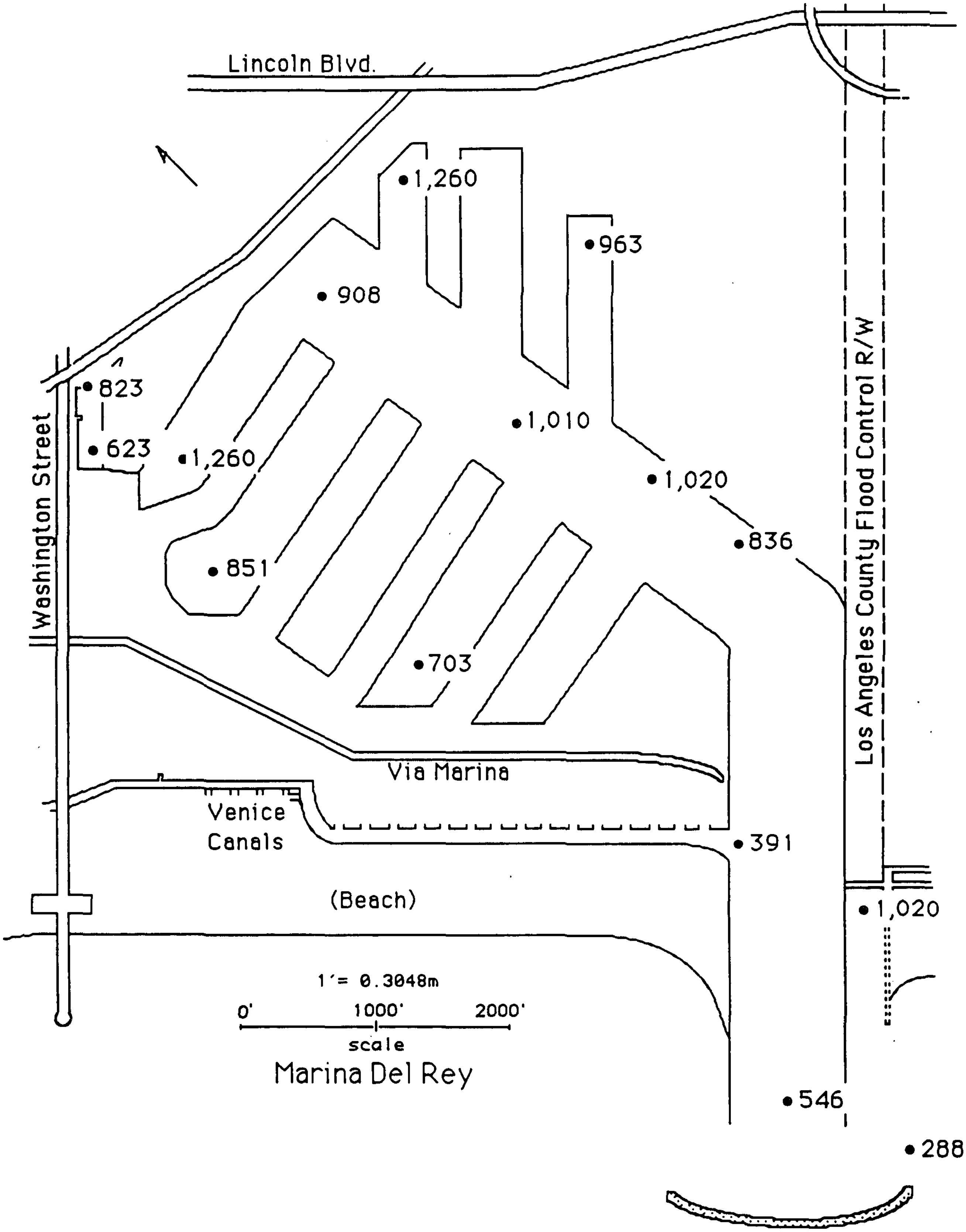


Figure IV.18. Total phosphorus in mg/kg dry wt., 27 October 1995.

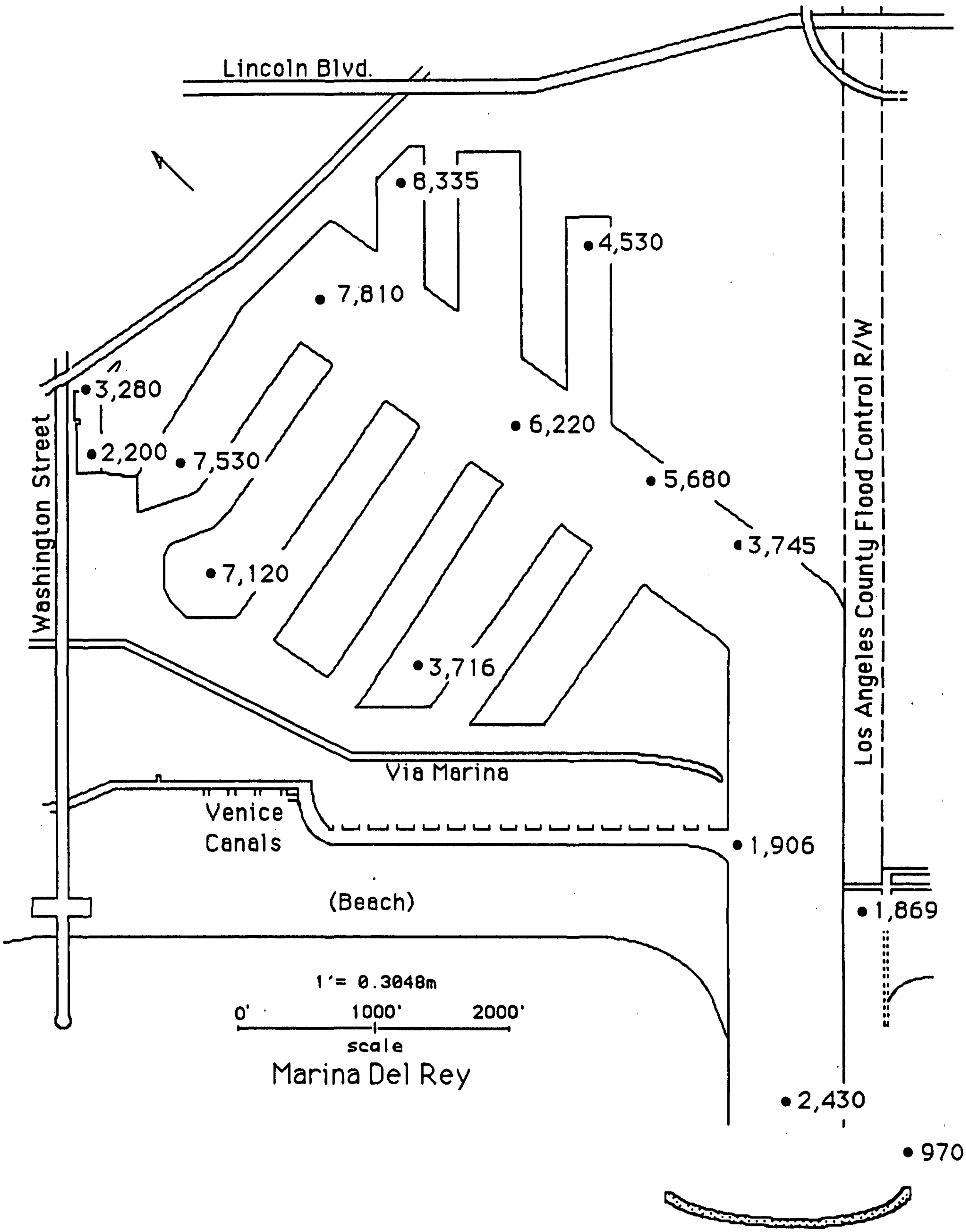


Figure IV.19. Potassium in mg/kg dry wt., 27 October 1995.

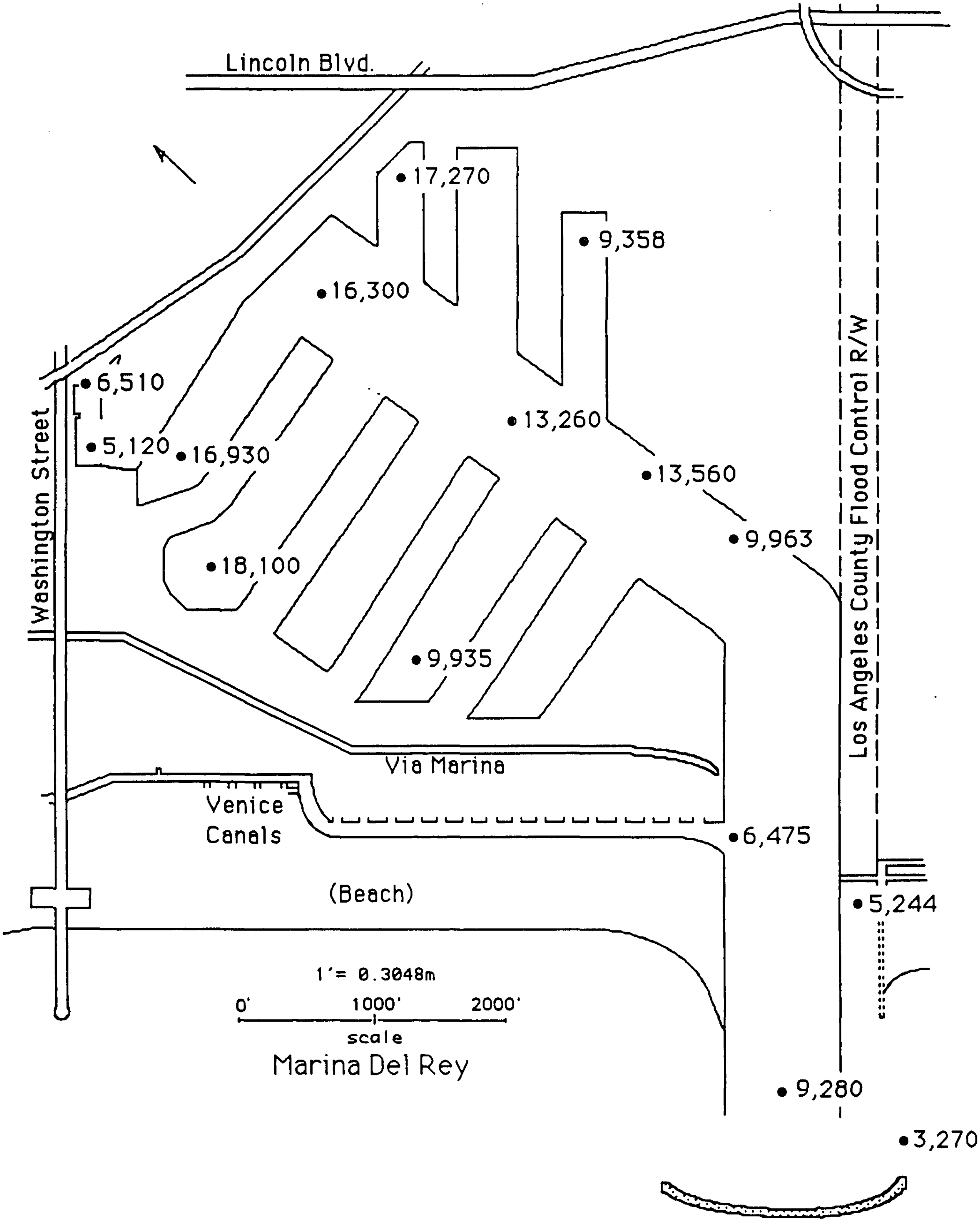


Figure IV.20. Sodium in mg/kg dry wt., 27 October 1995.

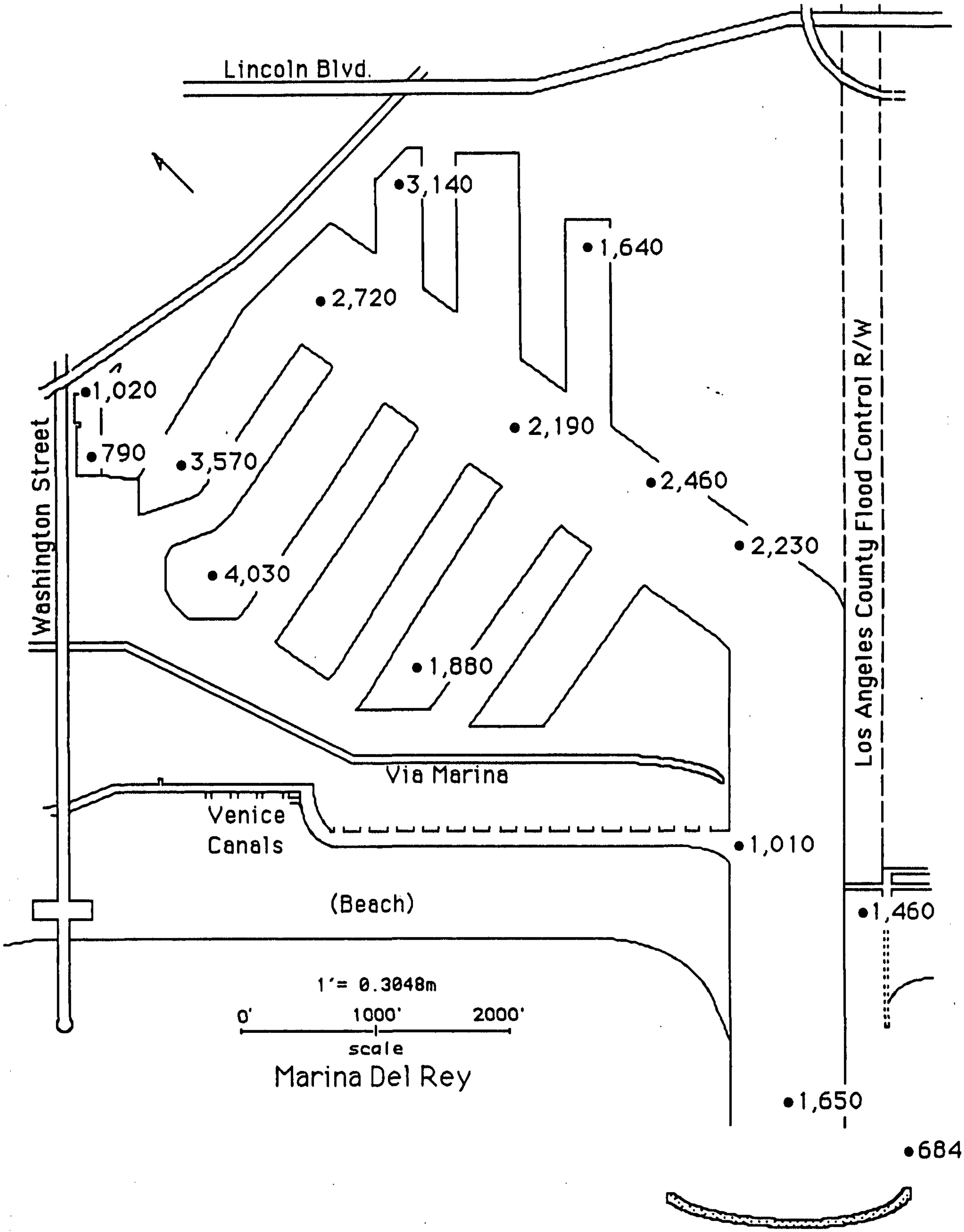


Figure IV.21. Sulfate in mg/kg dry wt., 27 October 1995.

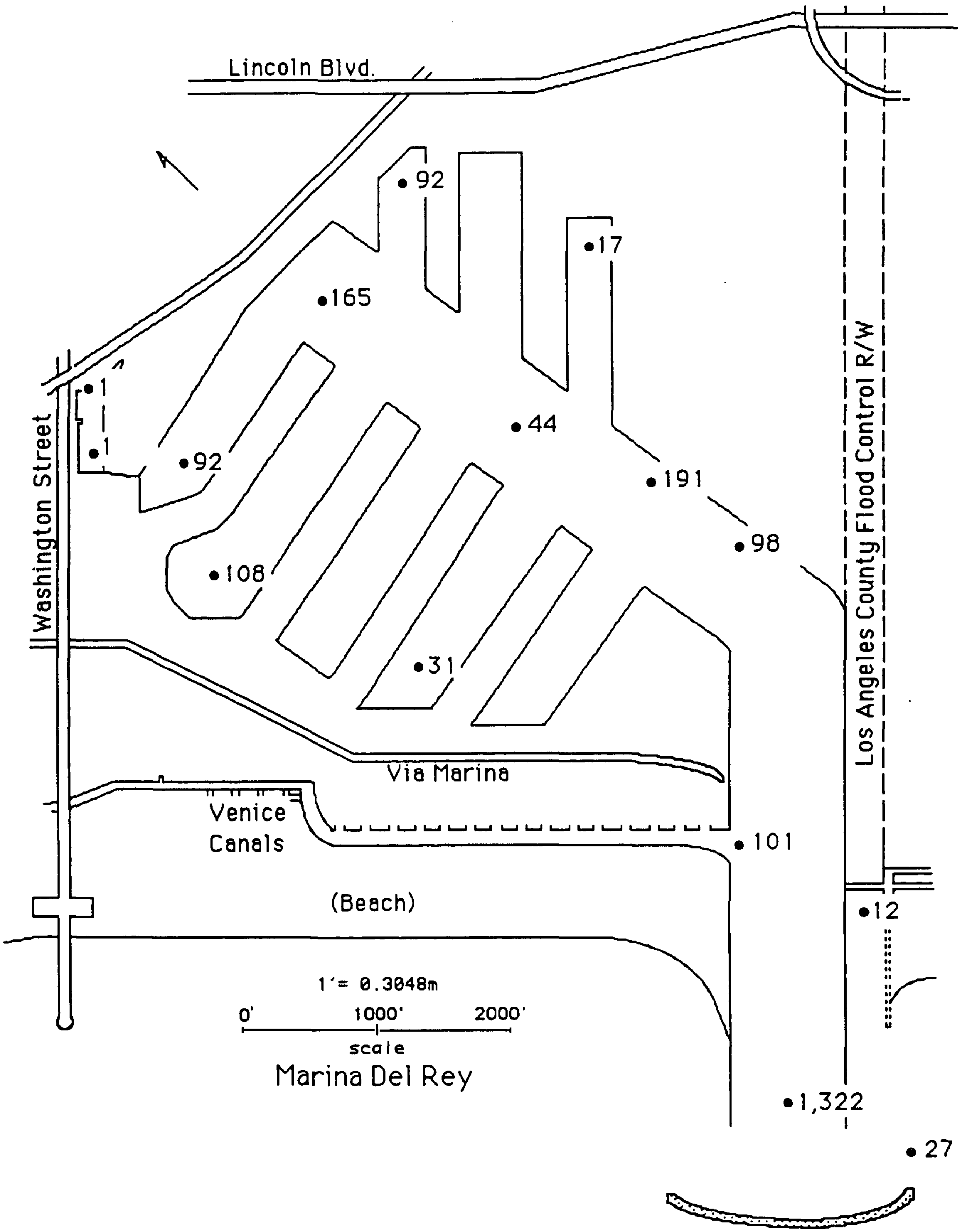


Figure IV.22. Hydrogen sulfides in mg/kg dry wt., 27 October 1995.

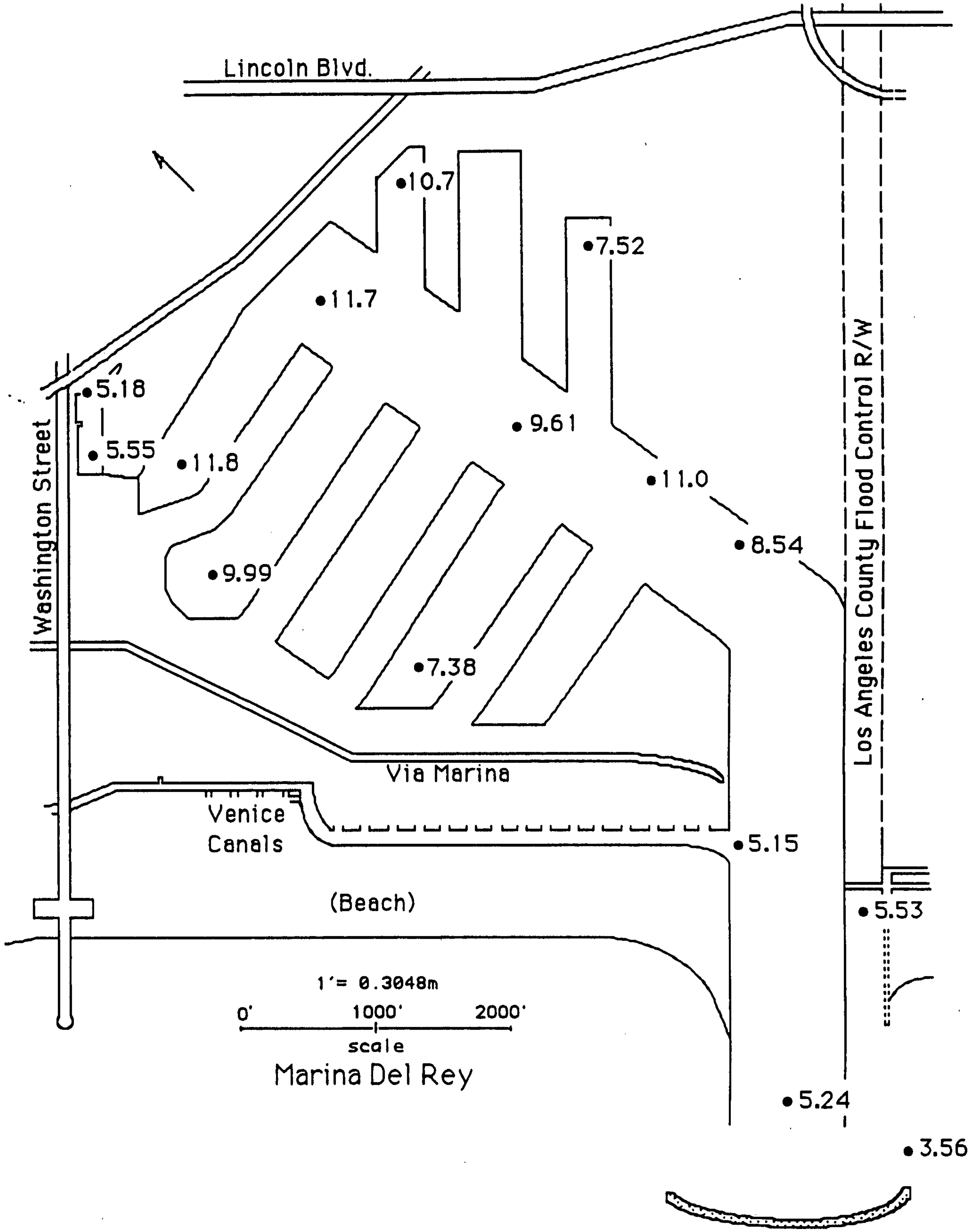


Figure IV.23. Arsenic in mg/kg dry wt., 27 October 1995.

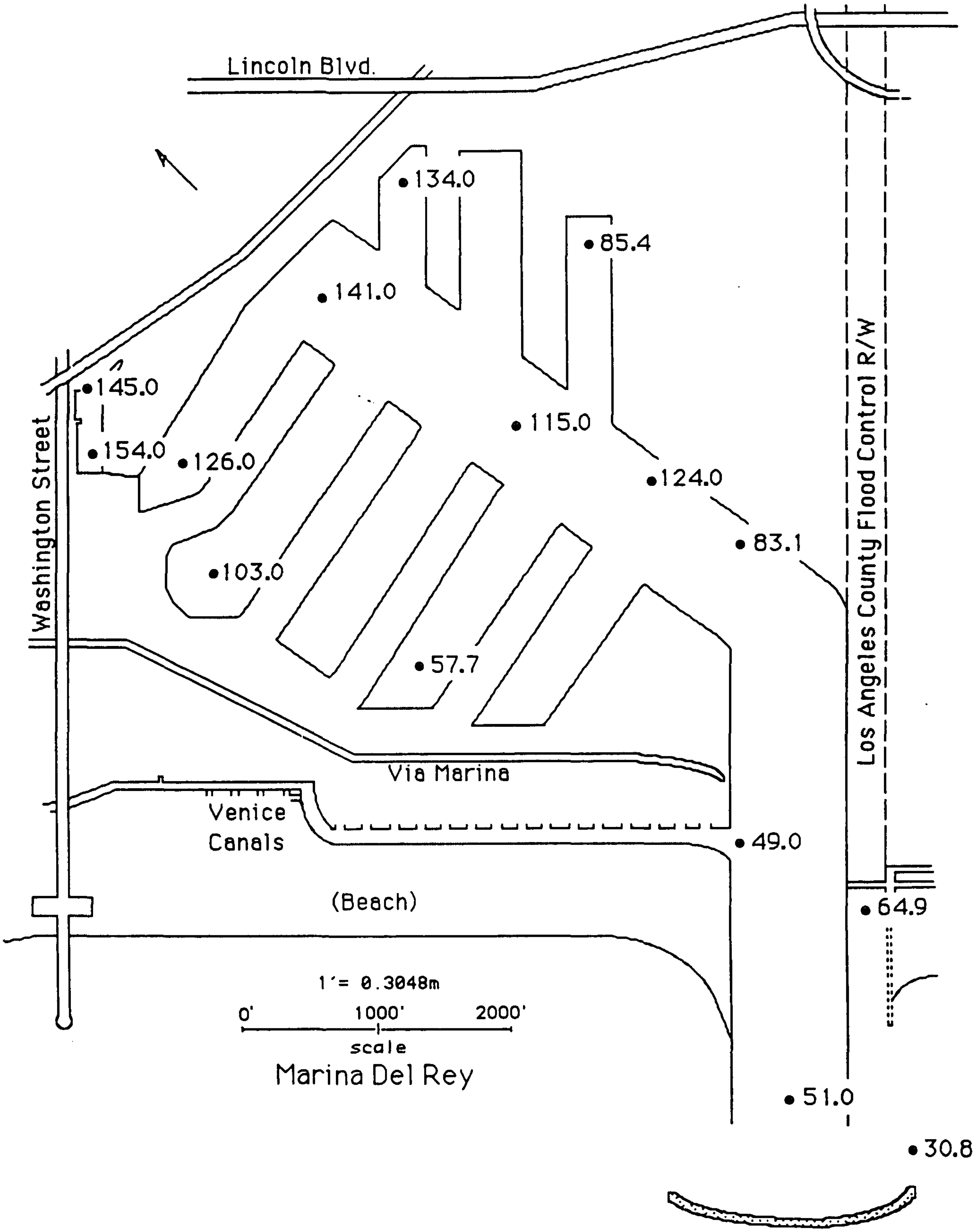


Figure IV.24. Barium in mg/kg dry wt., 27 October 1995.

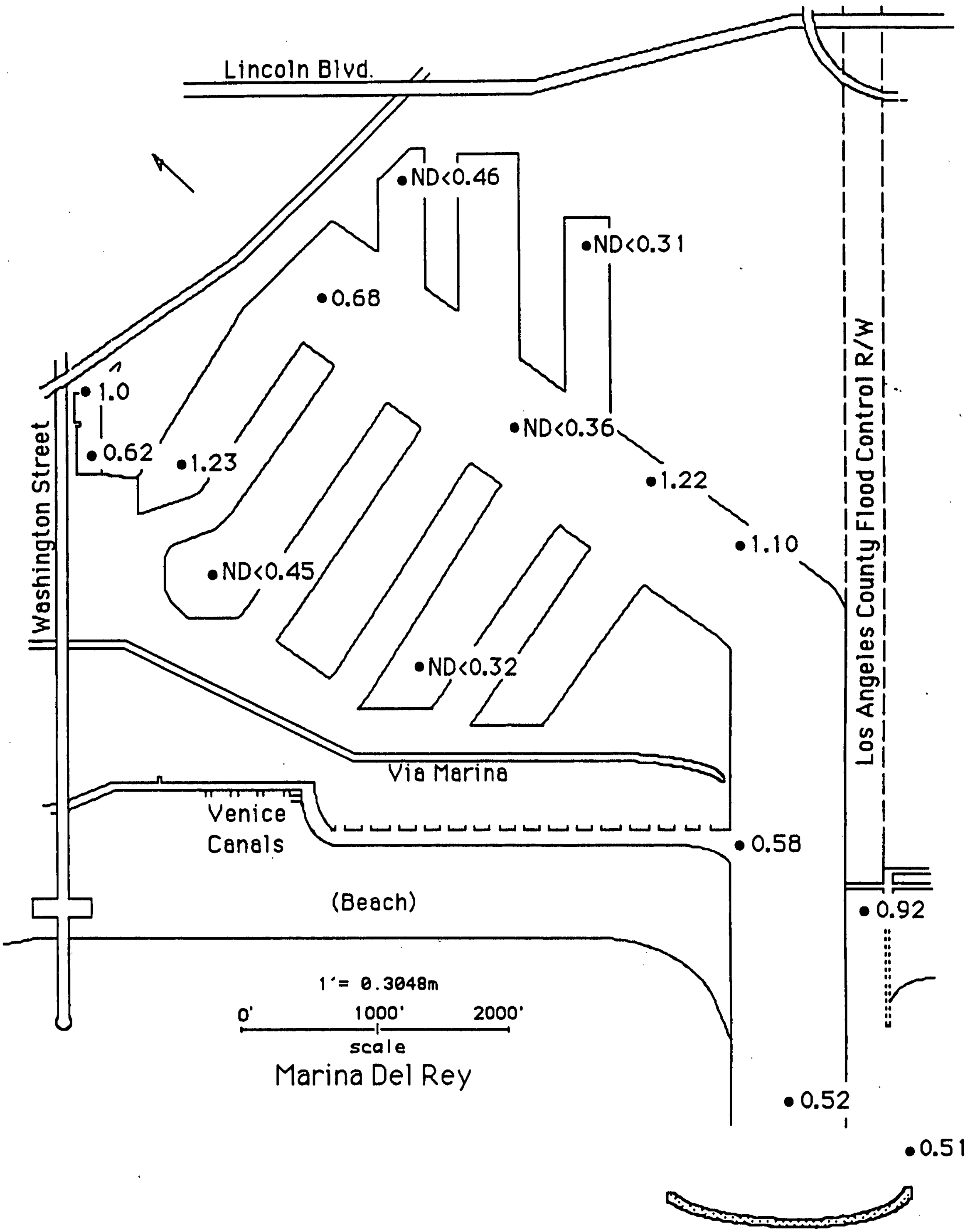


Figure IV.25. Cadmium in mg/kg dry wt., 27 October 1995.

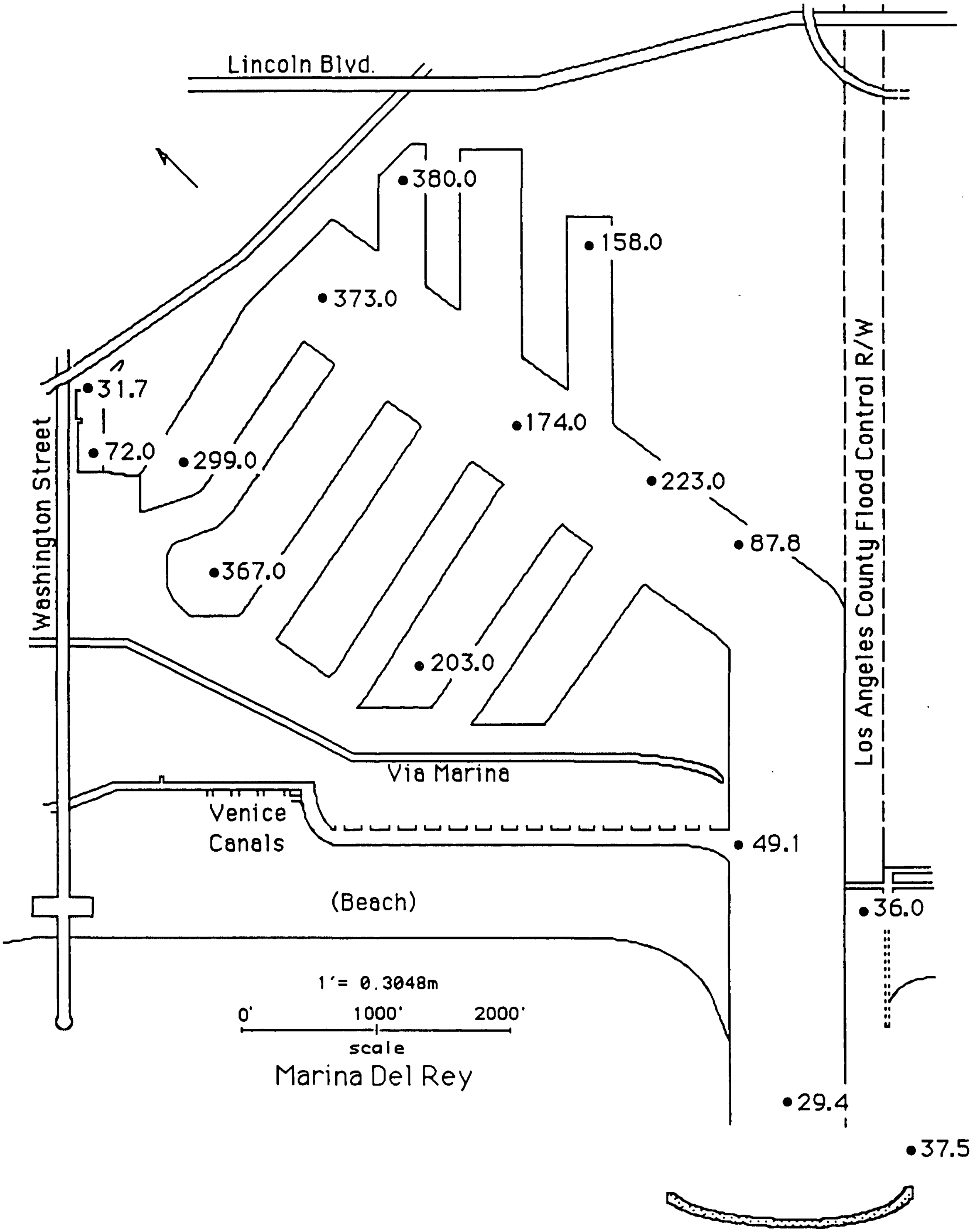


Figure IV.26. Copper in mg/kg dry wt., 27 October 1995.

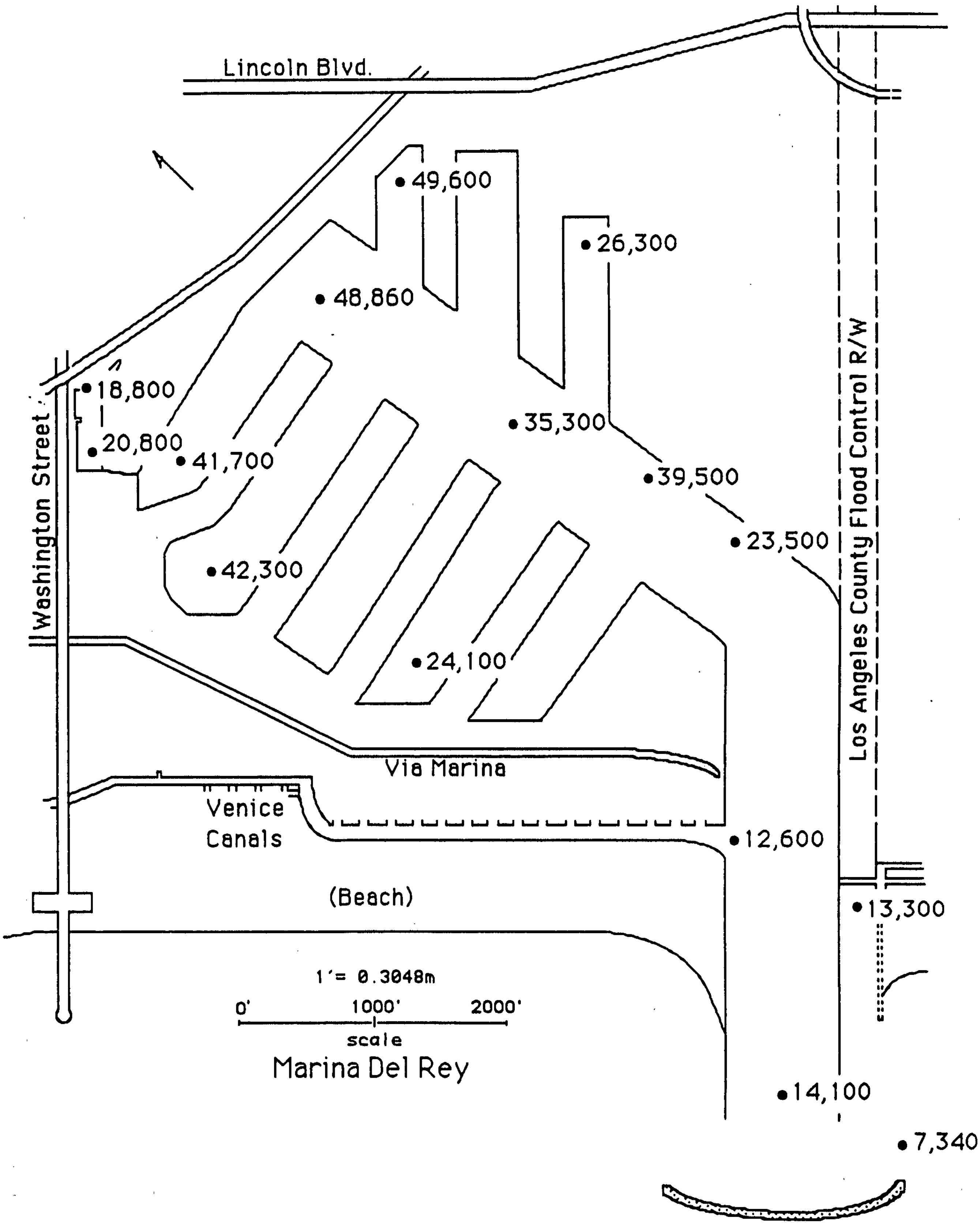


Figure IV.27. Iron in mg/kg dry wt., 27 October 1995.

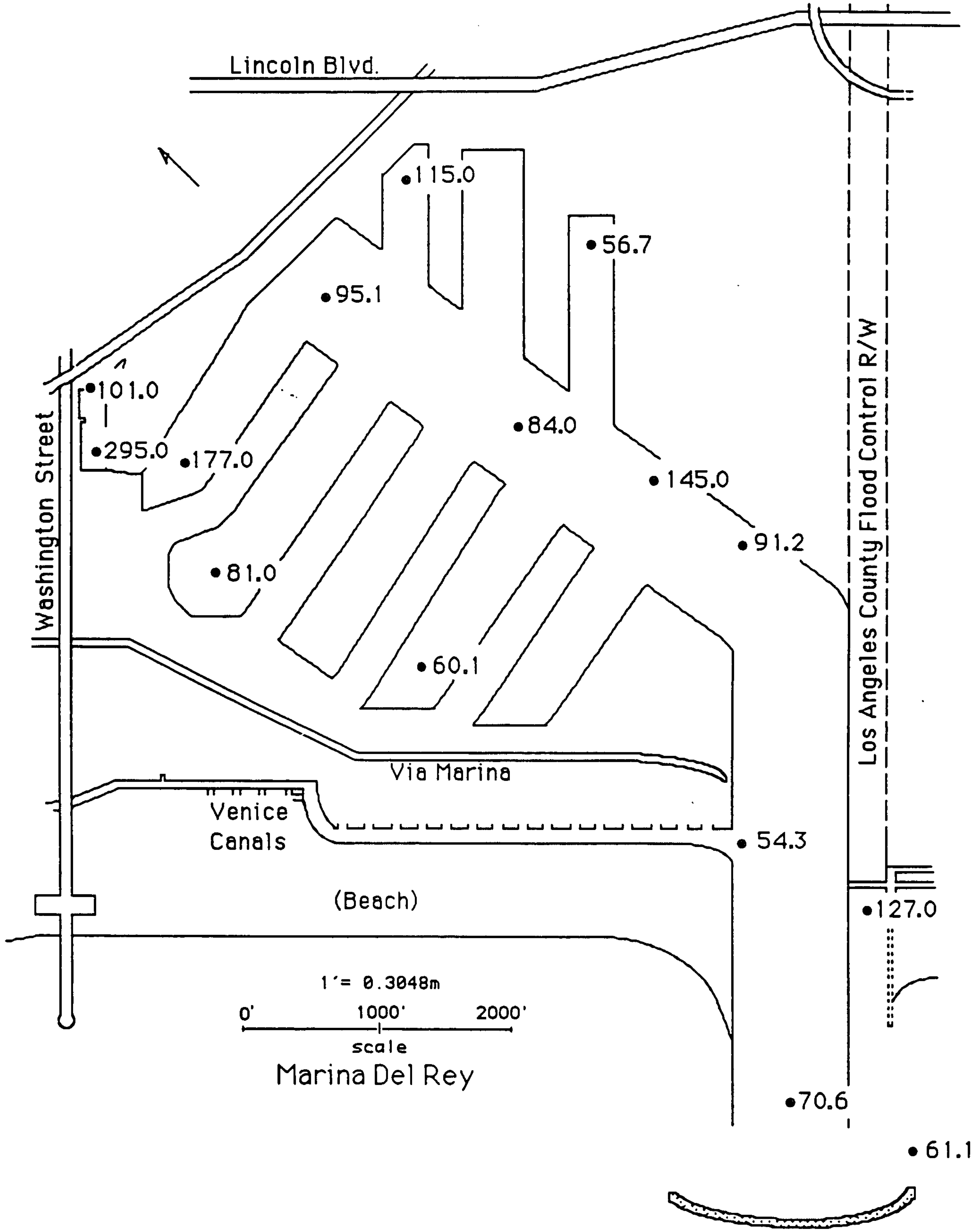


Figure IV.28. Lead in mg/kg dry wt., 27 October 1995.

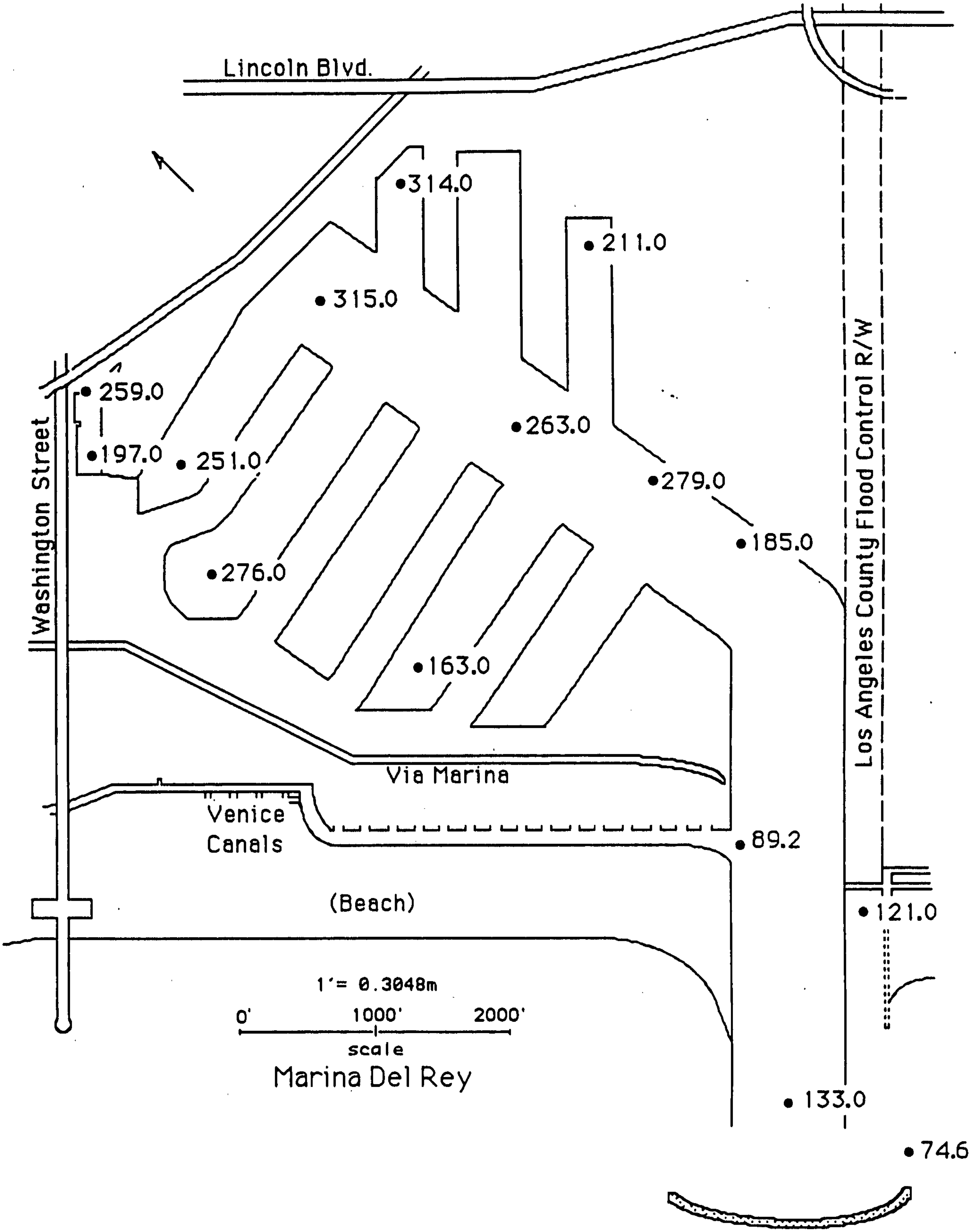


Figure IV.29. Manganese in mg/kg dry wt., 27 October 1995.

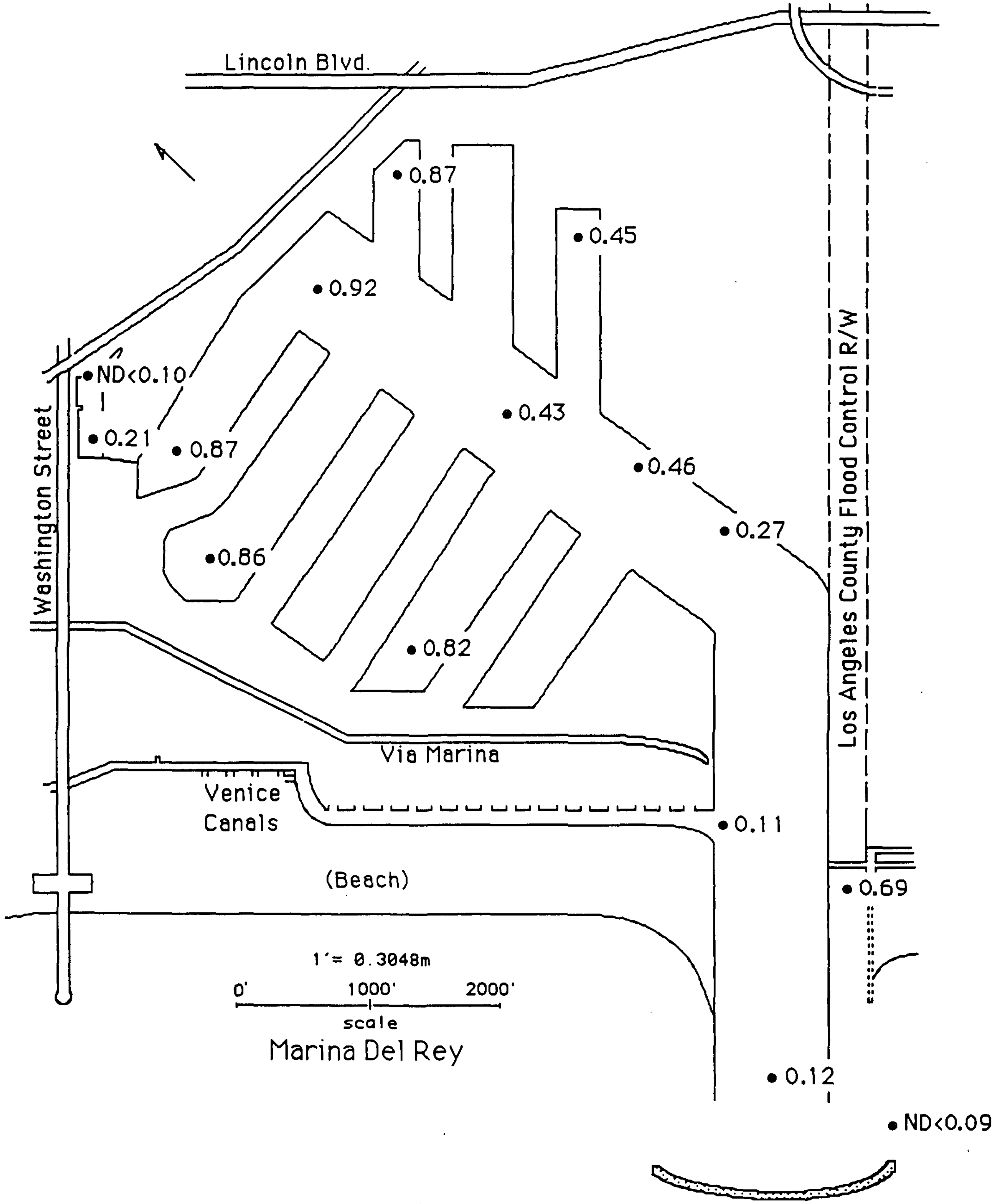


Figure IV.30. Mercury in mg/kg dry wt., 27 October 1995.

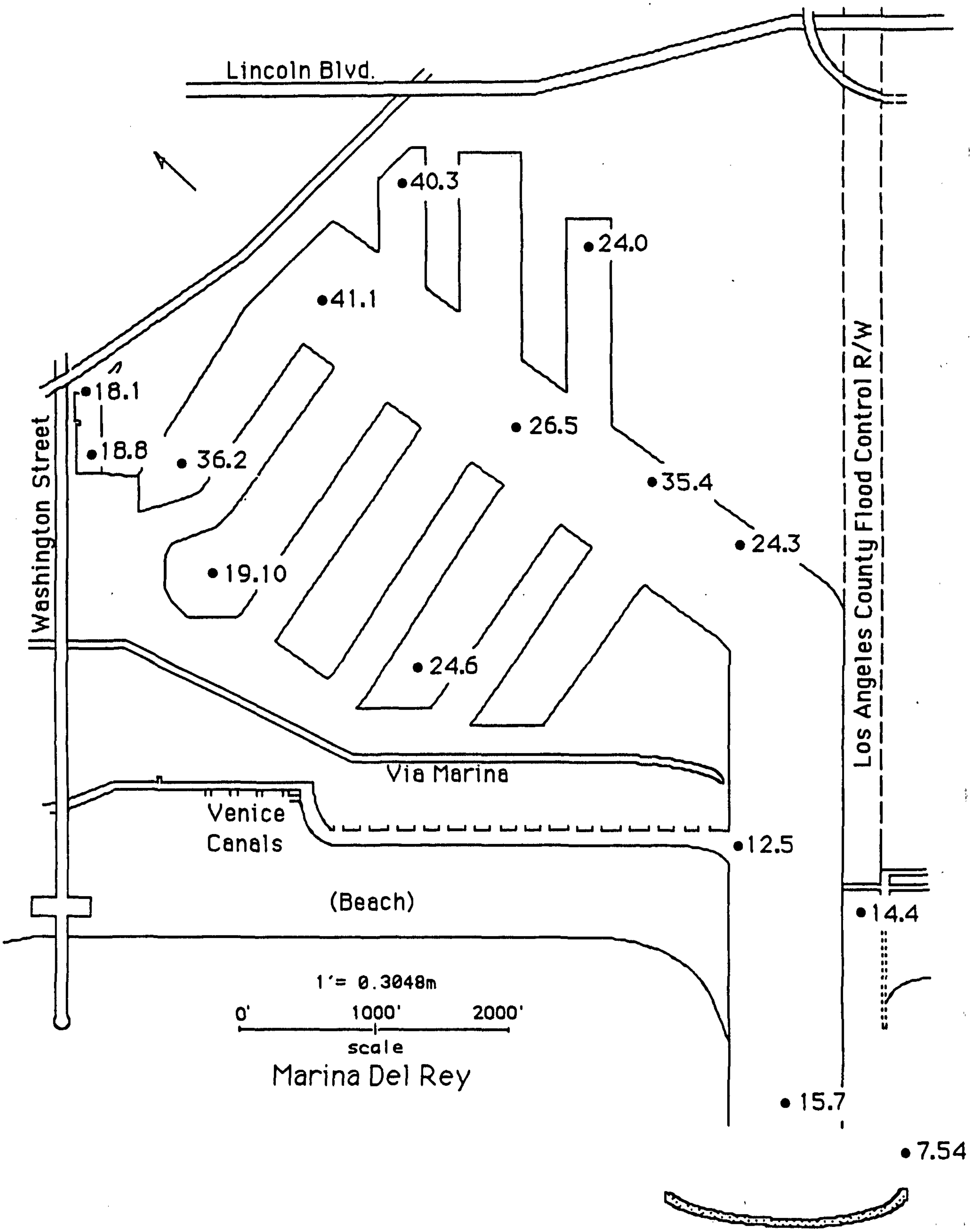


Figure IV.31. Nickel in mg/kg dry wt., 27 October 1995.

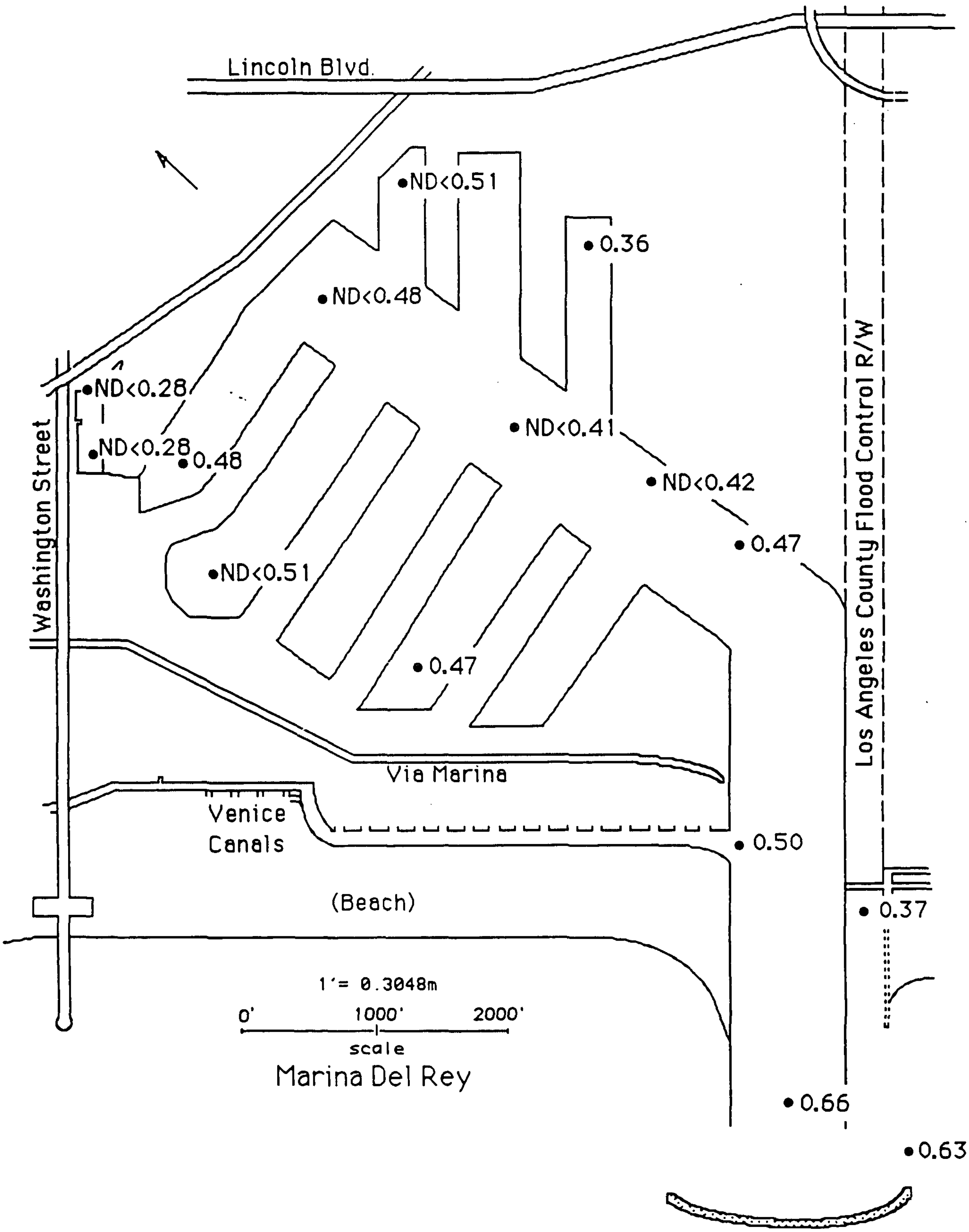


Figure IV.32. Selenium in mg/kg dry wt., 27 October 1995.

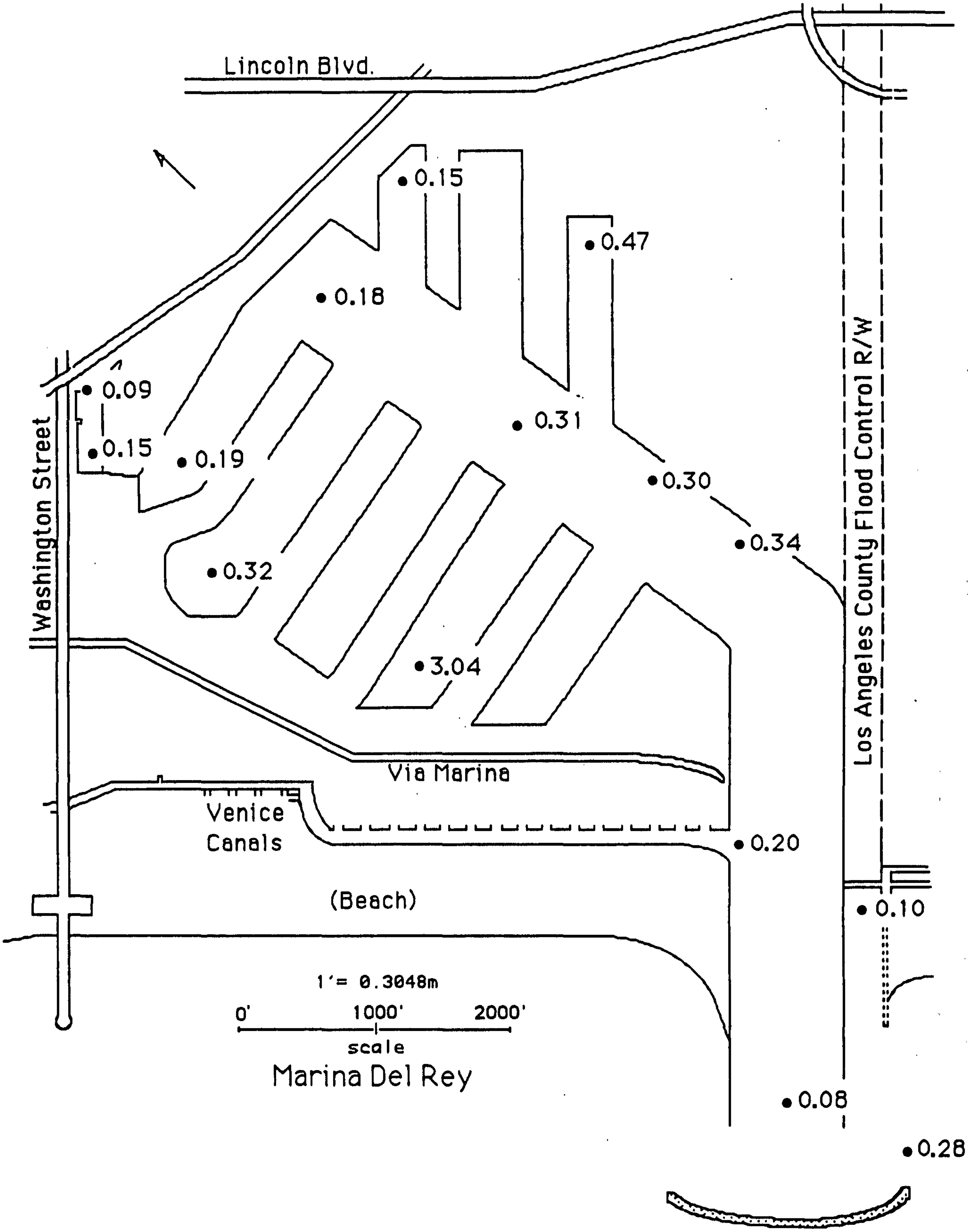


Figure IV.33. Tributyl tin in mg/kg dry wt., 27 October 1995.

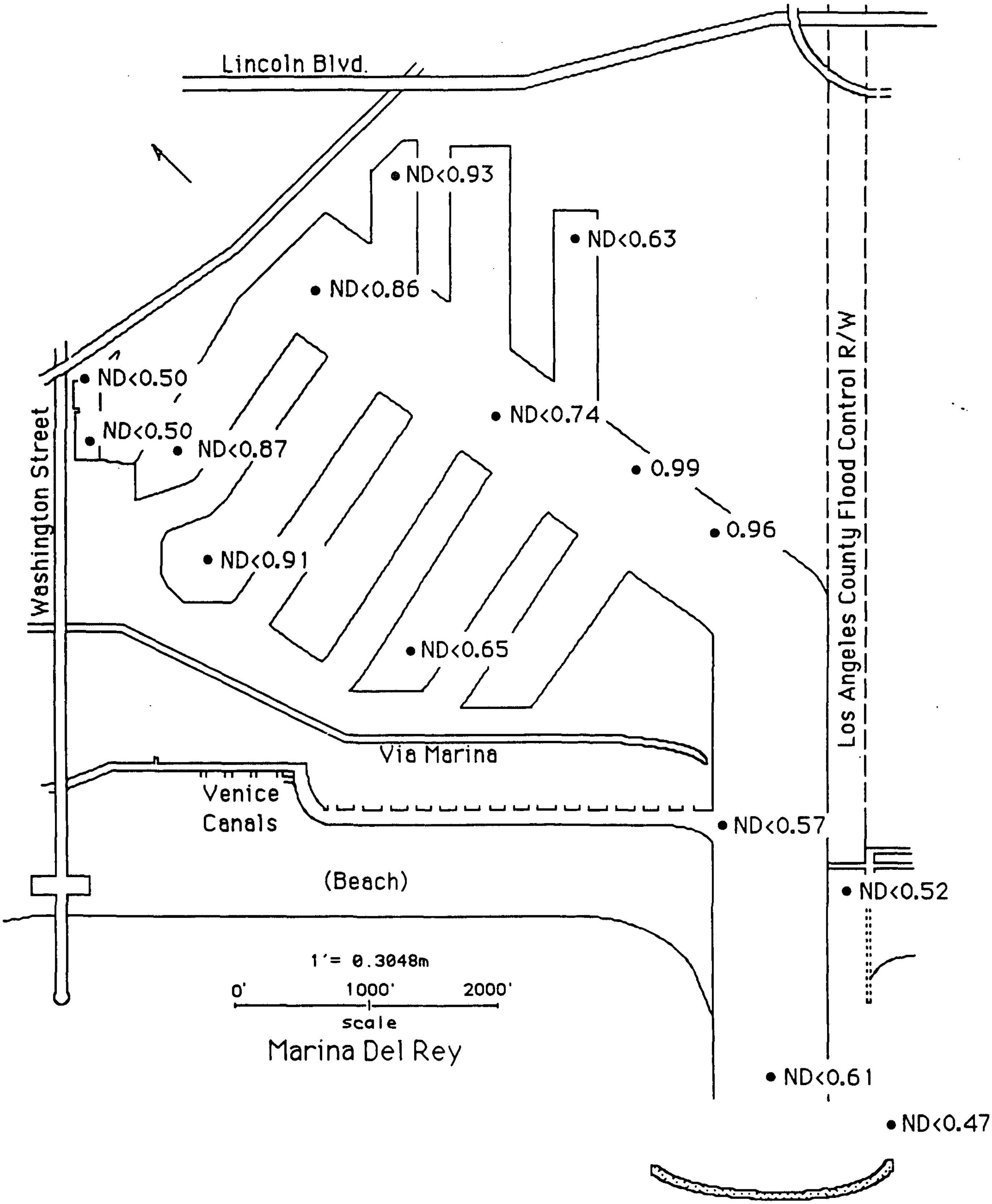


Figure IV.34. Silver in mg/kg dry wt., 27 October 1995.

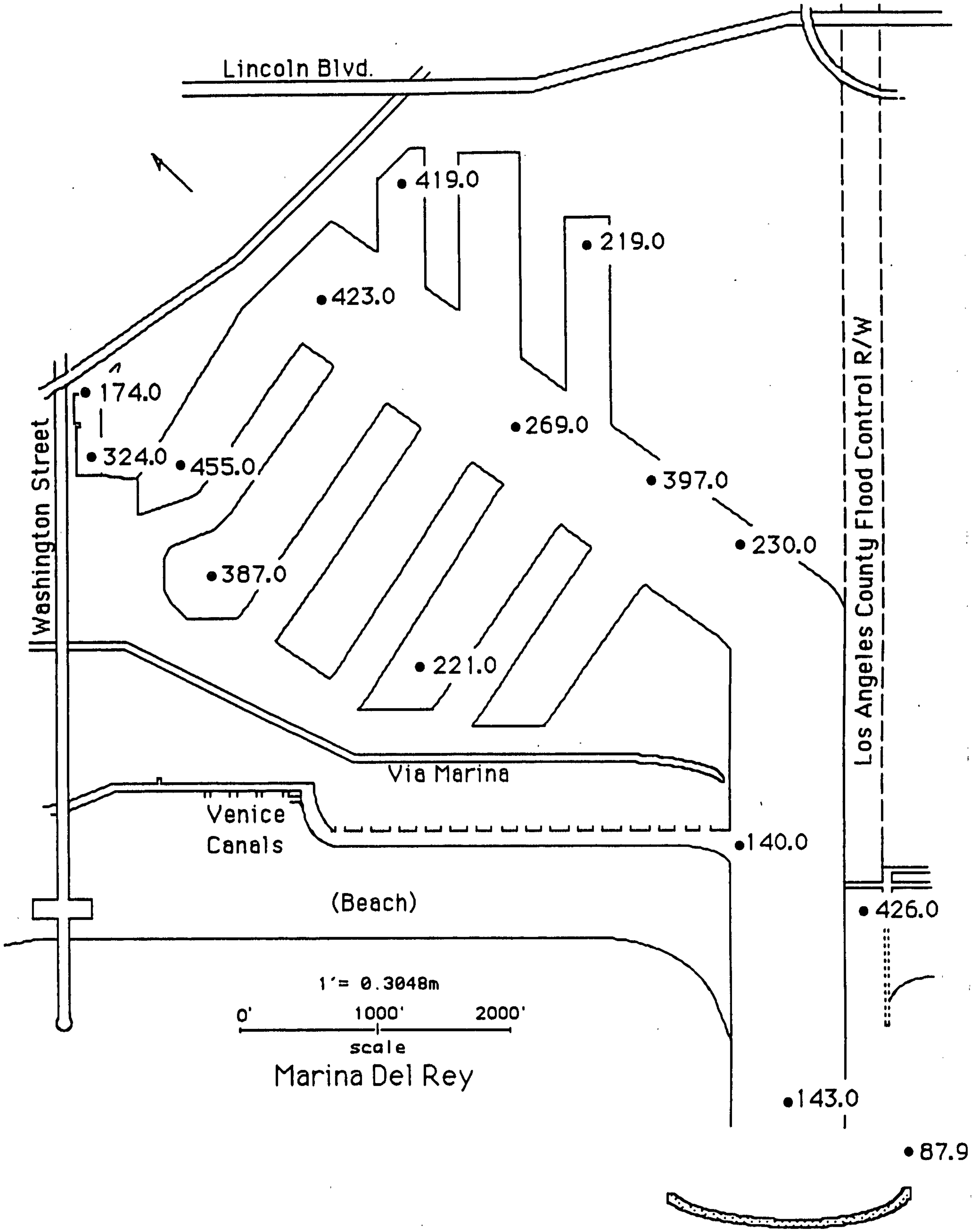


Figure IV.35. Zinc in mg/kg dry wt., 27 October 1995.

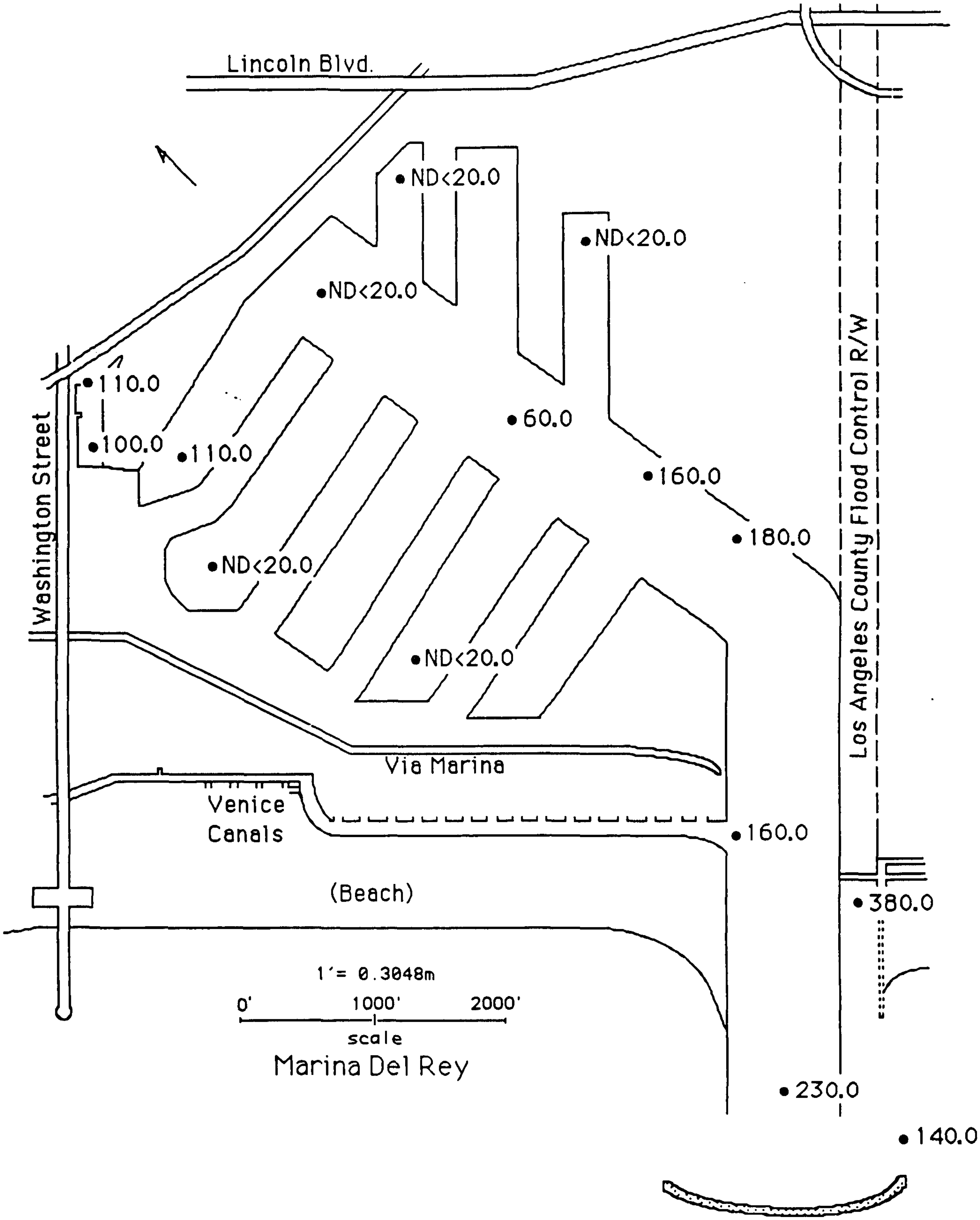


Figure IV.36. Chlordane in μg/kg (ppb) dry wt., 27 October 1995.

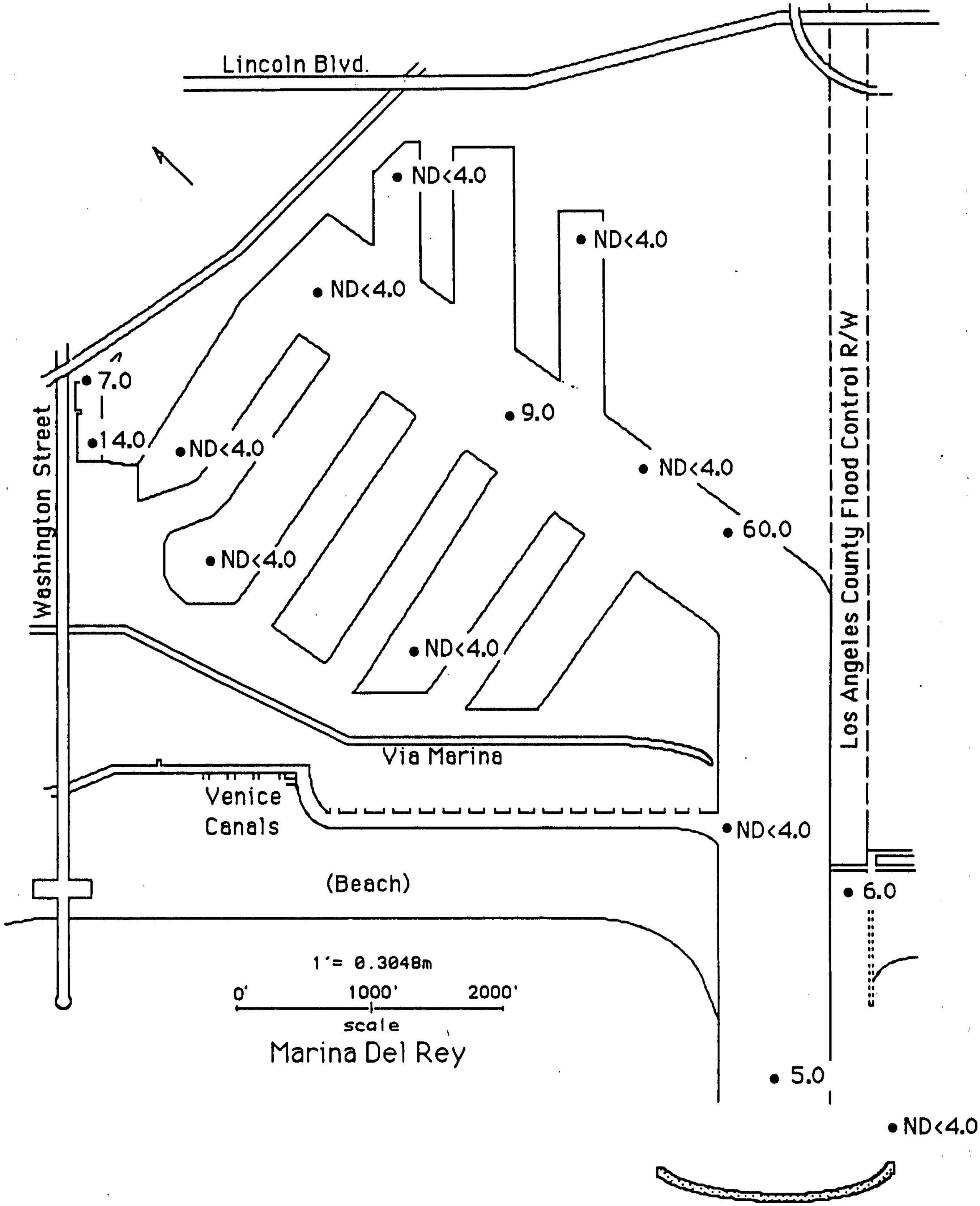


Figure IV.37. pp DDT in μg/kg (ppb) dry wt., 27 October 1995.

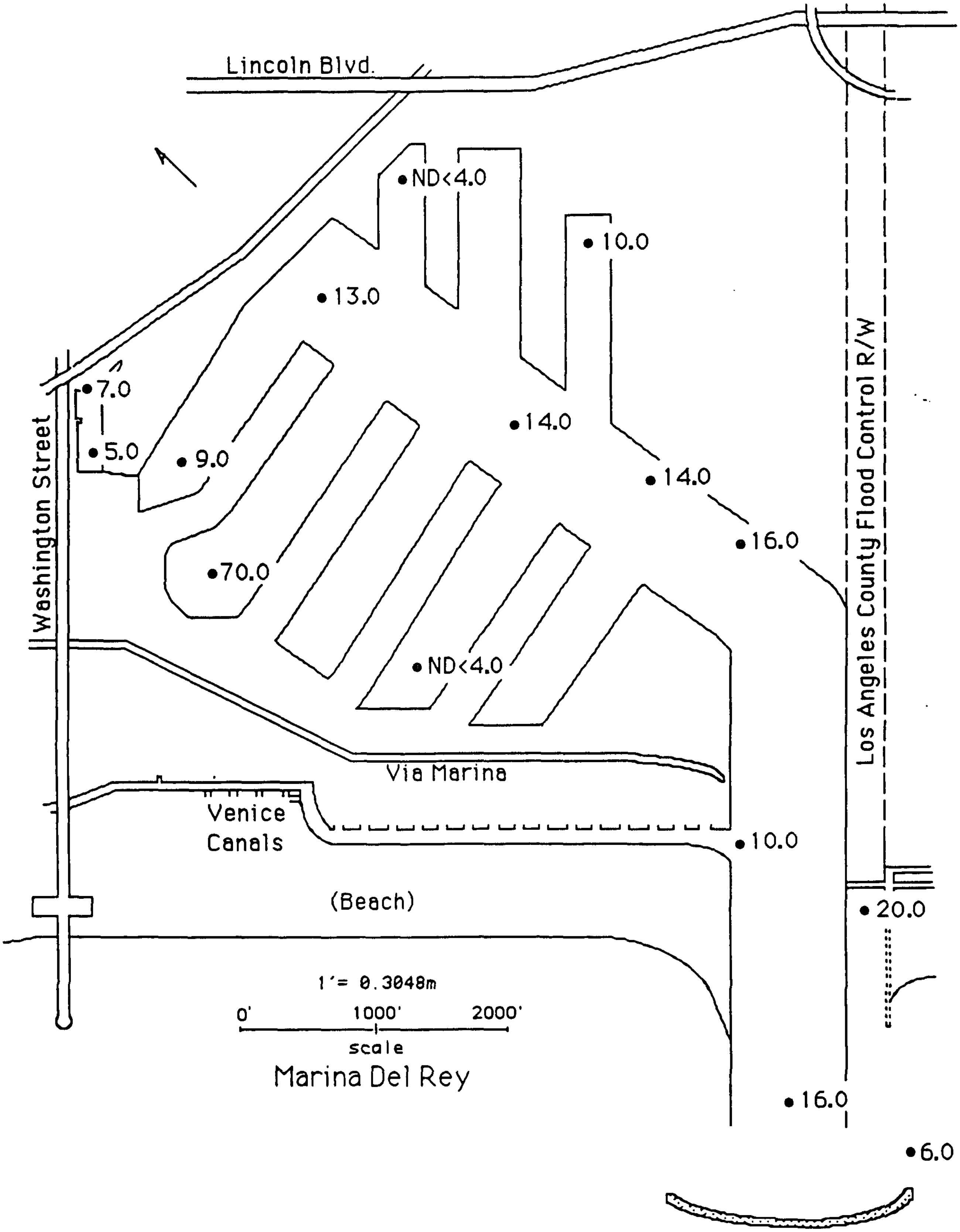


Figure IV.38. pp DDD in μg/kg (ppb) dry wt., 27 October 1995.

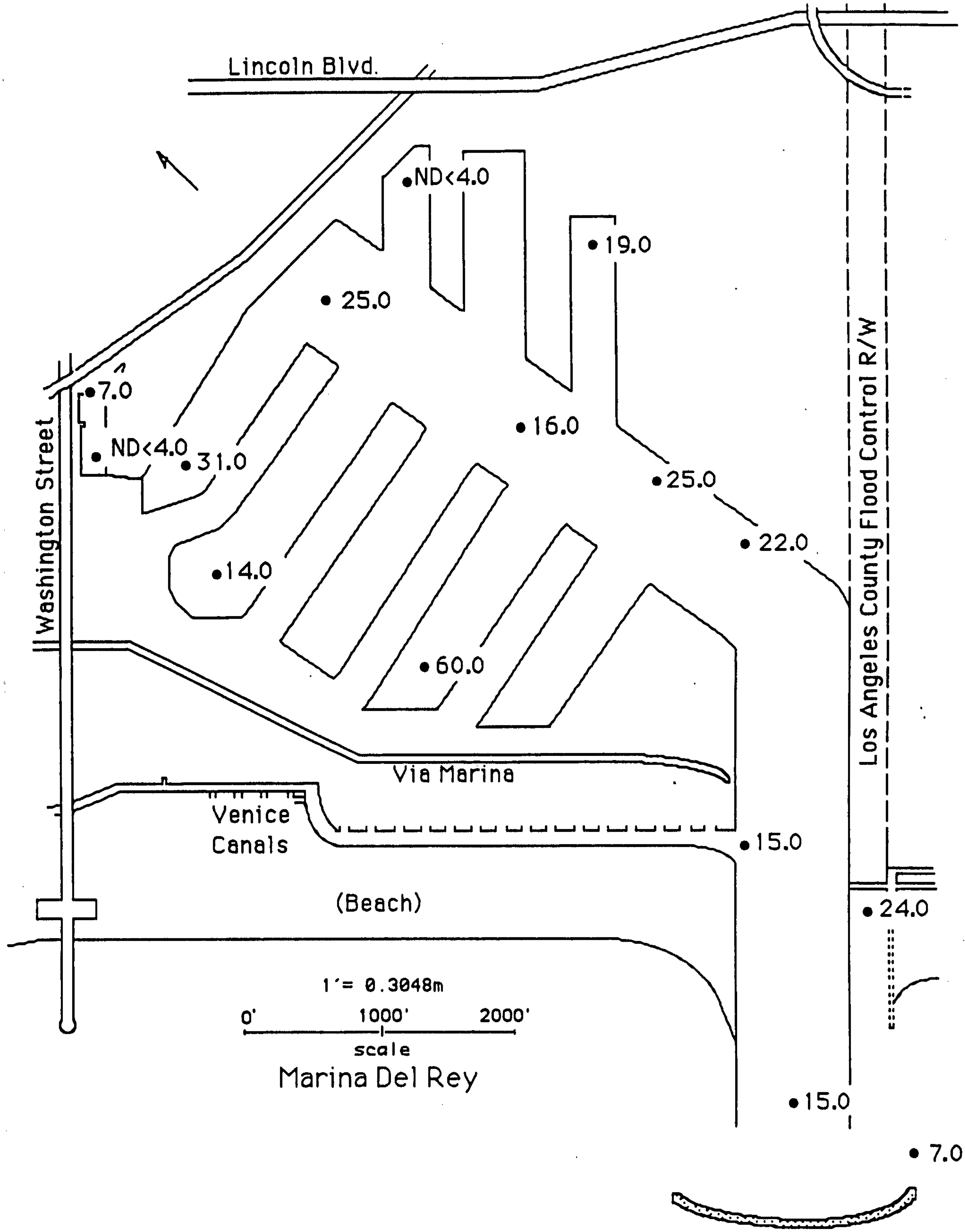


Figure IV.39. pp DDE in μg/kg (ppb) dry wt., 27 October 1995.

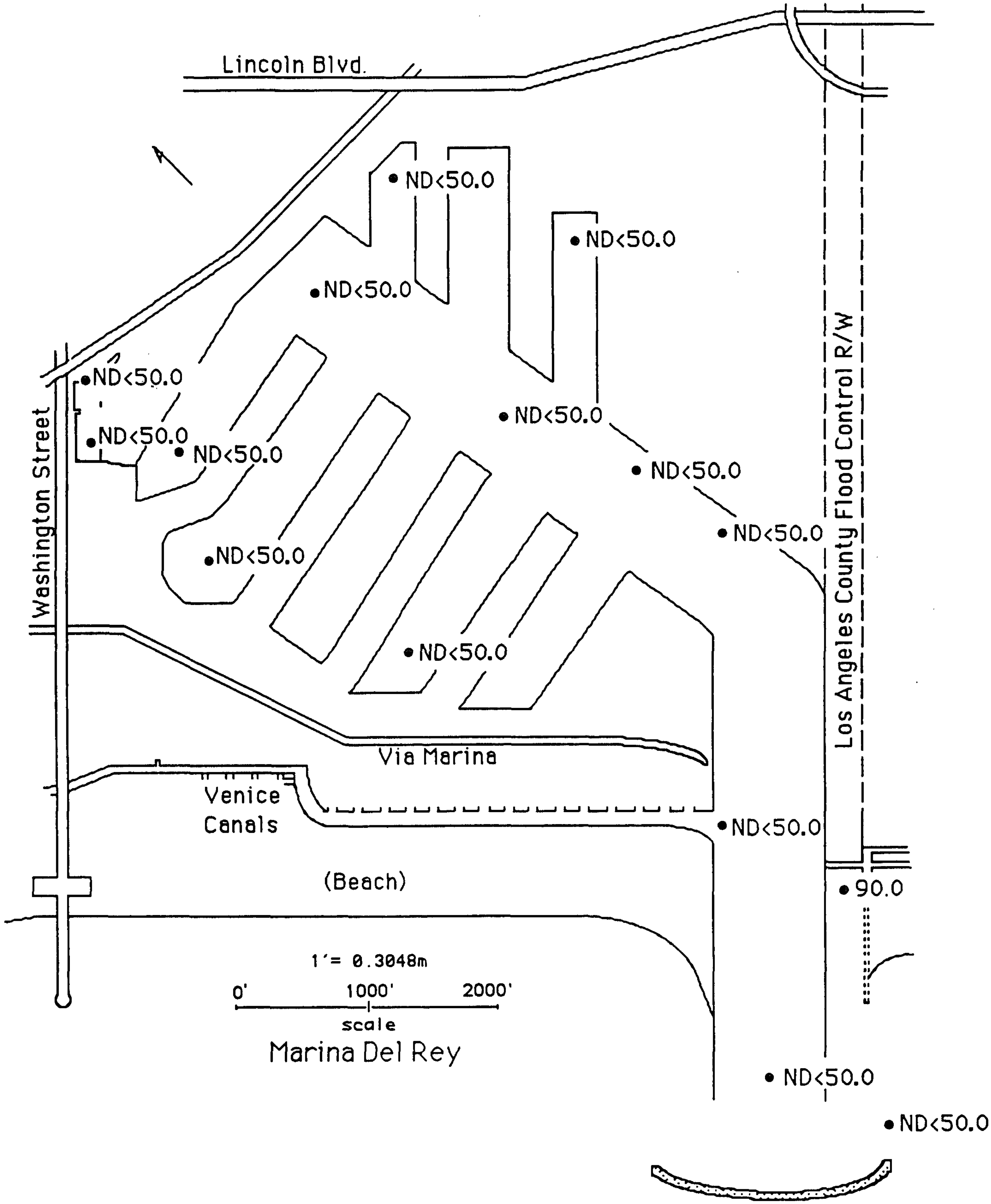


Figure IV.40. Arochlor 1254 in μg/kg (ppb) dry wt., 27 October 1995.

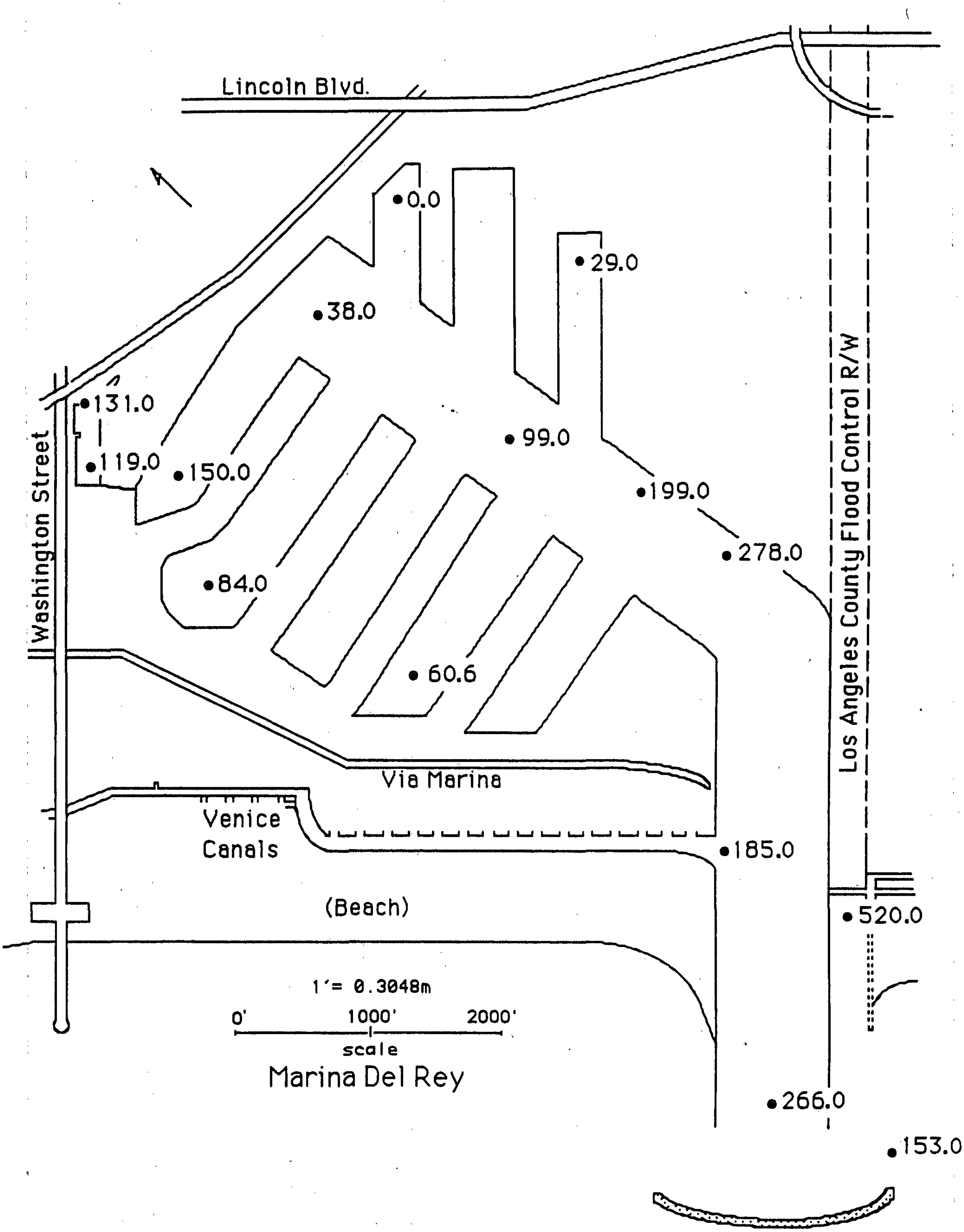


Figure IV.41. Total pesticides and chlorinated hydrocarbons in μg/kg (ppb) dry wt., 27 October 1995.

V. TERRESTRIAL CONTAMINATION IN OR NEAR OXFORD BASIN

INTRODUCTION

The site of the marina and the area bordering it on the north and east were known to have been contaminated by industrial use and dumping prior to and during World War II, according to local observers, but records of those activities are for the most part lacking. Although we have demonstrated, during more than a decade of monitoring, the incursion of contaminants into the marina through the flood control channels, we have had only limited information on the input of contaminants to Oxford Basin and/or Basin E from runoff in the immediate vicinity due to erosion of soils. A small pilot study was therefore undertaken.

On 16 November 1995, prior to the first substantial rainfall, soil and/or water samples were taken at 12 sites near Oxford Basin or Basin E and analyzed for trace metals, pesticides, PAHs and PCBs, using the same sample handling and analyses as those in the marina sediment chemistry program. Immediately following about 0.5 inches of rain on 13 December, the five stations where water was present and flowing were resampled for indications of increases, or decreases, in these parameters following the rainfall. The stations, shown in Figure V.1, were as follows:

A. At regular Station 13, inside Oxford Basin at the tide gate. Soil from above the highest high tide line was taken along with a water sample at water's edge.

B. At regular Station 22, at the storm drain at the northerly bend of Oxford Basin near Washington Street and Oxford Avenue. A major storm drain from Washington Blvd. to the northeast enters Oxford Basin here. A soil sample above highest high tide line and a water sample at the surface were taken.

C. On the eroding southerly bank near the inner end of Oxford Basin above the pump station. Soil and water sample taken in drainage.

D. On the northerly bank near the inner end of Oxford Basin beside the pump station. A storm drain runs beneath Berkeley Drive, and heavy seasonal surface storm drainage flow enters from Oxford Avenue and Dickson Street. Soil and

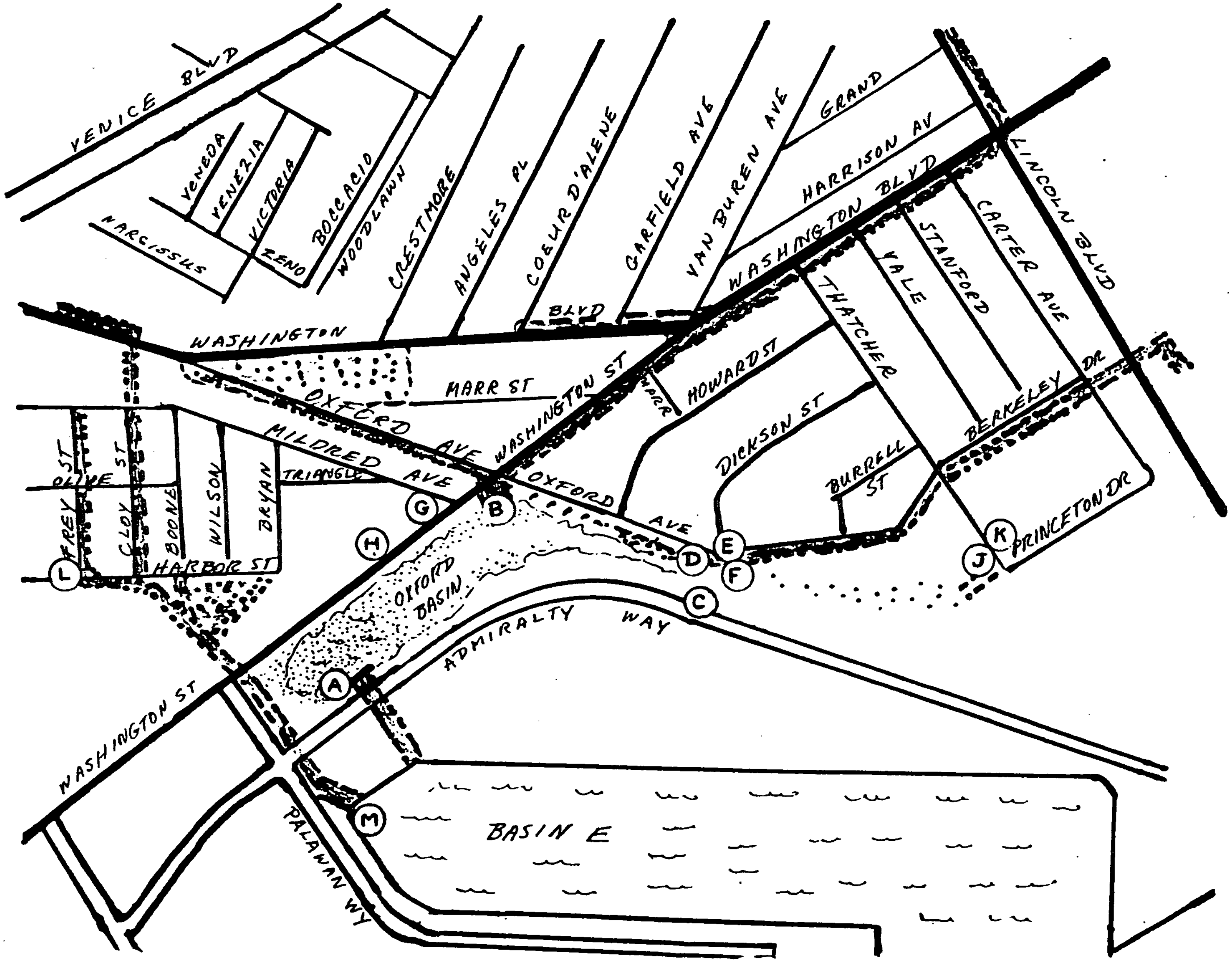


Figure V.1. Stations A-M, Locations in Special Study of Terrestrial Contamination in or near Oxford Basin water samples taken.

E. On the south side across from 801 Oxford Avenue near Dickson Street. Soil sample only.

F. At the innermost end of the drainage channel west of the parking lot at fence and telephone pole. Soil sample only.

G. On the north side of Washington Street at the northwest corner of Mildred Avenue. Soil sample only.

H. Vacant lot on the north side next to 691 Washington Street at speed limit sign. Soil sample only.

J. West of the corner of Thatcher Street and Princeton Drive at second telephone pole, in the swale leading to Oxford Basin. Trash trucks have been washed out in this area. Soil only.

K. On the east side of Thatcher Street near Princeton Drive by fence. A trash facility was operated on Thatcher Street. The area between Princeton and Berkeley Drive was extensively disturbed by construction off Lincoln Boulevard and Berkeley Drive. Soil sample only.

L. Northwest of the marina at the corner of Frey Street and Harbor Street in alley back of gray house. Soil sample only. This is along a major storm drain that flows into the west end of Basin E. Soil sample only.

M. At the dock in Basin E west of Edie's Diner where the Harbor Street and Washington Street collector system enters the marina. Both soil and water samples were taken.

RESULTS AND DISCUSSION OF TERRESTRIAL DRAINAGE PILOT STUDY

Effects Range-Low and Effects Range-Median for marine and estuarine sediments were determined by Long and Morgan (1990), based on data assembled from studies of such waters in the United States, including laboratory research on equilibrium-partitioning, spiked sediment bioassays, and evaluation of synoptically collected biological and chemical field data. The sediments tested in the present study are considered to be estuarine due to the residual salt content of soils in the former wetlands.

Trace Metal Contamination of Soils in Dry Weather

In Table V.1, trace metal contamination of soils at the 12 special stations sampled during dry weather on 16 November 1995 are compared with the ER-L and ER-M. Numbers in boldface indicate those parameters that exceeded the ER-L, and in some cases the ER-M.

Arsenic was not found at, or approaching, the ER-L level of 33 ppm. The range in arsenic concentrations was similar to those found in the marina (Table IV.2) except at Station E, where the value was nearly double the marina peak value. The arsenic mean for the regular marina survey sediment stations, including Ballona Creek and Oxford Basin (Stations 12, 13 and 22) in 1995 was 7.9 ppm, and 8.52 ppm if those stations are excluded, as compared to the mean of 8.15 ppm in the special stations. All of these numbers are below the estimated average in the Southern California Bight of about 10 ppm (Soule and Oguri, 1996; Mearns et al., 1991).

Cadmium was detected at seven of 12 special stations, and, where detected, levels were generally higher than those in the marina. The highest value, of 5.36 ppm at Station D, exceeded the ER-L of 5.0 ppm, whereas marina station values have always been low. The mean for the regular 12 marina stations was 0.04 ppm and for the 15 stations including Oxford basin and Ballona Creek, 0.49 ppm, indicating the degree of contamination from those sources. The only similar peak we have previously measured was at Station 13 in May 1992 at 5.54 ppm, following the rainy season, which suggests that contaminated sediment in runoff from the area was responsible.

Levels of chromium did not approach the ER-L of 80 ppm. The range in chromium values was lower at the special stations as compared to that in the 15 marina stations; the mean at special stations was 31.44 ppm as compared to 51.24 ppm at 12 marina stations and 45.95 ppm in all 15 regular stations, suggesting that **the marina is a source or sink for chromium.** The range in the Southern California Bight was from 4 ppm

Table V.1. Dry Weather Trace Metal Contaminants in Soil Compared to the Effects Range-Low (ER-L) and Effects Range-Median (ER-M) on 16 November 1995

mg/kg dry wt	13A	22B	C	D	E	F	G	H	J	K	L	M	ER-L	ER-M
Arsenic	8.49	5.88	4.17	4.65	22.3	9.43	9.84	4.72	5.85	12.5	4.49	5.2	33	85
Barium	328	96	53.6	139	129	188	134	176	120	137	118	11.6	N	N
Boron	21.3	10.4	7.87	11.4	12.6	14.0	7.0	11.6	5.48	5.83	8.64	18.1	N	N
Cadmuim	3.19	1.11	ND	**5.36**	1.28	1.58	ND	2.93	ND	1.37	ND	ND	5.0	9.0
Chromium	42.4	23.7	9.69	35.5	29.6	28.1	46.9	40.8	30.0	42.8	22.7	24.6	80	145
Copper	**125**	28.1	15.0	**78.2**	35.2	65.7	25.8	**112**	27.1	48.6	25.6	**73.4**	70	310
Lead	**455**	31.2	**37.8**	**138**	**42.7**	**105**	29.4	**452**	**59.2**	**48.0**	25.5	**391**	35	110
Manganese	290	204	158	310	310	304	423	265	329	412	300	179	N	N
Mercury	**0.2**	0.08	ND	0.13	**0.16**	0.10	0.07	0.10	ND	0.11	ND	**0.16**	0.15	1.0
Nickel	**32.5**	19.8	10.0	**30.0**	24.7	2.22	28.7	**42.5**	21.9	**31.0**	18.8	25.6	30	50
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	2.2
Zinc	**607**	114	54.4	**2,894**	**161**	**255**	101	**605**	**140**	**237**	115	**338**	120	270
Tributyltin*	0.11*	0.79*	0.09*	0.22*	0.09*	0.14*	0.18*	0.18*	0.09*	0.10*	0.17*	0.16*		

Boldface: Exceeds the Effects Range-Low (ERL) (NOAA 1990)
*Exceeds 30 day state standard of 0.0014 mg/l in water, for human health; no soil standard exists.
N = None determined
ND = None detected

to 40 ppm (Mearns et al., 1991).

Copper levels exceeded the ER-L of 70 ppm at four special stations; it was highest at Station 13A, inside the tide gate, at Station H, across Washington Street, at Station D, by the pump house, and at Station M, east of Edie's dinner in Basin E. The range in copper levels was lower than those seen in the marina, and the mean for special stations was 54.98 ppm, well below the mean 198.4 ppm of the 12 regular marina stations or the 168.03 ppm of the 15 regular stations, indicating that **the marina is a source or sink for copper.** Stations 8, 9 and 11 in the inner marina all exceeded the ER-M in the October 1995 regular sediment survey, indicating a potentially severe impact on reproduction and/or development of invertebrates and fish larvae.

Lead dominated almost all the special stations, exceeding the ER-L at nine stations and the ER-M at five stations. Where lead levels exceeded the ER-M, they were greater than three to four times higher, indicating a serious toxic contamination at Station 13A inside the tide gate, at Station H on the north side of Washington Street, near the corner of Thatcher St. and Princeton Dr., and at Station M where the Washington St. drainage enters Basin E. The mean for lead at special stations was 151.23 ppm. much higher than that for the 15 regular stations of 107.61 ppm or 90.93 ppm, of the 12 marina stations. **These data suggest that more lead comes from outside the marina than from within it.**

Mercury exceeded the ER-L of 0.15 ppm slightly at special Station 13A and Station E on Oxford Street. The mean for special stations was 0.09 ppm, which was considerably lower than the mean for the 12 regular marina stations of 0.52 ppm and of 0.47 ppm for the 15 regular stations. **This suggests that the marina is more of a source or sink for mercury than the surrounding area.**

Nickel equaled or exceeded the ER-L at Stations 13A, D, H, and K, with the highest value at Station H of 42.5 ppm. The mean concentration for the special stations was 23.98 ppm. These values are similar to those of the regular marina stations, with a mean of 27.09 ppm and a maximum of 41.1 ppm at Station 11, at the head of the main channel.

Silver was not detected at the special stations. The ER-L for silver is 1.0 ppm; among the 12 marina stations, silver occurred only at Stations 4 and 25, which are on opposite ends of the Coast Guard-Sheriff's Department docks with values of 0.96 ppm and 0.99 ppm respectively, very close to the ER-L. The mean for the 12 marina stations would therefore be a low 0.16 ppm, but the reality is that **silver contamination is occurring or has been deposited at the Administration docks at toxic levels.**

Zinc exceeded the ER-L of 120 ppm at eight stations and the ER-M of 270 ppm at five of those locations. The zinc level of 2,894 ppm at Station D, at near the storm drain pump house, was particularly high, being more than 24 times the ER-L and ten times the ER-M value, a very serious level of contamination. The highest zinc level in the marina since 1990 that we observed was 647 ppm in April 1994 at Station 9. Only special stations 22A, C, G and L were below the ER-L, indicating a strong level of contamination in surface soils near Oxford Basin.

There are no ER-L or ER-M sediment values established for manganese, barium, boron, or tributyl tin. Manganese levels ranged from 158 mg/kg (ppm) at Station C to 423 ppm at Station G. The range for manganese was higher at the special terrestrial stations than it was in the regular marina stations and the mean was 290 ppm, as compared to 212.8 ppm for 12 regular stations within the marina and 203 ppm for the 15 regular stations. **These data indicate a higher terrestrial incidence of magnesium in soils at the special stations than in either the flood control channels or the marina itself.**

The range for barium at the special stations was from 11.6 ppm at Station M to 328 ppm at Station 13A, with a mean of 135.85 ppm. In comparison, the range for the 15 regular marina stations was 30.8 ppm at Station 1 to 154 ppm at Station 13, with Station 22 following with 145 ppm, both of the latter in Oxford Basin. The mean for 12 regular marina stations was 91.67 ppm. Ballona Creek had a moderate value of 64.9 ppm, indicating that **Oxford Basin and its surroundings are the significant sources of barium.**

Boron, a nonmetallic element used in boric acid, soaps, glass and enamels, was found at the special stations ranging from 5.48 ppm at Station J to 21.3 ppm at Station 13A, with a mean of 11.19 ppm. The range at 12 regular stations was from 5.7 ppm at Station 1 to 37.5 ppm at Station 9, with a mean of 24.39 ppm and 22.2 ppm for all 15 stations, indicating the lower values in Ballona Creek and Oxford Basin. **High values of boron occurred where vessels are concentrated and flushing is low, at inner marina Stations 8, 9, 10, 11 and at Station 25, the Administration docks.**

<u>Trace Metal Contamination in Water Before and After Rainfall</u>

Unfiltered, eight liter water samples were taken at those special stations where runoff was present during dry weather on 16 November 1995, and after 0.5 inches of rainfall on 13 December. Water was present only at Stations 13A, 22B, C, D, and M. Results are shown in Table V.2, and levels of metals are compared with California Ocean Plan Water Quality Objectives (State Water Resources Control Board, 1995).

Cadmium, chromium, mercury, nickel and selenium were undetected in water both before and after rainfall.

Arsenic was detected in every case before the rainfall but not afterward. None of the values reached the SWRCB Daily Limit standard, however.

Copper was detected only at Stations 22B and C before rainfall, and at levels below the SWRCB Daily Limit. **Copper increased substantially after rainfall at Stations 22B and C, and appeared at all stations at levels exceeding the SWRCB Daily Limit for dischargers.**

Iron, lead, manganese and zinc did not appear in water at any stations before the rain. After the rain, iron, lead and zinc appeared at all stations, and manganese at all but one station, in most cases at levels exceeding the Daily Limit. There is no daily limit for iron, but it is known to stimulate growth of phytoplankton, causing so-called red tide blooms in bays and coastal waters.

Silver occurred in water only at Station C before the rain, but it occurred at a concentration close to the Daily Limit.

Table V.2. Trace Metal Contamination in Runoff Water in or Near Oxford Basin Before and After 0.5" Rainfall

mg/L dry wt (ppm)	(1) 13A	(2) 13A	(1) 22B	(2) 22B	(1) C	(2) C	(1) D	(2) D	(1) M	(2) M	State Water Qual Daily Limit
Arsenic	0.013		0.018		0.026		0.011		0.016		0.032
Barium	0.053	0.020	0.051	0.022	0.056	0.023	0.040	0.021	0.04	0.014	
Cadmuim											0.004
Chromium											0.008
Copper		**0.031**	0.008	**0.020**	0.008	**0.023**		**0.020**		**0.018**	0.012
Iron		**0.52**		**0.88**		**0.41**		**0.46**		**0.020**	
Lead		**0.009**		**0.012**		**0.011**		**0.009**		**0.002**	0.008
Manganese		**0.029**		**0.030**		**0.021**		**0.020**			
Mercury											0.00016
Nickel											0.020
Selenium											0.060
Silver					0.026						0.0028
Tributyltin								**0.16**			
Zinc		**0.22**		**0.17**		**0.26**		**0.24**		**0.13**	0.080

1) Dry weather flow, 16 November 1995
2) After rainfall, 13 December 1995

Bold face shows parameters that increased after rain. Arsenic, barium and silver (where present), decreased.
Levels were below limits of detection where blank.

Tributyl tin occurred in water only at Station D, after the rainfall. There is no possible means for tributyl tin from vessel hulls to have gotten in to Station D during the rain, so either paint containing TBT was dumped or a terrestrial origin can be assumed. The compound is apparently also used as an antibiotic in some terrestrial paints. No ER-L or ER-M has been determined for toxicity of TBT in sediments but it is highly toxic to fish and invertebrate larvae in seawater in the parts per trillion range. It appears to degrade rather rapidly in sunlight in water.

Chlorinated Hydrocarbons (Pesticides) and PCBs in Soil in Dry Weather

No PCBs were detected in soil at special stations during dry weather sampling, although PCBs had been detected in the area of Stations G and K several years ago when there was a considerable influx into the marina (Soule et al., 1991). This condition possibly was due to large excavations near Lincoln Boulevard and Washington Boulevard or to other localized construction near by and may have been ameliorated by the extensive rainfall in subsequent years. Aroclor 1254 appeared only in Ballona Creek at Station 12 in the regular fall 1995 survey, with 90 ppb, exceeding the ER-L of 50 ppb for total PCBs considerably.

The chlorinated hydrocarbons Chlordane, p.p'DDT, p.p'DDD and p.p'DDE appeared in soil at almost all special stations in dry weather, at levels exceeding the ER-L, and in some cases, the ER-M (Table V.3).

Chlordane occurred in such excess at all stations except Station G as to be cause for great concern. With the ER-L of 0.5 ppb, the range of occurrences was from over 120 times to over 4000 times higher. The mean concentration was 401.66 ppb at special stations as compared to 108.67 ppb at regular survey stations. The maximum for special stations was at Station F, at 2,227 ppb as compared to the maximum for regular stations of 380 ppb, at Station 12 in Ballona Creek, suggesting runoff from adjacent land. Chlordane was in such widespread use for termite control and other purposes that the soil of the area surrounding the marina may be a source for years to come in spite of bans on its use.

Table V.3. Dry Weather Pesticides and Chlorinated Hydrocarbons in Soil[1], 16 November 1995

µg/kg dry wt (ppb)	13A	22B	C	D	E	F	G	H	J	K	L	M	ER-L	ER-M
Chlordane	**167**	**116**	**61.8**	**338**	**398**	**2,227**		**888.6**	**235.3**	**143**	**63.3**	**182.0**	0.5	6
Dieldrin					**15.7**								0.02	8
p.p'DDT	**17.9**	**25**		**14.8**	**125**	**59.5**	**8.1**	**54.3**	**13.3**	**15.3**	**22.4**	**19.8**	1	7
p.p'DDD		**9.4**		**4.2**	**12.6**	**36.0**		**50.1**		**5.1**	**9.2**		2	20
p.p'DDE	**8.9**	**14.7**	**10.3**	**22.2**	**22.0**	**21.6**	**7.1**	**54.3**	**10.2**	**13.3**	**13.2**	**29.1**	2	15
Total DDTs	**26.8**	**26.6**	**10.3**	**41.2**	**9.6**	**117.1**	**15.2**	**158.7**	**23.5**	**33.7**	**44.8**	**48.9**	3	350

[1]No pesticides were detected in water in dry weather (16 Nov 1995) or wet weather flow (13 Dec 1995)

Boldface: Exceeds Effects Range-Low (ER-L) (NOAA, 1990). ER-M = Effects Range-Median.

Blank = below the limits of detection.

PCBs not detected: Aroclor 1016, 1221, 1232, 1242, 1248, 1254, 1260

Pesticides not detected: Aldrin, Alpha BHC, Beta BHC, Lindane, Endrin, Toxaphene, Heptachlor, Heptachlor epoxide

Dieldrin was found only at Station E, at 15.7 ppb, which is, however, 785 times higher than the ER-L. Dieldrin has been banned for many years. It was found at regular Station 12 in Ballona Creek only in October 1985 and in April 1994, the latter at a concentration of 30 ppb.

Levels of p.p'DDT ranged from below the limits of detection at Station D to 125 ppb at Station E, which are close together. **All stations except Station D had levels of p.p'DDT in excess of both the ER-L and the ER-M of 1.0 and 7.0 ppb respectively, with Station E having 125 times the ER-L.** This represents relatively new contamination, because it was on exposed surface but had not yet been degraded to DDD or DDE. The mean p.p'DDT concentration at special stations was 31.28 ppb as compared with a mean of 6.73 ppb at the regular stations, where the peak of 60 ppb occurred at Station 4, seaward of the Administration docks.

Levels of p.p'DDD, degraded p.p' DDT, in soil ranged from below the limits of detection at special stations 13A, C, G, J, and M, to 50.1 ppb at Station H. The p.p'DDD mean for special stations was 10.55 ppb while that for regular survey stations was 14.0 ppb, due mostly to a maximum of 70 ppb at Station 8, which is a shoaling area. **Where detected, all p.p'DDD values exceeded the ER-L of 2 ppb. The ER-M was exceeded at special stations F and H, and regular stations 8 and 12.**

Levels of p.p'DDE, also a degradation product of DDT, occurred well above the ER-L of 2.0 ppb at all special stations, and at five of these (Stations D, E, F, H and M) levels were in excess of the ER-M of 15 ppb.. The mean concentration at special stations was 18.9 ppb, and the maximum was 54.6 ppb at Station H, as compared with a mean 18.67 ppb at the regular stations, with a maximum of 60 ppb at Station 6, very similar values.

Total concentrations of DDTs in soils are considered to be more important than the concentrations of the separate forms. The mean of total DDTs at the special stations was 46.37 ppb, with a maximum of 158.7 ppb at Station H. The mean at regular stations was lower, 38.93 ppb, with a maximum of 98 ppb at Station 4, followed by 84 ppb at Station 8.

Only at Station 9, at the head of the main Channel in the marina, were DDTs below the limits of detection. **Since the ER-L for total DDTs is 3 ppb, all of the concentrations at stations in the marina, except those for Station 9, and at all of the special stations could have serious impact on the reproduction and development of fish and invertebrate larvae.**

Pesticides and Chlorinated Hydrocarbons in Water

No chlordane, dieldrin or DDTs were found in water samples taken before or after rainfall, although the sample size was necessarily small due to small amounts of water present. Water samples could only be obtained in dry weather at Stations 13A, 22B, C, D, and M, since the other stations did not have standing or running water. Chlordane and DDTs are considered to be human carcinogens at very low (parts per trillion) concentrations, according to the California Ocean Plan (SWRCB, 1995).

Polynuclear Aromatic Hydrocarbons (PAHs)

Polynuclear aromatic hydrocarbons (PAHs), also known as polycyclic aromatics or polyaromatics, are compounds of carbon and hydrogen consisting of two or more benzene rings in linear or cluster form. Aromatic hydrocarbons are found in petroleum and coal and their refined or combustion products (Mearns et al., 1991). Fluoranthene and pyrene are formed in power plant generation, open burning, and a relatively small amount from automobile emissions. Naphthalene and phenanthrene are major PAHs found in water associated with crude and refined oil. Metabolites of PAHs are often more toxic than the original compounds and some are listed as carcinogens on the Environmental Protection Agency Priority Pollutant list. The sources of PAHs reported in the Southern California Bight have been in treated sewage, oil spills. refinery wastes and, possibly, natural oil seeps and hydrothermal seeps (reviewed in Mearns et al., 1991).

PAHs have not been monitored in the regular marina program, partially because of budget constraints, and also because the techniques for measuring them were not well established when the monitoring program resumed in 1984. However, they would be

Table V.4. Polynuclear Aromatic Hydrocarbons (PAHs) detected in Soil and Water in or near Oxford Basin in Dry Weather on 16 November 1995*

μg/kg or l ppb	13 A-S	13 A-W	22 B-W	C-S	C-W	D-S	D-W	E-S	F-S	G-S	H-S	J-S	K-S	L-S	M-S	M-W	ER-L	ER-M
Naphthalene									**7,700**						**6,300**		340	2,100
Phenanthrene						190			**2,100**		100	80	80	80	**2,700**		225	1,380
Anthracene																	85	960
Fluoranthene			0.05			180			**860**	50	50	60	50	50	**1,400**		600	3,600
Pyrene			0.06			110			**560**						**1,800**		350	2,200
Benzor (a) anthracene															**560**		230	1,600
Chrysene			0.06			190			250						**850**		400	2,800
Benzo (b) fluoranthene						60		60	100						**560**			
Benzo (k) fluoranthene									70						**450**			
Benzo (a) pyrene						70			50						**1,100**		400	2,500
Dibenzo (a, h) anthracene																	60	260
Total PAH			0.17			800			**11,690**	50	150	140	130	130	**15,720**		4,000	35,000

ER-L = Effects Range-Low. ER-M = Effects Range-Median.

***None detected in wet weather water samples 13 December 1995**

*Not detected: Acenaphthalene, Acenaphthene, Fluorene, Benzo (g, h, i) perylene, Indeno (1, 2, 3-cd) pyrene

Blank = Below the limits of detection

components of the oil and grease parameter (Chapter IV) measured in the surveys.
For the special study PAHs were analyzed in soil in dry weather and in water before and after rainfall, shown in Talbe V.4.

No PAHs were detected in water samples taken after rainfall. This suggests that the PAHs accumulate in soil and water during dry weather. The only PAHs found in dry weather flow were at Station 22B, consisting of traces of fluoranthene, pyrene and chrysene.

Small amounts, below the ER-L, of phenanthrene and/or fluoranthene were found at special Stations D, G, H, J, K and L, and pyrene, chrysene, benzo(b)fluoranthene benzo(a)pyrene were found at Station D. **Station F, at the inner end well above the tidal line of the culvert into Oxford Basin, was seriously contaminated; with 22 times the ER-L of naphthalene and almost 10 times the ER-L of phenanthrene. Levels of fluoranthene and pyrene were also above the ER-L.**

The most critical contamination concerning the marina is at an unsuspected site, Station M, where the collector storm drains from Washington Street dump into the marina. In soil above high tide line, naphthalene measured over 18 times the ER-L and three times the ER-M; phenanthrene was 12 times the ER-L and twice the ER-M, while fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(a)fluoranthene, benzo(k)fluoranthene, and benzo(a)pyrene all exceeded the ER-L.

Total PAHs have separately determined ER-L and ER-M values; in the special study soil at Station F was almost three times the ER-L and Station M had almost four times the ER-L. **It is possible that continued flushing of the parking lot above Station M produced these high numbers. If that is the case, the discharge of PAHs into the marina from other parking lots much larger than the one above Station M could have a severe impact on marine life.**

PAHs are metabolized by organisms into reactive, water soluble epoxides which may be more toxic than the original compounds, potentially damaging essential proteins and

DNA, or they may be rendered nontoxic by certain peptides that are naturally occurring in organisms. Research results in the literature are inconclusive on some of the effects.

CONCLUSIONS

In dry weather, soils at most stations sampled, above the highest high tide line or completely isolated from it in the terrestrial area near Oxford Basin, are heavily contaminated by the heavy metals lead and zinc at levels far in excess of the Effects Range-Low (ER-L), and in some cases far exceeded the Effects Range-Median, established for toxicity in marine sediments. Since all of these stations are positioned to contribute sediment to the marina in wet weather flow, our evaluation was based on marine criteria.

Fewer stations were contaminated with excessive levels of copper, mercury and nickel. The most contaminated sites were Station 13A, above the tide gate, and Station D, at the pump station at the inner end of Oxford Basin. Other highly contaminated sites were Station H, across Washington Street, and Station M, where the Washington Street collector drains enter Basin E. **Comparison with October 1995 marina data indicates that more lead, zinc and barium come from outside the marina than from within it.**

Mean nickel concentrations are similar within and outside the marina.

Copper, mercury and boron data suggest that the marina is more of a source or sink than the adjacent terrestrial area.

In dry weather, none of the stations where drainage water was available had toxic levels of heavy metals. However, after a 0.5 inch rain, all of the stations with water present had levels of copper, iron, lead and zinc in excess of the SWRCB Daily Limits for effluent discharge. Tributyl tin, banned in anti-fouling paints in the marina, appeared at Station D, well above any possible contamination from marina waters.

No chlordane, dieldrin of DDTs were found in water samples before or after the rainfall.

Levels of Chlordane is dry weather soils were far in excess of the ER-L (more than 5,000 times at Station F) and the ER-M at all stations except Station G. The

mean concentration at the special stations was almost four times larger than the mean for marina stations, indicating a widespread terrestrial contamination at levels that would seriously harm the reproductive capabilities of marina organisms.

Dieldrin was found only at Station E, on the south side of Oxford Street at Dickson.

The p.p'DDT concentrations greatly exceeded the ER-L at all stations except Station C, where it was below the limits of detection, and exceeded the ER-M at all but Stations C and G. This form represents relatively new contamination as yet undegraded. The mean for special stations was 31.28 ppb as compared to 6.73 ppb for marina station sediments. This is a serious level of contamination, and suggests a much greater input of "new" DDT from terrestrial sources than from the marina.

A degradation product of p.p'DDT, p.p'DDD, occurred in a scattered distribution at special stations, but where present, exceeded the ER-L; it exceeded the ER-M at Stations F and H. The mean for p.p'DDD of 10.55 ppb at special stations was somewhat lower than the mean of 14.0 ppb for regular stations, but both are much higher than the ER-L of 2.0 ppb, and thus capable of seriously damaging marine life.

The other degradation product of p.p'DDT measured, p.p'DDE, occurred at levels well above the ER-L at all special stations, and at five stations, above the ER-M. The maximum was at Station H, on Washington Street, at more than three times the ER-M. The mean p.p'DDE of 18.9 ppb for the special stations was similar to that of the regular stations of 18.67 ppb as compared to the ER-l of 2.0 ppb, indicating a level of p.p'DDE contamination capable of inhibiting marine life in both the marina and the surrounding potential runoff areas.

The mean for total p.p'DDTs, which are more significant in terms of analyzing impacts, was 46.37 ppb for special stations and 38.93 ppb for marina stations. These values are far in excess of the ER-l of 3.0 ppb.

Polynuclear aromatic hydrocarbons (also known as polycyclic aromatic hydrocarbons, polyaromatic hydrocarbons or PAHs) were measured for the first time.

Trace amounts of three forms were found at Station 22B in dry weather flow, and none found in wet weather flow at special stations. Levels in soil in dry weather at Stations F and M exceeded the ER-L for a number of PAHs, including those usually associated with oil and petroleum products such as naphthalene and phenanthrene and others associated with power plants and open burning, and to a lesser extent with automobile emissions, such as fluoranthene and pyrene.

The most surprising was the high level of nine PAHs at Station M, where the collector drain system north of Washington Street enters the marina in Basin E. The source might be from the small parking lot above the sampling site. If this is the case, then the possibility exists that the larger parking lots in the marina area are a major source of contaminant poly nuclear aromatic hydrocarbons.

Considering the limitations of such a small pilot project survey as that conducted, results indicate that there are higher levels of some contaminants in the soils of the surrounding area subject to runoff than the sediments in the marina; in other cases the marina appears to be a source, or a sink, for contaminants found there at higher levels than in surrounding soils. Runoff water itself contained levels too low to be detected in most cases in small samples.

VI. MICROBIOLOGY

PUBLIC HEALTH BACTERIOLOGY

Protection of public health is of great importance to the user community in the marina. Although water contact is not the paramount use of the marina, contact with water occurs while boaters are performing maintenance, people are fishing, and youngsters are learning to sail, occasionally being dumped suddenly from their craft. The swimming area at the so-called Mother's Beach in Basin D directly exposes very vulnerable groups: the very young, and the handicapped that use the wheelchair access ramp.

Sources of Fecal Contamination

The specific sources of fecal contamination are difficult to identify in the constantly changing waters. Illegal discharge of heads in the marina has often been suspected, but the reality is that the great majority of violations of standards do not come during the summer months when vessels throughout the marina are more frequently used, but during the winter in conjunction with rainfall runoff episodes. Also, the dry weather violations only occasionally occur in the areas of concentrated vessels, in areas that are not adjacent to the beach or to stormwater conduits. Storm water runoff in Ballona Creek and Oxford Basin has been repeatedly demonstrated to be highly contaminated.

Tidal flushing of the beach area and rainfall runoff from the beach where numerous birds feed and rest when people are absent apparently contribute to contamination of the swimming area. Deploying overhead monofilament line appears to reduce the incidence of birds, perhaps because the thin, translucent material is not readily visible to the birds and startles them. Thicker, more visible polypropylene or nylon line does not seem to have the same effect. Beach area contamination in dry weather occurs occasionally from unknown sources, probably due primarily to tidal flux.

Localized runoff in dry and wet weather may carry contamination from dogs, cats, rabbits, birds, and from humans who do not always seek proper facilities, including proper handling of disposable diapers. Also, some boat operators, the Sheriff's Department and Fire Department routinely hose down decks to clean up pigeon, gull and pelican droppings.

7 April 1996 Sewer Malfunction near the Santa Monica Freeway and La Brea Avenue

Upgrades in recent years of the Los Angeles City Hyperion treatment Plant system, with larger holding tank capacity, have virtually halted overflows during storms into Ballona Creek. **However, a sewer malfunction on Sunday, 7 April 1996, at Adams Boulevard and Orange Drive, one block southwest of the intersection of the Santa Monica Freeway and La Brea Avenue, released an estimated 600,000 gallons of sewage.** This material flowed into Ballona Creek, increasing the normal range of total coliform bacteria from 20,00-100,000 CFU/100 ml to a maximum of 1,400,000 cfu/100 ml.

The shoreline north of the Ballona Creek mouth was not affected by the sewage spill but shoreline south of the entrance for 1.5 mi was strongly affected for two days. However, Mother's Beach was affected, with fecal coliforms of 2,000 CFU/100 ml, only on the third day, when coliform counts had returned to normal at all other creek and shoreline stations sampled, according to data provided by the Environmental Monitoring Laboratory, courtesy of Dr. John Dorsey. While studies of currents from meters deployed offshore of the breakwater indicate the northward direction of the longshore current, there was a distinct southward flow of waters in the surf zone during the sewer monitoring, as we have also observed for storm flows during our regular monitoring at Station 1.

Bacteriological Sampling Programs

Harbors Environmental Projects sampled surface waters at 18 stations in conjunction with their regular monthly monitoring program; of these stations, 14 are in the marina, two are in Ballona Creek and two are in Oxford Basin. Water samples were taken and iced until they were returned to the laboratory for appropriate dilution and incubation.

The Los Angeles County Department of Health Services (DHS) previously monitored five sites within the marina as a part of their weekly surveys of County beaches. The sampling stations in the marina were along the beach in Basin D and at the Harbor Patrol dock at the Administration building. Last year two beach stations were abandoned and a new one placed midway between them. In April 1996 the Harbor Patrol station was abandoned and a new station begun in Basin H at the ski launch ramp. The Harbor Patrol site was often in violation for coliforms, probably due to washing bird feces from the boats and docks, and from the activities at the adjacent fishing floats, where dogs, many birds, bait fish, and sometimes seals, are present.

Total Coliform Bacteria

Coliform bacteria (those inhabiting the colon) have been used for many years as indicators of fecal contamination of water supplies. They were initially believed to be harmless indicators of pathogens at a time when typhoid fever, dysentery and cholera were severe problems in the United States. More recently it has been recognized that coliforms themselves may cause gastroenteritis. The total coliform test is not effective in identifying human fecal contamination, however, because some coliforms are free living in soil and other vertebrates harbor coliform bacteria.

The Federal EPA, State and County public health standards for total coliform counts in recreational waters are that no single sample, when verified by a sample repeated in 48 hours, shall exceed 10,000 most probable numbers (MPN) per 100 ml. Since our sampling program is limited to one sample per month per station, we use the 10,000 MPN/100 ml as the relevant standard. Regulations state that if sampling were done on a daily basis, no more than 20 percent of the samples in a 30-day period could exceed 1,000 MPN/100ml, and no single sample could exceed 10,000MPN/100 ml. Sampling by the County is not normally done on a daily basis unless a problem is identified.

Fecal Coliforms

Fecal coliform tests primarily discriminate between soil bacteria and those in fecal material, including those from humans, warm blooded animals such as dogs, cats, birds, some fish, horses and barnyard animals, and some cold blooded fish species.

Standards for fecal coliforms provide that a minimum of not less than five samples in a 30 day period shall exceed a geometric mean of 200 MPN/100 ml, nor shall more than 10 percent of the total samples in a 60 day period exceed 400 MPN/100 ml. We have used 400 MPN/100 ml as our reference standard. It was proposed (SWRCB, 1995) to reduce the

400 MPN/100 ml to 200 MPN/100 ml, but this was put on hold while investigations continued on switching to an enterococcus standard in place of the fecal coliform measurement, although scientists indicate the need for both coliform and enterococcus measurements. A standard of 200 MPN/100 ml would have added 11 violations to the marina in HEP surveys during the rainy season but would not have affected the rest of the year at any station.

<u>Enterococcus</u>

Enterococcus bacteria comprise a portion of the *Streptococcus* bacteria that occur in human wastes. At one time they were believed to occur only in humans, but some *Streptococcus* species inhabit cows, horses, chickens and other birds. The species generally die off rapidly in the open, making them better indicators of fresh contamination. Our studies and those of the Department of Health Services have routinely measured all three bacterial indicators, but some monitoring agencies object to adding enterococcus because of the added cost of monitoring. However, the three measures taken together are much better indicators of actual health hazard conditions ((R. Kababjian, L.A. Cy. DHS, pers. comm.; Raloff, 1996).

The difficulty of the bacterial tests is that they require 72 hours to obtain results, requiring the DHS to post warnings whenever there is a potential problem rather than a known one. Efforts to establish other tests such as coprostanol for fecal contamination have been undertaken but they are not yet adequate or economically feasible for large scale monitoring.

The enterococcus standard used by the County has been the geometric mean of 35 colonies (C) per 100 ml, or that no single sample shall exceed 104 C/100 ml. We have used the latter as our standard. The SWRCB (1995) proposed as a limit a geometric mean of not more than 24 C/100 ml for a 30 day period or 12 C/100 ml for a six month period; 12 C/100 ml for a six month period requires a survey to determine the source of contamination. If the more stringent standard had been used during our surveys, violations would have increased to the point that almost all stations would have had enterococcus violations during the rainy season, and May and June would have been the only months with all stations free of violations.

RESULTS AND DISCUSSION

Association of Violations with Rainfall

In previous years it has been clearly demonstrated by our HEP surveys that the incidents of coliform and enterococcus violations were primarily associated with rainfall runoff episodes. Whereas the rainfall total (unofficial) in the rainfall year of July 1994-June 1995 in the Los Angeles basin was an extreme of 46.7 inches, the total in 1995-1996 was 20.8 inches, still well above the so-called average of 14 inches. The rainy periods last year were distributed between October and June, with an incredible 23.9 inches in January. This year rainfall was distributed between November and May, with the most intensive period in February, totaling 9.0 inches, and March, with 5.1 inches. The heavier rainfall in 1994-1995 may have actually reduced the number of total and fecal coliforms in Oxford Basin and Ballona Creek. No stations in or outside the marina had enterococcus violations during the 1994-1995 survey year.

The rainfall in 1995-1996 began with light rainfall in November, with the largest total in February, 9.0 inches of the 20.8 inches unofficially recorded for the year. **Most coliform violations were during the rainy season, but there was a serious increase in the number of enterococcus violations, presumably indicative of human wastes.**

Figures VI.1-12, at the end of this chapter, illustrate the coliform and enterococcus profiles through the marina according to distance from the breakwater, with lines demarking the violations of standards. Bacteriological data are tabulated in Appendix C.

Total Coliforms

As can be seen in Table VI.1, **total coliform violations according to HEP monthly surveys within the marina occurred only at Station 10 in March, whereas total coliform violations occurred in stations adjacent to the marina, at Station 22 at the Washington Street drain in Oxford Basin occurred in July, October, November, December, January, February and March.** Station 10 receives water from Station 13, at the tide gate

Table VI.1. Violations of Public Health standards at HEP Stations, July 1995 - June 1996

	Stations in Marina			Stations Adjacent to Marina		
	Coliforms			Coliforms		
Sampling Date	Total <10,000 MPN/100 ml.	Fecal <400 MPN/100 ml.	Enterococcus <104C/100 ml.	Total <10,000 MPN/100 ml.	Fecal <400 MPN/100 ml.	Enterococcus <104C/100 ml.
6 July		10		22		
10 Aug			19			1
7 Sept						
5 Oct				22	13, 22	
16 Nov		10	10, 20	22	1, 22	
14 Dec		10	10, 11	1, 12, 22	1, 12, 22	12, 22
4 Jan		3, 8, 10, 11, 19		22	1, 12, 13, 22	
1 Feb		10, 19	19	13, 22	1, 12, 13	
14 Mar	10	10, 20	4, 5, 10, 20	1, 12, 13, 22	1, 12, 13, 22	1, 12, 13, 22
4 Apr			20			12
2 May						
13 June						

Rainfall prior to monitoring (unofficial totals in north Los Angeles Basin)

1 Nov	0.2"
13 Dec	0.5"
23 Dec	0.7"
31 Jan	2.0"
4-13 Mar	4.6"

to Oxford basin, which was in violation in February and March. In Ballona Creek, Stations 1 and 12, were in violation in December and March, The actual numerical data for violations are presented in Table VI.2.

Fecal Coliforms

Within the marina, fecal coliform violations occurred at Station 10 in Basin E in July, November, December, January, February and March. One violation occurred at Station 20, at the tide gate in March. These two sites were impacted by the demolition of the existing docks, which were collapsing, and the removal during the summer of 503 cubic yards of highly contaminated sediment which had to be disposed of in a landfill. The bottom was then graded for installation of new docks for larger vessels. The vessels are quite crowded, but the sources of contamination are not apparent. Drainage from the adjacent parking lots or from the large storm drain that serves the Washington Street area might move animal and/or human wastes into the basin. **Because the violations were primarily during the rainy season, storm drain runoff is indicated and not vessel violations.** Fecal coliform violations in January and February at the wheel chair ramp, Station 19, in Basin D indicate the need to avoid waters during and after rainy periods. Vagrants have been observed using the ramp as a washing pavilion.

Outside the marina, fecal coliform violations were prominent in Oxford Basin at Stations 13 and 22 and in Ballona Creek at Stations 1 and 12 during the rainy season. There was a total of 44 fecal coliform violations in HEP surveys including both inside and outside the marina, in 1994-1995, as compared to a reduced number of 30 in 1995-1996.

Enterococcus Violations

In contrast to 1994-1995, when no enterococcus violations occurred in HEP monthly monitoring, there was an increase to 11 inside the marina and 8 outside the marina in 1995-1996. Within the marina, violations occurred in Basin E at Station 10 in November, December and March, and at Station 20 in November, March and April. **The enterococcus violations appeared to be primarily associated with runoff. There were**

Table VI.2. Violations of Bacterial Standards in Monthly HEP Surveys, July 1995 - June 1996

Stations 1 and 12 are in Ballona Creek; 13 and 22 are in Oxford Basin

Stations 10 and 20 under construction

			B.W		TideGate					M.B		E		B.C.	OxF	M-B	M-B	E	OxF	
Sampling Date	Rainfall* date, in.	Violation	1	2	3	4	5	6	7	8	9	10	11	12	13	18	19	20	22	25
6 July	0.0	TC																	>16,000	
		FC										500								
10 Aug	0.0	E	2.00														104			
7 Sept																				
5 Oct	0.0	TC																	>16,000	
		FC													2,400				>16,000	
16 Nov	1 Nov 0.2	TC																	>16,000	
		FC	700									790							410	
		E										576						682		
14 Dec	13 Dec 0.5	TC	>16,000											>16,000					>16,000	
		FC	9,000									500		>16,000					>16,000	
		E										120	169	>200				119	>200	
4 Jan	23 Dec 0.7	TC																	>16,000	
		E																		
1 Feb	31 Jan 2.0	TC													50,000				50,000	
		FC	1,100		1,600			500		500		2,200	500	2,000	800		800		1,700	
		E															>200			
14 Mar	4 Mar 0.7	TC	16,000									>16,000		16,000	50,000				>16,000	
	5 Mar 0.5	FC	9,000									3,000		2,400	>16,000			9,000	>16,000	
	12 Mar 2.0	E	240			104	130					>200		>200	>200			>200	>200	
	13 Mar 1.4																			
4 Apr	1 Apr 0.4	E												107				250		
2 May	0.0																			
13 June	0.0																			

*unofficial rainfall totals in northern Los Angeles Basin

TC = Total coliforms exceeding State single standard of 10,000 MPN/100 ml.
FC = Fecal coliforms exceeding EPA recommendation of 400 MPN/100 ml.
E = Enterococcus exceeding 104 colonies/100 ml.

two violations in Basin D at Station 19, the wheel chair ramp, one in August and one in February.

Enterococcus violations in Ballona Creek at Station 1 occurred in August and March, and at Station 12 in December, March and April. Violations in Oxford Basin occurred in December and March.

The reasons for the increase from zero in 1994-1995 to 19 enterococcus violations in the HEP surveys are unknown. The extreme amount of rainfall in January 1995, totaling 23.9 inches, probably flushed the area thoroughly, whereas lesser storm volumes in 1996 might have washed fecal material into basins but not out of the marina. In 1992-1993, the seasonal rainfall exceeded that in 1994-1995, but the largest monthly total was 16.5 inches in February 1993. In that year there were 18 enterococcus violations in the marina and 11 outside in Ballona Creek and Oxford Basin, as compared to 11 and 8 respectively in 1995-1996.

The increase in enterococcus in 1994-1995 does not parallel the decrease in fecal coliforms in the same period from 44 violations in 1993-1994 to 30. By including total coliforms, which increased from 4 to 14, the total violations increased slightly from 59 to 63. If rainy season violations in Ballona Creek, Oxford Basin and the disturbed Basin E were disregarded, the only violations of concern within the marina would be Station 19 in August in HEP surveys.

These data also illustrate the fallacy of attempts to allow public health agencies to rely only on total and fecal coliform counts or on enterococcus counts alone; both are needed to assess the incidence of contamination.

Los Angeles County Department of Health Services Surveys

The County Department of Health Services weekly surveys indicate that a preponderance of violations occurred during the rainy season in January, February and March 1996, as demonstrated in Table VI.3. The DHS stations sampled at the beach areas, indicated ongoing problems in the shallow water at the playground and between the lifeguard tower and the boatdock.

Table VI.3. Violations of bacterial standards in weekly surveys in Marine del Rey, July 1995 - June 1996 (Los Angeles County Department of Health Services)

Sample date	Rainfall date	Violation	Beach Playground area	Beach Between tower and boat dock	Fire dock	Harbor Patrol Dock	Basin H ski launch
1995							
14 Aug		E		120			
25 Sept		FC	500	500			
16 Oct		E		200			
20 Oct		FC		500			
27 Nov		FC		700			
1996							
16 Jan	16 Jan	E		140			
22 Jan	19, 21 Jan	TC	16,000	16,000	16,000		
		FC	2,400	16,000	1,300	1,700	
		E	200	200	200	200	
29 Jan		E		260			
20 Feb	19, 20 Feb	TC	16,000	16,000	16,000	16,000	
		FC	9,000	5,000	9,000	16,000	
		E	200	200	200	200	
4 Mar	27 Feb, 4 Mar	FC	5,000				
		E	200				
18 Mar	3, 12, 13, 14 Mar	FC		2,200			
Apr						Station	Station
						discont.	added
						Apr 96	Apr 96
28 May	16 May	E	210				
3 June		FC	500				
10 June		FC	500				500
17 June		FC	1,300				
		E	130				

TC = Total coliforms exceeding State single standard of 10,000 MPN/100 ml.
FC = Fecal coliforms exceeding EPA recommendation of 400 MPN/100 ml.
E = Enterococcus exceeding 104 colonies/100 ml.

The only total coliform violations occurred during the rainy season in January and February 1996. **There was one fecal coliform violation in dry weather at the playground area in September 1995, and three in June 1996. Elsewhere, there was one fecal coliform violation in June at the ski launch ramp in Basin H.**

The beach between the lifeguard tower and the boat dock had one dry weather enterococcus violation in August 1995 and one in October while the playground had one in May 1996 and one in June. All four stations had enterococcus violations in all four weeks in January and February and the playground had one violation on 4 March during rain.

Drainage after the rainy season may continue somewhat longer than the 72 hours following actual rainfall. The dry weather violations are to be considered more serious because that is the period of beach and shallow water recreation.

COLIFORM/ENTEROCOCCUS CONTAMINATION CONCLUSIONS

The question of sources continues to confound efforts to assure the public that the beach area is safe for body contact recreation. Violations were few in the dry season, but ideally there should be none, especially for enterococcus. Coliform contamination may be due to the many birds that rest or feed, particularly between the lifeguard tower and the boat dock. Monofilament line deployed between poles seems to be more effective in deterring seagulls than thicker, more visible lines, which can be easily seen by the birds and do not then intimidate them.

Some of the contamination may be due to the many dogs and cats, and sometimes vagrants, that frequent the area. [Following the HEP contract period, DHS found fecal coliform violations at the beach in three of five weeks in July, one in August and twice in September, but only one station had an enterococcus violation, in September, suggesting that most of the contamination may not have been of human origin. The jet ski launch ramp had high coliforms once in August.]

As has been the case in prior surveys, the incidence of coliform and enterococcus bacterial contamination in violation of public health standards is primarily associated with rainfall runoff, and as such occurs in the storm water

channels of Ballona Creek and Oxford Basin, or in the marina in Basin E connected to Oxford Basin by the tide gate.

The substantial increase in enterococcus contamination may be associated with the amount of rainfall in the storm season or the intensity of a storm period. **The extreme rains (23.9 inches) in January 1995 may have flushed away localized contamination, whereas the less severe rains of 1995-1996 caused material to be flushed into the local area but not flushed out to sea.**

We do not subscribe to the arbitrary grading system given by some environmental action groups to characterize various beaches because we have been unable to determine what criteria are used in 'failing' a given beach. Certainly a beach in a low energy marine area such as Mother's Beach would flush more slowly than an open coastal beach; the tradeoff, however, is that open coastal beaches have far rougher waters that are potentially dangerous to small children. **Beach closures by DHS should be strictly observed, and even in the absence of beach posting, water should be avoided for at least 72 hours after a rainfall or when drainage into the area can be observed.**

BIOCHEMICAL OXYGEN DEMAND

Five Day Biochemical Oxygen Demand (BOD_5) is a comparative measure of the amount of dissolved oxygen removed from the water column due to microbial breakdown of complex organic molecules generally associated with plant or animal debris. Numerous bacteria and other microbials are normal inhabitants of coastal waters and immediately attack organic debris or wastes, digesting them for assimilation, recycling nutrients in the ecosystem. These bacteria utilize dissolved oxygen in so doing.

Water samples were taken at the surface and at two meter depth intervals in the water column using a Naumann sampler. Sampling was performed as much as possible on falling tides to obtain mixed marina waters rather than tidally introduced bay waters, although it is not always feasible to do so. Water is decanted into glass BOD bottles without bubbling, stoppered with ground glass stoppers, water sealed, covered with plastic caps and iced until delivered to the laboratory. Samples are diluted with water collected at sea and aged in the dark for one to two months with air bubbling through it continuously.

Most marina waters require no dilution, but samples from normally high BOD locations such as Ballona Creek and Oxford Basin may be diluted by two to three times. No bacterial seed is needed for marina waters. Dissolved oxygen is determined immediately after dilution, before incubation for five days at 20°C, and immediately after incubation, using an Orion Oxygen probe. If dilution were made with fresh water, bacteria would be shocked into dormancy, which would delay uptake of oxygen and require longer incubation, as we have previously demonstrated.

BOD_5 RESULTS AND DISCUSSION

The mean BOD_5 for 1995-1966 was less than 2.0 mg/l, as is typical of the marina (e.g., Soule et al., 1996); in fact, the mean for both years was identical at 1.79 mg/l. The difference was that in 1995-1996, the highest values were 8.6 mg/l in December 1995 and 8.7 mg/l in February 1996, whereas in 1994-1995 there were five maxima above 8.7 mg/l, with 9.7 mg/l in July 1994, 10.3 mg/l in January and March 1995, 13.0 mg/l in April and 11.2 mg/l in June. **All of the 1994-1995 maxima were in Oxford Basin, perhaps indicating the greater rainfall runoff in the higher rainfall years which flushed surrounding areas. The similar mean for both years would indicate a somewhat lower BOD_5 in the marina itself during the higher rainfall year.** This was similar to the results in 1992-1993, also a high rainfall year, although the mean was lower, at 1.36 mg/l (Soule et al., 1993).

Table VI.4 tabulates the minima, maxima and means for the monthly surveys during 1995-1996, and indicates the tide phases during sampling. Figures VI.13 through VI.24, at the end of this chapter, illustrate the monthly BOD_5 values at the surface, 2 m and 4 m depths, if the latter depths are reached. Generally, depending on tide phase, depths of 4 m are reached only in Ballona Creek and the entrance channel and the main channel to Station 5. Station 19, at the beach, and Stations 13 and 22 in Oxford Basin are surface only locations.

The minima in 1995-1996 were below 1.0 mg/l in all months except during or after

Table VI.4. Monthly Biochemical Oxygen Demand: minimum, maximum and mean (mg/l), 1995-1996

Month	Minimum	Station	Maximum	Station	Mean	Tide Phase
July	0.9	11(t)	4.3	22	1.68	falling/rising
August	0.9	6(m)	4.9	22	1.38	rising/falling
September	0.8	2(t), 6(t), 25(t)	2.6	22	1.16	rising/falling
October	0.9	25(b)	3.4	19(t)	1.55	falling
November	0.8	11(t)	2.7	13, 22	1.37	falling
December[1]	1.0	25(b)	8.6	13	2.51	falling
January	0.6	25(m)	3.2	12(t)	1.26	falling
February[1]	1.1	8(b)	8.7	22	2.27	falling
March[1]	1.4	3(b), 25(b)	6.8	13	2.68	falling
April	0.6	11(t)	4.9	12(t)	1.72	rising/falling
May	1.0	5(b)	3.2	10(b)	2.11	rising/falling
June	0.7	2(b)	3.6	1(t)	1.83	rising/falling

[1] Rain in preceeding few days
t = top, m = middle, b = bottom of water column

rainy periods in February and March, while they were at 1.0 mg/l in December and May. The minima, as indicated in Table VI.4, were generally in main channel stations, as was the case the previous year.

Examination of the relative depth of the BOD_5 minima and maxima indicate that they are apparently patchy in distribution. There were six instances of minima occurring in the surface layer (t), two instances in the mid water column (m) and seven instances in near bottom waters of the main channel waters. In contrast, the maxima were mostly found in Oxford Basin at Stations 13 and 22, where only the surface layer can be sampled. The exceptions were at Station 19 in October, Station 12 in January and April, Station 10 in May and Station 1 in June. The maximum value at Station 10 was the only one in bottom waters. Monthly maxima are at times relatively low, usually in months without rainfall.

Occurrences of values in excess of 4.0 mg/l and the depths at which they occurred were examined in Table VI.5. Stations 13 and 22 in Oxford Basin were most often in

Table VI.5. Depths are listed (in m) where Biochemical Oxygen Demand values were greater than 4.0 mg/l, tabulated as a function of month and station, 1995-1996; B.O.D. samples were collected every 2 m.

	Station Number (Ordered relative to distance from the breakwater)																	
	12	1	2	3	4	25	5	7	6	11	9	8	18	19	10	20	13	22
Jul	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
Aug	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
Sep	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oct	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	*	--	--
Nov	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dec	0,2	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Jan	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Feb	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Mar	0	--	--	--	--	--	--	--	0	--	--	--	--	0	--	--	0	0
Apr	0,2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jun	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

* station 20 not occupied - large crane working in area

Table VI.6. Depths are listed (in m) where Biochemical Oxygen Demand values were greater than 2.0 mg/l, tabulated as a function of month and station, 1995-1996; B.O.D. samples were collected every 2 m.

	Station Number (Ordered relative to distance from the breakwater)																	
	12	1	2	3	4	25	5	7	6	11	9	8	18	19	10	20	13	22
Jul	0,2	0,2	2,4	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Aug	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	--	0
Sep	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
Oct	--	--	--	--	--	0	--	--	--	--	--	--	--	0	0,2	*	0	0
Nov	0,2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
Dec	0,2,4	0,2,4	0,2,4	--	--	0	--	--	--	--	--	--	--	0	2	0	0	0
Jan	0,2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Feb	0,2	0,2,4	0,2,4	0,2,4	2	0,2	0	--	--	--	--	--	0	0	--	--	0	0
Mar	0,2	0,2,4	0,2,4	--	0,2	--	0,2,4	--	0,2	0,2	0,2	0,2	0,2	0	--	--	0	0
Apr	0,2	0,2	0,2,4	--	--	--	--	--	--	--	--	--	--	--	0	--	0	0
May	0,2	2,4	0,2,4	0	0,4	0,2	--	4	--	--	2,4	0,4	2	0	0,2,4	2	0	0
Jun	0,2	0,2	0,2	0,2,4	--	--	2,4	--	--	--	--	--	--	--	--	--	--	0

* station 20 not occupied - large crane working in area

excess of 4.0 mg/l, and they, with Station 19, are surface only stations. The other occurrences were mostly in Ballona Creek at Station 12 in surface waters, with one occurrence each at Station 1, Station 10 and at Station 6. These latter occurrences are all during the rainy season.

If the values in excess of 2 mg/l are examined (Table IV.6), those in Ballona Creek and the outer marina show a more or less uniform distribution through the water column during the rainy season. However, during the dry season, the higher values are more patchy and may occur on the surface, or at 2 and/or 4 m. These might indicate phytoplankton blooms. None of these values are sufficient to indicate that depletion of dissolved oxygen occurring which would unduly impact the marina ecosystem.

BIOCHEMICAL OXYGEN DEMAND CONCLUSIONS

The five day Biochemical Oxygen Demand indicates the amount of organic debris or waste by the amount of dissolved oxygen utilized in microbiological degradation of those chemicals. **Levels in the marina proper are generally low, less than 1.0 mg/l, except during and after seasonal rainstorms. This indicates that oxygen reduction or stress due to organic load is not normally a problem in the marina, as it might be if vessel wastes were commonly dumped.** Dissolved oxygen could be depleted during rainfall episodes when BOD_5 levels are high. **Ballona Creek and Oxford Basin provide almost all of the maximum BOD_5 values, and although the volume of Oxford Basin flow does not compare with that of Ballona Creek, the high BODs indicate impacts on the marina, at least in Basin E.**

The quantity of BOD in Ballona Creek is probably trivial as far as impacts on the receiving waters of Santa Monica Bay are concerned and would quickly be assimilated as necessary nutrients in the ecosystem. Toxic organic materials are not measured as BOD_5, however, because they would inhibit or destroy the normal microbials that would potentially digest the organic matter.

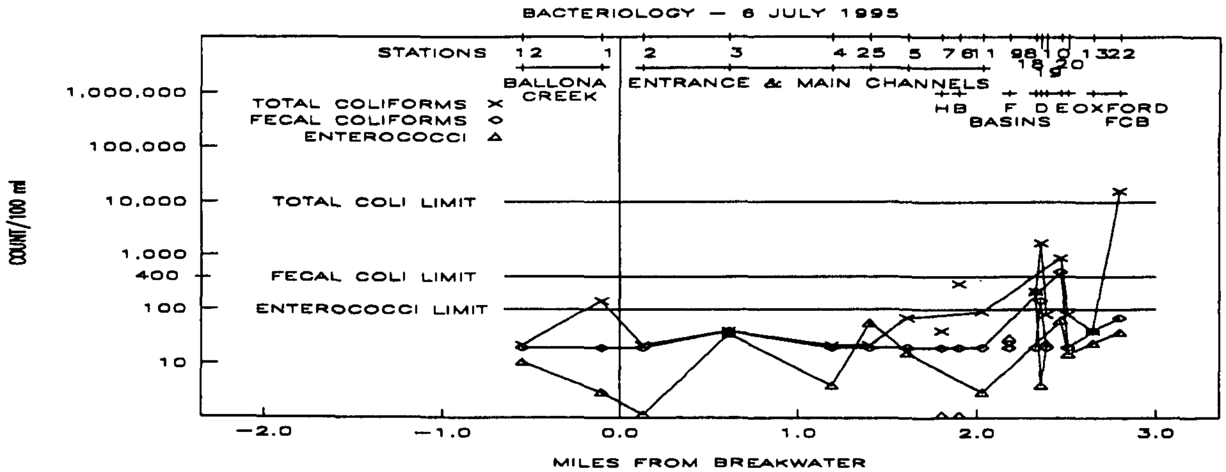


Figure VI.1. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 6 July 1995. Public health limits are indicated by transverse lines.

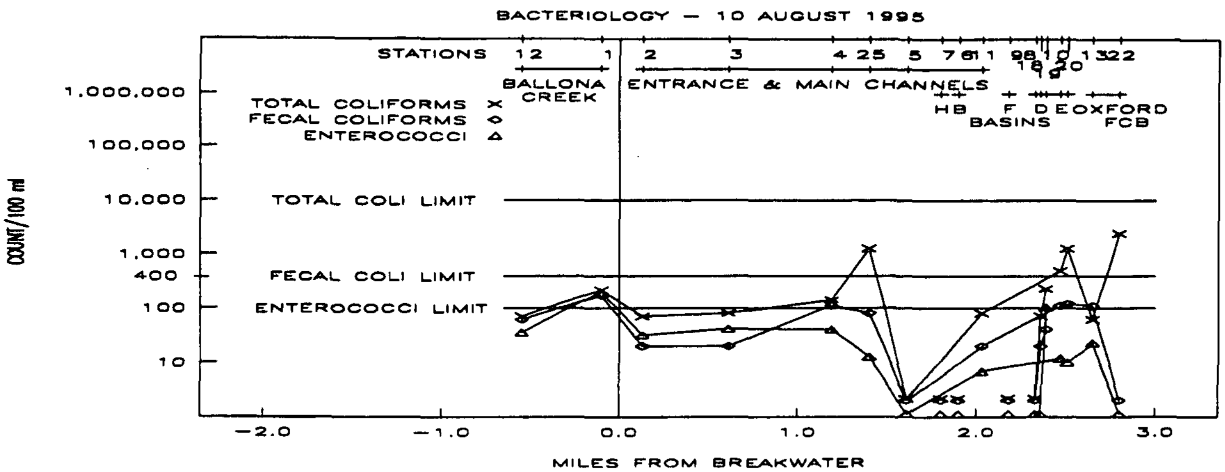


Figure VI.2. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). August 1995. Public health limits are indicated by transverse lines.

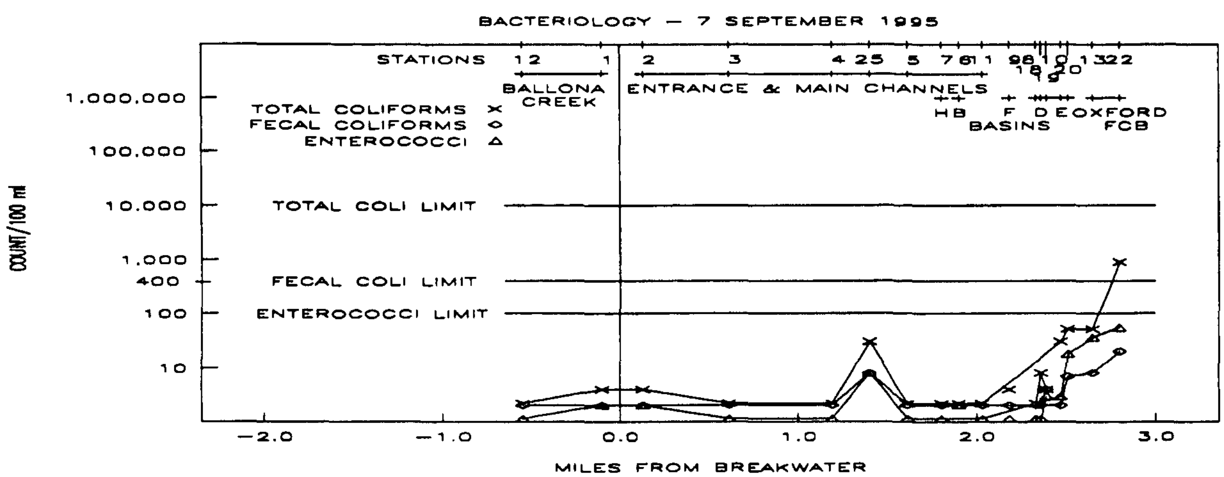


Figure VI.3. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). September 1995. Public health limits are indicated by transverse lines.

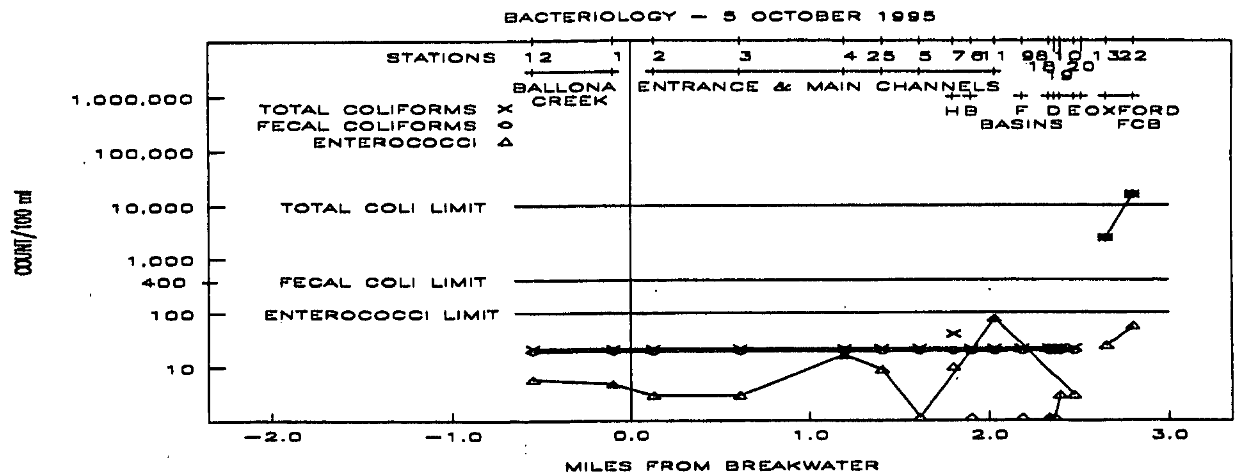


Figure VI.4. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). October 1995. Public health limits are indicated by transverse lines.

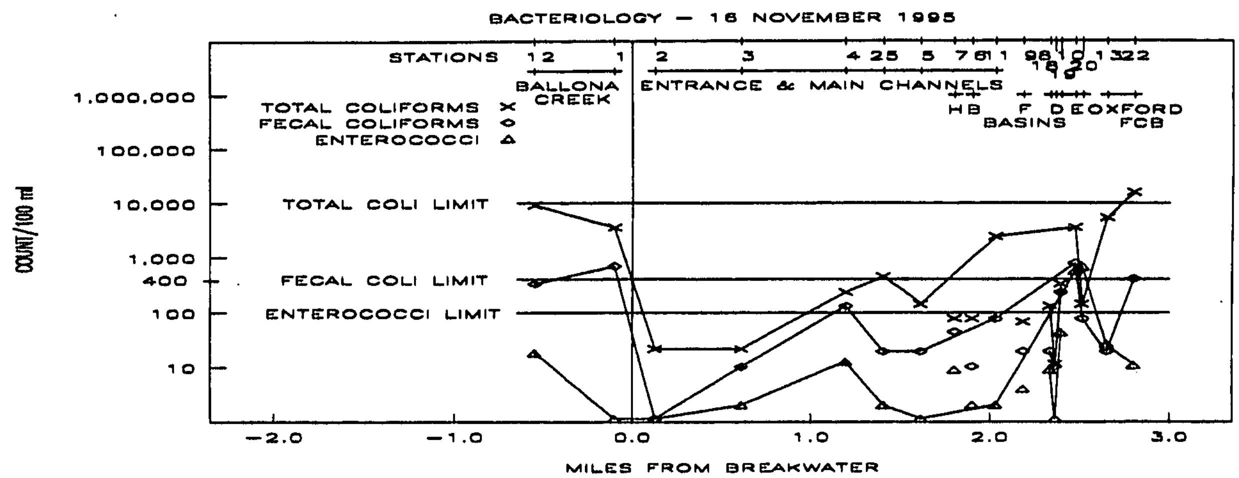


Figure VI.5. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). November 1995. Public health limits are indicated by transverse lines.

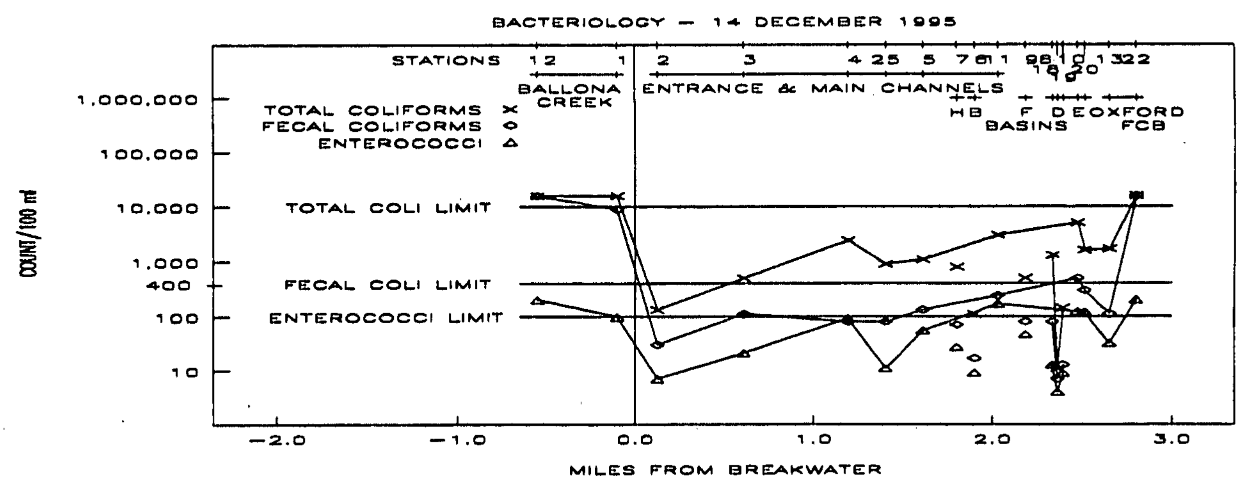


Figure VI.6. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). December 1995. Public health limits are indicated by transverse lines.

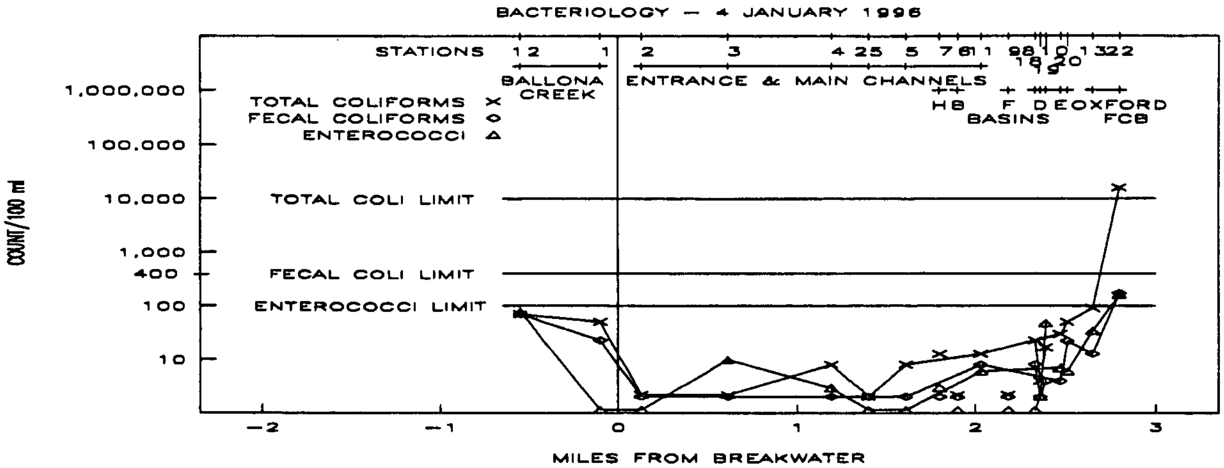


Figure VI.7. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 4 January 1996 Public health limits are indicated by transverse lines.

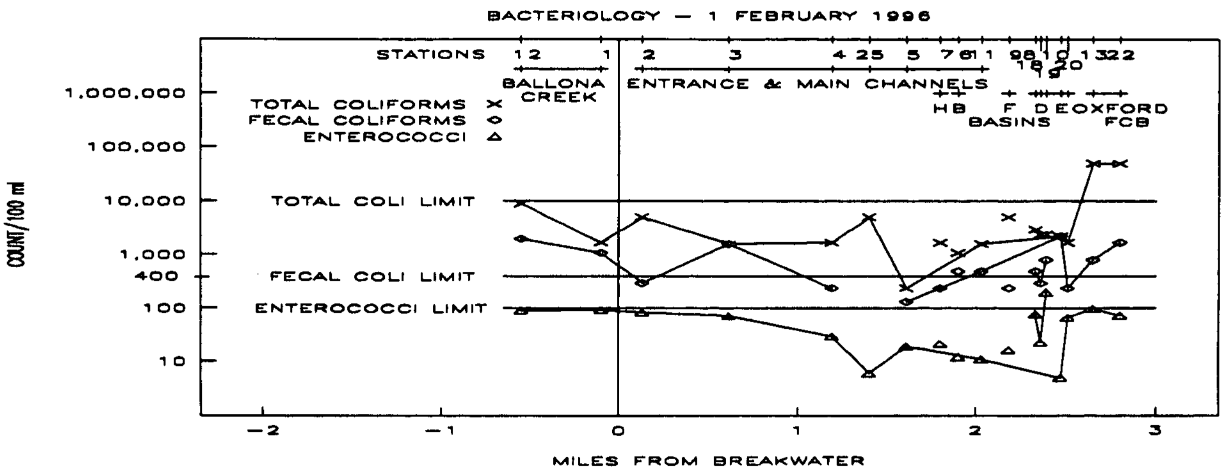


Figure VI.8. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 1 February 1996. Public health limits are indicated by transverse lines.

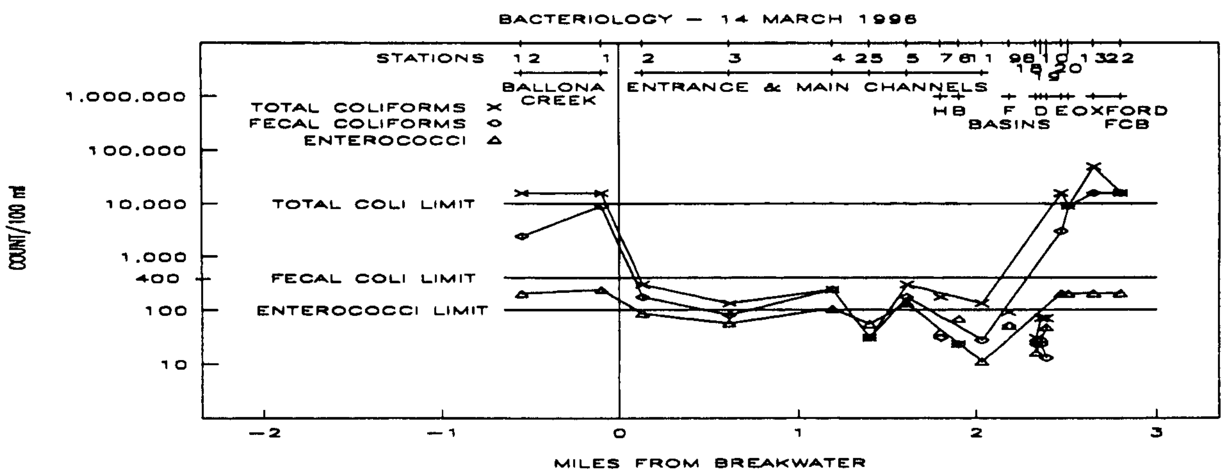


Figure VI.9. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). 14 March 1996. Public health limits are indicated by transverse lines.

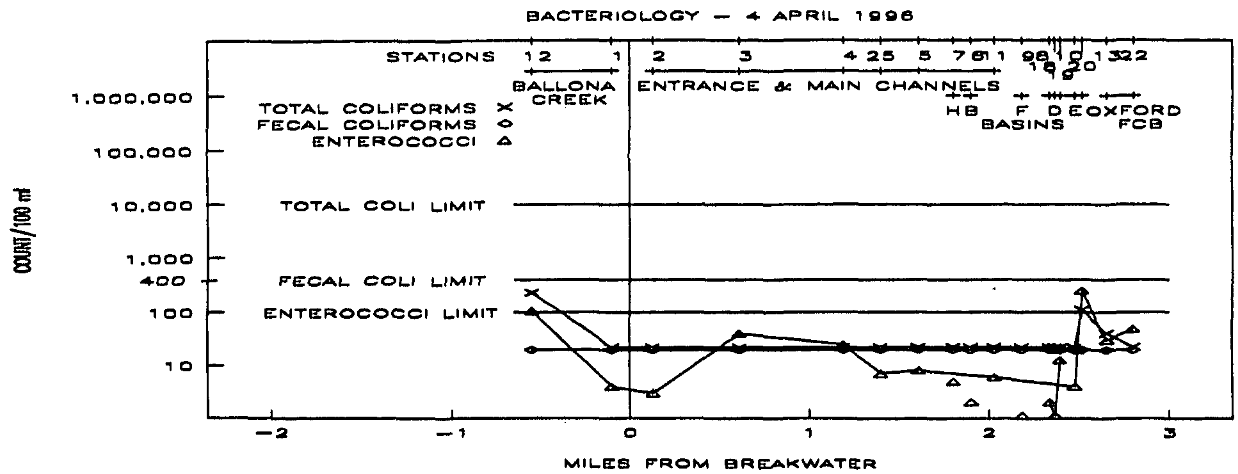


Figure VI.10. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). April 1996 Public health limits are indicated by transverse lines.

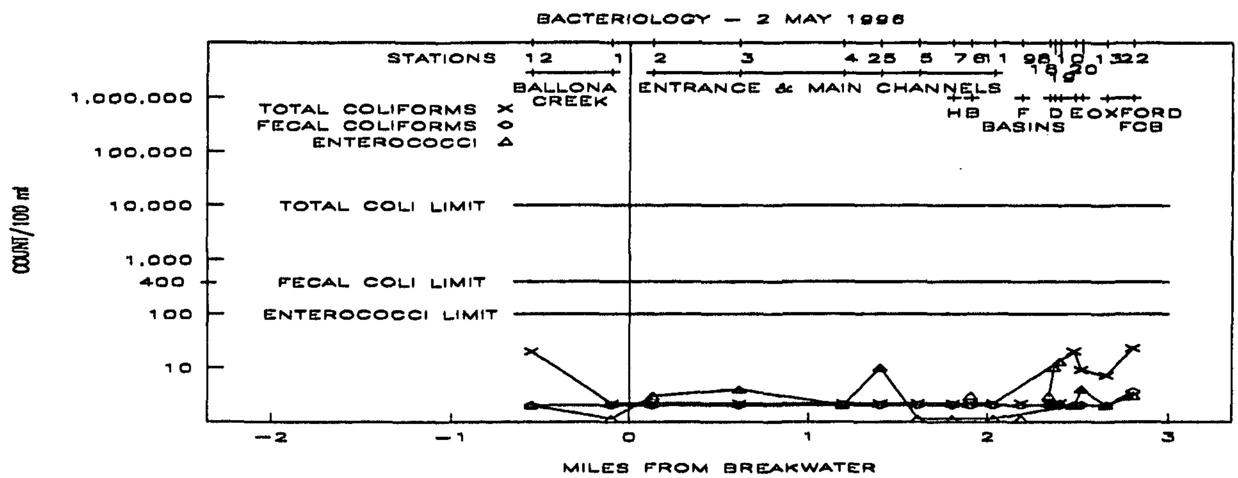


Figure VI.11. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). May 1996. Public health limits are indicated by transverse lines.

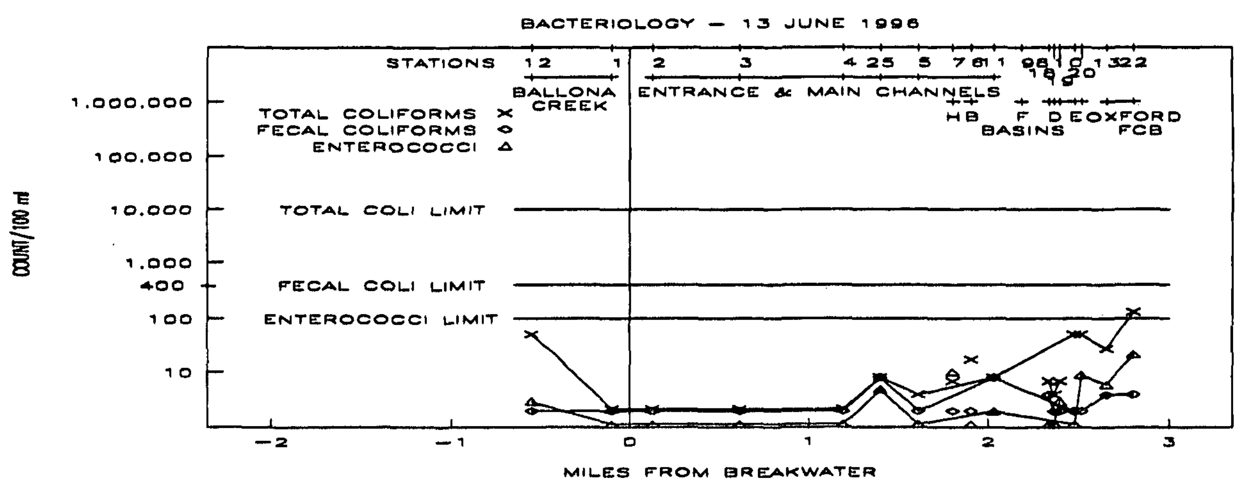


Figure VI.12. Total and fecal coliform (MPN/100ml) and Enterococcus (colonies/100ml). June 1996. Public health limits are indicated by transverse lines.

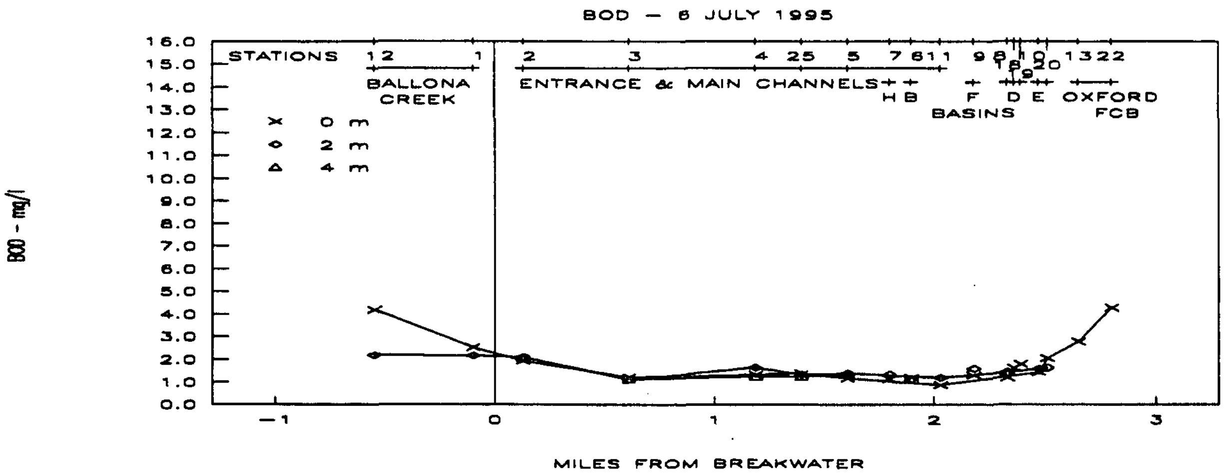


Figure VI.13. Five-day biochemical oxygen demand (mg/l), 6 July 1995.

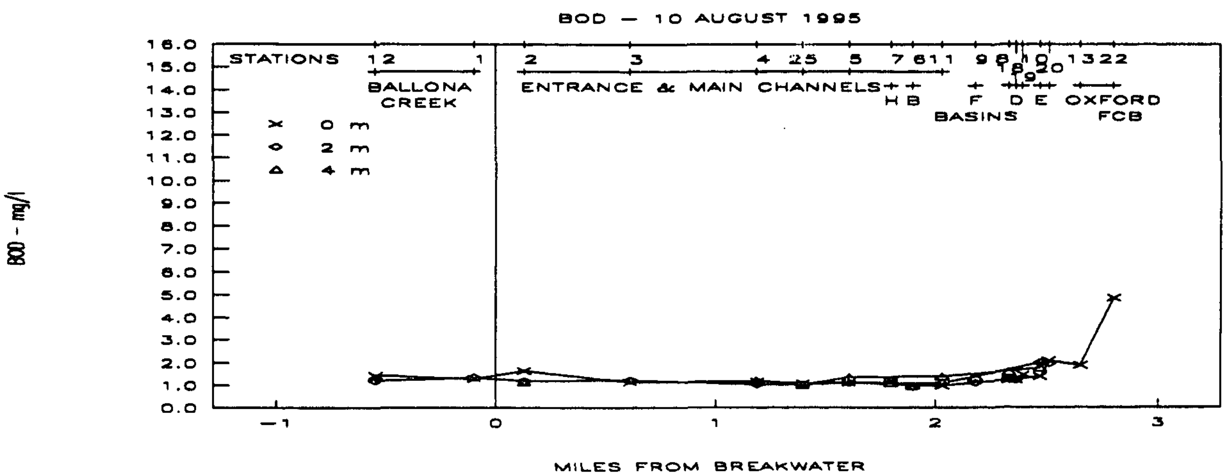


Figure VI.14. Five-day biochemical oxygen demand (mg/l), 10 August 1995.

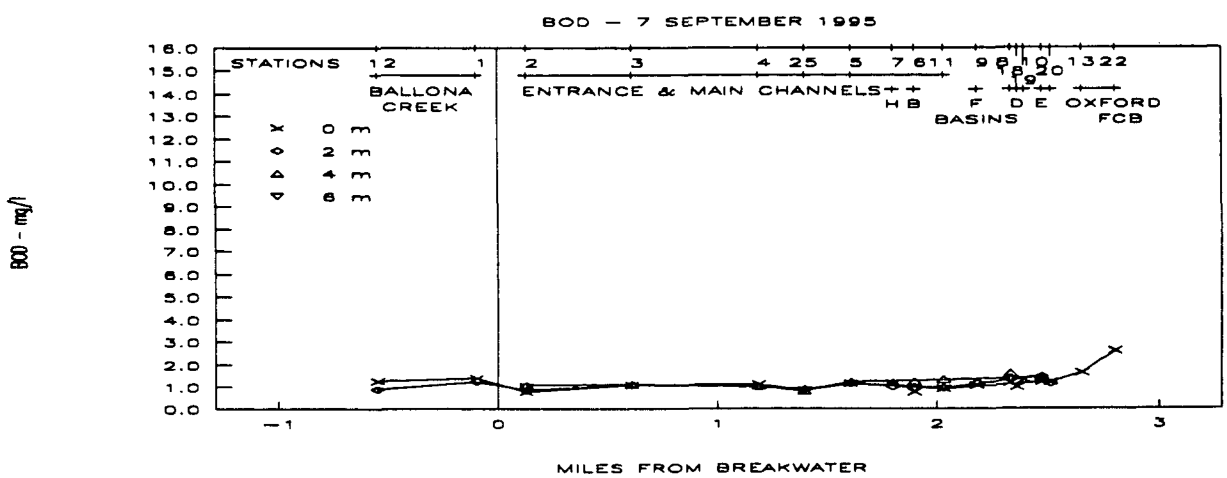


Figure VI.15. Five-day biochemical oxygen demand (mg/l), 7 September 1995.

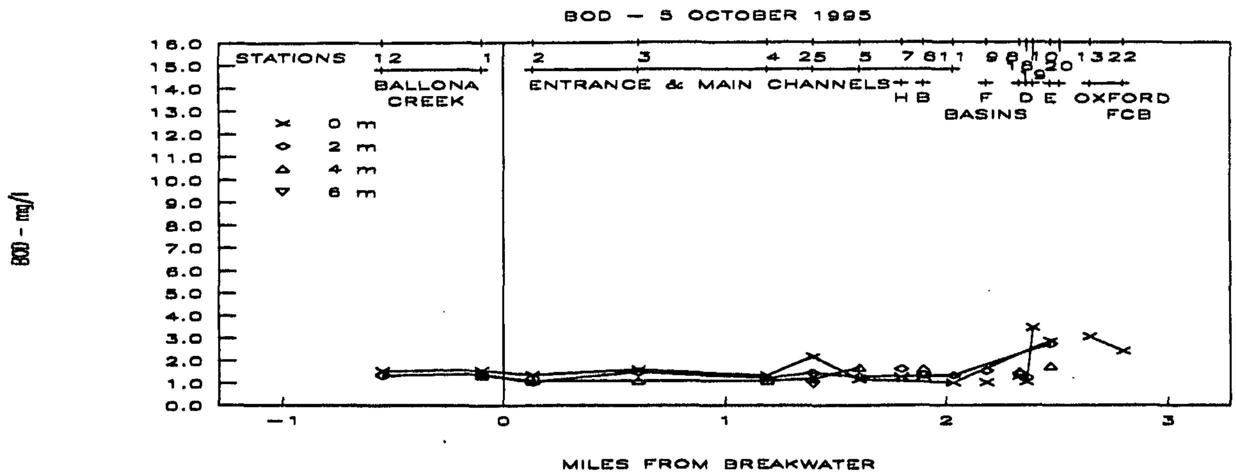


Figure VI.16. Five-day biochemical oxygen demand (mg/l), 5 October 1995.

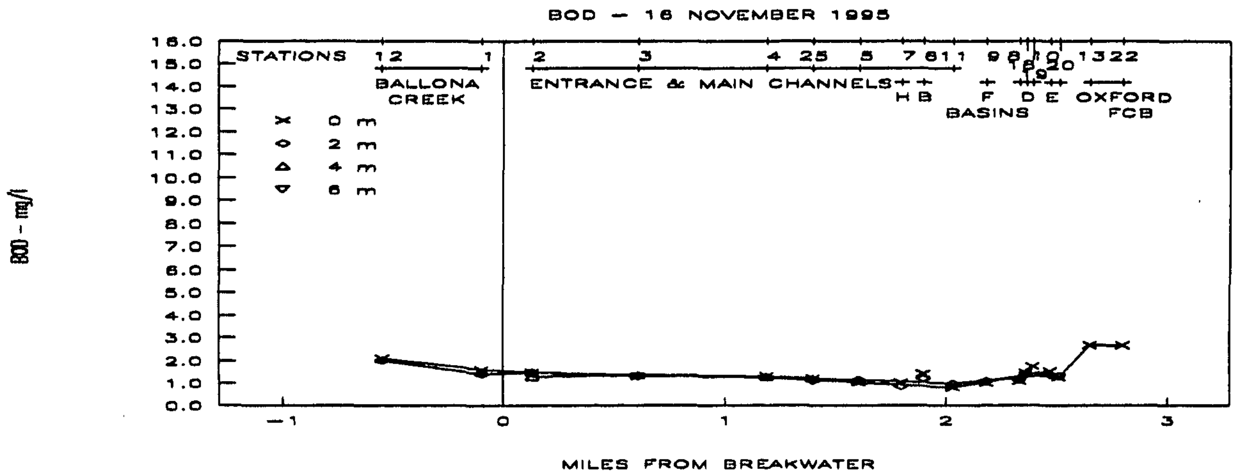


Figure VI.17. Five-day biochemical oxygen demand (mg/l), 16 November 1995.

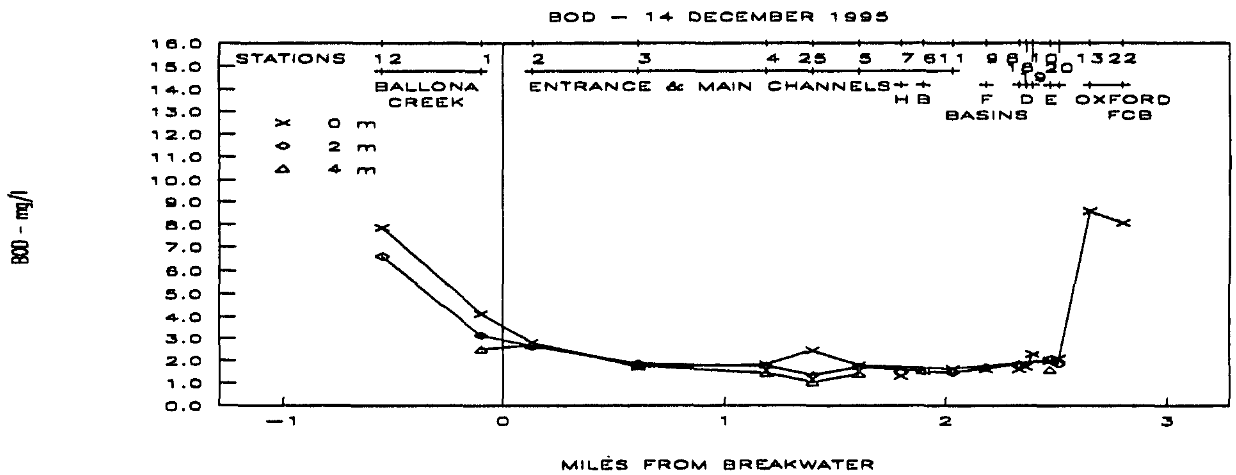


Figure VI.18. Five-day biochemical oxygen demand (mg/l), 14 December 1995.

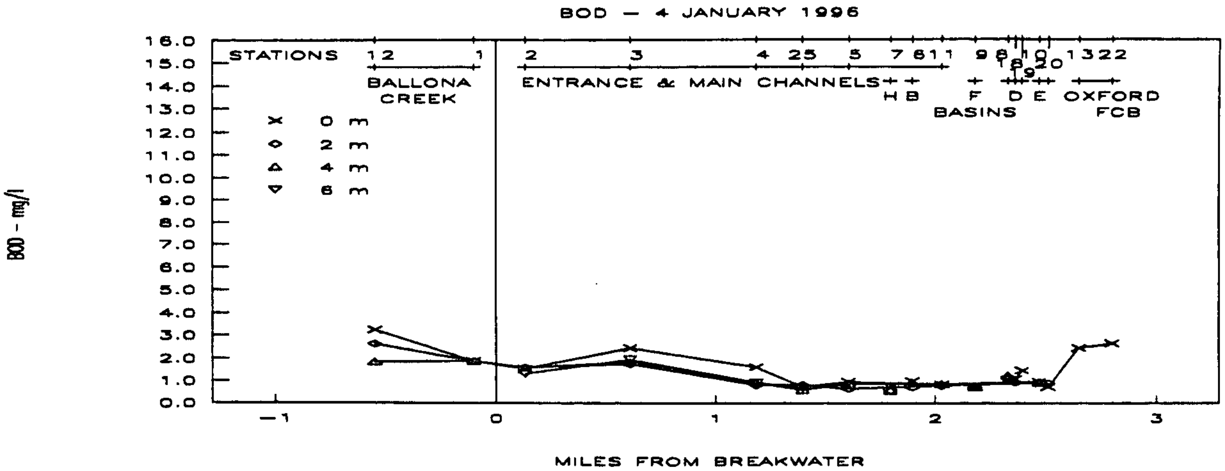


Figure VI.19. Five-day biochemical oxygen demand (mg/l), 4 January 1996.

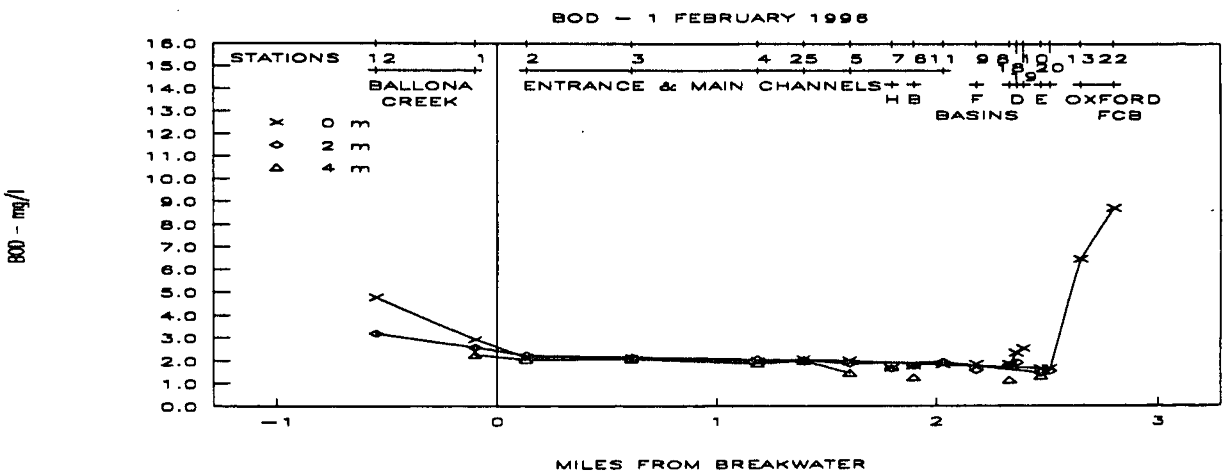


Figure VI.20. Five-day biochemical oxygen demand (mg/l), 1 February 1996.

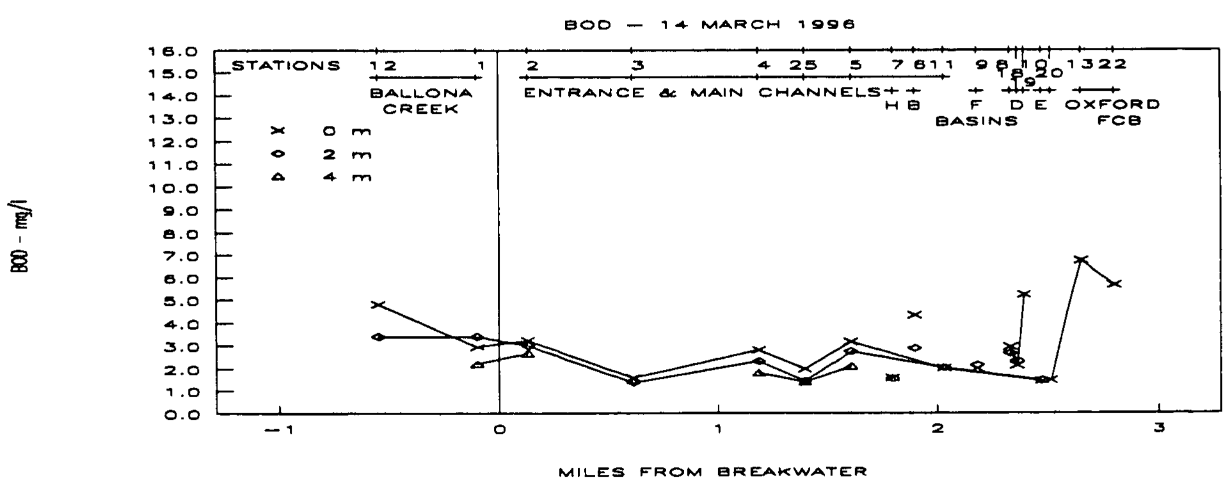


Figure VI.21. Five-day biochemical oxygen demand (mg/l), 14 March 1996.

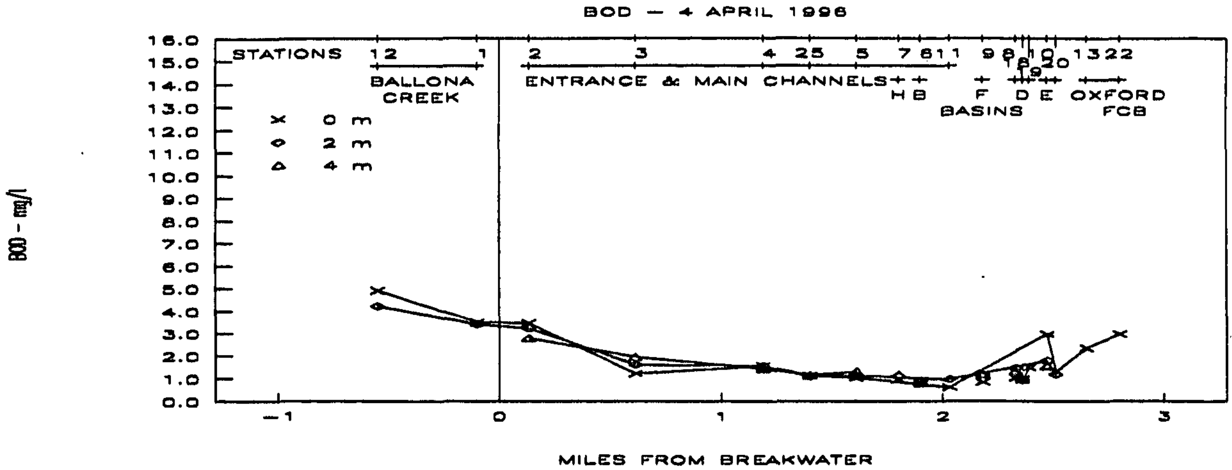


Figure VI.22. Five-day biochemical oxygen demand (mg/l), 4 April 1996.

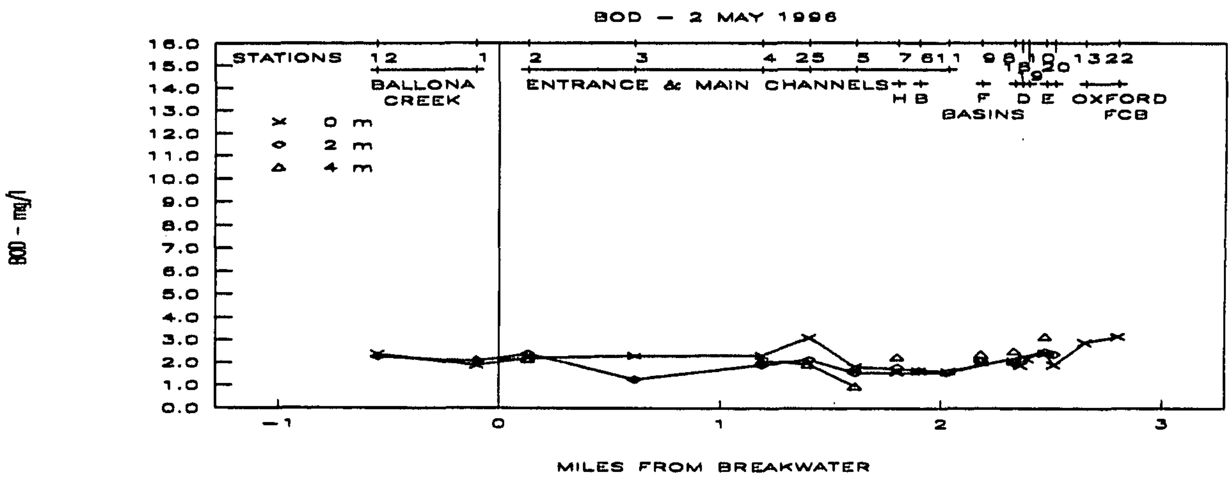


Figure VI.23. Five-day biochemical oxygen demand (mg/l), 2 May 1996.

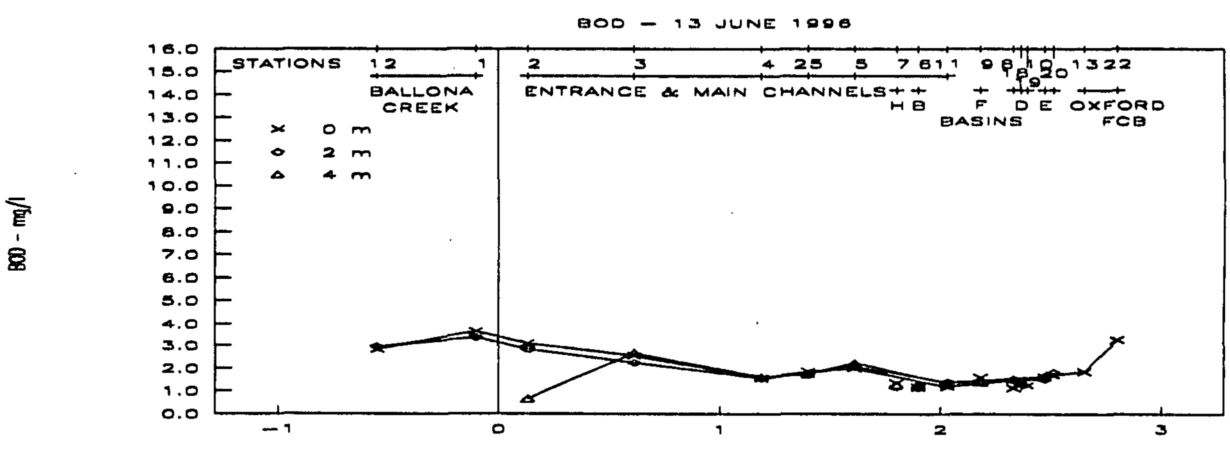


Figure VI.24.. Five-day biochemical oxygen demand (mg/l), 13 June 1996.

VII. BENTHIC FAUNA

INTRODUCTION

The benthic fauna consists of species living in or on the bottom sediments (the benthos). The benthic community is a very important component of the marina ecosystem because it serves as a major consumer of particulate organic matter and microbial organisms such as bacteria, protists and algae; in turn the benthic fauna provide food for the food web consisting of juvenile and adult bottom feeders and omnivores.

The Worms

Because the benthic sediments are largely fine grained, silty and sometimes unconsolidated, the marine habitat is most attractive to the polychaete annelid worms that have short reproductive cycles and are often tolerant of contaminants, low dissolved oxygen and to variations in temperature and salinity. Nematode round worms are the most opportunistic; they reproduce rapidly and more tolerant of lower salinities and disturbed environments. Although they occur in very large numbers in Ballona Creek (Stations 12 and 1) and at Station 2 in the entrance channel, and thus dominate the total numbers in the marina, they rarely occur at the normal salinities (chlorinities) in sediments in the rest of the marina. Oligochaete annelid worms also occasionally appear in large numbers in a few disturbed areas. Neither nematodes nor oligochaetes seem to be attractive to consumers.

Crustacean and Molluscan Species

Amphipod crustaceans and a few molluscan species are also frequently present, although the occurrences of mollusc species are sporadic and primarily occur at the mouth of Ballona Creek and the outer entrance channel. Factors influencing their incidence include the grain size of the sediment, the amount of ambient contamination, the volume and velocity of stormwater runoff and the force of storm waves that erode or deposit new sand in the entry. Newly deposited sediments are recolonized from adjacent populations or by invertebrate eggs and pelagic larvae that are carried into the marina on tides.

Dredging is a manmade event that can influence the distribution and diversity of species. The dredging in November and December 1994 removed some contaminated sediments and decreased the deposits along the breakwater and jetties, but subsequent storms in January and March 1995 deposited even more sediment than was removed, but fortunately it was relatively clean sand from Santa Monica Bay. The fauna was altered by these events, however, changing the dominant species in most cases.

PROCEDURES

Field Sampling

The benthic survey was conducted on 26 October 1995, the usual period for the Fall survey, although in the previous year the survey was conducted at the end of September because dredging was originally scheduled to begin in October. The benthic survey was conducted from the University of Southern California Research Vessel *Golden West* at Stations 1 through 12 and 25, using a Campbell grab, a modified Van Veen which samples 0.1 m^2 of bottom surface. The Reinecke box corer is a quantitatively more accurate sampler but requires a larger vessel which cannot work at the shallower marina stations.

Subsamples for determining grain size and chemical contaminants are taken from the surface and the remaining sample is screened through 1.0 and 0.5 mm mesh screens where larger grained sediments and debris are found, or through a 0.5 mm screen where sediments are primarily finer silts. Animals retained on the screens are rinsed with seawater into containers of seawater and ten percent formalin; seawater buffers the formalin. The animals are transferred to 70 percent ethanol in the laboratory and rough sorted until identification and enumeration by taxonomists. Numbers are multiplied by 10 to project the number of individuals per square meter of bottom sampled.

Species Identification and Data Analysis

After specimens are identified to the lowest possible taxon, numbers of species and individuals are determined, and species are ranked according to the most numerous at each station and in the entire marina. These lists can then be compared with those from previous reports (Soule and Oguri, 1977, 1980, 1985, 1986, 1987, 1988, 1990; Soule, Oguri and

Jones, 1991, 1992a, b, 1993; Soule, Oguri and Pieper, 1996).

The species diversity index (SDI) is computed by two methods, the Shannon-Wiener SDI (SWSDI) and the Gleason SDI (GSDI). The GSDI was used in the 1970s, and the SWSDI was added when studies were resumed in 1984; the GSDI tends to be more influenced, or biased, by large numbers of a single species than does the SWSDI. The species diversity concept has been widely used, but is sometimes overemphasized in specialized environments such as marinas and harbors.

RESULTS AND DISCUSSION

Complete data on the October 1995 survey are included in Appendix D, where species are listed according to taxonomic group, with the numbers of individuals of each taxon at each station given, as well as total numbers and the number of stations at which they occur.

There is a large data base for September or October surveys beginning in 1976 through 1978, and from 1984 through 1995 except for October 1993, when funding was not available. Stations 1 through 11 were established in 1976, and Stations 12 and 25 were added in 1989. Stations 13 and 22 in Oxford Basin are not included as they cannot be reached by vessel, and sometimes are only wetlands (exposed mudflats). Table VII.1 gives the numbers of species/numbers of individuals for all Fall surveys.

Population Density

The impacts of the extremely high rainfall runoff in the winter and spring of 1994-1995 and the deposition of new sediments at the creek mouth, the breakwater and the entrance channel jetties can be seen. Individuals can be swept out to sea in runoff during heavy rains and the substrate altered. The number of individuals per m^2 dropped at Station 12 from 253,900 in Fall 1994 to 111,700 in Fall 1995, and at Station 2 from 1,053,900 to 70,840. However, they increased at Station 1 from 10,800 to 54,650/m^2.

The mean number of individuals at Stations 1 through 11, including nematodes, was 15,705/m^2 in 1995 as compared with 102,308/m^2 in 1994, largely influenced by the reduction of nematode numbers, particularly at Station 2. Without nematodes, however,

Table VII.1. Numbers of benthic taxa or species/individuals per square meter in fall season.

Sta	28 Oct 1976	16 Sep 1977	21 Sep 1978	25 Oct 1984	18 Oct 1985	23 Oct 1986	22 Oct 1987	20 Oct 1988	12 Oct 1989	18 Oct 1990	17 Oct 1991	21 Oct 1992	29 Sept 1994	26 Oct 1995
1	60/17,180	31/29,210	35 / 1,340	60 / 6,800	38 / 5,490	55 /225,520	39 / 6,530	31 /11,550	25 / 1,640	38 /71,990	121 / 26,700	10 / 1,000	62 / 10,800	60 / 54,650
2	32/ 8,070	41/75,060	52 / 9,490	48 /12,260	38 / 6,190	*	39 / 3,840	74 /56,510	34 /76,100	54 /97,410	76 /310,060	30 / 9,110	41 /1,053,900	41 / 70,840
3	78/17,540	25/23,920	68 / 8,600	52 /12,270	51 / 9,690	79 / 38,830	50 /42,160	56 / 9,195	72 /24,230	69 /48,150	33 / 10,020	42 / 9,310	70 / 17,410	66 / 22,990
4	68/13,050	67/28,700	59 /13,370	43 / 9,750	32 / 5,820	37 / 4,820	44 / 5,980	33 / 3,040	37 / 2,760	37 / 9,070	40 / 11,050	55 /20,800	53 / 11,010	48 / 2,940
5	35/ 7,620	31/15,740	29 / 7,500	37 / 7,800	21 / 1,960	30 / 2,750	22 / 2,840	19 / 1,200	16 / 2,350	38 / 9,230	30 / 4,270	27 / 2,190	34 / 2,740	34 / 3,640
6	39/ 4,340	25/ 8,480	28 / 6,350	23 / 9,290	25 / 4,710	33 / 11,060	29 /11,510	24 /12,940	25 / 6,380	18 / 3,400	19 / 3,170	25 / 6,270	25 / 10,780	26 / 5,150
7	33/10,230	32/32,740	34 /15,550	31 /12,700	27 / 6,130	39 / 18,870	20 / 4,700	16 /14,740	26 / 4,590	23 /14,970	20 / 6,100	21 / 3,860	26 / 7,420	21 / 5,510
8	21/ 5,330	9/ 5,390	25 /14,730	19 / 4,090	29 / 7,240	35 / 14,950	21 / 3,040	16 / 1,990	13 / 2,740	29 /12,780	14 / 850	21 / 8,770	22 / 3,720	11 / 650
9	36/ 6,150	23/ 8,220	24 /11,690	21 / 2,420	22 / 7,220	18 / 11,150	12 / 1,890	15 / 2,460	12 / 780	18 / 3,860	19 / 2,220	18 / 2,320	15 / 1,200	15 / 1,510
10	25/ 7,560	11/ 2,540	30 / 8,490	21 / 6,870	36 /15,280	33 / 14,280	24 / 4,150	30 / 9,610	17 / 2,410	28 / 7,390	15 / 1,090	16 / 2,480	16 / 1,720	22 / 2,660
11	21/ 8,710	28/20,060	15 / 1,770	20 / 3,450	20 / 5,180	22 / 6,120	16 / 2,650	11 / 630	10 / 360	19 / 1,530	16 / 1,560	16 / 1,840	20 / 2,690	24 / 2,220
Mean Stations 1-11, with nematodes	41/ 9,616	29 /22,733	36 / 8,989	34 / 7,973	30 / 6,810	38 / 34,635	29 / 8,117	29 /11,260	26 /11,304	33 /25,435	37 / 34,281	25 / 6,177	35 / 102,308	34 / 15,705
Mean Stations 1-11, without nematodes	40/ 8,499	29 /16,655	36 / 8,946	34 / 7,555	30 / 6,031	37 / 20,480	28 / 5,241	29 /11,200	26 / 5,400	33 /12,074	36 / 7,144	25 / 5,830	35 / 13,784	33 / 8,665
12									21 /18,320	38 /33,330	82 /272,070	47 /20,580	51 /253,900	47 / 111,700
25									43 / 8,530	32 /22,550	46 / 12,170	51 /19,390	38 / 8,990	59 / 8,420
Mean all Stations with nematodes									27 /11,630	34 /25,820	41 / 50,872	29 / 8,302	36 /106,791	36 / 22,529
Mean all Stations without nematodes									27 / 6,828	34 /12,926	41 / 14,055	29 / 8,008	36 / 21,885**	36 / 11,725

* No sample was taken due to dredging.

** Count of 21,885 was erroneously listed last year as 31,885.

there was still a decrease from $13{,}784/m^2$ to $8{,}665/m^2$, indicating an impact. The mean for all stations, including Stations 12 and 25, in 1995, with nematodes, was $22{,}529/m^2$ as compared to $106{,}791/m^2$ in 1994. There was a decrease in numbers of individuals of other species, indicated by the decrease in the mean for all stations from 21,885 to $11{,}725/m^2$.

The mean number of individuals/m^2, including nematodes, for the 11 stations in 1994 were the highest seen in all marina surveys; without nematodes numbers were exceeded only in 1977 and 1986. When Stations 12 and 25 are included, mean numbers were far higher than in the years since 1989, even when nematodes were not included.

Some stations experienced large increases in numbers of individuals while others experienced large decreases. Station 12, in Ballona Creek at the foot bridge, decreased to 42.3 percent of the 1994 total, while the number of individuals increased five fold at Station 1, at the mouth of the creek. At Station 2, the population decreased to only 6.7 percent of the 1994 numbers. Populations at Stations 3, 5, 9 and 10 increased slightly over 1994 numbers, and those of Station 25 and 11 decreased slightly, while those at Stations 4, 6, 7 and 8 decreased by large amounts.

Figure VII.1 illustrates the variations in the total number of benthic individuals in millions, for the annual surveys conducted, comparing the numbers with and without nematode worms. The fluctuations in numbers without nematodes are much less extreme than those with nematodes included. Patterns are not easily discernible; there were low population years in cooler weather in the 1970s, and even lower in El Niño years in the mid-1980s. There were very low numbers in the years that were preceded by dry years such as 1984, 1987, 1988 and 1989 but an increase in 1990 after a dry year and decreases in 1992 and 1995 following wetter years. Numbers, excepting nematodes, were highest in 1990.

Number of Species

The mean number of species for all stations with or without nematodes did not change between 1994 and 1995, although there were minor changes at some stations. It must be noted that the nematodes constitute a very numerous group about which little is known; expert taxonomists have not described and named local marine species and so they

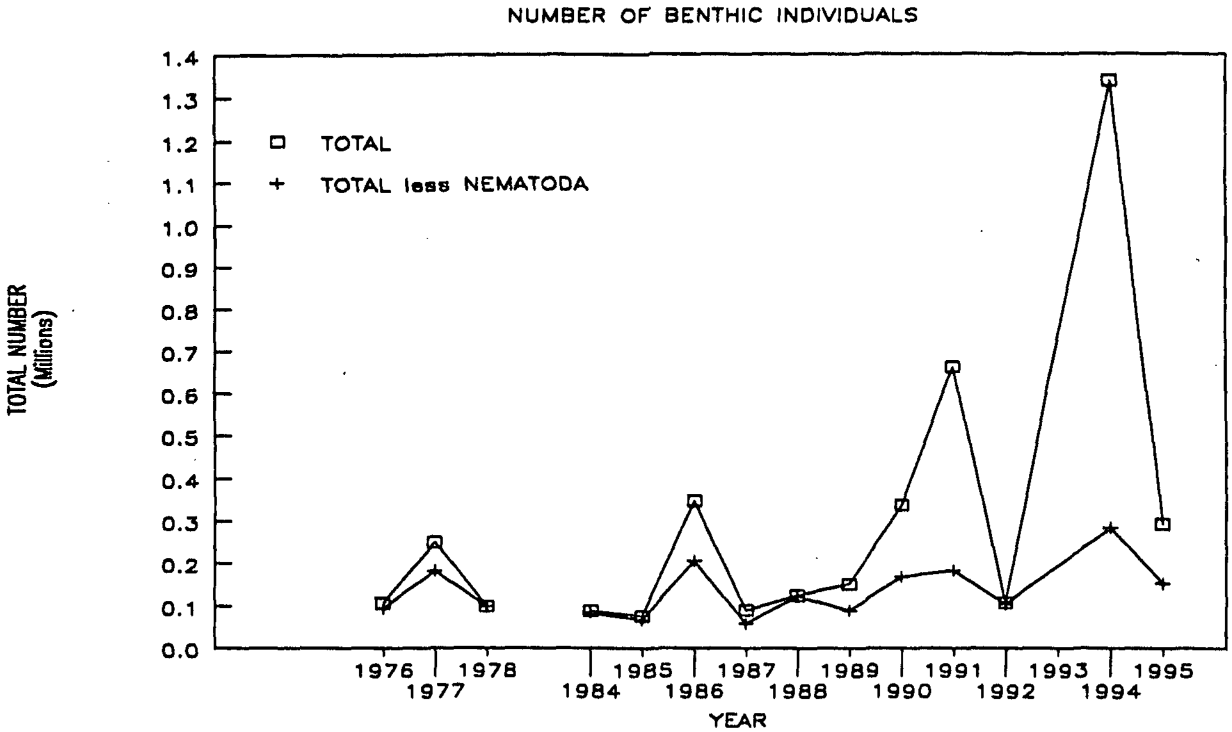


Figure VII.1. Total number of benthic individuals (in millions) by year, with and without nematodes.

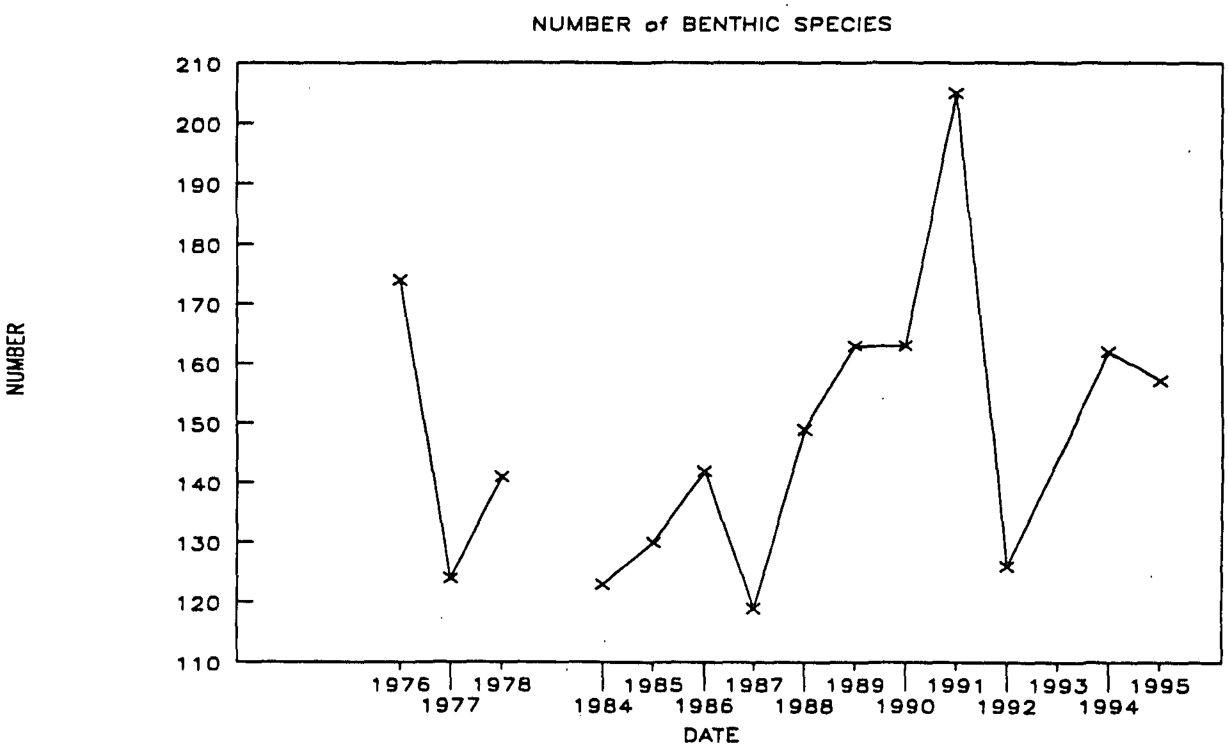


Figure VII.2. Total number of benthic species by year. Stations 12 and 25 were added in 1989.

are counted as one species or taxon. However, this may cause undercounting the number of species if there are actually several species involved.

Figure VII.2 illustrates the total number of species by year. By far the best year was 1991 in that regard, but that was followed by a large decline in 1992 and a recovery in 1994.

There was no change in the number of species/m^2 between 1994 and 1995 at Stations 2, 5, and 9, and slight changes at Stations 1 and 6. The number of species/m^2 decreased at Station 12. 3, 4, and 7, and declined 50 percent at Station 8, the most serious decline coupled with a large decline in population. There were increases in number of species/m^2 at Stations 10, 11 and 25. It is possible that the removal of highly contaminated sediments adjacent to Station 10 may have improved that area and Station 11, although Station 10 had much higher populations through 1990 than it does now, while Station 11 has been improving slowly since 1988 when the area was altered by installation of new slips and increasing occupancy of larger vessels.

Figures VII.3, 4 and 5 illustrate the variation in numbers of species for the years surveyed. It can be seen that Ballona Creek and the entrance channel tend to have the extremes, with especially high numbers in 1991 (Figure VII.3). Station 3 has had a more stable and fairly high number of species, but that station is more heavily influenced by construction or cleanup activities in Ballona Lagoon and the Venice Canals than by the sand bars at the entrance of the marina.

The number of benthic species declines at the inner end of the entrance channel at Station 4 and at the outer end of the main channel, at Stations 25 and 5, coupled with those in the outer Basins, B and H. Station 4 appeared to be in better condition in the 1970s (Figure VII.5) before so many vessels were located at the administration docks, now handling the County Sheriff's Harbor Patrol, the County Fire Department's Life Guards and the U.S. Coast Guard's boats, plus occasional derelict or damaged vessels.

Conditions are most often poor at Station 11, at the end of the main channel, and at

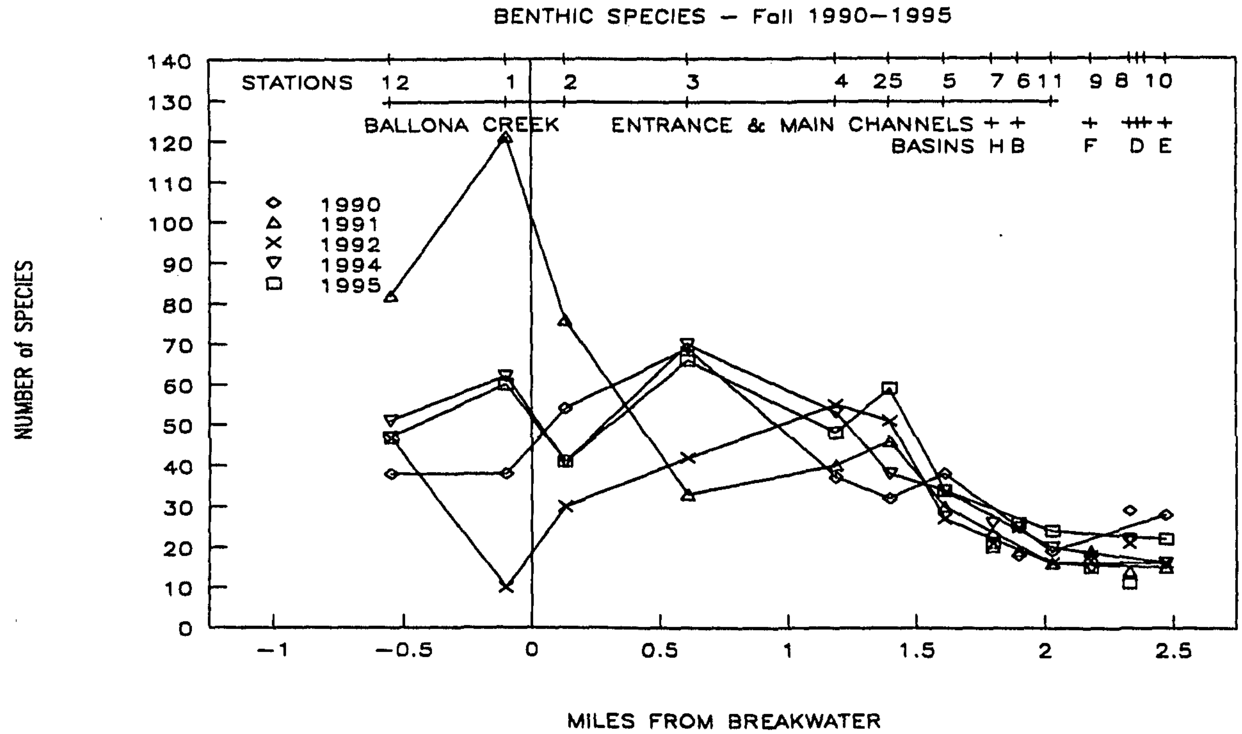


Figure VII.3. Number of benthic species/m² by station in fall months, 1990-1995.

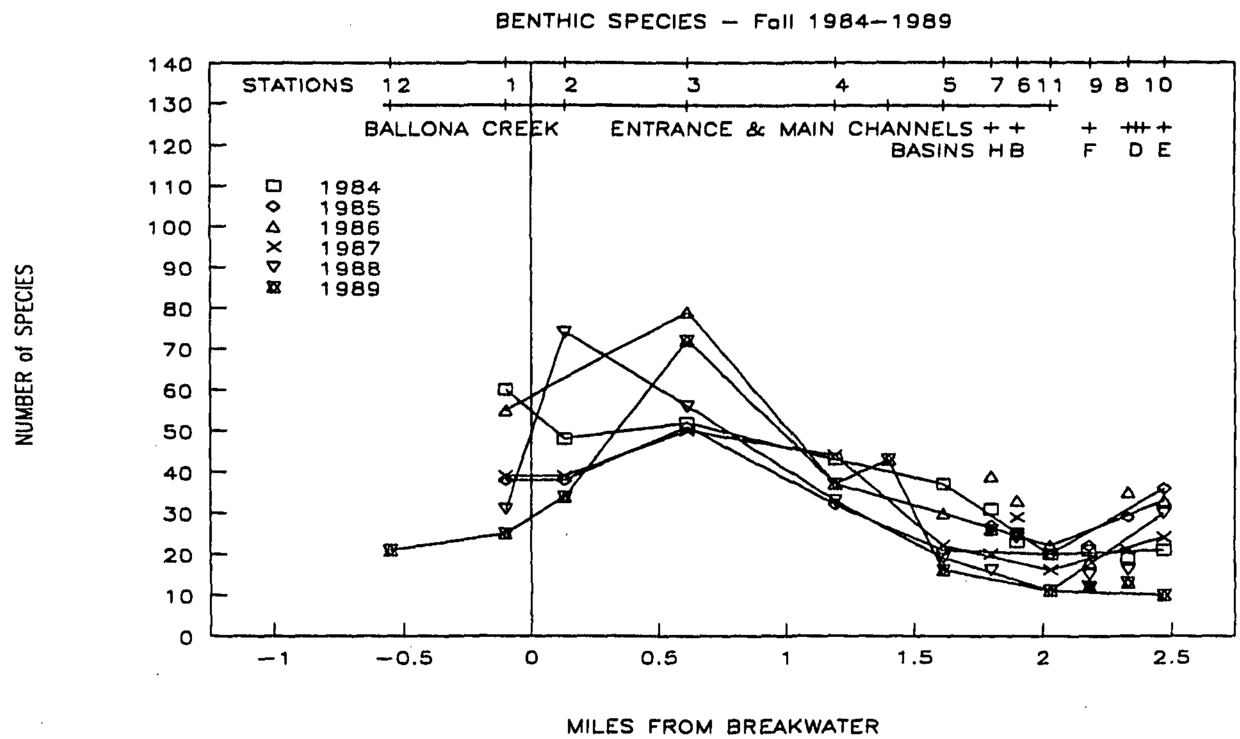


Figure VII.4. Number of benthic species/m² by station in fall months, 1984-1989.

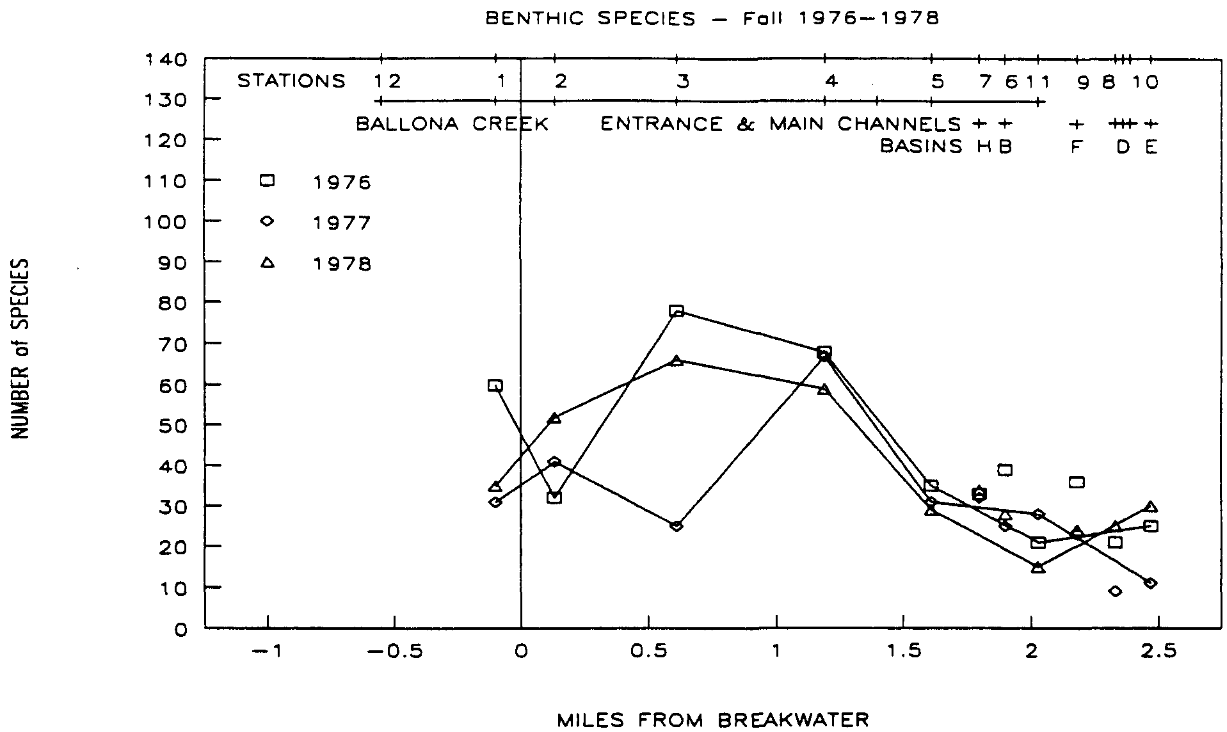


Figure VII.5. Number of benthic species/m² station in fall months, 1976-1978.

Basins D, E, and F, where circulation is the lowest and deposition of contaminated fine sediments most likely. Station 8, near the beach in Basin D, had the best numbers of species in 1986 and 1990, and the worst in 1977 and 1995, for unknown reasons. Inspection of Table VII.1 indicates that more stations in the inner marina had their lowest numbers of species in the 1988-1992 period, in part when Aroclors were found in the marina, but also when the sand bars were accumulating at the marina entrance, which decreases the already poor circulation in the inner marina.

Species Diversity

The range in species diversity as evaluated by the Shannon Wiener Species Diversity Index (SWSDI) in October 1995 was from 1.17 at Stations 2 and 7 to 2.91 at Station 4. This can be compared to the wider range in 1994, a low of 0.48 at Station 2 to a high of 2.83 at Station 4 (Table VII.2).

Station 2 decreased in diversity rapidly after scoring a 2.40 in 1987, reaching a low of 0.44 in 1991; it recovered to 1.75 in 1992 and then dropped to 0.48 in 1994. The 1995 score of 1.17 is thus an improvement over 1994, although it was tied with Station 7 as the lowest in 1995. The effects at Station 2 may be associated with the accumulations of contaminated sediments behind the sandbars that have occluded the entrance channel. There was a major dredging in 1987, followed by extensive accumulation in subsequent years. The minor knockdown dredging in 1992 failed to clear the buildup. The larger dredging in November and December 1994 may have resulted in better diversity at Station 2, since it did not receive the brunt of extreme stormwater runoff and storm related new sand deposition that affected Station 1 at the mouth of Ballona Creek.

In all, Stations 12, 1, 3, 5, 7, 8 and 11 experienced large or small declines in SWSDI in 1995, whereas diversity increased at Stations 2, 4, 25, 6, 9 and 10. There are undoubtedly a number of factors involved, with each site being affected differently.

Although all the changes do not relate well to the pollution scores (Chapter IV) for trace metals or chlorinated hydrocarbons, effects of particular parameters may be indicated. The slight change at Station 11 should probably be regarded as insignificant, but otherwise declines are probably mostly related to runoff from the extremely wet winter and storms in 1994-1995, and concomitant changes in grain size. Stations 12 and 1 are obviously so related. Station 8 had a large increase in fine sediments, with their associated burden of trace metals and a decrease in diversity. This station also has bacterial problems that may be associated with runoff from the beach and adjacent parking lots. Runoff also includes bird fecal material since that is a popular resting area for gulls and shore birds.

The trends in the Gleason SDI were similar to those with the Shannon Wiener SDI except at Stations 9 and 11, where they were reversed. The decrease at Station 9 in the GSDI was small, as was the decrease in SWSDI at Station 11.

Figures VII.6, 7 and 8 compare the changes in SWSDI throughout the marina in the 1990s, 1980s and 1970s, as monitored. Stations 12 and 25 were added in 1989. The greatest variations from year to year were at Station 1, with Station 3 showing considerable variation in the 1980s. Station 2 data indicate the recent problems in 1989, 1991 and 1994 in a cluster of low values, lower than in the 1970s or other 1980s surveys, and lower than at

Table VII.2. Shannon-Wiener (SWI) and Gleason(GI) Species Diversity Indices, fall seasons.

	25 Oct 84		18 Oct 85		23 Oct 86		22 Oct 87		20 Oct 88		12 Oct 89		18 Oct 90		17 Oct 91		21 Oct 92		29 Sept 94		26 Oct 95	
	SWI	GI	SWI	GI	SWI	GI	SWI	GI	SWI	GI	SWI	GI	SWI	GI	SWI	GI	SWI	GI	SWI	GI	SWI	GI
Station																						
1	3.09	5.30	1.71	4.30	1.49	4.38	2.41	4.33	0.88	3.21	1.76	3.24	0.82	3.31	2.34	11.77	1.97	1.30	1.76	6.45	1.51	5.41
2	2.25	4.02	2.19	4.81	*		2.40	4.60	2.02	6.67	0.58	2.94	1.19	4.61	0.44	5.93	1.75	3.18	0.48	2.88	1.17	3.58
3	2.44	4.35	2.78	5.45	1.86	7.42	1.46	4.60	2.95	6.03	2.84	7.03	1.90	6.31	2.11	3.47	2.10	4.49	2.78	7.07	1.82	6.47
4	2.20	3.66	2.10	3.58	2.48	4.25	2.76	4.94	2.55	3.99	2.99	4.54	2.15	3.95	2.25	4.19	1.51	5.43	2.83	5.59	2.91	5.89
5	2.25	3.20	2.13	2.64	1.90	3.66	2.04	2.64	2.23	2.54	1.42	1.93	2.23	4.05	2.17	3.47	2.34	3.38	2.75	4.17	2.23	4.02
6	1.96	1.92	2.29	2.84	2.27	3.44	1.22	2.99	1.43	2.43	1.60	2.74	2.33	2.09	2.13	2.23	2.23	2.74	1.62	2.58	2.16	2.93
7	1.87	2.55	1.67	2.98	2.12	3.86	1.96	2.25	0.76	1.56	2.18	2.97	1.42	2.29	1.66	2.18	2.04	2.42	1.41	2.81	1.17	2.32
8	1.81	1.70	1.89	3.15	2.30	3.54	1.76	2.49	1.61	1.97	1.10	1.52	1.98	2.96	2.02	1.93	1.95	2.20	2.1	2.55	1.67	1.54
9	1.83	1.98	1.06	2.36	1.50	1.82	1.19	1.46	1.70	1.79	1.88	1.65	1.62	2.06	2.09	2.34	1.74	2.19	1.53	1.97	1.90	1.91
10	1.82	1.80	2.19	3.36	2.24	3.34	2.10	2.76	2.22	3.16	1.58	2.06	2.01	3.03	2.07	2.00	1.69	1.92	2.06	2.01	2.23	2.66
11	2.04	1.82	1.39	2.22	1.91	2.41	1.39	1.90	1.90	1.56	1.99	1.53	2.13	2.46	1.76	2.04	2.04	2.00	2.18	2.41	2.16	2.98
Mean																						
1-1	2.14	2.93	1.94	3.42	2.00	3.81	1.88	2.90	1.88	3.17	1.81	2.92	1.81	3.37	1.91	3.79	1.94	2.84	1.96	3.68	1.90	3.61
12											0.55	2.04	1.65	3.56	1.32	6.47	1.56	4.63	1.7	4.02	1.32	3.96
25											2.37	4.64	2.06	3.09	2.29	4.78	2.16	5.06	2.2	4.06	2.76	6.42
Mean all stations											1.76	2.99	1.81	3.37	1.90	4.07	1.93	3.15	1.96	3.74	1.92	3.85

* No sample was taken due to dredging.

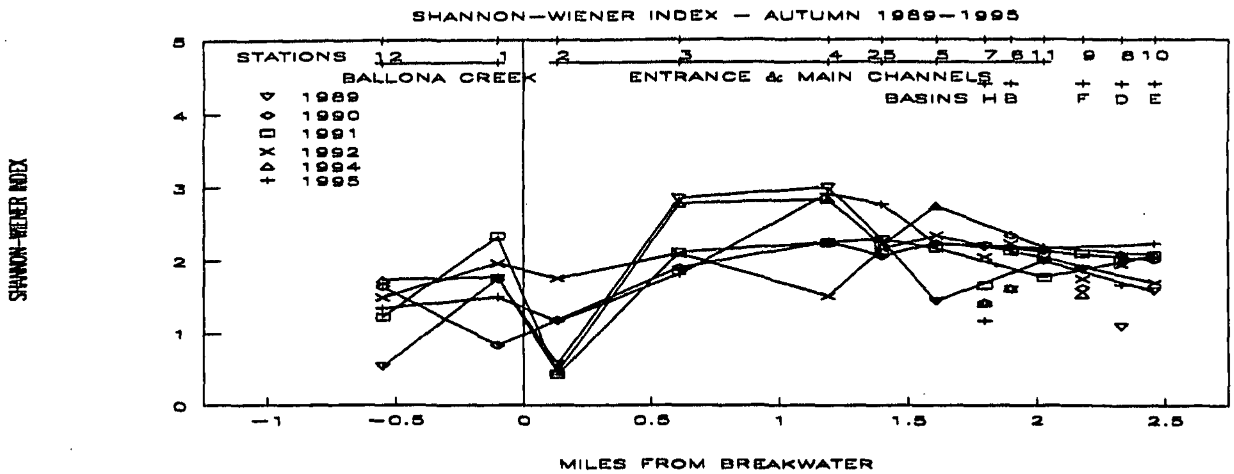


Figure VII.6. Shannon-Wiener Species Diversity Index, autumn 1989-1995.

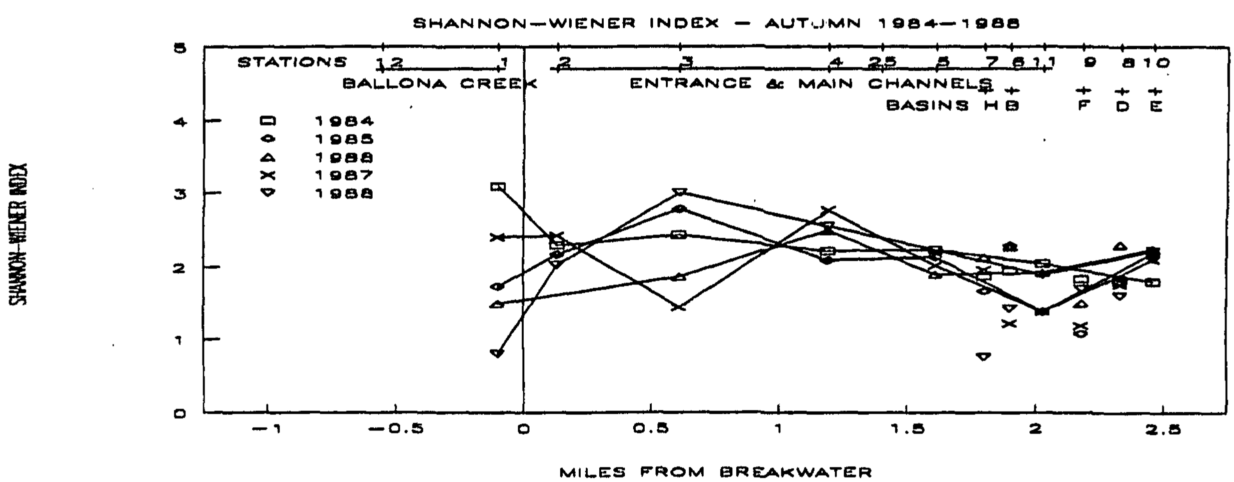


Figure VII.7. Shannon-Wiener Species Diversity Index, autumn 1984-1988.

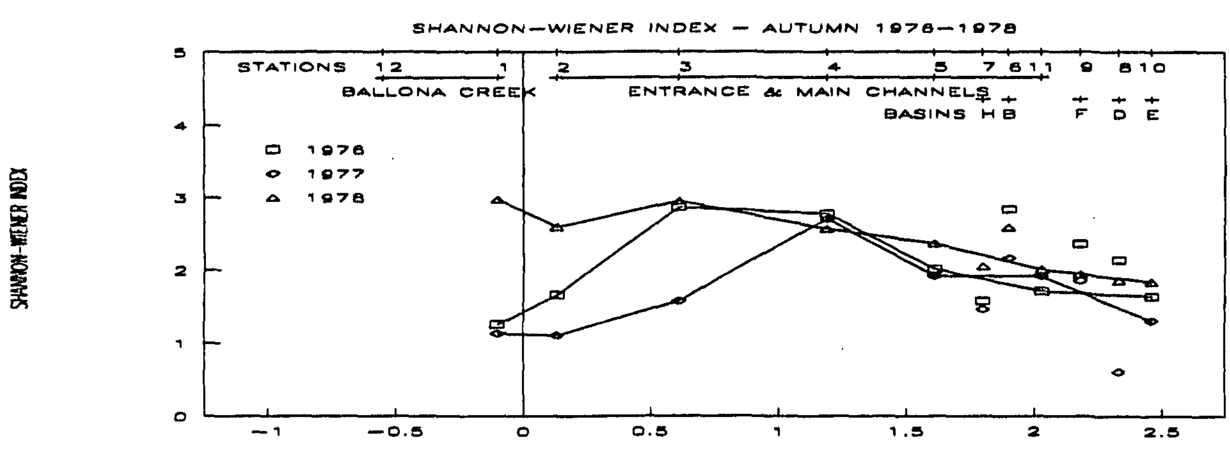


Figure VII.8. Shannon-Wiener Species Diversity Index, autumn 1976-1978.

some of the inner harbor stations.

Outliers, those stations on the graphs that fall outside the general trend lines and are mostly located in the basins, indicate sites where diversity was poor (Figures VII.6, 7, 8). This was apparent at Stations 7 and 8 in 1989, although conditions were not as bad as at Stations 12 and 2. In 1988, Station 7 had diversity almost as low as Station 1. In 1976, outliers show that Stations 6, 8, and 9 had good diversity, while Station 8 had poor diversity in 1978. The causes may be associated at various sites with rainfall runoff, salinity and changes in sediment grain size, with fluctuations in trace metals and chlorinated hydrocarbons and/or other factors.

Spatial Distribution and Dominant Species/Taxa

The Nematoda (round worms or thread worms) dominated the fauna again in October 1995, with 47.95 percent of the total fauna (Table VII.3). This, however, represented a considerable reduction on the numbers of nematodes from 1994, when they comprised 79.58 percent of the fauna (Soule et al., 1996). Nematodes occurred in large numbers only in Ballona Creek at Stations 12 and 1 and at Station 2, with a few at Stations 3 and 4 in 1994. The reductions of about 50 percent occurred at Stations 12 and 2, but increased at Station 1, perhaps because of the deposition of new sediment to colonize. A very few were found at Station 6 in 1995.

Because of the extreme dominance of nematodes in 1994 due to the overwhelming numbers at a few stations, data were calculated on dominance with and without nematodes. The second most dominant group was the capitellid polychaete annelid worms *Mediomastus*, which includes several species that cannot be distinguished in the surveys, but have been in the past variously identified as *Mediomastus ambiseta, M. californiensis* or *Capitita ambiseta*. In 1994, they comprised 6.56 percent of the fauna, or 32.12 percent if the nematodes are excluded. In 1995, this percentage increased to 19.21 percent, or 36.9 percent if nematodes are excluded. Complete benthic taxonomic classifications, with prior identifications, are presented in Appendix D.

Pseudopolydora paucibranchiata, a spionid polychaete annelid worm, had the next

Table VII.3. Dominant benthic species/taxa ranked by percentage of total fauna, with and without nematodes, 26 October 1995.

Species/Taxa - counts/m² (Stations)	1	2	3	4	5	6	7	8	9	10	11	12	25	TOTAL NOs	PERCENTAGE WITH NEMATODES	PERCENTAGE WITHOUT NEMATODES	OCCURR-ENCES
Nematoda, unid.	29400	48000				50						63000		140450	47.95%		4
Mediomastus spp.	320	3320	14370	610	90	150	200	40	160	200	140	34270	2390	56260	19.21%	36.91%	13
Pseudopolydora paucibranchiata	15610	40		60	1560	1030	50	40	110	370	60	60	80	19070	6.51%	12.51%	12
Oligochaeta, unid.		13160	230	10		30	20			110	10		10	13580	4.64%	8.91%	8
Aphelochaeta sp.			30	250		1010	4050	10	700	10	820		1100	7980	2.72%	5.24%	9
Leitoscoloplos pugettensis		40	810	440	440	640	70	360	50	320	160	160	280	3770	1.29%	2.47%	12
Dorvillea (*Shistomeringos*) *longicornis*	50	200	470			110	150		30	140		1600	80	2830	0.97%	1.86%	9
Oxyurostylis pacifica	120	1680		170	10							700	70	2750	0.94%	1.80%	6
Polyophthalmus pictus	2060	120	10	20								450		2660	0.91%	1.75%	5
Prionospio heterobranchia	230	160	580	220	110	30	50	20			10	520	440	2370	0.81%	1.55%	11
Prionospio lighti		20	510	10					10	30		1290	400	2270	0.78%	1.49%	7
Micrura sp.			250	40			10		50		10	1890	10	2260	0.77%	1.48%	7
Notomastus sp.	30		340	10	10							1840		2230	0.76%	1.46%	5
Laevicardium substriatum	100	680	210	10	10							910	30	1950	0.67%	1.28%	7
Tagelus subteres	290	1040	60	130	10							20	340	1890	0.65%	1.24%	7
Mediomastus californiensis			1200				40						580	1820	0.62%	1.19%	3
Amphideutopus oculatus	240		1360	40	30								120	1790	0.61%	1.17%	5
Armandia brevis	640	520	110									480		1750	0.60%	1.15%	4
Grandidierella japonica		80		10	160	1380				30	10	10	20	1700	0.58%	1.12%	8
Mayerella banksia	170	120	170	180	20	50		30		30	30	650	110	1560	0.53%	1.02%	11
Paranemertes californica	40	60	70	10								1240	20	1440	0.49%	0.94%	6
Errano (*Lumbrineris*) *lagunae*			90	40	10		200	30	100		130		810	1410	0.48%	0.93%	8
Spio maculata	1320													1320	0.45%	0.87%	1
Rudilemboides stenopropodus	470	30	540	10	80		30				20	70	40	1290	0.44%	0.85%	9
Euchone limnicola			40	20	170	50	490	20	170		210		100	1270	0.43%	0.83%	9
Streblospio benedicti								40		950	10		200	1200	0.41%	0.79%	4
Protodorvillea gracilis	1150													1150	0.39%	0.75%	1
Lumbrineris sp.		80		60	390	80		50		40	20	90		810	0.28%	0.53%	8
Exogone lourei	40	180	80	180		10	10			20	10	130	120	780	0.27%	0.51%	10
Anoropallene palpida												750		750	0.26%	0.49%	1
Bathyleberis sp.		360	40	20	20								290	730	0.25%	0.48%	5
Caulleriella alata	600		10											610	0:21%	0.40%	2
Cirriformia tentaculata				10	80		30		50		380	10	30	590	0.20%	0.39%	7
Scoloplos acmeceps	130	40	70		20	200				20	20		20	520	0.18%	0.34%	8
Leporimetis obesa	200	10	30	20								150	40	450	0.15%	0.30%	6
Zeuxo normani	20	200	20		140	70								450	0.15%	0.30%	5
Scolelepis occidentalis			150	20	20	20						210	10	430	0.15%	0.28%	6
Capitella capitata	60	200								50		80	10	400	0.14%	0.26%	5
Apoprionospio pygmaea	320			20								10	20	370	0.13%	0.24%	4
Tubulanus polymorphus	40		180	20							10	10	50	310	0.11%	0.20%	6

Table VII.4. Dominant benthic species/taxa ranked on number of station occurrences, 26 October 1995.

Stations Species/Taxa - counts/m²	1	2	3	4	5	6	7	8	9	10	11	12	25	TOTAL NOs	OCCURR-ENCES
Mediomastus spp.	320	3320	14370	610	90	150	200	40	160	200	140	34270	2390	56260	13
Pseudopolydora paucibranchiata	15610	40		60	1560	1030	50	40	110	370	60	60	80	19070	12
Leitoscoloplos pugettensis		40	810	440	440	640	70	360	50	320	160	160	280	3770	12
Prionospio heterobranchia	230	160	580	220	110	30	50	20			10	520	440	2370	11
Mayerella banksia	170	120	170	180	20	50		30		30	30	650	110	1560	11
Exogone lourei	40	180	80	180		10	10			20	10	130	120	780	10
Aphelochaeta sp. (cf. *Tharyx parvus*)			30	250		1010	4050	10	700	10	820		1100	7980	9
Dorvillea (*Shistomeringos*) *longicornis*	50	200	470			110	150		30	140		1600	80	2830	9
Rudilemboides stenopropodus	470	30	540	10	80		30				20	70	40	1290	9
Euchone limnicola			40	20	170	50	490	20	170		210		100	1270	9
Oligochaeta, unid.		13160	230	10		30	20			110	10		10	13580	8
Grandidierella japonica		80		10	160	1380				30	10	10	20	1700	8
Errano (*Lumbrineris*) *lagunae*			90	40	10		200	30	100		130		810	1410	8
Lumbrineris sp.		80		60	390	80		50		40	20	90		810	8
Scoloplos acmeceps	130	40	70		20	200				20	20		20	520	8
Prionospio lighti		20	510	10					10	30		1290	400	2270	7
Micrura sp.			250	40			10		50		10	1890	10	2260	7
Laevicardium substriatum	100	680	210	10	10							910	30	1950	7
Tagelus subteres	290	1040	60	130	10							20	340	1890	7
Cirriformia tentaculata				10	80		30		50		380	10	30	590	7
Oxyurostylis pacifica	120	1680		170	10							700	70	2750	6
Paranemertes californica	40	60	70	10								1240	20	1440	6
Leporimetis obesa	200	10	30	20								150	40	450	6
Scolelepis occidentalis			150	20	20	20						210	10	430	6
Tubulanus polymorphus	40		180	20							10	10	50	310	6
Deltamysis sp. *A*					20		40		20	40	100		10	230	6
Nephtys caecoides				30		50	20		20		10		40	170	6
Spiophanes missionensis	10		10		10				10		20		20	80	6
Polyophthalmus pictus	2060	120	10	20								450		2660	5
Notomastus sp.	30		340	10	10							1840		2230	5
Amphideutopus oculatus	240		1360	40	30								120	1790	5
Bathyleberis sp.		360	40	20	20								290	730	5
Zeuxo normani	20	200	20		140	70								450	5
Capitella capitata	60	200								50		80	10	400	5
Acteocina inculta			10			50			20			110	20	210	5
Alpheus sp.					10				10		10	140	10	180	5
Corophium acherusicum		50	20	10	60							10		150	5
Clevelandia ios			10		10		10					10	10	50	5
Nematoda, unid.	29400	48000				50						63000		140450	4

highest percentage, with 6.51 percent of the total individuals, and in fourth place were the Oligochaeta (meaning "other bristled"), which are related to terrestrial earthworms in lacking the many bristled appendages found in polychaetes ("many bristled"). The marine oligochaetes, like the nematodes, have not been studied to distinguish whether one or more species not yet described are present. They were most prevalent at Station 12 and 2 in 1994, but disappeared from Station 12 in 1995, leaving a substantial population at Station 2.

There were fewer representatives of phyla other than nematodes and annelids in the top twenty or so taxa in 1995. Molluscan species are usually confined to Ballona Creek and the outer marina, but in 1995 there were fewer individuals of the bivalves *Laevicardium substratum, Macoma nasuta* and *Tellina* spp. than in 1994. In addition, there were far fewer of the crustaceans, including the cummacean *Oxyurostylus pacifica*, and the gammarids *Amphideutopus oculatus* and *Grandidierella japonica*. The nemertean worm *Micrura* sp. decreased in the marina, but *Paranemertes californica* increased (Appendix D).

Ranking the species according to their number of occurrences at stations in the marina (Table VII.4) provides a different picture of the fauna. The nematodes, which ranked first in total numbers occurred in only four of 13 stations, down from five in 1994, and the oligochaetes which ranked fourth ranking in total numbers occurred at only eight of 13 stations.

The polychaetes *Mediomastus* spp. and *Pseudopolydora paucibranchiata* usually occur at all stations, although the latter was missing at Station 3 in 1995, and *Leitoscoloplos pugettensis* was missing at Station 1. The exceptions to the dominance of polychaetes within the top ten taxa were the crustacean caprellid *Mayerella banksia*, which was present at 11 of 13 stations and the gammarid *Rudilemboides stenopropodus*, present at nine of 13 stations.

<u>Station Characteristics</u>

The dominant species at each station are considered below in the context of the various physical and chemical parameters measured. Proximity to the bay is linked with normal sea salinities most of the year, but to large amounts of freshwater and pollutants that occasionally inundate Stations 12 and 1, and to some extent, Station 2.

Station 12

Located just seaward of the Pacific Avenue foot bridge, the Ballona Creek station had a moderate ranking for trace metal and nonmetallic contaminants and the highest ranking by far for pesticides, mostly Chlordane, and chlorinated hydrocarbons in both 1994 and 1995. It was the only station where Aroclor was found in 1995. The percentage of the finest grain sizes decreased from 46.5 to 22.7 percent following the extreme rainfall runoff in the winter of 1994-1995 and a dry summer season.

The dominant species or higher taxa in 1994 were as follows: Nematoda (possibly one or more species), 51.6 percent; the polychaetes *Mediomastus* spp (spp. means several species, unidentifiable), 24.5 percent; Oligochaeta (possibly one or more species), 3.5 percent; the polychaete *Capitella capitata*, 2.8 percent; the bivalve *Tagelus californianus*, 2.4 percent; and the sand dwelling polychaete *Neanthes arenaceodentata*, 2.3 percent. The dominant 1995 species were polychaetes except for the nemertean worm *Micrura*, as shown below:

Species/Taxa	Percent
Nematoda, unid.	56.40
Mediomastus spp.	30.68
Micrura sp.	1.69
Notomastus sp.	1.65
Dorvillea longicornis, formerly *Schistomeringos longicornis*	1.43
Prionospios lighti	1.15

Station 1.

Located midway between the end of the south jetty and the terminal breakwater, Station 1 is most strongly influenced by tidal action, oceanic storms and runoff. It had the lowest score in 1995 for selected trace metal and nonmetallic contaminants, but it ranked high in pesticides and chlorinated hydrocarbons, as might be expected downstream from Station 12. The finest grained sediments decreased from 34.5 percent in 1994 to 7.7

percent in 1995, while the coarse fractions (25 and 35 mesh screen), indicating sands, increased from 0.30 percent each in 1994 to 11.0 and 14.0 percent respectively in 1995.

The dominant species/taxa in 1994 were more diverse in higher taxa than they were in 1995, as follows: Nematoda, 58.6 percent; the crustacean cumacean *Oxyurostylus pacifica*, 14.4 percent; and the polychaetes *Mediomastus* spp., 6.3 percent; *Armandia brevis*, 4.8 percent; *Polydora nuchalis*, 2.3 percent and *Apoprionospio pygmaea*, 1.0 percent.

In 1995, Nematoda and polychaetes were the dominant species, as follows:

Species/Taxa	Percent
Nematoda	53.80
Pseudopolydora paucibranchiata	28.56
Polyophthalmus pictus	3.77
Spio maculata	2.42
Protodorvillea gracilis	2.10
Armandia brevis	1.17

Station 2

Located between the ends of the entrance channel jetties, Station 2 represents a shoaling area where contaminated sediments from the marina can accumulate behind the sandbars. The sediments there showed a decrease in 1995 of the coarse fractions and the finest <200 fraction but a small increase in the next finest fraction of 200 screen mesh. The trace metal and nonmetallic contaminant ranking decreased somewhat to the medium low category from Fall 1994 to Fall 1995, down from medium high in April 1994, indicating that it is better flushed since the November-December 1994 dredging. Selenium was the highest in the survey there. The total pesticides increased in 1995 because of the largest amount of Chlordane found inside the marina, and second only to Station 12. The area was higher than expected in chemical oxygen demand, oil and grease and organic nitrogen.

The dominant species/taxa in 1994 were: Nematoda, an enormous 91.6 percent, which caused the very low SWSDI of 0.48; the crustacean gammarid *Corophium acherusicum*, 1.9 percent; the polychaete *Mediomastus* spp., 1.9 percent; Oligochaeta, 1.5 percent; the cumacean *Oxyurostylis pacifica*, 1.3 percent and the polychaete *Capitella capitata*, 0.2 percent. The 1995 dominant species were better balanced, with one species of crustacean and two molluscan species in addition to nematodes and oligochaetes, as follows:

Species/Taxa	Percent
Nematoda	67.76
Oligochaeta	18.58
Mediomastus spp.	4.69
Oxyurostylis pacifica	2.37
Tagelus subteres	1.47
Laevicardium substriatum	0.96

Station 3

Station 3, located at the tide gate to Ballona Lagoon and the Venice Canals, is subjected to changes in flushing and in sediment from those sources. The extreme rainfall in the winter of 1994-1995 may have been the cause of the change in sediment character, with the finest size increasing from 17.7 percent to 31.0 percent. The coarse grained fractions decreased, but the midsize grouping of 60 mesh screen continued to dominate at 46.2 percent. Station 3 had the second lowest score on trace metals and nonmetallic contaminants, but had a relatively high score in pesticides due to the presence of Chlordane, probably from years of use in termite control on the old houses in that area.

The dominant species/taxa in 1994 were: the syllid polychaete *Exogone*, sp. A, 25.3 percent, a species that usually occurs in much of the marina but in much lower numbers; the gammarid *Rudilemboides stenopropodus*, 17.1 percent; the polychaete *Mediomastus* spp, 10.3 percent; Nematoda, 5.0 percent; the bivalve *Tagelus californianus*, 4.5 percent; and the polychaete *Scoloplos acmeceps*, 4.4 percent. In 1995, there was a decrease in *Exogone* to 0.35 percent, and the dominant species were two gammarids, *Amphideutopus* and *Rudilemboides*, and four polychaetes, as follows:

Species/Taxa	Percent
Mediomastus spp	62.51
Amphideutopus oculatus	5.92
Mediomastus californienis	5.22
Leitoscoloplos pugettensis	3.52
Prionospio heterobranchia	2.52
Rudilemboides stenopropodus	2.35

Station 4

Station 4 is off the riprap in front of the apartments seaward of the administration building and docks. It is a quiet water, depositional area except during heavy surge events, and the sediment size is mostly 200 or <200 screen mesh size. This did not change much between 1994 and 1995, although the minimal coarser fractions decreased even more following the rains of 1994-1995. Sediments washed from the basins and the main channel may have accumulated there. The trace metal ranking in 1995 was medium high, no doubt associated with the amount of fine grained sediments. The pesticide scores were also high, with Chlordane and DDTs present. Fresh DDT was the highest in the marina and possibly reflects some nearby use.

The 1994 benthic diversity was high for the marina, with the dominant species as follows: the gammarids *Amphideutopus oculatus* and *Rudilemboides stenopropodus* comprised 29.5 percent of the fauna; the polychaetes *Pseudopolydora paucibranchiata* contributed 10.5 percent, *Mediomastus* spp., 10.1 percent, *Leitoscoloplos pugettensis*, 8.2 percent and *Exogone* sp.A, 6.5 percent; the bivalve *Tagelus californianus* contributed 6.5 percent also. The 1995 dominant species were all polychaetes except for the caprellid *Mayerella banksia*, as follows:

Species/Taxa	Percent
Mediomastus spp.	20.75
Leitoscoloplos pugettensis	14.97
Aphelochaeta sp., formerly called locally *Tharyx parva*	8.50
Prionospio heterobranchia	7.48
Mayerella banksia	6.12
Exogone lourei formerly Species A	6.12

Station 25

Station 25, added in 1989, is located between the public fishing docks and the administration docks where the Life Guard vessels, Sheriff's Harbor Patrol and the U.S. Coast Guard are based. The site is almost entirely composed of the fine grained sediments (200 and <200 screen mesh), and changed little after the high rainfall season and the winter storm waves. This lack of circulation causes debris to accumulate on the surface and the sediments to have the highest ranking for trace metals and nonmetallic contaminants in the marina. Station 25 was high in Chlordane, but unlike the adjacent Station 4, it did not have detectable fresh DDT, only degraded DDD and DDE.

In 1994, diversity was good, with the polychaetes dominating; *Mediomastus* spp. having 36.8 percent, *Pseudopolydora paucibranchiata*, 21.7 percent, *Lumbrineris* sp.A, 6.3 percent, *Aphelochaeta parvus*, 5.8 percent and *Prionospio heterobranchia*, 4.4 percent; the mysid shrimp *Deltamysis* sp.A provided 5.2 percent. In 1995 diversity improved still more, with an SWSDI of 2.76, second highest in the marina. The dominant species were:

species/Taxa	Percent
Mediomastus spp.	28.36
Aphelochaeta sp.	13.06
Errano lagunae, formerly *Lumbrineris lagunae*	9.62
Mediomastus californiensis	6.89
Prionospio heterobranchia	5.23
Prionospio lighti	4.75
Tagelus subteres	4.04
Bathylebris sp.	3.44

Although the top seven species were all polychaetes, there were relatively high percentages of the bivalve *Tagelus subteres* and the crustacean ostracod *Bathylebris*, sp., which usually only occurs in small numbers at Stations 2, 3, 4, 25 and 5 in the entrance and main channels.

Station 5

Located in the center of the main channel off Burton Chace Park, Station 5 is a shoaling area, where sediments may settle when flushed from the basins by rainfall. The total of the two finest sediment sizes, 200 and <200 screen mesh size, was 97.6 percent in 1994 and rose slightly following the rainy 1994-1995 season to 98.8 percent in 1995.

The ranking at Station 5 for selected trace metals and nonmetallic contaminants is usually in the medium high range, which can be associated with the high levels of fine particles. However, the station ranks relatively low in pesticides, which are not complexed with fine sediments in the way that trace metals are, although Chlordane and the DDTs are present.

The Shannon-Wiener SDI was higher in 1994, at 2.75, with the numbers of individuals more evenly divided among the dominant species, although the SWSDI was still good in 1995, at 2.23. The dominant species/taxa in 1994 were as follows: the polychaetes *Leitoscoloplos pugettensis*, 16.1 percent, *Lumbrineris* sp. A, 15 percent, *Euchone limnicola*, 14.6 percent and *Prionospio heterobranchia*, 6.2 percent; the gammarid crustaceans *Amphideutopus oculatus* furnished 8.8 percent and the gammarid *Rudilemboides stenopropodus*, 5.1 percent. In 1995 the top four dominant species were polychaetes, and the next two were crustaceans, as follows:

Species/Taxa	Percent
Pseudopolydora paucibranchiata	42.86
Leitoscoloplos pugettensis	12.09
Lumbrineris, sp.	10.71
Euchone limnicola	4.67
Grandidierella japonica	4.40
Zeuxo normani	3.85

Station 6

Located on the seaward side of the marina at the inner end of Basin B, Station 6 is a quiet water site with less commercial or parking lot runoff than most of the other basins. The sediment is mostly fine, having had 33.0 percent 200 screen mesh size and 55.6 percent <200 mesh in 1994. The rains of 1994-1995 may have flushed the basin somewhat because those percentages decreased to 30.4 and 45.0 respectively in 1995. The selected trace metal and nonmetallic contaminant rankings have increased from medium low in April 1994 to moderate in October 1994 and 1995. The station has a low pesticide score, ranking fourth lowest in the survey.

The dominant fauna in 1994 were all polychaetes: *Pseudopolydora paucibranchiata*, 52.2 percent; *Leitoscoloplos pugettensis*, 19.5 percent; *Aphelochaeta 'parvus'*, 11.5 percent; *Mediomastus* spp., 4.4 percent; *Scoloplos acmeceps*, 2.3 percent; and *Polydora ligni*, 2.2 percent. In 1995, the SWSDI improved from 1.62 in October 1994 to 2.16, and there was a large shift to the gammarid crustacean, *Grandidierella japonica*, as is shown below:

Species/Taxa	Percent
Grandidierella japonica	26.80
Pseudopolydora paucibranchiata	20.00
Aphelochaeta sp.	19.61
Lietoscoloplos pugettensis	12.43
Scoloplos acmeceps	3.88
Mediomastus spp.	2.91

Station 7

Station 7 is on the landward side of the marina at the inner end of Basin H; it is at the boat launch and jet ski ramp, with drainage from large parking lots and adjacent land. Boat yards are located at the seaward end of Basin H. The area is essentially composed of very fine sediments, which declined following the heavy rainfall season of 1994-1995 from 96.6 percent 200 and <200 screen mesh size in Fall 1994 to 92.7 percent in Fall 1995. Sediment contamination by trace metals and nonmetallic contaminants has ranked moderate until April 1994 when it increased to medium high, after which it fell to medium low in the Fall and rose again to moderate in October 1995. The site is the second lowest in the marina for pesticides. The SWSDI peaked at 2.18 in 1989 and has declined to a low of 1.17 in 1995.

In the Fall of 1994, the fauna was dominated by polychaetes, with *Aphelochaeta* (formerly identified locally as *Tharyx parva*) comprising 67.0 percent; this was followed by *Leitoscoloplos pugettensis*, 19.5 percent; *Pseudopolydora paucibranchiata*, 4.8 percent; *Mediomastus* spp., 4.7 percent; *Euchone limnicola*, 2.3 percent; and *Exogone* sp. A, 3.5 percent. The Fall of 1995 dominant species were again all polychaetes, with an even larger percentage of *Aphelochaeta*, which affected the SWSDI, as indicated by the following:

Species/Taxa	Percent
Aphelochaeta sp.	73.50
Euchone limnicola	8.89
Mediomastus spp.	3.63
Errano lagunae (formerly *Lumbrineris lagunae*)	3.63
Dorvillea longicornis (formerly *Schistomeringos longicornis*)	2.72
Leitoscoloplos pugettensis	1.27

Station 8

Station 8 is located off the beach in Basin D in the channel at the innermost boat slip area. Basin D has the only beach in the marina, known as Mothers' Beach, but also provides resting and feeding areas for many birds, especially during the off season when they are undisturbed. There have been persistent problems with coliform violations in 1996, but sources other than the birds have not been identified. The swimming area is also home to a bed of the seagrass *Ruppia maritima*, rare in southern California (Chapter IX) and provides habitat for many fish, on occasion, and invertebrates.

The station is very silty, increasing from 80.0 percent fine grained sediments of 200 or <200 screen mesh size in Fall 1994 to 96.1 percent in Fall 1995. Contamination ranking for selected metals and nonmetallic contaminants has fluctuated; from moderate in 1989 and 1990, to medium high in May 1991 and high in October 1991. It then decreased to moderate in 1992 and April 1994, to medium high in 1995, indicating heavy runoff or deposition, or both. The pesticide score in 1995 was relatively low, due mostly to degraded DDD and DDE. **The SWSDI is, misleadingly, higher, at 1.67, than would indicate the truly poor conditions there, due to low numbers of both species and individuals. In fact, the number of species dropped from 22/m^2 in 1994 to 11/m^2 in 1995, and the number of individuals dropped from 3,720/m^2 to 860/m^2 in that period. This area appears to be in trouble ecologically, probably from sedimentation.**

In 1994, the dominant species were mostly polychaetes, as follows: *Leitoscoloplos pugettensis*, 36.8 percent; *Euchone limnicola*, 14.8 percent; *Scoloplos acmeceps*, 10.5 percent; the caprellid *Mayerella banksia*, 9.4 percent; *Mediomastus* spp., 9.1 percent and *Prionospio heterobranchia*, 4.6 percent. In 1995, *Leitoscoloplos pugettensis* increased its percentage, decreasing diversity, as follows:

Species/taxa	Percent
Leitoscoloplos pugettensis	55.38
Lumbrineris sp.	7.59
Mediomastus spp.	6.15
Pseudopolydora paucibranchiata	6.15
Streblospio benedicti	6.15
Mayerella banksia	4.62
Errano lagunae	4.62

Station 9

Located at the inner end of Basin F, this station receives runoff from storm drains and parking lots. It is a low energy area, with a silty bottom. The finest sediments, 200 and <200 screen mesh size, actually increased from 95.2 percent in 1994 to 99.2 percent in 1995. The ranking for selected trace metals and nonmetallic contaminants increased from medium high to fourth highest in the marina in 1995, but it was the lowest in pesticides. This was not true through 1994, when Aroclors and DDTs were present, giving it a medium high ranking for pesticides and chlorinated hydrocarbons.

The SWSDI index was highest in 1991, at 2.09, and decreased to 1.90 in 1995. The station had the highest number of species, 36 in 1976, but construction of more slips and adjacent commercial/urban areas has degraded the fauna until there were only 15 species in Fall 1994 and 1995. In 1978 and 1986 there were over 11,000 individuals, but this has decreased to 1200 in 1994 and 1510 in 1995. The dominant polychaete species in Fall 1994 were: *Leitoscoloplos pugettensis*, 57.4 percent; *Mediomastus* spp., 18.9 percent; *Lumbrineris* sp. A, 6.6 percent; *Schistomeringos longicornis* (now *Dorvillea*), 2.5 percent; the caprellid *Mayerella banksia*, 2.5 percent and the phoronid *Phoronis* sp. , 1.6 percent. The following species/taxa were dominant in 1995:

Species/Taxa	Percent
Aphelochaeta sp.	46.36
Euchone limnicola	11.26
Mediomastus spp.	10.60
Pseudopolydora paucibranchiata	7.28
Errano lagunae	6.62
Leitoscoloplos pugettensis	3.31
Micrura sp.	3.31
Cirriformia tentaculata	3.31

Station 10

Station 10, located at the end of the channel in Basin E, was affected by changes made in the Spring of 1995, when contaminated sediments had accumulated to the point of thrusting floating docks out of the water in places. Docks were removed, contaminated sediment removed by clamshell dredge, and slips for much larger vessels constructed. One change observed was that the total of the fine sediments (200 and <200 screen mesh size) declined from 96.7 percent in the Fall of 1994 to 83.3 percent, while the coarser sediments increased somewhat. This was no doubt due to removal of deposits that impeded flushing, allowing tidal exchange and dry weather runoff from Oxford Basin and Washington Street to move through the area better.

That contaminants continue to pollute the area is indicated by the fact that the selected trace metal and nonmetallic contaminant ranking for Station 10 has continued to be in the high category, being second highest in the 1995 survey. The special terrestrial study of Oxford Basin (Chapter V) indicates that there were high levels of some contaminants that could be carried by sediments in runoff into the marina. Deposition from the marina itself would also occur because Basin E has low tidal exchange, being farthest from the bay. The pesticide/chlorinated hydrocarbon ranking has fluctuated; it was high in 1989 and 1990, but was low in October 1991, and rose to high again in October 1992. The ranking decreased to moderate in April 1994, but returned to high ranking by the Fall of 1994. Following the cleanup, the score dropped to medium low, but there were substantial amounts of Chlordane, DDD and DDE present.

The benthic fauna changed between 1994 and 1995, with the dominant species in 1994 being: four polychaetes, *Leitoscoloplos pugettensis*, 33.7 percent; *Pseudopolydora paucibranchiata*, 8.7 percent; *Lumbrineris* sp., 7.6 percent; and *Mediomastus* spp., 6.4 percent; the mysid shrimp *Deltamysis* sp.A provided 16.3 percent and the caprellid *Mayerella banksia*, 12.8 percent. The dominant species in 1995 were all polychaetes, as follows:

Species/Taxa	Percent
Streblospio benedicti	35.71
Pseudopolydora paucibranchiata	13.91
Leitoscoloplos pugettensis	12.03
Mediomastus spp.	7.52
Dorvillea longicornis	5.26
Polydora cornuta	4.89

Station 11

Station 11 is located at the inner end of the main channel, formerly open water, but where large vessels have been closely berthed for the last several years. Storm drains and parking lot drains are located in the area. Sediments are fine, indicative of low flushing, but the percentage of 200 and <200 screen mesh size decreased from 98.8 percent in Fall 1994 to 91.6 percent in October 1995, suggesting that the 1994-1995 rainfall may have moved some finest sediments seaward. The ranking for trace metals and nonmetallic contaminants has been in the high category since 1989, except for Fall 1994 when it decreased slightly to the top of the medium high category, returning to the third highest in the survey in 1995. The ranking for pesticides and chlorinated hydrocarbons was high or medium high in 1989, 1990 and May of 1991, but decreased to low or medium low in October 1991 and 1992; it increased to moderate in April 1994, decreased to medium low in September 1994, and dropped to low in October 1995. Only DDD and DDE were found in 1995. The earlier fluctuations suggest pulses of input from terrestrial sources and later recirculation throughout the marina.

The dominant fauna in 1994 consisted of five polychaete species: *Leitoscoloplos pugettensis*, 28.6 percent; *Pseudopolydora paucibranchiata*, 17.5 percent; *Mediomastus* spp., 16.7 percent; *Euchone limnicola*, 10.0 percent; *Lumbrineris* sp. A, 6.7 percent; and one caprellid, *Mayerella banksia*. The dominant species changed in 1995, to the following:

Species/Taxa	Percent
Aphelochaeta sp.	36.94
Cirriformia tentaculata	17.12
Euchone limnicola	9.46
Leitoscoloplos pugettensis	7.21
Mediomastus spp.	6.31
Errano lagunae	5.86

CONCLUSIONS

Benthic faunal numbers and species composition present seem to be most influenced by the physical conditions in the marina associated with high or low rainfall runoff, accumulations of very fine sediments due to decreased circulation and flushing and disturbances such as storm waves with associated sand deposition.

The absence of species that might be expected in that environment may well be

due to toxic levels of some trace metals and pesticides or chlorinated hydrocarbons.

Altogether, 157 species occurred in the marina, as compared to 162 species in 1994; in either case, most of those occur in small numbers at one or a few stations. The most common polychaetes, such as *Mediomastus* spp. and *Pseudopolydora paucibranchiata*, occur at all, or almost all, stations in large numbers, while species like *Aphelochaeta* sp. (formerly identified as *Tharyx parvus* locally) and *Leitoscoloplos pugettensis* occur at almost all stations but in fewer numbers. Such species seem to be able to cope with a variety of sediment grain sizes, chemical contamination, varying salinities and manmade or natural disturbances, perhaps due in part to rapid reproduction. Other species are delicately balanced in regard to one or more of these factors and may appear in limited numbers or may appear in limited distribution patterns. The nematodes and oligochaetes are examples of those that appear in very large numbers but distribution is limited to a few stations.

The generally very fine sediments may militate against crustaceans other than a few species of gammarids, caprellids and mysids, and against some large molluscan species. Depth in the marina is associated with the amount of water circulation in the marina, with the shallowest waters being located in the areas of poor circulation or flushing. These areas also generally show the siltiest sediments that have the greatest capability for complexing with trace metals.

Levels of many trace metals, nonmetallic contaminants, pesticides and sometimes chlorinated hydrocarbons exceed threshold toxicities (Chapter IV) in organisms typical of the benthic community, but it is not known how many of these chemicals are actually bioavailable when complexed to sediments. This is an area of information being pursued at laboratories around the country and in Europe, but the task is exceedingly difficult just from sheer numbers of species and chemicals involved. Many of the benthic species are still undescribed (unidentifiable) in the scientific literature let alone having been tested for toxicity levels of single compounds or complexes of compounds. Species that have been considered "typical", or indicators, may in fact not be.

There is natural fluctuation in populations, regardless of manmade impacts. The system appears to be relatively stable and resilient, within the range of fluctuation. **It is clear from the information gathered, however, that study of the benthic fauna in the marina points out the areas of severe stress, in particular in 1995, the drastic decline at Station 8, near Mother's Beach in Basin D.**

Benthic studies, coupled with sediment and other investigations, also demonstrated the "cork in the bottle" effect of the sandbars in the entrance channel and the mouth of Ballona Creek. The effects of heavy and light seasonal rainfall runoff are not as consistent, because each station may be affected differently, but decreases in the species diversity index coincided with areas receiving possibly contaminated runoff or physically disruptive impact: at Stations 12 and 1 in Ballona Creek, at Station 3, which receives the Ballona Lagoon-Venice Canal flow, at Stations 7 and 8 in the inner basins, and at Station 5 in mid-main channel. Dredging apparently had beneficial effects, as seen at Stations 2 at the entrance channel and Station 10 in Basin E.

VIII. FISH FAUNA

INTRODUCTION

Marina del Rey provides habitat for larval, juvenile and adult fish species associated with nearshore, embayment and estuarine waters. Even though the marina is an artificial construction, it functions as an important small wetlands in the southern California region, where about ninety percent of the natural wetlands have been lost due to development. The original Ballona wetlands was a large natural estuarine system stretching north of the present Venice Canals, east to the Baldwin Hills and in places to downtown Los Angeles, and south to Palos Verdes peninsula. There were numerous small channels that met behind a barrier beach, but these were gradually altered by dumping and filling for subdivisions, farming, industrial development, oil and gas recovery and storage, and finally by major channelization for stormwater runoff control prior to construction of the marina. The only remnant of the original system was a small lake that became the swimming area in Basin D.

Construction of jetties and the breakwater increased the amount of rocky substrate available in an area of the coast that was predominantly sandy beach or silty wetlands. Thus the marina became an attractant for fish species that would not have been present in the area and which form a large component of the marina fish community. It is this group that is severely impacted whenever sand and silt accumulate to form sandbars, covering the rocks which provide shelter and support the algae and invertebrates on which the fish feed.

Although some species live entirely in the marina, many fish shed their eggs outside the breakwater and the eggs are carried into the marina by the tide, where the hatching larvae find an abundance of plankton for nutrition; the phytoplankton also provide turbidity that helps hide the larvae from predation by other fish and birds. The numbers of pelicans, gulls, scoters, terns and other species that

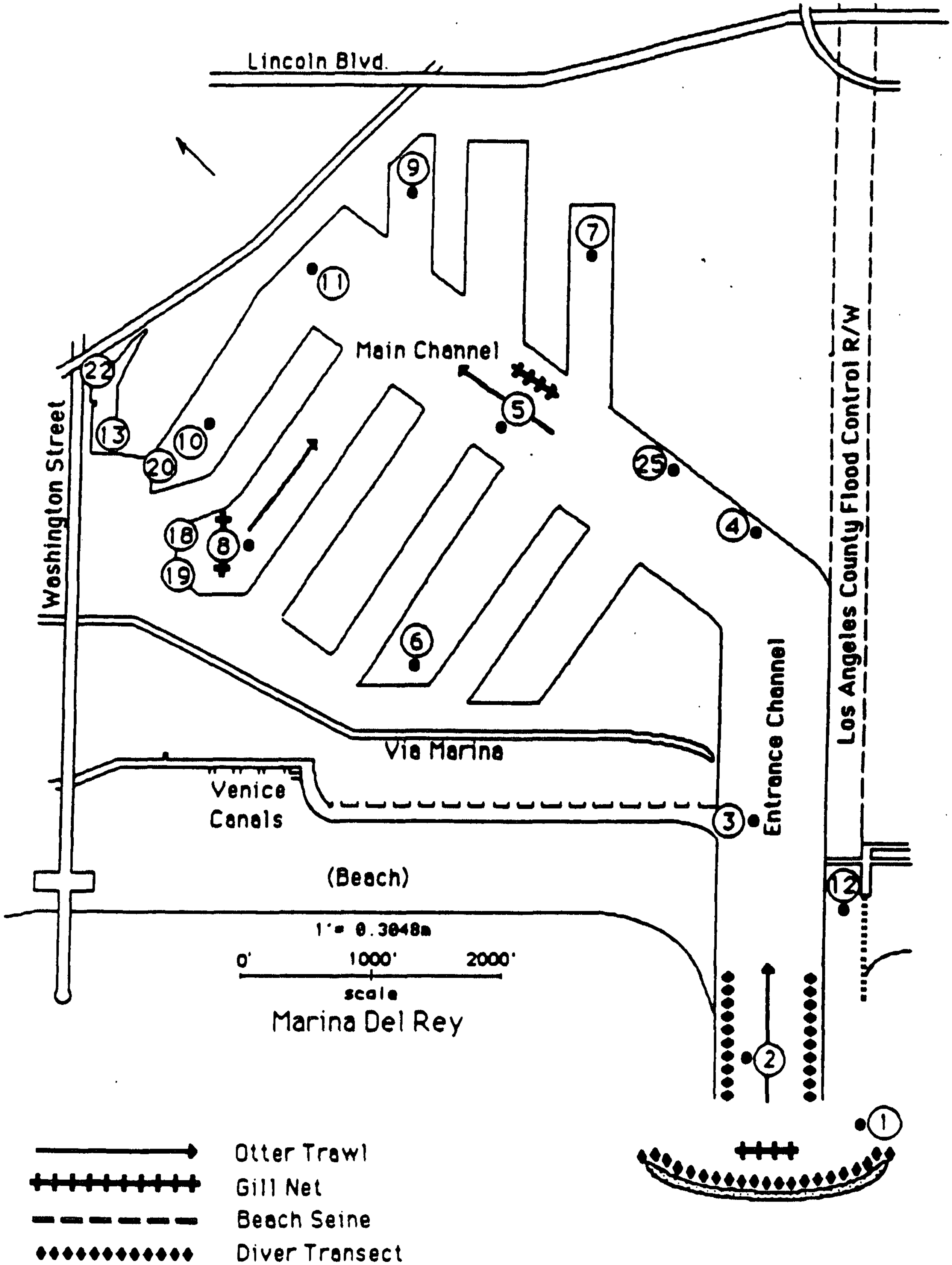


Figure VIII.1 Fish survey stations for Marina Del Rey

frequent the area give testimony that the fish provide an extensive resource in the ecosystem.

Schools of small forage fish swim into the marina, probably while feeding on weakly swimming zooplankton that are carried in by currents and tides and feed on phytoplankton and bacterioplankton; small fish may in turn be followed into the marina by larger predators. The seagrass beds in Basin D attract fish to feed on the smaller fish and invertebrates sheltered there. The vertical basin walls do not provide the amount of habitat for embayment species that contoured or sloping rocky walls would furnish had the marina been so constructed, but there are still a number of fish that are undercounted because these fish shelter beneath slips and are often not caught in the standard survey techniques.

Marina fish populations may be disturbed by natural events such as large storms, heavy rains, warming such as El Niño events , extreme summer heat and by manmade impacts such as dredging, illegal dumping of chemicals, sewage or debris, illegal pumping of sewage holding tanks, and by oil spills and slicks due to accidents or improper handling.

Past Fish Surveys

Harbors Environmental Projects (HEP) first conducted surveys as a part of a study of monitoring methods, funded jointly by Los Angeles County and the NOAA-USC Sea Grant Program in 1977-1979. Studies were continued on a voluntary basis in 1980-1981 by Dr. John S. Stephens, Jr., and his staff from the *Vantuna* Research Group at Occidental College. After a hiatus, surveys were resumed by the *Vantuna* Group, with Dan Pondella, II, as a part of the HEP monitoring program for the County Department of Beaches and Harbors.

PROCEDURES

Survey stations, shown in Figure VIII.1, and techniques were standardized in 1984 and have been continued through May 1996. These include: trawls performed using a semiballoon otter trawl towed for ten minutes at three locations; a 100 ft (32.8 m) multimesh gill net deployed at three locations for 45 minutes each; and a 100 ft (32.8 m)

Table VIII.1. Number of fish species for the various sampling methods used at Marina Del Rey in the fall from 1984 to 1995. Overall species totals are also included.

METHOD / YEAR	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984
DIVER SURVEY	9	23	17	10	18	20	22	24	24	20	19	24
BEACH SEINE	6	6	5	4	8	7	7	5	8	17	5	5
GILL NET	1	4	1	2	3	1	2	2	8	6	4	4
OTTER TRAWL	6	3	7	7	7	7	8	10	8	4	3	4
ICHTHYOPLANKTON	3	9	6	8	11	11	3	4	11	7	9	7
TOTALS	21	35	29	28	37	36	35	39	44	42	38	37

Table VIII.2. Number of fish species for the various sampling methods used at Marina Del Rey in the spring from 1984 to 1996. Overall species totals are also included.

METHOD / YEAR	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1984
DIVER SURVEY	19	10	15	17	20	23	11	22	15	18	22	20
BEACH SEINE	9	9	6	10	9	8	8	5	8	10	10	7
GILL NET	2	4	5	3	3	1	2	1	6	7	9	6
OTTER TRAWL	11	8	11	7	9	8	12	12	9	7	6	14
ICHTHYOPLANKTON	9	7	12	10	9	11	14	12	8	11	11	10
TOTALS	39	33	37	37	39	41	27	43	32	41	44	45

beach seine deployed at 2.5 m depth about 30 m from shore and fished to the shore. Also, diver surveys were performed along the inner side of the breakwater and along the jetties in the entrance channel, and egg and larvae (ichthyoplankton) were collected at Stations 2, 5 and 8 using a 333um mesh plankton net at 1.0 m depth for two minutes and on the bottom for three minutes. A diver assisted benthic sled keeps the net on the bottom regardless of irregularities on the bottom and the vessel speed. Ichthyoplankton counts are now standardized to counts per 1000 m^3.

Fall beach seine and diver surveys were conducted on 13-14 October 1995, but the otter trawls, ichthyoplankton and gill net surveys had to be postponed until 18 November. Spring surveys were conducted in 6 and 8 May 1996.

RESULTS AND DISCUSSION

Numbers of Species

More than 90 species, or higher taxa not identifiable to species level, have been identified in Marina del Rey surveys since 1984, which exceeds the numbers found in other wetlands in Los Angeles Counties (Stephens et al, 1991; Soule et al., 1991; Soule et al., 1996), although other wetlands have not been so extensively studied. The number of species found in any given survey varies greatly, depending on seasonality and natural or manmade events, such as storms, water temperature, siltation, and dredging. Numbers are usually higher in the spring, according to May surveys, but there have been some exceptions. Tables VIII.1 and VIII.2 present the numbers of species in fall and spring surveys.

Figure VIII.2 illustrates the wide variability in numbers of species, this variability provides alow confidence levels ($r^2 = 0.564$ in spring and 0.166 in fall). Low numbers of species in the spring of 1988 and 1990 may have been partly due to influxes of Aroclor from an unknown source into the marina in toxic amounts (Soule et al., 1991; 1992a, b). Low numbers of species in October 1992 may have been due to knockdown dredging. It must be recognized that short term, seasonal and annual temperature fluctuations will affect numbers, and that semiannual surveys may well miss seasonal trends such as late

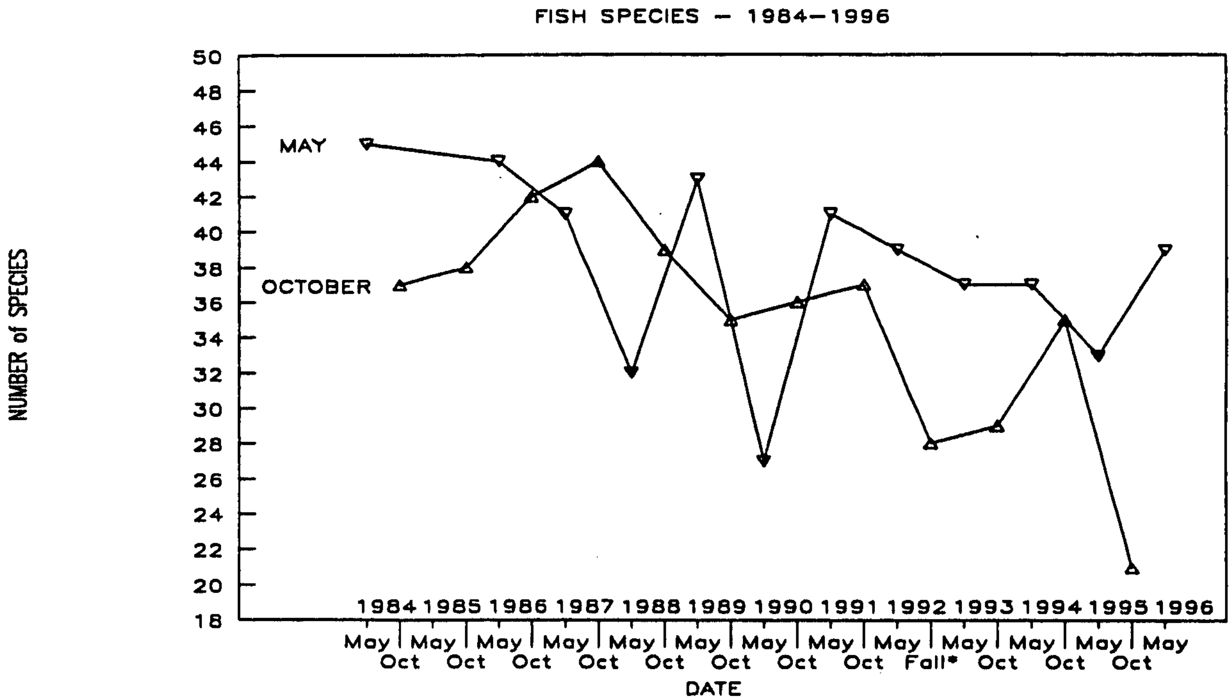


Figure VIII.2. Number of fish species by month and year. Fall of 1992 survey, marked with an asterisk, was interrupted by the start of dredging.

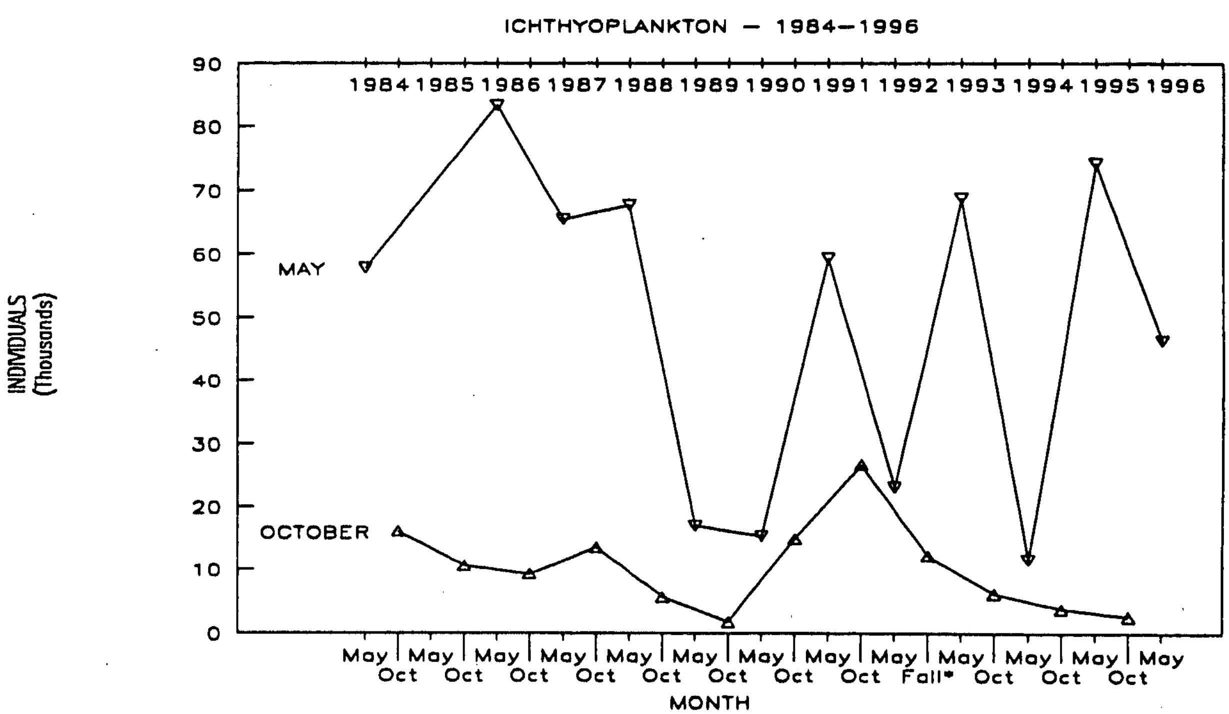


Figure VIII.3. Ichthyoplankton abundance by month and year. Fall of 1992 survey, marked with an asterisk, was interrupted by the start of dredging.

spring warming or cooling, El Niño events and effects of rainfall variation.

In October 1993, deposition from the 1992-1993 heavy runoff probably had already impacted the rocky habitat. In October 1995, sand deposited during severe storms in 1994-95 affected even more of the rocky breakwater and north jetty habitat. **The fall 1995 surveys produced the lowest number of species in all surveys, 21, in part due to the disappearance of much of the rocky habitat, which was covered by sediments.** The lateness of the surveys for otter trawl, gill net and ichthyoplankton, in November, may have affected those numbers, although they were not inconsistent with totals in some previous years. Moreover, there was an unusually late autumn in 1995, which produced late recruitment peaks in fishes in King Harbor.

Dredging in November and December of 1994 was insufficient to clear the jetties and breakwater, and the severe storms associated with record rainfall in 1994-1995 more than filled the dredged cavitations, with the result that the May 1995 number of fish species was low, totaling 33, approaching the low of 32 in the spring of 1988, when waters were quite turbid, probably due to an extreme tide.

The May 1996 survey indicated that there was a great rebound from May 1995 and the fall of 1995 surveys in the number of species present, 39, which is the highest since 1991. Major dredging, with hydraulic transport of sediments to southern beaches for replenishment, was performed, moving 230,000 cy of sand and sediment between 19 March and 5 April 1996. **It was feared that dredging just one month before the May survey would be severely disruptive to fish, but the uncovering of the rocky habitat more than compensated for the disturbance caused.** The rocky habitat fishes were no doubt recruited from outside the breakwater and in the entrance channel. Some resuspended sediments will provide organic particles which provide food for some forage fish as well.

<u>Mean Numbers of Species</u>

The mean number of species for the six fall surveys in the 1980s was 39 species or taxa, as compared to 33 in five 1990s surveys calculated through 1994; however, the 1995

Table VIII.3. Fish abundance by method for fall surveys from 1984 to 1995. Total abundance is also Included.

METHOD / YEAR	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984
BEACH SEINE	416	1016	1542	311	213	740	554	486	70	400	241	303
GILL NET	33	83	37	60	77	1	5	49	27	13	17	19
OTTER TRAWL	14	5	14	28	451	213	59	251	20	13	6	14
TOTAL FISH	463	1104	1593	399	741	954	618	786	117	426	264	336
ICHTHYOPLANKTON (larvae only) (standardized per 1,000 m³)	2537	3703	6077	12241	26777	14887	1714	5556	13535	9300	10608	16065

Table VIII.4. Fish abundance by method for spring surveys from 1984 to 1996. Total abundance is also Included.

METHOD / YEAR	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1984
BEACH SEINE	3321	8165	1418	406	351	10760	3550	1253	14135	791	476	186
GILL NET	36	49	22	68	21	197	263	20	65	56	42	80
OTTER TRAWL	64	22	37	20	12	46	33	34	95	26	17	136
TOTAL FISH	3421	8236	1477	494	384	243	3846	1307	14295	873	535	402
ICHTHYOPLANKTON (larvae only) (standardized per 1,000 m³)	46400	74242	11615	68756	23128	59354	15368	16998	67630	65423	83344	57801

total of only 21 species brought the 1990s fall mean for six surveys down to 31. **The mean for all 12 fall surveys since 1984 is now 35.**

The mean number of species in the five spring surveys in the 1980s was 41, whereas it is 38 for the seven 1990s surveys. **The mean is 39 species for 12 spring periods.**

The mean number of species for all 24 surveys, spring and fall, since 1984 is 37. This is slightly, but not much, above the mean for the 1977-1979 surveys of 35 species, indicating that the number of species is relatively stable over long periods in spite of short term variability. Stability is influenced by natural phenomena over a long term, but it is also dependent upon amelioration of accumulations of sand and silt by dredging or flushing, and natural or manmade remediation of impacts such as chemical usage or spills.

Abundance: Numbers of Individuals

The numbers of fish are almost always lower in the fall surveys than they are in the spring, but variability is quite high from year to year. Tables VIII.3 and VIII.4 summarize the numbers of individuals caught by the various techniques for the fall and spring respectively.

Beach seine collections in the fall have ranged from a low of 70 fish in 1987 to a high of 1,542 in 1993, and in the spring the range was from 186 in 1984 to 14,135 in 1988.

Gill netting has resulted in the fall in numbers of fish ranging from one in 1990 to 83 in 1994, and in the spring the range has been from 20 in 1989 to 263 in 1990.

Otter trawl take has ranged in the fall from five individuals in 1994 to 451 in 1991, and in the spring from 12 in 1992 to 136 in 1984.

The number of ichthyoplankton larvae varies greatly, usually dependent upon the number of topsmelt (*Atherinops affinis*) larvae,.which move in and out of the marina, or on Gobiidae type A/C larvae, of *Clevelandia ios, Ilypnus gilberti* and/or *Quietula y-cauda*, which cannot be distinguished from one another at the young larval stage.

Counts from ichthyoplankton tows have in the past been difficult to compare with data from different surveys, but in recent years the practice has been to standardize them to numbers per 1000 m^3. All the ichthyoplankton surveys have been recalibrated and restandardized, so that numbers will differ from some of those reported in earlier Harbors Environmental Projects publications on the 1980s (e.g., Soule and Oguri, 1985, 1986, 1987, 1988, 1990). The mean number of ichthyoplankton in fall surveys in the 1980s was 9,463/1000 m^3, but the mean increased in the fall 1990s surveys to 11,037/1000 m^3, largely due to relatively high numbers in fall 1991. Numbers in 1994 and 1995 were low.

Figure VIII.3 illustrates the lower numbers of ichthyoplankton that occur in the fall as compared to the spring, but the range in fall numbers is much smaller than the variation in the spring. **The mean for all 12 fall surveys was 10,250 ichthyoplankton per 1000 m^3. The mean for spring surveys in the 1980s was 31,178/1000 m^3 and in the 1990s it was 42,695/1000 m^3, a considerable improvement; the mean for all 12 surveys was 37,896/1000 m^3.**

Variability of the spring surveys is great, but the single spring surveys performed may simply indicate fluctuation due to the fact that numbers of ichthyoplankton can change with the tides or the spring water temperatures rather than representing an actual annual deviation from the norm. The cues for reproduction for some species are signaled in the spring by an increase from the winter lows, which may occur early or late, depending on when the southern countercurrent (undercurrent) weakens, allowing cooling, followed later by warming of California Current waters. Weakening of stormwater runoff flow may also allow more eggs and larvae shed outside in the bay to come into the marina on tidal exchanges. Nutrients from terrestrial runoff stimulate blooms of phytoplankton and nourish zooplankton reproduction and feeding; these in turn attract spawning or feeding fish and support the fish larvae carried in by currents, wind or tide.

__Fall 1995__

The principal differences in the numbers of species found in the fall of 1995, as compared to previous years, was the dearth of species in the diver survey: nine, as compared to 23 in fall 1994 (Table VIII.1). There were decreases in the number of gill net species and ichthyoplankton species as well, although these decreases were similar to those numbers found occasionally in past surveys. The diver survey helped to confirm that the deposition of sand and sediment on the north jetty was more severe after the winter storms in January-March 1995 than it had been preceding the dredging in November and December 1994.

Table VIII.5, at the end of this chapter, presents the list of species and their numbers according to sampling site and technique for fall 1995. The species found in the diver survey were all adults of species that are always or almost always present at the jetties and breakwater except for a subadult *Chromis punctipinnis*, the blacksmith. One species that had always been present in the fall surveys until 1995 is *Halichoeres semicinctus*, the rock wrasse.

Numbers in the beach seine were more than 50 percent lower than last year, based mostly on fewer *Atherinops affinis* (topsmelt), but those numbers vary so greatly that no significance can be attached to it (Table VIII.3). Present were *Anchoa compressa*, the deep-bodied anchovy, which was seen in the fall only in 1985 and 1988, and *Mustelus californicus*, the California smoothhound shark, which was seen only in 1991. These species may be more dependent on ocean water temperatures, and are apparently occasional visitors.

In a separate study consisting of five additional fall beach seines, the *Vantuna* Research Group collected seven species, five of which did not appear in the regular fall 1995 survey, but are species that often appear in regular surveys:

Acanthogobius flavimanus, yellowfin goby
Anisotremus davidsonii, sargo
Clevelandia ios, arrow goby
Fundulus parvipinnus, California killifish
Hypsopsetta guttulata, diamond turbot
Leptocottus armatus, staghorn sculpin
Strongylura exilis, California needlefish

The fall 1995 ichthyoplankton survey (Table VIII.6, appended) found only three larval taxa and some unknowns, and the numbers were low, second only to the lowest number in 1989. The lateness of the survey, in November, might have been blamed, but the *Vantuna* Research Group's data from King Harbor at that time indicated a good number of ichthyoplankton species and individuals present. Comparison with the numbers collected, particularly at Trawl Station 2, in fall 1994 indicated many more species and individuals were present before the winter storms that caused so much sand deposition during the 1994-1995 winter season, decreasing circulation and flushing.

Spring 1996

The improvement in the number of species in the spring 1996 survey was impressive, up from 33 the previous May and the low of 21 in the fall survey (Table VIII.1). Moreover, the numbers were improved only a month after massive dredging was performed and 230,000 cys moved for beach replenishment downcoast, which was unexpected. This certainly demonstrates the beneficial role of sand removal in improving the rocky habitat and increasing circulation in the marina.

The largest increase was in the number of species observed in the diver surveys of the newly exposed rocky habitats. Table VIII.7 lists the species and numbers by technique, except for ichthyoplankton, which are enumerated in Table VIII.8. The number of species found in otter trawls and ichthyoplankton surveys increased, but gill net species dropped from four to two. Gill net species have been few since 1988, except in 1994, when five species were caught.

In 1988, Station 8, near the gill net sites, began an increase in contamination score from low, to moderate, to medium high by 1991 (Chapter IV), after which the score declined to moderate by April 1994 and medium low by September 1994. Unfortunately, the ranking rose over the summer to medium high in the fall of 1995.

Ichthyoplankton counts were high in spring 1996, at 46,400/1000 m^3, but were not as high as in spring 1995, when they numbered 74,242/1000 m^3 (Table VIII.4). Both numbers are considerably higher than those in spring 1994, when only 11,615/1000 m^3

were counted. The spring 1994 results perhaps demonstrated that the relatively modest dredging in November and December 1994, unfortunately followed by massive influx of storm-borne sand, did not improve the entrance habitat as did the 1995 dredging.

Common Species Occurrences

About 20 species, or high taxa for larvae, are almost always present in the marina, while another 20 species are present at any one time, varying from species that are rarely present to those that are frequently present. Tables VIII.9 and 10 present the lists of species occurring in the fall and spring, respectively, since 1984.

Species present in all 12 fall surveys were:

Atherinops affinis, topsmelt
Embiotoca jacksoni, black surfperch
Girella nigrans, opaleye
Paralabrax clathratus, kelp bass
Paralabrax nebulifer, barred sand bass
Paralichthys californicus, California halibut

Missing for one fall survey were:

Chromis punctipinnus, blacksmith, (1994)
Halichoeres semicinctus, rock wrasse (1995)
Mugil cephalus, striped mullet (1993)
Oxyjulis californica, señorita (1986)
Rhacochilus vacca, pile surfperch (1993)

Species present in all 12 spring surveys were:

Atherinops affinis, topsmelt
Embiotoca jacksoni, black surfperch
Engraulis mordax, anchovy
Girella nigricans, opaleye
Paralabrax clathratus, kelp bass
Paralabrax nebulifer, barred sand bass

Missing in one spring survey were:

Halichoeres semicinctus, rock wrasse (1990)
Heterostichus rostratus, giant kelpfish (1995)
Hypsypops rubicundus, Garibaldi (1986)
Micrometrus minimus, dwarf surfperch (1995)
Rhacochilus vacca, pile surfperch (1992)
Seraphus politus, queenfish (1996)

Larvae too young to be identifiable to species but always present in the fall were: the Gobiidae A/C larvae (*Clevelandia ios*, arrow goby; *Ilypnus gilberti*, cheekspot goby; and/or *Quietula y-cauda*, shadow goby; and *Hypsoblennius* spp. (*H. gentilis*, bay blenny; *H. gilberti*, rockpool blenny; and/or *H. jenkinsi*, mussel blenny).

The Gobiidae were not always seen in the spring but have been since 1989; whether this is a sampling/identification artifact is unknown. The *Hypsoblennius* larvae were present in all spring surveys as well.

Contract efforts have not included summer surveys. However, the *Vantuna* Research Group provided records of a July 1995 beach seine that produced one more species than had been found in the survey of 23 May 1995. Interestingly, five of the species present in July were not present in May (Soule et al., 1996). Those present in both periods were *Anchoa Compressa* (deep bodied anchovy), *Anisotremus davidsonii*, (sargo), *Atherinops affinis* (topsmelt), *Pleuronichthys ritteri* (spotted turbot) and *Umbrina roncador* (yellowfin croaker). Missing in July were *Atractoscion nobilis* (white sea bass), *Mugil cephalus* (striped mullet), *Paralabrax nebulifer* (barred sand bass) and *Strongylura exilis* (California needlefish). This may indicate a considerable shift in the summer-tolerant species or those that matured and left the marina, or may be just a sampling artifact.

Soule et al. (1996) discussed the species of the various families common to the marina, their habitat preferences and their roles in the marina ecosystem. For further references, see Emmett, Stone, Hinton and Monaco, 1991, and Miller and Lea, 1992.

<u>Less Common Occurrences</u>

Mearns (1988) emphasized that the rare and unusual occurrences of species serve as possible indicators of oceanic phenomena such as warmer El Niño events or colder water incursions, named La Niña by some. In 1984, 1987 and 1992-1995 waters were warmer in winter, while 1988 through 1991 had lower winter temperatures.

Examples of the presence of warm water species are *Urolophus halleri*, the round stingray, which has appeared in the marina in warm water periods in 1984-1986 and 1990-1992 and again in 1995-1996 (Tables VIII.9,10). *Myliobatus californica*, the bat ray, is another species that comes during warm periods and disappears during colder water periods.

Paralabrax maculatofasciatus, the spotted sand bass, was present in the fall in warm periods but has not been reported in the fall surveys since 1990 or the spring surveys since 1992. *Sardo chilensis*, the Pacific bonito, was recorded in the fall of 1984, 1986 and 1987, and in the spring in 1984, but has not been seen in surveys since, although local boaters say they have observed them from time to time chasing topsmelt schools into the marina. Other species that are infrequent may represent cold water periods, or may simply be those that venture into the marina from Santa Monica Bay.

CONCLUSIONS

The mean number of species for all 24 survey periods is 37, down from 38 before the fall 1995 surveys, when an unprecedented low of 21 species was found when the breakwater and jetties were inundated with sand and silt. There was dramatic recovery following extensive dredging in the spring just a month before the May 1996 survey.

The marina continues to provide significant habitats for nearshore and wetlands species, especially rocky reef species, and eggs, larvae and subadults of many others. larger fish follow feeding schools of bait fish into the marina. Schooling bait fish like *Atherinops* swim in and out of the marina depending on the occurrence of zooplankton and phytoplankton on which to feed. The distribution of plankton is very patchy, depending on tides, winds, runoff and nutrients. However, **the surveys clearly indicate the presence of fish using the marina as a valuable shelter, a nursery ground or as a feeding site.**

The fish are vulnerable to natural and manmade impacts; the marina is affected by the dominant coastal current and temperature regimes and by rainfall and stormwater runoff. Some manmade impacts can be controlled but others cannot; the terrestrial sediments around the marina are in some cases quite contaminated and could influence the fish populations.

Table VIII.5. Fish species and numbers collected, by technique, October 13-14, November 16, 1995.[1]

	DIVER TRANSECTS BREAKWATER			BEACH SEINE	GILL NET STATIONS			OTTER TRAWL STATIONS		
	Terminal	South	North		#2	#5	#8	#2	#5	#8
Species										
Anchoa compressa				120						
Atherinops affinis				285	2		31			
Chromis punctipinnis	5S									
Citharichthys stigmaeus								1		
Embiotoca jacksoni	3A									
Girella nigricans	10A	3A	5A							
Hypsopsetta guttulata								1		
Hypsypops rubicundus	5A									
Mugil cephalus				1						
Mustelus californicus				7						
Oxyjulis californica	10A									
Paralabrax clathratus	7A	2A								
Paralabrax nebulifer	3A	5A		1					3	1
Paralichthys californicus			1A					3	2	
Pleuronichthys ritteri								1		
Rhacochilus vacca	5A									
Umbrina roncador				2						
Xystreurys liolepis								2		
Species/Station	8	3	2	6	1	0	1	5	2	0
No. individual Stations	48	10	6	416	2	0	31	8	5	1
Species/Technique		9		6		1			6	

A=Adult, J=Juvenile, S=Subadult

[1]Diver transects, beach seine, 13-14 October
Gill net, otter trawls, 16 November

Table VIII.6. Ichthyoplankton egg and larvae totals standardized ($1000m^3$), 16 November 1995.

Species		Stations 2 S	2 B	5 S	5 B	8 S	8 B	
Gibbonsia elegans	L		13					
Gobiidae Type A/C+	L	11	1713		163		302	
Hypsoblennius spp.[1]	L		54		272	9		
Unknown Eggs	E	70	124	4	31	2	12	
				Subtotals				Totals
Totals, (standardized per $1000m^3$)	L	11	1780	0	435	9	302	2537
	E	70	124	4	31	2	12	243

L = Larvae E = egg S = surface B = bottom

\+ Gobiidae A/C = *Clevelandia ios*, *Ilypnus giberti* and/or *Quietula y-cauda*.

[1] *Hypsoblennius* spp. = a mix of *H. gentilis* and *H. jenkinsi* larvae too young to identify.

Table VIII.7. Fish species and numbers collected, 6 and 8 May 1996

	DIVER TRANSECTS BREAKWATER			BEACH SEINE	GILL NET STATIONS			OTTER TRAWL STATIONS		
	Terminal	South	North		#2	#5	#8	#2	#5	#8
Species										
Acanthogobius flavimanus				2						
Anchoa compressa				483						31
Anisotremus davidsoni				3						
Atherinops affinis		93A	4S	2800	2		31			
Chromis punctipinnis	14S	10S								
Citharichthys stigmaeus								1		
Clevelandia ios				22						
Cymatogaster aggregata		115J						1		
Embiotoca jacksoni	10A, 1S	1A,1S,40J	1J							
Fundulus parvipinnis				5						
Genyonemus lineatus								4		
Gibbonsia elegans		1A								
Girella nigricans	34A, 24S	14A, 6S	2A, 9S							
Gobiesox rhessodon								1		
Halichoeres semicinctus	1A									
Hermosilla azurea	1A	1S	2A							
Heterostichus rostratus	1J	1A, 1S								
Hypsopsetta guttulata								1		2
Hypsypops rubicundus	5A									

A=adult, S=subadult, J=juvenile

Table VIII.7. Continued

	DIVER TRANSECTS BREAKWATER			BEACH SEINE	GILL NET STATIONS			OTTER TRAWL STATIONS		
	Terminal	South	North		#2	#5	#8	#2	#5	#8
Species										
Ilypnus gilberti										1
Leptocottus armatus				1						
Micrometrus minimus		1J	1A, 3J							
Myliobatis californica	1A		1S							
Oxyjulis californica		1A								
Paralabrax clathratus	14A, 6S	5A, 1S								
Paralabrax nebulifer	7A, 2S	4A, 9S	2A, 4S					8		1
Paralichthys californicus								3	2	3
Phanerodon furcatus		8A								
Pleuronectidae (unid. turbot)		1S								
Pleuronichthys ritteri				1				2		
Rhacochilus vacca		6J	1A							
Strongylura exilis				4			3			
Umbrina roncador								3		
Urolophus halleri		2A								
Species/Station	10	16	8	9	1	0	2	9	1	5
# Fish/station	121	320	30	3321	2	0	34	24	2	38
Species/Technique		19		9		2			11	

A=adult, S=subadult, J=juvenile

Table VIII.8. **Ichthyoplankton egg and larvae totals standardized (per 1000m³), May 8, 1996.**

Species	Stations 2 S	2 B	5 S	5 B	8 S	8 B
Atherinopsis Californiensis				13		
Cheilotrema saturnum		10		13		
Engraulis mordax	14			214	10	1114
Gibbonsia spp.	14	10				
Gobiesox rhessodon		224		27		11
Gobiidae Type A/C	127	2540	324	39618	58	216
Lepidogobius lepidus		10				
Hypsoblennius spp.	324	286	312	723	68	97
Paraclinus integripinnis				13		
Unknown Larvae					10	
Unknown Eggs	146	140	14	23	65	500

Table VIII.9. Fall incidence of fish species and larval taxa in Marina del Rey, 1984 - 1995.

Year / Species	Fall 84	85	86	87	88	89	90	91	++92	93	94	95
Acanthogobius flavimanus			X	X	X					X		
Albula vulpes									X	X		
Anchoa compressa		X			X							X
Anchoa delicatissima				X								
Anisotremus davidsoni	X	X	X			X	X	X		X	X	
Atherinops affinis	X	X	X	X	X	X	X	X	X	X	X	X
Atherinopsis californiensis			X	X							X	
Atractoscion nobilis			X					X				
Cheilotrema saturnum	X	X	X	X	X	X		X	X		X	
Chitonotus pugetensis					X							
Chromis punctipinnis	X	X	X	X	X	X	X	X	X	X		X
Citharichthys stigmaeus						X						X
*Clevelandia ios**			X			X	X					
Clinocottus analis		X	X		X						X	
Cymatogaster aggregata	X					X	X		X			
Embiotoca jacksoni	X	X	X	X	X	X	X	X	X	X	X	X
Engraulis mordax	X		X		X	X	X	X	X	X	X	
Fundulus parvipinnis	X	X	X		X	X	X	X		X	X	
Genyonemus lineatus		X		X	X			X	X			
Gibbonsia elegans+		X	X	X		X	X	X	X		X	X
Gillichthys mirabilis			X							X		
Girella nigricans	X	X	X	X	X	X	X	X	X	X	X	X
Gobiesox rhessodon		X					X	X	X		X	
Gobiidae A/C*	X	X	X	X	X	X	X	X	X	X	X	X
Gobiidae non A/C											X	
Halichoeres semicinctus	X	X	X	X	X	X	X	X	X	X	X	
Hermosilla azurea	X	X	X		X		X			X	X	
Heterodontus francisci	X											
Heterostichus rostratus		X	X	X	X	X	X		X	X	X	
Hippoglossina stomata									X			
Hyperprosopon argenteum	X							X				
Hypsoblennius spp.[1]	X	X	X	X	X	X	X	X	X	X	X	X
Hypsoblennius gentilis		X	X	X								
Hypsoblennius gilberti			X							X		
Hypsoblennius jenkinsi	X									X	X	
Hypsopsetta guttulata	X		X	X	X	X	X	X	X	X		X
Hypsypops rubicundus	X	X	X	X	X		X	X		X	X	X
Ilypnus gilberti	X		X					X				
Kyphosidae											X	
Lepidogobius lepidus (= Gobiidae D larvae)	X	X		X	X			X				
leptocottus armatus			X			X		X	X		X	

* = *Clevelandia ios, Ilypnus gilberti* and/or *Quietula y-cauda;* if one or more species is also present as adult, duplicate count would result. A Gobiidae-non A/C occurred in October 94.

\+ = Larvae identifiable only to genus; no other species of *Gibbonsia* occurs in the area (=Clinidae Type A).

++ = diver survey, beach seine conducted on 3 December after completion of dredging.

1 larvae of *H. gilberti* and/or *H. jenkinsi*

Table VIII.9. Continued

Year / Species	Fall 84	85	86	87	88	89	90	91	++92	93	94	95
Medialuna californiensis				X								
Menticirrhus undulatus			X	X								
Micrometrus minimus	X	X	X	X	X	X	X	X		X	X	
Mugil cephalus	X	X	X	X	X	X	X	X	X		X	X
Mustelus californicus								X				X
Mustelus henlei				X								
Myliobatis californica			X	X	X	X		X	X		X	
Oligocottus/Clinocottus A						X		X				
Oxyjulis californica	X	X		X	X	X	X	X	X	X	X	X
Paraclinus integripinnis		X	X				X				X	
Paralabrax clathratus	X	X	X	X	X	X	X	X	X	X	X	X
P. maculatofasciatus	X	X	X	X		X	X					
Paralabrax nebulifer	X	X	X	X	X	X	X	X	X	X	X	X
Paralichthys californicus	X	X	X	X	X	X	X	X	X	X	X	X
Phanerodon furcatus				X	X			X			X	
Pleuronectidae										X	X	
Pleuronichthys coenosus		X		X								
Pleuronichthys ritteri		X	X	X	X	X	X			X		X
Pleuronichthys verticalis				X								
*Quietula y-cauda**			X			X						
Rhacochilus toxotes	X			X	X		X					
Rhacochilus vacca	X	X	X	X	X	X	X	X	X		X	X
Sarda chiliensis	X		X	X								
Sardinops sagax caeruleus	X	X	X	X			X		X		X	
Sciaenidae complex 2					X							
Scorpaena guttata										X		
Scorpaenichthys marmoratus						X						
Sebastes serranoides		X		X	X	X		X				
Semicossyphus pulcher				X	X							
Seriphus politus	X	X		X	X	X	X	X	X			
Sphyraena argentea	X	X		X			X					
Squatina californica		X										
Stenobrachius leucopsarus							X					
Strongylura exilis	X				X	X	X	X		X	X	
Symphurus atricauda	X											
Syngnathus sp.		X										
Syngnathus leptorhynchus				X			X					
Synodus lucioceps					X							
Umbrina roncador	X	X	X	X	X				X			X
Urolophus halleri			X					X				
Xenistius californiensis	X			X		X	X			X	X	
Xystreurus liolepis					X			X				X

Table VIII.10. Spring incidence of fish species and larval taxa in Marina del Rey, 1984-1996.

	Years											
Species	84	86	87	88	89	90	91	92	93	94	95	96
Acanthogobius flavimanus				X	X				X	X		X
Albula vulpes	X			X				X				
Anchoa compressa	X	X	X						X	X	X	X
Anisotremus davidsonii	X	X	X		X			X	X	X	X	X
Atherinops affinis	X	X	X	X	X	X	X	X	X	X	X	X
Atherinopsis californiensis		X	X		X					X		X
Aractoscion nobilis	X	X	X									
Brachyistius frenatus								X				
Cheilotrema saturnum		X	X	X	X	X	X					X
Chromis punctipinnis		X	X	X			X	X	X	X	X	X
Citharichthys stigmaeus	X		X									X
Clevelandia ios	X	X	X	X						X	X	X
Clinocottus analis	X			X	X		X					
Coryphopterus nicholsii			X		X				X			
Cymatogaster aggregata		X	X		X	X	X	X	X	X	X	X
Embiotoca jacksoni	X	X	X	X	X	X	X	X	X	X	X	X
Engraulis mordax	X	X	X	X	X	X	X	X	X	X	X	X
Fundulus parvipinnis	X		X	X		X	X		X		X	X
Genyonemus lineatus	X	X	X		X	X	X		X	X	X	X
Gibbonsia elegans	X				X	X	X			X		X
Gillichthys mirabilis							X			X		
Girella nigricans	X	X	X	X	X	X	X	X	X	X	X	X
Gobiesox rhessodon		X	X		X	X	X	X	X	X	X	X
Gobiidae type A/C					X	X	X	X	X	X	X	X
Halichoeres semicinctus	X	X	X	X	X		X	X	X	X	X	X
Hermosilla azurea					X			X	X	X		X
Heterodontus francisci	X				X	X	X					
Heterostichus rostratus	X	X	X	X	X	X	X	X	X	X		X
Hippoglossina stomata		X										
Hyperprosopon argenteum		X										
Hypsoblennius gentilis		X										
Hypsoblennius jenkinsi	X		X	X	X							
Hypsoblennius spp.	X	X	X	X	X	X	X	X	X	X	X	X
Hypsopsetta guttulata	X		X		X	X	X	X	X	X	X	X
Hypsurus caryi							X	X	X		X	
Hypsypops rubicundus	X		X	X	X	X	X	X	X	X	X	X
Ilypnus gilberti	X	X	X	X		X	X					X
Lepidogobius lepidus	X	X						X				X
Leptocottus armatus		X	X	X	X	X	X	X				X
Menticirrhus undulatus		X		X	X		X			X	X	
Micrometrus minimus	X	X	X	X	X	X	X	X	X	X		X
Mugil cephalus	X	X	X	X		X		X		X		

Table VIII.10. Continued

Species	Years											
	84	86	87	88	89	90	91	92	93	94	95	96
Mustelus henlei											X	
Mustelus californicus								X				
Mustelus sp.								X				
Myliobatis californica		X	X		X	X	X	X	X		X	X
Oxyjulis californica	X	X	X		X		X	X	X	X	X	X
Oxylebius pictus						X						
Paraclinus integripinnis					X	X				X	X	X
Paralabrax clathratus	X	X	X	X	X	X	X	X	X	X	X	X
P. maculatofasciatus	X	X	X		X	X	X	X				
P. nebulifer	X	X	X	X	X	X	X	X	X	X	X	X
Paralichthys californicus	X	X		X	X	X	X	X		X	X	X
Phanerodon furcatus		X			X	X	X		X			X
Pleuronectidae[1]												X
Pleuronichthys ritteri	X		X	X	X		X	X	X	X	X	X
P. verticalis		X				X	X					
Quietula y-cauda	X	X	X	X	X	X	X					
Rhacochilus toxotes						X	X		X			
R. vacca	X	X	X	X	X	X	X		X	X	X	X
Rhinobatos productus	X											
Sarda chiliensis	X											
Sardinops sagax caeruleus	X	X	X	X	X		X	X	X	X		
Sciaenidae II[2]			X			X						
Scorpaena guttata		X			X			X		X		
Scorpaenichthys marmoratus	X				X		X					
Sebastes auriculatus	X											
Sebastes serranoides	X	X		X								
Seriphus politus	X	X	X	X	X	X	X	X	X	X	X	
Sphyraena argentea		X		X		X			X			
Stenobrachius leucopsarus		X										
Strongylura exilis		X	X			X		X	X	X	X	X
Syngnathus leptorhynchus	X		X		X							
Syngnathus species						X	X					
Typhlogobius californiensis	X	X				X		X	X		X	
Umbrina roncador	X		X					X	X	X	X	X
Urolophus halleri	X		X	X	X		X	X	X		X	X
Xystreurys liolepis	X											

[1] Pleuronectidae = unidentifiable turbot larvae

[2] Sciaenidae II = larvae of *Atractoscion*, *Cheilotrema*, *Menticirrhus* or *Umbrina*

IX. EVALUATION OF SEA GRASS BEDS IN BASIN D, MARINA DEL REY

INTRODUCTION

Marina del Rey, the largest man-made marina in the world, was constructed on the remains of wetlands which formed part of the estuary for Ballona Creek. A small, sandy beach at the inner end of Basin D in the marina (Figure IX.1) is the last remnant of the wetlands. It is extremely valuable, in part, because it contains the only substantial occurrence of *Ruppia maritima*, a sea grass, in southern California.

The seagrass bed of *R. maritima* is an important primary producer in this basin and is a habitat for many species of crustaceans and fish, providing substrate and shelter for the organisms. A higher number of species of fish are observed in Basin D than in the other basins, probably because schools of fish come into the basin to feed on organisms living in the sea grass. *R. maritima* is visited by the now rare bone fish (e.g., Soule et al., 1996) and is a nursery for larval and juvenile fish (Soule et al., 1993, 1996).

Ruppia maritima beds were mapped in Basin D during the period from 1979 to 1981 and again in 1990 (Gregorio, 1982, 1990). A third study in 1991 found that the *R. maritima* beds had disappeared (Gregorio, 1991). This is a development worthy of concern, not only because the *R. maritima* beds are so rare and support a diverse fauna, but also because it is potentially an indicator of contamination or perturbation in the basin.

The water quality, microbiology, sediment contamination, benthic fauna and ichthyology of Marina del Rey have been studied by Harbors Environmental Projects of the University of Southern California since 1976. Soule and Oguri (1977, ff.) have published thirteen volumes on the marina through 1996. The *Ruppia maritima* studies were done as special projects for Soule and Oguri.

The purpose of this study was to assess the current status of *R. maritima* in Basin D and to compare it to the results from the previous studies.

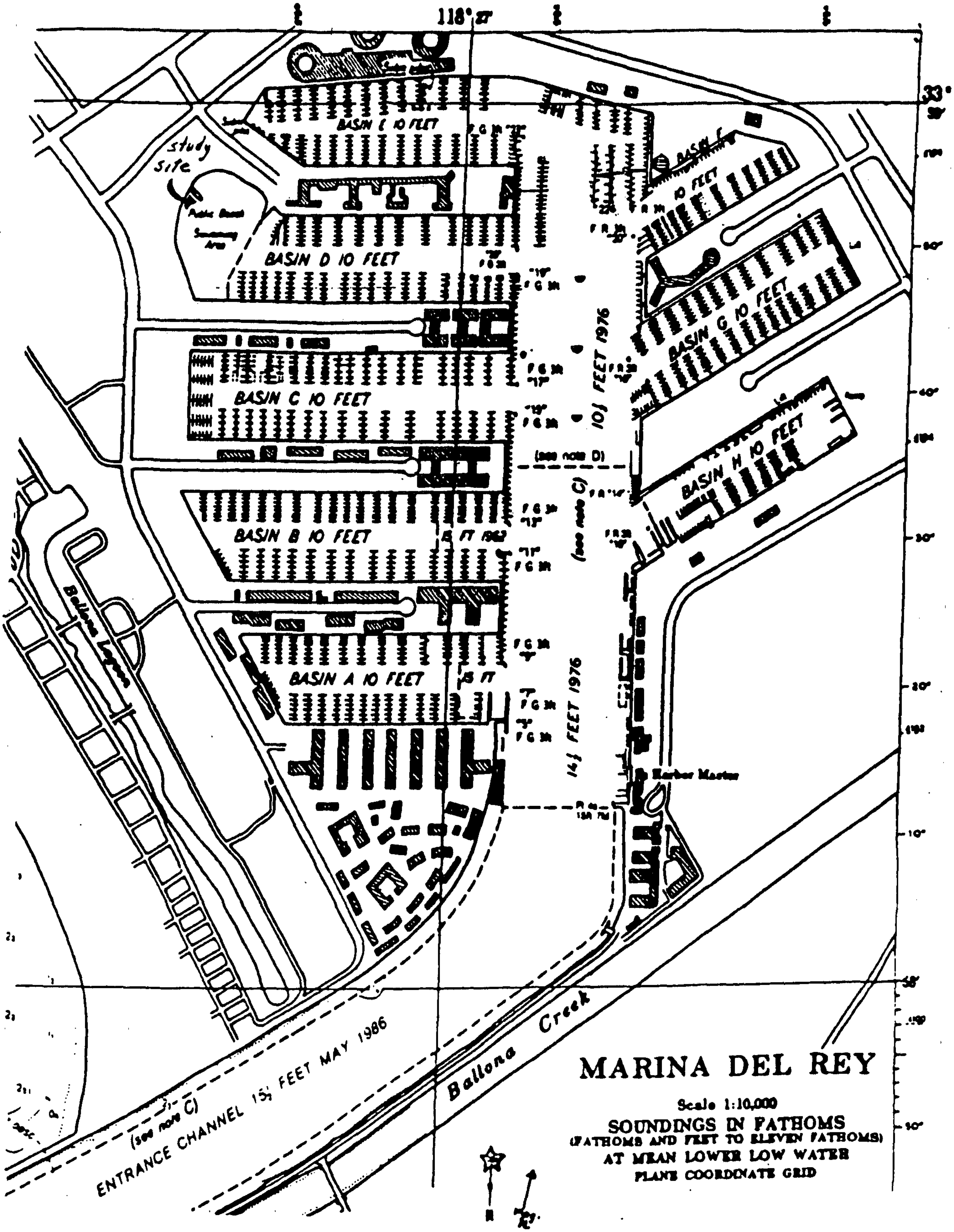


Figure IX.1, Marina chart with sea grass study site indicated in Basin D.

ACKNOWLEDGMENTS

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PROCEDURES

The presence and distribution of *Ruppia maritima* were determined in the swimming area at the inner end of Basin D. This underwater area was visually mapped by snorkeling and observations were recorded on underwater slates. Observations were made from January 1996 to April 1996, at low to medium tides, and during the morning hours.

RESULTS AND DISCUSSION

Two separate beds of *Ruppia maritima* were observed in Basin D (Figure IX.2). The small bed in the northwestern area of the basin was circular, approximately one meter in diameter. The seagrass in the bed was approximately six centimeters high. The larger bed was approximately seven meters long and three meters wide at its largest point. The length of the grass in this larger bed was varied, although it was never over fifteen centimeters high. In both beds, blades were shorter than in the previous studies.

The location and shape of the beds can be compared to previous surveys in 1979-1981 and 1990 (Gregorio, 1982, 1990). The general location of the larger bed was similar, although the shape was changed somewhat, and the present bed does not extend into the present swimming area (Figure IX.2). The location of the smaller bed recorded in 1990 (Gregorio, 1990) was in a similar location, but the bed was much smaller in 1996.

Several other species of flora and fauna were observed in and around the water of Basin D. Red algae, *Enteromorpha spp.*, *Colpomenia sinuosa*, *Egregia laevigata* and filamentous algae were observed. Mussels, sponges, tunicates, polychaete worms, sea hares and several unidentified species of fish were observed in addition to blennies.

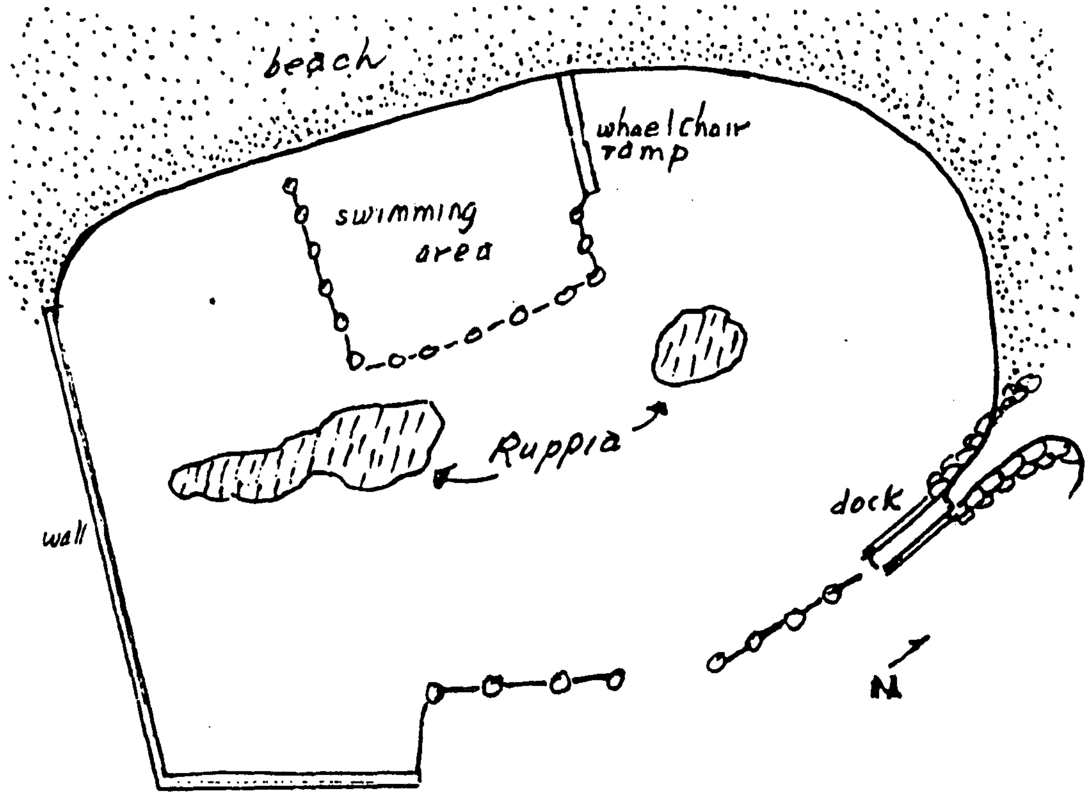

Figure IX.2. Location of seagrass *Ruppia maritima* in Basin D.

The percentage of finest grained silt (<number 200 sieve) at Station 8 in Basin D increased from 50.69 percent in October 1990 to 86.90 percent in May 1991, and to 91.88 percent in October 1991. There were heavy rains in March 1991 even though it was a low rainfall year. The increase in fines alone might account for impacts on the sea grass from changes in consolidation turbidity and perhaps in contaminants complexed to these finest sediments. The fines were greatly decreased in April and September 1994 to about 50 percent but by October 1995 they had increased to 96.2 percent (Soule et al., 1993, 1996), which may have decreased the *Ruppia* beds again. The 1994-1995 rainfall year was very high, which would have produced extensive runoff into the basin. February and March 1996 also had extensive rainfall, although 1995-1996 was not a high rainfall year.

CONCLUSIONS

The *Ruppia maritima* beds have regrown in Basin D. They have returned to roughly the same areas as sighted before, although the beds are not as widespread or as lush as they were in previous studies. In the previous studies, the blade length was longer and the beds covered more area.

Several limiting factors were present which could have affected the data. The water in Basin D was extremely turbid due to the silty bottom, cloudy weather, extensive rainfall and an abundance of phytoplankton. Therefore, it is possible that more areas of *Ruppia maritima* are present in the basin and were not seen. Another factor is that *R. maritima* is known to have a summer growth season (Gregorio, 1990). This could account for the discrepancy in the amount of *R. maritima* between previous studies and this one, since our study had to be completed during the spring.

The loss of the *Ruppia maritima* beds in 1991 may have been due to the impact of a great influx of sediment and possible contaminants in the basin in 1991. The return of *R. maritima* may have followed a reduction in sediment load in subsequent years.

In conclusion, it was found that two beds of *Ruppia maritima* returned to Basin D after 1991. They are roughly the same in location and shape as beds in previous studies, but are not as large and blade length is shorter than in previous studies.

By J. Aleah Nesteby, Long Beach Polytechnic High School and Dorothy F. Soule, University of Southern California, Los Angeles 90089-0371.

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APPENDIX A

CRUISE LOGS

JULY 1995 - JUNE 1996

WATER SAMPLING MDR: 6 July 1995

Martek, Coliform, BOD, Sal, DO, pH, Transmissometer, Secchi Disk

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PERSONNEL:

D. Soule, PI.,	USC
M. Oguri	USC
R. Pieper	USC
T. Van Tress	USC
A. Zeller	USC

VESSEL: *Bay Watch*

S. Butler
B. Hogue

TIDE PDT: HIGH 0420 3.2 ft. - LOW 0950 1.6 ft
WEATHER: High fog
RAIN: 0.0
LEFT DOCK: 0803

STATIONS	TIME	WIND/K		COMMENTS
12	0812	W	5	Water clear but green, a fish jumping. Ran to Venice Pier. Fog low
1	0817	W	5	Shallow water, tide dropping, flat calm
2	0833	W	5	Clear of debris
3	0840	W	6	
4	0850	W	5	
25	0855	W	6	Fog coming in
5	0905	NW	6	Wind switched
6	0915	W	6	Fog low
18	0935	W	7	
8	0940	SW	6	
19	0940	SW	6	Hand sampled from beach
10	0955			
20	1003	SW	5	Dock being rebuilt for larger vessels
11	1012	SW	0-7	Gusty
9	1020	SW	9	
7	1033	SW	6-7	
13	1059			Hand sampled from shore
22	1110			Hand sampled from shore, tide low. Lots of enteromorpha alga

WATER SAMPLING MDR: 10 August 1995

Martek, Coliform, BOD, Sal, DO, pH, Transmissometer, Secchi Disk

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PERSONNEL: D. Soule, PI., USC
M. Oguri USC
R. Pieper USC
T. Van Tress USC
J. Kendrick USC

VESSEL: *Bay Watch*

S. Butler

VOLUNTEER: M. Sandrene, Intern, CSU Marine Institute

TIDE PDT: HIGH 1007A - 5.0 ft - LOW 0347A - 1.0, 1532P 1.2 ft
WEATHER: Clear, cool
RAIN: 0.0
LEFT DOCK: 0750

STATIONS	TIME	WIND/K		COMMENTS
				Rising tide
12	0805			Clean
1	0812	S	4	Water clean
				Outside breakwater 4 ft swell ± 10 sec interval from south. Tropical storm off Baja California
2	0828	SE	4	
3	0835	S	5	Floating trash between 3-4
4	0842	S	5	
25	0850	S	6	Floating kelp, trash
5	0900	S	6	"Bay Watch" being filmed
6	0915	S	6	
18	0935	S	7	Tide dropping
19	0935			Hand sampled from beach
8	0940	S	4	
10	0954	S	4	Clam shell dredge is churning up sediment in last slips, water black, sulfide smell, 350 cu yds sediment have been removed to Bakersfield dump where docks were torn out. Sed curtain around site for *RegentSea* but water seeping into adjacent water
20	1005	S	4	
11	1020	S	5	
9	1029	S	4	Lots of kids in sabots sailing
7	1042	SW	7	

WATER SAMPLING MDR: 10 August 1995, cont'd.

Martek, Coliform, BOD, Sal, DO, pH, Transmissometer, Secchi Disk

STATIONS	TIME	WIND/K		COMMENTS
13	1110	W	8	Hand sampled from shore. Lots of ducks swimming, many smelt inside tide gates, water somewhat black from "dredging" (stirring/leveling) on other side of gate
22	1115			Hand sampled from shore. Need new key

WATER SAMPLING MDR: 7 September 1995

Martek, Coliform, BOD, Sal, DO, pH, Transmissometer, Secchi Disk

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PERSONNEL:

D. Soule, PI.,	USC
M. Oguri	USC
R. Pieper	USC
T. Van Tress	USC
C. Kendrick	USC

VESSEL: *Bay Watch*

S. Butler
J. Rosenstein

TIDE PDT: HIGH 0901 5.2 ft. - LOW 1441 1.0 ft
WEATHER: Hot, sultry, scattered high clouds, rainbow
RAIN: 0.0
LEFT DOCK: 0820

STATIONS	TIME	WIND/K		COMMENTS
12	0827	SW	3	12x12 lumber in channel, washed from freeway in spring storms, now floating in the high tide, wandering
1	0835	SW	5	Water very clear
2	0840	W	6	
3	0845	W	7	Getting cloudier
4	0900			
25	0910			Hotter, sultry, clearing
5	0916			
6	0927			
18	0945	W	4	Water greenish, floating sea grass, mullet jumping, uprooted plants
19	0945			Hand sampled from beach
8	0950	SW	4	Few people on beach
10	1006	SW	5	New docks under construction, may not get in to Sta. 20
20	1013			Got in to W side, rest of area full of rubble. Large fish jumping by Station 10. Small slick; boater says "it has been here a week"
11	1025	S	4	Water green
9	1033	S	6	
7	1045			
13	1110			Hand sampled from shore
22	1118			Hand sampled from shore

WATER SAMPLING MDR: 5 October 1995

Martek, Coliform, BOD, Sal, DO, pH, Transmissometer, Secchi Disk

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PERSONNEL: D. Soule, PI., USC
M. Oguri USC
T. Van Tress USC
C. Kendrick USC
VOLUNTEER: V. Marinkovitch

VESSEL: *Bay Watch*

S. Butler
D Holden

TIDE PDT: HIGH 0759 5.1 ft. - LOW 1356 1.0 ft
WEATHER: Foggy, clear by 9AM
RAIN: 0.0
LEFT DOCK: 0810

STATIONS	TIME	WIND/K		COMMENTS
12	0817	N	5	Foggy
1	0825	N	5	Floating debris
2	0835	N	5	
3	0847			
4	0858			
25	0910	N	2-5	
5	0922			Water clean
6	0930	N	3.5	
18	0950			
19	0950			Hand sampled from beach
8	0955			
10	1012			Large crane on barge being moved into slip
20	1020			Unable to get into slip. Starting dredging work
11	1023	S	5	
9	1035	SW	4	
7	1047	SW	7	
13	1115			Hand sampled from shore. Fresh water flowing into Marina
22	1125			Hand sampled from shore

PERSONNEL: D. Soule PI., USC
M. Oguri USC
R Pieper USC
B. Jones USC
T. Van Tress USC
C. Kendrick USC

RESEARCH VESSEL: *Golden West*
SKIPPER Marty Maher

SCCWRP: Ann Brierton Zeller, Consultant
GERLINGER ASSOC.: T. Gerlinger

ASSOCIATED LABS: B. Webber
M. Ritter

WEATHER: Clear
RAIN: 0.0
LEFT DOCK: 0840

STATION	TIME	RESULTS AND COMMENTS
12	0900	1st grab jammed with plastic sack, debris. 2nd grab okay, sulfide smell, 2 large jars. **Water samples taken for Sea Grant & L. A City (B. Jones).** **Extra grab taken for SCCWRP, 2 grabs extra for Gerlinger for <u>Neanthes</u> worms**
1	0920	**Extra grab taken for SCCWRP**
	0940	1 grab, sandy, 2 large jars
2	0955	1st grab plastic bag jam. 2nd grab plastic bag jam. **Extra grab for SCCWRP**
3	1020	1st grab jammed with mussels, large clusters in sand. Next grab mud. 2 small jars
4	1035	1 jar
25	1045	1 jar
5	1120	1 jar
6	1140	1 jar
10	1145	1 jar
8	1155	1 Jar
11	1230	1 Jar
9	1245	1 jar
7	0110	1 Jar
13		Oxford Street Flood Control Basin, hand sampled from shore for Chemistry only
22		Oxford Street Flood Control Basin, hand sampled from shore for Chemistry only

WATER SAMPLING MDR: 16 November 1995

Martek, Coliform, BOD, Sal, DO, pH, Transmissometer, Secchi Disk

PERSONNEL:	D. Soule, PI.,	USC	VESSEL: *Bay Watch*
	M. Oguri	USC	
	R. Pieper	USC	S. Butler
	T. Van Tress	USC	B. Harkness
	C. Kendrick	USC	
ASSOCIATED LABS.	Bob Webber		

TIDE PST: HIGH 0452 4.4 ft. - LOW 1058 2.3 ft
WEATHER: Foggy
RAIN: 1 Nov. - 0.2"
LEFT DOCK: 0805

STATIONS	TIME	WIND/K		COMMENTS
12	0818			
1	0825	N	5	Oxy boat doing trawls
2	0835	N	7.5	
3	0842	N	5	Tide flowing heavily out of tide gate
4	0850			
25	0900	N	4	Derelict vessel from fire at sea tied up since Oct, diesel slick by dock.
5	0907	N	3	Heavy fog
6	0917	NE	4	
18	0937			Many gulls on beach
19	0937			Hand sampled from beach
8	0945			
10	1000			Docks complete, *RegentSea, Dandiana* in
20	1005			Station nearer Edies' Diner on westside due to docked vessel
11	1015	NE	4	
9	1025			
7	1037			
13	1105			Hand sampled from shore
22	1128			Hand sampled from shore

WATER SAMPLING MDR: 14 December 1995

Martek, Coliform, BOD, Sal, DO, pH, Transmissometer, Secchi Disk

PERSONNEL: D. Soule, PI., USC
M. Oguri USC
R. Pieper USC
T. Van Tress USC
C. Kendrick USC

VESSEL: *Bay Watch*

T. Estlow
T. Whitmore

TIDE PDT: HIGH 1334 3.5 ft. - LOW 0842 2.7 ft
WEATHER: Sunny, cool
RAIN: 13 Dec. - 0.5", 14 - 0.3"
LEFT DOCK: 0810

Many pelicans on dock

STATIONS	TIME	WIND/K	COMMENTS
12	0825	In lee of bridge	Water chocolate brown, lots of trash stranded by high tide on jetty, visibility 6", lots of surge
1	0835	N 7	Water very brown from surf over breakwater, surge up the channel
2	0840	N 6	Rough - heavy swells from NW. Another storm coming
3	0855	N 4	Tide gate open, big flight of least tern
4	0900		Warm and calm
25	0900		
5	0918	NW 5	
6	0928	E 6	
18	0947		Pelicans on dock. Kelp floating
19	0947		Hand sampled from beach
8	0955		
10	1010		
20	1015		*RegentSea* using soapsuds, running into water
11	1025	E 3	
9	1037		
7	1050	SW 5	
13	1110		Hand sampled from shore
22	1120		Hand sampled from shore

WATER SAMPLING MDR: 4 January 1996

Martek, Coliform, BOD, Sal, DO, pH, Transmissometer, Secchi Disk

PERSONNEL: D. Soule, P.I. USC
M. Oguri USC
T. Van Tress USC
C. Kendrick USC
ASSOCIATED LAB. Bob Webber
SCMI TRAINEE: Melanie Nagy

VESSEL: *Bay Watch*

T. Estlow
P. Navarro

Guest: Michele MaCabe

TIDE PST: HIGH 0750 6.0 ft. - LOW 1459 -0.5 ft
WEATHER: High fog, low clouds
RAIN: 23 Dec. - 0.7"
LEFT DOCK: 0810

STATIONS	TIME	WIND/K		COMMENTS
12	0825			Water calm with swells 12 sec. intervals
1	0837	N	5	Floating plastic cups washed from rocks by high tide
2	0847	N	4	Racing shells on station
3	0900			
4	0913			Overcast, chilly
25	0923			
5	0935			
6	0946	NE	3	
18	1005	NE	5	
19	1005			Hand sampled from beach
8	1010	NE	4	
20	1028			Vessel tied up at normal station, readings taken beside it. *Chelsea* party boat, *RegentSea*
10	1033		<2	
11	1042		<2	Overcast
9	1052	N	4	
7	1105	SW	5	Still overcast, wind switched to SW
13	1120			Hand sampled from shore
22	1130			Hand sampled from shore

WATER SAMPLING MDR: 1 February 1996

Martek, Coliform, BOD, Sal, DO, pH, Transmissometer, Secchi Disk

PERSONNEL: D. Soule, P.I. USC
M. Oguri USC
R. Pieper USC
T. Van Tress USC

VESSEL: *Bay Watch*

T. Estlow

SCMI: Carrie Wolf

TIDE PDT: HIGH 0705 506 ft. - LOW 1411 -0.3 ft
WEATHER: Weather clearing after 2" rain downtown & foothills
RAIN: 31 Jan. - 2.0"
LEFT DOCK: 0805 Dock slips full of CRUD: Plastics, tennis balls, pine needles, from high tide and rainfall

STATIONS	TIME	WIND/K		COMMENTS
				± 50 killer whales off Palos Verdes last Monday. Big fire Sea Castle Hotel Santa Monica - smoke towering all morning
12	0818			Surge rolling up channel at long 20 second intervals, birds feeding in creek bed
1	0828			Heavy swells coming over breakwater. Many terns, pelicans feeding
2	0837			Shoal markers moved from south jetty toward breakwater by storm.
3	0845			Tide flow strong from Ballona Lagoon
4	0854			Large group of cormorants on rocks resting
25	0903			Skimmer boat out but not picking up anything
5	0911			Partly cloudy with thunderheads, blue sky
6	0921	W	3	Clouding over
18	0937	SW	5	Foam on water
19	0937	SW	5	Hand sampled from beach
8	0950	SW	8	Foam clumps, may be sewage?
10	1008	SW	3	
20	1015			Slip very crowded with all boats in
11	1025	SW	5	Clearing, clouds still lingering
				Hotel fire in Santa Monica still pouring black smoke
9	1035	W	10	Front to west moving in

STATIONS	TIME	WIND/K	COMMENTS
7	1047	W 6	
13	1115		Hand sampled from shore
22	1120		Hand sampled from shore

WATER SAMPLING MDR: 14 March 1996

Martek, Coliform, BOD, Sal, DO, pH, Transmissometer, Secchi Disk

PERSONNEL: D. Soule, PI. USC
M. Oguri USC
R. Pieper USC
T. Van Tress USC
C. Kendrick USC

VESSEL: *Bay Watch*

S. Butler

TIDE PST: HIGH 0439 5.1 ft. - LOW 1153 -0.3 ft
WEATHER: Sunny, calm following heavy rains. Snow visible on Mt Wilson
RAIN: 4 Mar. - 0.7", 5 - 0.5", 12 - 2.0", 13 - 1.4", 14 - 0.4"
LEFT DOCK: 0810

STATIONS	TIME	WIND/K		COMMENTS
				Water very green near breakwater, no debris
12	0825			Water chocolate brown
1	0832			Very calm, low swells
2	0839	N	4	Gusts to 4 K
3	0847	NW	4	Water flowing out of Ballona Lagoon
4	0855	W	5	Cormorants on rocks
25	0902	W	5	Floating kelp, scattered trash 2 pair mallards
5	0910	W	6	Water green
6	0920	SW	5	Calm
				Debris near end of main channel (not on station)
18	0935	SW	5	Tide very low
19	0935	SW	5	Hand sampled from beach
8	0940	SW	7	Water clear, green
10	0957	SW	5	Clouds gathering in east
20	1000	SW	6	*Chelsea* party boat at tide gate. Sample taken by wall beside Edie's diner. Mussel clusters on wall
11	1010	SW	5	Water low
7	1017	SW	6	
9	1017	SW	6	
13	1056			Hand sampled from shore. Water flowing into MDR
22	1102			Hand sampled from shore

WATER SAMPLING MDR: 4 April 1996

Martek, Coliform, BOD, Sal, DO, pH, Transmissometer, Secchi Disk

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PERSONNEL:		
	M Oguri	USC
	R. Pieper	USC
	T. Van Tress	USC
	R. Bester	USC
	M. McCabe	

VESSEL: *Bay Watch*

Tom Estlow
Phil Navarro

TIDE PST: HIGH ft. - LOW ft
WEATHER: Warm, Sunny, calm
RAIN: 12 Mar. - 2.0", 13 - 1.4", 14 - 0.4", 28 - 0.1"
LEFT DOCK: 0850

Red tide off shore from Santa Monica to Redondo for the past two weeks, but not in Marina del Rey, coincided with rainy period.

STATIONS	TIME	WIND/K		COMMENTS
				Gusty winds coming up at dock. Lot of plastic in water.
12	0902	SW	4	Water clean
1	0911	SW	4-6	Low swells
2	0917	SW	4	Lots of Pelicans on breakwater. Dredging being done. Taking sand over to beach. Took several pictures. Debris in water near dredge boat.
3	0941	SW	6-7	Gate closed
4	0951	SW	7	Water getting very choppy
25	0959	SW	7	No lifeguard boats docked, all dispersed to different areas
5	1008	SW	7-9	Clear
6	1018	S	7	Slight ripple
18	1035	SW	6	
19	1035	SSW	6	Hand sampled from beach
8	1040	SW	7-8	Clear and calm
10	1055	SW	6	
20	1102			
11	1109	SW	5	Calm, water low
9	1118	SW	7-8	
7	1129	SW	9	
13				Hand sampled from shore.
22				Hand sampled from shore

WATER SAMPLING MDR: 2 May 1996

Martek, Coliform, BOD, Sal, DO, pH, Transmissometer, Secchi Disk

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PERSONNEL:

M Oguri	USC
R. Pieper	USC
D. Soule	USC
T. Van Tress	USC
C. Kendrick	USC

VESSEL: *Bay Watch*

Tom Estlow
Phil Navarro

TIDE PDT: HIGH 0935 4.3 ft. - LOW 1504 1.0 ft
WEATHER: Partial high fog, temp. mild
RAIN: 16 Apr. - 1.0", 18 - 0.3"
LEFT DOCK: 0805

Red tide was present off Santa Monica two weeks ago, phosporescent at night (17th). Coincided with rainy period.

STATIONS	TIME	WIND/K		COMMENTS
12	0817			2 ft. swell, 16 second interval
1	0825			Very calm
2	0830	<2		Partial overcast
3	0840			
4	0848	SW	6	Partial clearing
25	0855	SW	6	Floating trash, bait boat in, many terns, gulls, pelicans
5	0903	W	6	
6	0916	SW	3	Mild gusts
18	0938	SW	7	
19	0938	SW	7	Sample from shore
8	0940	SW	4	
10	0955	SW	4	Mostly clear. Mallard pair with 18 babies.
20	1003	S	5	
11	1010	SW	5	3 more mallard pairs
9	1020	SW	5	
7	1038	SW	8	Clear
13	1050			Hand sampled from shore
22	1105			Hand sampled from shore

WATER SAMPLING MDR: 13 June 1996

Martek, Coliform, BOD, Sal, DO, pH, Transmissometer, Secchi Disk

PERSONNEL: M Oguri USC
D. Soule USC
T. Van Tress USC
C. Kendrick USC

VESSEL: *Bay Watch*

Shelley Butler

SCMI: Jeff Zwahler

TIDE PDT: HIGH 0908 3.8 ft. - LOW 1402 1.8 ft
WEATHER: Sun beginning to break through
RAIN: 16 May - 0.1"
LEFT DOCK: 0810

STATIONS	TIME	WIND/K		COMMENTS
12	0820	E	5	
1	0827	SE	2	
2	0835	SE	5	
3	0845	W	4	Sun out
4	0855	W	7	Flat calm inside, wind rising
25	0913	SW	5	Water clean
5	0913	SW	6	
6	0925			
19	0943	SW	6	
18	0943	SW	6	
8	0950	SW	8	
10	1005	SW	8	
20	1010	SW	9	
11	1020	SW	7	
9	1032	SW	10	
7	1045	SW	10	
13	1110			Land sampling. Several bat rays about 12" diameter trapped in Oxford Basin
22	1115			Land sampling

APPENDIX B

PHYSICAL WATER QUALITY DATA

JULY 1995 - JUNE 1996

Table B1. Physical Water Quality Data. 6 July 1995

CRUISE: MDR 95-96
WEATHER: Overcast, light haze, cool
PRIOR RAINFALL: 16 June 1.9″

TIDE	TIME	HEIGHT (ft)
High	0420 PST	3.2
Low	0950 PST	1.6

Station Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Tran %T	FU	Secchi m	NH3+NH ug-at/l	BOD mg/l
1	0821	0	19.3	32.8	7.6	8.2	80	11	2.5 +	4.8	2.5
5k W		1	19.5	33.4	7.6	8.2	80				
		2	19.2	34.1	7.6	8.2	81			7.7	2.2
2	0832	0	20.9	34.4	7.7	8.1	68	11	1.8	2.9	1.9
5k W		1	20.9	34.4	7.5	8.1	68				
		2	20.7	34.4	7.4	8.1	68			7.6	2.1
		3	19.8	34.4	7.6	8.2	72				
		4	18.9	34.8	7.6	8.2	76			3.5	2.1
		5	17.3	34.7	6.7	8.1	80				
3	0840	0	20.6	34.4	6.8	8.0	76	11	2.2	9.6	1.2
6k W		1	20.4	34.5	6.1	8.0	78				
		2	20.2	34.5	6.2	8.0	77			5.6	1.2
		3	20.1	34.5	6.6	8.1	74				
		4	18.8	34.7	7.0	8.1	75			5.1	1.1
		5	18.3	34.8	7.2	8.2	78				
4	0850	0	21.1	34.4	7.1	8.1	73	11	2.0	3.3	1.3
5k W		1	21.1	34.4	7.3	8.1	73				
		2	21.1	34.5	7.3	8.1	73			3.4	1.7
		3	20.6	34.5	6.8	8.1	73				
		4	18.7	34.8	6.6	8.1	71			4.5	1.3
5	0905	0	21.5	34.3	7.2	8.1	71	11	2.0	4.0	1.2
6k NW		1	21.2	34.5	7.3	8.1	70				
		2	21.4	34.5	7.1	8.1	70			5.1	1.4
		3	21.1	34.5	6.5	8.1	62				
		4	19.6	34.5	6.8	8.1	67			4.8	1.3
		5	19.1	34.8	6.9	8.1	55				
6	0916	0	21.1	34.7	7.0	8.1	72	11	2.4	4.1	1.2
6k W		1	21.2	34.6	7.0	8.1	73				
		2	21.2	34.6	7.0	8.1	73			4.7	1.1
		3	21.2	34.6	6.5	8.1	73				
7	1031	0	21.4	34.6	6.8	8.1	66	11	1.6	4.3	1.1
9k SW		1	21.5	34.7	6.7	8.1	66				
		2	21.5	34.6	6.7	8.1	66			4.8	1.3
		3	20.8	34.8	6.1	8.0	57				

Table B1. 6 July 1995. (continued)

Station Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Tran %T	FU	Secchi m	NH3+NH ug-at/l	BOD mg/l
8	0940	0	21.5	34.8	7.5	8.1	68	10	1.5	4.9	1.2
6k SW		1	21.6	34.7	7.3	8.1	68				
		2	21.6	34.6	7.0	8.1	68			4.6	1.4
		3	21.5	34.6	6.6	8.1	64				
9	1018	0	21.5	34.2	6.6	8.0	67	12	1.5	5.6	1.3
9k SW		1	21.7	34.2	6.8	8.0	66				
		2	21.5	34.5	7.1	8.1	58			4.6	1.6
		3	21.1	34.7	5.9	8.0	49				
10	0958	0	21.7	34.1	5.8	8.0	61	11	1.5	6.9	1.4
0		1	21.7	34.3	5.7	8.0	59				
		2	21.7	34.4	5.1	8.0	56			9.2	1.6
		3	21.2	34.6	5.3	8.0	49				
11	1012	0	21.5	34.3	6.6	8.0	83	11	2.0	6.1	0.9
7k SW		1	21.5	34.4	6.7	8.0	80				
		2	21.5	34.5	6.8	8.1	69			6.5	1.2
		3	21.2	34.5	6.6	8.1	57				
12	0815	0	21.4	24.8	6.7	8.2	75	14	2.5	7.3	4.2
5k W		1	19.9	31.8	5.9	8.0	87				
		2	18.7	34.0	7.0	8.1	88			6.2	2.2
13	1059	0	23.4	33.7	1.0	7.8				9.0	2.8
18	0935	0	21.5	34.5	7.1	8.1	66	10	1.5	4.7	1.6
7k W		1	21.6	34.6	6.9	8.1	64				
19	0935	0								4.7	1.8
20	1003	0	21.6	34.2	5.6	7.9	69	12	1.5	8.1	2.0
5k SW		1	21.7	34.3	5.8	8.0	60				
		2	21.5	34.5	4.9	8.0	56			8.1	1.6
22	1110	0	21.8	20.7	8.3	8.2				7.9	4.3

Table B1. 6 July 1995. (continued)

Station Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Tran %T	FU	Secchi m	NH3+NH ug-at/l	BOD mg/l
25	0857	0	21.3	34.3	7.3	8.1	73	11	2.0	3.5	1.4
6k W		1	21.4	34.5	7.2	8.1	73				
		2	21.3	34.5	7.1	8.1	73			4.7	1.3
		3	20.0	34.8	6.5	8.1	73				
		4	18.9	34.8	6.6	8.1	69			6.0	1.3
		5	18.4	34.8	6.7	8.1	68				
	Average		20.8	34.1	6.68	8.08	69.5	11.2	1.9	5.64	1.68
	Number		66	66	66	66	64	15	15	37	37
	St. Dev.		1.12	2.08	0.95	0.07	8.16	0.91	0.37	1.76	0.74
	Maximum		23.4	34.8	8.25	8.22	88	14	2.5	9.58	4.28
	Minimum		17.3	20.7	0.99	7.84	49	10	1.5	2.90	0.90

Table B2. Physical Water Quality Data. 10 August 1995

CRUISE: MDR 95-96
WEATHER: Clear, warm
PRIOR RAINFALL: 0.0"

TIDE	TIME	HEIGHT (ft)
High	1007 PST	5.0
Low	1432 PST	1.2

Station Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Tran %T	FU	Secchi m	NH3+NH ug-at/l	BOD mg/l
1	0814	0	20.6	34.4	7.7	8.2	80	4	3.0 +	4.6	1.3
4k S		1	20.6	34.4	7.7	8.2	82				
		2	20.4	34.4	7.8	8.2	83			4.9	1.3
2	0826	0	20.4	34.4	7.7	8.2	81	4	3.7	5.0	1.6
4k SE		1	20.4	34.4	7.7	8.2	81				
		2	20.3	34.4	7.7	8.2	81			5.3	1.2
		3	20.3	34.4	7.8	8.2	81				
		4	20.3	34.4	7.7	8.2	81			5.3	1.2
		5	20.3	34.4	7.7	8.2	80				
3	0835	0	20.2	34.4	7.8	8.2	79	5	2.5	6.6	1.2
5k S		1	20.2	34.4	7.9	8.2	80				
		2	20.2	34.4	7.7	8.2	80			6.4	1.2
		3	20.2	34.5	7.7	8.2	80				
4	0844	0	20.8	34.2	7.3	8.1	79	5	2.2	7.5	1.2
5k S		1	20.7	34.3	7.2	8.1	78				
		2	20.5	34.3	7.4	8.2	74			7.5	1.0
		3	20.4	34.3	7.5	8.2	73				
		4	20.3	34.3	7.6	8.2	72			7.6	1.2
		5	20.3	34.4	7.5	8.2	71				
5	0901	0	21.2	34.1	7.8	8.1	76	6	2.3	6.4	1.1
6k S		1	21.2	34.2	7.6	8.1	74				
		2	21.1	34.3	7.3	8.1	68			6.5	1.1
		3	21.0	34.4	7.4	8.1	66				
		4	20.8	34.4	7.3	8.1	62			6.6	1.4
		5	20.6	34.4	7.1	8.1	57				
6	0916	0	21.5	34.3	7.4	8.1	81	6	3.5	6.7	1.0
6k S		1	21.5	34.3	7.4	8.1	80				
		2	21.4	34.3	7.6	8.1	80			6.8	0.9
		3	21.3	34.3	7.5	8.1	80				
		4	21.2	34.3	6.8	8.1	79			6.7	1.0
7	1042	0	21.6	34.5	7.1	8.0	72	7	2.4	6.0	1.2
7k SW		1	21.5	34.5	7.0	8.0	73				
		2	21.5	34.5	7.0	8.0	73			6.5	1.2
		3	21.4	34.5	6.9	8.0	75				
		4	21.0	34.5	6.6	8.0	69			7.2	1.1

Table B2. 10 August 1995. (continued)

Station Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Tran %T	FU	Secchi m	NH3+NH ug-at/l	BOD mg/l
8	0940	0	21.9	34.3	7.3	8.1	79	6	2.5	6.5	1.2
4k S		1	21.8	34.3	7.4	8.1	75				
		2	21.7	34.3	7.3	8.1	65			5.6	1.3
		3	21.7	34.3	7.2	8.1	70				
		4	21.4	34.4	6.2	8.0	58			5.8	1.6
9	1029	0	22.1	34.3	7.4	8.0	74	7	2.1	5.8	1.4
4k S		1	22.1	34.3	7.2	8.1	81				
		2	21.7	34.3	7.2	8.1	62			5.5	1.1
		3	21.2	34.4	6.5	8.0	71				
		4	20.8	34.4	6.4	8.0	57			6.4	1.3
10	1000	0	22.1	34.3	6.7	8.0	57	11	1.5	6.4	1.4
4k S		1	22.1	34.2	6.8	8.0	56				
		2	21.9	34.2	6.7	8.0	59			6.3	2.0
		3	21.7	34.3	6.2	8.0	60				
		4	21.4	34.4	5.2	7.9	54			7.6	1.7
11	1020	0	22.0	34.3	7.0	8.0	75	7	2.6	7.6	1.0
5k S		1	22.0	34.2	6.9	8.0	78				
		2	21.8	34.3	7.0	8.1	74			5.8	1.1
		3	21.3	34.4	6.7	8.0	63				
		4	21.0	34.4	6.2	8.0	47			5.6	1.4
12	0807	0	20.5	34.2	7.7	8.2	82	4	3.7	4.5	1.4
0		1	20.5	34.2	7.5	8.2	84				
		2	20.5	34.2	7.5	8.2	84			4.7	1.2
		3	20.5	34.2	7.5	8.2	84				
13	1109	0	22.2	34.2	5.1	7.8				12.7	1.9
18	0935	0	21.9	34.3	7.3	8.1	71	5	2.5 +	8.4	1.2
7k S		1	21.9	34.3	7.3	8.1	75				
		2	21.9	34.3	7.3	8.1	75			7.9	1.2
19	0935	0								8.8	1.5
20	1006	0	22.0	34.2	6.5	8.0	61	12	1.5	7.9	2.1
		1	22.0	34.2	6.3	8.0	61				
		2	21.7	34.2	5.6	7.9	52			8.1	2.0
		3	21.7	34.3	5.5	7.9	52				
22	1119	0	23.7	33.9	6.9	8.0				7.6	4.9

Table B2. 10 August 1995. (continued)

Station Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Tran %T	FU	Secchi m	NH3+NH ug-at/l	BOD mg/l
25	0850	0	20.9	34.2	7.1	8.1	77	6	1.8	5.6	1.1
6k S		1	20.7	34.3	7.2	8.1	66				
		2	20.5	34.4	7.3	8.2	63			5.7	1.0
		3	20.4	34.4	7.3	8.2	63				
		4	20.3	34.4	7.4	8.2	61			5.9	1.0
		5	20.3	34.4	7.3	8.2	59				
	Average		21.1	34.3	7.12	8.09	71.5	6.3	2.5	6.58	1.38
	Number		74	74	74	74	72	15	15	43	43
	St. Dev.		0.71	0.10	0.60	0.09	9.50	2.27	0.68	1.41	0.61
	Maximum		23.7	34.5	7.87	8.21	84	12	3.7	12.72	4.86
	Minimum		20.2	33.9	5.07	7.75	47	4	1.5	4.46	0.90

Table B3. Physical Water Quality Data. 7 September 1995

CRUISE:	MDR 95-96	TIDE	TIME	HEIGHT (ft)
WEATHER:	Clear, warm	High	0901 PST	5.2
PRIOR RAINFALL: 0.0″		Low	1441 PST	1.0

Station Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH ug-at/l	BOD mg/l
1	0837	0	21.1	34.1	7.5	8.3	75	4	4.0 +	3.04	1.4
5k SW		1	21.0	34.1	7.6	8.3	77				
		2	20.7	34.2	7.6	8.3	77			2.99	1.2
		3	20.7	34.2	7.8	8.3	77				
2	0842	0	21.3	34.4	8.1	8.3	76	4	6.5 +	2.68	0.8
6k W		1	21.3	34.4	7.8	8.3	77				
		2	21.0	34.4	7.6	8.3	77			2.46	0.9
		3	20.8	34.3	7.6	8.3	77				
		4	20.7	34.3	7.7	8.3	77			4.40	1.1
		5	20.6	34.3	7.8	8.3	77				
		6	20.3	34.4	7.6	8.3	76			4.16	1.0
3	0852	0	21.2	34.2	7.4	8.2	72	5	4.5 +	4.02	1.1
7k W		1	20.7	34.4	7.5	8.2	74				
		2	20.7	34.4	7.6	8.2	76			3.30	1.1
		3	20.6	34.4	7.7	8.2	76				
		4	20.5	34.4	7.6	8.2	75			2.98	1.1
4	0901	0	21.4	34.2	7.3	8.2	70	6	3.0	3.14	1.1
0		1	21.2	34.2	7.3	8.2	72				
		2	21.0	34.2	7.4	8.2	72			3.20	1.0
		3	20.7	34.2	7.5	8.2	73				
		4	20.5	34.3	7.4	8.2	73			3.53	1.0
		5	20.2	34.3	7.4	8.2	68				
5	0916	0	23.2	34.4	7.4	8.1	67	7	2.5	3.56	1.2
0		1	23.0	34.3	7.6	8.1	65				
		2	22.5	34.2	7.2	8.1	65			3.38	1.1
		3	21.4	34.2	7.2	8.1	62				
		4	20.5	34.2	7.2	8.1	58			3.50	1.2
		5	20.3	34.2	7.1	8.1	56				
6	0927	0	23.1	34.4	7.2	8.1	70	6	2.8	2.69	0.8
0		1	23.0	34.3	6.8	8.1	70				
		2	22.7	34.3	7.2	8.1	65			2.81	1.0
		3	22.0	34.3	6.9	8.1	56				
		4	21.2	34.3	6.5	8.1	48			3.50	1.2
		5	20.5	34.3	5.6	8.1	49				

Table B3. 7 September 1995. (continued)

Station Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	
7	1045	0	23.3	34.5	7.1	8.1	61	7	2.4	3.49	1.1
7k SW		1	23.1	34.5	6.9	8.1	61				
		2	22.6	34.5	7.0	8.1	60			2.78	1.0
		3	21.6	34.5	7.1	8.1	54				
		4	20.6	34.5	6.7	8.1	53			2.77	1.2
8	0949	0	23.4	34.5	6.8	8.1	59	4	2.5	2.97	1.2
4k SW		1	23.3	34.5	7.0	8.1	58				
		2	23.3	34.5	7.0	8.1	58			2.92	1.4
		3	21.7	34.5	6.6	8.1	41				
		4	21.3	34.5	5.6	8.0	43			2.97	1.6
9	1033	0	23.0	34.3	7.0	8.1	57	8	2.3	4.27	1.0
6k SW		1	22.8	34.4	7.1	8.1	57				
		2	22.6	34.4	7.0	8.1	54			2.24	1.1
		3	22.0	34.5	6.6	8.1	50				
		4	21.1	34.5	6.2	8.0	45			3.20	1.2
10	1006	0	23.0	34.4	6.1	8.0	56	7	1.7	4.39	1.2
5k SW		1	22.8	34.3	6.3	8.0	57				
		2	22.1	34.5	6.3	8.0	44			4.50	1.5
		3	21.6	34.5	5.7	8.0	41				
		4	21.3	34.5	5.7	8.0	38			4.70	1.4
11	1024	0	23.5	34.3	6.6	8.0	67	7	2.7	3.83	0.9
4k S		1	23.3	34.3	6.7	8.0	68				
		2	22.4	34.4	7.0	8.1	61			3.44	1.0
		3	22.0	34.5	7.4	8.1	56				
		4	21.4	34.5	6.4	8.1	56			2.84	1.3
12	0830	0	21.5	33.3	7.1	8.2	76	4	4.0 +	3.90	1.3
3k W		1	21.5	33.7	7.5	8.2	79				
		2	21.4	33.8	7.6	8.2	79			4.33	0.9
		3	21.2	33.9	7.5	8.3	79				
13	1110	0	22.8	33.9	5.3	7.7				15.00	1.6
18	0945	0	23.5	34.5	7.0	8.1	67	5	2.0	2.91	1.0
4k W		1	23.5	34.5	6.8	8.1	65				
19	0945	0								3.45	1.3
20	1013	0	23.0	34.1	6.3	8.0	50	8	2.0	5.72	1.2
0		1	22.4	34.2	5.8	8.0	49				
		2	22.2	34.3	5.7	8.0	46			5.73	1.1

Table B3. 7 September 1995. (continued)

Station Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	
22	1118	0	24.7	33.4	5.2	7.6				7.11	2.6
25	0908	0	22.0	34.2	7.0	8.1	69	6	2.5	4.80	0.8
0		1	21.7	34.2	6.9	8.1	69				
		2	21.2	34.2	7.1	8.1	67			4.53	0.9
		3	20.6	34.2	7.4	8.2	65				
		4	20.4	34.2	7.4	8.2	63			3.74	0.8
		5	20.4	34.2	7.1	8.2	60				
	Average		21.8	34.3	7.0	8.1	63.7	5.9	3.0	3.91	1.16
	Number		76	76	76	76	74	15	15	44	44
	St. Dev.		1.07	0.23	0.64	0.11	11.06	1.41	1.21	1.94	0.29
	Maximum		24.7	34.5	8.1	8.3	79	8	6.5	15.00	2.57
	Minimum		20.2	33.3	5.2	7.6	38	4	1.7	2.24	0.76

Table B4. Physical Water Quality Data. 5 October 1995

CRUISE: MDR 95-96
WEATHER: Light fog, clearing
PPRIOR RAINFALL: 0.0"

TIDE	TIME	HEIGHT (ft)
High	0759 PST	5.1
Low	1356 PST	1.0

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans. %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
1	0825	0	21.0	34.6	7.5	8.2	92	8	3.8	2.45	1.55
5k N		1	21.0	34.6	7.6	8.2	91				
		2	20.8	34.6	7.5	8.2	90				1.41
		3	20.8	34.6	7.6	8.2	89				
		4	20.8	34.6	7.5	8.2	89				1.38
2	0835	0	20.7	34.6	7.4	8.2	86	6	4.0	2.70	1.37
5k N		1	20.7	34.7	7.5	8.2	87				
		2	20.7	34.7	7.5	8.2	87			2.98	1.06
		3	20.7	34.7	7.5	8.2	88				
		4	20.6	34.7	7.4	8.2	88			3.06	1.12
		5	20.6	34.7	7.4	8.2	87				
3	0847	0	20.9	34.5	6.9	8.2	85	6	2.3	2.56	1.58
0		1	20.9	34.5	7.2	8.2	84				
		2	20.9	34.6	7.2	8.2	85			2.54	1.50
		3	20.6	34.6	7.0	8.2	85				
		4	20.5	34.7	7.0	8.2	85			2.72	1.11
		5	20.5	34.7	7.0	8.2	84				
4	0858	0	21.2	34.6	7.0	8.2	79	8	2.5	2.41	1.34
0		1	21.2	34.6	7.2	8.2	78				
		2	21.0	34.6	7.1	8.2	79			2.21	1.24
		3	20.9	34.6	6.9	8.2	79				
		4	20.7	34.7	6.9	8.2	81			2.60	1.12
5	0920	0	21.9	34.5	7.0	8.2	76	10	3.0	2.32	1.17
0		1	21.9	34.6	7.0	8.2	75				
		2	21.7	34.6	7.2	8.2	75			2.42	1.29
		3	21.5	34.6	7.1	8.2	72				
		4	20.8	34.6	6.8	8.2	69			2.32	1.68
		5	20.6	34.6	5.8	8.1	69				
6	0930	0	21.7	34.6	6.6	8.1	78	10	3.0	2.90	1.30
3.5k N		1	21.8	34.6	6.8	8.1	78				
		2	21.8	34.6	6.9	8.1	77			3.00	1.35
		3	21.6	34.7	6.7	8.1	71				
		4	20.7	34.5	5.1	8.1	61			2.81	1.62
7	1047	0	22.0	34.6	5.6	8.1	68	12	2.0	2.70	1.28
		1	21.7	34.5	6.2	8.1	67				
		2	21.8	34.5	6.0	8.1	67			3.00	1.62
		3	21.5	34.6	5.8	8.1	62				

Table B4. 5 October 1995. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans. %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
8	0955	0	21.9	34.6	7.0	8.1	74	10	3.0	2.22	1.32
0		1	22.0	34.5	7.1	8.1	74				
		2	22.0	34.5	7.2	8.1	74			2.22	1.40
		3	21.9	34.5	6.8	8.1	70				
		4	21.2	34.6	5.7	8.1	61			3.20	1.51
9	1034	0	22.2	34.4	5.4	8.0	71	12	2.0	3.10	1.02
4k SW		1	21.9	34.5	5.9	8.1	62				
		2	21.5	34.5	6.1	8.1	54			3.12	1.53
		3	21.2	34.5	5.9	8.0	51				
10	1014	0	22.0	34.4	5.8	8.0	73	14	2.0	6.03	2.87
0		1	22.0	34.3	6.2	8.0	77				
		2	21.9	34.4	6.1	8.0	63			3.84	2.72
		3	21.6	34.5	5.7	8.0	52				
		4	21.1	34.5	4.6	7.9	52			4.17	1.73
11	1025	0	22.0	34.5	6.4	8.0	77	10	2.5	3.99	1.02
5k S		1	22.0	34.4	6.1	8.0	76				
		2	21.9	34.5	6.0	8.0	76			3.60	1.33
		3	21.4	34.6	5.8	8.0	68				
12	0817	0	20.8	31.9	6.7	8.1	89	8	4.0	3.33	1.54
5k N		1	20.8	33.8	7.1	8.1	92				
		2	20.9	34.2	7.5	8.1	92				1.35
		3	20.9	34.4	7.5	8.1	92				
13	1115	0	22.4	34.3	5.4	7.5				5.62	3.06
18	0945	0	22.1	34.5	7.0	8.1	74	10	3.0	2.51	1.06
0		1	22.1	34.5	7.2	8.1	74				
		2	22.0	34.5	7.2	8.1	74			2.42	1.24
19	0945	0								2.91	3.45
20		Station not occupied. Large crane being maneuvered.									
22	1125	0	22.4	33.9	4.2	7.7				8.75	2.40

Table B4. 5 October 1995. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans. %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
25	0910	0	21.3	34.6	6.8	8.2	77	8	2.5	2.80	2.16
2.5k N		1	21.4	34.7	7.0	8.2	78				
		2	21.3	34.6	6.7	8.1	79			2.71	1.44
		3	21.3	34.6	6.5	8.1	80				
		4	20.7	34.7	6.5	8.2	76			2.91	1.21
		5	20.5	34.8	6.2	8.1	61				
		6	20.4	34.8	5.7	8.1	48			3.32	0.96
	Average		21.3	34.5	6.63	8.10	75.9	9.4	2.8	3.17	1.55
	Number		71	71	71	71	69	14	14	38	41
	St. Dev.		0.56	0.35	0.75	0.11	10.81	2.19	0.68	1.23	0.56
	Maximum		22.4	34.8	7.61	8.19	92	14	4.0	8.75	3.45
	Minimum		20.4	31.9	4.23	7.52	48	6	2.0	2.21	0.96

Table B5. Physical Water Quality Data. 16 November 1995

CRUISE: MDR 95-96
WEATHER: Foggy
PRIOR RAINFALL: 1 Nov. 0.2"

TIDE	TIME	HEIGHT (ft)
High	0452 PST	4.4
Low	1058 PST	2.3

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
1	0823	0	18.0	31.6	7.0	8.0	92	10	4.2	5.02	1.60
5k N		1	17.7	33.9	7.3	8.0	92				
		2	17.4	34.2	7.2	8.0	93			3.91	1.39
		3	17.4	34.3	7.4	8.0	92				
		4	17.3	34.4	7.4	8.0	92			4.96	
2	0832	0	18.3	34.3	7.0	8.0	85	10	3.5	4.03	1.49
7.5k N		1	18.4	34.3	7.0	8.0	87				
		2	18.4	34.3	7.0	8.0	88			5.30	1.49
		3	18.2	34.2	7.3	8.0	90				
		4	18.0	34.2	7.4	8.0	90			6.42	1.29
3	0842	0	18.5	34.5	6.3	7.9	85	10	3.0	6.13	1.31
0		1	18.5	34.4	6.2	7.9	85				
5k N		2	18.5	34.4	6.2	7.9	85			6.35	1.33
		3	18.5	34.4	6.2	7.9	85				
		4	18.5	34.4	6.2	8.0	85			6.17	1.36
		5	18.1	34.5	6.3	8.0	85				
		6	17.7	34.5	7.0	8.0	75			6.29	1.29
4	0851	0	18.5	34.5	6.3	7.9	82	10	3.0	5.49	1.30
0		1	18.6	34.5	6.2	7.9	84				
		2	18.4	34.5	6.2	8.0	85			5.71	1.26
		3	18.4	34.5	6.3	8.0	85				
		4	18.4	34.5	6.4	8.0	86			6.20	1.29
5	0910	0	18.8	34.2	6.1	7.9	64	10	2.8	6.48	1.04
4K N		1	18.9	34.3	5.8	7.9	81				
		2	18.7	34.3	5.8	7.9	79			6.11	1.15
		3	18.5	34.5	6.5	8.0	74				
		4	18.2	34.5	6.5	8.0	71			5.74	1.12
6	0917	0	18.7	34.4	5.6	7.9	75	10	2.3	6.93	1.42
4k NE		1	18.7	34.4	5.6	7.9	76				
		2	18.7	34.5	5.6	7.9	77			8.60	1.19
		3	18.7	34.5	5.6	7.9	76				
7	1035	0	18.9	34.6	5.6	7.9	69	12	1.9	7.90	1.04
		1	19.0	34.6	5.7	7.9	68				
		2	19.0	34.5	5.7	7.9	67			7.54	0.86
		3	18.7	34.6	6.1	8.0	62				

Table B5. 16 November 1995. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
8	0945	0	18.8	34.3	5.8	7.9	75	12	2.2	7.25	1.10
0		1	18.9	34.4	5.7	7.9	75				
		2	18.8	34.5	5.8	7.9	76			5.95	1.14
		3	18.8	34.4	5.9	7.9	77				
9	1025	0	18.9	34.3	5.5	7.9	67	12	1.9	9.20	1.01
0		1	19.1	34.4	5.6	7.9	70				
		2	19.0	34.5	5.8	7.9	67			7.90	1.09
		3	18.9	34.5	5.6	7.9	64				
10	1000	0	18.9	33.9	4.5	7.8	67	12	1.5	7.17	1.53
		1	19.0	34.2	4.4	7.8	67				
		2	19.0	34.2	4.5	7.8	67			11.00	1.37
		3	19.1	34.3	4.7	7.8	64				
11	1013	0	18.8	34.5	5.5	7.9	77	10	2.9	8.50	0.81
4k NE		1	18.9	34.4	5.3	7.9	78				
		2	18.9	34.4	5.3	7.9	78			9.00	0.96
		3	18.9	34.5	5.5	7.9	66				
12	0818	0	17.6	21.1	6.9	8.0	76	13	3.0 +	6.31	2.10
0		1	18.1	32.3	7.2	8.0	89				
		2	18.0	34.2	7.1	8.0	92			7.25	2.01
13	1105	0	18.8	33.1	3.4	7.7				15.00	2.66
18	0935	0	18.7	34.3	5.9	7.9	75	12	2.2	7.03	1.45
0		1	18.8	34.4	5.8	7.9	74				
		2	18.8	34.4	5.8	7.9	73			6.64	1.41
19	0935	0								4.91	1.75
20	1005	0	18.8	33.9	4.7	7.8	72	12	1.5	11.00	1.26
		1	19.0	34.1	4.6	7.8	71				
		2	19.1	34.2	4.7	7.8	62			9.90	1.30
		3	19.1	34.3	4.7	7.9	57				
22	1128	0	19.1	33.0	1.9	B.16				18.31	2.65

Table B5. 16 November 1995. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
25	0858	0	18.6	34.5	6.1	7.9	84	10	3.1	7.25	1.20
4k N		1	18.7	34.5	6.0	7.9	84				
		2	18.6	34.5	6.0	7.9	85			5.98	1.11
		3	18.6	34.5	5.9	7.9	86				
		4	18.4	34.5	6.1	7.9	87			6.44	1.19
		5	18.0	34.5	6.6	8.0	82				
	Average		18.6	34.1	5.92	7.92	78.1	11.0	2.6	7.33	1.37
	Number		69	69	69	69	67	15	15	40	39
	St. Dev.		0.44	1.65	0.96	0.09	9.11	1.10	0.73	2.69	0.40
	Maximum		19.1	34.6	7.43	8.04	93	13	4.2	18.31	2.66
	Minimum		17.3	21.1	1.88	7.52	57	10	1.5	3.91	0.81

Table B6. Physical Water Quality Data. 14 December 1995

CRUISE: MDR 95-96
WEATHER: Sunny, cool
PRIOR RAINFALL: 13 Dec. 0.5"

TIDE	TIME	HEIGHT (ft)
High	0842 PST	2.7
Low	1334 PST	2.5

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans. %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
1	0835	0	16.5	29.3	7.3	8.1	32	18	0.3	14.25	4.13
7k N		1	16.6	32.8	8.2	8.1	44				
		2	16.7	34.0	8.2	8.1	42			7.30	3.16
		3	16.9	34.1	8.3	8.1	44				
		4	16.8	34.1	8.4	8.1	34			6.55	2.48
		5	16.9	34.1	8.4	8.1	35				
2	0842	0	16.7	34.4	8.2	8.2	50	14	1.0	3.55	2.80
6k N		1	16.8	34.2	8.6	8.2	54				
		2	16.8	34.2	8.6	8.2	50			3.17	2.63
		3	16.8	34.2	8.8	8.2	49				
		4	16.8	34.2	8.3	8.2	49			3.60	2.70
3	0852	0	16.4	32.6	6.0	8.0	89	12	2.0	7.46	1.70
4k N		1	16.5	32.6	6.4	8.0	88				
		2	16.7	32.8	6.4	8.0	86			8.24	1.86
		3	16.7	32.9	6.4	8.0	86				
		4	17.0	33.4	7.2	8.1	84			8.93	1.77
		5	17.0	33.7	7.2	8.1	73				
4	0902	0	16.5	32.8	6.2	8.0	90	12	2.1	10.00	1.79
0		1	16.6	32.8	6.2	8.0	90				
		2	16.6	32.8	6.4	8.0	91			9.10	1.72
		3	16.8	33.1	6.8	8.0	89				
		4	16.9	33.4	7.8	8.1	79			7.10	1.42
		5	17.0	33.7	7.3	8.1	77				
5	0918	0	16.8	32.7	6.1	8.0	90	11	2.4	18.00	1.75
5k NW		1	16.9	33.0	5.8	8.0	88				
		2	16.9	33.1	6.0	8.0	87			9.70	1.70
		3	16.9	33.2	6.0	8.0	87				
		4	17.0	33.5	6.6	8.1	83			10.00	1.39
6	0928	0	16.6	33.0	6.1	8.0	87	11	2.3	11.13	1.54
5k E		1	16.6	33.0	6.1	8.0	87				
		2	16.7	33.0	6.0	8.0	87			10.23	1.51
		3	16.7	33.1	6.0	8.0	87				

Table B6. 14 December 1995. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans. %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
7	1052	0	17.2	33.1	5.9	8.0	90	13	2.5	11.00	1.30
5k SW		1	17.2	33.1	5.8	8.0	89				
		2	17.2	33.1	5.7	8.0	89			12.00	1.47
		3	17.1	33.1	5.7	8.0	89				
8	0948	0	16.6	33.0	7.4	8.0	82	12	2.3	10.25	1.58
0		1	16.6	32.9	6.3	8.0	89				
		2	16.6	32.8	6.1	8.0	88			10.15	1.83
		3	16.7	33.1	6.1	8.0	89				
9	1038	0	17.2	32.6	5.7	7.9	89	13	2.1	10.53	1.59
0		1	17.2	32.8	5.8	8.0	87				
		2	17.1	32.9	5.8	8.0	84			11.40	1.68
		3	17.1	33.0	5.8	8.0	85				
10	1009	0	17.2	29.9	5.1	7.9	76	14	1.8	12.96	1.98
0		1	17.3	31.5	5.4	7.9	85				
		2	17.3	32.4	5.4	7.9	86			14.00	2.03
		3	17.3	32.7	5.4	8.0	86				
		4	17.3	33.2	4.6	7.9				14.89	1.60
11	1025	0	16.9	32.6	5.8	8.0	85	13	2.1	13.60	1.61
3k E		1	17.0	32.7	5.8	8.0	84				
		2	17.1	33.1	5.6	8.0	77			10.61	1.46
		3	17.1	33.1	5.6	8.0	80				
12	0827	0	15.9	9.3	5.9	8.0	4	18	0.1	34.50	7.85
0		1	16.7	30.4	6.9	8.1	46				
		2	16.8	32.0	7.4	8.1	46			26.60	6.60
13	1115	0	14.1	1.4	5.8	7.2				41.93	8.59
18	0948	0	16.5	33.0	6.2	8.0	82	12	1.8	9.20	1.71
0		1	16.5	32.9	6.3	8.0	89				
19	0948	0								12.41	2.27
20	1015	0	17.0	27.5	4.7	7.9	78	14	1.4	17.74	2.07
0		1	17.2	31.7	5.0	7.9	85				
		2	17.2	32.3	5.3	7.9	85			17.61	1.84
22	1122	0	16.4	1.4	5.8	7.2				47.37	8.03

Table B6. 14 December 1995. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans. %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
25	0909	0	16.5	32.6	5.9	8.0	92	11	2.7	8.60	2.43
0		1	16.6	32.8	5.9	8.0	93				
		2	16.6	33.0	6.1	8.0	93			9.60	1.33
		3	16.8	33.1	6.5	8.1	89				
		4	17.0	33.5	6.7	8.1	82			9.30	1.04
		5	17.0	33.7	6.9	8.1	78				
	Average		16.8	31.6	6.44	7.99	76.3	13.2	1.8	13.19	2.51
	Number		69	69	69	69	66	15	15	39	39
	St. Dev.		0.43	6.03	1.02	0.16	19.41	2.14	0.75	9.26	1.88
	Maximum		17.3	34.4	8.76	8.16	93	18	2.7	47.37	8.59
	Minimum		14.1	1.4	4.60	7.18	4	11	0.1	3.17	1.04

Table B7. Physical Water Quality Data. 4 January 1996

CRUISE:	MDR 95-96	TIDE	TIME	HEIGHT (ft)
WEATHER:	High fog, low clouds	High	0750	6.0
PRIOR RAINFALL:	23 Dec. 0.7"	Low	1459	-0.5

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
1	0838	0	15.6	32.8	9.2	8.1	90	10	3.5	3.64	1.89
5k N		1	15.8	33.5	10.0	8.2	88				
		2	15.9	34.1	10.1	8.2	88			3.58	1.87
		3	15.9	34.2	10.2	8.2	87				
		4	15.9	34.2	10.3	8.2	86			3.63	1.88
2	0847	0	15.6	34.2	9.4	8.1	85	10	3.0	5.70	1.52
5k N		1	15.8	34.2	9.6	8.1	85				
		2	15.7	34.2	10.0	8.2	85			4.51	1.59
		3	15.8	34.2	9.9	8.2	86				
		4	15.8	34.2	9.9	8.2	86			4.43	1.60
		5	15.8	34.2	9.7	8.1	87				
		6	15.7	34.2	9.6	8.1	87			4.03	1.30
3	0900	0	15.4	34.0	8.7	8.1	85	10	3.0	4.75	2.46
0		1	15.3	34.0	8.5	8.1	86				
		2	15.4	33.9	9.1	8.1	86			3.96	1.77
		3	15.5	34.0	9.1	8.1	85				
		4	15.5	34.1	8.3	8.0	85			4.48	1.84
		5	15.4	34.1	8.7	8.0	85				
		6	15.7	34.2	9.2	8.1	84			3.98	1.97
4	0912	0	15.3	34.2	8.0	8.0	84	10	3.0	5.90	1.63
0		1	15.3	34.2	8.2	8.0	84				
		2	15.3	34.2	8.3	8.0	84			5.43	0.82
		3	15.3	34.2	8.5	8.0	84				
		4	15.4	34.2	8.7	8.0	84			4.85	0.93
		5	15.4	34.2	8.7	8.1	84				
		6								4.88	0.93
5	0935	0	15.1	34.2	7.7	8.0	67	10	2.5	7.10	0.97
0		1	15.1	34.2	7.8	8.0	80				
		2	15.1	34.2	7.9	8.0	80			6.52	0.66
		3	15.1	34.2	7.9	8.0	80				
		4	15.1	34.2	8.0	8.0	80			5.83	0.89
		5	15.0	34.2	7.9	8.0	80				
6	0946	0	14.8	33.8	7.8	8.0	58	10	2.5	6.15	1.01
3k E		1	14.8	33.8	7.9	8.0	74				
		2	14.8	33.8	8.1	8.0	76			5.97	0.71
		3	14.8	33.8	8.0	8.0	76				
		4	14.7	34.1	8.2	8.0	79			5.78	0.95

Table B7. 4 January 1996. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
7	1105	0	15.0	34.2	7.6	7.9	79	12	2.0	7.99	0.75
5k SW		1	15.0	34.2	7.8	7.9	75				
		2	15.0	34.2	7.8	7.9	80			8.30	0.57
		3	15.0	34.2	7.8	7.9	80				
		4	15.0	34.2	7.6	7.9	80			8.16	0.59
8	1010	0	14.6	34.0	8.4	8.0	44	12	1.5	6.65	1.07
5k E		1	14.6	34.0	8.4	8.0	74				
		2	14.6	34.0	8.5	8.0	77			6.51	1.12
		3	14.6	34.0	8.5	8.0	77				
		4	14.6	34.0	8.5	8.0	73			5.68	1.25
9	1052	0	15.1	34.2	7.7	8.0	32	12	2.0	5.33	0.72
4k N		1	15.1	34.2	8.0	8.0	73				
		2	15.1	34.2	8.1	8.0	73			5.39	0.71
		3	15.0	34.2	7.9	8.0	78				
		4	15.0	34.2	8.1	8.0	79			5.24	0.76
10	1033	0	14.8	33.9	7.9	8.0	50	10	2.0	6.32	0.98
0		1	15.0	33.9	8.0	8.0	70				
		2	15.1	34.0	8.1	8.0	71			6.08	0.93
		3	15.1	34.0	8.0	8.0	74				
		4	15.1	34.1	7.9	8.0	70			6.50	0.90
11	1042	0	15.0	34.1	8.1	8.0	65	10	2.0	6.78	0.86
0		1	14.9	34.1	8.1	8.0	80				
		2	15.0	34.1	8.0	8.0	80			5.22	0.79
		3	14.9	34.1	7.9	8.0	78				
		4								6.41	0.89
12	0830	0	15.3	30.0	8.5	8.1	87	12	3.5	8.13	3.25
0		1	15.8	33.4	9.8	8.1	89				
		2	15.8	33.7	10.1	8.1	89			5.94	2.64
		3	15.9	33.9	10.0	8.1	88				
		4								5.71	1.86
13	1132	0	15.0	34.1	7.4	7.7				7.40	2.47
18	1006	0	14.7	34.1	8.5	8.0	59	12	2.0	5.51	1.09
5k NE		1	14.6	34.0	8.5	8.0	74				
		2	14.6	34.0	8.6	8.0	79			6.80	0.93
19	1006	0								5.49	1.47

Table B7. 4 January 1996. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
20	1028	0	14.9	33.9	7.8	8.0	80	12	1.5	6.70	0.73
0		1	14.9	33.9	7.8	8.0	81				
		2	15.0	34.0	7.9	8.0	77			6.36	0.89
22	1140	0	15.2	32.0	7.4	7.9				7.81	2.67
25	0923	0	15.2	34.2	7.6	8.0	82	12	3.1	5.11	0.74
0		1	15.2	34.2	7.8	8.0	83				
		2	15.2	34.2	7.8	8.0	82			5.14	0.83
		3	15.3	34.2	7.8	8.0	79				
		4	15.3	34.2	7.9	8.0	79			5.59	0.60
		5	15.3	34.2	8.2	8.0	77				
		6	15.4	34.2	8.2	8.0	76			5.51	0.70
	Average		15.2	34.0	8.45	8.02	78.5	10.9	2.5	5.78	1.26
	Number		79	79	79	79	77	15	15	50	50
	St. Dev.		0.37	0.55	0.78	0.08	9.85	1.00	0.65	1.19	0.63
	Maximum		15.9	34.2	10.27	8.17	90.0	12.0	3.5	8.30	3.25
	Minimum		14.6	30.0	7.43	7.74	32.0	10.0	1.5	3.58	0.57

Table B8. Physical Water Quality Data. 1 February 1996

CRUISE: MDR 95-96
WEATHER: Clearing, intermittent showers.
PRIOR RAINFALL: 21 Jan. 0.3", 31 2.0"

TIDE	TIME	HEIGHT (ft)
High	0705	5.6
Low	1422.0	-0.3

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
1	0826	0	14.3	23.1	9.4	8.1	36	17	0.3	11.66	2.94
0		1	14.1	29.5	9.5	8.1	51				
		2	13.9	33.4	10.1	8.1	64			9.68	2.59
		3	13.8	33.9	10.1	8.1	68				
		4	13.8	33.9	10.0	8.1	55			5.39	2.28
2	0836	0	14.2	26.3	9.5	8.0	52	14	1.0	9.00	2.14
0		1	14.2	26.8	9.3	8.1	56				
		2	14.0	30.4	9.6	8.1	59			8.90	2.24
		3	13.9	32.0	9.7	8.1	63				
		4	13.9	33.3	9.8	8.1	66			6.60	2.04
		5	13.8	33.7	9.9	8.1	66				
3	0844	0	14.4	24.5	9.1	8.0	49	14	1.0	10.00	2.13
0		1	14.3	26.7	9.0	8.0	53				
		2	14.1	31.7	9.6	8.1	65			9.30	2.14
		3	13.9	33.1	9.7	8.1	67				
		4	13.9	33.3	9.6	8.1	68			6.70	2.07
		5	13.9	33.7	9.4	8.1	69				
4	0854	0	14.5	26.1	8.8	8.0	53	14	1.1	10.00	1.99
0		1	14.4	29.6	9.1	8.1	64				
		2	14.1	32.2	9.4	8.1	67			15.00	2.06
		3	14.0	33.1	9.5	8.1	71				
		4	14.0	33.7	9.5	8.1	72			8.94	1.88
		5	14.0	33.9	9.4	8.1	73				
5	0911	0	14.7	25.0	8.8	8.0	47	14	0.9	13.28	2.00
0		1	14.3	30.2	9.0	8.0	55				
		2	14.1	32.5	9.5	8.1	62			13.33	1.89
		3	13.9	33.2	9.6	8.1	66				
		4	14.1	33.5	9.0	8.0	76			7.00	1.46
		5	14.3	34.0	8.4	7.9	75				
6	0923	0	14.5	27.5	12.1	8.0	46	14	0.9	13.00	1.77
3k W		1	14.4	28.7	9.0	8.0	51				
		2	14.3	32.0	9.0	7.9	69			12.00	1.77
		3	14.3	33.4	8.8	7.9	73				
		4	14.3	33.7	8.7	7.9	75			7.20	1.26

Table B8. 1 February 1966. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
7	1047	0	14.9	26.8	8.8	8.0	52	15	1.3	11.92	1.69
6k W		1	14.7	29.3	8.8	7.9	56				
		2	14.5	32.3	8.6	7.9	73			14.85	1.64
		3	14.4	33.7	8.3	7.9	75				
8	0949	0	14.9	25.2	8.9	8.0	44	14	1.0	14.00	1.86
8k SW		1	14.7	31.2	8.8	7.9	57				
		2	14.6	31.2	8.7	7.9	69			11.00	1.79
		3	14.5	33.3	8.5	7.9	68				
		4	14.4	34.0	8.0	7.9	68			9.00	1.14
9	1033	0	15.0	23.7	8.8	7.9	52	16	1.1	13.00	1.86
10k W		1	14.7	27.6	8.8	7.9	59				
		2	14.5	32.5	8.4	7.9	69			11.96	1.57
		3	14.5	33.7	8.1	7.8	70				
10	1006	0	15.0	25.5	8.8	7.8	61	15	1.2	12.02	1.66
3k SW		1	14.7	30.5	8.2	7.8	66				
		2	14.6	32.3	8.2	7.9	72			10.03	1.46
		3	14.5	33.7	8.1	7.9	73				
		4	14.6	33.9	7.0	7.8	70			8.64	1.30
11	1023	0	14.9	27.4	8.9	7.9	53	16	1.1	10.09	1.81
5k SW		1	14.6	31.8	9.0	8.0	55				
		2	14.2	32.4	9.2	8.0	68			7.88	1.92
		3	14.3	33.4	8.4	7.9	72				
12	0818	0	14.5	14.4	8.6	8.0	11	17	0.2	30.74	4.78
0		1	14.1	31.1	9.4	8.0	56				
		2	14.0	32.4	9.5	8.1	58			18.29	3.20
		3	13.9	33.2	9.6	8.1	60				
13	1115	0	17.0	6.4	8.5	7.2				37.66	6.47
18	0943	0	14.8	25.4	8.9	8.0	45	15	1.0	12.00	2.31
5k SW		1	14.7	30.2	8.8	7.9	57				
		2	14.6	32.8	8.5	7.9	61			11.00	1.90
		3	14.4	33.4	8.5	7.9	68				
19	0943	0								9.90	2.51
20	1013	0	15.0	25.5	7.8	7.9	62	15	1.5	9.96	1.66
0		1	14.7	28.8	7.9	7.8	64				
		2	14.6	32.4	8.0	7.9	71			9.77	1.54

Table B8. 1 February 1966. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
22	1120	0	15.8	5.2	8.4	7.2				42.69	8.73
25	0902	0	14.5	27.3	8.9	8.0	57	13	1.5	12.10	2.06
0		1	14.3	30.1	9.2	8.0	64				
		2	14.1	32.4	9.3	8.0	69			11.14	2.01
		3	14.0	33.4	9.3	8.0	72				
		4	14.0	33.7	9.1	8.0	72			8.34	1.98
		5	14.1	34.0	8.8	8.0	71				
	Average		14.4	30.0	8.99	7.96	61.9	14.9	1.0	12.50	2.27
	Number		75	75	75	75	73	15	15	42	42
	St. Dev.		0.47	5.38	0.68	0.15	10.7	1.15	0.36	7.37	1.35
	Maximum		17.0	34.0	12.05	8.13	76.0	17.0	1.5	42.69	8.73
	Minimum		13.8	5.2	7.00	7.17	11.0	13.0	0.2	5.39	1.14

Table B9. Physical Water Quality Data. 14 March 1996

CRUISE: MDR 95-96
WEATHER: Sunny, calm, snow on mountains
PRIOR RAINFALL: 4 Mar. 0.7", 5 0.5", 12 2.0", 13 1.4"

TIDE	TIME	HEIGHT (ft)
High	0439	5.1
Low	1153	-0.3

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
1	0832	0	14.7	27.7	8.4	8.1	54	15	0.7	8.79	2.94
0		1	15.1	31.5	8.2	8.1	70				
		2	15.1	33.0	8.3	8.1	72			4.32	3.41
		3	14.9	33.7	8.1	8.1	73				
		4	14.8	33.9	7.7	8.1	73			4.06	2.21
2	0838	0	15.8	31.7	8.7	8.1	71	12	2.2	2.76	3.23
0		1	15.6	31.9	8.5	8.1	74				
		2	15.4	33.1	8.7	8.2	74			2.80	3.00
		3	15.0	33.9	8.3	8.1	74				
		4	14.9	34.3	8.2	8.1	74			2.85	2.68
3	0847	0	15.6	32.6	7.9	8.1	78	10	2.7	4.03	1.59
0		1	15.5	32.9	7.8	8.1	76				
		2	15.5	33.1	7.6	8.1	75			4.21	1.38
		3	15.3	33.8	7.7	8.1	74				
4	0855	0	16.0	31.8	8.1	8.2	72	12	2.8	2.67	2.81
5k W		1	15.9	32.9	7.9	8.1	73				
		2	15.8	33.5	7.8	8.1	73			2.50	2.33
		3	15.6	33.7	7.7	8.1	74				
		4	15.3	34.2	7.9	8.2	76			2.87	1.83
5	0905	0	16.2	31.5	8.8	8.2	68	14	2.2	3.87	3.16
6k SW		1	16.1	31.8	8.7	8.2	67				
		2	16.1	33.1	8.1	8.2	68			3.18	2.74
		3	15.9	33.7	7.7	8.1	65				
		4	15.8	33.9	7.2	8.1	59			2.90	2.10
6	0919	0	15.7	31.4	9.0	8.3	67	14	2.2	2.92	4.31
5k SW		1	15.8	32.0	8.7	8.2	68				
		2	15.8	32.6	7.7	8.1	68			2.84	2.90
		3	16.0	33.9	6.8	8.0	64				
7	1030	0	16.4	31.8	8.0	8.1	74	12	2.9	4.00	1.60
7k W		1	16.4	31.8	7.8	8.1	75				
		2	16.2	33.3	7.1	8.0	70			4.24	1.57
8	0941	0	15.9	31.2	9.1	8.2	66	14	1.7	2.65	2.94
7k SW		1	15.9	32.2	8.7	8.2	67				
		2	16.1	33.1	8.3	8.1	65			3.30	2.67
		3	16.2	33.7	6.8	8.1	56				

Table B9. 14 March 1996. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
9	1018	0	16.6	31.5	8.5	8.1	69	12	2.2	5.04	2.00
6k SW		1	16.5	31.7	7.6	8.1	69				
		2	16.2	32.3	7.4	8.1	67			3.97	2.16
10	0951	0	16.5	31.4	6.8	8.0	70	14	2.0	5.82	1.45
5k SW		1	16.3	32.3	7.4	8.1	70				
		2	16.3	33.1	7.3	8.1	71			5.35	1.47
		3	16.3	33.7	5.3	8.0	68				
11	1009	0	16.4	31.8	8.4	8.2	68	12	2.3	2.89	2.03
5k SW		1	16.2	32.0	8.4	8.1	69				
		2	16.2	33.2	8.0	8.1	68			4.90	2.04
12	0826	0	14.1	12.8	7.3	8.1	15	17	0.3	11.47	4.81
0		1	15.0	33.1	7.7	8.1	65				
		2	15.0	33.6	7.9	8.1	74			6.49	3.41
13	1056	0	17.9	11.1	6.5	7.5				12.00	6.75
18	0935	0	15.1	31.1	8.6	8.2	66	14	1.5	3.50	2.12
5k SW		1	15.9	32.3	8.5	8.2	60				
		2	16.2	33.4	7.5	8.3	54			3.13	2.32
19	0935	0								3.07	5.24
20	1002	0	16.5	31.2	6.7	8.0	70	14	2.2	6.36	1.49
6k SW		1	16.4	31.9	7.0	8.0	71				
22	1102	0	17.7	19.2	4.6	7.4				9.60	5.65
25	0902	0	16.0	31.9	7.8	8.1	74	12	2.8	2.80	1.99
5k W		1	15.8	32.9	7.5	8.1	74				
		2	15.7	33.7	7.4	8.1	72			5.90	1.46
		3	15.7	33.9	7.3	8.1	70				
		4	15.4	34.2	7.3	8.1	69			5.75	1.40
	Average		15.8	31.7	7.78	8.10	68.4	13.2	2.0	4.59	2.68
	Number		60	60	60	60	58	15	15	37	37
	St. Dev.		0.65	4.21	0.80	0.13	8.73	1.64	0.72	2.37	1.25
	Maximum		17.9	34.3	9.10	8.27	78	17	2.9	12.00	6.75
	Minimum		14.1	11.1	4.62	7.42	15	10	0.3	2.50	1.38

Table B10. Physical Water Quality Data. 4 April 1996

CRUISE: MDR 95-96
WEATHER: Sunny, calm
PRIOR RAINFALL: 28 Mar. 0.1", 1 Apr. 0.4"

TIDE	TIME	HEIGHT (ft)
High	0923	4.6
Low	1510	-0.7

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
1	0911	0	15.8	34.1	7.9	8.2	74	10	2.7	4.79	3.50
4-6k SW		1	15.7	34.3	8.0	8.3	76				
		2	15.6	34.3	7.9	8.2	75			2.98	3.42
		3	15.4	34.2	7.9	8.2	73				
2	0917	0	16.2	34.2	8.0	8.3	74	11	2.4	2.68	3.49
4-5k SW		1	16.2	34.2	8.3	8.3	74				
		2	15.8	34.0	7.8	8.2	73			3.36	3.26
		3	15.0	34.2	7.6	8.1	73				
		4	14.7	34.2	7.3	8.1	73			3.15	2.81
		5	14.5	34.2	7.3	8.1	72				
3	0941	0	17.8	33.7	6.7	8.0	65	13	2.1	5.41	1.22
		1	17.3	33.9	6.5	8.0	66				
		2	16.2	34.2	6.6	8.0	64			3.82	1.63
		3	15.8	34.1	6.3	8.0	69				
		4	14.8	34.0	6.4	8.0	71			4.60	1.95
		5	13.9	34.2	6.4	8.0	72				
4	0951	0	18.0	33.9	6.9	8.0	69	13	2.2	4.91	1.56
7k SW		1	17.9	33.9	6.9	8.0	71				
		2	17.9	33.8	7.2	8.0	71			3.92	1.55
		3	17.7	33.8	7.2	8.0	71				
		4	15.3	33.8	6.7	8.0	73			3.23	1.45
		5	14.7	33.8	6.6	8.0	73				
5	1008	0	18.5	33.9	6.8	8.0	72	12	2.3	3.06	1.06
7-9k W		1	18.4	33.9	7.1	8.0	73				
		2	18.2	33.9	7.0	8.0	73			4.80	1.13
		3	17.4	33.9	7.3	8.0	70				
		4	17.1	33.9	6.6	8.1	68			5.01	1.32
		5	15.8	34.4	6.5	8.0	63				
6	1018	0	18.4	34.1	7.0	8.0	71	12	2.5	3.32	0.92
7k SW		1	18.3	33.9	7.0	8.0	73				
		2	18.1	33.9	7.1	8.0	72			3.03	0.90
		3	17.8	33.9	7.0	8.0	66				
		4	17.8	33.9	6.9	8.0	63			2.93	0.83

Table B10. 4 April 1966. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
7	1129	0	18.6	33.7	6.5	8.0	73	12	2.3	3.20	0.97
9k W		1	18.3	33.8	6.4	8.0	76				
		2	18.3	33.9	6.6	8.0	75			3.40	1.11
		3	17.8	33.9	6.8	8.0	72				
		4	17.6	33.9	6.6	8.0	73			3.60	1.21
8	1040	0	18.7	33.9	7.0	8.0	68	12	1.3	3.70	1.06
6-8k SW		1	18.5	33.9	7.0	8.0	66				
		2	18.3	33.9	7.4	8.0	60			3.80	1.48
		3	18.2	33.9	7.4	8.0	59				
		4	18.1	33.9	7.3	8.0	66			3.20	1.33
9	1118	0	18.8	33.9	6.8	8.0	71	13	1.9	3.20	0.87
7-8k SW		1	18.6	33.9	6.6	8.0	71				
		2	18.1	33.9	6.7	8.0	66			3.30	1.16
		3	18.0	33.9	6.5	8.0	66				
		4	17.8	33.9	6.5	8.0	51			3.60	1.18
10	1055	0	18.8	33.6	7.2	8.0	71	12	2.0	3.30	2.97
6k SW		1	18.6	33.8	6.9	8.0	70				
		2	18.4	33.8	6.7	8.0	68			3.60	1.78
		3	18.3	33.8	6.2	7.9	64				
		4	18.3	33.9	5.9	7.9	61			3.50	1.57
11	1109	0	18.9	33.9	6.9	8.0	71	12	2.2	4.10	0.64
5k WSW		1	18.8	33.9	6.7	8.0	69				
		2	18.7	33.9	6.5	8.0	62			3.70	0.97
		3	18.2	33.9	6.4	8.0	61				
12	0902	0	16.0	31.3	7.2	8.2	77	13	2.4	4.56	4.94
4k SW		1	15.8	33.1	7.6	8.2	76				
		2	15.7	33.9	7.8	8.2	74			5.00	4.25
		3	15.7	34.0	7.9	8.2	72				
13	1154	0	19.2	34.2	6.9	7.5				5.74	2.34
18	1035	0	18.8	33.7	7.3	8.0	66	12	1.3	2.85	0.97
5-6k SW		1	18.4	33.9	7.3	8.0	67				
		2	18.3	33.9	7.3	8.0	62			2.75	0.94
19	1035	0								2.94	1.51
20	1102	0	18.8	33.8	6.7	8.0	73	12	2.3	3.40	1.32
0		1	18.7	33.7	6.9	8.0	70				
		2	18.6	33.8	6.8	8.0	71			3.30	1.19

Table B10. 4 April 1966. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
22	1201	0	21.4	33.4	8.8	7.9				5.57	2.98
25	0959	0	18.0	33.9	6.7	8.0	70	12	2.3	3.64	1.14
		1	17.9	33.9	6.8	8.0	73				
		2	17.8	33.9	6.7	8.0	73			3.65	1.12
		3	17.7	34.1	6.5	8.0	74				
		4	14.7	34.3	6.5	8.0	73			4.17	1.17
		5	14.6	34.2	6.6	8.0	74				
	Average		17.4	33.9	6.98	8.03	69.7	12.1	2.1	3.76	1.72
	Number		75	75	75	75	73	15	15	43	43
	St. Dev.		1.47	0.36	0.53	0.11	4.78	0.77	0.40	0.79	1.01
	Maximum		21.4	34.4	8.75	8.26	77	13	2.7	5.74	4.94
	Minimum		13.9	31.3	5.88	7.48	51	10	1.3	2.68	0.64

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
			20.7	34.5	6.8	8.1	68.9	11.0	1.9		1.5
			61	61	61	61	61	14	14		33
			1.06	0.32	0.63	0.06	7.64	0.53	0.34		0.36
			21.7	34.8	7.7	8.2	83	12	2.5		2.5
			17.3	32.8	4.9	7.9	49	10	1.5		0.9

Table B11. Physical Water Quality Data. 2 May 1996

CRUISE: MDR 95-96
WEATHER: Clear, warm, 20% cloud cover
PRIOR RAINFALL: 16 Apr. 1.0", 18 0.3"

TIDE	TIME	HEIGHT (ft)
High	0935	4.3
Low	1504	1.0

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
1	0825	0	19.5	34.3	8.7	8.2	78	8	4.4	3.5	1.9
0		1	19.2	34.3	9.2	8.2	81				
		2	18.9	34.3	9.2	8.2	84			3.2	2.0
		3	18.9	34.3	9.2	8.2	84				
		4	18.9	34.3	9.2	8.2	84			3.4	2.1
2	0832	0	19.5	34.0	8.2	8.1	75	10	3.5	4.0	2.2
		1	19.3	34.2	8.3	8.1	77				
		2	19.1	34.3	8.8	8.2	78			4.7	2.4
		3	19.1	34.3	8.8	8.2	80				
		4	19.1	34.4	8.9	8.2	80			5.2	2.2
		5	19.0	34.4	8.9	8.2	78				
3	0841	0	19.9	33.1	8.1	8.2	71	12	1.8	3.1	2.3
		1	20.0	34.0	8.2	8.1	64				
		2	19.5	34.2	8.3	8.1	64			3.3	1.3
		3	19.3	34.3	8.5	8.1	68				
4	0849	0	20.2	34.4	7.8	8.1	66	12	2.2	3.2	2.3
6k SW		1	20.0	34.3	8.0	8.1	66				
		2	19.6	34.4	7.9	8.1	67			3.9	1.9
		3	19.5	34.3	7.9	8.1	68				
		4	19.4	34.4	8.0	8.1	70			4.1	2.1
		5	19.3	34.4	7.8	8.1	68				
5	0900	0	20.9	34.3	8.0	8.1	66	12	2.2	3.1	1.8
6k W		1	20.8	34.2	8.3	8.1	68				
		2	20.5	34.3	8.1	8.1	66			3.4	1.6
		3	20.4	34.3	8.0	8.1	63				
		4	20.3	34.5	7.3	8.1	56			3.2	1.0
		5	19.1	34.5	6.8	8.0	51				
6	0917	0	20.7	34.3	8.4	8.1	72	11	2.6	3.3	1.6
3k SW		1	20.7	34.3	8.4	8.1	72				
		2	20.7	34.3	8.4	8.1	71			3.0	1.7
		3	20.6	34.3	8.1	8.1	67				
7	1033	0	20.8	34.5	7.7	8.0	65	12	2.2	3.1	1.6
8k SW		1	20.8	34.4	7.7	8.1	64				
		2	20.4	34.5	7.7	8.1	58			3.6	1.8
		3	20.0	34.5	7.4	8.0	56				
		4	19.5	34.4	6.4	8.0	53			3.9	2.3

Table B11. 2 May 1966. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
8	0940	0	20.9	34.4	7.8	8.1	63	11	1.8	3.1	2.1
4k SW		1	20.9	34.3	8.1	8.1	64				
		2	20.9	34.2	8.1	8.1	62			3.3	2.0
		3	20.9	34.2	8.0	8.1	62				
		4	19.6	34.4	5.0	7.9	52			3.3	2.5
9	1020	0	21.2	34.2	7.7	8.1	59	13	1.7	3.4	2.0
5k SW		1	21.1	34.2	7.6	8.0	59				
		2	20.2	34.4	6.7	8.0	49			3.4	2.1
		3	20.0	34.4	6.7	8.0	46				
		4	19.7	34.3	5.9	7.9	48			3.4	2.4
10	0955	0	21.4	33.9	6.6	8.0	65	13	1.8	3.6	2.4
4k SW		1	21.4	33.9	7.1	8.0	63				
		2	21.0	34.1	6.8	8.0	57			3.9	2.5
		3	20.0	34.2	6.1	7.9	48				
		4	19.7	34.2	5.4	7.9	48			4.1	3.2
11	1011	0	21.1	34.2	7.8	8.1	61	13	2.3	3.4	1.6
5k SW		1	21.0	34.2	7.7	8.1	61				
		2	20.6	34.2	7.7	8.1	58			3.3	1.6
		3	20.1	34.2	7.3	8.0	53				
12	0818	0	19.7	31.8	7.6	8.1	81	10	3.2	6.0	2.4
0		1	19.3	33.5	8.6	8.1	81				
		2	19.2	33.9	8.6	8.1	81			6.4	2.3
		3	19.1	34.0	8.8	8.1	81				
13	1100	0	21.3	33.9	6.1	7.9				8.2	2.9
18	0933	0	21.1	34.3	8.0	8.1	66	12	2.0	3.2	1.9
7k SW		1	21.1	34.3	8.1	8.1	66				
		2	21.0	34.3	8.1	8.1	64			3.5	2.2
19	0933	0								3.3	2.2
20	1003	0	21.0	34.1	7.9	8.0	54	14	1.4	8.9	1.9
5k S		1	21.0	34.1	8.6	8.0	50				
		2	20.7	34.1	7.2	7.9	50			7.1	2.4
22	1105	0	22.6	33.9	7.5	7.9				7.7	3.2

Table B11. 2 May 1966. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
25	0855	0	20.2	34.3	7.6	8.1	64	12	2.0	3.6	3.1
6k SW		1	20.2	34.3	7.8	8.1	64				
		2	19.8	34.3	7.5	8.1	62			4.7	2.1
		3	19.7	34.3	7.2	8.0	59				
		4	19.5	34.4	7.4	8.1	62			5.3	1.9
		5	19.4	34.4	7.5	8.1	64				
	Average		20.2	34.2	7.80	8.07	65.2	11.7	2.3	4.15	2.11
	Number		73	73	73	73	71	15	15	42	42
	St. Dev.		0.80	0.36	0.85	0.07	9.95	1.45	0.77	1.47	0.45
	Maximum		22.6	34.5	9.22	8.19	84.0	14.0	4.4	8.90	3.17
	Minimum		18.9	31.8	5.00	7.87	46.0	8.0	1.4	3.02	0.98

Table B12. Physical Water Quality Data. 13 June 1996

CRUISE: MDR 95-96
WEATHER: Partial overcast
PRIOR RAINFALL: 16 May 0.1"

TIDE	TIME	HEIGHT (ft)
High	0908	3.8
Low	1402	1.8

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
1	0826	0	19.8	33.1	8.7	8.3	74	13	1.8	3.3	3.6
5k SE		1	19.5	33.7	9.1	8.3	76				
		2	19.3	33.9	9.0	8.3	78			3.2	3.4
		3	18.0	33.8	8.6	8.2	80				
2	0834	0	19.3	33.9	9.0	8.3	77	12	1.6	3.0	3.1
5k SE		1	18.7	34.0	8.5	8.2	81				
		2	18.5	34.0	8.7	8.2	80			3.3	2.8
		3	18.4	33.9	8.7	8.2	80				
		4	18.4	33.9	8.7	8.2	81			2.9	0.7
		5	18.0	33.9	8.7	8.2	81				
3	0844	0	20.7	33.6	8.0	8.2	72	13	1.5	2.9	2.5
4k W		1	20.3	33.6	8.0	8.2	70				
		2	19.8	33.7	8.3	8.2	71			2.6	2.2
		3	19.7	33.6	8.1	8.2	72				
		4	19.2	33.7	8.2	8.2	74			2.7	2.7
4	0855	0	20.8	33.5	7.4	8.2	70	12	1.7	2.5	1.5
7k W		1	20.4	33.7	7.3	8.2	70				
		2	20.1	33.7	7.6	8.2	68			2.9	1.6
		3	19.9	33.7	7.8	8.2	67				
		4	19.7	33.7	7.9	8.2	67			3.7	1.6
		5	19.7	33.7	8.0	8.2	66				
5	0913	0	21.3	33.7	7.6	8.1	67	12	1.5	2.4	2.0
6k SW		1	21.4	33.7	7.6	8.1	67				
		2	21.3	33.7	7.4	8.1	66			2.3	2.1
		3	21.1	33.7	7.3	8.1	66				
		4	21.1	33.7	7.3	8.1	66			2.4	2.2
		5	20.8	33.8	6.6	8.1	63				
6	0924	0	21.6	33.8	7.3	8.1	73	12	2.0	2.1	1.2
6k SW		1	21.5	33.8	7.4	8.1	72				
		2	21.5	33.8	7.4	8.1	72			4.0	1.2
		3	21.4	33.8	7.3	8.1	72				
		4	21.2	33.9	6.6	8.0	64			4.0	1.3

Table B12. 13 June 1966. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
7	1045	0	21.9	33.7	6.5	8.0	60	13	1.5	3.3	1.3
10k SW		1	21.9	33.8	6.4	8.0	60				
		2	21.8	33.8	6.5	8.0	59			8.3	1.2
		3	21.7	33.8	6.3	8.0	58				
		4	21.4	33.9	6.3	8.0	54			2.7	1.3
8	0948	0	21.9	33.8	7.0	8.0	60	13	1.5	3.1	1.2
8k SW		1	21.9	33.8	6.9	8.0	60				
		2	21.7	33.8	7.1	8.0	61			2.8	1.5
		3	21.7	33.8	7.1	8.0	61				
		4	21.4	33.9	5.2	7.9	61			2.6	1.5
9	1030	0	22.2	33.7	6.6	8.0	57	13	1.3	4.5	1.6
10k SW		1	22.1	33.7	6.6	8.0	57				
		2	21.8	33.9	5.8	7.9	55			4.0	1.4
		3	21.6	33.8	5.8	7.9	48				
		4	21.4	33.8	6.0	8.0	43			3.4	1.4
10	1005	0	22.2	33.7	7.0	8.0	63	13	1.5	3.5	1.6
8k SW		1	22.1	33.7	7.0	8.0	65				
		2	22.0	33.7	6.9	8.0	66			3.6	1.5
		3	21.9	33.7	6.5	8.0	57				
		4	21.7	33.9	3.4	7.8	48			3.4	1.7
11	1022	0	22.1	33.8	6.8	8.0	64	12	1.5	2.7	1.2
7k SW		1	22.0	33.8	6.7	8.0	63				
		2	21.9	33.8	6.3	8.0	54			3.4	1.4
		3	21.7	33.8	6.5	8.0	54				
		4	21.4	33.8	5.9	8.0	54			3.5	1.3
12	0818	0	20.6	18.7	8.0	8.4	77	12	1.8	4.1	2.8
6k SE		1	19.7	32.1	8.1	8.2	77				
		2	18.7	33.5	8.2	8.2	80			4.7	2.9
		3	18.5	33.7	8.2	8.2	80				
13	1113	0	22.6	33.7	6.4	7.9				10.1	1.9
18	0944	0	21.8	33.8	7.1	8.0	63	12	1.5	4.1	1.4
6k SW		1	21.8	33.8	7.1	8.0	63				
		2	21.8	33.8	7.3	8.0	63			3.2	1.4
19	0944	0								4.0	1.3

Table B12. 13 June 1966. (continued)

Station/ Wind	Time	Depth m	Temp. C	Sal. °/oo	DO mg/l	pH	Trans %T	FU	Secchi m	NH3+NH4 ug-at/l	BOD mg/l
20	10112	0	22.2	33.7	6.2	8.0	65	14	1.5	3.7	1.7
9k SW		1	22.4	33.7	6.2	8.0	68				
		2	22.2	33.7	6.2	8.0	60			3.6	1.8
22	1120	0	23.9	33.4	8.8	8.0				9.2	3.3
25	0903	0	21.1	33.6	7.0	8.1	73	12	1.8	4.0	1.8
5k SW		1	21.0	33.7	7.2	8.1	70				
		2	20.9	33.7	7.4	8.2	67			3.0	1.8
		3	20.7	33.7	7.5	8.2	67				
		4	20.5	33.7	7.3	8.2	67			3.0	1.7
		5	20.2	33.7	7.3	8.2	63				
	Average		20.9	33.5	7.26	8.09	66.4	12.5	1.6	3.69	1.83
	Number		75	75	75	75	73	15	15	44	44
	St. Dev.		1.25	1.74	0.99	0.12	8.53	0.62	0.17	1.62	0.69
	Maximum		23.9	34.0	9.08	8.41	81	14	2.0	10.14	3.64
	Minimum		18.0	18.7	3.39	7.77	43	12	1.3	2.14	0.67

APPENDIX C

COLIFORM AND ENTEROCOCCUS BACTERIA

JULY 1995 - JUNE 1996

Table C.1. Coliform and enterococcus bacteria in surface waters, July, August 1995

	6 July 1995				10 August 1995		
	Prior rainfall° - 0.0"				Prior rainfall° - 0.0"		
	Coliform				Coliform		
Station	Total (MPN/100ml)	Fecal	Enterococcus (Colonies/100ml)	Station	Total (MPN/100ml)	Fecal	Enterococcus (Colonies/100ml)
1	140	<20	3	1	220	170	200
2	20	<20	<1	2	70	20	32
3	40	40	36	3	80	20	42
4	20	20	4	4	140	110	40
5	70	20	16	5	<2	<2	<1
6	300	<20	<1	6	<2	<2	<1
7	40	20	1	7	<2	<2	<1
8	210	<20	220	8	<2	<2	<1
9	<20	<20	30	9	<2	<2	<1
10	900	500	62	10	500	110	12
11	90	<20	3	11	80	20	7
12	<20	<20	11	12	70	60	35
13	40	40	24	13	60	110	23
18	1,700	140	4	18	70	20	1
19	80	<20	24	19	230	40	104
20	80	<20	15	20	1,300	120	10
22	>16,000	70	38	22	2,400	<2	<1
25	<20	<20	57	25	1,300	80	13
Avg.	1,099	58	31	Avg.	362	49	29
Num.	18	18	18	Num.	18	18	18
St.D.	3,637	111	50	St.D.	632	53	49
Max.	>16,000	500	220	Max.	2,400	170	200
Min.	<20	<20	<1	Min.	<2	<2	<1

° unofficial rainfall totals

Table C.2. Coliform and enterococcus bacteria in surface waters, September, October 1995

	7 September 1995 Prior rainfall° - 0.0″				5 October 1995 Prior rainfall° - 0.0″		
Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)	Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	4	<2	2	1	<20	<20	5
2	4	2	2	2	<20	<20	3
3	<2	<2	<1	3	<20	<20	3
4	<2	<2	<1	4	<20	<20	17
5	2	2	1	5	<20	<20	<1
6	2	<2	2	6	<20	<20	1
7	<2	<2	<1	7	40	20	10
8	2	<2	1	8	<20	<20	<1
9	4	<2	<1	9	<20	<20	1
10	30	<2	3	10	<20	<20	3
11	<2	<2	<1	11	<20	<20	79
12	<2	<2	1	12	<20	<20	6
13	50	8	35	13	2,400	2,400	25
18	8	<2	<1	18	<20	<20	1
19	4	4	3	19	<20	<20	3
20	50	7	18	20	Crane barge in slip		
22	900	20	54	22	>16,000	>16,000	56
25	30	8	8	25	<20	<20	9
Avg.	61	4	8	Avg.	1,101	1,100	13
Num.	18	18	18	Num.	17	17	17
St.D.	204	4	14	St.D.	3,766	3,767	21
Max.	900	20	54	Max.	>16,000	>16,000	79
Min.	<2	<2	<1	Min.	<20	<20	<1

° unofficial rainfall totals

Table C.3. Coliform and enterococcus bacteria in surface waters, November, December 1995

16 November 1995				14 December 1995			
Prior rainfall° - 1 Nov 0.2"				Prior rainfall° - 13 Dec 0.5"			
Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)	Station	Coliform Total (MPN/100ml)	Coliform Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	3,500	700	<1	1	>16,000	9,000	98
2	20	<1	<1	2	130	30	7
3	20	<11	2	3	500	110	21
4	230	130	13	4	2,400	80	91
5	140	20	1	5	1,100	130	55
6	78	<11	2	6	110	17	9
7	78	45	9	7	800	70	27
8	130	20	9	8	1,300	80	13
9	68	20	4	9	500	80	46
10	3,500	790	576	10	5,000	500	120
11	2,400	78	2	11	3,000	240	169
12	9,200	330	19	12	>16,000	>16,000	>200
13	5,400	20	27	13	1,700	110	32
18	<11	<11	1	18	11	7	4
19	330	230	44	19	140	13	9
20	140	78	682	20	1,600	300	119
22	>16,000	410	11	22	>16,000	>16,000	>200
25	450	20	2	25	900	80	11
Avg.	2,316	163	78	Avg.	3,733	2,380	68
Num.	18	18	18	Num.	18	18	18
St.D.	4,109	236	196	St.D.	5,614	5,225	66
Max.	>16,000	790	682	Max.	>16,000	>16,000	>200
Min.	<11	<1	<1	Min.	11	7	4

° unofficial rainfall totals

Table C.4. Coliform and enterococcus bacteria in surface waters, January, February 1996

	4 January 1996				1 February 1996		
	Prior rainfall° - 23 Dec 0.7"				Prior rainfall° - 31 Jan 2.0"		
	Coliform				Coliform		
Station	Total (MPN/100ml)	Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)	Station	Total (MPN/100ml)	Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	50	23	<1	1	1,700	1,100	91
2	<2	<2	1	2	5,000	300	82
3	2	<2	10	3	>1,600	1,600	71
4	8	<2	3	4	1,700	240	29
5	8	<2	<1	5	240	130	19
6	<2	<2	<1	6	1,100	500	12
7	13	2	3	7	1,700	240	21
8	23	8	<1	8	3,000	500	77
9	<2	<2	<1	9	5,000	240	16
10	30	4	7	10	2,200	2,200	5
11	13	8	6	11	>1,600	500	11
12	70	70	78	12	9,000	2,000	89
13	90	13	34	13	50,000	800	97
18	4	2	2	18	2,400	300	22
19	17	4	48	19	2,400	800	>200
20	50	22	6	20	1,700	240	66
22	16,000	170	10	22	50,000	1,700	72
25	2	2	<1	25	5,000	<2	6
Avg.	910	19	12	Avg.	8,074	744	55
Num.	18	18	18	Num.	18	18	18
St.D.	3,660	40	20	St.D.	14,955	666	48
Max.	16,000	170	78	Max.	50,000	2,200	>200
Min.	<2	<2	<1	Min.	240	<2	5

° unofficial rainfall totals

Table C.5. Coliform and enterococcus bacteria in surface waters, March, April 1996

14 March 1996				4 April 1996			
Prior rainfall° - 4 Mar 0.7", 5 0.5", 12 2.0", 13 1.4"				Prior rainfall° - 1 Apr 0.4"			
	Coliform				Coliform		
Station	Total (MPN/100ml)	Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)	Station	Total (MPN/100ml)	Fecal (MPN/100ml)	Enterococcus (Colonies/100ml)
1	16,000	9,000	240	1	<20	<20	4
2	300	170	84	2	<20	<20	3
3	130	80	56	3	<20	<20	40
4	240	240	104	4	20	<20	25
5	300	170	130	5	<20	<20	8
6	23	23	67	6	<20	<20	2
7	170	30	38	7	<20	<20	5
8	30	23	16	8	<20	<20	2
9	90	50	51	9	<20	<20	<1
10	>16,000	3,000	>200	10	<20	<20	4
11	130	27	11	11	<20	<20	6
12	16,000	2,400	>200	12	230	20	107
13	50,000	>16,000	>200	13	40	<20	30
18	70	23	29	18	<20	<20	<1
19	70	13	48	19	<20	<20	13
20	9,000	9,000	>200	20	110	<20	250
22	>16,000	>16,000	>200	22	20	<20	49
25	30	30	54	25	<20	<20	7
Avg.	6,921	3,127	107	Avg.	38	20	31
Num.	18	18	18	Num.	18	18	18
St.D.	12,345	5,338	76	St.D.	51	0	59
Max.	50,000	>16,000	240	Max.	230	20	250
Min.	23	13	11	Min.	<20	<20	<1

° unofficial rainfall totals

Table C.6. Coliform and enterococcus bacteria in surface waters, May, June 1996

	2 May 1996 Prior rainfall° - 0.0″				13 June 1996 Prior rainfall° - 0.0″		
	Coliform				Coliform		
Station	Total (MPN/100ml)	Fecal	Enterococcus (Colonies/100ml)	Station	Total (MPN/100ml)	Fecal	Enterococcus (Colonies/100ml)
1	<2	<2	<1	1	2	<2	1
2	<2	<2	3	2	<2	<2	<1
3	<2	<2	4	3	<2	<2	<1
4	<2	<2	2	4	<2	<2	<1
5	<2	<2	<1	5	4	<2	<1
6	<2	<2	3	6	17	<2	<1
7	<2	<2	1	7	7	2	10
8	<2	<2	3	8	7	4	<1
9	<2	<2	<1	9	<2	<2	3
10	20	<2	2	10	50	2	<1
11	<2	<2	1	11	8	8	2
12	20	<2	2	12	50	<2	3
13	7	<2	2	13	27	4	6
18	<2	<2	10	18	4	<2	1
19	<2	<2	13	19	7	2	3
20	9	<2	4	20	50	<2	9
22	23	4	3	22	130	4	21
25	<2	<2	10	25	8	8	5
Avg.	6	2	4	Avg.	21	3	4
Num.	18	18	18	Num.	18	18	18
St.D.	7	0	3	St.D.	31	2	5
Max.	23	4	13	Max.	130	8	21
Min.	<2	<2	<1	Min.	<2	<2	<1

° unofficial rainfall totals

APPENDIX D

BENTHIC FAUNA

JULY 1995 - JUNE 1996

Table D1. Benthic fauna by station, 26 October 1995. The number of stations at which the species occurred are listed.

Phylum / Subphylum / Class / Subclass / Division / Order / Suborder / Section / Family / Genus & species	Stations 1	2	3	4	5	6	7	8	9	10	11	12	25	TOTAL NOs	OCCURR-ENCES
ANNELIDA															
OLIGOCHAETA															
Oligochaeta, unid.		13160	230	10		30	20			110	10		10	13580	8
POLYCHAETA															
Ampharetidae															
Ampharete labrops			20											20	1
Melinna oculata			10	10										20	2
Capitellidae															
Capitella capitata	60	200								50		80	10	400	5
Mediomastus acutus				30										30	1
Mediomastus californiensis			1200				40						580	1820	3
Mediomastus spp.	320	3320	14370	610	90	150	200	40	160	200	140	34270	2390	56260	13
(*Mediomastus ambiseta*)															
(*M. californiensis*)															
(*Capitita ambiseta*)															
Notomastus sp.	30		340	10	10							1840		2230	5
Chaetopteridae															
Chaetopterus variopedatus	10													10	1
Spiochaetopterus costarum			10									40		50	2
Chrysopetalidae															
Paleanotus bellis		10												10	1

Table D1. Benthic fauna by station, 26 October 1995. (continued)

Stations	1	2	3	4	5	6	7	8	9	10	11	12	25	TOTAL NOs	OCCURR-ENCES
Cirratulidae															
Aphelochaeta sp.			30	250		1010	4050	10	700	10	820		1100	7980	9
Cirratulidae unid.												10		10	1
(*Tharyx* sp.)															
Caulleriella alata	600		10											610	2
Chaetozone acuta												20		20	1
Chaetozone corona				10										10	1
Cirriformia tentaculata				10	80		30		50		380	10	30	590	7
Cirriformia sp., juv.				10										10	1
Monticellina dorsobranchialis			10											10	1
(*Monticellina* sp)															
Monticellina sp.					20									20	1
(*Tharyx* nr. *tesselata*)															
Cossuridae															
Cossura candida										10			30	40	2
Dorvilleidae															
Protodorvillea gracilis	1150													1150	1
Dorvillea (*Shistomeringos*) *longicornis*	50	200	470			110	150		30	140		1600	80	2830	9
(*Shistomeringos longicornis*)															
(*Dorvillea articulata*)															
Eunicidae															
Marphysa sp *A* (SCAMIT)			10											10	1
(*Marphysa belli oculata*)															
Flabelligeridae															
Pherusa capulata													10	10	1
Glyceridae															
Glycera americana		20	10	20										50	3
Glycera nana				10										10	1
(*Glycera capitata*)															
Glycera tenuis	10											10		20	2
Goniadidae															
Goniada littorea					10									10	1

Table D1. Benthic fauna by station, 26 October 1995. (continued)

Stations	1	2	3	4	5	6	7	8	9	10	11	12	25	TOTAL NOs	OCCURR-ENCES
Hesionidae															
Microphthalmus sp.	190				10									200	2
Micropodarke dubia	10													10	1
Podarke pugettensis			10											10	1
(*Ophiodromus pugettensis*)															
Lumbrineridae															
Errano lagunae			90	40	10		200	30	100		130		810	1410	8
(*Lumbrineris lagunae*)															
Lumbrineris erecta			10			30				90				130	3
Lumbrineris sp *B* (Harris)				30	30					10			50	120	4
Lumbrineris sp.		80		60	390	80		50		40	20	90		810	8
Maldanidae															
Metasychis disparidentatus					10								10	20	2
(*Asychis disparidentata*)															
Praxillella sp.	30													30	1
Nephtyidae															
Nephtys caecoides				30		50	20		20		10		40	170	6
Nephtys cornuta							10							10	1
(*Nepthys c. franciscana*)															
Nereididae															
Neanthes acuminata	10		20							40			10	80	4
(*Neanthes arenaceodentata*)															
Nereis procera								10						10	1
Onuphidae															
Diopatra ornata	10											210		220	2
Opheliidae															
Armandia brevis	640	520	110									480		1750	4
(*Armandia bioculata*)															
Polyophthalmus pictus	2060	120	10	20								450		2660	5
Orbiniidae															
Leitoscoloplos pugettensis		40	810	440	440	640	70	360	50	320	160	160	280	3770	12
(*Leitoscoloplos elongatus*)															
(*Haploscoloplos elongatus*)															
Scoloplos acmeceps	130	40	70		20	200				20	20		20	520	8

Table D1. Benthic fauna by station, 26 October 1995. (continued)

Stations	1	2	3	4	5	6	7	8	9	10	11	12	25	TOTAL NOs	OCCURR-ENCES
Pectinariidae															
Pectinaria californiensis			10	10									40	60	3
(*Pectinaria c. newportensis*)															
Phyllodocidae															
Eumida longicornuta	40													40	1
(*Eumida sanquinea*)															
Phyllodoce hartmanae	50	100												150	2
Polynoidae															
Malmgreniella nigralba			20											20	1
Tenonia priops		30												30	1
Sabellidae															
Chone mollis	50		10				10							70	3
Euchone limnicola			40	20	170	50	490	20	170		210		100	1270	9
Sigalionidae															
Sthenelanella uniformis						10								10	1
Spionidae															
Apoprionospio pygmaea	320			20								10	20	370	4
(*Prionospio pygmaeus*)															
Laonice cirrata													10	10	1
Spio maculata	1320													1320	1
(*Microspio maculata*)															
(*Spio maculata*)															
(*Nerinides maculata*)															
Prionospio lighti		20	510	10					10	30		1290	400	2270	7
(*Prionospio cirrifera*)															
(*Minuspio cirrifera*)															
Paraprionospio pinnata					10								10	20	2
Polydora cornuta		40								130				170	2
Prionospio heterobranchia	230	160	580	220	110	30	50	20			10	520	440	2370	11
(*Prionospio h. neportensis*)															
Pseudopolydora paucibranchiata	15610	40		60	1560	1030	50	40	110	370	60	60	80	19070	12
Scolelepis occidentalis			150	20	20	20						210	10	430	6
(*S. foliosa occidentalis*)															

Table D1. Benthic fauna by station, 26 October 1995. (continued)

Stations	1	2	3	4	5	6	7	8	9	10	11	12	25	TOTAL NOs	OCCURR-ENCES
Scolelepis squamata										10	10	30		50	3
(*Scolelepis acuta*)															
(*Nerinides acuta*)															
Spiophanes bombyx	10													10	1
Spiophanes missionensis	10		10		10				10		20		20	80	6
Streblospio benedicti								40		950	10		200	1200	4
Syllidae															
Brania brevipharyngea		40										50		90	2
Exogone lourei	40	180	80	180		10	10			20	10	130	120	780	10
Sphaerosyllis californiensis	20	20												40	2
Terebellidae															
Amaeana occidentalis				10									10	20	2
ARTHROPODA															
CRUSTACEA															
COPEPODA															
CYCLOPOIDEA															
Cyclopoidea, unid.		10	20										10	40	3
HARPACTICOIDEA															
Harpactiocoida, unid.	90													90	1
OSTRACODA															
Bathyleberis sp.		360	40	20	20								290	730	5
MALACOSTRACA															
EUCARIDA															
DECAPODA															
Brachyura															
Cancridae															
Cancer sp., juv.	20													20	1
Caridea															
Alpheidae															
Alpheus sp.					10				10		10	140	10	180	5
CAPRELLIDEA															
Aeginellidae															
Mayerella banksia	170	120	170	180	20	50		30		30	30	650	110	1560	11

Table D1. Benthic fauna by station, 26 October 1995. (continued)

Stations	1	2	3	4	5	6	7	8	9	10	11	12	25	TOTAL NOs	OCCURR-ENCES
Caprellidae															
Caprella equilibra	10													10	1
Caprella sp.												10		10	1
GAMMARIDEA															
Aoridae															
Grandidierella japonica		80		10	160	1380				30	10	10	20	1700	8
Rudilemboides stenopropodus	470	30	540	10	80		30				20	70	40	1290	9
Corophiidae															
Corophiidae, unid	40													40	1
Corophium acherusicum		50	20	10	60							10		150	5
Isaeidae															
Amphideutopus oculatus	240		1360	40	30								120	1790	5
Photis brevipes	20													20	1
Ischyroceridae															
Eohaustorius washingtonianus	10													10	1
Ericthonius brasiliensis		40												40	1
Megaluropidae															
Gibberosus myersi	30													30	1
Oedicerotidae															
Monoculodes hartmanae	20	10	30											60	3
Synchelidium rectipalmum	10	10												20	2
Phoxocephalidae															
Eyakia robusta													90	90	1
Podoceridae															
Podocerus brasiliensis	10													10	1
Pontogeneidae															
Pontogeneia sp.	10													10	1
CUMACEA															
Campylaspis rubromaculata						20	10					60		90	3
Cumella sp.													10	10	1
Oxyurostylis pacifica	120	1680		170	10							700	70	2750	6

Table D1. Benthic fauna by station, 26 October 1995. (continued)

Stations	1	2	3	4	5	6	7	8	9	10	11	12	25	TOTAL NOs	OCCURR-ENCES
ISOPODA															
Edotea sublittoralis	50													50	1
Uromunna ubiquita	20													20	1
(*Munna ubiquita*)															
Paranathura elegans					30	10								40	2
MYSIDACEA															
Deltamysis sp *A*					20		40		20	40	100		10	230	6
TANAIDACEA															
Zeuxo normani	20	200	20		140	70								450	5
(*Anatanis normani*)															
CHELICERATA															
PYCNOGONIDA															
Pycnogonida, unid.	30											10		40	2
Anoropallene palpida												750		750	1
Anoplodactylus erectus	10													10	1
ASCHELMINTHES															
Nematoda, unid.	29400	48000				50						63000		140450	4
CHORDATA															
CEPHALOCHORDATA															
Branchiostoma californiense	10													10	1
VERTEBRATA															
OSTEICHTHYS															
Gobiidae															
Clevelandia ios			10		10		10					10	10	50	5
CNIDARIA (COELENTERATA)															
ANTHOZOA															
Anemonactis sp.													10	10	1
Anthozoa, unid.	10		30											40	2
ACTINARIA															
Edwardsiidae															
Edwardsia sp *G* (MEC)						10							20	30	2
(*Edwardsia* sp)															

Table D1. Benthic fauna by station, 26 October 1995. (continued)

Stations	1	2	3	4	5	6	7	8	9	10	11	12	25	TOTAL NOs	OCCURR-ENCES
HYDROZOA															
HYDROIDA															
Tubularia sp.			20											20	1
ECHINODERMATA															
ECHINOIDEA															
Dendriticus excentricus	80													80	1
HOLOTHUROIDEA															
Leptosynapta sp.	40		20	10									40	110	4
OPHIUROIDEA															
Ophiuroidea, unid. juv.			20										10	30	2
Amphiodia digitata	10		80										10	100	3
NEMERTEA															
Carinoma mutabilis			20	10		10						10		50	4
Lineus bilineatus							10							10	1
Lineidae, unid.										10				10	1
Micrura sp.			250	40			10		50		10	1890	10	2260	7
Paranemertes californica	40	60	70	10								1240	20	1440	6
(*Paranemertes* sp)															
(*Tubulanus frenatus*)														1440	6
Tubulanus nothus					10									10	1
Tubulanus polymorphus	40		180	20							10	10	50	310	6
(*Tubulanus pellucides*)															
PHORONIDA															
Phoronis sp.			60			40					10		10	120	4
PLATHYHELMINTHES															
Notoplana sp.			10											10	1
Polycladida sp *A*			10											10	1
SIPUNCULIDA															
Apionosoma misakiana			140											140	1
Nephasoma diaphanes			10											10	1
Thysanocardia nigra	10													10	1

Table D1. Benthic fauna by station, 26 October 1995. (continued)

Stations	1	2	3	4	5	6	7	8	9	10	11	12	25	TOTAL NOs	OCCURR-ENCES
MOLLUSCA															
GASTROPODA															
PROSOBRANCHIA															
MESOGASTROPODA															
Calypteridae															
Crepidula onyx			20											20	1
Crepidula naticarum			50											50	1
(*Crepidula coei*)															
(*Crepidula preforans*)															
NEOGASTROPODA															
Columbellidae															
Mitrella aurentiaca		10												10	1
Conidae															
Conus californica			10											10	1
Nassariidae															
Nassarius tegula						10								10	1
Olividae															
Olivella baetica		10												10	1
Turridae															
Kurtziella plumbea			10											10	1
OPHISTHOBRANCHIA															
CEPHALASPIDEA															
Acteonidae															
Rictaxis punctocaelatus				10									10	20	2
Bullidae															
Bulla gouldiana												50		50	1
Atyidae (Haminocidae)															
Haminoea vesicula	10				20									30	2
Scaphandridae															
Acteocina inculta			10			50			20			110	20	210	5
(*Cylichnella inculta*)															

Table D1. Benthic fauna by station, 26 October 1995. (continued)

Stations	1	2	3	4	5	6	7	8	9	10	11	12	25	TOTAL NOs	OCCURR-ENCES
BIVALVIA (PELECYPODA)															
Cardiidae															
Laevicardium substriatum	100	680	210	10	10							910	30	1950	7
Cooperellidae															
Cooperella subdiaphana				30										30	1
Lasaeidae (Erycinidae)															
Lasaea subviridis			20											20	1
Lucinidae															
Parvilucina tenuisculpta			40									40		80	2
(*P. approximata*)															
Mactridae															
Mactra californica				10										10	1
Spisula sp.			10											10	1
Montacutidae															
Mysella sp *A*				10									30	40	2
Mysella sp *C*													10	10	1
Mytilidae															
Musculista senhousei		40												40	1
(*Musculus senhousei*)															
Solecurtidae															
Tagelus subteres	290	1040	60	130	10							20	340	1890	7
Tellinidae															
Leporimetis obesa	200	10	30	20								150	40	450	6
Macoma nasuta		20		20								30		70	3
(*Macoma acolasta*)															
Macoma yoldiformis			20	10										30	2
Tellina carpenteri		40		10								110		160	3
Ungulinidae															
Diplodonta orbella			110											110	1
Veneridae															
Pitar newcombianus													10	10	1
Protothaca staminea												140	40	180	2

APPENDIX E

UNOFFICIAL RAINFALL RECORDS FOR NORTHEAST LOS ANGELES DRAINAGE BASIN

1977-1996

by Dr. John D. Soule

Figure E.1. ANNUAL & MONTHLY RAINFALL IN INCHES - JULY 1986-JUNE 1996

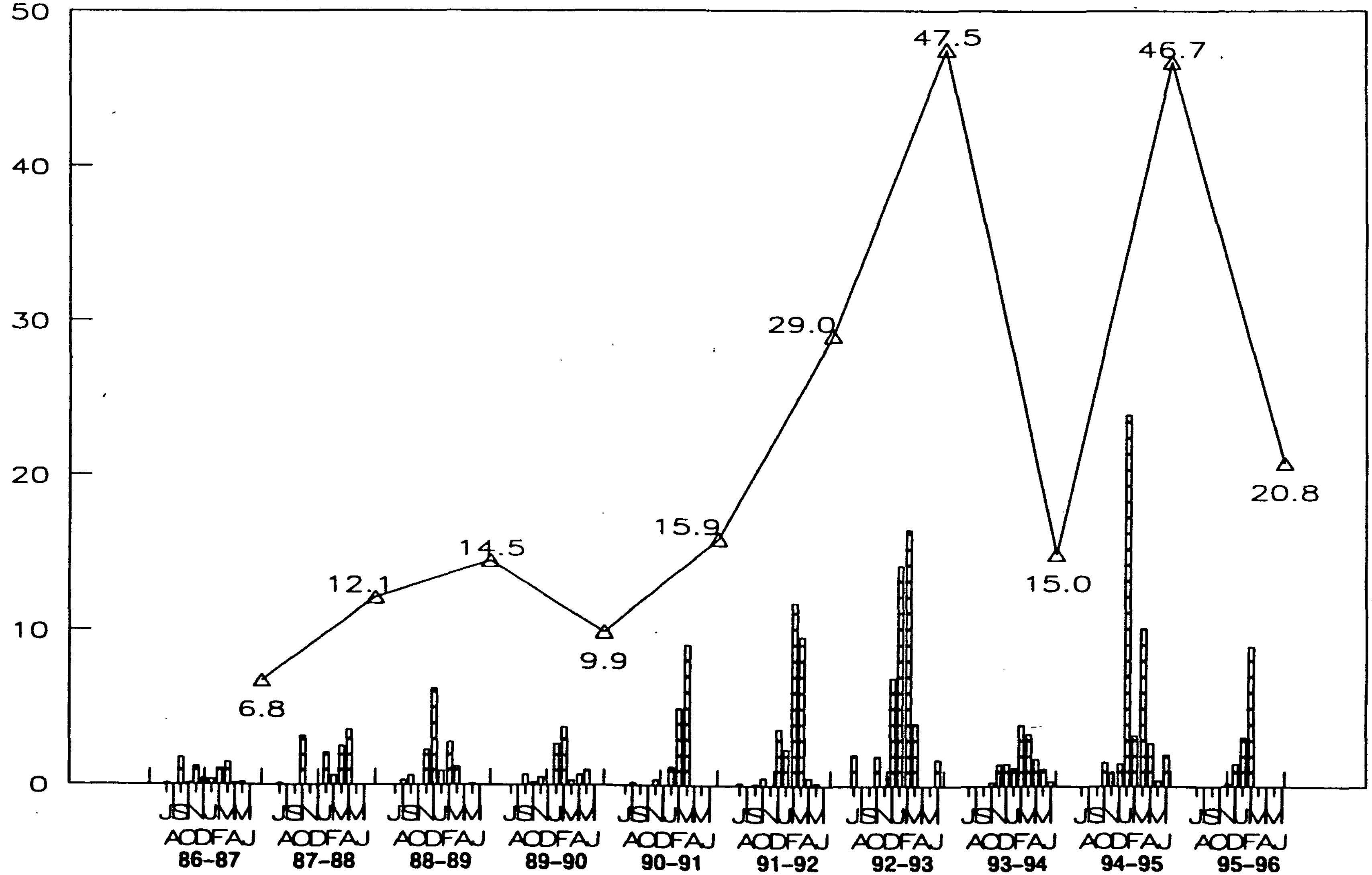

Table E.1. Rainfall in north Los Angeles Basin.
(Unofficial records; rainfall seasons begin 1 July and end 30 June)

1977-1978

Date		Inches	
Aug 77	17	2.2	
Total			**2.2**
Dec	17	0.5	
	23	0.1	
	25	0.5	
	29	4.3	
Total			**5.4**
Jan 78	3	0.2	
	4	0.7	
	6	0.3	
	9	0.7	
	14	1.8	
	30	0.1	
Total			**3.8**
Feb	5	1.1	
	6	0.4	
	7	0.7	
	26	0.1	
	28	2.8	
Total			**5.1**
Mar	1	2.1	
	2	1.1	
	3	0.3	
	4	3.0	
	5	0.6	
	22	1.0	
	30	0.7	
	31	0.1	
Total			**8.9**
Apr	4	0.3	
	6	0.6	
	15	1.7	
	25	0.3	
Total			**2.9**
May	1	0.1	
Total			**0.1**
1977-1978 TOTAL			**28.4**

1978-1979

Date		Inches	
Sept 78	5	0.5	
Total			**0.5**
Oct	20	0.1	
Total			**0.1**
Nov		0.9	
	13	0.1	
	21	0.7	
Total			**1.7**
Dec	18	2.4	
Total			**2.4**
Jan 79	5	2.5	
	9	0.2	
	16	2.1	
	18	0.2	
	28	0.1	
	31	2.4	
Total			**7.5**
Feb	1	0.3	
	2	0.7	
	14	0.3	
	20	1.2	
	21	0.4	
Total			**2.9**
Mar	1	0.8	
	13	0.2	
	16	0.9	
	18	0.1	
	20	0.95	
	22	0.1	
	29	3.6	
Total			**6.65**
May		0.1	
Total			**0.1**
1978-1979 TOTAL			**21.85**

1979-1980

Date		Inches	
Oct 79	20	0.8	
Total			**0.8**
Nov	7	0.4	
Total			**0.4**
Dec	21	0.1	
Total			**0.1**
Jan 80	7	0.1	
	8	0.1	
	9	2.4	
	10.	0.6	
	11	1.1	
	12	0.4	
	13	0.3	
	14	4.0	
	17	0.1	
	29	4.2	
Total			**13.3**
Feb	13	2.0	
	14	1.8	
	15	4.5	
	16	4.2	
	17	1.1	
	18	1.0	
	19	1.4	
	20	0.7	
	21	0.8	
Total			**17.5**
Mar	2	2.1	
	3	0.5	
	5	0.7	
	6	0.7	
	18	0.4	
	21	0.1	
	25	0.5	
Total			**5.0**
Apr	21	0.1	
	22	0.1	
	28	4.0	
Total			**4.2**
May	10	0.2	
	21	0.1	
	23	0.1	
Total			**0.4**
1979-1980 TOTAL			**41.7**

Table E.1. Rainfall in Los Angeles Basin (cont.)

1980-1981	Date	Inches	
Dec 80	4	0.8	
	7	0.1	
Total			**0.9**
Jan 81	11	0.2	
	23	0.4	
	28	1.2	
	29	1.6	
Total			**3.4**
Feb	9	0.8	
	25	0.6	
	28	1.4	
Total			**2.8**
Mar	1	1.2	
	5	1.2	
	6	0.1	
	19	1.1	
	26	0.1	
Total			**3.7**
Apr	2	0.1	
	18	0.5	
Total			**0.6**
1980-1981 Total			**11.4**

1981-1982	Date	Inches	
Sept 81	30	0.1	
Total			**0.1**
Oct	1	0.7	
	28	0.1	
Total			**0.8**
Nov	27	0.5	
	28	1.7	
Total			**2.2**
Dec	20	0.2	
	30	0.4	
Total			**0.6**
Jan 82	5	0.4	
	20	1.0	
	21	0.4	
	28	0.1	
Total			**1.9**
Feb	10	0.5	
	16	0.1	
Total			**0.6**
Mar	2	0.2	
	11	0.7	
	14	0.6	
	18	3.4	
	26	0.3	
	29	0.9	
Total			**6.1**
Apr	1	1.5	
	4	0.8	
Total			**2.3**
May	4	0.2	
Total			**0.2**
June	17	0.1	
Total			**0.1**
1981-1982 TOTAL			**14.9**

1982-1983	Date	Inches	
Sept 82	8	0.2	
	17	0.3	
	26	1.1	
Total			**1.6**
Oct	26	0.4	
Total			**0.4**
Nov	10	2.6	
	18	0.5	
	30	2.7	
Total			**5.8**
Dec	8	0.1	
	22	1.4	
	29	0.1	
Total			**1.6**
Jan 83	19	0.7	
	22	2.1	
	24	1.1	
	27	2.7	
	29	1.5	
Total			**8.1**
Feb	2	1.0	
	5	0.2	
	24	0.5	
	26	0.7	
	27	1.3	
	28	1.0	
Total			**4.7**
Mar	1	4.0	
	2	2.4	
	3	0.8	
	6	0.1	
	13	0.5	
	16	0.5	
	17	0.1	
	20	1.2	
Total			**9.6**
Apr	5	0.2	
	18	1.7	
	20	2.3	
	28	1.4	
	29	1.1	
	30	0.1	
Total			**6.8**
May	1	0.5	
Total			**0.5**
June	11	0.1	
Total			**0.1**
1982-1983 TOTAL			**39.2**

Table E.1. Rainfall in Los Angeles Basin (cont.)

1983-1984

Date		Inches	
Aug 83	15	0.3	
	19	1.3	
Total			**1.6**
Sept	20	0.2	
	29	3.0	
Total			**3.2**
Oct	4	0.3	
	6	0.2	
	8	0.2	
Total			**0.7**
Nov	1	0.5	
	12	0.7	
	17	0.1	
	19	0.2	
	24	1.0	
Total			**2.5**
Dec	1	0.1	
	3	0.5	
	9	0.7	
	11	0.1	
	25	2.2	
Total			**3.6**
Jan 84	16	0.2	
Total			**0.2**
Mar	14	0.4	
Total			**0.4**
Apr	6	0.1	
	19	0.3	
	27	0.2	
Total			**0.6**
1983-1984 Total			**12.8**

1984-1985

Date		Inches	
Aug 84	15	0.4	
Total			**0.4**
Sept	11	0.25	
Total			**0.25**
Oct	17	0.1	
Total			**0.1**
Nov	8	0.5	
	13	0.3	
	21	0.2	
	24	0.5	
	28	0.1	
Total			**1.6**
Dec	3	0.2	
	8	0.7	
	10	0.6	
	15	1.1	
	19	1.8	
	27	1.4	
Total			**5.8**
Jan 85	7	0.7	
	28	0.3	
Total			**1.0**
Feb	2	0.2	
	9	1.6	
	20	0.1	
Total			**1.9**
Mar	5	0.1	
	6	0.2	
	18	0.3	
	27	0.5	
	28	0.2	
Total			**1.3**
May	9	0.3	
Total			**0.3**
1984-1985 Total			**12.65**

1985-1986

Date		Inches	
Oct 85	21	0.5	
Total			**0.5**
Nov	11	1.2	
	24	2.0	
	29	0.7	
Total			**3.9**
Dec	2	0.35	
Total			**0.35**
Jan 86	4	0.5	
	31	3.5	
Total			**4.0**
Feb	7	0.2	
	13	1.1	
	15	2.4	
	16	0.2	
	17	0.2	
	19	1.0	
Total			**5.1**
Mar	8	1.75	
	10	0.8	
	12	0.1	
	13	1.0	
	16	2.4	
Total			**6.05**
Apr	5	0.5	
Total			**0.5**
1985-1986 Total			**20.4**

Table E.1. Rainfall in Los Angeles Basin (cont.)

1986-1987

Date		Inches	
July 86	22	0.1	
Total			**0.1**
Sept	23	0.2	
	24	1.6	
Total			**1.8**
Oct	2	0.1	
Total			**0.1**
Nov	15	0.1	
	17	1.1	
Total			**1.2**
Dec	6	0.4	
Total			**0.4**
Jan 89	6	0.35	
Total			**0.35**
Feb	9	0.2	
	13	0.75	
	22	0.1	
Total			**1.05**
Mar	6	0.7	
	15	0.2	
	21	0.6	
Total			**1.5**
Apr	3	0.1	
Total			**0.1**
May	25	0.2	
Total			**0.2**
1986-1987 Total			**6.8**

1987-1988

Date		Inches	
July 87	17	0.1	
Total			**0.1**
Oct	22	1.2	
	29	0.9	
	30	1.1	
Total			**3.2**
Jan 88	5	0.2	
	17	1.9	
Total			**2.1**
Feb	2	0.6	
Total			**0.6**
Mar	1	2.3	
	2	0.2	
Total			**2.5**
Apr	14	0.9	
	20	2.1	
	21	0.1	
	23	0.5	
Total			**3.6**
1987-1988 Total			**12.1**

1988-1989

Date		Inches	
Aug 88	24	0.3	
Total			**0.3**
Sept	20	0.6	
Total			**0.6**
Nov	14	1.3	
	23	0.7	
	25	0.3	
Total			**2.3**
Dec	16	3.4	
	18	0.3	
	20	1.3	
	22	0.3	
	27	0.95	
Total			**6.25**
Jan 89	3	0.1	
	4	0.1	
	5	0.7	
Total			**0.9**
Feb	4	1.1	
	9	1.6	
	13	0.1	
Total			**2.8**
Mar	2	0.6	
	25	0.6	
Total			**1.2**
May	15	0.1	
Total			**0.1**
1988-1989 Total			**14.45**

Table E.1. Rainfall in Los Angeles Basin (cont.)

1989-1990			
Date		Inches	
Sept 89	16	0.2	
	19	0.5	
Total			**0.7**
Oct	21	0.2	
Total			**0.2**
Nov	26	0.5	
Total			**0.5**
Jan 90	2	0.2	
	13	1.2	
	16	0.6	
	17	0.5	
	31	0.2	
Total			**2.7**
Feb	4	0.5	
	14	0.4	
	18	2.9	
Total			**3.8**
Nov	11	0.2	
	12	0.1	
Total			**0.3**
Apr	4	0.3	
	16	0.4	
Total			**0.7**
May	28	1.0	
Total			**1.0**
1989-1990 Total			**9.9**

1990-1991			
Date		Inches	
Aug 90	15	0.1	
	29	0.1	
Total			**0.2**
Nov	19	0.4	
Total			**0.4**
Jan 91	5	0.7	
	9	0.5	
Total			**1.2**
Feb	28	5.0	
Total			**5.0**
Mar	1	2.5	
	4	0.3	
	11	0.1	
	13	0.2	
	15	0.3	
	18	2.3	
	20	1.0	
	25	1.0	
	27	1.4	
Total			**9.1**
1990-1991 Total			**15.9**

1991-1992			
Date		Inches	
July 91	8	0.2	
Total			**0.2**
Sept	28	0.1	
Total			**0.1**
Oct	26	0..5	
Total			**0.5**
Dec	8	0.2	
	9	0.1	
	28	1.1	
	29	2.3	
Total			**3.7**
Jan 92	3	0.4	
	5	1.5	
	6	0.1	
	7	0.4	
Total			**2.4**
Feb	5	0.5	
	6	2.2	
	9	0.7	
	10	2.9	
	11	1.4	
	12	2.6	
	13	0.6	
	15	0.9	
Total			**11.8**
Mar	2	0.9	
	3	2.3	
	6	0.7	
	7	0.2	
	20	1.7	
	21	0.7	
	22	0.5	
	23	1.3	
	26	1.2	
	27	0.1	
Total			**9.6**
Apr	1	0.5	
Total			**0.5**
May	5	0.1	
	6	0.1	
Total			**0.2**
1991-1992 Total			**29.0**

Table E.1. Rainfall in Los Angeles Basin (cont.)

1992-1993			
Date		Inches	
Jul 92	8	0.1	
	11	0.45	
	12	0.5	
Total			**1.05**
Oct	21	0.1	
	23	0.1	
	24	0.3	
	30	1.45	
Total			**1.95**
Dec	4	0.1	
	7	3.6	
	11	0.1	
	17	0.7	
	27	0.6	
	29	1.9	
Total			**7.0**
Jan 93	2	0.5	
	6	1.5	
	7	2.6	
	8	0.2	
	12	2.0	
	13	1.2	
	14	0.8	
	15	1.2	
	16	0.8	
	17	2.0	
	18	1.3	
	30	0.1	
Total			**14.2**
Feb	7	2.5	
	8	8.1	
	9	0.4	
	14	0.6	
	18	2.4	
	20	0.6	
	23	1.7	
	26	0.1	
	27	0.1	
Total			**16.5**
Mar	25	0.3	
	26	3.2	
	27	0.6	
Total			**4.1**
June	5	1.7	
Total			**1.7**
1992-1993 Total			**46.54**

1993-1994			
Date		Inches	
Oct 93	11	0.25	
Total			**0.25**
Nov	11	0.6	
	30	0.8	
Total			**1.4**
Dec	11	0.8	
	14	0.6	
	18	0.1	
Total			**1.5**
Jan 94	23	0.5	
	25	0.6	
	26	0.1	
Total			**1.2**
Feb	4	0.9	
	7	0.6	
	8	0.7	
	18	1.8	
Total			**4.0**
Mar	6	0.6	
	7	0.1	
	11	0.1	
	19	0.7	
	24	1.6	
	25	0.3	
Total			**3.4**
Apr	9	0.2	
	25	0.4	
	26	1.0	
	27	0.2	
Total			**1.8**
May	6	0.2	
	7	0.2	
	17	0.5	
	25	0.2	
Total			**1.1**
June	15	0.3	
Total			**0.3**
1993-1994 Total			**14.95**

1994-1995			
Date		Inches	
Oct 94	4	0.4	
	5	1.1	
	13	0.1	
Total			**1.6**
Nov	8	0.1	
	10	0.7	
	25	0.1	
Total			**0.9**
Dec	13	0.3	
	24	1.2	
Total			**1.5**
Jan 95	3	0.5	
	4	2.7	
	5	0.7	
	7	1.1	
	8	1.2	
	9	0.7	
	10	7.0	
	11	2.6	
	12	0.5	
	14	0.6	
	15	0.6	
	16	0.1	
	20	0.1	
	22	0.2	
	23	2.7	
	24	0.5	
	25	1.9	
	26	0.2	
Total			**23.9**
Feb	8	0.1	
	11	0.1	
	13	0.4	
	14	2.7	
Total			**3.3**
Mar	3	1.0	
	4	0.1	
	5	2.5	
	6	0.7	
	10	0.4	
	11	2.6	
	12	0.6	
	21	1.2	
	23	1.1	
Total			**10.2**

Table E.1. Rainfall in Los Angeles Basin (cont.)

1994-1995 (cont.) Date		Inches		1995-1996 Date		Inches	
1994-95 Forward			**41.4**	Nov 95	1	0.2	
				Total			**0.2**
Apr	16	1.7					
	18	1.1		Dec	13	0.5	
Total			**2.8**		14	0.3	
					23	0.7	
May	14	0.2		**Total**			**1.5**
	15	0.1					
	24	0.1		Jan 96	16	0.7	
Total			**0.4**		19	0.2	
					21	0.3	
June	1	0.2			31	2.0	
	16	1.9		**Total**			**3.2**
Total			**2.1**				
				Feb	3	0.2	
1994-1995 Total			**46.7**		19	4.0	
					20	1.2	
					21	2.3	
					22	0.5	
					25	0.3	
					27	0.5	
				Total			**9.0**
				Mar	4	0.7	
					5	0.5	
					12	2.0	
					13	1.4	
					14	0.4	
					28	0.1	
				Total			**5.1**
				Apr	1	0.4	
					16	1.0	
					18	0.3	
				Total			**1.7**
				May	16	0.1	
				Total			**0.1**
				1995-1996 Total			**20.8**