U.S. Army Corps
of Engineers

Los Angeles District

LOS ANGELES REGIONAL DREDGED MATERIAL MANAGEMENT PLAN FEASIBILITY STUDY

BASELINE CONDITIONS (F3) REPORT TECHNICAL APPENDIX

U.S. Army Corps of Engineers
Los Angeles District
915 Wilshire Boulevard
Los Angeles, California 90017

August 2004

Table of Contents

List of Tables

List of Figures

1 INTRODUCTION

The Los Angeles Dredged Material Management Plan (DMMP) Feasibility Study (FS) is designed to evaluate dredging and disposal alternatives for use within the Los Angeles Region (Region). The area of the Los Angeles Basin for which the U.S. Army Corps of Engineers, Los Angeles District (USACE) DMMP FS is focused (Study Area) on is located along the coastal waters of Los Angeles County (the County). This area extends, generally, from Santa Monica Bay to the north down to Alamitos Bay to the south. Specific management areas for the DMMP FS include the mouth of Ballona Creek, Marina del Rey, King Harbor, Port of Los Angeles (POLA), Port of Long Beach (POLB), the Los Angeles River Estuary (LARE), and Alamitos Bay (Figure 1-1). The DMMP FS F3 report documents baseline conditions for the project by summarizing existing and future without project conditions for physical, chemical and biological data and environmental settings for the Study Area.

To provide the technical input needed to prepare the F3 Baseline Conditions Report, a compendium of technical documents have been prepared and consolidated in this Technical Appendix. Section 2 provides a historical record of previous dredging events conducted within the Study Area, including the final location for sediment disposal. This information is important because the rationale used in the DMMP FS for predicting future dredging events and disposal needs is based on the historical record. Section 3 then provides a summary of projected future dredging with the Study Area, including routine maintenance dredging and proposed capital improvement projects. Unless information is available to prove other wise, historical ratios of clean vs. contaminated sediment for each area are used to estimate future disposal needs.

Because many of the available technologies for treating and reusing contaminated dredged material are highly dependent on the chemical and physical composition of the sediments, the historical record of previous dredge characterization studies was used to predict future needs. Section 4 summarizes this physical and chemical characterization data for regional dredge material previously encountered within the Study Area. This information was developed by reviewing sediment characterization data from previous dredge events over the past 20 years.

A review of the coastal processes, including wind and wave dynamics, and sediment transport within the Study Area is provided in Section 5. This information is considered when reviewing the available technologies as many require specific conditions (e.g., low wave energy and current speed for aquatic capping projects) to successfully isolate the contaminated sediments.

Figure 1-1
Los Angeles Regional DMMP Feasibility Study Area

A review of the potential biological resources at risk from dredging and disposal operations within the Study Area is contained in Section 6. This information is presented as a baseline of available resources that may be affected by dredging activities within the region and will be used during the F4 evaluation to conduct a detailed Environmental Impact Assessment of all potential alternatives for use in the final Feasibility Study. Many of the available technologies presented in this document have the potential to create adverse water and/or air quality conditions. Therefore, understanding the nature of the resources potentially at risk is critical when conducting an evaluation of the project alternatives.

Because economic benefit (measured as NED) is one of the critical evaluation criteria when reviewing project alternatives, a detailed economic analysis of the importance of maintaining navigable channel depths through dredging is provided in Section 7 as a baseline analysis of the problem. This information will then be used as a starting point for the detailed F4 Feasibility Study evaluation.

The goal for this document to provide the technical details related to the above subjects to support the evaluation provided within the main F3 Baseline Conditions report. When deemed useful, details from this appendix have been duplicated in the main report.

2 DREDGING AND DISPOSAL HISTORY

2.1 Overview

Historical dredging events in the Study Area were compiled from various databases, permit archives, and prior studies. The events were identified from original data sources, reconciled among multiple references, and tabulated chronologically by dredging sites in the following sections. In the tables below that summarize dredging and disposal events for each site, dredging events are listed by the year (or the starting year for dredging events lasting for more than a year). The tables also include information on the project proponent, the dredge and disposal quantities, location and dredge method, as well as the source of data. For dredging quantities obtained from permit archives, it was assumed that the figures provide a good measure of the quantities actually dredged, although discrepancies generally exist between the permitted and pay volumes. In cases where only disposal records exist, it was assumed that the corresponding dredging volumes are identical. For entries where descriptions in the records are incomplete or sketchy, best knowledge based on professional experience in the Los Angeles Region (Region) was used to complete the information. In cases where significant differences in dredging quantities occur among records, selection was weighted toward records with relatively complete documentation. In such a case, if the adopted quantity is not the greatest among the records, the difference is also listed as a separate entry to account for potentially unidentified events. The total maintenance, capital improvement dredge volumes and corresponding average annual rate for completed projects in the Study Area are also shown.

2.2 Santa Monica Bay

2.2.1 *Marina del Rey*

Marina del Rey Harbor, the largest man-made small craft harbor in the world, was created from the original Ballona Wetlands area in the early 1960s (1960 to 1963). The capital project excavated approximately 9.2 million cubic meters (m^3) of material out of the site, and placed approximately 2.3 million m^3 of the dredged sediment on Dockweiler Beach downcoast to prevent the anticipated erosion after the creation of the harbor (USACE 1986). Since then, the harbor entrance channels have been periodically dredged by the U.S. Army Corps of Engineers, Los Angeles District to maintain the designated safe navigation dimensions.

The primary source of shoaling in the southern portion of the entrance channel is sediment discharge from the neighboring Ballona Creek during storm runoff events. Littoral drift of sediment from up- and downcoast beaches also contributes to the shoaling of the entrance channels. The sediment in the entrance channel shoals is, in general, relatively sandy but typically contains an appreciable portion of contaminated material unacceptable for unrestricted ocean disposal. Specifically, sediment in the north entrance channel, which is largely derived from littoral transport, is typically uncontaminated and suitable for beach replenishment or open water disposal at offshore disposal sites such as LA-2. Sediment from the south entrance channel, which primarily originates from Ballona Creek discharges, tends to be contaminated and requires special handling and disposal. The USACE conducts maintenance dredging of the federally designated navigation channels in the harbor. Table 2-1 presents a chronology of historical dredging and disposal events in Marina del Rey Harbor since the completion of the offshore breakwater in 1965.

A total of approximately 1.5 million m^3 has been dredged from the Marina del Rey Harbor entrance channel and vicinity between 1969 and 1999 (Table 2-1). The average annual maintenance dredging rate has been approximately 49,000 m^3 per year over that period, with a frequency of once every three to five years.

2.2.2 *King Harbor*

King Harbor in its present-day form was developed in the early 1960s and dedicated in 1966, although the north breakwater was constructed in the late 1930s (1937 to 1939) with extension completed in 1958 (USACE 1988a). Since the completion of the harbor-breakwater complex, the harbor has been dredged historically to maintain safe navigation depths. The primary source of harbor shoaling is the prevailing upcoast littoral drift south of the harbor, especially during storms. The sediment in the harbor shoals is typically sandy and free of contamination, and has historically been used for beach replenishment south of the harbor. A total of approximately 120,000 m^3 was reportedly dredged from the harbor in 1990 to remove sediment shoaled after storms (SMBRP 1994). There is, however, a lack of documentation of historical dredging events at the harbor based on permit archives, dredging and disposal databases, and personal communications, which perhaps further indicates the relative rarity of dredging occurrence in the harbor.

Table 2-1 Dredging and Disposal History for Marina del Rey

Year [a]	Project Proponent	Project	Dredging			Disposal		Source [c]
			Location	Quantity (m^3)	Method	Site	Quantity (m^3)	
1969	USACE	Channel Maintenance	Ballona Creek mouth	298,024	-- [d]	Del Rey Beach	298,024	5
1973	USACE	Channel Maintenance	South side of north jetty	12,308	-- [d]	Upcoast of north jetty	12,308	5
1981	USACE	Channel Maintenance	Entrance channel; Ballona Creek mouth	166,241	-- [d]	South of Dockweiler Beach	166,241	1, 5
1987	USACE	Channel Maintenance	Jetty tips; Ballona Creek mouth	27,000	-- [d]	Dockweiler Beach	27,000	1, 5
1992	USACE	Channel Maintenance	Ballona Creek mouth	16,438	-- [d]	Local Knockdown	16,438	3, 5
1994	USACE	Channel Maintenance	Entrance channel	43,580	Clamshell	Port of Los Angeles shallow water habitat	43,580	2, 3, 5
1996	USACE	Emergency Maintenance	Entrance channel	181,964	Clamshell/hydraulic	Beach	181,964	1, 2, 3
1998	USACE	Emergency Maintenance	Entrance channel	96,200	Hydraulic	LA-2	39,759	1, 2, 3, 4
						Harbor Infill	56,441	
1999	USACE	Channel Maintenance	Entrance channel	627,003 [b]	Clamshell	Beach	245,422	1
						Harbor Infill	381,581	

Total Maintenance Dredging Volume = 1,468,758 m^3 (1,921,063 cy)
Overall Maintenance Dredging Rate = 48,959 m^3/yr (64,036 cy/yr)
(a) Year indicates start of project.
(b) Volume difference exists with data from other Sources 2 and 3.
(c) Source:

1. USACE. 2003. Zone of Siting Feasibility Study Draft Report.
2. Navigation Data Center. USACE record. http://www.iwr.usace.army.mil/ndc.
3. USACE. 2003. Dredging Analysis Appendix Marina del Rey and Ballona Creek Feasibility Study.
4. Ocean Disposal Database. U.S. Army Corps of Engineers (Corps), Research and Development Center, Waterways Experiment Station, Environmental Laboratory. http://www.wes.army.mil/el/odd/odd.html.
5. USACE. 1995. Marina del Rey and Ballona Creek, CA, Final Reconnaissance Report.

(d) No record.

2.3 San Pedro Bay

2.3.1 *Port of Los Angeles*

Los Angeles Harbor, founded in 1907, underwent major development during the period of 1910 through 1930s that culminated in the completion of the federal San Pedro Breakwater in 1937. Since then, the ever increasing demand of shipping needs, especially with the advent of containerized shipping and growing vessel sizes, has necessitated continued capital improvements of the harbor including channel deepening, terminal expansion, and wharf replacement.

The current channel deepening project for the Main Channel, East Basin and West Basin will increase the channel depth to -16.1 meters mean lower low water (MLLW) to accommodate larger, deeper-draft vessels, which is expected to generate a total of 6.1 million m^3 (8 million cubic yards) of dredged sediment. Dredging for this project began in September 2002 and is expected to be completed in 2005.

The sediment accumulated in the harbor is typically silty with widely varied quality levels ranging from being highly contaminated at certain inner harbor locations such as the Consolidated Slip, to being relatively clean in the approach channel. USACE conducts maintenance and capital improvement dredging of the federally designated navigation channels in the harbor. Maintenance dredging of berthing locations, on the other hand, generally comes under the Port of Los Angeles (POLA). Table 2-2 presents a chronology of historical maintenance and capital improvement dredging and disposal events in Los Angeles Harbor since 1978.

The data indicate that a total of approximately 2 million m^3 has been dredged from Los Angeles Harbor for harbor maintenance between 1978 and 2002 at an average annual dredging rate of approximately 85,000 m^3 per year. In addition, a total of approximately 57.6 million m^3 of dredged material has been generated from harbor capital improvement projects in Los Angeles Harbor between 1980 and 1997 at an average annual rate of approximately 3.4 million m^3 per year. This total accounts for the completed capital improvement projects and does not include the volume of the current POLA Channel Deepening Project.

Table 2-2 Dredging and Disposal History for Port of Los Angeles (page 1 of 5)

Year [a]	Project Proponent	Project	Dredging			Disposal Site		Source [f]
			Location	Quantity (m^3)	Method	Site	Quantity (m^3)	
1978	Port of Los Angeles	Cerritos Channel Maintenance	Cerritos Channel	-- [g]	Hydraulic	LA-2	71,872	3
1978	-- [g]	Harbor Maintenance	Los Angeles Harbor	-- [g]	-- [g]	Ocean disposal	76,455 [e]	1
1979	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	9,481	1, 3
1980	Port of Los Angeles	Port of Los Angeles Main Channel and Super Tanker Channel Deepening [b]	Los Angeles Harbor	10,801,630 [d]	-- [g]	Pier 300 and Shallow Water Habitat	10,801,630 [d]	5
1982	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	53,522	1, 3
1982	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Hydraulic	LA-2	84,106	1, 3
1982	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Hydraulic	LA-2	49,699	1, 3
1982	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	57,345	1, 3
1982	National Steel and Shipbuilding	Harbor Maintenance	Los Angeles Harbor	-- [g]	-- [g]	LA-5	153,685	3
1983	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	612	3
1983	-- [g]	Harbor Maintenance	Los Angeles Harbor	-- [g]	-- [g]	Ocean disposal	48,549 [e]	1
1984	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	4,282	3
1984	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	93,281	3
1985	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	6,270	3

Table 2-2 Dredging and Disposal History for Port of Los Angeles (page 2 of 5)

Year [a]	Project Proponent	Project	Dredging			Disposal Site		Source [f]
			Location	Quantity (m^3)	Method	Site	Quantity (m^3)	
1985	-- [g]	Harbor Maintenance	Los Angeles Harbor	-- [g]	-- [g]	Ocean disposal	106,070 [e]	1
1986	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	38,230	3
1986	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	6,270	3
1986	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	53,522	3
1986	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	32,113	3
1987	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	11,469	3
1987	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	76,919	3
1987	-- [g]	Harbor Maintenance	Los Angeles Harbor	-- [g]	-- [g]	Ocean disposal	89,448 [e]	1
1988	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	76,460	3
1988	-- [g]	Harbor Maintenance	Los Angeles Harbor	-- [g]	-- [g]	Ocean disposal	60,625 [e]	1
1989	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	76,460	1, 3
1990	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	76,460	1, 3
1991	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	Clamshell	LA-2	22,938	1, 3
1993	Port of Los Angeles	Harbor Maintenance	Los Angeles Harbor	-- [g]	-- [g]	LA-3	5,352	1, 3
1993	Port of Los Angeles	Berth 226-231 Maintenance	Los Angeles Harbor	-- [g]	-- [g]	-- [g]	-- [g]	4
1995	USACE	Maintenance	Los Angeles Harbor	35,951	Hopper and Clamshell	Open water and upland	-- [g]	1, 2

Table 2-2 Dredging and Disposal History for Port of Los Angeles (page 3 of 5)

Year [a]	Project Proponent	Project	Dredging			Disposal Site		Source [f]
			Location	Quantity (m^3)	Method	Site	Quantity (m^3)	
1995	USACE, Port of Los Angeles	Pier 400 Stage I [b]	Los Angeles Harbor	22,768,140	Clamshell, hydraulic, and hopper	Pier 400 Landfill	22,768,140 [h]	8
1996	USACE, Port of Los Angeles	Port of Los Angeles East Basin Maintenance	Los Angeles Harbor	-- [g]	Hydraulic	LA-2	22,020	1, 3
1997	Port of Los Angeles	Berths 238-239 Wharf Repair and Fender Upgrade Project	Los Angeles Harbor	5,352 [d]	-- [g]	-- [g]	-- [g]	4
1997	Port of Los Angeles	Berths 51-55 Maintenance	Los Angeles Harbor	11,468 [d]	-- [g]	-- [g]	-- [g]	4
1997	USACE, Port of Los Angeles	Pier 400 Stage 2 Deep Draft Navigation Project [b]	Los Angeles Harbor	23,993,246	Clamshell and hydraulic dredge [i]	LA-2 Stage 2 CSWH Stage 2/CSWH	1,422,981 18,364,447 2,572,466 1,633,352 [j]	6
1998	USACE, Port of Los Angeles	Port of Los Angeles O&M	Los Angeles Harbor	-- [g]	Hopper	LA-2	118,360	1, 3
1998	Port of Los Angeles	Berths 49-50 Maintenance	Los Angeles Harbor	-- [g]	-- [g]	-- [g]	-- [g]	4
1998	Port of Los Angeles	Berth 144 Wharf Rep.	Los Angeles Harbor	108,567 [d]	-- [g]	LA-2 ARSSS [c]	99,392 9,175	4
1999	Port of Los Angeles	Berth 71 Maintenance	Los Angeles Harbor	--	-- [g]	-- [g]	-- [g]	4
1999	Port of Los Angeles	Berths 51-55 Maintenance	Los Angeles Harbor	114,683 [d]	-- [g]	ARSSS	114,683 [d]	4
1999	Port of Los Angeles	Berths 121-126 Maintenance	Los Angeles Harbor	22,937 [d]	-- [g]	LA-2	22,937 [d]	4
1999	Port of Los Angeles	Berths 163-164 Maintenance	Los Angeles Harbor	30,582 [d]	-- [g]	LA-2 ARSSS	22,937 7,645	4
1999	Port of Los Angeles	Berth 191 Maintenance	Los Angeles Harbor	5,352 [d]	-- [g]	LA-2 ARSSS	3,823 1,529	4
1999	Port of Los Angeles	Berths 216-221 Maintenance	Los Angeles Harbor	30,582 [d]	-- [g]	ARSSS	30,582 [d]	4

Table 2-2 Dredging and Disposal History for Port of Los Angeles (page 4 of 5)

Year [a]	Project Proponent	Project	Dredging			Disposal Site		Source [f]
			Location	Quantity (m^3)	Method	Site	Quantity (m^3)	
1999	Port of Los Angeles	Berths 118-120 Maintenance	Los Angeles Inner Harbor	6,116 [d]	-- [g]	ARSSS	6,116 [d]	4
1999	Port of Los Angeles	West Basin Entrance Berths 97-102	Los Angeles Harbor	-- [g]	-- [g]	-- [g]	-- [g]	4
2001	Port of Los Angeles	LA Inner Harbor Basin Berths 212-215 Maintenance	Los Angeles Harbor	16,820 [d]	Clamshell	ARSSS	16,820 [d]	4
2001	Port of Los Angeles	Berths 167-169 Maintenance	Los Angeles Harbor East Basin Channel	4,587 [d]	Clamshell	ARSSS	4,587 [d]	4
2001	Port of Los Angeles	Berths 148-151 Maintenance	Los Angeles Harbor Main Channel and Turning Basin	7,646 [d]	Clamshell	ARSSS	7,646 [d]	4
2001	Port of Los Angeles	Berths 261-265 Maintenance	Los Angeles Harbor Fish Harbor	19,114 [d]	Clamshell	ARSSS	19,114 [d]	4
2002	Port of Los Angeles	Berth 100 Wharf Construction	Los Angeles Harbor	26,759 [d]	Clamshell	ARSSS	26,759 [d]	4
2002 [k]	USACE	Port of Los Angeles Channel Deepening Project [b]	Los Angeles Harbor	6,116,439 [d]	Hydraulic and clamshell	Southwest Slip West	1,146,832 [d]	7
						Southwest Slip East	688,099 [d]	
						Eelgrass Shallow Water Habitat	76,456 [d]	
						Pier 300	1,223,288 [d]	
						Pier 400	2,217,209 [d]	
						Cabrillo Shallow Water Habitat	764,555 [d]	

Table 2-2 Dredging and Disposal History for Port of Los Angeles (page 5 of 5)

Total Maintenance Dredging Volume = 2,028,391 m^3 (2,653,035 cy)

Overall Maintenance Dredging Rate = 84,516 m^3/yr (110,543 cy/yr)

Total Capital Improvement Dredging Volume = 57,563,016 m^3 (75,289,580 cy) [k]

Overall Capital Improvement Dredging Rate = 3,386,060 m^3/yr (4,428,799 cy/yr) [k]

(a) Year Indicates start of project.

(b) Capital improvement project.

(c) Anchorage Road Soil Storage Site.

(d) Estimated or maximum permitted amount.

(e) Difference between quantities provided by Source 1 and by other records. Reflects potential quanities unaccounted for by sources available to present study.

(f) Source:

1. USACE. 2003. Zone of Siting Feasibility Study Draft Report.
2. Navigation Data Center. USACE record. http://www.iwr.usace.army.mil/ndc.
3. Ocean Disposal Database. Corps Waterways Experiment Station. http://www.wes.army.mil/el/odd/odd.html.
4. Los Angeles Regional Water Quality Control Board (LARWQCB) 401 Permit Information.
5. USACE. 1980. Plans and Specifications for Dredging and Outfall Sewer at Los Angeles Harbor, Los Angeles, California DACW09-80-B-0030.
6. USACE. 2000. Monthly Summary Report No.036, Report Period September 2000, Port of Los Angeles Pier 400 Stage 2 Construction Project. Prepared by Gahagan & Bryant Associates, Inc.
7. USACE. 2002. Final Supplemental Environmental Assessment for the POLA Channel Deepening Project, San Pedro Bay, California. Prepared by USACE South Pacific Division.
8. Gahagan & Bryant Associates, Inc. Project Files for Pier 400 Stage I.

(g) No record.

(h) Source 1 1997 quantities are close to Pier 400 Stage I and II.

(I) 550,536 m^3 done by Clamshell, remaining done by hydraulic dredge.

(j) Recored indicated 1,633,352 m^3 was disposed at both Stage 2 and Cabrillo Shallow Water Habitat (CSWH).

(k) The POLA Channel Deepening Project began in 2002 and is expected to be completed in 2005. The volume is not included in the total capital improvement dredging volume and rate since it is an on-going project.

2.3.2 *Port of Long Beach*

Long Beach Harbor was founded in 1911. Built out of some 800 acres of mudflats at the mouth of the Los Angeles River, the early development and improvement of the harbor roughly parallel those of the neighboring Los Angeles Harbor and was marked by the completion of the Long Beach Breakwater in 1949. Discovery of oil in 1936 brought oil extraction operations to the harbor, which has resulted in appreciable modification to the harbor bottom bathymetry due to subsidence of land and creation of oil islands and depressions. Similar to the Los Angeles Harbor, the ever increasing demand of shipping needs, especially with the advent of containerized shipping and growing vessel sizes, has necessitated continued capital improvements of the harbor including channel deepening, terminal expansion, and wharf replacement. Recent capital improvements in the harbor include the deepening of the approach channel to -23 meters, MLLW to accommodate deep-draft crude tankers.

The sediment accumulated in the harbor is typically silty with varied quality levels ranging from being appreciably contaminated at certain inner harbor locations such as Channel Two, to being relatively clean in the approach channel. USACE conducts maintenance and capital improvement dredging of the federally designated navigation channels in the harbor. Maintenance dredging of berthing locations, on the other hand, generally comes under the Port of Long Beach (POLB). Table 2-3 presents a chronology of historical maintenance and capital improvement dredging and disposal events in Long Beach Harbor since 1976.

The data indicate that a total of approximately 1.9 million m^3 has been dredged from Long Beach Harbor for harbor maintenance from 1976 to 2003, at an average annual dredging rate of approximately 71,000 m^3 per year. In addition, a total of approximately 14.2 million m^3 of dredged material has been generated from harbor capital improvement projects in Long Beach Harbor over the same period at an average annual rate of approximately 644,000 m^3 per year.

2.3.3 *Los Angeles River Estuary*

The Los Angeles River Estuary (LARE) connects the Los Angeles River with San Pedro Bay in the Long Beach Harbor, and drains the highly urbanized Los Angeles River Watershed. The outlet of the Los Angeles River flood control channel was constructed during the period of 1919 to 1923. The estuary is surrounded by recreational and commercial facilities and serves as part of the transportation corridor for coastal cruise liners transiting from Queensway Marina to Santa Catalina Island. Sediment discharged from the Los Angeles River has historically shoaled in the waterways of the estuary, created navigation hazards for recreational and commercial vessels using facilities along the shores of the estuary such as Queensway Marina, Golden Shore Boat Ramp, Rainbow Harbor/Marina and Long Beach Shoreline Marina. Closures of facilities by excessive shoals occurred relatively frequently in the winter following storm events.

Table 2-3 Dredging and Disposal History for Port of Long Beach (page 1 of 3)

Year [a]	Project Proponent	Project	Dredging			Disposal Site		Source [g]
			Location	Quantity (m^3)	Method	Site	Quantity (m^3)	
1976	Port of Long Beach	Harbor Maintenance	Long Beach Harbor	--[h]	Clamshell	LA-2	37,083	1,3
1977	Port of Long Beach	Harbor Maintenance	Long Beach Harbor	--[h]	Clamshell	LA-2	14,374	1,3
1980	Port of Long Beach	Harbor Maintenance	Long Beach Harbor	--[h]	Clamshell	LA-2	45,876	1,3
1981	Port of Long Beach	Harbor Maintenance	Long Beach Harbor	--[h]	Clamshell/ hydraulic	LA-2	439,645	3
1981	--[h]	Capital Improvement [b]	Long Beach Harbor	--[h]	--[h]	Ocean Disposal	768,378	1
1982	Port of Long Beach	Harbor Maintenance	Long Beach Harbor	--[h]	Clamshell	LA-2	30,584	3
1982	Port of Long Beach	Harbor Maintenance	Long Beach Harbor	--[h]	Clamshell	LA-2	38,230	3
1982	--[h]	Harbor Maintenance	Long Beach Harbor	--[h]	--[h]	Ocean Disposal	114,679 [f]	1
1982	--[h]	Capital Improvement [b]	Long Beach Harbor	--[h]	--[h]	Ocean Disposal	259,949	1
1983	--[h]	Harbor Maintenance	Long Beach Harbor	--[h]	--[h]	Ocean Disposal	11,468	1
1984	Port of Long Beach	Harbor Maintenance	Long Beach Harbor	--[h]	Clamshell	LA-2	15,292	1,3
1985	Port of Long Beach	Harbor Maintenance	Long Beach Harbor	--[h]	Clamshell	LA-2	91,752	1,3
1985	Port of Long Beach	Harbor Maintenance	Long Beach Harbor	--[h]	Clamshell	LA-2	15,292	1,3
1985	Port of Long Beach	Harbor Maintenance	Long Beach Harbor	--[h]	Clamshell	LA-2	61,168	1,3
1986	Port of Long Beach	Harbor Maintenance	Long Beach Harbor	--[h]	Clamshell	LA-2	30,584	3
1986	--[h]	Harbor Maintenance	Long Beach Harbor	--[h]	--[h]	Ocean Disposal	110,859 [f]	1
1987	U.S. Navy	--[h]	Long Beach, CA	--[h]	--[h]	LA-2	35,554	1,3
1992	Port of Long Beach	Harbor Maintenance	Long Beach Harbor	--[h]	Hopper/ Clamshell	LA-2	87,929	3
1992	Port of Long Beach	Port of Long Beach 5-Year Maintenance	Berths F206 - F207	1,888	Clamshell	Former Ford Site Berths 95-97	13,908	1, 4
			Berths E25 - E26	5,942				
			Berths F208 - F209	2,194				
			Berths F204 - F205	3,884				

Table 2-3 Dredging and Disposal History for Port of Long Beach (page 2 of 3)

Year [a]	Project Proponent	Project	Dredging			Disposal Site		Source [g]
			Location	Quantity (m^3)	Method	Site	Quantity (m^3)	
1992	--[h]	Capital Improvement [b]	Long Beach Harbor	--[h]	--[h]	Ocean Disposal	550,021	1
1993	Port of Long Beach	Harbor Maintenance	Long Beach Harbor	--[h]	Hopper/ clamshell	LA-2	462,124	3
1996	--[h]	Capital Improvement [b]	Long Beach Harbor	--[h]	--	Ocean Disposal	535,188	1
1997	Port of Long Beach	Port of Long Beach 5-Year Maintenance	Berths E24 - E26	14,909	Clamshell	Former Ford Site Berths 95-97	15,826	4
			Berths B76 - B79	917	Clamshell			
1998	Port of Long Beach	Port of Long Beach 5-Year Maintenance	Long Beach Harbor	19,144	Clamshell	Pier A	19,144	4
1998	Port of Long Beach	Pier A Marine Terminal - Inner Harbor Maintenance	Long Beach Harbor	--[h]	--[h]	--[h]	--[h]	4
1998	USACE	Main Channel Deepening [b]	Long Beach Harbor	4,970,400 [d]	Undefined	Overboard and open water	--[h]	2
1999	Port of Long Beach	Harbor Maintenance	Long Beach Harbor	--	Hopper	LA-2	92,975	1,3
1999	Port of Long Beach	Port of Long Beach 5-Year Maintenance	Long Beach Harbor	15,215	Clamshell	Pier E	15,215	4
1999	Port of Long Beach	--[h,b]	Long Beach Harbor	--[h]	Hydraulic	LA-2	1,812,102	3
1999	Port of Long Beach	Pier T Marine Terminal West Basin Dredging [b]	Long Beach Harbor	1,524,968 [d]	--[h]	Harbor Infill [c]	1,524,968 [d]	4
1999	--[h]	Capital Improvement [b]	Long Beach Harbor	491,075 [f]	--[h]	Stock Piling	--[h]	1
						Capping and Upland	--[h]	
2000	Port of Long Beach	Port of Long Beach 5-Year Maintenance	Long Beach Harbor	15,368	Clamshell	Pier T	15,368	4
2000	Port of Long Beach	Berths J245-J247 Deepening [b]	Port of Long Beach Pier J	--[h]	Hopper	Western Anchorage	--[h]	4

Table 2-3 Dredging and Disposal History for Port of Long Beach (page 3 of 3)

Year [a]	Project Proponent	Project	Dredging			Disposal Site		Source [g]
			Location	Quantity (m^3)	Method	Site	Quantity (m^3)	
2000	Port of Long Beach	Terminal Island Container Facilities Expansion [b]	Port of Long Beach Pier T	305,822 [d]	Hopper/ clamshell	Dry Docks #2 and #3	305,822 [d]	4
			Western Anchorage	764,555 [d]		Navy Mole Site	764,555 [d]	
2000	--[h]	Capital Improvement [b]	Long Beach Harbor	--[h]	--[h]	Harbor Infill	1,677,433 [f]	1
2002	Carnival Corporation	Passenger Terminal Facility Long Beach Maintenance	Long Beach Harbor	11,468 [d]	Clamshell	Pier G [e]	11,468 [d]	4
2002	Port of Long Beach	Port of Long Beach 5-Year Maintenance	Long Beach Harbor	24,428	Clamshell	Pier G	11,583	4
			Long Beach Harbor		Clamshell	Western Anchorage	12,845	
2002	Port of Long Beach	Piers G/J Southeast Basin Deepening [b]	Port of Long Beach Southeast Basin and Outer Harbor Borrow Site	275,010	Hydraulic	Pier G Landfill	275,010	4
2003	Port of Long Beach	Piers G/J Southeast Basin Deepening [b]	Long Beach Harbor	235,483	--[h]	Western Anchorage	235,483	4

Total Maintenance Dredging Volume =1,850,825 m^3 (2,420,788 cy)

Overall Maintenance Dredging Rate = 71,186 m^3/yr (93,107 cy/yr)

Total Capital Improvement Dredging Volume = 14,170,384 m^3 (18,534,160 cy)

Overall Capital Improvement Dredging Rate = 644,108 m^3/yr (842,462 cy/yr)

(a) Year Indicates start of project.

(b) Capital Improvement Project.

(c) Harbor Infill site includes Pier E Slip 2, nearshore upcoast from Alamitos Bay west jetty (Peninsula Beach), Navy Mole in West Basin and Main Channel fill site.

(d) Estimated or maximum permitted amount.

(e) Pier G Berth 236 Wharf Rehabilitation Project.

(f) Difference between quantities provided by Source 1 and by other records. Reflects potential quantities unaccounted for by sources available for present study.

(g) Source:

1. USACE. 2003. Zone of Siting Feasibility Study Draft Report. U.S. Army Corps of Engineers, Los Angeles District.
2. Navigation Data Center. U.S. Army Corps of Engineers, Los Angeles District record. http://www.iwr.usace.army.mil/ndc.
3. Ocean Disposal Database. U.S. Army Corps of Engineers, Waterways Experiment Station. http://www.wes.army.mil/el/odd/odd.html.
4. LARWQCB 401 Permit Information.

(h) No record.

The sediment in the shoals affecting the navigation channel consists typically of a relatively high percentage of silt and clay, and is often contaminated and unsuitable for unrestricted ocean, nearshore, or upland disposal. USACE conducts maintenance of the navigation channel between Queensway Marina and San Pedro Bay, for which federally designated channel dimensions were established relatively recently, at a dredging cycle of approximately two years. The City of Long Beach has also historically performed maintenance dredging of the estuary on an as-needed basis to support access to various facilities in the estuary. Table 2-4 presents a chronology of historical maintenance dredging and disposal events in the LARE since 1979.

The data indicate that a total of approximately 1.2 million m^3 has been dredged from the LARE and vicinity for access and navigation channel maintenance between 1979 and 2001. The average annual maintenance dredging rate has been approximately 86,000 m^3 per year based on the period between 1990 and 2001.

2.4 Alamitos Bay

Alamitos Bay is a recreational harbor consisting of a circular waterway that surrounds Naples and contains seven boat basins and the Marine Stadium, a narrow, rectangular water body built in the 1920's as the rowing venue for the 1932 Olympics. The bay receives watershed runoff directly from Los Cerritos Channel and indirectly from San Gabriel River located next to the bay entrance. The bay has been historically dredged by the City of Long Beach every winter season to maintain channel and basin depths to support boating activities. Table 2-5 presents a chronology of historical maintenance dredging and disposal events in the bay during the past decade.

The data indicate that a total of approximately 111,000 m^3 has been dredged from Alamitos Bay for entrance channel and basin maintenance from 1994 to 2002. The average annual maintenance dredging rate has been approximately 14,000 m^3 per year over the same period.

Table 2-4 Dredging and Disposal History for Los Angeles River Estuary (page 1 of 2)

Year [a]	Project Proponent	Project	Dredging			Disposal		Source [c]
			Location	Quantity (m^3)	Method	Site	Quantity (m^3)	
1979	--[d]	Maintenance	Los Angeles River Estuary	--[d]	--[d]	Ocean Disposal	271,417 [f]	1
1980	City of Long Beach [e]	Downtown Shoreline Marina Mole	Los Angeles River Estuary	841,010	--[d]	--[d]	--[d]	7
1988	City of Long Beach	West Beach Area Maintenance	Long Beach	--[d]	--[d]	--[d]	--[d]	5
1990	USACE	Los Angeles River Estuary Maintenance	Los Angeles River Estuary	112,533	Hydraulic/ clamshell	Confined	--[d]	2
1990	USACE	Golden Shore Boat Ramp Area Maintenance	Los Angeles River Estuary	19,114 [b]	--[d]	--[d]	--[d]	4
1991	USACE	Queensway Marina Navigation Channel Maintenance	Los Angeles River Estuary	93,276 [b]	--[d]	POLB Infill - Pier J	93,458	1, 4
1992	City of Long Beach	Los Angeles River Estuary Maintenance	Los Angeles River Estuary	8,000-15,000 [b]	--[d]	--[d]	--[d]	4
1994	City of Long Beach	Los Angeles River Estuary Maintenance	Los Angeles River Estuary	69,000-77,000 [b]	--[d]	--[d]	--[d]	4
1995	USACE	Queensway Marina Navigation Channel Emergency Maintenance	Los Angeles River Estuary	229,366	Hydraulic	Long Beach Outer Harbor borrow pit	230,100	1, 2, 4, 6
1997	USACE	Maintenance	Los Angeles River Estuary	62,428	Hydraulic/ clamshell	Overboard and open water	--[d]	1, 2
1999	USACE	LA River Estuary Maintenance	Los Angeles River Estuary	126,330	Hydraulic	LA-2	25,232	1, 2, 3
						POLB Infill - Pier E	101,098	
2000	City of Long Beach	Catalina Cruises Terminal Basin Dredging	Los Angeles River Estuary	--[d]	Hydraulic	Harbor Infill	103,346	1, 5
2001	USACE	LA River Estuary Pilot Study	Los Angeles River Estuary	103,346	--[d]	North Energy Island Borrow Pit	103,346	1

Table 2-4 Dredging and Disposal History for Los Angeles River Estuary (page 2 of 2)

Total Maintenance Dredging Volume = 1,213,156 m^3 (1,586,748 cy)

Overall Maintenance Dredging Rate = 85,613 m3/yr (111,978 cy/yr) Rate is based on records from 1990-2001

(a) Year indicates start of project.

(b) Estimated or maximum permitted amount.

(c) Source:

1. USACE. 2003. Zone of Siting Feasibility Study Draft Report.
2. Navigation Data Center. USACE record. http://www.iwr.usace.army.mil/ndc.
3. Ocean Disposal Database. USACE, Waterways Experiment Station. http://www.wes.army.mil/el/odd/odd.html.
4. USACE. 1996a. LARE Navigation Channel Alternatives. Prepared for USACE.
5. LARWQCB 401 Permit Information.
6. Contaminated Sediments Task Force Metadata.
7. City of Long Beach, personal communication.

(d) No record.

(e) One-time initial construction project.

(f) Record not included in total rate due to gap in records.

Table 2-5 Dredging and Disposal History for Alamitos Bay

Year [a]	Project Proponent	Project	Dredging			Disposal		Source [c]
			Location	Quantity (m^3)	Method	Site	Quantity (m^3)	
1988	City of Long Beach	East Beach Area Maintenance	East Beach	-- [d]	-- [d]	-- [d]	-- [d]	1
1994	City of Long Beach	Harbor Maintenance	Entrance Channel	10,226	Hydraulic	East Beach [b]	10,226	1
1995	City of Long Beach	Alamitos Bay Basin One Maintenance	Basin One	13,284	Hydraulic	East Beach [b]	13,284	1
1996	City of Long Beach	Harbor Maintenance	Entrance Channel	34,405	Hydraulic	East Beach [b]	34,405	1
1997	City of Long Beach	Harbor Maintenance	Entrance Channel	5,373	Hydraulic	East Beach [b]	5,373	1
1998	City of Long Beach	Harbor Maintenance	Entrance Channel	11,010	Hydraulic	East Beach [b]	11,010	1
1999	City of Long Beach	Harbor Maintenance	Entrance Channel	2,515	Hydraulic	East Beach [b]	2,515	1, 2
2001	City of Long Beach	Harbor Maintenance	Entrance Channel	14,144	Hydraulic	East Beach [b]	14,144	1, 2
2002	City of Long Beach	Harbor Maintenance	Entrance Channel	19,680	Hydraulic	East Beach [b]	19,680	1, 2

Total Maintenance Dredging Volume = 110,637 m^3 (144,708 cy)
Overall Maintenance Dredging Rate = 13,830 m^3/yr (18,088 cy/yr)
(a) Year indicates start of project.
(b) Beach nourishment 30.3 meters offshore at east end of East Beach adjacent to Alamitos Jetty.
(c) Source:
1. LARWQCB 401 Permit information.
2. Dredging volume obtained from post-dredging seasonal report from the City of Long Beach to USACE.
(d) Permit exists, but no quantity information.

2.5 Summary

In the last three decades, the Region has generated substantial amounts of dredged material from maintenance and capital improvement projects in its major harbors, marinas, and navigation channels. Table 2-6 summarizes the historical dredging volumes from major dredging sites in the Region.

Table 2-6 Dredging Volumes Summary

Location	Period of Available Record	Maintenance Dredging		Capital Improvement Dredging	
		(m^3)	(m^3/year)	(m^3)	(m^3/year)
Marina del Rey	1969-1999	1,469,000	49,000	-	-
POLA	1978-2002	2,028,000	85,000	57,563,000	3,386,000
POLB	1976-2003	1,851,000	71,000	14,170,000	664,000
LARE	1979-2001	1,213,000	86,000 [1]	-	-
Alamitos Bay	1994-2002	111,000	14,000	-	-
	Regional Total	**6,672,000**	**305,000**	**71,733,000**	**4,050,000**

1. Rate based on record between 1990 and 2001.

The dredging history in the Region based on available records indicates that a total of approximately 6.7 million m^3 of dredged material has been generated from harbor and channel maintenance projects over the past decades at an annual rate of approximately 305,000 m^3 per year. Among the total dredged volume, approximately 72 million m^3 of the dredged material has been generated from capital improvement projects in the Ports over the same period at an annual rate of about 4 million m^3 per year. The data indicate that the regional total dredging volume and rate associated with capital improvement projects are over 10 times those of maintenance projects, which suggests that capital improvement projects in the Ports have been the dominant dredged material generator in the Region.

Disposal practices in the Region include harbor infill, open ocean disposal, nearshore open water disposal, beach fill, shallow water habitat fill, and stockpiling. Table 2-7 presents the quantities by disposal methods for materials from the major dredging sites in the Region. Harbor infill includes records for Port fill activities and confined disposals. Open ocean disposal refers to sites such as LA-2 or LA-3. Nearshore open water refers to disposal records for nearshore, overboard, and borrow pit (e.g., North Energy Island Borrow Pit). Beach fill include beach placement and nourishment. Shallow water habitat (SWH) indicates disposal at locations designated for SWH. Stock piling refers to the disposal of dredge material at the Anchorage Road Soil Storage Site (ARSSS) for the POLA and Western Anchorage for the POLB. The mixed disposal method refers to the combination of harbor infill and shallow water habitat disposal records in which the volume breakdown for each method was not available. Volumes from disposal events with methods that are indeterminate from available records are grouped under “unspecified”.

Table 2-7 Disposal Method Volumes Summary

Disposal Method	Marina del Rey	Port of Los Angeles	Port of Long Beach	Los Angeles River Estuary	Alamitos Bay	Regional Total	Percent of Total
Harbor Infill	438,000	41,133,000	4,650,000	410,000	-	46,631,000	60%
Open Ocean	40,000	3,154,000	5,661,000	297,000	-	9,152,000	12%
Nearshore Open Water	16,000	36,000	4,970,000	395,000	-	5,417,000	7%
Beach Fill	931,000	-	-	-	111,000	1,042,000	1%
Shallow Water Habitat	44,000	2,572,000	-	-	-	2,616,000	3%
Stock Piling	-	245,000	739,000	-	-	984,000	1%
Mixed [1]	-	12,435,000	-	-	-	12,435,000	16%
Unspecified	-	17,000	-	111,000	-	128,000	0%

1. Disposal includes both harbor infill and shallow water habitat.

The disposal data indicate that approximately 60 percent (46.6 million m^3) of the total historical volume of dredged material from the Region has been used as infill for harbor infrastructure development and expansion projects at the POLA and POLB. This is followed by 12 percent (9.1 million m^3) disposed of offshore at designated ocean disposal sites including LA-2 and LA-3 and 7 percent (5.4 million m^3) at nearshore disposal sites such as the Energy Island Borrow Pit. Beach fill and shallow water habitat fill, two of the primary beneficial reuses practiced in the Region, have accounted for approximately 1 percent (1 million m^3) and 3 percent (2.6 million m^3) of the total disposal volume in the Region, respectively. In addition, about 1 percent of the total historical volume generated in the Region has been kept for stock piling at the Ports' storage facilities. A significant 16 percent (12.4 million m^3) of the total volume was disposed as mix that included both harbor infill and SWH. This volume was from two of the capital improvement projects at the POLA. The unspecified disposal volumes were minimal relative to the total dredge volume.

The volumetric breakdown between statutorily contaminated and uncontaminated (clean) dredged material has not been determined on a project-by-project basis. The disposal method does not always indicate if the dredge material is contaminated or not, except for open ocean disposal which must only consist of uncontaminated material.

3 FUTURE DREDGING AND DISPOSAL NEEDS

3.1 Overview

In this section, the projected future dredging and disposal need for the Study Area is discussed. The projected need is estimated based on historical dredging and disposal records summarized in the last section and discussions with agencies responsible for sponsoring dredging operations (e.g., USACE, Port of Los Angeles (POLA), Port of Long Beach (POLB), and City of Long Beach).

The Los Angeles Dredged Material Management Plan (DMMP) Feasibility Study (FS) requires a projection of the future dredging and disposal needs over the next 20 years. Anticipated capital improvement projects are only projected for the POLA and the POLB. The Ports have relatively accurate projections for short-term (five to six years) capital improvement needs compared to long-term needs. Similarly, the Ports' estimates for future maintenance needs records will be more accurate for the short-term than the long-term. For the other locations, agency maintenance projections based on historical records will also be more accurate for the short-term rather than the long-term. The uncertainty in the long-term future projections is a result of the uncertainty of success for future source control measures to reduce sediment (especially contaminated sediments) loads to the shore in the long-term. Hence, similar to any future projection, the projected dredging and disposal needs for the Study Area in shorter-terms (five to six years) will be more accurate than the projection for the long-term (over the next 20 years).

3.2 Santa Monica Bay

3.2.1 *Marina del Rey*

The Los Angeles District U.S. Army Corps of Engineers (USACE) anticipates continuing regular maintenance dredging programs at the Marina del Rey entrance channels. The projected maintenance dredging need is anticipated at a rate of 50,000 to 100,000 cubic meters (m^3) per year, which is consistent with the historical dredging rate. It is estimated that about one-fourth of the dredge volume will be contaminated. For the short-term, it is anticipated that Marina del Rey will need to be dredged every three to five years for a volume of about 150,000 to 250,000 m^3. The next dredge event is planned for 2005 with an expected volume of 300,000 to 350,000 m^3. No capital improvement projects are expected for Marina del Rey.

The short-term projected rate is expected to continue until a sediment control alternative is implemented. USACE is currently conducting a feasibility study to evaluate several sediment control alternatives at Marina del Rey and along Ballona Creek to reduce sediment depositions at the harbor entrance and hence reduce the need for future maintenance dredging. In addition, source control best management practices (BMPs) have been and will continue to be installed in portions of the Ballona Creek watershed. Therefore, a long-term projection is difficult to accurately estimate. However, based on the short-term projected rate, 1 to 2 million m^3 of sediment, with 250,000 – 500,000 m^3 being contaminated, could be generated from Marina del Rey over the next 20 years.

3.2.2 *King Harbor*

Since the King Harbor was dedicated in 1966, there is only one reported maintenance dredging event of 120,000 m^3 in 1990. Other than that single event, no other record of maintenance dredging or capital improvements can be found. Hence, dredging need for King Harbor is expected to be minimal, if any, over the next 20 years.

3.3 San Pedro Bay

3.3.1 *Port of Los Angeles*

Currently the POLA Channel Deepening Project is underway, as discussed in the previous chapter. The project is expected to generate 6.1 million m^3 of sediment by the projected completion in 2005. Disposal will be limited within the POLA for harbor infill and shallow water habitat. The Channel Deepening Project is not considered in the evaluation of future dredging and disposal needs since disposal need have already been met. The POLA is currently planning other dredging projects scheduled between 2004 and 2009. The short-term dredging and disposal needs for the POLA can be estimated fairly accurately. These anticipated maintenance and capital improvement activities for the POLA are listed in Table 3-1. Several capital improvement projects shown in the table will involve substantial landside cutting (these cut volumes are shown in parentheses in the table). Strictly speaking, these are not dredging activities, but the cut volumes are included because this adds to the need for identifying suitable disposal options for the Los Angeles Region (Region).

Table 3-1 Projected Future Dredging of Sediment Quantities in the Port of Los Angeles

Year [1]	Total Volume (m^3)	Contaminated Volume (m^3)	Dredging Location	Comment
2004	69,470	570	Berth 36	Maintenance
		4,000	Berths 90-92	Maintenance
		3,800	Berths 93A-93B	Maintenance
		5,000	Berths 122-124	Maintenance
		5,100	Berths 127-131	Maintenance
		10,200	Berths 153-155	Maintenance
		2,200	Berths 165-166	Maintenance
		8,000	Berths 177-179	Maintenance
		6,300	Berths 180-181	Maintenance
		19,300	Berths 226-231	Maintenance
		5,000	Berth 240B	Maintenance
2005	69,470	8,400	Berths 57-58	Maintenance
		7,600	Berths 59-60	Maintenance
		770	Berth 94	Maintenance
		15,300	Berths 136-139	Maintenance
		7,600	Berths 195-199	Maintenance
		3,800	Berth 200A	Maintenance
		6,100	Berths 206-209	Maintenance
		2,300	Berths 210-211	Maintenance
		6,100	Berths 225-225	Maintenance
		11,500	Berths 232-236	Maintenance
	168,200 (145,300) [2]	168,200	Berths 145-147	Capital Improvement
	57,300 (35,100) [2]	29,100	Berths 173 & 176	Capital Improvement
	260,000 (206,500) [2]	130,000	Berths 206-209	Capital Improvement
	520,000 (405,200) [2]	260,000	Berths 226-236	Capital Improvement
2007	81,160	760	Berth 36	Maintenance
		11,500	Berths 45-47	Maintenance
		7,650	Berths 49-50	Maintenance
		3,100	Berths 87-90	Maintenance
		7,650	Berths 174-176	Maintenance
		7,650	Berths 182-186	Maintenance
		15,300	Berths 187-190	Maintenance
		15,300	Berth 240Z	Maintenance
		4,600	Berth 240A	Maintenance
		7,650	Berths 258-260	Maintenance
	994,000 (909,900) [2]	497,000	Berths 122-129	Capital Improvement
2008	313,500 (183,500) [2]	160,600	Berths 214-218	Capital Improvement
2009	41,100	3,800	Berths 51-55	Maintenance
		1,500	Berths 70-71	Maintenance
		3,800	Berths 118-120	Maintenance
		3,800	Berths 148-151	Maintenance
		6,100	Berths 167-169	Maintenance
		1,500	Berths 191-194	Maintenance
		7,650	Berths 212-215	Maintenance
		7,650	Berths 216-221	Maintenance
		1,500	Berths 238-239	Maintenance
		3,800	Berths 261-269	Maintenance
	252,300 (211,000) [2]	130,000	Berth 136	Capital Improvement

1. Year indicates first year of estimate schedule for Capital Improvements.
2. Volume for landside cutting.

Over the next six years, the POLA is expecting to generate a total of 261,200 m^3 due to maintenance dredging for a rate of 44,000 m^3 per year. It is expected that all maintenance dredging sediment will be contaminated. In addition to regular maintenance dredging, several capital improvement projects have been proposed for the POLA. Capital improvement projects are estimated to generate 2,576,000 m^3 of sediment over the next six years (429,000 m^3 per year) with 1,375,000 m^3 or 53 percent being contaminated. The combined maintenance and capital improvement needs for POLA will generate a total of 2,837,000 m^3 sediments at a rate of 473,000 m^3 per year over the next six years. Out of the total, 1,636,000 m^3 are considered contaminated.

It is difficult to project the dredging and disposal needs beyond 2009 and over the next 20 years. Capital improvement projects in the preliminary planning phase include the Cabrillo Marina Phase II and Waterfront Development projects. In addition, remedial action is also being contemplated for Consolidated Slip at the POLA. While sediment characterization in the Consolidated Slip is still underway, preliminary estimates indicate that about 400,000 to 800,000 m^3 are contaminated, not including Dominguez Channel.

The dredging and disposal need over the next 20 years for the POLA could be roughly estimated by combining the more accurate short-term projection and a long-term projection based on historical rates. The short-term maintenance dredging need is projected at a rate of 44,000 m^3 per year (all contaminated). This rate is about half of the historical maintenance rate, so the future maintenance dredging need between six and 20 years can be approximated between 44,000 – 85,000 m^3 per year. Therefore, POLA can expect to generate 880,000 to 1.5 million m^3 of contaminated sediment from maintenance dredging over the next 20 years. The future sediment generated from capital improvements between six and 20 years can be estimated between the six-year projection and historical capital improvement rates of 429,000 to 3.4 million m^3 per year. Over the next 20 years, POLA combined total projects could generate 9.46 to 51.5 million m^3 of sediment with 5.5 to 28.5 million m^3 of contaminated sediment.

3.3.2 *Port of Long Beach*

Similar to the POLA, the POLB has a fairly accurate projection of the dredging and disposal needs due to maintenance dredging and capital improvement projects over the next four to five years (2004 to 2008). A summary of these anticipated maintenance dredging and capital improvement projects over the next five years is listed in Table 3-2. The total volumes presented in the table include portions generated from landside cutting or shoreline excavation (these cut volumes are shown in parentheses under the contaminated volume). Strictly speaking, these are not dredging activities, but the cut volumes are included because this adds to the need for identifying suitable disposal options for the Region.

Table 3-2 Projected Future Dredging of Sediment Quantities in the Port of Long Beach

Year [1]	Total Volume (m^3)	Contaminated Volume (m^3)	Dredging Location	Comment
2004	841,000	650,000	Pier T Wharf Extension, Phase 2	Capital Improvement (2005) [3]
	321,000	268,000	Back Channel Navigation Safety Improvements	Capital Improvement
	153,000	153,000	On-Going Maintenance Dredge (5-yr permit June 30, 2003-2008)	Maintenance (2008) [3]
2005	1,223,000	(1,050,000) [2]	Pier S Dike Realignment & Berth	Capital Improvement
	765,000	0	Main Channel Deepening Phase II & Turning Basin Widening	Capital Improvement
2006	77,000	77,000	Pier T Berth T126 LNG Terminal to –50 ft, MLLW	Capital Improvement (2007) [3]
	593,000	153,000	Pier T Berth T124 Liquid Bulk Terminal to –80 ft, MLLW	Capital Improvement (2007) [3]
	765,000	(765,000) [2]	Pier E Slip 3 Widening	Capital Improvement (2007) [3]
Undefined[4]	306,000	306,000	DTSC/Navy Mandated Cleanup of AOEC-A	Capital Improvement
	1,147,000	(1,147,000) [2]	Pier F South Tip Removal	Capital Improvement

1. Year indicates first year of estimate schedule for Capital Improvements.
2. Shoreline Excavation.
3. Expected Completion Date.
4. Undefined but expected to be within five years.

The POLB estimates a total maintenance dredge volume of 153,000 m^3 between 2004 and 2008 resulting in a maintenance dredging rate of 31,000 m^3 per year. All maintenance dredging sediments are expected to be contaminated. The total projected sediment volume from capital improvement projects (dredging and shoreline excavation) is estimated to be 6,038,000 m^3 for a rate of 1,207,000 m^3 per year. The contaminated portion from capital improvement projects is estimated at 4,416,000 m^3 for a rate of 873,000 m^3 per year. The short-term total projected dredge volume for both maintenance and capital improvement is 6,191,000 m^3 with a rate of 1,238,000 m^3 per year. Of the total volume, 74 percent is contaminated for a volume of 4,569,000 m^3.

Dredging projects that may occur after Year 2008, but within the next 20 years include Pier S Berth 100 Wharf, Landfill Mole Lumber Terminal and Mandated IR Site (West Basin) cleanup. It is difficult to accurately project the dredging and disposal needs beyond the next five years.

The best long-term estimates will range between the short-term projection rate and the historical dredging rate presented previously. The long-term maintenance dredging projection for five to 20 years in the future can vary between the short-term projection of 31,000 m^3 per year and historical rate of 71,000 m^3 per year. Over the next 20 years, it can be estimated that 620,000 – 1.2 million m^3 of contaminated sediment could be generated from maintenance dredging. Capital improvements are expected to generate 1.2 million m^3 per year with 73 percent being contaminated over the next five years. Beyond the five-year projection, capital improvement projects can produce 644,000 to 1.2 million m^3 per year. The future 20-year total can range between 2.22 to 25.2 million m^3 of sediment with 1.8 to 18.7 million m^3 of contaminated sediment.

3.3.3 *Los Angeles River Estuary*

USACE and the City of Long Beach estimates the Los Angeles River Estuary (LARE) maintenance dredging need to be 53,000 m^3 per year, which is consistent with the historical dredging rate of 55,000 m^3 per year. It is estimated that 25 percent of the total will be contaminated. This rate can reasonably reflect the short-term dredging and disposal need for the LARE. Historical records indicate no capital improvement projects and none are expected.

The short-term rate can be expected to continue until sediment control BMPs are implemented within the Los Angeles River watershed to achieve the total maximum daily loads (TMDLs) that will be established in the future. BMPs to reduce sediment and contaminants have been installed and will continue to be implemented in portions of the watershed. It is difficult to determine when these BMPs will be fully in-place and what impact it will have on the sediment load to the LARE.

Assuming the short-term rate continues over the next 20 years, approximately 1.1 million m^3 of sediment with 275,000 m^3 of contaminated sediment could be generated from LARE. However, it is not always possible to separate the clean and contaminated portions. In which case, the entire volume is treated as contaminated sediment.

3.4 Alamitos Bay

For the future dredging and disposal needs for Alamitos Bay, the City of Long Beach expects to continue the annual maintenance dredging of the entrance channel. Historical maintenance dredging records for Alamitos Bay indicate an average annual dredging rate of approximately 14,000 m^3 per year. The City of Long Beach is also planning a capital improvement project of the Alamitos Bay Marina. This project is expected to generate 153,000 m^3 of sediment over three years. It is expected that one-fourth of the total volume (39,000 m^3) will be contaminated.

Over the next 20 years, the maintenance dredging and beach disposal can be expected to continue at the historical rate. The capital improvement project is expected to be a one-time event. Therefore, a combined total of 433,000 m^3 of sediment with 39,000 m^3 of contaminated sediment could be generated from Alamitos Bay.

3.5 Summary

Future dredging and disposal needs for the Study Area have been estimated based on projected needs and historical dredging records. Short-term (five to six years) projections obtained from USACE, POLA, POLB, and the City of Long Beach for maintenance and capital improvements needs reflect relatively accurate dredging and disposal needs. Long-term projections to 20 years in the future are based on ranges between the short-term projections and historical records and hence are less accurate. The accuracy is also reduced due to potential sediment source reductions attributed to source control measures being implemented in the watershed. Table 3-3 summarizes the 20-year projections of both maintenance dredging and capital improvements for each location. The Region can expect to generate 14.8 to 80.8 million m^3 of sediment with 8.0 to 49.4 million m^3 (54 to 61 percent) of contaminated sediment. This large range in volume is attributed to the long-term extrapolation of dredging rates and to the capital improvement projects within the POLA and POLB, as these are the dominant dredge sediment generators in the Region. Over the next 20 years, it is unlikely that capital improvement projects at the POLA and POLB will reach the historical rate as the Ports have limited space for expansion and development. Thus, it is more probable that the Region dredging and disposal need will be closer towards the lower end of the 20-year projection.

Table 3-3 20-Year Projection for Sediment Generation in the Los Angeles Region

Location	Projected 20-Year Total Volume (million m^3)	Projected 20-Year Total Contaminated Volume (million m^3)
Marina del Rey	1 - 2	0.25 - 0.50
King Harbor	0	0
Port of Los Angeles	9.46 - 51.5	5.5 - 28.5
Port of Long Beach	2.22 - 25.2	1.8 - 18.7
Los Angeles River Estuary	1.7	0.43 – 1.7
Alamitos Bay	0.43	0.04
Regional Total	**14.8 - 80.8**	**8.0 – 49.4**

4 REGIONAL SEDIMENT CHARACTERIZATION

This section provides an overview of sediment physical and chemical parameters typical of dredge material within the Los Angeles Regional Dredged Material Management Plan (DMMP) Study Area. Data are first summarized for Santa Monica Bay, then San Pedro Bay, Los Angeles River Estuary (LARE), and, finally, for Alamitos Bay.

4.1 Sediment Data Sources

The primary source of data used to prepare this summary is the Contaminated Sediments Task Force (CSTF) database constructed specifically for use in developing a Contaminated Sediments Management Strategy document and for the current Feasibility Study (FS). The primary sources of data used to create the database include work provided by the Port of Los Angeles (POLA), Port of Long Beach (POLB), City of Long Beach, County of Los Angeles (County), U.S. Army Corps of Engineers, Los Angeles District (USACE), National Oceanic Atmospheric Association (NOAA), and Southern California Coastal Water Research Project (SCCWRP). The database is located on the SCCWRP website at www.sccwrp.org.

The data contained within the CSTF database includes all sediment characterization information available for the region where the material was considered for aquatic or upland disposal. Other data (e.g., grain size, density, etc.) exists for sediment collected within portions of San Pedro Bay, but this information was not included in the current evaluation because it was collected for use in a specific fill project and was never considered for any other form of disposal. In other words, the material would not have been subjected to the recommendations provided in this plan. For example, portions of the Los Angeles Harbor channel deepening project were directly tied to the construction of the Pier 400 terminal within the POLA. The sediments were characterized for physical strength solely to determine fill site compatibility and the analyses did not include chemical measurements. As such, this information was excluded from the CSTF database and is not presented in this report.

Other sources of data that were used include the recently completed Los Angeles DMMP Pilot Studies (USACE 2002a), the Preliminary Draft Marina del Rey DMMP (Chambers Group 1998), and the Year 2000 Biological Survey of the Ports of Los Angeles and Long Beach (MEC 2002).

4.2 Santa Monica Bay/Marina del Rey

Within Santa Monica Bay, sediment management activities covered by the Los Angeles DMMP are limited to Marina del Rey, the mouth of Ballona Creek, and the jetty located at the mouth of King Harbor. Sediment characterization data (other than bathymetry and grain size) is readily available for Marina del Rey and Ballona Creek, but only one record exists for King Harbor. As such, the majority of the data presented in this section will be limited to the former two locations.

4.2.1 *Physical Characterization and Distribution*

4.2.1.1 *Grain Size and Organic Carbon*

Sediment grain size distribution in Marina del Rey/Ballona Creek sediments is summarized in Table 4-1. Sand content ranges from 51.2 percent to 97.9 percent with an average of 79.3 percent; silts range from less than 1 percent to almost 67 percent, with an average of 25.5 percent; and clays range from less than 1 percent to 59.5 percent with an average of 17 percent. Gravel is rarely encountered in Marina del Rey dredged material, averaging only 2.5 percent. A typical grain size distribution for the entrance of Marina del Rey is shown in Figure 4-1.

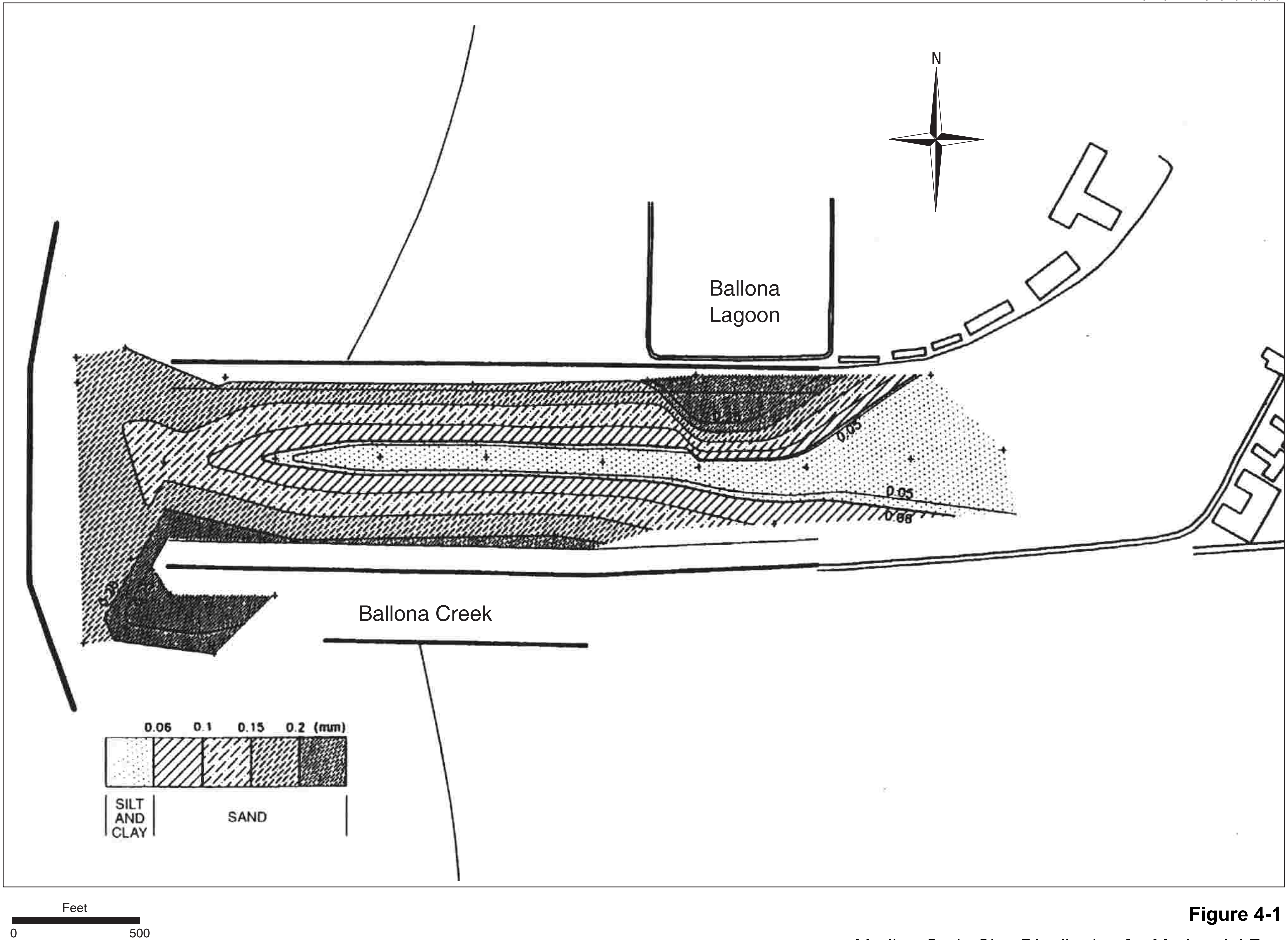
Table 4-1 Los Angeles CSTF Database - Summary of Sediment Physical Characteristics for Marina del Rey Dredged Sediments

Analyte	Units	Min	Max	Avg	N
Sand	PCT	51.2	97.9	79.3	38
Silt	PCT	0.6	66.8	25.5	98
Clay	PCT	0.9	59.5	17	97
Gravel	PCT	0.0	27.9	2.5	97
Total Nitrogen	mg/kg	1.2	4910	1049.7	140
Oil and Grease	mg/kg	3.0	9200	1531.3	150
Total Solids	PCT	57.8	89.4	74.1	65
Total Sulfides	mg/kg	0.1	1800	239.6	150
Total Volatile Solids	PCT	0.6	16.1	5.3	150
Percent Moisture	PCT	21.5	70	47.1	90

Total organic carbon (TOC) concentrations reported for Marina del Rey in the CSTF database appear erroneously high and cannot be confirmed. Typical TOC values for southern California harbors range from 1 to 3 percent.

4.2.1.2 *Engineering Properties*

Other than grain size data, no other engineering properties are available for Marina del Rey/Santa Monica Bay dredge sediments. Dredge materials from this area are not normally used for construction projects. As such, sediment geotechnical data is not generally collected or readily available.



Source: Moffatt and Nichol, 1994

Figure 4-1

Median Grain Size Distribution for Marina del Rey

4.2.2 *Chemical Characteristics and Distribution*

4.2.2.1 *Inorganics*

Marina del Rey sediment inorganic concentrations from the CSTF database are summarized in Table 4-2. Arsenic concentrations range from 1.8 milligrams per kilogram (mg/kg) to 938 mg/kg, with an average concentration of 12.1 mg/kg. The effects range-low (ER-L) for arsenic is 8.2 mg/kg and the effects range-median (ER-M) is 70 mg/kg, suggesting that the Marina del Rey material averages slightly above the ER-L, and individual data points occasionally exceed the ER-M.

Table 4-2 Los Angeles CSTF Database - Summary of Sediment Inorganic Concentrations for Marina del Rey Dredged Sediments

Analyte	Units	Min	Max	Avg	N
Arsenic	mg/kg	1.8	938	12.1	190
Barium	mg/kg	30.8	154	97.6	15
Boron	mg/kg	5.7	37.5	22.2	15
Cadmium	mg/kg	0.1	5.5	0.8	191
Chromium	mg/kg	5.7	86	38.9	191
Copper	mg/kg	1.7	455	126.6	191
Dibutyltin	µg/kg	nd	nd	nd	40
Iron	mg/kg	3360	71500	31371	150
Lead	mg/kg	3.6	575	128.4	206
Manganese	mg/kg	26.2	366	206.3	150
Mercury	mg/kg	0.0	2.8	0.5	191
Monobutyltin	µg/kg	4.1	6.2	5.1	40
Nickel	mg/kg	3.7	210	21.5	191
Selenium	mg/kg	0.1	2.4	0.9	115
Silver	mg/kg	0.1	4.8	1.2	116
Tetrabutyltin	µg/kg	1.3	11	5.0	7
Tributyltin	µg/kg	1.3	3040	174.7	190
Zinc	mg/kg	13.9	647	220.1	191

nd = non-detected

Cadmium concentrations range from 0.1 mg/kg to 5.5 mg/kg with an average concentration of 0.8 mg/kg. The ER-L for cadmium is 1.2 mg/kg and the ER-M is 9.6 mg/kg. Cadmium concentrations in the Marina del Rey material occasionally exceed the ER-L, but the average concentration is below the ER-L and the ER-M was never exceeded.

Chromium concentrations range from 5.7 mg/kg to 86 mg/kg, with an average concentration of 38.9 mg/kg. The ER-L for chromium is 81 mg/kg and the ER-M is 370 mg/kg. As Cadium, chromium concentrations in the Marina del Rey material occasionally exceed the ER-L, but the average concentration is below the ER-L and the ER-M was never exceeded.

Copper concentrations range from 1.7 mg/kg to 455 mg/kg, with an average concentration of 126.6 mg/kg. The ER-L for copper is 34 mg/kg and the ER-M is 270 mg/kg, suggesting that, on average, Marina del Rey sediments exceed the ER-L, but not the ER-M. The maximum concentration observed, however, did exceed the ER-M.

Lead concentrations range from 3.6 mg/kg to 575 mg/kg, with an average concentration of 128.4 mg/kg. The ER-L for lead is 46.7 mg/kg and the ER-M is 218 mg/kg, suggesting that, on average, Marina del Rey sediments exceed the ER-L for lead, but not the ER-M. The maximum concentration observed, however, did exceed the ER-M.

Mercury concentrations range from undetected to 2.8 mg/kg, with an average concentration of 0.5 mg/kg. The ER-L for mercury is 0.15 mg/kg and the ER-M is 0.71 mg/kg. As such, mercury frequently exceeds the ER-L, and occasionally the ER-M.

Nickel concentrations range from 3.7 mg/kg to 210 mg/kg, with an average concentration of 21.5 mg/kg. The ER-L for nickel is 20.9 mg/kg and the ER-M is 51.6 mg/kg. As with most of the other metals, the ER-L is frequently exceeded (average concentration is just above the ER-L), and the ER-M is occasionally exceeded.

Selenium concentrations range from 0.1 mg/kg to 2.4 mg/kg, with an average concentration of 0.9 mg/kg. No ER-L or ER-M values are available for selenium.

Silver concentrations range from 0.1 mg/kg to 4.8 mg/kg, with an average concentration of 1.2 mg/kg. The ER-L for silver is 1 mg/kg and the ER-M is 3.7 mg/kg. As with most of the other metals, the ER-L is frequently exceeded (average concentration is just above the ER-L), and the ER-M is occasionally exceeded.

Zinc concentrations range from 13.9 mg/kg to 647 mg/kg, with an average concentration of 220.1. The ER-L for zinc is 150 mg/kg and the ER-M is 410 mg/kg. On average, zinc concentrations exceed the ER-L concentration, and maximum concentrations occasionally exceed the ER-M.

4.2.2.2 *Semi-Volatile Organics*

Marina del Rey sediment semi-volatile organic concentrations (SVOA) are summarized in Table 4-3. With the exception of thirteen compounds (all the phenolic compounds, acenaphthylene, dimethyl phthalate, and naphthalene), all were detected in at least one of the samples tested. As expected, concentrations vary by chemical and the range in concentrations for some compounds is quite large. Sediment screening values (e.g., ER-L, ER-M) do not exist for all the SVOA compounds tested. A summary of reported values for compounds that were detected in at least one sample and that have screening values available follows.

Table 4-3 Los Angeles CSTF Database - Summary of Sediment SVOA Concentrations for Marina del Rey Dredged Sediments

Analyte	Units	Min	Max	Avg	N
2,4-Dichlorophenol	µg/kg	nd	nd	nd	6
2,4-Dimethylphenol	µg/kg	nd	nd	nd	6
2,4-Dinitrophenol	µg/kg	nd	nd	nd	6
2-Chlorophenol	µg/kg	nd	nd	nd	6
2-Methyl-4,6-dinitrophenol	µg/kg	nd	nd	nd	6
2-Nitrophenol	µg/kg	nd	nd	nd	6
4-Chloro-3-methylphenol	µg/kg	nd	nd	nd	6
4-Nitrophenol	µg/kg	nd	nd	nd	6
Acenaphthene	µg/kg	0.7	0.7	0.7	59
Acenaphthylene	µg/kg	nd	nd	nd	59
Anthracene	µg/kg	6.0	34	16.4	59
Benzo(a)anthracene	µg/kg	2.0	135	54.8	59
Benzo(a)pyrene	µg/kg	0.7	142	48.4	59
Benzo(b)fluoranthene	µg/kg	16	116	65.1	38
Benzo(bk)fluoranthenes	µg/kg	1.0	60	35.8	21
Benzo(g,h,i)perylene	µg/kg	1.0	212	93.7	59
Benzo(k)fluoranthene	µg/kg	18	127	64.2	38
bis(2-ethylhexyl) Phthalate	µg/kg	30	2600	691.7	7
Butylbenzyl Phthalate	µg/kg	28	341	150.3	7
Chrysene	µg/kg	2.0	204	64.2	59
Dibenzo(a,h)anthracene	µg/kg	34	34	34	59
Diethyl phthalate	µg/kg	53	53	53	7
Dimethyl phthalate	µg/kg	nd	nd	nd	7
Di-n-butyl phthalate	µg/kg	21	64	33.5	7
Di-n-octyl phthalate	µg/kg	64	64	64	7
Fluoranthene	µg/kg	1.0	334	70.5	59
Fluorene	µg/kg	0.6	30	11.4	59
Indeno(1,2,3-c,d)pyrene	µg/kg	1.0	131	61.6	59
Methoxychlor	mg/kg	5.0	6.5	5.5	30
Methoxychlor	µg/kg	7.1	7.1	7.1	46
Naphthalene	µg/kg	nd	nd	nd	59
Pentachlorophenol	µg/kg	nd	nd	nd	6
Phenanthrene	µg/kg	0.8	226	47.1	59
Phenol	µg/kg	nd	nd	nd	6
Pyrene	µg/kg	0.6	593	127.7	59
Total PAHs	µg/kg	15	1890	723.7	31

nd = non-detected

Acenaphthene concentrations average 0.7 micrograms per kilogram (µg/kg) which is below the ER-L of 16 µg/kg. Anthracene concentrations average 16.4 µg/kg which is below the ER-L of 85.3 µg/kg.

Benzo(a)anthracene concentrations range from 2 µg/kg to 135 µg/kg, with an average concentration of 54.8 µg/kg. The ER-L for benzo(a)anthracene is 261 µg/kg and the ER-M is 1,600 µg/kg, both of which are above the maximum concentration reported.

Benzo(a)pyrene concentrations range from 0.7 µg/kg to 142 µg/kg, with an average concentration of 48.4 µg/kg. The ER-L for benzo(a)pyrene is 430 µg/kg and the ER-M is 1,600 µg/kg, both of which are above the maximum concentration reported.

Chrysene concentrations range from 2 µg/kg to 204 µg/kg, with an average concentration of 64.2 µg/kg. The ER-L for chrysene is 384 µg/kg and the ER-M is 2,800 µg/kg suggesting that chrysene is not a chemical of concern.

Dibenzo(a,h)anthracene concentrations average 34 µg/kg. The ER-L for dibenzo(a,h)anthracene is 63.4 µg/kg which is higher than the maximum value reported (only one detect).

Fluoranthene concentrations range from 1 µg/kg to 334 µg/kg, with an average concentration of 70.5 µg/kg. The ER-L for fluoranthene is 600 µg/kg and the ER-M is 5,100 µg/kg, both of which are above the maximum concentration reported.

Fluorene concentrations range from 0.6 µg/kg to 30 µg/kg, with an average concentration of 11.4 µg/kg. The ER-L for fluorene is 19 µg/kg and the ER-M is 540 µg/kg. While the upper screening value is never exceeded, the lower ER-L value appears to occasionally be exceeded.

Phenanthrene concentrations range from 0.8 µg/kg to 226 µg/kg, with an average concentration of 47.1 µg/kg. The ER-L for phenanthrene is 240 µg/kg which is above the maximum concentration reported.

Pyrene concentrations range from 0.6 µg/kg to 593 µg/kg, with an average concentration of 127.7 µg/kg. The ER-L for pyrene is 665 µg/kg and the ER-M is 2,600 µg/kg, both of which are above the maximum concentration reported.

Lastly, total Polycyclic Aromatic Hydrocarbon (PAH) concentrations range from 15 µg/kg to 1,890 µg/kg, with an average concentration of 723.7 µg/kg. The ER-L for total PAHs is 4,022 µg/kg, which is well above the maximum concentration reported.

4.2.2.3 *Pesticides/PCBs*

Marina del Rey sediment pesticide and Polychlorinated Biphenyl (PCB) concentrations, as reported in the CSTF database, are summarized in Table 4-4. Dichlorodiphenyltrichloroethane (DDT) concentrations range from 0.7 µg/kg to 86 µg/kg, with an average concentration of 19.4 µg/kg. The ER-L for DDT is 1.58 µg/kg and the ER-M is 46.1 µg/kg, which suggests that DDT is a chemical concern for future sediment dredging in the area. Other pesticides were detected, but no screening data are available for comparison.

Table 4-4 Los Angeles CSTF Database - Summary of Sediment Pesticide/PCB Concentrations for Marina del Rey Dredged Sediments

Analyte	Units	Min	Max	Avg	N
2,4,6-Trichlorophenol	µg/kg	nd	nd	nd	6
2,4'-DDD	µg/kg	nd	nd	nd	60
2,4'-DDT	µg/kg	nd	nd	nd	60
4,4'-DDD	µg/kg	0.6	175	20.6	196
4,4'-DDE	µg/kg	1.0	169	32.3	196
4,4'-DDT	µg/kg	0.7	86	19.4	181
alpha-BHC	µg/kg	0.4	0.4	0.4	136
beta-BHC	µg/kg	nd	nd	nd	121
delta-BHC	µg/kg	0.4	0.8	0.6	76
gamma-BHC (Lindane)	µg/kg	1.0	1.0	1.0	136
Aldrin	µg/kg	0.6	0.6	0.6	136
Aroclor 1016	µg/kg	nd	nd	nd	122
Aroclor 1221	µg/kg	nd	nd	nd	122
Aroclor 1232	µg/kg	nd	nd	nd	122
Aroclor 1242	µg/kg	nd	nd	nd	122
Aroclor 1248	µg/kg	nd	nd	nd	122
Aroclor 1254	µg/kg	20	153	82.6	152
Aroclor 1260	µg/kg	10	755	127.8	137
alpha-Chlordane	µg/kg	0.4	8.3	3.3	53
gamma-Chlordane	µg/kg	0.5	28	4.7	68
Chlordane	µg/kg	10	562	144.6	128
Dieldrin	µg/kg	1.0	71.6	27.7	151
Endosulfan I	µg/kg	0.4	23	5.5	91
Endosulfan II	µg/kg	2.0	26	6.1	76
Endosulfan sulfate	µg/kg	1.0	2.0	1.6	61
Endrin	µg/kg	0.9	5.0	2.2	121
Endrin aldehyde	µg/kg	0.6	9.0	3.2	106
Endrin ketone	µg/kg	0.6	4.0	1.5	53
Heptachlor	µg/kg	0.3	0.3	0.3	136
Heptachlor epoxide	µg/kg	0.3	3.9	1.3	166
Total PCBs	µg/kg	nd	nd	nd	45
Toxaphene	µg/kg	32	32	32	136

nd = non-detected

Although no ER-L screening values exists for PCBs, elevated concentrations are reported for Marina del Rey sediments. Concentrations of Aroclor 1260, a common PCB cogener, range from 10 µg/kg to 755 µg/kg. Other screening values for PCBs (e.g., Puget Sound Dredged Disposal Analysis screen levels [PSDDA SL's]) suggest concentrations as low as 130 µg/kg may cause aquatic impacts.

4.3 San Pedro Bay

Sediment management areas within San Pedro Bay include the POLA, POLB, and the shipping lanes, which connect the two with the outer harbor (i.e. outside of the federal breakwater). The majority of the sediment characterization data available for the ports has been separated into two categories (POLA and POLB), based on study sponsor. As such, the data are reported separately within this section.

4.3.1 *Physical Characteristics and Distribution*

4.3.1.1 *Grain Size and Organic Carbon*

A general survey of the San Pedro Harbor, conducted by MEC in 2000 (MEC 2002), shows a variable grain size distribution within San Pedro Bay, depending on the habitats sampled (Figure 4-2 and Table 4-5). As expected, the shallow water man-made mitigation areas in the Ports consistently contained the highest sand content while the back channel, dead-end reaches contained the highest silt/clay content. The following subsections summarize the available grain size and organic carbon data conducted specifically as part of various dredge characterization projects and contained in the CSTF database.

4.3.1.1.1 Port of Los Angeles

Sediment grain size distribution within the POLA is summarized in Table 4-6. Sand contents range from 2 percent to 99.4 percent with an average of 55.1 percent; silt contents range from 0 percent to 80 percent, with an average of 27.8 percent; and clay contents range from 0 percent to 45.4 percent with an average of 9.3 percent. Gravel contents are much lower, ranging from 0 percent to 46.9 percent and averaging 2.1 percent. Organic carbon contents for POLA dredge materials are reported ranging from 0.1 percent to 11 percent, and averaging 1.2 percent.

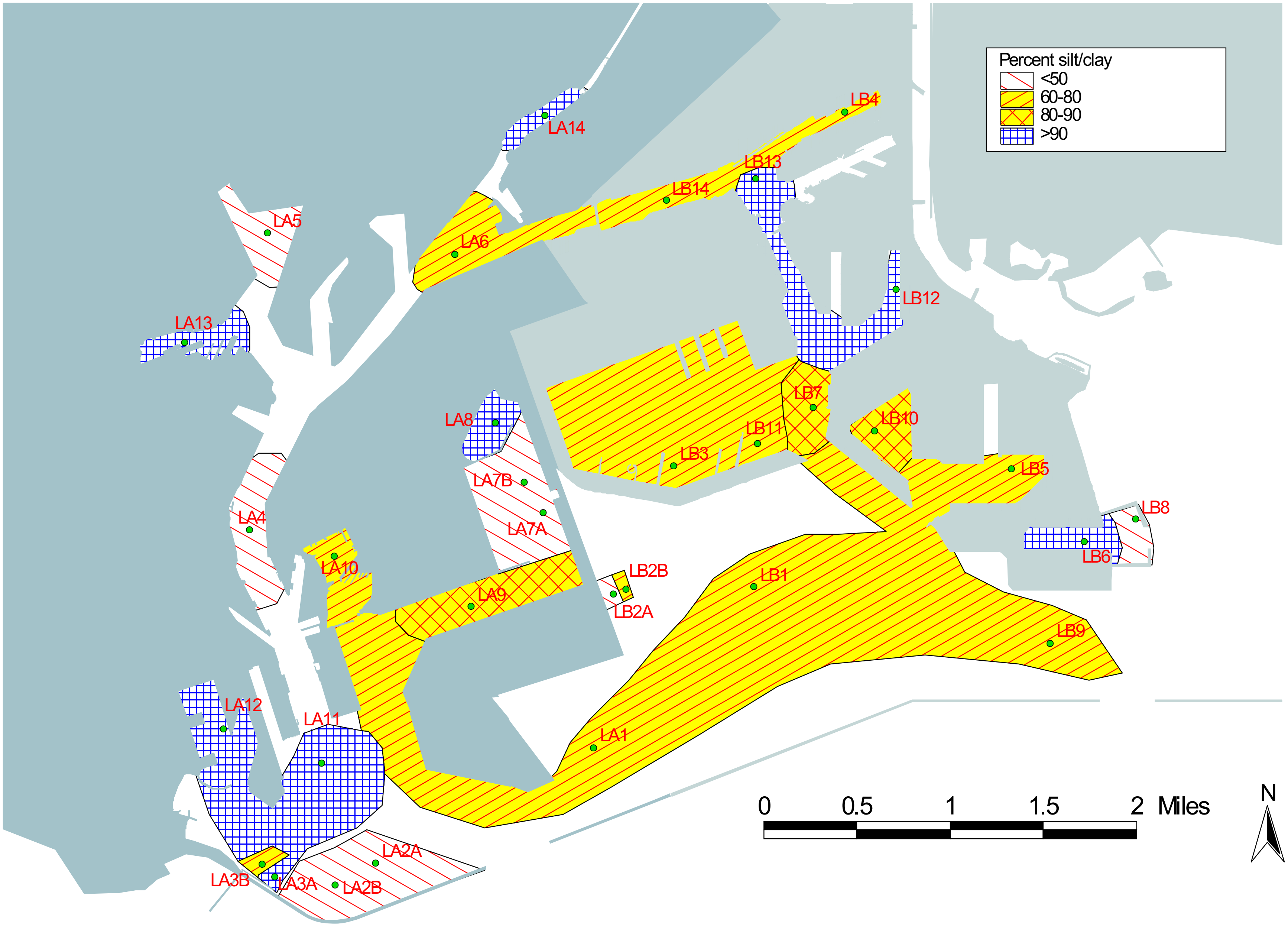


Figure 4-2

Percentage of silt/clay in sediments sampled in Long Beach and Los Angeles Harbors, January 2000

Table 4-5 Sediment Grain Size Characteristics in Long Beach and Los Angeles Harbors, January 2000

Habitat / Station	Depth (m)	Median size (phi)	Median size (microns)	Dispersion	Skewness	% Gravel	% Sand	% Silt	% Clay	% Coarse	% Fines (Silt + Clay)	Mean (phi)	Mean (microns)
Deepwater Open													
LA1	13	5.945	16.234	3.030	0.136	0.000	29.412	44.674	25.915	0.018	70.588	6.356	12.208
LA11	16	7.645	4.997	2.424	0.010	0.000	7.298	48.737	43.965	0.032	92.702	7.668	4.916
LB1	12	4.691	38.713	1.598	0.408	0.000	24.121	64.547	11.332	0.030	75.879	5.343	24.638
LB9	25	4.776	36.498	2.138	0.392	0.000	35.773	49.983	14.244	0.042	64.227	5.614	20.414
Deepwater Channel													
LA4	16	2.511	175.450	2.471	0.598	0.265	75.071	13.788	10.876	0.885	24.664	3.989	62.965
LA9	16	7.066	7.464	2.863	-0.068	0.000	15.958	51.553	32.489	0.056	84.042	6.872	8.539
LB7	24	6.946	8.111	2.693	0.060	0.000	10.651	53.770	35.579	0.030	89.349	7.106	7.257
LB13	20	7.167	6.956	2.336	0.162	1.042	5.068	55.194	38.696	1.288	93.891	7.547	5.347
LB14	18	5.900	16.744	2.979	0.284	0.000	19.880	52.356	27.765	0.013	80.120	6.745	9.323
Deepwater Basin													
LA5	17	3.297	101.716	2.894	0.689	0.049	63.097	20.340	16.514	0.120	36.854	5.290	25.552
LA6	16	4.938	32.611	2.459	0.029	5.096	23.226	57.825	13.853	11.163	71.678	5.009	31.062
LA12	11	8.349	3.066	2.542	0.163	0.000	0.747	45.235	54.017	0.216	99.253	8.764	2.300
LB3	15	6.111	14.465	2.921	0.156	0.000	25.432	46.985	27.583	0.026	74.568	6.568	10.542
LB5	15	5.495	22.181	2.738	0.296	0.021	24.356	53.087	22.535	0.115	75.622	6.304	12.654
LB10	21	6.854	8.643	3.130	0.076	0.000	16.672	47.880	35.448	0.031	83.328	7.091	7.333
LB11	15	5.510	21.948	2.658	0.320	0.000	23.036	55.843	21.122	0.022	76.964	6.360	12.173
Deepwater Slip													
LA13	11	7.477	5.614	3.121	0.201	0.000	6.491	49.551	43.958	0.010	93.509	8.106	3.630
LB4	15	5.007	31.098	3.169	0.378	0.059	30.850	44.921	24.171	0.795	69.092	6.206	13.548
LB6	17	6.830	8.791	2.491	0.238	0.000	6.258	58.327	35.415	0.037	93.742	7.422	5.832
LB8	15	3.197	109.033	0.773	-0.064	0.642	86.579	9.308	3.471	0.814	12.779	3.148	112.809
LB12	16	8.056	3.756	2.249	0.195	0.000	0.553	48.732	50.714	0.000	99.447	8.494	2.773
Shallow Mitigation													
LA2A	4	3.900	66.974	1.864	0.282	0.000	52.801	36.443	10.756	0.270	47.199	4.427	46.503
LA2B	4	3.089	117.524	1.577	0.351	0.017	72.491	19.365	8.128	0.241	27.493	3.643	80.069
LA7A	4	2.985	126.325	1.608	0.419	0.359	78.523	12.363	8.755	1.266	21.118	3.659	79.187
LA7B	4	4.030	61.220	2.763	0.534	0.084	49.643	32.958	17.314	0.177	50.272	5.505	22.020
LB2A	4	3.488	89.121	0.788	0.192	0.043	80.136	15.210	4.611	0.124	19.822	3.639	80.262
LB2B	4	4.651	39.791	1.897	0.387	0.000	36.956	51.206	11.837	0.065	63.044	5.386	23.916
Shallow Water Open													
LA3A	4	5.901	16.731	2.615	0.346	0.838	11.327	61.614	26.221	1.010	87.835	6.805	8.942
LA3B	4	6.129	14.293	2.487	0.328	0.000	7.865	66.392	25.743	0.123	92.135	6.944	8.122
Shallow Water Channel													
LA14	6	6.304	12.655	2.439	0.369	0.000	8.534	65.755	25.711	0.274	91.466	7.203	6.786
Shallow Water Basin													
LA8	4	7.088	7.352	2.412	0.215	0.016	5.067	56.760	38.157	0.060	94.917	7.607	5.130
LA10	6	6.778	9.112	3.440	-0.115	0.000	30.063	37.163	32.774	0.068	69.937	6.383	11.985

Table 4-6 Los Angeles CSTF Database - Summary of Sediment Physical Characteristics for Port of Los Angeles Dredged Sediments

Analyte	Units	Min	Max	Avg	N
Sand	PCT	2.0	99.4	55.1	207
Silt	PCT	0.0	80	27.8	207
Clay	PCT	0.0	45.4	9.3	229
Granule	PCT	0.0	12.7	1.6	126
Gravel	PCT	0.0	46.9	2.1	72
Ammonia	mg/kg	2.9	92.0	17.4	89
TOC	PCT	0.1	11	1.2	283
Total Nitrogen	mg/kg	0.0	5200	1100	31
Oil and Grease	mg/kg	0.5	32000	919.2	168
Total Solids	PCT	39.7	88.5	66.8	232
Dissolved sulfides	mg/kg	0.0	14	0.8	250
Total Sulfides	mg/kg	0.1	3120	106	270
Total Volatile Solids	PCT	0.6	10.1	3.6	47
Percent Moisture	PCT	12.9	43.7	27.8	43

nd = non-detected

4.3.1.1.2 Port of Long Beach

Sediment grain size distribution within the POLB is summarized in Table 4-7. Sand contents range from 4.6 percent to 98.9 percent with an average of 44.4 percent; silt contents range from 0.9 percent to 77.1 percent, with an average of 37.4 percent; and clay contents range from 0.1 percent to 42.8 percent with an average of 15.7 percent. Gravel contents range from 0 percent to 20.7 percent, with an average of only 1.9 percent. Organic carbon contents for POLB dredge materials are reported ranging from 0 percent to 2.6 percent, and averaging 0.7 percent.

Table 4-7 Los Angeles CSTF Database - Summary of Sediment Physical Characteristics for Port of Long Beach Sediments

Analyte	Units	Min	Max	Avg	N
Sand	PCT	4.6	98.9	44.4	86
Silt	PCT	0.9	77.1	37.4	153
Clay	PCT	0.1	42.8	15.7	159
Gravel	PCT	0.0	20.7	1.9	133
Ammonia	mg/kg	(9.0)	430	76.2	12
TOC	PCT	0.0	2.6	0.7	130
Total Nitrogen	mg/kg	400	2537	1049.8	9
Oil and Grease	mg/kg	6.7	1420	169.8	85
Total Solids	pct	36	89.8	69.6	291
Dissolved Sulfides	mg/kg	0.0	42	4.8	371
Total Sulfides	mg/kg	0.1	920	79.3	373
Total Volatile Solids	PCT	1.0	3.3	2.1	13
Percent Moisture	PCT	12.9	43.7	27.8	43

nd = non-detected

4.3.1.2 *Engineering Properties*

The most valuable information available to engineers designing beneficial reuse projects (e.g., port landfill material) for dredge materials is a detailed grain size distribution map for the Study Area (USACE 2002b). The geology of San Pedro Bay is diverse enough that virtually any desired engineering qualities could be obtained if so desired. No databases are currently available that contain or summarize this information, as it is not required for compliance with any state or federal permit requirements. Furthermore, the data are typically only used internally at the ports during project design and not formally reported.

One representative example that is available, however, is the Pier E slip fill (Volume 5: Sheet 270, Drawing Number HD 10-1436-PE4, POLB, 1998) conducted by the POLB (USACE 2002b). According to the POLB's design documents, the strategy for fill construction included placing less-suitable maintenance removal dredge materials at the bottom of the fill and using the better surcharge materials on the surface. Geotechnical tests conducted on core samples collected from the target San Pedro Harbor dredge areas for use as the surcharge material show the following ranges of physical characteristics:

Test	Average
Dry Density (pcf)	89
Moisture Content (%)	31
Liquid Limit (%)	49
Plasticity Index (%)	23
Unconfined Comp. Strength (tsf)	1
Amount Passing No. 200 Sieve (%)	52
Amount Passing No. 4 Sieve (%)	100
Amount Passing No. 40 Sieve (%)	99

4.3.2 *Chemical Characteristics and Distribution*

4.3.2.1 *Inorganics*

4.3.2.1.1 Port of Los Angeles

POLA dredge material inorganic concentrations from the CSTF database are summarized in Table 4-8. Arsenic concentrations range from 0.2 mg/kg to 130 mg/kg, with an average concentration of 6.8 mg/kg. The ER-L for arsenic is 8.2 mg/kg and the ER-M is 70 mg/kg, suggesting that the POLA material averages slightly below the ER-L, but individual data points occasionally exceed both the ER-L and ER-M.

Table 4-8 Los Angeles CSTF Database - Summary of Sediment Inorganic Concentrations for Port of Los Angeles Dredged Sediments

Analyte	Units	Min	Max	Avg	N
Aluminum	mg/kg	6190	35100	16339	32
Antimony	mg/kg	0.1	26.8	2.8	32
Arsenic	mg/kg	0.2	130	6.8	286
Barium	mg/kg	51.3	381	196.5	32
Beryllium	mg/kg	0.8	1.1	0.9	32
Butyltin	µg/kg	20.0	28	24	3
Cadmium	mg/kg	0.1	10.1	0.9	286
Chromium	mg/kg	11.9	1040	54.8	286
Cobalt	mg/kg	4.1	13.9	8.1	32
Copper	mg/kg	1.6	2510	95.6	286
Dibutyltin	µg/kg	1.0	150000	1904.8	295
Iron	mg/kg	12700	44700	24653.1	32
Lead	mg/kg	1.6	1280	60	286
Manganese	mg/kg	155	489	272.9	32
Mercury	mg/kg	0.0	677	3.5	283
Molybdenum	mg/kg	0.3	63.6	5.9	32
Monobutyltin	µg/kg	1.0	9000	581.6	292
Nickel	mg/kg	6.6	119	27.6	286
Selenium	mg/kg	0.1	15	1.2	286
Silver	mg/kg	0.1	21	0.5	286
Tetrabutyltin	µg/kg	2.0	61	16.6	248
Thallium	mg/kg	0.1	0.5	0.3	32
Tin	mg/kg	0.3	56.6	9.5	32
Tributyltin	µg/kg	1.0	250000	2344.2	295
Vanadium	mg/kg	32.8	106.0	53.1	32
Zinc	mg/kg	10.0	2320	159.6	286

nd = non-detected

Cadmium concentrations range from 0.1 mg/kg to 10.1 mg/kg with an average concentration of 0.9 mg/kg. The ER-L for cadmium is 1.2 mg/kg and the ER-M is 9.6 mg/kg. Like arsenic, cadmium concentrations in the POLA material occasionally exceed the ER-L and ER-M, but the average concentration is below the ER-L.

Chromium concentrations range from 11.9 mg/kg to 1,040 mg/kg, with an average concentration of 54.8 mg/kg. The ER-L for chromium is 81 mg/kg and the ER-M is 370 mg/kg. While the average concentration is below the ER-L, exeedances of both the ER-L and ER-M are also been reported.

Copper concentrations range from 1.6 mg/kg to 2,510 mg/kg, with an average concentration of 95.6 mg/kg. The ER-L for copper is 34 mg/kg and the ER-M is 270 mg/kg, suggesting that, on average, POLA sediments exceed the ER-L, but not the ER-M. The maximum concentration reported, however, does exceed the ER-M.

Lead concentrations range from 1.6 mg/kg to 1,280 mg/kg, with an average concentration of 60 mg/kg. The ER-L for lead is 46.7 mg/kg and the ER-M is 218 mg/kg, suggesting that, on average, POLA sediments exceed the ER-L for lead, but not the ER-M. The maximum concentration reported, however, does exceed the ER-M.

Mercury concentrations range from undetected to 677 mg/kg, with an average concentration of 3.5 mg/kg. The ER-L for mercury is 0.15 mg/kg and the ER-M is 0.71 mg/kg. As such, mercury concentrations appear to frequently exceed the ER-L and ER-M.

Nickel concentrations range from 6.6 mg/kg to 119 mg/kg, with an average concentration of 27.6 mg/kg. The ER-L for nickel is 20.9 mg/kg and the ER-M is 51.6 mg/kg. As with most of the other metals, the ER-L is frequently exceeded in the POLA material (average concentration is just above the ER-L), and occasionally also the ER-M.

Selenium concentrations range from 0.1 mg/kg to 15 mg/kg, with an average concentration of 1.2 mg/kg. No ER-L or ER-M values are available for selenium.

Silver concentrations range from 0.1 mg/kg to 21 mg/kg, with an average concentration of 0.5 mg/kg. The ER-L for silver is 1 mg/kg and the ER-M is 3.7 mg/kg. While the average concentration is below the ER-L, the maximum concentration reported does exceed the ER-M.

Zinc concentrations range from 10 mg/kg to 2,320 mg/kg, with an average concentration of 159.6 mg/kg. The ER-L for zinc is 150 mg/kg and the ER-M is 410 mg/kg. On average, zinc concentrations barely exceed the ER-L concentration, but the maximum concentration reported was significantly above the ER-M.

4.3.2.1.2 Port of Long Beach

POLB dredge material inorganic concentrations from the CSTF database are summarized in Table 4-9. Arsenic concentrations range from 0.95 mg/kg to 43 mg/kg, with an average concentration of 9.2 mg/kg. The ER-L for arsenic is 8.2 mg/kg and the ER-M is 70 mg/kg, suggesting that the POLB material averages slightly above the ER-L and individual data points occasionally exceed both the ER-L and ER-M.

Table 4-9 Los Angeles CSTF Database - Summary of Sediment Inorganic Concentrations for Port of Long Beach Dredged Sediments

Analyte	Units	Min	Max	Avg	N
Antimony	mg/kg	7.7	13.2	11	63
Arsenic	mg/kg	1.0	43	9.2	297
Beryllium	mg/kg	0.3	1.3	0.7	63
Butyltin	µg/kg	2.0	2.0	2.0	8
Cadmium	mg/kg	0.0	6.6	0.8	398
Chromium	mg/kg	7.4	513	42.8	297
Copper	mg/kg	2.0	1400	64.4	286
Dibutyltin	µg/kg	0.7	32	6.2	352
Lead	mg/kg	0.8	6940	50.6	422
Mercury	mg/kg	0.0	4.70	0.6	316
Monobutyltin	µg/kg	1.9	28.6	6.5	281
Nickel	mg/kg	1.7	133	23.4	317
Selenium	mg/kg	0.1	5.1	0.7	297
Silver	mg/kg	0.0	7.2	0.6	297
Tetrabutyltin	µg/kg	1.0	36	9.3	321
Thallium	mg/kg	0.3	0.6	0.5	63
Tributyltin	µg/kg	1.0	72.7	14.1	352
Zinc	mg/kg	14.4	4170	145.6	367

nd = non-detected

Cadmium concentrations range from non-detected to 6.6 mg/kg with an average concentration of 0.8 mg/kg. The ER-L for cadmium is 1.2 mg/kg and the ER-M is 9.6 mg/kg, suggesting that the POLB material averages slightly below the ER-L, but individual data points occasionally exceed the ER-L. The ER-M was never exceeded.

Chromium concentrations range from 7.4 mg/kg to 513 mg/kg, with an average concentration of 42.8 mg/kg. The ER-L for chromium is 81 mg/kg and the ER-M is 370 mg/kg. While the average concentration is below the ER-L, exeedances of both the ER-L and ER-M are also been reported.

Copper concentrations range from 1.9 mg/kg to 1,400 mg/kg, with an average concentration of 64.4 mg/kg. The ER-L for copper is 34 mg/kg and the ER-M is 270 mg/kg, suggesting that, on average, POLB sediments exceed the ER-L, but not the ER-M. The maximum concentration reported, however, does exceed the ER-M.

Lead concentrations range from 0.8 mg/kg to 6,940 mg/kg, with an average concentration of 50.6 mg/kg. The ER-L for lead is 46.7 mg/kg and the ER-M is 218 mg/kg, suggesting that, on average, POLB sediments exceed the ER-L for lead, but not the ER-M. The maximum concentration reported, however, does significantly exceed the ER-M.

Mercury concentrations range from 0.02 mg/kg to 4.7 mg/kg, with an average concentration of 0.6 mg/kg. The ER-L for mercury is 0.15 mg/kg and the ER-M is 0.71 mg/kg. As such, mercury concentrations are reported above both the ER-L and ER-M.

Nickel concentrations range from 1.7 mg/kg to 133 mg/kg, with an average concentration of 23.4 mg/kg. The ER-L for nickel is 20.9 mg/kg and the ER-M is 51.6 mg/kg. As with most of the other metals, the ER-L is frequently exceeded in the POLB material (average concentration is just above the ER-L), and occasionally also the ER-M.

Selenium concentrations range from 0.1 mg/kg to 5.1 mg/kg, with an average concentration of 0.7 mg/kg. No ER-L or ER-M values are available for selenium.

Silver concentrations range from 0.01 mg/kg to 7.2 mg/kg, with an average concentration of 0.6 mg/kg. The ER-L for silver is 1 mg/kg and the ER-M is 3.7 mg/kg. While the average silver concentration does not exceed the ER-L, the maximum concentration exceeds both the ER-L and ER-M.

Zinc concentrations range from 14.4 mg/kg to 4,170 mg/kg, with an average concentration of 145.6 mg/kg. The ER-L for zinc is 150 mg/kg and the ER-M is 410 mg/kg. On average, zinc concentrations are barely below the ER-L concentration, but the maximum concentration reported was significantly above the ER-M.

4.3.2.2 *Semi-Volatile Organics*

4.3.2.2.1 Port of Los Angeles

POLA sediment SVOA concentrations are summarized in Table 4-10. With the exception of fifteen compounds (all of the phenolic compounds, dibenzofuran, dibutyl phthalate, and methoxychlor), all were detected in at least one of the samples tested. As expected, concentrations vary by chemical and the range in concentrations for some compounds is quite large. Sediment screening values (e.g., ER-L, ER-M) do not exist for all the SVOA compounds tested. A summary of reported values for compounds that were detected and that have screening values available follows.

Acenaphthene concentrations average 166 µg/kg, which is higher than the ER-L of 16 µg/kg, but below the ER-M of 500 µg/kg. Acenaphthylene concentrations average 77.8 µg/kg, which is higher than the ER-L of 44 µg/kg, but below the ER-M of 640 µg/kg. Anthracene concentrations average 327.9 µg/kg, which is above the ER-L of 85.3 µg/kg, but below the ER-M of 1,100 µg/kg. The maximum anthracene concentration reported, however, was 24,000 µg/kg.

Table 4-10 Los Angeles CSTF Database - Summary of Sediment SVOA Concentrations for Port of Los Angeles Dredged Sediments

Analyte	Units	Min	Max	Avg	N
1-Methylnaphthalene	µg/kg	5.0	337	48.1	24
1-Methylphenanthrene	µg/kg	14	1570	188.3	24
2,3,4,6-Tetrachlorophenol	µg/kg	nd	nd	nd	22
2,3,6-trimethylnaphthalene	µg/kg	11	851	134.5	24
2,4,5-Trichlorophenol	µg/kg	nd	nd	nd	62
2,4,6-Trichlorophenol	µg/kg	nd	nd	nd	90
2,4-Dichlorophenol	µg/kg	12	12	12	90
2,4-Dimethylphenol	µg/kg	0.2	3.1	1.2	90
2,4-Dinitrophenol	µg/kg	nd	nd	nd	43
2,6-Dichlorophenol	µg/kg	nd	nd	nd	22
2,6-Dimethylnaphthalene	µg/kg	6.0	248	53.8	24
2-Chloronaphthalene	µg/kg	12	12	12	41
2-Chlorophenol	µg/kg	0.2	0.2	0.2	97
2-Methyl-4,6-dinitrophenol	µg/kg	nd	nd	nd	83
2-Methylnaphthalene	µg/kg	0.1	428	51.5	119
2-Methylphenol	µg/kg	0.2	0.2	0.2	62
2-Nitrophenol	µg/kg	nd	nd	nd	90
3-Methylphenol	µg/kg	nd	nd	nd	22
4,6-Dinitro-2-methylphenol	µg/kg	nd	nd	nd	7
4-Chloro-3-methylphenol	µg/kg	nd	nd	nd	90
4-Methylphenol	µg/kg	0.2	1.6	0.9	62
4-Nitrophenol	µg/kg	nd	nd	nd	90
Acenaphthene	µg/kg	0.3	1500	166.3	276
Acenaphthylene	µg/kg	0.1	450	77.8	276
Anthracene	µg/kg	0.1	24000	327.9	276
Benzo(a)anthracene	µg/kg	0.1	17200	350.6	276
Benzo(a)pyrene	µg/kg	0.1	8710	520.3	276
Benzo(b)fluoranthene	µg/kg	0.1	7160	530.6	273
Benzo(bk)fluoranthenes	µg/kg	420	450	435	3
Benzo(e)pyrene	µg/kg	335	4650	1345.1	24
Benzo(g,h,i)perylene	µg/kg	0.1	2510	249.9	276
Benzo(k)fluoranthene	µg/kg	0.1	13100	585.4	273
bis(2-ethylhexyl) Phthalate	µg/kg	0.0	2330	293.5	189
Butylbenzyl Phthalate	µg/kg	10	373	57.2	189
Chrysene	µg/kg	0.1	19000	486.5	276
Dibenzo(a,h)anthracene	µg/kg	0.3	966	134.5	271
Dibenzofuran	µg/kg	nd	nd	nd	3
Dibutyl Phthalate	µg/kg	nd	nd	nd	31
Diethyl phthalate	µg/kg	9.8	53	19.5	189
Dimethyl phthalate	µg/kg	12	695	212.1	189
Di-n-butyl phthalate	µg/kg	0.1	260	52.5	158
Di-n-octyl phthalate	µg/kg	12	170	59.5	189
Fluoranthene	µg/kg	0.1	73400	1003.8	276
Fluorene	µg/kg	0.1	1520	142.2	276
Indeno(1,2,3-c,d)pyrene	µg/kg	0.0	2810	287	276
Methoxychlor	µg/kg	nd	nd	nd	238
Naphthalene	µg/kg	0.3	2600	209.7	271
Pentachlorophenol	µg/kg	nd	nd	nd	90
Perylene	µg/kg	222	2320	716.6	24
Phenanthrene	µg/kg	0.1	4720	252.2	276
Phenol	µg/kg	0.8	0.8	0.8	90
Pyrene	µg/kg	0.1	56300	1330.7	276
Total PAHs	µg/kg	0.0	236000	8125	160

nd = non-detected

Benzo(a)anthracene concentrations range from 0.1 µg/kg to 17,200 µg/kg, with an average concentration of 350.6 µg/kg. The ER-L for benzo(a)anthracene is 261 µg/kg and the ER-M is 1,600 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is exceeded, but not the ER-M. Maximum concentrations, however, do occasionally exceed the ER-M threshold value.

Benzo(a)pyrene concentrations range from 0.1 µg/kg to 8,710 µg/kg, with an average concentration of 520.3 µg/kg. The ER-L for benzo(a)pyrene is 430 µg/kg and the ER-M is 1,600 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is exceeded, but not the ER-M. Maximum concentrations, however, do occasionally exceed the upper ER-M value.

Chrysene concentrations range from 0.1 µg/kg to 19,000 µg/kg, with an average concentration of 486.5 µg/kg. The ER-L for chrysene is 384 µg/kg and the ER-M is 2,800 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is exceeded, but not the ER-M. Maximum concentrations, however, do occasionally exceed the upper ER-M threshold value.

Dibenzo(a,h)anthracene concentrations range from 0.3 µg/kg to 966 µg/kg, with an average concentration of 134.5 µg/kg. The ER-L for dibenzo(a,h)anthracene is 63.4 µg/kg and the ER-M is 260 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is exceeded, but not the ER-M. Maximum concentrations, however, do occasionally exceed the upper ER-M threshold value.

Fluoranthene concentrations range from 0.1 µg/kg to 73,400 µg/kg, with an average concentration of 1,003.8 µg/kg. The ER-L for fluoranthene is 600 µg/kg and the ER-M is 5,100 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is exceeded, but not the ER-M. Maximum concentrations, however, do occasionally exceed the upper ER-M threshold value.

Fluorene concentrations range from 0.1 µg/kg to 1,520 µg/kg, with an average concentration of 142.2 µg/kg. The ER-L for fluorene is 19 µg/kg and the ER-M is 540 µg/kg. As with the previous compounds, on average, the lower ER-L threshold sediment screening value is exceeded, but not the ER-M. Maximum concentrations, however, do occasionally exceed the upper ER-M threshold value.

Naphthalene concentrations range from 0.3 µg/kg to 2,600 µg/kg, with an average concentration of 209.7 µg/kg. The ER-L concentration 160 µg/kg and the ER-M is 2,100 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is exceeded, but not the ER-M. Maximum concentrations, however, do occasionally exceed the upper ER-M threshold value.

Phenanthrene concentrations range from 0.1 µg/kg to 4,720 µg/kg, with an average concentration of 252.2 µg/kg. The ER-L for phenanthrene is 240 µg/kg and the ER-M is 1,500 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is slightly exceeded, but not the ER-M. Maximum concentrations, however, do occasionally exceed the upper ER-M threshold value.

Pyrene concentrations range from 0.1 µg/kg to 56,300 µg/kg, with an average concentration of 1,330.7 µg/kg. The ER-L for pyrene is 665 µg/kg and the ER-M is 2,600 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is exceeded, but not the ER-M. Maximum concentrations, however, do occasionally exceed the upper ER-M threshold value.

Lastly, total PAH concentrations range from non-detected to 236,000 µg/kg, with an average concentration of 8,125 µg/kg. The ER-L for total PAHs is 4,022 µg/kg and the ER-M is 44,792 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is exceeded, but not the ER-M. Maximum concentrations, however, do occasionally exceed the upper ER-M threshold value.

4.3.2.2.2 Port of Long Beach

POLB SVOA concentrations are summarized in Table 4-11. Sediment screening values (e.g., ER-L, ER-M) do not exist for all the SVOA compounds tested. A summary of reported values for compounds that have screening values available and were detected in at least one sample are as follows.

Acenaphthene concentrations average 681 µg/kg, which is higher than both the ER-L of 16 µg/kg and the ER-M of 500 µg/kg. Acenaphthylene concentrations average 59.6 µg/kg, which is higher than the ER-L of 44 µg/kg, but below the ER-M of 640 µg/kg. Anthracene concentrations average 125.3 µg/kg, which is above the ER-L of 85.3 µg/kg, but below the ER-M of 1,100. The maximum anthracene concentration reported, however, was 2,250 µg/kg.

Benzo(a)anthracene concentrations range from 0.1 µg/kg to 2,740 µg/kg, with an average concentration of 203.1 µg/kg. The ER-L for benzo(a)anthracene is 261 µg/kg and the ER-M is 1,600 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is not exceeded. Maximum concentrations, however, do occasionally exceed the upper ER-M threshold value.

Benzo(a)pyrene concentrations range from non-detected to 5,220 µg/kg, with an average concentration of 347.6 µg/kg. The ER-L for benzo(a)pyrene is 430 µg/kg and the ER-M is 1,600 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is not exceeded. Maximum concentrations, however, do occasionally exceed the upper ER-M threshold value.

Table 4-11 Los Angeles CSTF Database - Summary of Sediment SVOA Concentrations for Port of Long Beach Dredged Sediments

Analyte	Units	Min	Max	Avg	N
1,2,4,5-Tetrachlorobenzene	µg/kg	nd	nd	nd	6
1,2,4-Trichlorobenzene	µg/kg	3200	5900	4275	68
1,2-Dichlorobenzene	µg/kg	nd	nd	nd	64
1,2-Diphenylhydrazine	µg/kg	nd	nd	nd	5
1,3-Dichlorobenzene	µg/kg	nd	nd	nd	64
1,4-Dichlorobenzene	µg/kg	3000	5200	3800	68
1-Chloronaphthalene	µg/kg	nd	nd	nd	5
1-Naphthylamine	µg/kg	nd	nd	nd	5
2,3,4,6-Tetrachlorophenol	µg/kg	nd	nd	nd	5
2,4,5-Trichlorophenol	µg/kg	nd	nd	nd	69
2,4,6-Trichlorophenol	µg/kg	nd	nd	nd	175
2,4-Dichlorophenol	µg/kg	nd	nd	nd	175
2,4-Dimethylphenol	µg/kg	nd	nd	nd	175
2,4-Dinitrophenol	µg/kg	nd	nd	nd	175
2,4-Dinitrotoluene	µg/kg	4000	7860	5390	68
2,6-Dichlorophenol	µg/kg	nd	nd	nd	5
2,6-Dinitrotoluene	µg/kg	nd	nd	nd	64
2-Chloronaphthalene	µg/kg	nd	nd	nd	132
2-Chlorophenol	µg/kg	3300	5700	4200	179
2-Methyl-4,6-dinitrophenol	µg/kg	nd	nd	nd	34
2-Methylnaphthalene	µg/kg	nd	nd	nd	137
2-Methylphenol	µg/kg	nd	nd	nd	69
2-Naphthylamine	µg/kg	nd	nd	nd	5
2-Nitroaniline	µg/kg	nd	nd	nd	64
2-Nitrophenol	µg/kg	nd	nd	nd	175
2-Picoline	µg/kg	nd	nd	nd	5
3,3'-Dichlorobenzidine	µg/kg	nd	nd	nd	64
3-Methylcholanthrene	µg/kg	nd	nd	nd	5
3-Nitroanaline	µg/kg	nd	nd	nd	5
3-Nitroaniline	µg/kg	nd	nd	nd	59
4,6-Dinitro-2-methylphenol	µg/kg	nd	nd	nd	141
4-Aminobiphenyl	µg/kg	nd	nd	nd	5
4-Bromophenyl Phenyl Ether	µg/kg	nd	nd	nd	64
4-Chloro-3-methylphenol	µg/kg	3500	6800	4500	174
4-Chloroaniline	µg/kg	nd	nd	nd	64
4-Chlorophenyl Phenyl Ether	µg/kg	nd	nd	nd	64
4-Methylphenol	µg/kg	nd	nd	nd	64
4-Nitroanaline	µg/kg	nd	nd	nd	123
4-Nitrophenol	µg/kg	3600	8600	4975	179
7,12-Dimethylbenz(a)anthracene	µg/kg	nd	nd	nd	5
a-,a-Dimethylphenethylamine	µg/kg	nd	nd	nd	5
Acenaphthene	µg/kg	10	9100	681	347
Acenaphthylene	µg/kg	3	510	59.6	343
Acetophenone	µg/kg	nd	nd	nd	5
Aniline	µg/kg	nd	nd	nd	64
Anthracene	µg/kg	0.0	2250	125.3	343
Benzidine	µg/kg	nd	nd	nd	5
Benzo(a)anthracene	µg/kg	0.1	2740	203.1	343
Benzo(a)pyrene	µg/kg	0.0	5220	347.6	343
Benzo(b)fluoranthene	µg/kg	0.0	9030	490.9	255
Benzo(bk)fluoranthenes	µg/kg	20	3700	330.5	88
Benzo(g,h,i)perylene	µg/kg	0.0	3470	219.3	343
Benzo(k)fluoranthene	µg/kg	0.0	4690	349.7	255
Benzoic Acid	µg/kg	nd	nd	nd	64

Table 4-11 Los Angeles CSTF Database - Summary of Sediment SVOA Concentrations for Port of Long Beach Dredged Sediments

Analyte	Units	Min	Max	Avg	N
Benzyl Alcohol	µg/kg	nd	nd	nd	64
Bis(2-chloroethoxy)methane	µg/kg	nd	nd	nd	64
Bis(2-chloroethyl)ether	µg/kg	nd	nd	nd	64
Bis(2-chloroisopropyl)ether	µg/kg	nd	nd	nd	64
bis(2-ethylhexyl) Phthalate	µg/kg	15	1110	179	200
Butylbenzyl Phthalate	µg/kg	4	180	54.7	200
Chrysene	µg/kg	0.1	4250	270.5	343
Dibenz(a,j)acridine	µg/kg	nd	nd	nd	5
Dibenzo(a,h)anthracene	µg/kg	10	1830	118.1	343
Dibenzofuran	µg/kg	nd	nd	nd	69
Diethyl phthalate	µg/kg	2	59	17.1	200
Dimethyl phthalate	µg/kg	39	39	39	200
Di-n-butyl phthalate	µg/kg	5	205	90.3	200
Di-n-octyl phthalate	µg/kg	11	28	15.6	200
Diphenylamine	µg/kg	nd	nd	nd	5
Ethyl methanesulfonate	µg/kg	nd	nd	nd	5
Fluoranthene	µg/kg	0.1	7280	269.7	343
Fluorene	µg/kg	0.1	7670	228.7	343
Hexachlorobenzene	µg/kg	nd	nd	nd	59
Hexachlorobutadiene	µg/kg	nd	nd	nd	64
Hexachlorocyclopentadiene	µg/kg	nd	nd	nd	64
Hexachloroethane	µg/kg	nd	nd	nd	64
Indeno(1,2,3-c,d)pyrene	µg/kg	0.1	5000	263.7	338
Isophorone	µg/kg	nd	nd	nd	64
Methoxychlor	µg/kg	nd	nd	nd	254
Methyl methanesulfonate	µg/kg	nd	nd	nd	5
Naphthalene	µg/kg	0.1	825	105.7	343
Nitrobenzene	µg/kg	nd	nd	nd	64
N-Nitrosodimethylamine	µg/kg	nd	nd	nd	64
N-Nitroso-di-n-butylamine	µg/kg	nd	nd	nd	5
N-Nitrosodi-n-propylamine	µg/kg	3600	6400	4775	68
N-Nitrosodiphenylamine	µg/kg	nd	nd	nd	64
N-Nitrosopiperidine	µg/kg	nd	nd	nd	5
p-Dimethylaminoazobenzene	µg/kg	nd	nd	nd	5
Pentachlorobenzene	µg/kg	nd	nd	nd	5
Pentachloronitrobenzene	µg/kg	nd	nd	nd	5
Pentachlorophenol	µg/kg	3100	6800	4325	179
Phenacetin	µg/kg	nd	nd	nd	5
Phenanthrene	µg/kg	0.1	15900	264.7	343
Phenol	µg/kg	20	6200	2252.5	179
Pronamide	µg/kg	nd	nd	nd	5
Pyrene	µg/kg	0.0	12400	624.1	347
Total PAHs	µg/kg	nd	54000	3944.7	176

nd = non-detected

Chrysene concentrations range from 0.1 µg/kg to 4,250 µg/kg, with an average concentration of 270.5 µg/kg. The ER-L for chrysene is 384 µg/kg and the ER-M is 2,800 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is not exceeded. Maximum concentrations, however, do occasionally exceed the upper ER-M threshold value.

Dibenzo(a,h)anthracene concentrations range from 10 µg/kg to 1,830 µg/kg, with an average concentration of 118.1 µg/kg. The ER-L for dibenzo(a,h)anthracene is 63.4 µg/kg and the ER-M is 260 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is exceeded. Additionally, maximum concentrations exceed the upper ER-M threshold value.

Fluoranthene concentrations range from 0.1 µg/kg to 7,280 µg/kg, with an average concentration of 269.7 µg/kg. The ER-L for fluoranthene is 600 µg/kg and the ER-M is 5,100 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is not exceeded. Maximum concentrations, however, do occasionally exceed the upper ER-M threshold value.

Fluorene concentrations range from 0.1 µg/kg to 7,670 µg/kg, with an average concentration of 228.7 µg/kg. The ER-L for fluorene is 19 µg/kg and the ER-M is 540 µg/kg. As with the previous compounds, on average, the lower ER-L threshold sediment screening value is exceeded, but not the ER-M. Maximum concentrations, however, do occasionally exceed the upper ER-M threshold value.

Naphthalene concentrations range from 0.1 µg/kg to 825 µg/kg, with an average concentration of 105.7 µg/kg. The ER-L concentration 160 µg/kg and the ER-M is 2,100 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is not exceeded. Maximum concentrations, however, do occasionally exceed the ER-L threshold value, but not the ER-M.

Phenanthrene concentrations range from 0.1 µg/kg to 15,900 µg/kg, with an average concentration of 264.7 µg/kg. The ER-L for phenanthrene is 240 µg/kg and the ER-M is 1,500 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is slightly exceeded, but not the ER-M value. Maximum concentrations, however, do occasionally exceed the upper ER-M threshold value.

Pyrene concentrations range from non-detected to 12,400 µg/kg, with an average concentration of 624.1 µg/kg. The ER-L for pyrene is 665 µg/kg and the ER-M is 2,600 µg/kg. This indicates that, on average, the ER-L screening value is not exceeded. Maximum concentrations, however, do occasionally exceed both the ER-L and ER-M threshold values.

Lastly, total PAH concentrations range from non-detected to 54,000 µg/kg, with an average concentration of 3,944 µg/kg. The ER-L for total PAHs is 4,022 µg/kg and the ER-M is 44,792 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is not exceeded; however, maximum concentrations do occasionally exceed the upper ER-M threshold value.

4.3.2.3 *Pesticides/PCBs*

4.3.2.3.1 Port of Los Angeles

POLA sediment pesticide and PCB concentrations, as reported in the CSTF database, are summarized in Table 4-12. DDT concentrations range from non-detected to 450 µg/kg, with an average concentration of 21.8 µg/kg. The ER-L for DDT is 1.58 µg/kg and the ER-M is 46.1 µg/kg, which suggests that DDT is a chemical concern for future sediment dredging in the area. Other pesticides were detected, but no screening data are available for comparison.

Table 4-12 Los Angeles CSTF Database - Summary of Sediment Pesticide/PCB Concentrations for Port of Los Angeles Dredged Sediments

Analyte	Units	Min	Max	Avg	N
2,4'-DDD	µg/kg	0.0	79.7	9.4	50
2,4'-DDE	µg/kg	0.0	1442	56.8	50
2,4'-DDT	µg/kg	0.0	64.3	12.5	50
4,4'-DDD	µg/kg	0.0	650	18.4	267
4,4'-DDE	µg/kg	0.0	713	56.2	267
4,4'-DDT	µg/kg	0.0	450	21.8	267
Aldrin	µg/kg	1.9	23	9.5	280
alpha-BHC	µg/kg	0.7	20	5	280
alpha-Chlordane	µg/kg	2.1	65	8.2	197
Aroclor 1016	µg/kg	100	1300	682.5	159
Aroclor 1221	µg/kg	100	130	115	154
Aroclor 1232	µg/kg	100	130	115	154
Aroclor 1242	µg/kg	13	1230	333.2	280
Aroclor 1248	µg/kg	100	130	115	159
Aroclor 1254	µg/kg	0.0	4000	190	285
Aroclor 1260	µg/kg	13	6900	303.2	285
Aroclor 1262	µg/kg	nd	nd	nd	16
beta-BHC	µg/kg	1	1	1	280
Chlordane	µg/kg	nd	nd	nd	88
delta-BHC	µg/kg	1.1	1.4	1.3	280
Dieldrin	µg/kg	0.4	3.4	1.3	280
Endosulfan I	µg/kg	1.1	14	5.5	280
Endosulfan II	µg/kg	0.4	130	44.5	280
Endosulfan sulfate	µg/kg	9	9	9	280
Endrin	µg/kg	0.0	30	4.9	280
Endrin aldehyde	µg/kg	nd	nd	nd	235
Endrin ketone	µg/kg	0.6	2.4	1.5	175
gamma-BHC (Lindane)	µg/kg	0.8	4.1	1.9	280
gamma-Chlordane	µg/kg	2.2	130	22.9	197
Heptachlor	µg/kg	2.4	2.6	2.5	271
Heptachlor epoxide	µg/kg	nd	nd	nd	271
Mirex	µg/kg	nd	nd	nd	32
Total PCBs	µg/kg	1.2	6900	332.2	206
Toxaphene	µg/kg	nd	nd	nd	280

nd = non-detected

Although no ER-L screening values exists for PCBs, elevated concentrations are reported for POLA sediments. Concentrations of Aroclor 1260, a common PCB cogener, range from 13 µg/kg to 6,900 µg/kg. Other screening values for PCBs (e.g., PSDDA SL's) suggest concentrations as low as 130 µg/kg may cause aquatic impacts.

4.3.2.3.2 Port of Long Beach

POLB sediment pesticide and PCB concentrations, as reported in the CSTF database, are summarized in Table 4-13. DDT concentrations range from 0.2 µg/kg to 610 µg/kg, with an average concentration of 69.2 µg/kg. The ER-L for DDT is 1.58 µg/kg and the ER-M is 46.1 µg/kg, which suggests that DDT is a chemical concern for future sediment dredging in the area. Other pesticides were detected, but no screening data are available for comparison.

Table 4-13 Los Angeles CSTF Database - Summary of Sediment Pesticide/PCB Concentrations for Port of Long Beach Dredged Sediments

Analyte	Units	Min	Max	Avg	N
2,3,7,8-TCDD	ng/kg	nd	nd	nd	12
2,3,7,8-TCDF	ng/kg	nd	nd	nd	12
4,4'-DDD	µg/kg	0.4	150	11.1	309
4,4'-DDE	µg/kg	2	160	19	309
4,4'-DDT	µg/kg	0.2	610	69.2	314
Aldrin	µg/kg	2	100	26.6	261
alpha-BHC	µg/kg	5.3	120	30.8	256
alpha-Chlordane	µg/kg	nd	nd	nd	133
Aroclor 1016	µg/kg	240	920	654	257
Aroclor 1221	µg/kg	nd	nd	nd	267
Aroclor 1232	µg/kg	nd	nd	nd	267
Aroclor 1242	µg/kg	nd	nd	nd	285
Aroclor 1248	µg/kg	40	1720	384.3	266
Aroclor 1254	µg/kg	10	1000	155.6	285
Aroclor 1260	µg/kg	10	1200	160.1	290
Aroclor 1262	µg/kg	nd	nd	nd	3
beta-BHC	µg/kg	nd	nd	nd	256
Chlordane	µg/kg	nd	nd	nd	126
delta-BHC	µg/kg	nd	nd	nd	259
Dieldrin	µg/kg	2	122	44.4	264
gamma-BHC (Lindane)	µg/kg	18	102	73.8	261
gamma-Chlordane	µg/kg	0.1	1.2	0.4	133
Endosulfan I	µg/kg	0.6	0.6	0.6	259
Endosulfan II	µg/kg	nd	nd	nd	259
Endosulfan sulfate	µg/kg	0.5	3	1.8	258
Endrin	µg/kg	0.3	114	21.3	264
Endrin aldehyde	µg/kg	5	5	5	259
Endrin ketone	µg/kg	0.3	2.2	1	133
Heptachlor	µg/kg	16	86	62.8	264
Heptachlor epoxide	µg/kg	0.2	1	0.5	259
Total PCBs	µg/kg	44	74	59.4	28
Toxaphene	µg/kg	98	10300	1382.1	260

nd = non-detected

Although no ER-L screening values exists for PCBs, elevated concentrations are reported for POLA sediments. Concentrations of Aroclor 1260, a common PCB cogener, range from 10 µg/kg to 1,200 µg/kg. Other screening values for PCBs (e.g., PSDDA SL's) suggest concentrations as low as 130 µg/kg may cause aquatic impacts.

4.4 Los Angeles River Estuary

As described in Section 2.3.3, sediment deposition in the LARE reflects the flow pattern of runoff from the Los Angeles River. The eastward bending of the estuary flow course has resulted in a deposition pattern where silt predominantly accretes along the northeastern shore (inner bend) of the estuary, whereas sand mostly accumulates on the opposite side (outer bend) of the estuary. Lenses of relatively coarse sediment are present off Queensway Marina and at locations upstream.

Physical and chemical laboratory results from previous maintenance dredging characterization studies are available dating back to 1979. These results have been summarized and are presented in the following sections.

4.4.1 *Physical Characterization and Distribution*

4.4.1.1 *Grain Size and Organic Carbon*

Sediment grain size distribution in the LARE is summarized in Table 4-14. Sand contents range from 19 percent to 97 percent with an average of 61 percent; silt contents range from 1 percent to 45 percent, with an average of 24 percent; and clay contents range from 2 percent to 36 percent with an average of 13 percent. Gravel is rarely encountered in LARE dredged material, averaging only 1.4 percent. Organic carbon contents in LARE dredge materials range from 0.1 percent to 3 percent, averaging 1.3 percent.

Table 4-14 Los Angeles CSTF Database - Summary of Sediment Physical Characteristics for LARE Dredged Sediments

Analyte	Units	Min Detect	Max Detect	Avg Detect	N
Sand	PCT	18.8	97	61.2	12
Silt	PCT	1.2	45.4	24.1	12
Clay	PCT	1.8	36.2	13.3	12
Gravel	PCT	0.0	4.8	1.4	12
TOC	PCT	0.1	3	1.3	11
Total Sulfides	mg/kg	0.3	2500	540.9	16
Dissolved sulfides	mg/kg	0.2	110	36.6	16

nd = non-detected

4.4.1.2 *Engineering Properties*

With the exception of the recently completed DMMP Pilot Capping Study (USACE 2002a), little data exists on the geotechnical engineering properties of dredge materials from the LARE. Table 4-15 provides a summary of engineering properties from sediment cores collected throughout the dredge prism for the 2001 maintenance dredge event. Specific gravities for the material ranged from 2.3 to 2.7; dry densities from 655 kg/m^3 to 1,920 kg/m^3; and void ratios from 0.39 to 2.05. The material had a liquid limit ranging from 30 to 55, and a plastic limit from 28 to 45. Moisture contents (reported as a percent) ranged from 14.6 for the areas with the highest sand content to 115.9 for areas with higher silt and clay contents.

Table 4-15 Summary of Geotechnical Engineering Parameters for Cores from the LARE

Sample Number	Mudline El. MLLW (Ft.)	Sample Depth Interval	Top of Sample El. MLLW (Ft.)	Sediment Description	LABORATORY TEST RESULTS										
									Atterberg Limits			Grain Size Distribution			
					Moisture Content (%)	Specific Gravity	Dry Density (kg/m^3)	Void Ratio	Liquid Limit	Plastic Limit	PI	% Gravel	% Sand	% Silt	% Clay
LAR-Core-1-1	-1.4	0-3	-1.4	Sand	18.5	2.623	1,760	0.49				0	97.4	1.6	1
LAR-Core-1-2		3-4.5	-4.4	Sand	26.2	2.626	1,550	0.69				0.8	96	2.1	1.1
LAR-Core-1-3		4.5-7.5	-5.9	Slightly clayey, very silty sand	59.3	2.559	1,010	1.52				0.7	70.4	21.4	7.5
LAR-Core-1-4		7.5-10	-8.9	Slightly clayey, very silty sand	47.4	2.704	1,190	1.28				0.8	64.5	27.1	7.6
LAR-Core-1-5		10-13	-11.4	Organic slightly clayey, very sandy silt(OL)	61.3	2.656	1,010	1.63	43	34	9	1.8	46.8	39.2	12.2
LAR-Core-1-6		13-14.8	-14.4	Organic, clayey, very sandy Silt (OH)	68.9	2.513	915	1.73	55	45	10	0.5	27	57	15.5
															1460
LAR-Core-2-1	-2.2	0-3	-2.2	Slightly silty Sand with trace gravel	30.6	2.653	1,460	0.81				5	83.4	7.7	3.9
LAR-Core-2-2		3-6	-5.2	Sand with trace silt	25.7	2.702	1,600	0.69				0.3	93.9	4.2	1.6
LAR-Core-2-3		6-9	-8.2	Silty Sand	32.2	2.604	1,410	0.84				0.2	84.9	11.5	3.4
LAR-Core-2-4		9-12	-11.2	Slightly clayey, very silty Sand	61.5	2.54	995	1.56	30	28	2	2.1	66.5	25	6.4
LAR-Core-2-5		12-15.2	-14.2	Silty Sand	52.1	2.583	1,110	1.35				0.4	85.7	9.6	4.3
LAR-Core-3-1	-3.8	0-3	-3.8	Sand	19.9							0.5	98	0.8	0.7
LAR-Core-3-2		3-4.9	-6.8	Sand with trace gravel	14.6	2.667	1,920	0.39				5	93.7	0.6	0.7
LAR-Core-3-3		4.9-8	-8.7	Slightly clayey, silty Sand	77.7	2.633	865	2.05				0.8	77.3	15.4	6.5
LAR-Core-3-4		8-11	-11.8	Slightly clayey, very silty Sand	72.3	2.289	865	1.65				0	66.4	25.2	8.4
LAR-Core-3-5		11-13	-14.8	Slightly clayey, very silty Sand	49.1	2.404	1,110	1.18				0.7	68.5	24	6.8
LAR-Core-3-6		13-16	-16.8	Sand	28	2.538	1,490	0.71				0	98.3	1.1	0.6
LAR-Core-4-1	-4	0-3	-4	Very sandy silt	27.1							0	47.4	51.9	0.7
LAR-Core-4-2		3-4.6	-7	Organic, slightly clayey, silty Sand	115.9	2.639	655	3.06				0	72.8	20.3	6.9
LAR-Core-4-3		4.6-6.4	-8.6	Slightly silty Sand	30.8	2.326	1,360	0.72				0	90.2	7.7	2.1
LAR-Core-4-4		6.4-9.4	-10.4	Organic, slightly clayey, very silty Sand	69.7	2.624	930	1.83				0	57.9	32.7	9.4
LAR-Core-4-5		9.4-13.0	-13.4	Organic, very silty Sand	63.6	2.519	960	1.60				0	76.9	18.3	4.8
LAR-Core-4-6		13.0-16.4	-17	Sand	31.5	2.545	1,410	0.80				0	97.4	1.4	1.2

4.4.2 *Chemical Characteristics and Distribution*

4.4.2.1 *Inorganics*

LARE material inorganic concentrations from the CSTF database are summarized in Table 4-16. Arsenic concentrations range from 0.7 mg/kg to 12.3 mg/kg, with an average concentration of 5 mg/kg. The ER-L for arsenic is 8.2 mg/kg and the ER-M is 70 mg/kg, suggesting that the LARE material averages slightly below the ER-L, but individual data points occasionally exceed the ER-L. The ER-M for arsenic was never exceeded.

Table 4-16 Los Angeles CSTF Database - Summary of Sediment Inorganic Concentrations for LARE Dredged Sediments

Analyte	Units	Min Detect	Max Detect	Avg Detect	N
Arsenic	mg/kg	0.7	12.3	5.0	17
Cadmium	mg/kg	0.1	2.6	0.9	17
Chromium	mg/kg	10	69.5	36.4	17
Copper	mg/kg	11.4	116	51.8	17
Lead	mg/kg	7.2	200	64.9	17
Mercury	mg/kg	0.0	0.6	0.3	16
Nickel	mg/kg	8.0	39	22.5	17
Selenium	mg/kg	0.5	2.2	0.9	17
Silver	mg/kg	0.1	1.2	0.4	17
Zinc	mg/kg	42.3	360	151.7	17
Butyltin	µg/kg	2.0	24	13.3	9
Tributyltin	µg/kg	1.9	290	69.7	15
Dibutyltin	µg/kg	1.0	54	21.9	15
Monobutyltin	µg/kg	nd	nd	nd	6

nd = non-detected

Cadmium concentrations range from 0.1 mg/kg to 2.6 mg/kg with an average concentration of 0.9 mg/kg. The ER-L for cadmium is 1.2 mg/kg and the ER-M is 9.6 mg/kg. Like arsenic, cadmium concentrations in the LARE material occasionally exceed the ER-L, but the average concentration is below the ER-L and the ER-M was never exceeded.

Chromium concentrations range from 10 mg/kg to 69.5 mg/kg, with an average concentration of 36.4 mg/kg. The ER-L for chromium is 81 mg/kg and the ER-M is 370 mg/kg, both above the maximum concentrations reported in the CSTF database.

Copper concentrations range from 11.4 mg/kg to 116 mg/kg, with an average concentration of 51.8 mg/kg. The ER-L for copper is 34 mg/kg and the ER-M is 270 mg/kg, suggesting that, on average, LARE sediments exceed the ER-L, but not the ER-M.

Lead concentrations range from 7.2 mg/kg to 200 mg/kg, with an average concentration of 64.9 mg/kg. The ER-L for lead is 46.7 mg/kg and the ER-M is 218 mg/kg, suggesting that, on average, LARE sediments exceed the ER-L for lead, but not the ER-M.

Mercury concentrations range from undetected to 0.6 mg/kg, with an average concentration of 0.3 mg/kg. The ER-L for mercury is 0.15 mg/kg and the ER-M is 0.71 mg/kg. As with copper and lead, mercury frequently exceeds the ER-L, but not the ER-M.

Nickel concentrations range from 8 mg/kg to 39 mg/kg, with an average concentration of 22.5 mg/kg. The ER-L for nickel is 20.9 mg/kg and the ER-M is 51.6 mg/kg. As with most of the other metals, the ER-L is frequently exceeded in the LARE material (average concentration is just below the ER-L), but not the ER-M.

Selenium concentrations range from 0.5 mg/kg to 2.2 mg/kg, with an average concentration of 0.9 mg/kg. No ER-L or ER-M values are available for selenium.

Silver concentrations range from 0.1 mg/kg to 1.2 mg/kg, with an average concentration of 0.4 mg/kg. The ER-L for silver is 1 mg/kg and the ER-M is 3.7 mg/kg, suggesting the LARE material silver concentrations are rarely of concern.

Zinc concentrations range from 42.3 mg/kg to 360 mg/kg, with an average concentration of 151.7 mg/kg. The ER-L for zinc is 150 mg/kg and the ER-M is 410 mg/kg. On average, zinc concentrations barely exceed the ER-L concentration, and occasionally fall between the ER-L and the ER-M. The ER-M was never exceeded.

Another source of chemical data for the LARE, not yet contained in the CSTF database, comes from the DMMP Pilot Capping Study (USACE 2002a). The results from this recent sediment characterization of the LARE show similar concentrations as the CSTF database.

4.4.2.2 *Semi-Volatile Organics*

LARE sediment SVOA concentrations are summarized in Table 4-17. With the exception of three compounds (2-methylnaphthalene, dibenzofuran, and methoxychlor), all were detected in at least one of the samples tested. As expected, concentrations vary by chemical and the range in concentrations for some compounds is quite large. Sediment screening values (e.g., ER-L, ER-M) do not exist for all the SVOA compounds tested. A summary of reported values for compounds that have screening values available follows.

Table 4-17 Los Angeles CSTF Database - Summary of Sediment SVOA Concentrations for LARE Dredged Sediments

Analyte	Units	Min Detect	Max Detect	Avg Detect	N
2-Methylnaphthalene	µg/kg	nd	nd	nd	9
Acenaphthene	µg/kg	18	18	18	16
Acenaphthylene	µg/kg	20	28	22.7	16
Anthracene	µg/kg	16	350	69.5	16
Benzo(a)anthracene	µg/kg	28	380	129.3	16
Benzo(a)pyrene	µg/kg	25	530	217	16
Benzo(b)fluoranthene	µg/kg	36	730	284.2	16
Benzo(g,h,i)perylene	µg/kg	38	294	123.6	16
Benzo(k)fluoranthene	µg/kg	28	480	198.3	16
bis(2-ethylhexyl) Phthalate	µg/kg	29	16200	3977.3	16
Butylbenzyl Phthalate	µg/kg	14	449	164.5	16
Chrysene	µg/kg	41	530	199.6	16
Dibenzo(a,h)anthracene	µg/kg	18	68	41	16
Dibenzofuran	µg/kg	nd	nd	nd	9
Diethyl phthalate	µg/kg	22	23	22.7	16
Dimethyl phthalate	µg/kg	24	24	24	16
Di-n-butyl phthalate	µg/kg	28	311	91.9	16
Di-n-octyl phthalate	µg/kg	79	240	160.2	16
Fluoranthene	µg/kg	62	840	261.9	16
Fluorene	µg/kg	18	39	27.8	16
Indeno(1,2,3-c,d)pyrene	µg/kg	25	310	164.6	16
Methoxychlor	µg/kg	nd	nd	nd	15
Naphthalene	µg/kg	55	55	55	16
Phenanthrene	µg/kg	30	233	95.4	16
Pyrene	µg/kg	90	1200	431.3	16
Total PAHs	µg/kg	1270	2580	1858	7

nd = non-detected

Acenaphthene concentrations average 18 µg/kg which is slightly higher than the ER-L of 16 µg/kg. Acenaphthylene concentrations average 22.7 µg/kg, well below the ER-L of 44 µg/kg. Anthracene concentrations average 69.5 µg/kg which is below the ER-L of 85.3 µg/kg; however, maximum concentrations are reported as high as 350 µg/kg. The ER-M for anthracene (1,100 µg/kg) was not exceeded in any of the samples.

Benzo(a)anthracene concentrations range from 28 µg/kg to 380 µg/kg, with an average concentration of 129.3 µg/kg. The ER-L for benzo(a)anthracene is 261 µg/kg and the ER-M is 1,600 µg/kg. This indicates that, on average, the lower ER-L threshold sediment screening value is not exceeded, but maximum concentrations occasionally exceed the ER-M threshold value.

Benzo(a)pyrene concentrations range from 25 µg/kg to 530 µg/kg, with an average concentration of 217 µg/kg. The ER-L for benzo(a)pyrene is 430 µg/kg and the ER-M is 1,600 µg/kg. This indicates that benzo(a)pyrene rarely exceeds the lower ER-L screening threshold. Chrysene concentrations range from 41 µg/kg to 530 µg/kg, with an average concentration of 199.6 µg/kg. The ER-L for chrysene is 384 µg/kg and the ER-M is 2,800 µg/kg suggesting that chrysene is typically not a chemical of concern.

Dibenzo(a,h)anthracene concentrations range from 18 µg/kg to 68 µg/kg, with an average concentration of 41 µg/kg. The ER-L for dibenzo(a,h)anthracene is 63.4 µg/kg which is only slightly lower than the maximum value reported.

Fluoranthene concentrations range from 62 µg/kg to 840 µg/kg, with an average concentration of 261.9 µg/kg. The ER-L for fluoranthene is 600 µg/kg and the ER-M is 5,100 µg/kg. This suggests that fluoranthene occasionally fails the lower threshold screening criteria, but never the upper threshold value.

Fluorene concentrations range from 18 µg/kg to 39 µg/kg, with an average concentration of 27.8 µg/kg. The ER-L for fluorene is 19 µg/kg and the ER-M is 540 µg/kg. While the upper screening value is never exceeded, the lower value appears to be frequently exceeded. Naphthalene was only reported as a single detection in the CSTF database and the concentration (55 µg/kg) was well below the ER-L concentration of 160 µg/kg.

Phenanthrene concentrations range from 30 µg/kg to 233 µg/kg, with an average concentration of 95.4 µg/kg. The ER-L for phenanthrene is 240 µg/kg which is above the maximum concentration reported.

Pyrene concentrations range from 90 µg/kg to 1,200 µg/kg, with an average concentration of 431.3 µg/kg. The ER-L for pyrene is 665 µg/kg and the ER-M is 2,600 µg/kg. This indicates that, although the average concentration is below the lower screening threshold, it is still potentially a chemical of concern for LARE sediments due to the high maximum concentrations reported in the database.

Lastly, total PAH concentrations range from 1,270 µg/kg to 2,580 µg/kg, with an average concentration of 1,858 µg/kg. The ER-L for total PAHs is 4,022 µg/kg, which is well above the maximum concentration reported.

Other data, not yet contained in the CSTF database, suggests that some areas of the LARE contain much higher PAH concentrations, which easily exceeded the lower screening threshold values (Chambers Group 1998). As an example, a total PAH concentration of 17,473 µg/kg was recorded at one station in the LARE during a 1997 sampling event. The most recent sampling event (USACE 2002a), however, yielded results similar to those presented above.

4.4.2.3 *Pesticides/PCBs*

Despite the large potential upland source area to the LARE, pesticides and PCBs are rarely detected during sediment characterization studies for maintenance dredging (Table 4-18). DDT and its derivatives were detected and reported in the CSTF database, but at concentrations very close to the method detection limits. Arochlor 1248, 1254, and 1260 were also detected, but no ER-L type values exist for screening evaluation. The same is true for total dioxins, which were also detected.

Table 4-18 Los Angeles CSTF Database - Summary of Sediment Pesticide/PCB Concentrations for LARE Dredged Sediments

Analyte	Units	Min Detect	Max Detect	Avg Detect	N
2,3,7,8-TCDD	ng/kg	nd	nd	nd	3
4,4'-DDD	µg/kg	0.0	0.0	0.0	15
4,4'-DDE	µg/kg	0.0	0.1	0.0	15
4,4'-DDT	µg/kg	0.0	0.0	0.0	15
alpha-BHC	µg/kg	nd	nd	nd	15
beta-BHC	µg/kg	nd	nd	nd	15
delta-BHC	µg/kg	nd	nd	nd	15
gamma-BHC (Lindane)	µg/kg	nd	nd	nd	15
Aldrin	µg/kg	nd	nd	nd	15
Aroclor 1016	µg/kg	nd	nd	nd	15
Aroclor 1221	µg/kg	nd	nd	nd	15
Aroclor 1232	µg/kg	nd	nd	nd	15
Aroclor 1242	µg/kg	nd	nd	nd	15
Aroclor 1248	µg/kg	0.1	0.1	0.1	15
Aroclor 1254	µg/kg	0.1	0.1	0.1	15
Aroclor 1260	µg/kg	0.0	94	15.5	15
Chlordane	µg/kg	nd	nd	nd	15
Dieldrin	µg/kg	0.0	0.0	0.0	15
Endosulfan I	µg/kg	nd	nd	nd	15
Endosulfan II	µg/kg	nd	nd	nd	15
Endosulfan sulfate	µg/kg	nd	nd	nd	15
Endrin	µg/kg	0.0	0.0	0.0	15
Endrin aldehyde	µg/kg	nd	nd	nd	15
Heptachlor	µg/kg	nd	nd	nd	15
Heptachlor epoxide	µg/kg	nd	nd	nd	15
Toxaphene	µg/kg	nd	nd	nd	15
Total TCDD	ng/kg	3.4	4.3	3.8	3

nd = non-detected

4.5 Alamitos Bay

As described in Section 2.4, sediment deposition into Alamitos Bay is from the Los Cerritos Channel and the San Gabriel River. The bay is regularly dredged once a year to maintain channel and basin depths for boating activities. Physical and chemical laboratory results from a previous Bay Protection and Toxic Cleanup Program/National Oceanic and Atmospheric Administration (BPTCP/NOAA) study are presented in the following sections.

4.5.1 *Physical Characterization and Distribution*

4.5.1.1 *Grain Size and Organic Carbon*

Sediment grain size distribution in Alamitos Bay is summarized in Table 4-19. Most of the data in Table 4-19 represent only one sampling event and therefore averages and ranges do not apply. From the one sampling event, total sand content was 21.8 percent, total silt was 49.8 percent, total clay was 28.4 percent and total fines were 78.3 percent. Total organic carbon contents ranged from 0.6 to 1.7 percent with an average of 0.9 percent in the Alamitos Bay sediments.

Table 4-19 BPTCP/NOAA Database - Summary of Sediment Physical Characteristics for Alamitos Bay Sediments

Analyte	Units	Min	Max	Avg	N
Clay	PCT	28.4	28.4	na	1
Clay (total)	PCT	28.4	28.4	na	1
Coarse Sand	PCT	0.0	0.0	na	1
Coarse Silt	PCT	10.6	10.6	na	1
Fine Sand	PCT	21.8	21.8	na	1
Fine Silt	PCT	39.3	39.3	na	1
Fines (total)	PCT	78.3	78.3	na	1
Percent Fines	PCT	32.4	91	65.1	10
Percent Moisture	PCT	48.2	48.2	na	1
Sand (total)	PCT	21.8	21.8	na	1
Silt (total)	PCT	49.8	49.8	na	1
TOC	PCT	0.6	1.7	0.9	10

4.5.1.2 *Engineering Properties*

Other than grain size data, no other engineering properties are available for Alamitos Bay dredge sediments. Dredge materials from this area are not normally used for construction projects. As such, sediment geotechnical data is not generally collected or readily available.

4.5.2 *Chemical Characteristics and Distribution*

4.5.2.1 *Inorganics*

Inorganic chemical concentrations in Alamitos Bay are summarized in Table 4-20. Arsenic concentrations range from 5.5 mg/kg to 9.7 mg/kg, with an average concentration of 7.3 mg/kg. The ER-L for arsenic is 8.2 mg/kg and the ER-M is 70 mg/kg, suggesting that Alamitos Bay material averages slightly below the ER-L, but individual data points occasionally exceed the ER-L. The ER-M for arsenic was never exceeded.

Cadmium concentrations range from 0.3 mg/kg to 1.0 mg/kg with an average concentration of 0.6 mg/kg. The ER-L for cadmium is 1.2 mg/kg and the ER-M is 9.6 mg/kg. Cadmium concentrations in Alamitos Bay material are always low and have never exceeded the ER-L or ER-M.

Chromium concentrations range from 44.0 mg/kg to 63.0 mg/kg, with an average concentration of 53.1 mg/kg. The ER-L for chromium is 81 mg/kg and the ER-M is 370 mg/kg, both above the maximum concentrations reported in the BPTCP/NOAA database.

Copper concentrations range from 35.0 mg/kg to 69.1 mg/kg, with an average concentration of 52.0 mg/kg. The ER-L for copper is 34 mg/kg and the ER-M is 270 mg/kg, suggesting that, on average, Alamitos Bay sediments exceed the ER-L, but not the ER-M.

Table 4-20 BPTCP/NOAA Database - Summary of Sediment Metal Characteristics for Alamitos Bay Sediments

Analyte	Units	Min	Max	Avg	N
Aluminum	mg/kg	37000	93800	59160	5
Antimony	mg/kg	0.9	1.8	1.3	5
Arsenic	mg/kg	5.5	9.7	7.3	5
Cadmium	mg/kg	0.3	1.0	0.6	5
Chromium	mg/kg	44	63.0	53.1	5
Copper	mg/kg	35.0	69.1	52	5
Iron	mg/kg	26000	39000	34360	5
Lead	mg/kg	43	94.6	59.5	5
Manganese	mg/kg	410	478	439.6	5
Mercury	mg/kg	0.1	0.3	0.2	4
Nickel	mg/kg	24	37	30.5	5
Selenium	mg/kg	0.2	0.4	0.3	3
Silver	mg/kg	0.3	0.5	0.4	4
Tin	mg/kg	2.4	5.1	3.8	5
Tributyltin	µg/kg	0.0	0.0	0.0	5
Zinc	mg/kg	120	200	160	5

Lead concentrations range from 43.0 mg/kg to 94.6 mg/kg, with an average concentration of 59.5 mg/kg. The ER-L for lead is 46.7 mg/kg and the ER-M is 218 mg/kg, suggesting that, on average, Alamitos Bay sediments exceed the ER-L for lead, but not the ER-M.

Mercury concentrations range from 0.1 mg/kg to 0.3 mg/kg, with an average concentration of 0.2 mg/kg. The ER-L for mercury is 0.15 mg/kg and the ER-M is 0.71 mg/kg. As with copper and lead, mercury frequently exceeds the ER-L, but not the ER-M.

Nickel concentrations range from 24.0 mg/kg to 37 mg/kg, with an average concentration of 30.5 mg/kg. The ER-L for nickel is 20.9 mg/kg and the ER-M is 51.6 mg/kg. As with most of the other metals, the ER-L is frequently exceeded but the ER-M is not.
Selenium concentrations range from 0.2 mg/kg to 0.4 mg/kg, with an average concentration of 0.3 mg/kg. No ER-L or ER-M values are available for selenium.

Silver concentrations range from 0.3 mg/kg to 0.5 mg/kg, with an average concentration of 0.4 mg/kg. The ER-L for silver is 1 mg/kg and the ER-M is 3.7 mg/kg, suggesting that silver concentrations are rarely of concern in Alamitos Bay sediments.

Zinc concentrations range from 120 mg/kg to 200 mg/kg, with an average concentration of 160 mg/kg. The ER-L for zinc is 150 mg/kg and the ER-M is 410 mg/kg. On average, zinc concentrations exceed the ER-L concentration, however, the ER-M was never exceeded.

4.5.2.2 *Organics*

Alamitos Bay organic concentrations are summarized in Table 4-21. All of the organic compounds listed below were detected in at least one of the samples tested. As expected, concentrations vary by chemical and the range in concentrations for some compounds is quite large. Sediment screening values (e.g., ER-L, ER-M) do not exist for all of the listed compounds tested.

Table 4-21 BPTCP/NOAA Database - Summary of Sediment Organic Concentrations for Alamitos Bay Sediments

Analyte	Units	Min	Max	Avg	N
1-Methylnaphthalene	µg/kg	4.7	4.7	4.7	1
1-Methylphenanthrene	µg/kg	5.2	11	7.7	5
2,3,5-trimethylnaphthalene	µg/kg	2.1	2.1	2.1	1
2,6-Dimethylnaphthalene	µg/kg	3.7	12	7.9	4
2-Methylnaphthalene	µg/kg	5.9	11.9	9.2	5
Acenaphthene	µg/kg	2.2	2.2	2.2	1
Acenaphthylene	µg/kg	4.3	4.3	4.3	1
Anthracene	µg/kg	5.7	12	8.9	5
Benzo(a)anthracene	µg/kg	41	68	51.7	5
Benzo(a)pyrene	µg/kg	56	97.8	74.6	5
Benzo(b)fluoranthene	µg/kg	84.5	84.5	84.5	1
Benzo(e)pyrene	µg/kg	67	98	84.3	5
Benzo(g,h,i)perylene	µg/kg	89.2	89.2	89.2	1
Benzo(k)fluoranthene	µg/kg	87.7	87.7	87.7	1
Biphenyl	µg/kg	2.2	2.2	2.2	1
Chrysene	µg/kg	73.2	140	96.6	5
Coronene	µg/kg	20.1	20.1	20.1	1
Dibenzo(a,h)anthracene	µg/kg	14	31	20.8	5
Dibenzothiophene	µg/kg	4.0	4.0	4.0	1
Fluoranthene	µg/kg	110	190	152	5
Fluorene	µg/kg	2.8	6.2	4.5	2
Hexachlorobenzene	µg/kg	0.2	0.2	0.2	2
Indeno(1,2,3-c,d)pyrene	µg/kg	72.4	72.4	72.4	1
Naphthalene	µg/kg	12.6	12.6	12.6	1
Perylene	µg/kg	22	30	25.7	5
Phenanthrene	µg/kg	34	76	58.3	5
Pyrene	µg/kg	110	190	156	5
Low molecular weight PAHs, total	µg/kg	59.5	125.3	96.4	5
High molecular weight PAHs, total	µg/kg	517	800	661.7	5
Total PAHs	µg/kg	576.5	919.5	758.1	5

Despite the large potential upland source area that drains into Alamitos Bay, pesticides and PCBs are detected in very low concentrations in the sediments (Table 4-22). DDT and its derivatives were detected and reported BPTCP/NOAA database. Most derivatives were detected at low concentrations very close to the method detection limits. 4,4' DDE was the only derivative that was elevated with concentrations ranging from 14.0 µg/kg to 39.8 µg/kg with an average concentration of 28.3 µg/kg. Arochlor 1254 concentration in the sediment was 75.7 µg/kg, but no ER-L type values exist for screening evaluation.

Table 4-22 BPTCP/NOAA Database - Summary of Sediment Pesticide/PCB Characteristics for Alamitos Bay Sediments

Analyte	Units	Min	Max	Avg	N
2,4'-DDD	µg/kg	1.1	2.4	1.6	4
2,4'-DDE	µg/kg	1.5	4.4	2.8	5
2,4'-DDT	µg/kg	0.8	0.8	0.8	1
4,4'-DDD	µg/kg	2.7	6.2	4.8	5
4,4'-DDE	µg/kg	14	39.8	28.3	5
4,4'-DDT	µg/kg	2.0	5.7	3.8	2
Aroclor 1254	µg/kg	75.7	75.7	75.7	1
Chlordene - alpha (of tech. Chlordane)	µg/kg	0.6	0.6	0.6	1
cis-Chlordane	µg/kg	1.2	3.5	2.6	5
cis-Nonachlor	µg/kg	2.4	2.4	2.4	1
Dieldrin	µg/kg	1.5	1.5	1.5	1
Endosulfan II	µg/kg	1.5	1.5	1.5	1
Endosulfan sulfate	µg/kg	1.4	1.4	1.4	1
Heptachlor epoxide	µg/kg	0.3	0.3	0.3	1
p,p'-DDMU	µg/kg	2.0	2.0	2.0	1
p,p'-Dichlorobenzophenone (deriv of DDT)	µg/kg	0.9	0.9	0.9	1
Total PCBs	µg/kg	18.2	80.6	52.6	5
Trans-chlordane	µg/kg	4.2	4.2	4.2	1
Trans-Nonachlor	µg/kg	1.4	4.1	3.1	5

5 COASTAL ENGINEERING

5.1 Climate

5.1.1 *General Climate*

The Study Area has a subtropical climate with mild temperatures throughout the year. The climate is influenced by the large-scale weather patterns in the Pacific Ocean and by the mountain ranges surrounding the coastal plain. Pacific storm paths extend to the Los Angeles Region (Region) during late fall, winter, and early spring. The Region is covered by marine air most of the year, with occasional interruption by air from inland, particularly during fall and winter. One of the most characteristic climate features in the Region is the low cloudiness during the night and morning, and sunny conditions in the afternoon. The overall low cloudiness, together with the prevalent westerly sea breeze produces generally mild temperatures throughout the year. The 30-year average daily minimum and maximum temperatures are approximately 3 °C in January and 29 °C in July, respectively (LACDPW 1991). High temperatures almost always occur with low humidity conditions. Haze and fog accompanied by moist marine layers and light winds frequent the Region. Foggy nights or mornings are rare during the summer, but account for approximately 25 percent of the nights and mornings during the winter (NCDC 2003).

5.1.2 *Winds*

Wind patterns in the Study Area are characterized by the prevailing westerly winds (sea breezes) during the day, and light easterly or northeasterly breezes during the night and early morning. Monthly average winds are typically 9.7 to 14.5 kilometers per hour (kmh) near Santa Monica Bay as measured at the Los Angeles International Airport, and 7.2 to 11.1 kmh in Long Beach as measured at the Long Beach Airport (NCDC 2003). Figure 5-1 shows the annual wind pattern over the Study Area and Southern California Bight in general (SWQCB 1965). Short-term wind data from the San Pedro Breakwater in San Pedro Bay indicate the winds in the open bay are twice as strong as those measured at the Long Beach Airport (USACE 1994), apparently due to the inland location of the latter. The strongest winds in the Study Area tend to be from the west or north following the passage of winter storm fronts (NCDC 2003 and USACE 1994). Southeasterly winds associated with approaching winter storm fronts can also be important in the area (USACE 1994).

Gusty Santa Ana winds occur in the Region primarily between October and February with December having the highest frequency of events. The winds blow from the northeast through the mountain passes and canyons to the coastal plain at speeds of approximately 64.4 kmh with gusts up to 96.6 kmh in widespread areas and 161 kmh in favored areas (NWS 2003). The Santa Ana wind brings extremely dry air and dust clouds to the areas near the coast several times each year (NCDC 2003). The flow pattern of Santa Ana winds along favored courses in the Region (Kurtz 1977) is shown in Figure 5-2. As shown in the figure, the Study Area can be significantly affected by Santa Ana winds. For example, Santa Ana winds in 1933 caused significant damages to the Los Angeles/Long Beach Harbors (Marine Advisers 1965).

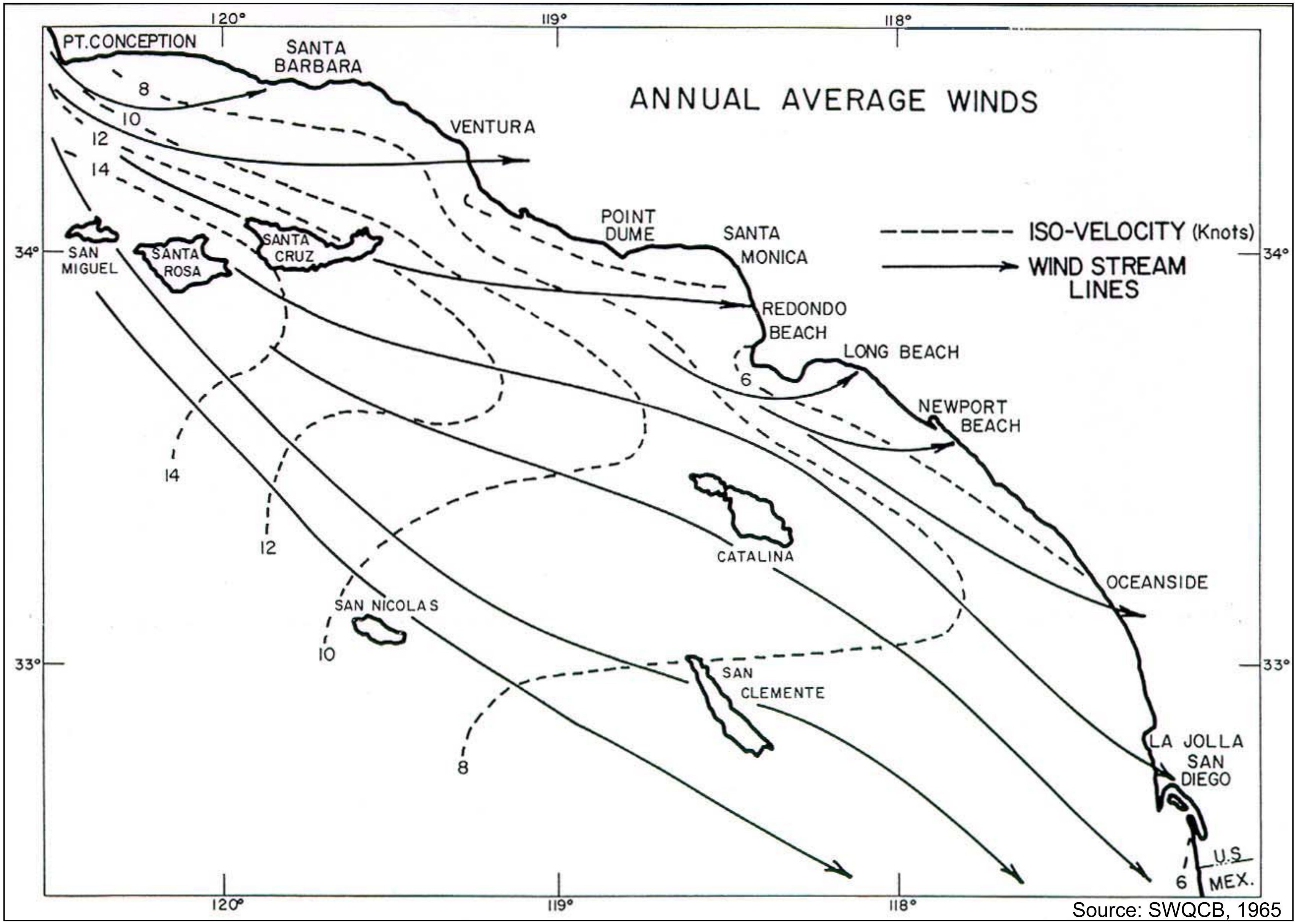


Figure 5-1

Annual Average Winds of the Southern California Bight

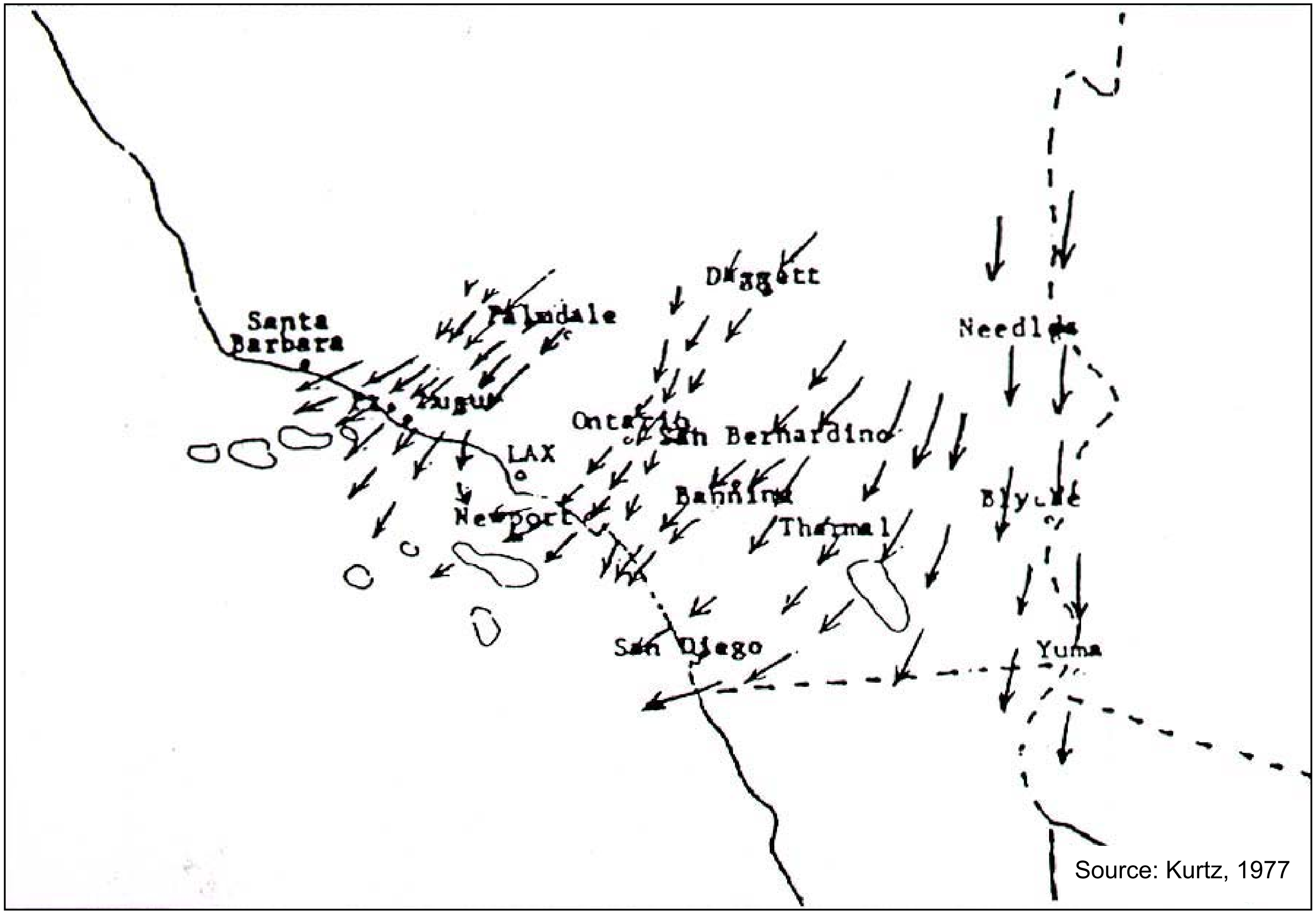


Figure 5-2

Favored Courses of Santa Ana Winds of the Southern California Bight

5.1.3 *Precipitation*

Precipitation in the Study Area occurs primarily during winter months. Measurable precipitation occurs in approximately 25 percent of the days during the period of late October through early April. In contrast, precipitation during the months of July and August is essentially nonexistent in three years out of four (NCDC 2003). Relatively infrequent thunderstorms occur over the coastal ranges in the summer when moist air moves in from the south and southeast. Rainfall amounts generally increase from the lower-altitude coastal plain to the inland mountains. Annual precipitation on the coast as measured at the Los Angeles International Airport is approximately 30.5 centimeters (cm) on average, with a range of 7.6 cm in the driest year to 73.7 cm in the wettest year. In comparison, annual precipitation at the inland Los Angeles Civic Center in downtown Los Angeles is approximately 38.1 cm on average, with a range of 10.2 cm in the driest year to 86.4 cm in the wettest year (WRCC 2003). Figure 5-3 shows the long-term average pattern of annual precipitation within the Study Area (NWS 2001).

5.1.4 *Storms*

The types of storms historically affecting the Study Area include general winter storms, local storms, and general summer storms. Some combination of these types can also occur during individual storm events (USACE 1979).

General winter storms occur primarily during the months of December through March. The storms are typically generated in the Gulf of Alaska or subtropical Pacific Ocean near Hawaii as a result of interaction between polar and tropical air masses over the northern Pacific Ocean. The storms from the Gulf of Alaska approach southern California from the northwest and are generally of light or moderate intensity, whereas those from the subtropical Pacific Ocean reach the Region from the west and are typically intensive. The storms are often accompanied by heavy and widespread precipitation in the Region that can last for days.

Local storms can occur throughout the year, but are more frequent during the winter. The storms are usually associated with tropical moisture that reaches the Region from the south or east during the summer or with storm cold fronts or deep upper-level low pressure centers during the winter. The storms are typically accompanied by high-intensity precipitation for durations of three hours or shorter.

General summer storms occasionally occur during the summer and early fall. The storms are usually tropical cyclones generated off the coast of Mexico that travel up-coast and approach the Study Area from the south. The storms can reach hurricane intensity upon arrival in the Study Area.

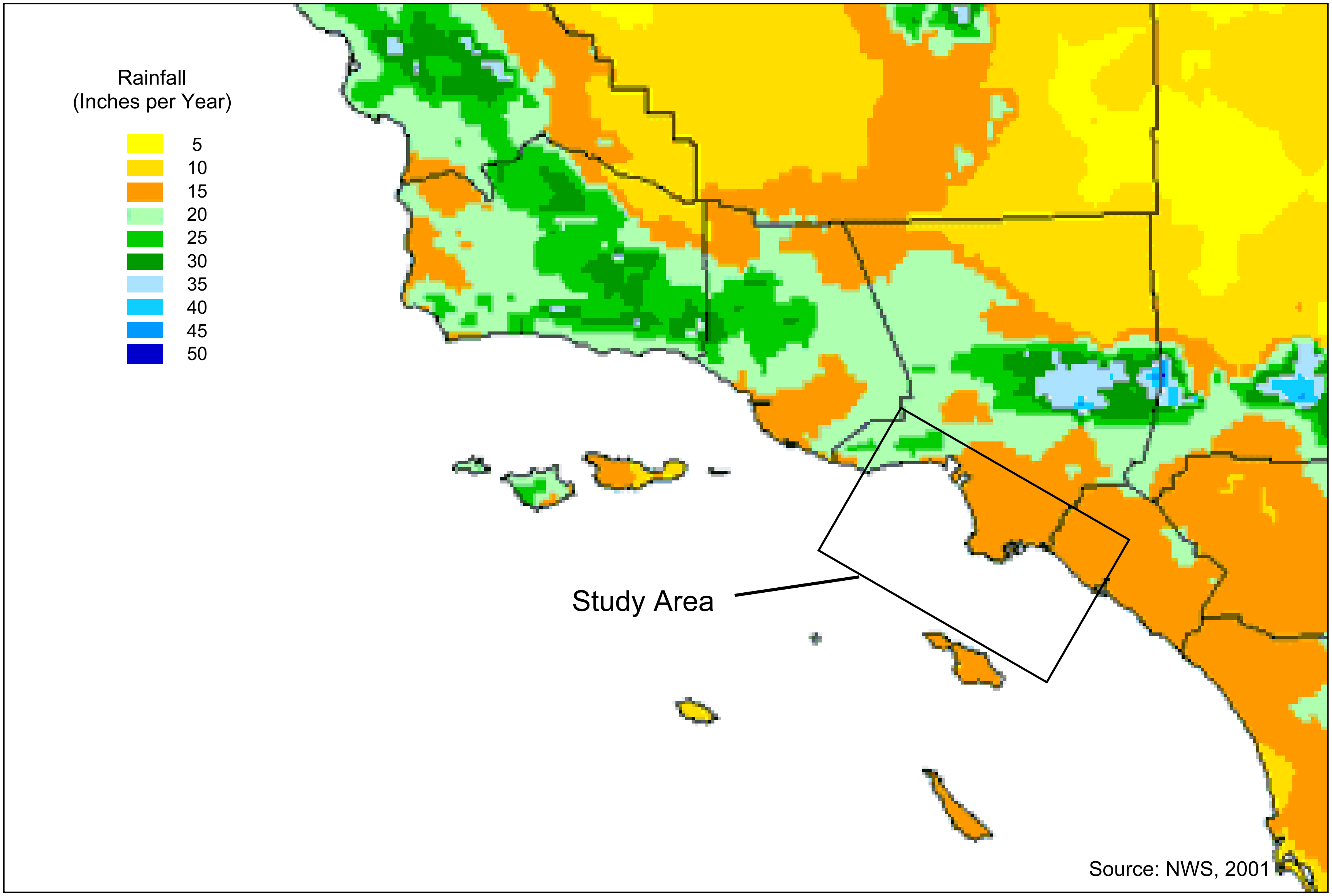


Figure 5-3

Precipitation Pattern (1961-1990)

5.2 Oceanographic Conditions

5.2.1 *Water Levels*

5.2.1.1 *Tides*

Tidal exchanges along the Southern California coastline are of the mixed semidiurnal nature, consisting of two unequal high tides and two unequal low tides in a period of 24 hours and 50 minutes. The National Oceanic and Atmospheric Administration (NOAA) monitors gauging stations around the United States to obtain ocean water level measurements. Table 5-1 shows representative tidal elevations for the Study Area based on water levels recorded at NOAA Station 9410660 in Los Angeles Outer Harbor for the National Tidal Datum Epoch (NTDE) of 1983-2001 (NOAA 2003).

Table 5-1 Tidal Elevation at Los Angeles Outer Harbor (Tide Epoch: 1983 to 2001)

Datum	Elevation (m MLLW)
Highest Observed Water Level (01/27/1983)	2.38
Mean Higher High Water (MHHW)	1.67
Mean High Water (MHW)	1.45
Mean Sea Level (MSL)	0.86
Mean Low Water (MLW)	0.29
North American Vertical Datum–1988 (NAVD)	0.06
Mean Lower Low Water (MLLW)	0.00
Lowest Observed Water Level (12/17/1933)	-0.83

The data show that tides in San Pedro Bay have a vertical range (between mean lower low water [MLLW] and mean higher high water [MHHW]) of approximately 1.7 m and a mean sea level at approximately 0.9 meters MLLW. The tidal range and tidal elevations at different locations within the Study Area vary slightly from those recorded in San Pedro Bay as a result of interactions with land forms.

The tidal datums presented above were based on 19 years of measurements during the 1983 to 2001 tidal epoch. A tidal epoch is a specific 19-year period adopted by NOAA as the official time segment for use in obtaining tidal datums. It was selected such that it is long enough to include all significant tidal constituents with varying periods and average out effects of non-astronomical processes of tectonic, oceanographic, meteorological or climatic origins (Reid 1990). The updated datums based on the new NTDE were published on April 21, 2003, which replaced the datums based on the 1960 to 1978 NTDE that had been in use for the past two decades. The new datums indicate a rise of approximately 0.04 meters over those of the past epoch.

5.2.1.2 *Sea Level Rise*

Water levels represented by tidal datums presented previously include the contributions from tidal and non-tidal processes with time scales shorter than or equal to the NTDE. For processes with time scales longer than the NTDE, however, these datums only reflect a snap shot of its contributions to water levels during the specific NTDE. The continued modulation of the longer period processes necessitates periodic update of the tidal datums so as to capture the effects of these processes on water levels in an epoch by epoch manner. One such process is the continued sea level changes resulting from, among other potential factors, global climatic changes. Sea level rises at a rate of 0.0020 to 0.0021 meters per year was reported for the past century for the La Jolla area (Hicks and Hickman 1988; USACE 1990; and USACE 1991). An accelerated rise at a rate of approximately 0.006 to 0.03 meters per year was predicted for this century (Hoffman et al. 1983). Although sea level rise, along with local land form changes, has been considered a primary reason for updating to a new NTDE (Gill and Scherer 1998 and NOAA 2000a), continued accelerated sea level rise in the decades to come still needs to be addressed for long-term projects.

5.2.1.3 *Storm Surge*

Storm surge can occur in the Study Area during the occasional tropical storms that reach the Region. Storm surge is the rise of water level at or near the coast during the passage of a storm such as hurricane or tropical cyclone. Primary mechanisms for surge development include low atmospheric pressure within the storm, wind setup, wave setup, and geostrophic tilt of longshore currents (Reid 1990). Atmospheric depression associated with a storm creates an upward suction over the water surface and causes the water level to rise within the periphery of the storm. Wind setup is created when the onshore component of the winds within the storm system exerts wind stress over the water surface and drives water toward the shore, resulting in water level rise at the coast. Wave setup results when the decrease in shore-normal momentum flux across the surf zone due to wave breaking is compensated by a rise in water level at the shore. Geostrophic tilt of sea surface due to the Coriolis effect on the currents forced by longshore winds contributes to water level rise at the shore if the land is situated to the right of the direction of the currents. The water level rise due to storm surge allows storm waves to reach more inland locations along the coast and cause damage to properties, increases erosion, and shoals navigation channels.

Storm surge becomes significant in regions of open, expansive coasts with wide continental shelves experiencing frequent hurricane-level tropical storms. These conditions exist along the Gulf coast and much of the east coast. Storm surge in southern California is relatively insignificant due to the relatively narrow continental shelves (USACE 1989) and moderate tropical storm conditions in both strength and frequency. Although storm surge has not been systematically studied for the Study Area, estimates can be made based on historical tropical storm records in the Region and historical water level measurements at the NOAA tide stations at Santa Monica Pier in Santa Monica Bay and Los Angeles Outer Harbor in San Pedro Bay.

5.2.2 *El Nino Southern Oscillation*

El Nino Southern Oscillation (ENSO) affects the oceanographic conditions in the Study Area periodically. ENSO is a climatic phenomenon characterized by decreased atmospheric pressure in the eastern tropical Pacific Ocean and weakened easterly trade winds across the tropical Pacific Ocean. During an ENSO event, the equatorward California Current is weakened, and the warm Equatorial Countercurrent moves poleward into the northern Pacific Ocean, bringing warm water into the Southern California Bight. The weakening of the easterly trade winds permits warm water mass piled up in the western Pacific Ocean to flow back to the east, which bifurcates north and south when reaching the Americas and results in increases in sea levels and temperatures along the west coasts of the continents (Chelton and Davis 1982). Occurring at an approximate periodicity of three to five years (Graham and White 1988), ENSO conditions in the Region were accompanied by increases in water level (Chelton and Davis 1982 and Flick and Badan-Dangon 1989), water temperature (Dailey et al. 1993), and frequency of vigorous winter storms with poleward coastal winds (Hickey 1993). The yearly mean sea level record in San Diego indicates that ENSO events raised water level by up to 0.09 m over normal for durations of one to two years (USACE 1991). The 1982 to 1983 ENSO events brought severe winter storms and exceptionally high waves to the coast of southern California during January to March 1983 (Seymour et al. 1984), causing severe property damage (USACE 1983 and Kerr 1988) and beach erosion (USACE 1988b). The beaches downcoast of Oceanside Harbor suffered considerable loss of sand during the storms (USACE 1983).

5.2.3 *Waves*

5.2.3.1 *Wave Exposure*

Wave climate in the Study Area is affected by the presence of offshore islands, shallow banks, and coastal submarine canyons that partially shelter the coastline from deep ocean surface waves. Man-made structures such as the San Pedro Breakwaters and harbor structures in the Los Angeles/Long Beach Harbor complex substantially shelter the northern part of San Pedro Bay. The wave pattern within the Study Area is thus spatially complex due to the reflection, refraction, diffraction, and dissipation of the incident deep ocean waves. In general, deepwater waves approach the Study Area through the west exposure window between the Channel Islands and San Nicolas Island and south exposure window between San Clemente Island and the shores of Orange and San Diego Counties. The waves that approach the Study Area from the west window consist primarily of swell generated by distant extratropical storms in the northern Pacific Ocean, while those approach from the south window include swell generated by tropical storms off the Mexican coast and southern hemisphere winter storms in the southern Pacific Ocean, as well as seas generated by prefrontal winds of extratropical storms.

As an illustration of wave sheltering of the Study Area by the offshore islands and land forms, a snap shot of wave conditions in the Southern California Bight is shown in Figure 5-4.

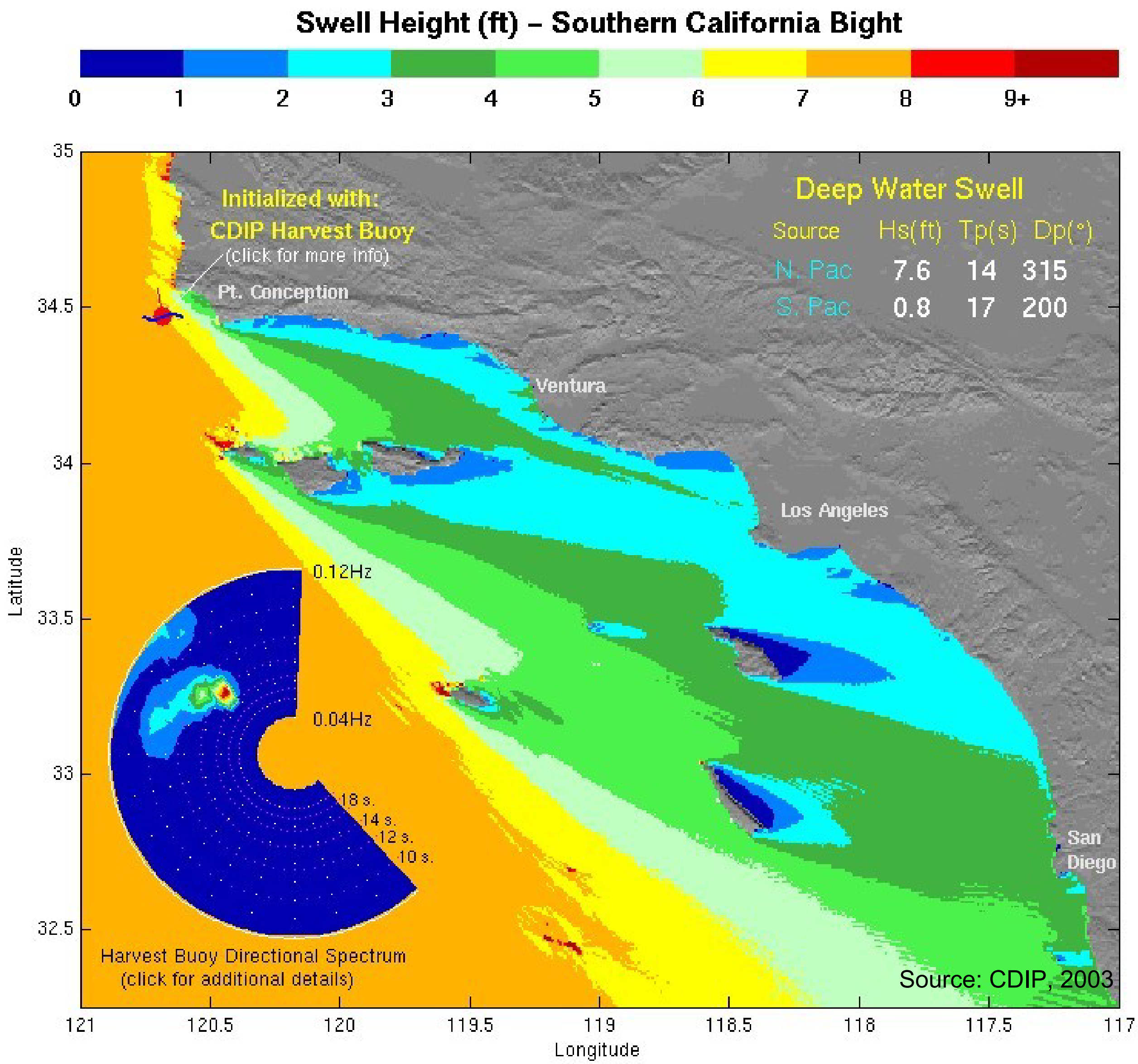


Figure 5-4

Wave Sheltering of the Southern California Bight

The figure shows wave conditions over the area at 14:23 Pacific Standard Time (PST) on March 19, 2003 computed based on deepwater wave conditions measured at the Coastal Data Information Program (CDIP) Harvest Buoy wave gauge off Point Conception (CDIP 2003). At that specific moment, wave conditions over the Study Area were produced primarily by deepwater waves approaching the Southern California Bight from northwest (315° azimuth) with a significant wave height of 2.3 meters and peak energy wave period of 14 seconds (sec). As shown in the figure, the wave heights decreased as the waves approached the shoreline due to the effects of diffraction, refraction, dissipation, and island sheltering. By the time the waves arrived at the shoreline, the wave heights were only about 0.6 to 0.9 meters. Although swell from the south (200° azimuth) was present, its energy was negligible compared with that from the northwest and, therefore, did not appear in the directional wave spectrum.

5.2.3.2 *Wave Conditions*

Wave conditions in the Study Area result from waves generated by extratropical storms, tropical storms, and southern hemisphere extratropical storms. Prefrontal winds and local winds also generate waves of shorter periods within the Region. These wave sources that govern the wave conditions in the Southern California Bight are illustrated in Figure 5-5.

Extratropical storm waves approach the Study Area primarily from the west during northern hemisphere winter storms. The extratropical storm waves generated by the north Pacific low pressure systems developed along the polar front are the predominant wave component affecting the Study Area during winters. Most commonly, these storms will traverse the mid-Pacific before turning northeastward toward the Gulf of Alaska with swell propagating and decaying over a distance of approximately 2,414 kilometers toward the coast of the Study Area. Occasionally, the storm systems may occur much closer to the coast following a northeast, east, or southeast trajectory (USACE 1996b). Extratropical storm swell generated by historical severe storm events ranges from approximately 4.3 to 10.4 meters high in the deepwater with periods of 12 to 22 sec and approach directions of 250 to 289° (USACE 1996b). Occasional occurrences of southeasterly swell of the same category approaching from the Mexican coast were also recorded (Strange et al. 1993). The corresponding swell in San Pedro Bay was estimated to be approximately 2.7 to 5.5 meters high with periods of 12 to 19 sec and approach directions of 179 to 227° (Strange et al. 1993).

Tropical storm waves generated by tropical cyclones approach the Study Area from southeast off the Mexican coast during northern hemisphere summers. These storms occur approximately 15 to 20 times a year and affect the Study Area when taking a southeasterly track. Tropical storm swell generated by historical severe storms ranges from 1.8 to 3.4 meters in height in deepwater with periods of 9 to 15 sec and approach directions of 153 to 195° (USACE 1996b). The corresponding swell in San Pedro Bay was estimated to be approximately 1.8 to 4.0 m high with periods of 9 to 15 sec and approach directions of 176 to 192° (Strange et al. 1993).

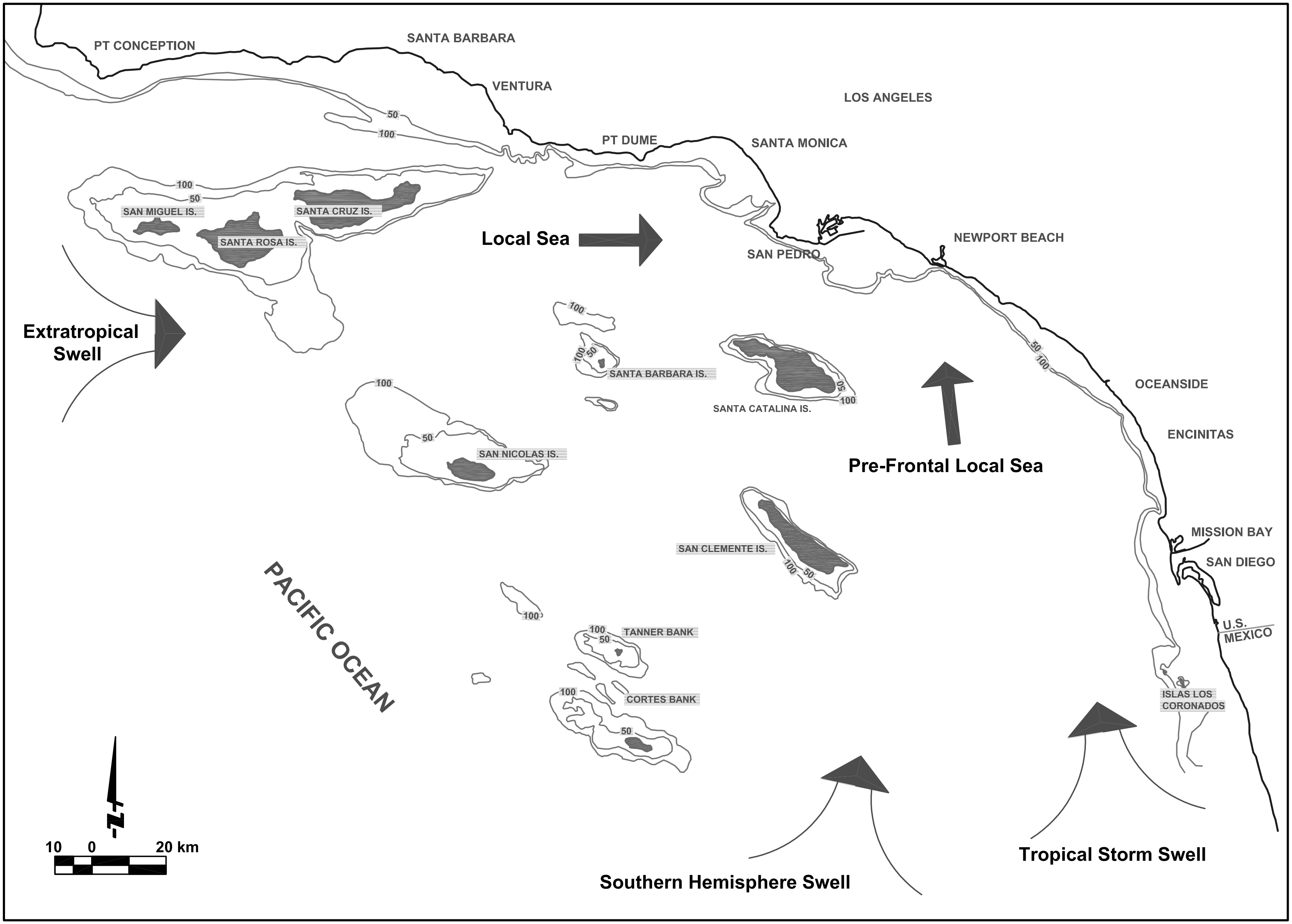


Figure 5-5

Sources of Wave Climate

Southern hemisphere swell generated by south Pacific storm systems during southern hemisphere winters approaches the Study Area from a south-southwest window. The swell generated by historical severe storms ranges approximately 0.9 to 2.7 meters high in deepwater with periods of 15 to 23 sec and approach directions of 190 to 221°. Under operational conditions, the swell are typically 0.30 to 0.9 m high (USACE 1988c), but can reach 0.9 to 1.5 meters approximately three days per month (Strange et al. 1993). The long travel distances of these waves, however, result in the characteristically narrow frequency bands of these waves, which tend to enhance the potential for amplification nearshore.

Prefrontal seas generated by strong winds prior to frontal passages approach the Study Area from the southeast. These waves are typically 0.9 to 1.8 meters high with periods of 6 to 8 sec. Seas generated by local winds can occur simultaneously with swell from distant storms to produce high wave conditions in the nearshore.

Extreme wave statistics for Santa Monica Bay based on severe historical wave events just off the Santa Monica Breakwater (USACE 1995) are summarized in Table 5-2.

Table 5-2 Extreme Waves off Santa Monica Breakwater

Return Period (year)	Wave Height[1] (m)
2	2.59
5	3.60
10	4.48
25	5.82
50	6.92
100	8.08

1. Extratropical and tropical storm waves.

In the table, estimated storm wave heights for return periods of 2, 5, 10, 25, 50, and 100 years are shown. Similar extreme wave statistics for San Pedro Bay near the San Pedro Breakwater (Pier 400 Consultants 1993) are shown in Table 5-3. The estimates indicate that the extreme wave conditions in San Pedro Bay are relatively mild compared with those in Santa Monica Bay, partially due to the fact that the dominant extratropical storm waves from the west tend to abate significantly over San Pedro Shelf through refraction resulting from the generally southward orientation of isobaths in the area.

Table 5-3 Extreme Waves off San Pedro Breakwater

Return Period (year)	Wave Height[1] (m)
25	4.18
50	4.72
100	5.27

1. Extratropical and tropical storm waves.

The extreme conditions of tropical storm waves in San Pedro Bay were found to be comparable to those of extratropical storm waves (Pier 400 Consultants 1993). Southern hemisphere swell is generally not a controlling factor in the extreme wave conditions in the Study Area (Strange et al. 1993).

5.3 Currents

Currents in the Study Area are composed predominantly of large-scale circulation and tidal currents. Other processes such as wave-generated longshore currents and rip-currents are limited to the vicinity of the narrow surf zone along the coastal edges of the Study Area.

The large-scale current system within the Southern California Bight consists of the California Current, Southern California Countercurrent, Southern California Eddy, and California Undercurrent. The equatorward California Current flows along the western edge of the bight and is a well-documented eastern boundary current that dominates the flow within the bight and is the strongest during summer. The California Current branches shoreward and then poleward, forming the Southern California Countercurrent that starts off Baja California with a seasonal maximum during winter, and at times the Southern California Eddy with a seasonal maximum during summer and early fall. The California Undercurrent, which flows approximately 244 to 274 meters below water surface with relatively high temperature and salinity, moves poleward over the continental slope and is the strongest during summer. The California Current moves closer to shore during spring and away from shore during summer, which results in a predominantly equatorward flow during summer and poleward flow during winter (DiGiaComo and Holt 2003 and Jackson 1986). The large-scale circulation pattern within the Southern California Bight is shown in Figure 5-6 (Hickey 1992). The current speeds of circulation vary with location. Measurements indicated typical current speeds of 0.09 to 0.21 meters per second (mps) in the Study Area. Latest field monitoring on the Palos Verdes shelf showed that currents flow toward the northwest along the shelf and upper slope with speeds ranging from 0.21 to 0.30 mps. No obvious seasonal structure was observed in the flow (Noble et al. 2002).

Tidal currents in mid-depths within the Study Area have a median speed of about 0.06 to 0.12 mps, and the highest 10-percentile speed of 0.15 to 0.21 mps. Near-bottom current speeds are similar to the mid-depth speeds on average. The current speeds in all depths vary with season, and are typically higher in winter than in summer at most locations. Seasonal current speed variations of approximately 50 percent were observed in Santa Monica Bay. The speeds of net subtidal currents (with frequencies lower than those of the tides) are typically an order of magnitude smaller and predominantly alongshore (SCCWRP 1993).

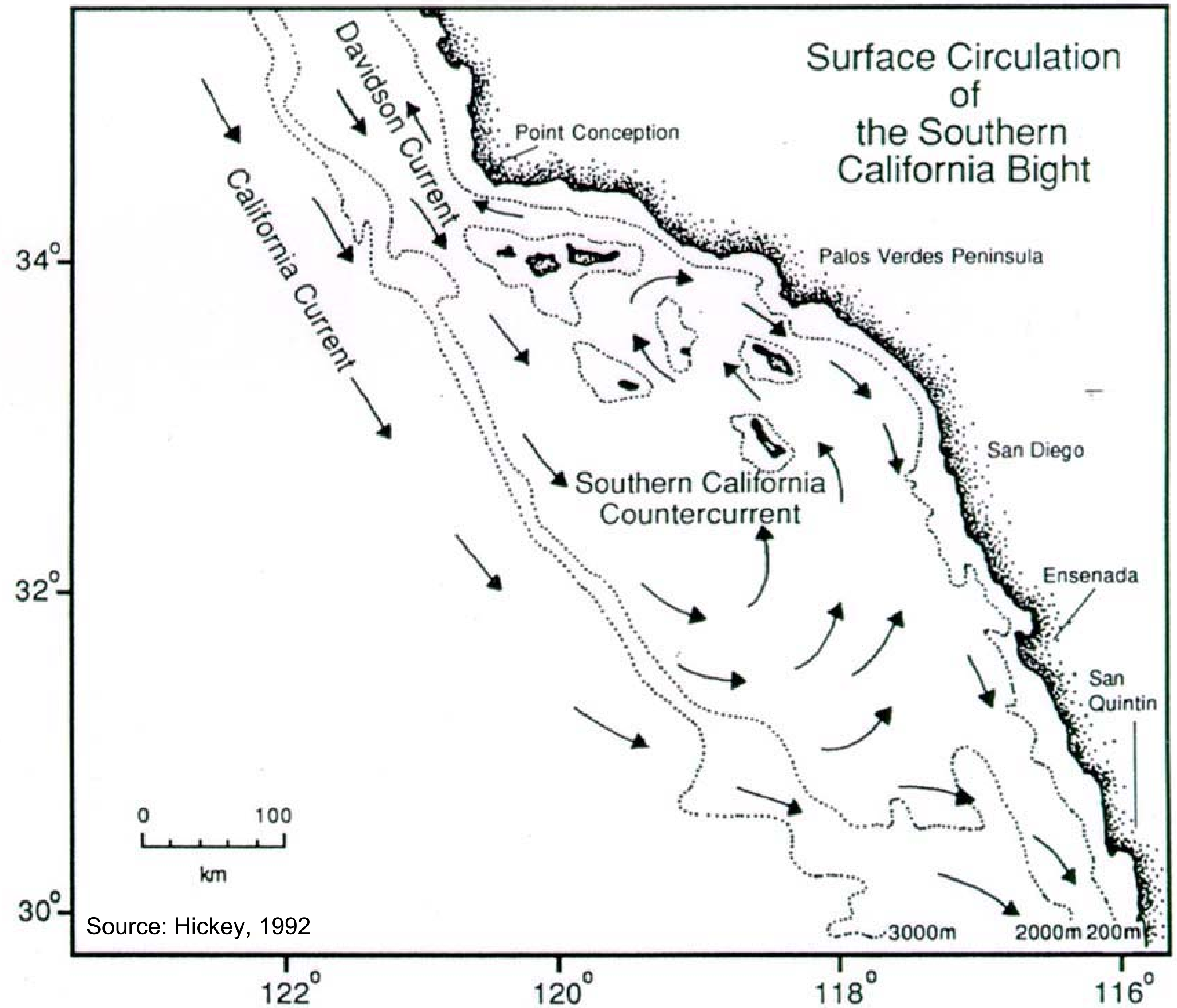


Figure 5-6

Circulation Pattern of the Southern California Bight

5.4 Sedimentation

Sedimentation within the Study Area consists of littoral drift in the nearshore and sedimentation on and near the shelves. Littoral drift is composed of sediment transport in and near the surf zone in longshore and cross shore directions driven primarily by wave-induced currents. Sedimentation on the continental shelves is driven by a combination of surface gravity waves, internal waves, and subtidal currents. Nearshore sedimentation, together with sediment sources and sinks along the coast, as well as human activities such as beach filling and borrowing, defines the sediment budget along the shoreline of the Study Area.

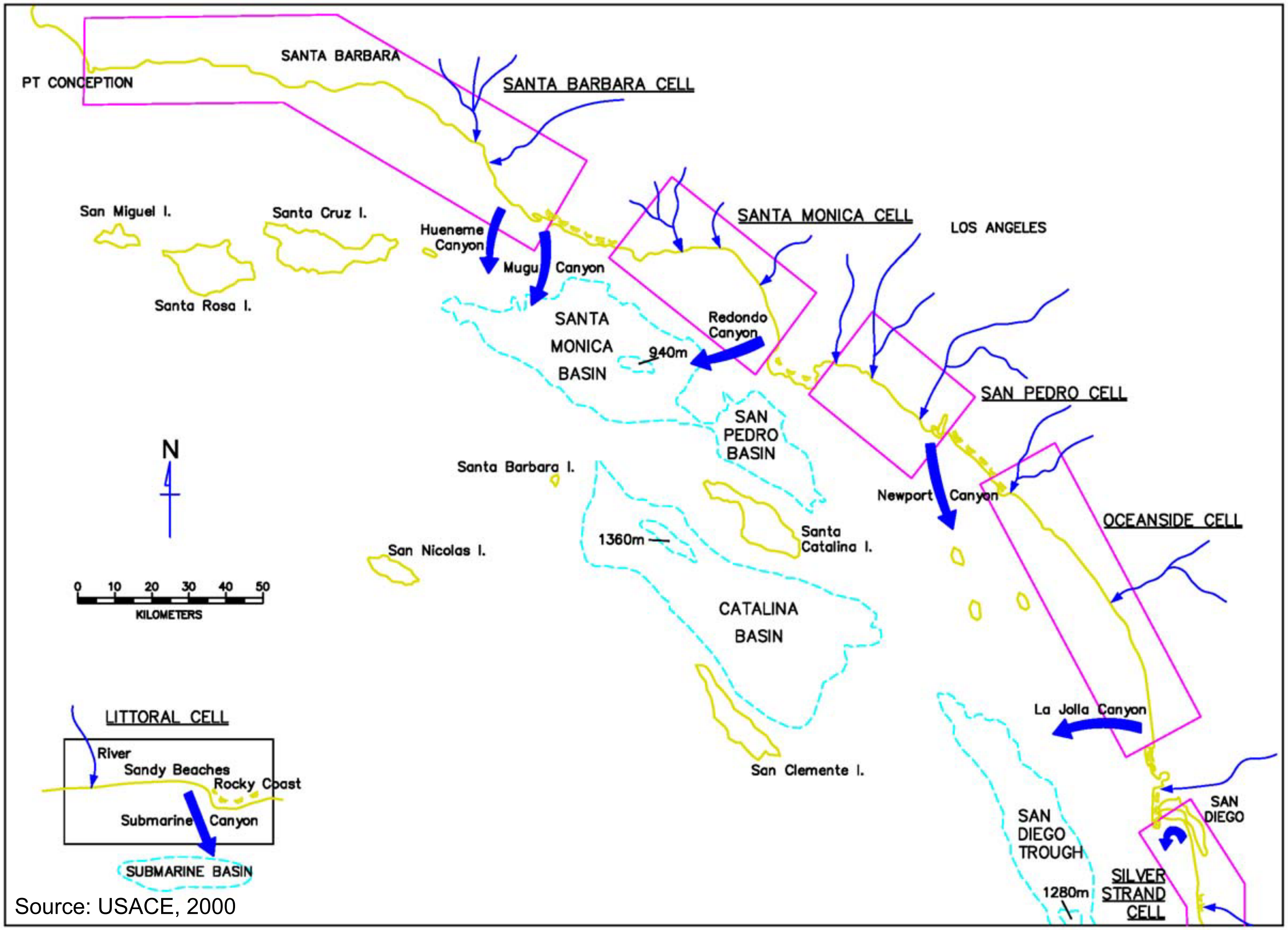
5.4.1 *Littoral Drift*

5.4.1.1 *Littoral Cell*

A littoral cell is a coastal compartment or physiographic unit that contains sediment sources and sinks and is bounded by geographic boundaries across which there is minimal sediment transport. The littoral cells within the Study Area include the Santa Monica littoral cell and the San Pedro littoral cell. Figure 5-7 shows the boundaries of these two littoral cells in the regional setting (USACE 2000a). In the figure, major sediment sources (rivers and cliffs) and sinks (submarine canyons and harbors) are also shown. Deeper water on the continental shelf beyond the depth of wave influence may also be a sink for littoral sediments. Streams affecting the Study Area include Malibu Creek, Topanga Creek, and Ballona Creek within Santa Monica Bay and Dominguez Channel, Los Angeles River, and San Gabriel River in San Pedro Bay. In addition to these major streams, there are numerous storm drains along the shoreline that contribute sediment loads to the coast during storm events. Coastal cliffs are present along Huntington Cliffs in the southern reach of San Pedro Bay shoreline. Submarine canyons in the Study Area include Dume, Santa Monica, Redondo, and Newport Submarine Canyons, among which Redondo and Newport Submarine Canyons are known sediment sinks for littoral sediment in the Study Area. Harbor complexes in the Study Area including Marina del Rey, King Harbor, Los Angeles/Long Beach Harbors, and Alamitos Bay are also significant interceptors or traps for littoral sediment.

5.4.1.2 *Longshore Transport*

Longshore sediment transport in the Santa Monica littoral cell is marked by predominantly downcoast drift with occasional upcoast reversals as a result of seasonal variations in wave approach direction. The net longshore drift is downcoast (southward) at a rate of approximately 146,029 to 191,138 cubic meters/year (m^3/yr) off Santa Monica Beach (USACE 1985; DMJM 1984; USACE 1989; and Ingle 1966), 151,381 m^3/yr off Dockweiler Beach, and 167,437 m^3/yr off Manhattan and Hermosa Beaches (Landrum and Brown 1996).



Source: USACE, 2000

Figure 5-7

Littoral Cells from Point Conception to San Diego

Sediment movement in the San Pedro littoral cell is obstructed by the presence of the Los Angeles/Long Beach Harbor complex, which also alters the wave conditions near the beaches. The longshore transport rate along the neighboring beaches, however, has not been reliably established.

Farther downcoast off Seal Beach and the beaches of Orange County, longshore sediment transport occurs in both directions with net drift directed to the downcoast (southeast) direction. The longshore transport rate was estimated to be approximately 211,017 m^3/yr off Surfside-Sunset Beach, 85,630 m^3/yr off Huntington Beach near Santa Ana River, and 97,098 m^3/yr off Newport Beach (Hales 1980). More recent estimates put longshore transport at 12,232 m^3/yr off Seal Beach and 155,969 m^3/yr off Surfside-Sunset Beach, from which the rate progressively decreases to 17,584 m^3/yr off Newport Bay (USACE 2000a).

5.4.1.3 *Cross-shore Transport*

Cross-shore sediment transport occurs in the littoral zones of the Study Area primarily in the form of seasonal movement of beach sediment as the beaches adjust profiles in response to seasonal wave conditions. This transport is reflected in the seasonal changes in beach widths in the Study Area. Cross-shore transport in the form of offshore loss to the deepwater occurs near the Redondo and Newport Submarine Canyons. Relatively appreciable offshore loss in the range of 7,645 to 16,820 m^3/yr was also believed to occur along the southern reach of San Pedro Bay off Huntington Beach (USACE 2000a). Significant sediment exchanges between the littoral zone and the inner shelves are also expected to occur during severe storms. Such events were believed to be related to the seafloor deepening at relatively large depths off Santa Monica and significant increases of inner-shelf derived sediment on the upper foreshores in Santa Monica Bay after major extreme storms such as the storm of January 17 to 18, 1988 (Lee 1993; Lee and Osborne 1995; and Lu 1992).

5.4.2 *Shelf Sedimentation*

Sedimentation on the continental shelves within the Study Area is characterized by resuspension of sediment by wave action and transport by subtidal currents. While the mid-shelf sediment tends to be resuspended primarily by surface gravity waves, sediment in the deeper portions of the shelves can often be resuspended by internal waves that are present in regions such as continental breaks. Transport of the resuspended sediment in the nearshore portions of the shelves mostly follow the subtidal currents, which are largely directed parallel to the isobaths. In the deeper portions of the shelves where internal waves occur (e.g., near the shelf break off Santa Monica Bay), sediment was observed to transport offshore across the shelf breaks and deposit on the continental slopes (Lee et al. 2003).

Relative extensive shelf resuspension and sedimentation studies were conducted for the Palos Verdes shelf, the narrow shelf that marks the transition from Santa Monica Bay to San Pedro Bay. Sedimentation on the Palos Verdes shelf is characterized by predominantly northwestward fluxes along the shelf, with occasional southeastward reversals. Shelf sediment is typically resuspended by gravity waves from the seabed and transported by prevailing currents at the time of resuspension. The currents that carry the suspended sediment are generally independent of wave conditions (Wiberg et al. 2002) and can include those produced by internal waves and tidal processes (Jones et al. 2002). It was estimated that the frequency of significant resuspension and transport is approximately 10 events per year in approximately 61 m of water on the shelf and 3 events per year in 91 meters of water beyond the shelf break. The net sediment transport rate during high wave events was estimated at approximately 43 kilograms (0.035 cy assuming a bulk density of 1.6 tons per m^3) per hour per 0.3 meters of shelf width along the shelf toward the northwest (Wiberg et al. 2002).

6 BIOLOGICAL RESOURCES

6.1 Santa Monica Bay/Marina del Rey

6.1.1 *Aquatic Species*

6.1.1.1 *Adult and Juvenile Fishes*

Fish community data available for Santa Monica Bay/Marina del Rey provides a generalized picture of the fishes associated with this portion of the Study Area. Fish communities in Marina del Rey include those associated with the sandy bottom, shallow soft bottom, water column, and the rocky substrate of the entrance jetties and breakwater. Fish observed in Marina del Rey studies include diamond turbot (*Hypsopsetta guttulata)*, bat rays (*Myliobatis californicus*), California halibut (*Paralichthys califoricus)*, blennies (*Hypsoblennius* spp.), spotted turbot (*Pleuronichthys ritteri)*, white croaker (*Genyonemus lineatus)*, yellowfin croaker (*Umbrina roncador)*, California killifish (*Fundulus parvipinnis)*, topsmelt (*Atherinops affinis*), arrow gobies (*Cleviandia ios)*, shadow gobies (*Quietula y-cauda)*, striped mullet, (*Mugil cephalis)* Northern anchovy (*Engraulis mordax)*, Pacific sardines (*Sardinops sagax)*, queenfish (*Seriphus politus)*, blacksmith (*Chromis punctipinnis)*, opaleye (*Girella nigricans)*, pile surfperch (*Damalichthys vacca)*, black surfperch (*Embiotoca jacksoni)*, rock wrasse (*Halochoeres semicinctus)*, giant kelpfish (*Heterostichus rostratus)*, garibaldi (*Hypsypops rubicundus)*, seniorita fish (*Oxyjulis californica)*, kelp bass (*Paralabrax clathratus)*, barred sand bass (*Paralabrax nebulifer)*, and dwarf surfperch (*Medialuna californiensis)* (USACE 1998). Three special interest species found in Marina del Rey are the California halibut, California grunion (*Leuresthes tenuis)*, and white seabass.

The following information on adult and juvenile fish species found at Marina del Rey is summarized from the Chambers Group Environmental Impact Statement/Report on harbors and marinas in the Los Angeles area, which was prepared for the USACE in September 1998.

Approximately 19 fish taxa regularly occur in Marina del Rey and can be considered the characteristic fish population of the harbor. Table 6-1 includes a list of fish species recorded in Marina del Rey and Santa Monica Bay since 1964. Six taxa that have been present in every survey include: topsmelt, black surfperch, opaleye, blennies, kelp bass, and barred sand bass. An additional 13 taxa were recorded in at least 20 of the 26 surveys since 1984. These taxa include blacksmith, pile surfperch, northern anchovy, goby larvae of several species, rock wrasse, giant kelpfish, diamond turbot, garibaldi, dwarf surfperch, seniorita, California halibut, spotted turbot, and queenfish.

The subtidal softbottom fishes of Marina del Rey are typical of those found in other southern California harbors, shallow waters of Santa Monica Bay, and along the southern California coast (Stephens et al. 1991). Frequently recorded subtidal soft bottom species in Marina del Rey include diamond turbot, bat ray, California halibut, spotted turbot, white croaker, and yellowfin croaker.

Table 6-1 A list of fish species recorded in Marina del Rey and Santa Monica Bay since 1964 (page 1 of 2)

Scientific Name	Common Name	Scientific Name	Common Name	Scientific Name	Common Name
Acanthogobius flavimans	Yellowfin goby	*Genyonemus lineatus*	White croaker	*Micrometrus minimus*	Dwarf perch
Albula vulpes	Bonefish	*Gibbonsia elegans*	Spotted kelpfish	*Mugil cephalis*	Striped mullet
Amphisticus argenteus	Barred surfperch	*Gillichthys mirabilis*	Longjaw mudsucker	*Mustelus californicus*	Gray smoothound
Anchoa compressa	Deepbody anchovy	*Girella nigricans*	Opaleye	*Mustelus heniei*	Brown smoothound
Anchoa delicatissima	Slough anchovy	*Gobiesox rhessondon*	California clingfish	*Myliobatis californicus*	Bat ray
Anisotremus davidsoni	Sargo	*Gobiedae*	Goby	*Oligocottus/Clinocottus A*	Sculpin
Atherinops affinis	Topsmelt	*Halochoeres semicinctus*	Rock Wrasse	*Oxyjulis californica*	Senorita
Atherinopsis californiensis	Jacksmelt	*Hermosilla azurea*	Zebraperch	*Oxylebius pictus*	Painted greenling
Atractoscion nobilis	White sea bass	*Heterodontus francisci*	Horn shark	*Paraclinus integripinnis*	Reef finspot
Brachyistius frenatus	Kelp surfperch	*Heterostichus rostratus*	Giant kelpfish	*Paralabrax clathratus*	Kelp bass
Bryx arctus	Snubnose pipefish	*Hippoglossina stomata*	Bigmount sole	*Paralabrax maculatofasciatus*	Spotted sand
Charcharodon carcharius	White shark	*Hyperprosopon argenteum*	Walleye surfperch	*Paralabrax nebulifer*	Barred sand bass
Cheilotrema saturnum	Black Croaker	*Hyperprosopon argenteum*	Walleye surfperch	*Paralabrax sp.*	Sea bass
Chitonodus pugetensis	Roughback sculpin	*Hypsoblennius gentilis*	Bay blenny	*Paralichthys califoricus*	California halibut
Chromis punctipinnis	Blacksmith	*Hypsoblennius gilberti*	Rockpool blenny	*Perciformes*	Perch
Citharichthys stigmaeus	Speckled sandab	*Hypsoblennius jenkinsi*	Mussel blenny	*Phanerodon furcatus*	White surfperch
Cleviandia ios	Arrow goby	*Hypsopsetta guttulata*	Diamond turbot	*Platyrhinoides triseriata*	Thornback ray
Clinocottus analis	Wooly sculpin	*Hypsurus caryl*	Rainbow surfperch	*Pleuronectidae*	Flatfish
Coryphopterus nichosii	Blackeye goby	*Hypsypops rubicundus*	Garibaldi	*Pleuronichthys coenosus*	C-O turbot
Cymatogaster aggregata	Shiner surfperch	*Ilypnus gilberti*	Cheekspot goby	*Pleuronichthys ritteri*	Spotted turbot
Damalichthys vacca	Pile surfperch	*Lepidogobius lepidus*	Bay goby	*Pleuronichthys verticalis*	Hornyhead turbot
Embiotoca jacksoni	Black surfperch	*Leptocottus armatus*	Staghorn sculpin	*Quietula y-cauda*	Shadow goby
Engraulidae	Anchovy	*Leuresthes tenuis*	California grunion	*Raja binoculata*	Big skate
Engraulis mordax	Northern anchovy	*Medialuna californiensis*	Dwarf surfperch	*Rhacochilus toxotes*	Rubberlip surfperch
Fundulus parvipinnis	California killifish	*Menticirrhus undulatus*	California corbina	*Rhinobatos productus*	Shovelnose guitarfish

Table 6-1 A list of fish species recorded in Marina del Rey and Santa Monica Bay since 1964 (page 2 of 2)

Scientific Name	Common Name	Scientific Name	Common Name	Scientific Name	Common Name
Roncador stearnsi	Spotfin croaker	*Semicossyphus pulcher*	California sheepshead	*Synodus lucioceps*	California lizardfish
Sarda chilensis	Pacific Bonito	*Seriphus politus*	Queenfish	*Triakis semifaciata*	Leopard shark
Sardinops sagax	Pacific sardine	*Sphyraena argentea*	California barracuda	*Typhlogobius californiensis*	Blind goby
Scaenidae complex 2	Croaker	*Squatina californica*	Pacific angel shark	*Umbrina roncador*	Yellowfin croaker
Scorpaena guttata	Spotted Scorpionfish	*Stenobrachius leucopsaura*	Bay pipefish	*Urolophus halleri*	Round stingray
Scorpaenichthys	Cabezon	*Strongylura exilis*	California needlefish	*Xenistius californiensis*	Salema
Sebastes auriculatus	Brown rockfish	*Symphurus atricauda*	California tonguefish	*Xystreurys liolepis*	Fantail sole
Sebastes serranoides	Olive rockfish	*Syngnathus leptorhynchus*	Bay pipefish		

The shallow water soft bottom habitat supports a number of fish species characteristic of tidal wetlands (Stephens et al. 1991). Common fishes of the shallow soft bottom habitat include California killifish, shadow goby, arrow goby, and striped mullet.

The most abundant water column fish in Marina del Rey is the topsmelt. Topsmelt are present throughout the marina along with northern anchovy, queenfish, and Pacific sardines. Topsmelt and queenfish are present throughout the year, whereas northern anchovies are more abundant in the spring and Pacific sardines in late spring (Soule et al. 1996).

The riprap supports many fish species characteristic of rocky habitats in southern California. Common fish species on the breakwall and jetties include blacksmith, opaleye, pile surfperch, black surfperch, rock wrasse, giant kelpfish, garibaldi, seniorita, kelp bass, barred sand bass, and dwarf surf perch.

Ichthyoplankton abundance in Marina del Rey varies seasonally with more fish eggs and larvae are collected in the spring surveys than in the fall (Stephens et al. 1991). Over the years, taxa most consistently collected include blennies of the genus *Hypsoblennius*, gobies (*Quietula y-cauda, Ilypnus gilberti*, and *Clevlandia ios*), Pacific sardine, and queenfish. The May 1997, ichthyoplankton collections were notable because egg counts were extremely high. Egg counts ranged from 10,924 to 126,034 per station, which greatly exceeded the previous high count of 6,782 eggs in 1991. The egg catch in 1997 was dominated by three species of anchovy (*Engraulis mordax*, *Anchoa delicatissima,* and *Anchoa compressa*). Larval fish counts in recent surveys (October 1996 and May 1997) were dominated by gobies, blennies, and, in the spring, anchovies.

The Ballona Wetlands, located between Marina del Rey and the Westchester bluffs, are the last major wetlands in Los Angeles County (County). Ballona wetlands provide a spawning ground for fish of Santa Monica Bay and for appropriate habitat for juvenile life stages.

Fish within the lower reached of Ballona Creek which spend most of their lives in the brackish water of estuary channels include species such as: Long-jawed mudsucker (*Gillichthys mirabilis*), shadow goby, arrow goby, cheekspot goby (*Ilypnus gilberti*), California killifish and the yellowfin goby. Ballona Creek fish which spend their adult lives in nearshore ocean waters, but use estuaries as breeding grounds or nurseries include examples such as: California halibut, diamond turbot, topsmelt and staghorn sculpin (*Ilypnus gilberti*).

6.1.1.2 *Special Interest Fish Species*

Two special interest fish species found within Marina del Rey are California halibut and white sea bass. California halibut and white seabass are prized by sport and commercial fishermen and have experienced notable declines in recent years. California grunions are another special interest fish species found near Marina del Rey.

California halibut spawn in nearshore areas. Spawning occurs throughout the year, but peaks in winter and spring. The pelagic eggs and larvae drift in the water column as part of the plankton for about a month; then the juvenile fish settle to the bottom. Juveniles are typically found in embayments, and adults are found along the coast.

California halibut are generally present within Marina del Rey having been collected in otter trawls and beach seines (Soule et al. 1996). Halibut larvae have frequently been caught in the ichthyoplankton tows. In their 1990 to 1991 surveys, California State University Northridge captured California halibut in otter trawls in every season in both Marina del Rey and the Ballona Creek (Allen 1991). In the October 1996 and May 1997 Marina del Rey surveys, California halibut were captured at every station in each season. Halibut larvae were captured in the ichthyoplankton tows in May 1997, but not October 1996. Halibut were not captured in the beach seines in 1996 or 1997 (Chambers Group 1998). In summary, the frequent records of California halibut in Marina del Rey indicate that this harbor is an important habitat for halibut populations of Santa Monica Bay.

White seabass is an open coast species known to move in and out of harbors and bays. Very young white seabass live in drift algae just beyond the surf line while older juveniles occupy bays and shallow coastal waters, often near rocks or kelp. Adults are usually found near reefs or kelp beds (Chambers Group 1998).

White sea bass were frequently recorded in Marina del Ray in the 1980s, but have been much less common in the 1990s (Soule et al. 1996). Two white seabass were caught in otter trawls by California State University Northridge in October 1990 (Allen 1991) and a white seabass was caught by the Harbors Environmental Project (HEP) in October of 1991 (Soule et al. 1996). No white seabass were collected in the October 1996 or May 1997 surveys (Chambers Group 1998).

California grunions are a special interest fish species in the project area. Grunion are a small, nearshore schooling fish that spawns on sandy beaches during the highest night time tides between March and August. Eggs incubate a few centimeters deep in the sand above the level of subsequent waves. The eggs hatch during the next spring tide series. Grunion spawn on Dockweiler State Beach in the vicinity of Marina del Rey (California Department of Parks and Recreation 1992). Grunion spawning runs occur on beaches within Santa Monica Bay including north of Venice Pier about 3.2 km north of Marina del Rey and near the Hyperion Waste Treatment Plant about 3.2 km south of Marina del Rey but could occur on any of the sand beaches in the area (Chambers Group 1998).

6.1.1.3 *Plankton*

Phytoplankton productivity within Marina del Rey Harbor was studied by HEP as part of an unrelated baseline marine ecology survey (Soule and Oguri 1977). This study found that phytoplankton productivity within Marina del Rey followed the general pattern of seasonal variation noted elsewhere off the southern California coast (Chambers Group 1998). Productivity was low in winter followed by a spring bloom in April. Productivity declined in May followed by sporadic localized blooms in summer and fall. The areas within Marina del Rey with the highest phytoplankton productivity were at the mouth of Ballona Creek and in an inland basin. Average annual productivity ranged from 11.47 milligrams of carbon per hour per square meter (mgC/hr/m^2) in the main entrance channel by the opening of Ballona Lagoon to 21.1 mgC/hr/m^2 at the back of the basin.

Phytoplankton studies within Marina del Rey have not occurred since that original baseline survey, however, a small bloom was observed in July of 1996 and a large red tide plankton bloom were noted during a study by Aquatic Bioassay Consulting Laboratories, Inc. (ABC) in 1997. Seasonal phytoplankton blooms in the open waters of Santa Monica Bay in the vicinity of Marina del Rey have been documented in studies by Southern California Coastal Water Research Project (SCCWRP) (Kleppel and Manzanella 1980 and Chambers Group 1998). Diatom blooms were recorded most frequently during spring and summer. During 1980, a bloom of the dinoflagellate (*Gymnodinium splendens*) occurred in March followed by a *G. flavum* in late July. Green algal blooms were also observed in late summer.

Zooplankton in the nearshore waters of southern California shows clear seasonal patterns of abundance (Dawson and Pieper 1993). Maximum zooplankton biomass occurs between April and June and the minimum is between December and February. Surveys in eastern Santa Monica Bay found that the nearshore zooplankton community was dominated by *Acartia tansa* (Chambers Group 1998). Recently, Scripps Institute of Oceanography reported that the rise in sea surface temperatures corresponded with a decline in zooplankton biomass (1995). Zooplankton are a vital link in the food chain, serving as the principal food for a variety of commercially important species.

The Marina del Rey baseline survey (Soule and Oguri 1977) found that zooplankton assemblages within Marina del Rey were dominated by copepods of the genus *Acartia* (A. *californiensis* and A. *tonsa*). This copepod tends to dominate the zooplankton in southern California harbors (Dawson and Pieper 1993). Other copepods observed in Marina del Rey included *Paracalanus palvus* and *Coryaceus anglicus*. Copepods comprised over 98.5 percent of the zooplankton followed by cladocerans which accounted for 0.84 percent. Other less significant groups included larvaceans (0.34 percent), crab larvae (0.14 percent), barnacle larvae (0.12 percent), and fish eggs and larvae (0.04 percent). *Acartia* was the only copepod collected in the back of the marina. Cladocerans (*Evadne nordmanni*, *Podon po/yphemoides*, *Penila avirostris* and *Evadne spinefera*) were present mainly at the harbor entrance and in the main channel and were absent in the inner marina areas. Conversely, ascidean larvae were most abundant within the marina. Seasonal distribution patterns noticed in the baseline survey included a drop in abundance of *Acartia* at the mouth of Ballona Creek during the rainy season (November through February) and a decrease in cladoceran abundance during spring (March, April, and May). Ascidean larvae were nearly absent from December through May.

6.1.1.4 *Benthic and Epibenthic Invertebrates*

Benthic invertebrates are defined as those associated with the interface between overlying water and the sea floor. Benthic communities have been historically considered as an indicator of sediment conditions. Contaminated sediments are heavily populated with pollution tolerant species and have low species diversity, whereas clean sediments generally do not sustain pollution tolerant species and have higher species diversity. The benthic communities within the project area consist of similar assemblages of species, however are significantly different between habitat types.

The benthic invertebrate communities of Santa Monica Bay consist of the epifauna or those species such as crabs, sea pens, and starfish that live on the sediments and infauna or the worms, crustaceans, and molluscs that live within the sediments. Characteristic benthic species of Santa Monica Bay are listed in Table 6-2.

Table 6-2 Characteristic Benthic Species of Santa Monica Bay

Scientific Name	Common Name	Scientific Name	Common Name
Aglaja inernis	Navanax	*Mediomastus ambiseta*	Capitellid thread worm
Alia carinata	gastropod	*Megathura crenulata*	Keyhole limpet
Amphiodia urtica	Brittlestar	*Muricea californica*	Golden gorgonian
Apalsia californica	Sea hare	*Mytilus* sp.	Mussels
Astropecten armatus	Spiny sand star	*Nassarius* sp.	Nassa
Astropecten verrilli	California sand star	*Pagurus spilocarpus*	Hermit crab
Balanus glandula	Acorn barnacle	*Panulirus interruptus*	California spiny lobsters
Balanophyllia elegans	Orange cup coral	*Panulirus interruptus*	California spiny lobsters
Callianassa sp.	Ghost shrimp	*Paracyathus stearnsii*	Cup coral
Cancer anthonyi	Yellow rock crab	*Pollicipes polymerus*	Goose Barnacle
Capitella capitata	Bristleworm	*Portunus xantusii*	Swimming crab
Cerithidea californica	California horn shell	*Prionospio heterobranchia*	Worm
Chthamalus	stellate barnacle	*Protothaca staminea*	Common littleneck
Dendraster excentricus	Sand dollar	*Pseudopolydora paucibranchiata*	Spionid worm
Dioparta	Tube worm	*Pyromaia tuberculata*	American spider crab
Donax gouldi	Bean clam	*Renilla kollikeri*	Sea pansy
Emerita analoga	Pacific sand crab	*Rhepoxynius bicuspidatus*	Arthropod
Hemigrapsus nudus	Mudflat crab	*Styela montereyensis*	Tunicate
Heterocrypta occidentalis	Sandflat elbow crab	*Strongylocentrotus franciscanus*	Red sea urchin
Heterophoxus oculatus	arthropod	*Stylatulla elongate*	Sea pen
Hippolyte californiensis	Slender green shrimp	*Tegelus californianus*	California jackknife clam
Leptopecten latiauratus	Kelp scallop	*Tetraclita squamosa*	Thatched barnacle
Macoma sp.	Bent-nose clam	*Tivela stultorum*	Pismo Clam
Mactra sp.	California mactra	*Uca crenulata*	Fiddler crab

Nearshore infaunal communities in Santa Monica Bay offshore from Marina del Rey are dominated by the ophiuroid *Amphiodia urtica* and the arthropods *Rhepoxynius bicuspidatus* and *Heterophoxus oculatus* (Chambers Group 1998). These species are all considered to be relatively sensitive to pollution.

Closer to shore where anthropogenic effects are more prevalent and the habitat is more disturbed, Soule et al. (1991) determined the infaunal community of Marina del Rey was dominated by species of polychaete worms that prefer fine-grained sediments and can tolerate sediments with elevated levels of chemicals. Molluscs, crustaceans, and echinoderms, taxa that tend to be sensitive to chemicals were relatively rare. Areas that were disturbed by storms or manmade events or that have contaminated sediments were found to be dominated by nematode round worms, oligochaete worms and opportunistic polychaete worms like *Capitella capitata*, *Mediomastus ambiseta*, *Pseudopolydora paucibranchiata*, *Tharyx* sp., and *Priosospio heterobranchia*.

The greatest species diversity and abundance was found at the entrance of Marina del Rey, where influence from the ocean is greatest, and declined to the back portions of the marina where species abundance was sparse (Chambers Group 1998). In general, the number of invertebrate taxa declined from the entrance of Marina del Rey to the back portions of the marina (Soule et al. 1996). This trend has been shown in different studies over the last three decades. The HEP of the University of Southern California (USC 1976) has sampled 13 stations within Marina del Rey over 18 seasons since 1976. Results show the same trend of higher species diversity and abundance at the entrance declining towards the back of the marina. At the entrance, a high of 121 taxa occurred in 1991 and the largest abundance of 1,053,900 individuals per m^2 occurred in 1994. The lowest values identified in the back portion of the marina were 9 taxa in 1977 and 360 individuals per m^2 in 1989 (Soule et al. 1996). A more recent survey conducted by Aquatic Bioassay and Consulting Laboratories Inc. (ABC) in 1997 confirmed the trends recorded by the HEP. Infaunal abundance ranged from a low of 216 individuals per m^2 at the back of basin to a high of 12,640 per m^2 at the harbor entrance. Species diversity ranged from a low of 28 species at the back of the basin to a high of 78 species in the main channel.

No studies were found that have documented hard bottom benthic communities on the riprap of the Marina del Rey breakwater and jetties (Chambers Group 1998). Based on observations of riprap in other harbors, it is assumed that they support a typical hard bottom community dominated by barnacles such as *Balanus glandula* and *Chthamalus* sp. and various species of limpets in the upper intertidal, and mussels (*Mytilus edulis* and/or *M. californianus*) and barnacles (*Pollicipes polymerus* and *Tetraclita squamosa*) in the mid-to-lower intertidal. The subtidal riprap probably supports gorgonians (*Muricea californica* and *M.fruticosa*), giant keyhole limpets (*Megathura crenulata*), tunicates (*Styela montereyensis*), and sea urchins (*Strongylocentrotus franciscanus* and *S. purpuratus*) (Chambers Group 1998).

The sandy beaches upcoast and downcoast of Marina del Rey support a typical sandy intertidal invertebrate community including bean clams (*Donax gouldi*) and sand crabs (*Emerita analoga*) (California Department of Parks and Recreation 1992). Pismo clam (*Tivela stultorum*) beds have been identified in the California Department of Fish and Game (CDFG) Resource Atlas (Blunt 1980) as occurring north of Venice Pier and south of the Hyperion outfall, but not in the immediate vicinity of Marina del Rey.

Subtidal hard bottom habitat is limited offshore from Marina del Rey. Scattered natural cobble bed areas of low relief are located off the harbor entrance (Lewis and McKee 1989) and two artificial reefs constructed of quarry rock and concrete rubble have been installed in approximately 19.5 meters water depth off the harbor entrance. These hard bottom habitats have been found to support a diverse assemblage of bottom invertebrates including aggregate anemones (*Corynactis califomica*), gorgonians (*Muricea califomica* and *M.fruticosa*), and cup corals (*Paracyathus stearnsii* and *Balanophyllia elegans*) as well as a variety of algae, sponges and bryozoans (Chambers Group 1998).

The infaunal community in the Ballona Channel varies from year to year due to the dynamic nature of the habitat itself. Infaunal invertebrate populations varied depending on the amount of rainfall, dry weather flows, overflows of sewage into the channel, and accumulation of debris (Soule et al. 1992). Densities varied between a low of 18,320 individuals per m^2 in October 1989 and a high of 272,070 individuals per m^2 in October 1991. The total number of taxa ranged between 0.55 in October 1989 and 2.22 in May of 1991. In some years, the community in the Ballona Channel was dominated by opportunistic nematode and polychaete worms indicative of disturbed habitats as observed in Marina del Rey (Chambers Group 1998).

The subtidal areas within the Ballona wetlands support many species of benthic and burrowing invertebrates. Some of the common species of invertebrates found in the subtidal areas include the fiddler crab (*Uca crenulata*), mudflat crab (*Hemigrapsus nudus*), ghost shrimp (*Callianassa* sp.), slender green shrimp (*Hippolyte californiensis*), sea hare (*Apalsia californica*), mussels (*Mytilus* sp.), California mactra (*Mactra* sp.), common littleneck (*Protothaca staminea*), California jacknife clam (*Tagelus californianus*), bent-nose clam (*Macoma* sp.), nassa (*Nassarius* sp.), navanax (*Aglaja inernis*), and the California horn shell (*Cerithidea californica*) (Chambers Group 1998).

6.1.1.5 *Kelp and Macroalgae*

Submerged aquatic vegetation is relatively sparse throughout Santa Monica Bay. In Marina del Rey, submerged aquatic vegetation is limited to giant kelp (*Macrocystis pyrifera*) growing on riprap areas of the outer harbor. Kelp beds extend low relief, hard bottom habitat from the seafloor to the surface, creating a vertically structured habitat. In California, kelp beds provide protection and habitat for more than 800 species of fishes and invertebrates, many of which are uniquely adapted for life in kelp forests. Because most established kelp beds occur over hard bottom substrate, giant kelp beds in Santa Monica Bay are limited to two areas, the Palos Verdes Shelf and the area from Malibu west to Point Dume.

Along the middle portion of the bay, macroalgae such as the large brown algae (*Sargassum muticum*) is found along the with rock breakwater and jetty structures. In the extreme north and south of Santa Monica Bay, red and brown macroalgae , including *Sargassum* spp., *Taonia* spp., *Gigartina* spp., and *Corallina* spp. inhabit rocky reefs (USACE 2002c).

6.1.1.6 *Eelgrass*

The primary submerged aquatic vegetation type which overlaps with areas typically affected with elevated sediment contaminants is the angiosperm *Zostera marina*, often referred to as eelgrass. It inhabits shallow soft-bottom substrates in bays and estuaries from Alaska to Baja California, and is generally tolerant of a wide range in physical habitat characteristics such as temperature and salinity. With respect to sediments, eelgrass beds often accrete sediments and function ecologically as substrate for epifauna and nursery habitat for juvenile fish, such as the California halibut. With respect to in-water projects (such as dredging), National Oceanic Atmospheric Association (NOAA) Fisheries requires that any impacts to eelgrass beds be mitigated at a ratio of 1.2 acres for every acre impacted (National Marine Fisheries Service 1991). Within Santa Monica Bay only sparse eelgrass beds limited to soft bottoms are found. No beds are located in areas that require periodic maintenance dredging.

6.1.1.7 *Marine Mammals*

The marine mammals observed in Santa Monica Bay are similar to those found throughout southern California and specifically, San Pedro Bay. The species and populations within this area are described in the San Pedro Bay biological resources section (Section 6.2.1.6).

6.1.2 *Nearshore Terrestrial Species*

6.1.2.1 *Birds*

Marina del Rey provides a protected habitat for several marine-associated species. The highest abundance of water birds is in the winter when large numbers of waterfowl, gulls, and shorebirds migrate south from breeding grounds in the north. Loons (*Gavia* sp.), grebes (*Podicep* sp.), and ducks swim and feed in the open waters of the marina. The breakwater provides a protected roosting area for the California Brown Pelican (*Pelecanus occidentalis californicus*) and double-crested, pelagic and Brandt's cormorants (*Phalacrocorax* sp.) The breakwater and channel jetties provide foraging for shorebirds such as black oystercatchers (*Haematopus bachmani*), black and ruddy turnstones (*Arenaria* sp.), surfbirds, and wandering tattlers (*Heteroscelus incanus*) that prefer rocky shores (Holt 1990 and Childs 1993). As in the Los Angeles and Long Beach Harbors (San Pedro Bay), gulls utilize most of the habitats in the harbor including the open water, armored shoreline, docks, and the sandy shore of Mother's Beach in Basin D. The limited amount of sandy shore in the harbor provides foraging space for shorebirds such as marbled godwits (*Limosa fedoa)*, whimbrels (*Numenius phaeopus*), and willets (*Catoptrophorus semipalmatus*). Terns (*Sterna* sp.), which dive for fish from the air, also forage in the protected open water of the marina. Caspian terns (*Sterna caspia)* and Forester's terns (*Sterna forsteri*) are found in the harbor year round. In the summer, the California least tern (*Sterna antillarum browni)* nests on Dockweiler State Beach and forages in the marina.

Shorebirds forage on the mudflats of Ballona Lagoon and grebes, herons, gulls terns and waterfowl use the open water. Some of the common birds found in the Ballona wetlands are great blue heron (*Ardea herodias*), green-backed heron (*Butorides striatus*), black-crowned night-heron (*Nycticorax nycticorax*), snowy egret (*Egretta thula*), great egret (*Casmerodius albus*), long-billed curlew (*Numenius Americanus*), California least tern, Forster's Tern, belted kingfisher (*Ceryle alcyon*), California gull (*Larus californicus*), double-crested cormorant (*Phalacrocorax auritus*) and western grebe (*Aechmophorus occidentalis*).

6.1.2.2 *Threatened and Endangered Birds*

The California least tern (*Sterna antillarum browni*), California brown pelican (*Pelecanus occidentalis californicus*), and western snowy plover (*Charadrius alexandrinus nivosus*) are the primary species that could be potentially impacted by contaminated sediments under the Endangered Species Act (ESA) of 1973. These birds are in a similar situation to the fish that they consume, insofar as there are multiple potential routes of exposure by which they can be impacted by contaminated sediments. The California least tern and the California brown pelican forage in southern California waters and are thereby exposed to the risks of contact with waters impacted by the resuspension of contaminated sediments and incidental ingestion of waters with elevated levels of contaminants as they forage, and ingestion of prey species which may contain elevated levels of contaminants due to bioaccumulation.

The California least terns forage in many southern California bay and estuary waters. A large, important California least tern colony is located on Dockweiler State Beach approximately 122 meters up-coast from the northern entrance jetty to Marina del Rey.

The California brown pelican is present in southern California throughout the year and commonly forage in semi-exposed waters. Brown pelicans use the bay year-round for foraging and rest, but are not known to breed there (LAHD 1997). Breakwaters such as the Marina del Rey breakwater, which are relatively free from human disturbances, are especially important roosting sites for brown pelicans.

The western snowy plover is federally listed as threatened and is a state species of special concern. This species inhabits sandy beaches where it forages and nests. Wintering western snowy plovers occur in the vicinity of Marina del Rey. Page et al. (1986) counted wintering snowy plovers between 1979 and 1985 on nine occasions and observed between one and eight plovers per year in the vicinity of Marina del Rey.

6.1.2.3 *Wetland Plants*

The Ballona Creek wetlands are located south of the Ballona Channel in Marina del Rey and include approximately 185 acres of degraded wetland habitat. Habitats include pickelweed salt marsh, mudflats and channels. Although degraded, the marsh still supports a viable wetland ecosystem. The Ballona Lagoon, located north of Marina del Rey is an artificially confined tidal slough channel approximately 1,219 meters long and 46 to 61 meters wide. The lagoon contains some remnant salt march vegetation including pickelweed (*Salicornia* sp.) and *Jaumea* sp.

The plant community in the Ballona Creek wetlands consists of plants capable of tolerating a wide range of conditions from submergence in salt water, exposure to air, and submergence to fresh water. Examples include pickleweed (*Salicornia virginica* and *S. subterminalis*), Sea-blite (*Suada californica*), saltgrass (*Distichlis spicata*), jaumea (*Jaumea carnosa*), seaside heliotrope (*Heliotropium curassavicum*), alkali heath (*Fankenia salina*) and alkali weed (*Cressa truxillensis*).

Ballona Creek wetlands also support coastal strand plants. Some of the species of coastal strand plants include beach lupine (*Lupinus chamissonis*), beach primrose (*Camissonia cheiranthifolia*), sand verbena (*Abronia maritima* and *A. umbellata*), mock heather (*Ericameria ericoides*), dune buckwheat (*Eriogonum parvifolium*), beach wallflower (*Erysimum insulare*), beach bur (*Ambrosia chamissonis*), sea rocket (*Cakile maritima*) and phaecelia (*Phacelia ramosissima*).

6.2 San Pedro Bay

6.2.1 *Aquatic Species*

6.2.1.1 *Adult and Juvenile Fishes*

The Los Angeles-Long Beach Harbor complex in San Pedro Bay is a transient or permanent habitat for over 130 species of juvenile and adult fish (Horn and Allen 1981; MEC 1988; USACE; and LAHD 1984). MEC recently conducted a harbor-wide (Long Beach and Los Angeles Harbors) estimate of the total number of fish (MEC 2002).

The 2000 Biological Baseline Survey (MEC 2002) conducted for the Port of Los Angeles (POLA) and the Port of Long Beach (POLB) serves as a valuable record of the diverse nature of fish species present in San Pedro Bay. The survey concluded that no significant differences were found between the fish populations within both the Los Angeles and Long Beach harbors. The survey included a variety of habitat types (e.g., shallow subtidal, deepwater) representing all aspects of the nearshore areas of San Pedro Bay.

In the 2000 survey, 74 fish species were recorded in the POLB and POLA (MEC 2002). The survey used a variety of sampling methods to collect demersal, pelagic, and nearshore fish species representing all aspects of the water column. The most abundant species observed included the northern anchovy (*Engraulis mordax*), white croaker (*Genyonemus lineatus*), queenfish (*Seriphus politus*), topsmelt (*Atherinops affinis*), and Pacific sardine (*Sardinops sagax*), which together accounted for 90 percent of the total abundance. These species plus the bat ray (*Myliobatis californica*) and barracuda (*Sphyraena argentea*) accounted for 77 percent of the total biomass observed. These species may then be considered to be a generalized list of species of primary concern in the harbor complex. Of these species, consumption advisories have been issued for white croaker and queenfish caught within the Los Angeles/Long Beach Harbors (California Office of Environmental Health Hazard Assessment 2003) due to unacceptable levels of contaminants in tissues most likely the result of exposure to sediment contaminants.

A large number of fish larvae and juvenile-adult species have been reported in the harbor (HEP 1976 and 1979 and SCOSC 1980 and 1982), which reflects the variety of nursery and adult habitats present. Harbor fish larvae tend to be dominated by various species on a spatial and temporal basis. Larval abundance was significantly higher in spring and summer and a secondary peak occurred in the fall (MEC 2002). Brewer (1983) found a similarity between the abundance of fish larvae and juvenile-adults in the harbor.

Larval abundance was generally lower on the Los Angeles side of the harbor, which was similar to the abundance pattern indicated for adult fish (MEC 2002). Larvae of pelagic or demersal species found over sand and/or mud bottoms as adults generally had a wide dispersal pattern within the harbor complex. In addition, some species were strongly associated with deep-water habitats while others were strongly associated with shallow-water habitats (MEC 2002). For example, bay goby (*Lepidogobius lepidus*) was more abundant at deep water locations. Larvae of flatfish generally had higher abundance in deep water habitats in the Outer Harbor, basins, and channels. Fish associated with vegetation and/or rocky substrate during some part of their life stage had a more localized larval distribution which was associated with the outer breakwater, riprap around Pier 400, eelgrass beds in the Pier 300 Shallow Water Habitat, other locations near riprap, or nearby macroalgae beds (MEC 2002). Larval fish data from Brewer (1983), MBC (1984), and the SCOSC (SCOSC 1980 and 1982) also demonstrates the importance of riprap or breakwaters as adult fish habitats.

6.2.1.2 *Special Interest Fish Species*

The California halibut (*Paralichthys califoricus)* is the only special interest fish species found within San Pedro Bay. California halibut are prized by sport and commercial fishermen and have experienced notable declines in recent years. California halibut spawn in nearshore areas throughout the year, with a peak in winter and spring. The pelagic eggs and larvae drift in the water column as part of the plankton for about a month; then the juvenile fish settle to the bottom. Juveniles are typically found in embayments, and adults are found along the coast.

6.2.1.3 *Plankton*

No recent studies of plankton populations have been conducted; however, phytoplankton and zooplankton in the harbors have been described in previous-studies (EQA and MBC 1978 and Soule and Oguri 1976 and 1979). In the Outer Harbor, seasonal phytoplankton patterns were marked by diatom-dominated spring blooms and more intense dinoflagellate-dominated fall blooms. All species present are typical components of the Southern California Bight shelf plankton community (Barnett and Jahn 1987) and additional details can be found in Section 6.1.1.3.

6.2.1.4 *Benthic and Epibenthic Invertebrates*

Benthic invertebrates are defined as those associated with the interface between overlying water and the sea floor. Benthic communities have been historically considered as an indicator of sediment conditions. Contaminated sediments are heavily populated with pollution tolerant species and have low species diversity, whereas clean sediments generally do not sustain pollution tolerant species and have higher species diversity. The benthic communities within the project area consist of similar assemblages of species, however are significantly different between habitat types.

The benthic environment within San Pedro Bay consists of a wide variety of habitats including deep water soft bottom, shallow water soft bottom, hard substrate (in the form of armored shorelines, pier structures, rocky substrate, breakwaters, and jetties) and natural substrates such as the eelgrass (*Zostera marina*) found in the shallows off the Cabrillo Beach area and in Seaplane Lagoon. The sediments typically consist of varying grain sizes, including sand, fine-fraction silts, and clays.

The dominant species found in the recent 2000 baseline survey included the non-indigenous polychaete, *Pseudopolydora paucibranchiata*. Other dominant species included the amphipod (*Amphideutopus oculatus*), ostracod (*Euphilomedes carcharodonta*), clam (*Theora lubrica*), and polychaete worms (*Cossura* sp. A, *Euchone limnicola*, *Mediomastus* spp., and *Monticellina siblina*) (MEC 2002). This study coincides with reports of dominant benthic species found previously in this area (HEP 1976, 1980; MBC 1984; and MEC 1988).

In the shallow water soft bottom habitats, the highest mean abundances occurred and included a diverse mix of amphipod crustaceans (e.g., *Acuminodeutopus heteruropus, Amphideutopus oculatus*, *Deflexilodes similis, Photis bifurcata*), ostracod crustaceans (*Euphilomedes carcharodonta*), bivalve molluscs (*Chione californiensis, Cooperella subdiaphana*, *Lyonsia californica*, *Macoma nasuta, Macoma yoldiformis, Tellina modesta*, *Thracia curta*), gastropod molluscs (*Acteocina culcitella*, *Olivella maculata, Nuculana taphria*), polychaetes (e.g., *Apoprionospio pygmaea*, *Glycera convoluta*, *Glycinde armigera*, *Leitoscoloplos puggetensis*, *Lumbrineris* spp., *Mediomastus* spp., *Monticellina siblina*, *Pectinaria californiensis*, *Spiophanes bombyx*, *Spiophanes missionensis*), and nemerteans (*Paranemertes californica*) (MEC 2002).

Organisms residing on hard substrates such as piers, jetties and breakwaters, within the Study Area typically include barnacles, bivalves, polychaete worms, snails, anemones, echinoderms, and algae. The hard substrate communities often include the bay mussel (*Mytilus galloprovincialis*) and the Pacific oyster (*Crassostrea gigas*). These long-lived bivalve species filter large volumes of water throughout their lifetimes. Incidental ingestion of resuspended particulates provides the potential to ingest and bioaccumulate associated contaminants. Other smaller filter feeding organisms on hard substrates face the same challenge with respect to particle-adsorbed contaminants. Contaminants ingested by hard substrate fauna may subsequently enter the food web via predation by fish species associated with hard substrate habitat such as surfperches (*Embiotocidae*).

Classic pollution tolerant species within the San Pedro Bay area include the bivalves in the genus *Solemya*, *Dorvelleid* polychaetes, and the polychaete species *Capitella capitata*, *Schistomerigos longicornis*, and *Notomastus* sp. (MEC 2002). Species more typically associated with uncontaminated sediments or other disturbances include the brittlestars of the genus *Amphiodia*, polychaetes such as *Maldane sarsi* and *Pectinaria californiensis*, and worms of the genus *Phoronis*. Presence/absence data relating to benthic species can be a strong indicator of the relative condition of the sediments or the site in terms of pollution load or stability of ambient conditions (e.g., dissolved oxygen concentration).

6.2.1.5 *Kelp and Macroalgae*

Giant Kelp (*Macrocystis* sp.) was transplanted to sections of San Pedro Bay and currently lines the inner side of the breakwater and along rock dikes in the outer bay (MEC 2002). The largest diversity of macroalgae occurs along the San Pedro Breakwater (12 dominant species) and areas of riprap (11 dominant species), however a general decline of algal diversity was found from the outermost portions of the harbors to the innermost channel environments (MEC 2002).

The protected nearshore areas of San Pedro Bay are dominated by sparse coverage of stress tolerant algal species such as *Ulva* spp. and *Enteromorpha* spp.; more exposed areas are typically dominated by red and brown algal species, including *Sargassum* spp., *Taonia* spp., *Gigartina* spp., and *Corallina* spp. (USACE and LAHD 1984).

The invasive exotic macroalgae, *Sargassum muicum*, was found in the Los Angeles River Estuary (LARE) during the 2000 survey of the harbor (MEC 2002). This algae is common throughout southern California bays (MEC 2002). Other exotic species found in the survey included *Codium fragile* ssp. *tomentosoides*, and *Undaria pinnatifida*. *Undaira pinnatifida* is native to Japan and has not previously been recorded on the west coast of North America (MEC 2002).

6.2.1.6 *Eelgrass*

Eelgrass (*Zostera marina*) is an important component of estuarine ecosystems and is considered a “Special Aquatic Site” under the Clear Water Act. It provides food and habitat for many birds, fish, and invertebrates. It also acts as a substrate for other primary producers such as diatoms and algae.

Eelgrass inhabits shallow soft-bottom substrates in bays and estuaries throughout California and is generally tolerant of the wide range in physical habitat characteristics such as temperature and salinity. Ecologically, eelgrass beds act as a substrate for epifauna and nursery habitat for juvenile fish such as the California halibut. With respect to in-water projects (such as dredging), NOAA Fisheries requires that any impacts to eelgrass beds be mitigated at a ratio of 1.2 acres for every acre impacted (National Marine Fisheries Service 1991).

Eelgrass has become established in shallow waters off Cabrillo Beach extending northward to the Cabrillo Marina as well as in the Pier 300 Shallow Water Habitat and Seaplane Lagoon in the POLA. In a recent 2000 survey for the POLA, a dramatic seasonal increase in eelgrass bed area from 21.66 acres in March to 42.27 acres by August was recorded. The coverage in August was considered to be healthy based on the observed density and growth as well as the presence of flowering turions (MEC 2002).

6.2.1.7 *Marine Mammals*

The marine mammals most commonly observed within the Study Area are similar to those that are found throughout southern California coastal waters. The short-beaked common dolphin (*Delphinus delphis*) has been sighted year round and is the most common marine mammals in the area. Bottlenose dolphins (*Tursiops truncates*), Risso’s dolphins (*Grampus griseus*), and Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) are also sighted in coastal waters. In the fall and spring, transient populations of blue whales (*Balaenoptera musculus*) and humpback whales (*Megaptera novaeangliae*) are found foraging off the coastal waters as well.

Significant seasonal shifts occur in the abundance and distribution for several species within the Study Area between cold and warm-water months (Forney and Barlow 1998). For example, cold-water species such as Dall’s porpoise (*Phocoenoides dalli*), northern right whale dolphins (*Lissodelphis borealis*), Pacific white-sided dolphins, and gray whales (*Eschrichtius robustus*) were observed only during the cold-water months of November through April. In contrast, blue whales were seen primarily during warm-water months, with the exception of one southbound migrant seen in November.

California sea lions (*Zalophus californianus*) are the most abundant pinniped in the southern coastal waters of the Study Area (NOAA 2000b). Harbor seals (*Phoca vitulina*) have also been recorded in the area in much less abundance. These pinnipeds are transient mammals that utilize the project Study Area primarily as feeding grounds. Many harbor seals can be viewed hauled out on ship channel buoys in both Los Angeles and Long Beach harbors and are attracted to these areas due to fishing vessels, local fish populations, and benthic invertebrate populations.

6.2.1.8 *Threatened and Endangered Marine Mammals*

As with many of the remaining whale species that still survive, the humpback and blue whales that migrate through California coastal waters are on the U.S. Endangered Species list. Blue whales were formerly heavily hunted for blubber and oil. Baleen was also an important whale product, valued for its plastic like properties that found application in a wide variety of products. Blues whales gained protection after the 1965 and 1966 whaling season despite the opposition of the whaling industry. Estimates of the remaining population range from 500 to 2,000 individuals (Nowak 1991).

The humpback whale has been killed for its oil, meat, hide, and baleen. North Pacific humpbacks spend the summer in temperate waters from the Aleutian Islands of Alaska to the Farallon Islands off the coast of central California. During the colder winter months, November to May, the majority of the North Pacific stock is found in the warm waters of Hawaii where they breed, calve, and nurse their young. The remaining animals are found off the coast of Baja California, Mexico, and throughout the islands south of Japan.

6.2.2 *Nearshore Terrestrial Species*

6.2.2.1 *Birds*

Over 100 bird species have been reported to occur within the Los Angeles-Long Beach Harbor, and 99 species were observed in the 2000-2001 surveys (MEC 2002). Of these, 70 percent could be considered water-associated, and 44 percent of all birds observed in the harbors over the year were gulls (MEC 2002). Other abundant taxa inlcuded terns, grebes, California brown pelican (an endangered species), and cormorants.

Pier 400, on of the largest terminal complexes in the POLA, is occupied primarily by gulls (*Larus* spp.), american crow (*Crovus brachyrhynchos*), common raven (*Crovus corax*), black skimmer (*Rhychops niger*), Caspian tern (*Stern caspia*), elegant tern (*Sterna elegans*), royal tern (*Sterna manxima*) and California least terns (*Sterna antillarum browni*) (Keane Biological Consulting 1999). Some bird species are year-round residents while others are winter or migrant visitors. Birds use habitats within the harbors primarily for resting and foraging, although some species breed there as well.

6.2.2.2 *Threatened and Endangered Birds*

Two state and federally listed endangered species, the California least tern and the California brown pelican (*Pelecanus occidentalis californicus*) regularly use the harbor area for foraging. The California state-endangered peregrine falcon (*Falco peregrinus*) also forages within the harbor area, while the state-endangered Belding's savannah sparrow (*Passerculus* *sandwichensis beldingi*) may only be a transient visitor in the area. One Belding's savannah sparrow was observed on the south side of Queensway Bay in March of 1984 (MBC 1984); none were observed during the 2000 to 2001 surveys (MEC 2002). The federally threatened western snowy plover (*Charadrius alexandrinus*) inhabits coastal sandy beaches and mudflats and has been sighted in San Pedro Harbor, with the latest reported sighting in 2001 on Pier 400 (Keane Biological Consulting 2002).

Several species of birds protected by the Migratory Bird Treaty Act, including the elegant tern, caspian tern, royal tern, black skimmer, black oystercatcher (*Haematopus bachmani*), and great blue heron (*Ardea herodias*), have been observed nesting in the harbor (MEC 2002). Individuals of these species not only use the harbor for breeding but forage on fish in the harbor (MEC 1988).

The California least tern is listed as endangered by both state and federal governments. This small seabird migrates north to southern and central California in May to breed (Massey 1974). California least terns nest in coastal areas adjacent to shallow marine and estuarine habitats, where they can forage on fish at the water surface by diving into the water. The California least tern begin laying their eggs in May. Chicks start hatching by June and begin maturing into fledglings by early July (MEC 1988 and Keane 1997b). The terns generally depart for their wintering grounds in August (Massey and Atwood 1981).

Shallow water areas of the Outer Harbor are considered important areas for California least tern foraging. Adult California least terns observed in the Outer Harbor in 1986 and 1987 were feeding off Terminal Island in shallow water areas and off the Middle Breakwater (MEC 1988). During surveys conducted in 1994 to 1996, adults were observed feeding off Terminal Island in shallow water areas east of Pier 300 and in areas south of Pier 300. In addition feeding was observed off of Cabrillo Beach. No survey of foraging at the Middle Breakwater was performed (Keane 1997a). After chicks hatched, foraging was more concentrated in the shallow waters adjacent to the colony (MEC 1988). Primary prey items of the California least tern are the northern anchovy, topsmelt, and jacksmelt (Atwood and Kelly 1984; Massey and Atwood 1984).

The California brown pelican is state and federally listed as an endangered species, protected by both state and federal legislation. Brown pelicans have been observed year-round in the harbor complex, although their numbers fluctuate seasonally due to an influx of post-breeding pelicans from Mexico in the summer. Studies conducted in 1983 and 1984 (MBC 1984) indicate that the highest densities of brown pelicans occur between early July and early November (several thousand birds), with a sharp decrease in numbers after November. Minimum densities were noted in late March. Brown pelicans were one of the most abundant bird species observed in the Outer Harbor during surveys conducted in 1986 and 1987 (MEC 1988). Similarly, the California brown pelican accounted for 9.5 percent of the total observations during 2000 to 2001 surveys and was ranked fourth in the number of observations for bird species observed within the Port (MEC 2002). Within the Outer Harbor, pelicans rest on breakwaters in areas with little human disturbance (MEC 1988). In particular, remote areas of the Middle Breakwater appear to be preferred resting spots (MBC 1984 and MEC 1988). Pelicans are diving birds that feed exclusively on fish. During the MEC (1988) study, pelicans were observed foraging in open waters off Terminal Island and in shallow waters adjacent to the Seaplane Anchorage.

The federally threatened western snowy plover inhabits coastal sandy beaches and flats. Even though the Study Area does not contain suitable habitat to support nesting or feeding by this species, individuals have been sighted in San Pedro Harbor, with the latest reported sighting in 2001 on Pier 400 (Keane Biological Consulting 2002).

6.2.2.3 *Wetland Plants*

Wetland habitats along the shoreline of San Pedro Bay are extremely limited within the Study Area due to a long history of development in the area. Wetland areas within the harbor include the Golden Shore Marine Reserve in the vicinity of the LARE (see Section 6.3), the Los Cerritos wetland complex located between the Long Beach Marina and the San Gabriel River Estuary (see Section 6.4), and the Cabrillo marsh within the POLA. Sporadic areas of pickleweed (*Salicornia virginica*) and saltgrass (*Distichlis spicata*) patches have been documented along minimally developed harbor shorelines (MBC 1999).

6.3 Los Angeles River Estuary

The LARE is located within inner harbor portions of San Pedro Bay. As such, biological assemblages are similar to those presented in Section 6.2. The following section presents a summary of the aquatic and nearshore species present in LARE that are similar to San Pedro Bay, in general, as well as species specific to the Estuary.

6.3.1 *Aquatic Species*

6.3.1.1 *Adult and Juvenile Fishes*

In 2002, MBC estimated fish populations within the Golden Shore Marine Reserve, located within the LARE (MBC 2003). These studies indicate that the most abundant species in this area are arrow goby (*Cleviandia ios)*, northern anchovy (*Engraulis mordax)*, white croaker (*Genyonemus lineatus*), queenfish (*Seriphus politus*), topsmelt (*Atherinops affinis*), and Pacific sardines (*Sardinops sagax*). Like the rest of the San Pedro Bay Inner Harbor, the fish community in the LARE is dominated by a few species that make up a very high percentage of the total catch. The eight most abundant species collected in four surveys (summarized in USACE and LAHD 1984) are: white croaker, northern anchovy, bay goby (*Lepidogobius lepidus*), queenfish, California tonguefish (*Symphurus atricauda*), white surfperch (*Phanerodon furcatus*), shiner surfperch (*Cymatogaster aggregata*), and Pacific butterfish (*Peprilus simillimus*). Bay goby and Pacific butterfish appear more abundant in the Inner Harbor than in the Outer Harbor community and species richness and diversity appear to decrease along a gradient from the Outer Harbor to the Inner Harbor (USACE and LAHD 1984, MEC 2002).

Within the LARE, the Golden Shore Marine Reserve samples were dominated by small fish species. The arrow goby comprised 84 percent of the total catch in 2002. Other species found in the Reserve included topsmelt, longjaw mudsucker (*Gillichthys mirabilis*), yellowfin goby (*Acanthogobius flavimanus*) and the western mosquitofish (*Gambusia affinis*).

The only exotic (non-indigenous) species collected in recent surveys was the yellowfin goby. This species is native to Japan, Korea, and northern China (Miller and Lea 1972, Eschmeyer et al. 1983) and was accidentally introduced into the Sacramento-San Joaquin estuary in the 1950s, through the ballast systems of ships (Brittan et al. 1963). A second population has been reported in Los Angeles, Long Beach Harbor, and Newport Bay (Haaker 1979), but has also been commonly collected in many of the southern California bays and lagoons (MEC 1993, MEC 1999, Merkel and Associates 2001).

Commercially and/or recreationally important species potentially resident to the LARE include the California halibut (*Paralichthys californicus*), barred sand bass (*Paralabrax nebulifer*), and the northern anchovy. In the recent MEC survey (2002), halibut abundance was relatively low with only 59 individuals collected over all stations within the harbor. Most halibut were collected at outer harbor stations and only small juveniles were mainly collected at the Long Beach Shallow Water Habitat. Barred sand bass was also low in total abundance (115 individuals collected), with more than 90 percent of the catch from the Cabrillo, Pier 300, and Long Beach Shallow Water Habitats (MEC 2002). Northern anchovy abundance was one of the highest in the Study Area as previously discussed.

6.3.1.2 *Plankton*

No recent studies of plankton populations have been conducted; however, phytoplankton and zooplankton in the harbors have been described in previous-studies (EQA and MBC 1978; and Soule and Oguri 1976, 1979). In the Outer Harbor, seasonal phytoplankton patterns were marked by diatom-dominated spring blooms and more intense dinoflagellate-dominated fall blooms. Additional detail can be found in Section 6.1.1.3.

6.3.1.3 *Benthic and Epibenthic Invertebrates*

The benthic environment within the LARE is similar to that for San Pedro Bay (Section 6.2) and consists of a wide variety of habitats including deep water soft bottom, shallow water soft bottom, hard substrate (in the form of armored shorelines, pier structures, and rocky substrate breakwater jetties), intertidal, subtidal and vegetated and unvegetated mudflats.

As noted in the San Pedro Bay discussion, the dominant species found in the recent MEC 2000 baseline survey included the non-indigenous polychaete, *Pseudopolydora paucibranchiata*.

Other dominant species included the amphipod (*Amphideutopus oculatus*), the ostracod (*Euphilomedes carcharodonta*), clam (*Theora lubrica*), and polychaete worms (*Cossura* sp. A, *Euchone limnicola*, *Mediomastus* spp.,*Monticellina siblina*). This study coincides with the reports of dominant benthic species found previously in this area (HEP 1976, 1980; MBC 1984; and MEC 1988).

The highest mean abundances occurred in the shallow water soft bottom habitats and included a diverse mix of amphipod crustaceans (e.g., *Acuminodeutopus heteruropus*, *Amphideutopus oculatus*, *Deflexilodes similis*, *Photis bifurcata*), ostracod crustaceans (*Euphilomedes carcharodonta*), bivalve molluscs (*Chione californiensis*, *Cooperella subdiaphana*, *Lyonsia californica*, *Macoma nasuta*, *Macoma yoldiformis*, *Tellina modesta*, *Thracia curta*), gastropod molluscs (*Acteocina culcitella*, *Olivella maculata*, *Nuculana taphria*), polychaetes (e.g., *Apoprionospio pygmaea*, *Glycera convoluta*, *Glycinde armigera*, *Leitoscoloplos puggetensis*, *Lumbrineris* spp., *Mediomastus* spp., *Monticellina siblina*, *Pectinaria californiensis*, *Spiophanes bombyx*, *Spiophanes missionensis*), and nemerteans (*Paranemertes californica*) (MEC 2002).

Within the Golden Shore Marine Reserve, the shallow water community consisted mainly of the polychaete annelid *Polydora cirrosa* and the arthropod *Monocorophium insidiosum.* Other less abundant species included Bay ghost shrimp *(Callianassa californiensis),* the Japanese mussel *Musculista senhousia*, and numerous clam species (i.e. Pacific littleneck, *Macoma nasuta*, *California tagelus* and *Cryptomya californica*.

The deeper subtidal areas of the Reserve were dominated by the polychaete annelid *Capitella capitata.* Other species included nematode and oligochaete annelid worms, the amphipod *Monocorophium insidiosum* and the leptostracan *Nebalia* sp B. All of these species were also found in the shallow water, intertidal habitat.

Classic pollution tolerant species within the LARE include the bivalves in the Genus *Solemya*, Dorvelleid polychaetes, and the polychaete species *Capitella capitata*, *Schistomerigos longicornis*, and *Notomastus* sp. (MEC 2002). The species typically associated with uncontaminated sediments or other disturbances include the brittlestars of the Genus *Amphiodia*, polychaetes such as *Maldane sarsi* and *Pectinaria californiensis*, and worms of the genus *Phoronis*. Presence/absence data relating to benthic species can be a strong indicator of the relative condition of the sediments or the site in terms of pollution load or stability of ambient conditions (e.g., dissolved oxygen concentration).

6.3.1.4 *Kelp and Macroalgae*

Macroalgae and kelp within the estuary are found primarily on hard substrates such as riprap and armored shoreline. These primary producers are an important source of both food and habitat for fish and invertebrates. Sparse populations of stress tolerant algal species such as *Ulva* spp. and *Enteromorpha* spp dominate within the estuary. On the outskirts of the estuary, more exposed areas are typically dominated by red and brown algal species including *Sargassum* spp., *Taonia* spp., *Gigartina* spp., and *Corallina* spp. (USACE and LAHD 1984).

The invasive exotic macroalgae, *Sargassum muicum*, was found in the LARE during the MEC 2000 baseline survey (MEC 2002). This algae is now common throughout southern California bays (MEC 2002).

6.3.1.5 *Eelgrass*

Recent eelgrass surveys recorded beds outside the estuary but within the POLA (Section 6.2.1.5), but not within the LARE itself. Eelgrass coverage ranges from approximately 50 acres in the spring to approximately 100 acres at their peak in the fall (MEC 2002). This pattern of expansion and contraction of eelgrass habitat is typical in marginal habitat areas (USACE 2002c).

6.3.1.6 *Marine Mammals*

California sea lions (*Zalophus californianus*) and harbor seals (*Phoca vitulina*) are relatively common within marina and harbor environments throughout the Study Area. They are most abundant on structures that they utilize to haul out on (i.e., channel buoys, breakwater jetties) and also commonly forage in the outer portions of harbors and marinas.

No cetaceans have been documented to regularly inhabit the LARE (LAHD 1999 and POLB 2000), but cetaceans observed in the outer harbor include gray whales (*Eschrichtius robustus*), Pacific bottlenose dolphins (*Tursiops truncates*), common dolphins (*Delphinus delphis*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), Risso's dolphins (*Grampus grieus*), and Pacific pilot whales (*Globicephala macrorhynchus*) (USACE and LAHD 1984). Sightings of these species within areas associated with sedimentation and low water circulation are rare.

6.3.2 *Nearshore Terrestrial Species*

6.3.2.1 *Birds*

Birds are an important ecological component of San Pedro Bay in general due to their high trophic position. Over 100 avian species use the various habitats within the Bay seasonally, year-round, or during migration (MEC 2002). Most of these species also inhabit the LARE area as summarized below.

The majority of birds in the project region are considered water-associated. MEC (2002) reported that of the 99 species observed in San Pedro Bay during 2000–2001 surveys, 69 species were considered to be dependent on marine habitats. The most abundant are surf scoter (*Melanitta perspicillata*), western gull (*Larus occidentalis*), Elegant Tern (*Sterna elegans*), California brown pelican (*Pelecanus occidentalis californicus*), Heermann's gull (*Larus heermanni*), and western grebe (*Aechmophorus occidentalis*). Ring-billed gull (*Larus*

delawarensis), black-bellied plover (*Pluvialis squatarola*), double-crested cormorant (*Phalacrocorax auritus*), least tern (*Sterna antillarum browni*), and Brandt's cormorant (*Phalacrocorax penicillatus*) are also present, at least seasonally (MEC 2002).
A small wetland area exists within the LARE (adjacent to the mouth of the Queensway Marina entrance) that provides the most optimal habitat for avian nesting and foraging within the estuary. This area, called the Golden Shore Marine Reserve, is located along the northeast shore of the Los Angeles River and was created to replace intertidal habitat lost during the creation of Rainbow harbor and provide un-vegetated and vegetated mudflats. These habitats are occupied by twenty species of resident shorebirds throughout the year and twenty four other species periodically throughout the year (USACE 2002c). Most (80 percent) of the bird species utilizing the Reserve for foraging and nesting, are marine.

6.3.2.2 *Threatened and Endangered Birds*

Two state and federally listed endangered species, the California least tern (*Sterna antillarum browni*) and the California brown pelican (*Pelecanus occidentalis californicus*) regularly use San Pedro Bay and the LARE. One site sampled within Los Angeles Harbor contributed nearly 24 percent of the state's least tern fledglings in 1999 (Keane 2002). The state-endangered peregrine falcon (*Falco peregrinus*) uses the harbor area, while the state endangered Belding's savannah sparrow (*Passerculus sandwichensis beldingi*) may be a transient visitor in the area. One Belding's savannah sparrow was observed on the south side of Queensway Bay in March of 1984 (MBC 1984); none were observed during 2000–2001 surveys (MEC 2002). The federally threatened western snowy plover (*Charadrius alexandrinus*) inhabits coastal sandy beaches and flats and has been sighted in Los Angeles Harbor, with the latest reported sighting in 2001 on Pier 400 (Keane Biological Consulting 2002).

Several species of birds protected by the Migratory Bird Treaty Act, including the elegant tern (*Sterna elegans*), caspian tern (*Sterna caspia*), royal tern (*Sterna maxima*), black skimmer (*Rynchops niger*), black oystercatcher (*Haematopus bachmani*), and great blue heron (*Ardea herodias*), have nested in the harbor (MEC 2002). Individuals of these species not only use the harbor for breeding but forage on fish in the harbor (MEC 1988). All may be present, at times, in the LARE Study Area.

6.3.2.3 *Wetland Plants*

Wetland habitats in the LARE are extremely limited due to development in the area, but include the Golden Shore Marine Reserve. Pickleweed (*Salicornia virginica*), Jaumea (*Jaumea carnosa*), Alkali heath (*Frankenia salina*), saltwort (*Batis maritima*) and saltgrass (*Distichlis spicata*) patches have been documented along minimally developed harbor shorelines and within the Marine Reserve (MBC 1999, 2003).

6.4 Alamitos Bay

Alamitos Bay lies directly adjacent to San Pedro Bay and shares many of the same habitats and, hence, biological species. Where relevant, information presented in Section 6.2 for San Pedro Bay is repeated for Alamitos Bay.

6.4.1 *Aquatic Species*

6.4.1.1 *Adult and Juvenile Fishes*

Alamitos Bay is in close proximity to San Pedro Bay and the LARE and supports similar aquatic habitats. As such, similar fish species are expected to be found within the bay. These species include the northern anchovy (*Engraulis mordax*), white croaker (*Genyonemus lineatus*), queenfish (*Seriphus politus*), topsmelt (*Atherinops affinis*), Pacific Sardine (*Sardinops sagax*), bay goby (*Lepidogobius lepidus*), California tonguefish, white surfperch, shiner surfperch, Pacific butterfish (*Peprilus simillimus*), and arrow goby (*Clevelandia ios*) (MEC 2002 and USACE and LAHD 1984).

Commercially and/or recreationally important species potentially resident to Alamitos Bay include the California halibut, barred sand bass, and the northern anchovy. In a recent MEC Analytical Systems (MEC) survey (2002) of nearby San Pedro Bay, halibut abundance was relatively low with only 59 individuals collected over all stations within the harbor. Most halibut were collected at outer harbor stations and only small juveniles were mainly collected at the Long Beach Shallow Water Habitat. Barred sand bass was also low in total abundance (115 individuals collected), with more than 90 percent of the catch from the Cabrillo, Pier 300, and Long Beach Shallow Water Habitats (MEC 2002). Northern anchovy abundance was one of the highest in the Study Area as previously discussed.

6.4.1.2 *Plankton*

No recent studies of plankton populations have been conducted specifically for Alamitos Bay; however, phytoplankton and zooplankton in the Study Area harbors have been described in previous-studies (EQA and MBC 1978; and Soule and Oguri 1976, 1979). In the San Pedro Outer Harbor, seasonal phytoplankton patterns were marked by diatom-dominated spring blooms and more intense dinoflagellate-dominated fall blooms. Additional details can be found in Section 6.1.1.3.

6.4.1.3 *Benthic and Epibenthic Invertebrates*

The benthic environment within Alamitos Bay is similar to that in San Pedro bay. It consists of a wide variety of habitats including deep water soft bottom, shallow water soft bottom, hard substrate (in the form of armored shorelines, pier structures, and rocky substrate breakwater jetties). The sediments typically consist of varying grain sizes, including sand, fine-fraction silts, and clays.

In the shallow water soft bottom habitats, the highest mean abundances occurred and included a diverse mix of amphipod crustaceans (e.g., *Acuminodeutopus heteruropus, Amphideutopus oculatus*, *Deflexilodes similis, Photis bifurcata*), ostracod crustaceans (*Euphilomedes carcharodonta*), bivalve molluscs (*Chione californiensis, Cooperella subdiaphana*, *Lyonsia californica*, *Macoma nasuta, Macoma yoldiformis, Tellina modesta*, *Thracia curta*), gastropod molluscs (*Acteocina culcitella*, *Olivella maculata, Nuculana taphria*), polychaetes (e.g., *Apoprionospio pygmaea*, *Glycera convoluta*, *Glycinde armigera*, *Leitoscoloplos puggetensis*, *Lumbrineris* spp., *Mediomastus* spp., *Monticellina siblina*, *Pectinaria californiensis*, *Spiophanes bombyx*, *Spiophanes missionensis*), and nemerteans (*Paranemertes californica*) (MEC 2002).

Organisms residing on hard substrates such as piers, jetties and breakwaters, within the Study Area typically include barnacles, bivalves, polychaete worms, snails, anemones, echinoderms, and algae. The hard substrate communities often include the bay mussel (*Mytilus galloprovincialis*) and the Pacific oyster (*Crassostrea gigas*). These long-lived bivalve species filter large volumes of water throughout their lifetimes. Incidental ingestion of resuspended particulates provides the potential to ingest and bioaccumulate associated contaminants. Other smaller filter feeding organisms on hard substrates face the same challenge with respect to particle-adsorbed contaminants. Contaminants ingested by hard substrate fauna may subsequently enter the food web via predation by fish species associated with hard substrate habitat such as surfperches (*Embiotocidae*).

6.4.1.4 *Kelp and Macroalgae*

The kelp and macroalgae species found in Alamitos Bay are expected to be similar to that found in areas of San Pedro Bay. Nearshore areas are dominated by sparse coverage of stress tolerant algal species such as *Ulva* spp. and *Enteromorpha* spp.; more exposed areas are typically dominated by red and brown algal species, including *Sargassum* spp., *Taonia* spp., *Gigartina* spp., and *Corallina* spp. (USACE and LAHD 1984).

6.4.1.5 *Eelgrass*

No areas of eelgrass are known to exist specifically within Alamitos Bay; however, given its presences in San Pedro Bay and existence of suitable habitat, this may only be a result of the fact that studies have not been conducted to document its presence.

6.4.1.6 *Marine Mammals*

The California sea lion (*Zalophus californianus*) is the most abundant pinniped in the southern coastal waters of the Study Area (NOAA 2000b). Harbor seals (*Phoca vitulina*) have also been recorded in the area in much less abundance. These pinnipeds are transient mammals that utilize the project Study Area primarily as feeding grounds. Many harbor seals can be viewed hauled out on ship channel buoys in both Los Angeles and Long Beach harbors and are attracted to these areas due to fishing vessels, local fish populations and benthic invertebrate populations. Both species can be found, at times, inhabiting the outer portions of Alamitos Bay.

6.4.2 *Nearshore Terrestrial Species*

6.4.2.1 *Birds*

Alamitos Bay supports habitats similar to San Pedro Bay and the LARE for the over 100 bird species have been reported to occur in the area. The dominant species are water-associated and include gulls (*Larus* spp.), grebes, cormorants, Black Skimmer (*Rhychops niger*), Caspian Tern (*Stern caspia*), Elegant Tern (*Sterna elegans*), Royal Terns (*Sterna manxima*) and California Least Terns (*Sterna antillarum browni*) (Keane Biological Consulting 1999). Some bird species are year-round residents while others are winter or migrant visitors. They use habitats within the harbors primarily for resting and foraging, although some species breed there as well.

In a survey conducted by the CDFG from October 1979 to March 1980, 53 species were identified in the Los Cerritos Wetland. Forty-eight of the species were water-associated, including five special status species (1981).

6.4.2.2 *Threatened and Endangered Birds*

Two state and federally listed endangered species, the California least tern (*Sterna antillarum browni*) and the California brown pelican (*Pelecanus occidentalis californicus*) regularly use the harbor area for foraging. The California least tern had been historically observed using the Los Cerritos Wetland as a nesting area as well as the state-endangered Belding's savannah sparrow (*Passerculus sandwichensis beldingi*) (NOAA 2000b). However, none of the sparrows were observed during the MEC 2000 to 2001 surveys (MEC 2002).

6.4.2.3 *Wetland Plants*

The Los Cerritos Wetlands is located between the Alamitos Bay Marina and the San Gabriel River Estuary. Wetland habitats found within the Los Cerritos Wetland and include a tidal salt marsh, mudflats, and intertidal mud flats. The salt marsh is dominated by pickleweed, saltgrass, glasswort, sea lavender, saltwort and salt cedar. Cordgrass is also present in the wetlands adjacent to the Los Cerritos Channel.

7 ECONOMIC ANALYSIS

7.1 Introduction

7.1.1 *Purpose*

This appendix aims to describe the current and likely future without project costs of dredging and disposal of dredged material for the relevant Study Area. These cost estimations will help form the basis for the feasibility study's estimation of potential cost reductions as the result of a more cost effective alternative to managing Los Angeles County's dredging and disposal activities.

7.1.2 *Methodology*

The Without Project (F3) Economic Analysis is prepared based upon the assumption that dredging operations throughout the Study Area will continue in the future. This will not be a typical Dredged Material Management Plan (DMMP) as defined in U.S Army Corps of Engineers (USACE) guidance, which would project the impacts/costs of not dredging to determine if the avoidance of these impacts outweigh the costs of dredging to the authorized depth. Potential benefits for this study will be projections of reduced costs associated with more efficient/cost effective and environmentally sound methods of disposal of dredged material.

This F3 Economic Analysis will include: a description of the Study Area (the Los Angeles County, with emphasis on county coastal areas), including demographics, land use and regional economic conditions; recreation resource values of the subject sites within the Study Area, particularly recreational boating; commercial operations at the harbors and ports, including the importance of the ports to the regional economy and the benefits of continued dredging to commercial navigation; and projected dredging and disposal of dredged material costs for each site to serve as a basis for determining potential benefits of alternatives. The evaluation of recreational and commercial values for the sites will be qualitative in nature, and will rely largely on existing data sources and prior reports and analysis. For example, the analysis will not include new projections of recreation visitation and values or projected cargo tonnage throughput for the ports, since the without project condition assumes that these values will not be impacted in the future without project condition; the without project condition assumes a continuation of current dredging maintenance practices. However, for Los Angeles River Estuary (LARE), a simple discussion of the occasional *temporary* impacts, as a result of significant shoal events, to the passenger ferry service to and from Catalina Island will be included. Such impacts have occurred in the past and are likely to continue in the future as a result of unanticipated shoaling resulting from storm events (necessitating emergency dredging). A comprehensive quantification of the economic impacts, however, is not included.

In this appendix, value associated with recreation is assumed to derive from such sources as beaches with public access, private conveyance of boats for the purpose of leisure, and sports organizations such as kayak clubs that depend on the harbor or waterway for their activities.

Other port or harbor activities will be classified as commercial navigation for the purposes of describing the value of the economic activity at the relevant locations. Such commercial activities include those directly associated with the trade and transport of goods, gaming services such as sportfishing, and tourist services involved in sightseeing and various ferry services.

7.2 The Study Area

This section will describe the relevant socio-economic features of the Los Angeles County (County) and of the local areas of interest for this study. The main contribution of this section will be to describe the greater economic environment of the harbors and the estuary. The next section will describe the particular activities at each site as well as the contribution that these activities make to the local and regional economies.

7.2.1 *Location*

All Study Areas are located within the County. There are 88 incorporated cities within the County. Unincorporated land accounts for more than 65 percent of the County. Marina del Rey Harbor is situated in southwest Los Angeles County on Santa Monica Bay. Marina del Rey lies within the Ballona Creek Watershed, which is a large area comprised of 337 square kilometers. The watershed is bounded by the Santa Monica Mountains to the north, extending eastward from the crest of the mountains traversing south and west to central Los Angeles and to Baldwin Hills. The eastern boundary of Marina del Rey lies in land 1.6 kilometers from the Pacific Coast. The Ports of Long Beach (POLB) and Los Angeles (POLA) are located in the San Pedro Bay, approximately 40 kilometers south of downtown Los Angeles and 176 kilometers northwest of San Diego Bay. The LARE is immediately adjacent to and just south of Long Beach Harbor, where the Los Angeles River meets Queensway Bay.

7.2.2 *Population*

The County has one of the most diverse multi-ethnic populations in the world, with people from one hundred forty countries, speaking 86 different languages. White, non-Hispanics constitute just less then half the population, while Hispanics (27 percent), African-Americans (12 percent), and Asian/Pacific Islanders (11 percent) account for significant portions of the populace.

According to the Los Angeles County Department of Finance, as of the year 2003 the County had a population of just less than 10 million. As shown in the table below, over the 10 years between 1990 and 2000, the County's population grew at a slightly slower rate than California's overall population, 12 percent compared to 14 percent. Growth in the City of Los Angeles accounted for around one-third of the County's growth between those years. If considered separately, the County would rank as the ninth most populous state, just behind Michigan. As shown below, the annual compound rate of population growth over the last three years has been lower for the majority of the large cities over as compared to growth between the years 1990 and 2000.

Table 7-1 Los Angeles County Population, 10 Largest Cities plus Marina Del Rey

	1990		2000	1990-2000 % Change		2003	2000-2003 % Change	
	Population	Percent [2]	Population	Total	Annual [1]	Population	Percent [2]	Annual [1]
LA County Total	8,863,052	100	9,884,300	12	1.10	9,979,600	100	0.32
Los Angeles City	3,485,557	39	3,823,000	10	0.93	3,864,400	39	0.36
Unincorporated Areas	970,194	11	1,036,300	7	0.66	1,048,600	11	0.39
Long Beach	429,321	4.8	457,600	7	0.64	481,000	4.8	1.66
Glendale	180,038	2.0	203,700	13	1.24	202,700	2.0	-0.16
Santa Clarita	110,690	1.2	151,300	37	3.17	162,900	1.6	2.47
Pomona	131,700	1.5	147,656	12	1.15	156,500	1.6	1.94
Torrance	133,107	1.5	147,400	11	1.03	144,400	1.4	-0.68
Pasadena	131,586	1.5	143,900	9	0.90	142,200	1.4	-0.39
Palmdale	68,946	0.8	122,400	78	5.91	127,200	1.3	1.28
Lancaster	97,300	1.1	132,400	36	3.13	126,100	1.3	-1.60
El Monte	106,162	1.2	120,000	13	1.23	121,900	1.2	0.52
Marina Del Rey	8,065	0.1	8,176	1	0.14	N/A	N/A	N/A
California	29,758,213	N/A	33,871,648	14	1.30	35,591,000	N/A	1.65

1. Compound.
2. Of Los Angeles County.
Source: California Department of Finance.

7.2.3 Land Use

The County encompasses over 10,000 square kilometers of land. Sixty-five percent of the County land is unincorporated. Mountains and flat lands make up near equal proportions of the County, and together comprise nearly 90 percent of the total acreage. The County has 130 kilometers of coastline.

All of the Harbors included in this study are surrounded by intense urban development. For the harbors in San Pedro Bay, which includes the POLA and POLB and the harbors of the LARE, the surrounding area is a mix of residential, commercial, recreational, and industrial development. The City of Long Beach includes heavy industrial and commercial development such as oil refineries and heavy industry. The area south of the LARE along the waterfront is characterized by dense residential development. A mix of residential and commercial development surrounds Marina Del Rey.

7.3 Economic Conditions

The following sections will give a broad view of the local and regional economic conditions as well as some of the economic issues most relevant to the study locations. Because much of the activity that occurs at the ports and harbors is influenced by, and influences, national and regional economic trends and developments, the following will include a description of trends and various forecasts for the national and regional economy, as well as explaining how such broad trends are relevant with respect to the local areas of interest. All forecasts are taken from local and regional economists and government agencies. The section will go on to discuss the current and likely future economic conditions at all four areas of interest. It is important to note that the included discussion is not meant to provide a detailed forecast of the local economies or of business at the ports and harbors, but rather to simply treat the economic activities and depict the economic importance of the Study Areas to the local, regional, and national economy.

7.3.1 Los Angeles County

California's economy is bigger than all but four countries of the world. Los Angeles County accounts for a significant portion of the state's output, and has, on its own, a greater economic output than all but fifteen countries of the world (Table 7-2).

Table 7-2 Los Angeles County Selected Economic Indicators

Los Angeles County Selected Economic Indicators	1990	2000	1990-2000 % Change
Total Taxable Retail Sales	50.992	60.023	18
Personal Income	190.37	276.68	45
Personal Income Per Capita	21,393	28,121	31
Rate of Inflation	5.8	2.3	(60)
Poverty Rate	15.1	22.1	46
Median Home Price	226,400	202,920	(10)
Median Family Income	38,900	52,100	34
Land Area	4,083	4,083	na
Housing Units	3,163,310	3,272,169	3.4
Labor Force	4,546,700	4,730,000	4.0
Employed	4,292,600	4,474,000	4.2
Unemployed	254,100	256,000	0.8
Unemployment Rate	5.6	5.4	(3.6)
Wage and Salary Jobs	4,133,300	4,075,600	(1.4)
Registered Voters		3,886,985	na
Registered Vehicles	6,308,399	6,290,976	-0.3

na = not applicable
Source: Los Angeles County Dept. of Regional Planning.

The County has a diversified multi-centered metropolis economy with strong manufacturing, services and trade sectors, international business and finance, communication (television and movies), transportation, and electronics. Christopher Thornberg, Senior Economist at UCLA Anderson Forecast, in an April 2003 presentation to the Citizens' Economy Efficiency Commission, described Los Angeles as an externally driven economy (Thornberg 2003). He says that much of the Los Angeles Region's (Region's) industries serve customers in other parts of the U.S. and the world. As such, the Region is particularly exposed to changes in external demand, which influences demand for exports and tourism services.

The County's top employing industries are outlined in Table 7-3. The County is the most prolific both in California and in the country with respect to manufacturing output; producing more than ten percent of the nation's output in such items as aircraft, aircraft equipment, aluminum, dental equipment, games and toys, gas transmissions and distribution equipment, guided missiles, space vehicles and propulsion units, and women's apparel (City of Los Angeles 2003). In terms of employment, the County is the second largest major manufacturing center in the U.S., with an estimated 605,000 employed as of 2001 (LAEDC 2003).

Table 7-3 Los Angeles County Employment and Trends by Industry

	1990		2000		1990-2000 % Change
	Number	Percent	Number	Percent	
Total Jobs	4,133,300	100	4,075,600	100	-1
Construction	133,100	3	128,000	3	-4
Finance-Insurance-Real Estate	277,600	7	235,700	6	-15
Manufacturing	834,600	20	635,900	16	-24
Mining	7,900	0.2	4,200	0.1	-47
Services	1,179,200	29	1,343,100	33	14
Trade	949,600	23	892,000	22	-6
Transportation-Utilities	211,600	5	241,800	6	14
Government	539,800	13	594,900	15	10
Federal	71,900	1.7	59,600	1.5	-17
State-Local	467,900	11	535,300	13	14

Source: Los Angeles County Dept. of Regional Planning.

Some of the major private employers in the County include: Boeing Co. (aircraft and aerospace manufacture), Kaiser Permanente (health maintenance organization), Ralph's Grocery Co. (retail supermarket), Bank of America (commercial banking), Target, and Pacific Bell (communications). The breakdown of sector significance with respect to employment in the County mirrors that of California overall. In 2001 the services sector accounted for 33 percent of non-agricultural wage and salary workers in the County, and wholesale and retail trade accounted for 22 percent (City of Los Angeles 2003). In California overall, the breakdown was 32 and 22 percent, respectively.

Data that fully reflects the impact of the most recent economic slowdown is still forthcoming and as a result is not included in the table. The following paragraphs will attempt to provide a broad overview of the nature and status of the regional economy and of its expected future developments.

California and Los Angeles County were, of course, an integral part of the engine of the Country's economic growth that persisted through much of the 1990s. The County, however, had a slower growth in both income and jobs than the adjacent counties, including Orange and Ventura. Between 1996 and 2000 the County had a 7.5 percent increase in non-farm jobs. While California has undoubtedly suffered in the wake of the dot-com bust, it is important to point out that the state's job losses appear to be closely in-step with the national trend. That is both the state and the nation have shed approximately 15 percent of their manufacturing jobs in the last three years (The Economist 2003). Furthermore, in both California and the nation, a quarter of those manufacturing jobs were in, what is considered, high-tech work. According to a report by economists at the California State University, Long Beach (CSULB), the Region and especially the County were hard hit by a struggling manufacturing sector, the aftereffects of both the terrorist attacks and the SARS virus, and the uncertain economic climate that resulted from the war in Iraq. However, the report predicts a strong recovery for all California counties in 2004 (CSULB 2003).

Between the years 1998 and 2002, the rate of unemployment in the County was slightly, but persistently higher than the rates for both California and the nation. At the time of writing, the latest numbers from the U.S. Bureau of Labor Statistics (BLS) show the trend continuing. The seasonally unadjusted unemployment rate as of December 2003 was 6.1 percent for the Los Angeles-Long Beach metropolitan area. The state and nation had unemployment rates of 6.1 percent and 5.4 percent, respectively.

As noted above, many of California's employment trends correspond to national patterns. While economic forecasting is highly complicated and fraught with uncertainty, if it is assumed that California will continue to mirror national trends in employment, estimates by the BLS of national employment through the year 2010 appear to indicate that there will be a continuing shift in the state from the manufacturing sector to the service-producing sector. The BLS anticipates total national employment to increase by 15 percent, slightly less than the 17 percent growth between 1990 and 2000. While overall employment is expected to increase 15 percent, the agency expects manufacturing to grow by only three percent, representing a decline in the sector's share of total jobs from 13 percent to 11 percent over the decade. County manufacturing jobs declined by nearly one-quarter over the decade 1990 to 2000 (Table 7-3). In line with the BLS forecasts, most local forecasters are predicting a positive but low rate of growth in durable and non-durable manufacturing for the County over the next decade. The table below shows the County trend in employment by sector between 1990 and 2000. The services sector persisted as the largest employer, followed by trade and manufacturing. While the absolute number of jobs in trade declined over the period, the sector's proportion of total employment remained essentially the same.

A forecast of County economic growth published by the State of California indicates that the service sector will remain the growth engine of jobs through 2007, averaging 2.3 percent per year, while overall job growth is expected to be closer to 1.3 percent (California Department of Transportation 2003).

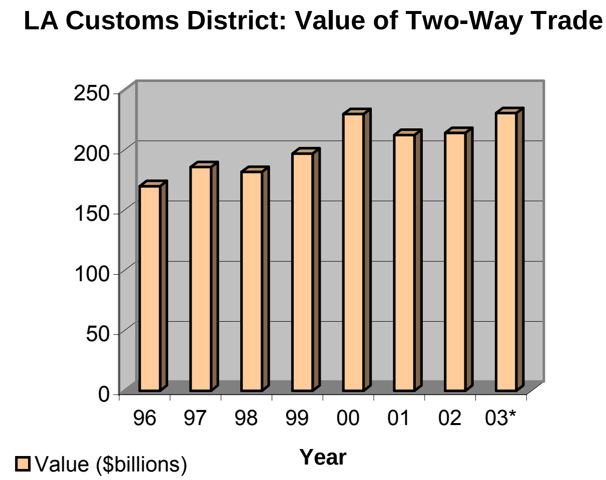
7.3.2 Local Economies: Trade and Tourism

The preceding sections described the County economy from a broad perspective, explaining its relation to the national economy; county trends were shown to generally mirror national trends. This section will delve into the particular local economies, within which the three harbors and the estuary exist. As will be discussed, all four of these sites are important, even indispensable, sources of economic activity. In the case of the POLA and the POLB, and the LARE, commercial navigation accounts for the vast majority of economic activity at these sites. Alternatively, Marina Del Rey is primarily a recreational harbor, and the LARE contains a mix of commercial and recreational navigation activity.

In order to understand the economics of the County's commercial ports, it is important to understand the broader overall trends in global seaborne trade. Over the last 50 years worldwide maritime trade has steadily expanded at a rate of two to three percent annually. In a report by Martin Stopford of Clarkson Research (a large UK-based shipping services provider), Stopford discusses some of the most important issues with respect to future seaborne trade growth, focusing on the likelihood and implications of an increasingly large shipping fleet (Stopford 2002). According to the report, most analysts assume that annual trade growth over the next 20 years will continue to be between two and three percent. Such a growth rate implies an increase in trade of approximately 64 percent over the period. Container trade, which over the past 20 years has had a growth rate of around 8 percent, is expected to continue to grow strongly over the next 20 years at around 6 percent annually, implying a trebling in its trade over the period (Stopford notes that such high estimates of sustained growth seem to implicitly assume overall improvements to capacity infrastructure). Such a high rate of growth in container trade has particular significance for the POLB, for which container trade accounts for two-thirds of its tonnage. The expectation of overall steady trade growth seems to underline the importance, as will be discussed below, of general infrastructure improvements. Obviously, the expected continued growth in trade represents a significant opportunity for the Los Angeles County Ports as well as for the County.

The Los Angeles County Economic Development Corporation (LAEDC) forecasted in July 2003 that overall growth in international trade–and in particular imports–will continue to expand through 2004, and that additional benefits may derive from a possible weaker U.S. Dollar, which would generally increase demand for domestic goods. As two of the principal ports in the nation, developments in international trade are important to the POLA and POLB.

The effects at the regional and nation levels of exchange rate changes are highly complex however, and as with most economic developments, there is a real trade-off brought about by any exchange rate change. Generally, a weaker dollar will help U.S. exporters gain price competitiveness abroad, and, holding all else constant, the volume of imports will decrease as dollar revenues to foreign firms decrease-which will increase domestic demand for goods produced by U.S. firms. A weaker dollar would benefit export trade in agricultural and manufacturing products–two very important revenue sources for the local, state, and regional economies.



The LAEDC estimates that the value of total two-way trade in 2003 within the Los Angeles Customs District (which includes the POLB, POLA, Port Hueneme, Los Angeles International Airport, and McCarran Field) should grow 7.6 percent to a record total of nearly $231 billion. This amount would be slightly higher than the $230 billion in the year 2000. In 1994 the customs district became the nations largest, surpassing New York in the value of imports and exports.

In its comprehensive July 2003 study of the California economy, the LAEDC claims that it regards Los Angeles County, "The real drama for the international trade industry is 'landslide,' where plans to deal with the capacity crunch on the 710 freeway out of the ports are running into heated opposition" (p.52). The report goes on to describe other issues associated with the imminent "capacity crunch", opposition to large trucks on the ports' arterial freeways, and local stakeholder opposition to 24-hour terminal operation.

In a May 2003 report, economists from CSULB came to many of the same conclusions regarding the prospects for near-term growth and the challenges faced by the County's ports. An article (CSULB 2003) reviewing the findings and forecasts of the economists states the following:

> "Considering the economic downturn of the nation, the ports [referring to the POLB and POLA] have continued to perform exceptionally well, but looking at the projected load levels of the near future, Magaddino said it is going to be a real challenge for the region to figure out how to move these goods. "It is true that a large percentage of those goods are consumed by our region, but it is also very important to note that there is a large percentage of those goods that funnel through our ports and our region and out to the rest of the United States," Magaddino said. "If we don't maintain the ability to move these goods, then those goods will go to other ports. That would mean that we would lose jobs. So, we need some significant improvement in this infrastructure."

While international trade is by far the principal activity at the POLA and POLB, other commercial navigation activity, such as cruise and ferry services utilize the ports as well as the facilities located within the LARE. Data recently released from the Department of Transportation's Maritime Administration shows that overall national cruise line passengers in the second quarter of 2003 were up seven percent over the same period the previous year. In its July 2003 study, the LAEDC lists the downtown Long Beach area as one of the economic “hot spots” within the County. This designation is the result of three factors: the new Carnival Cruises terminal; the imminent completion of the “Pike at Queensway Bay”; and the local housing boom. The combined expansion projects at the POLA and POLB are valued at nearly $2.5 billion. As will be discussed in greater detail in the following sections, these services bring in large amounts of tourism revenues, and clearly contribute significantly to the local economies. Data from the U.S. Bureau of Economic Analysis shows that direct tourism-related sales of the water transportation industry has, over the last 11 quarters, been increasing at an average annual rate of 10 percent. The LAEDC forecasts continued modest growth in tourism by domestic travelers over the next few years, which would, of course, benefit the harbors and the businesses associated with them.

Overall boating activity in California consistently expanded both in absolute numbers and in per capita participation between 1960 and 1996 as evidenced by the number of boat registrations (California DMV 2003). The data indicates that the boat population in the state increased five-fold over the period. During that same period the human population doubled its numbers. As a result, per capita ownership showed an increase from 11 boats per thousand persons to 27 boats per thousand persons in that time span. For the decade 1986 to 1996, there was a steady growth of around 2.5 percent per year in boat registrations throughout the state. While there was strong growth in vessel registration between 1986 and 1996, since then the number of boats per thousand persons decreased by over 6 percent. The number of boats registered as of December 2002 is only slightly higher than the 1996 number.

Finally, it is important to briefly note the contribution of the County’s beaches to the economy. A study by The Research Team estimates the economic impact of beach-related expenditures in the County between June and August of 2000 to be between $113 million and $118 million in direct and indirect effects. The direct effects correspond to a direct employment impact (equivalent annual full and part-time jobs) of nearly 8,500 jobs. The authors note that these estimates represent an upper bound on the economic losses that could result if beach attendance were to decline. Some level of beach attendance decline, which would incur some level of local financial loss as well as likely National Economic Development (NED) losses from recreation opportunities forgone, could result from beach closures, water quality deterioration, or decreased access to beach areas.

From the above discussion of some of the local and regional economic issues, the most important points include:

- Near and medium-term growth in seaborne trade (both absolute and as a percentage of total global trade) is expected to continue into the foreseeable future.
- Tourism-related revenues from water transportation have shown strong growth over the last few years and modest growth is expected into at least the near future.
- The POLB and POLA comprise two of the most important sources and conduits of economic activity in the Region and the nation. Expected future growth in seaborne trade represents both a significant opportunity and a formidable challenge to the ports,

as the ability to accommodate increased demand for port services depends on making improvements to overall infrastructure.

7.4 Future without Project Conditions

This section will describe in detail each of the four Study Areas with regards to their economic importance to the Region. The section will also describe the future costs of dredging and disposal for the various locations within the study area. For the POLA and POLB, and for Marina Del Rey, the continuation of maintenance dredging into the future is assumed. As stated previously, it is assumed that dredging at all sites will be maintained at such a level that neither commercial navigation nor recreational activity will be adversely impacted.

Under the future without project conditions, the costs can be said to be comprised of both the actual dredge and disposal cost as well as the study and regulatory costs that are associated with the completion and approval of the environmental report that are requisite for dredge and disposal activity to go forward. These study and regulatory costs are the result of conducting and approving, for example, Environmental Impact Statements or Environmental Assessments of a particular dredge and disposal event. Of course, of these two components, the costs for the actual dredging and disposal of the sediment comprise the vast majority of total without project costs. Thus, the following discussion will focus on this cost element, and no attempt will be made at this point to quantify the future without project study costs over the 20-year study period.

Additionally, this study does not develop or include single estimates of the expected future without project dredging and disposal costs for the various locations. Instead, the analysis uses as a basis the cost estimates developed in a previous feasibility study as well as recent dredging and disposal event cost information as available, and simply provides a range of costs given various scenarios and assuming particular unit costs. It is expected that as the study moves forward a single most likely scenario for dredge material disposal will be developed.

7.4.1 Marina Del Rey Harbor

A previous USACE study (USACE 2000b), the 2000 F4 Feasibility Study of Marina Del Rey and Ballona Creek (the 2000 study) estimated, among other things, the value of recreational and commercial navigation, as well as the overall economic impact of the existence of Marina Del Rey Harbor. The following sections will draw extensively from this report.

The Marina del Rey Harbor is the largest man-made small craft harbor in the world, accommodating over six thousand private pleasure boats. It began as a large undeveloped estuary, owned by the County, with Ballona Creek serving as a main outflow to the Pacific Ocean. Beginning in 1957, the area was dredged and prepared for development, but many delays were encountered through the harbor's complete construction. The harbor was successfully completed when an offshore breakwater was constructed in 1965 to protect the area from wave and storm action. Marina del Rey was formally dedicated in April 1965. Some important features of Marina Del Rey include the following: more than 6,000 recreational boat slips are available in the various marinas and hundreds of smaller boats in dry storage also claim Marina Del Rey as their home port; the total seating capacity of 35 restaurants and clubs represent the nations highest 2.6-square kilometer concentration of restaurant out-side of New York City; the boat launching ramp facilities make the marina a harbor of opportunity to about 100,000 trailer-class boats throughout the Southland; occupancy of the 5,800 apartment units holds consistently at 99 percent, and represents a population in excess of 10,800; seasonal day population often exceeds 30,000 persons.

The primary industries of employment in the Marina Del Rey area include: professional, scientific, management, administrative, and waste management services (22.0 percent); information (15.0 percent); educational, health, and social services (14.6 percent); and finance, insurance, real estate, and rental and leasing (12.9 percent) (City-data.com 2003). Public facilities constructed in recent years include Burton W. Chance Bark and Community Building, more than 580 linear meters of transient/gust boat docks, 55 meters of public fishing docks, Admiralty Park, view piers and promenade overlooking the main channel on both the north and south jetties.

The 2000 study, using modeling software, estimated very significant overall regional economic impacts (not including recreation value) of Marina activity on the surrounding communities. The breakdown of the economic impacts, once adjusted for inflation shows a total contribution to economic output of around $500 million. The inclusion of such estimates in this section, and the simple inflation of previous dollar amounts to current dollars, is merely meant to give a general idea of the economic importance of Marina del Rey to the regional economy.

7.4.2 Recreational Resource Value

As the world's largest man-made pleasure boat harbor, with the capacity for some 6,000 boats, Marina del Rey provides a wide variety of outdoor recreation opportunities. It offers activities ranging from walking, biking and beach activities to fishing and boating. This harbor offers a unique combination of amenities, making it a renowned California State attraction, not only in the U.S., but also around the globe. This study identifies three sources of recreational resource value at the Harbor: Park and beach activity; wet-berthed boating; and other classifications of boating including dry-berthed and launched.

Marina del Rey has four parks, including Admiralty Park, Aubrey E. Austin, Jr. Park, Burton W. Chase Park, and Harold Eddington Park. Admiralty Park consists of over 8 acres and has an 18-station exercise facility, a bike path, a jogging path, and landscaped lawn areas. Aubrey E. Austin, Jr. Park is located along the North Jetty Promenade near the Marina entrance and close to the ocean beach. This park offers fishing from the rock jetty and numerous lawn areas. Burton W. Chace Park is the largest park in Marina del Rey, 10 acres, and is significant because the County's Transient/Visitor docks are located there. This park is also equipped with picnic benches, a bicycle path, a fishing dock, and extensive grassy knolls. Harold Eddington Park is a small area comprised of walkways, lawns and benches. Also, of recreational value is the Marina's waterfront bike path. It is a segment of the Los Angeles 34-kilometer coastal bike path.

Mother's Beach, also referred to as Marina Beach, is situated inside of Marina del Rey Harbor at the base of Basin D. Being located inside of the marina, the beach is protected from the wave action of the ocean, which has allowed for the construction of a swimming ramp that can accommodate wheelchairs. Twelve acres comprise the beach area, which is staffed by Los Angeles County Lifeguards. More than two million visitors to the beach were counted between 1992 and 1997. In the six-year period from 1992 through 1997, beach attendance averaged just over 368,000 annually. No updated numbers were available at the time of writing.

According to U.S. Coast Guard estimates, about 10 percent of wet-berthed boats that depart from their slips simply cruise the harbor without going through the harbor entrance. Other within-harbor uses include rowing crew practice, scheduled dinghy races, rental boats, and dinner excursion boats. Launched boats, dry-berthed boats, and the "interior" uses of the harbor are classified as "other" boating in this report.

While wet-berthed boating accounts for the great majority of total recreational benefits at the Harbor, the 2000 study estimated additional significant recreation value associated with other boating classifications. A breakdown of the annual usage was determined to be 83 percent wet-berthed boats, 14 percent launched boats, and 3 percent dry-berthed boats. The study estimates (conservatively, according to the author) that the boating activities not associated with wet-berthed vessels have a recreational value equal to one-quarter of the value associated with wet-berthed boating. These other boating activities include the use of launched boats, dry berthed boats, and include various other boating activities that are related to "interior" Harbor uses (e.g. rowing clubs).

According to the 2000 study, the total estimated annual value of recreation at Marina Del Rey, converted to current dollars, is around $17 million. Recreation associated with wet-berthed boats accounts for half of the estimated recreation benefits. Other boating types and patronage of Mother's Beach each contribute about one-quarter of the total estimated value of recreation.

This estimation of the overall value of recreation at the Marina was originally made in order to help determine how much value would be foregone following a cessation of dredging maintenance activities. For our purposes, and in the absence of additional analysis, the estimation serves as a readily available quantification of approximate resource value at the marina. The 2000 feasibility report found the likely losses following non-maintenance to be between four and six million dollars annually, depending on assumptions. Underlying the calculated losses is the estimation that shoaling will incrementally reduce the volume of navigation at the Harbor, and that no navigation will be possible after following the seventh year of non-maintenance. Adjusting these numbers for inflation and annualizing with the 2004 federal interest rate of 5.625 percent results in an estimate of recreational value added by dredging of between five and seven million dollars.

7.4.3 Commercial Navigation

Marina Del Rey Harbor is used predominantly for its recreational resources as were described in the preceding section. There are, however, some commercial navigation activities undertaken via the Harbor, including an active sportfishing industry and a ferry service line to Catalina Island. As of 2000, there were five sportfishing charter vessels currently utilizing the harbor at Marina del Rey. These vessels are berthed at Fisherman's Village. The vessels are characterized as commercial passenger fishing vessels by the California Department of Fish and Game (CDFG). All of the sportfishing charter vessels offer half-day charters and at least one offers full-day charters and closed club charters.

Marina Del Rey is an irreplaceable resource for the sportfishing outfits that are currently located there. Respondents to a survey that was included as part of the 2000 study, indicated that relocating to alternative harbors would not be practical due to two main factors: a) there are no vacancies in other harbors for additional sportfishing charter boats since the slips dedicated to commercial fishing boats are occupied by commercial gill netters, lobstermen, and other sportfishing charter boats and b) the sportfishing charter boat business is dependent on being easily accessible to the public and Marina del Rey offers that to the entire Los Angeles Basin. The study estimated the total annualized loss in net income of the sportfishing outfits to approximate $145,000.

7.4.4 Projected Dredging/Sediment Removal & Disposal Costs

As detailed in Section 2.2.1 of this Appendix, the total maintenance dredging volume between the years 1969 and 1999 was just less than 1.5 million m^3. It follows that the average annual maintenance dredging volume over this period was around 49,000 m^3 (approximately 95,000 per event). Maintenance dredging was conducted on average every four years over this thirty-year period, but every two years over the past decade. USACE expects the annual dredge volume at this site over the next twenty years to be between 50,000 and 100,000 m^3.

Employing unit cost estimates and dredge volumes developed in the 2003 FS (USACE 2003b), Table 7-4 shows that as the percentage of contaminated material disposed at an upland location ranges from zero to one-hundred, the annual dredge and disposal cost, holding all else constant and excluding mobilization, demobilization, and administrative and design costs, ranges from approximately $0.8 million to $4.8 million. Table 7-4 combines the range of expected dredge volumes with the possible percentages of upland disposal of contaminated sediment, resulting in a wide range of cost for the different scenarios. For example, under the least cost scenario, only 50,000 m^3 are dredged per year (100,000 m^3 per event), and all of the contaminated material is disposed of at a local site of opportunity – in this case the North Energy Island Borrow Pit (NEIBP).

Continuing, the difference between the low and high end of the range of likely costs is attributable to varying assumptions about the disposal method for the contaminated material. As the 2003 FS describes, the low end of the specified cost range assumes disposal of the contaminated material at a contained ocean disposal site. At the highest end of this cost range, it is assumed that all contaminated material is disposed of at the ECDC landfill in Utah. According to the 2003 FS, the cost to dredge and dispose of the contaminated material at the upland location would be approximately $150/m^3$, not including an additional approximate 50 percent for others costs such as supervision and administration, design, contingency, etc. The cost estimate that includes the upland disposal of all contaminated sediments effectively serves as an upper bound of the cost of dredging and disposal at the harbor, given that it is likely that at least some portion of the contaminated material would be able to be disposed in a less costly manner. The volume of contaminated material that can be disposed of in less costly manners depends, of course, on the available sites of opportunity. Importantly though, as the 2003 FS states, the availability of sites of opportunity cannot be guaranteed into the future.

Table 7-4 Dredge and Disposal Costs with Varying Volumes of Upland Disposal of Contaminated Sediment

Percent of Contaminated Sediment Disposed Upland	Annual Maintenance Dredge and Disposal Cost Estimates[1]					
	0	20	40	60	80	100
Marina Del Rey (25% contaminated)[2]						
Total Volume = 50,000 m^3	$775,000	$1,100,000	$1,425,000	$1,750,000	$2,075,000	$2,400,000
Total Volume = 100,000 m^3	$1,550,000	$2,200,000	$2,850,000	$3,500,000	$4,150,000	$4,800,000
Average Cost Per Year	**$1,162,500**	**$1,650,000**	**$2,137,500**	**$2,625,000**	**$3,112,500**	**$3,600,000**
POLA (100% contaminated)[3]						
Total Volume = 44,000 m^3	$484,000	$1,707,200	$2,930,400	$4,153,600	$5,376,800	$6,600,000
Total Volume = 85,000 m^3	$934,120	$3,294,896	$5,655,672	$8,016,448	$10,377,224	$12,738,000
Average Cost Per Year	**$709,000**	**$2,501,000**	**$4,293,000**	**$6,085,000**	**$7,877,000**	**$9,669,000**
POLB (100% contaminated)[3]						
Total Volume = 31,000 m^3	$341,000	$1,202,800	$2,064,600	$2,926,400	$3,788,200	$4,650,000
Total Volume = 71,000 m^3	$780,890	$2,754,412	$4,727,934	$6,701,456	$8,674,978	$10,648,500
Average Cost Per Year	**$560,900**	**$1,978,600**	**$3,396,300**	**$4,813,900**	**$6,231,600**	**$7,649,300**
LARE (30% contaminated)[4]						
Total Volume = 86,000 m^3	$1,032,000	$1,744,100	$2,456,200	$3,168,200	$3,880,300	$4,592,400
Average Cost Per Year	**$1,032,000**	**$1,744,100**	**$2,456,200**	**$3,168,200**	**$3,880,300**	**$4,592,400**

1. Table can be read in columns as the dredge and disposal cost when varying the amount of sediment that is disposed of at an upland facility. The remainder of the contaminated sediment is assumed to be disposed of at a local site of opportunity.
   For three of the four sites, two annual dredge volumes are given, representing the expected range of volumes as specified in Section 3 of this report.
   Unit cost of upland disposal for all sites assumed to be $150/m^3$, as estimated in USACE 2003b Attachment B, page 1. All estimates exclude general conditions, design, supervision and administration, and contingency costs.
   The inclusion of administrative, design, contingency, and general conditions costs will increase the final cost by approximately 50 percent.
2. Based on $14/m^3$ dredge and ocean or beach disposal of clean material, and $20/m^3$ of contaminated material to the NEIBP. Estimate taken from USACE 2003b, Operation and Maintenance, Table 5, and Attachment C, page 1, respectively.
3. Based on $11/m^3$ disposal of contaminated material to a local site of opportunity. Source: USACE Coastal Engineering.
4. Based on $12/m^3$ dredge and disposal of all material to a local site of opportunity. Source: USACE Coastal Engineering.

7.5 Los Angeles Harbor

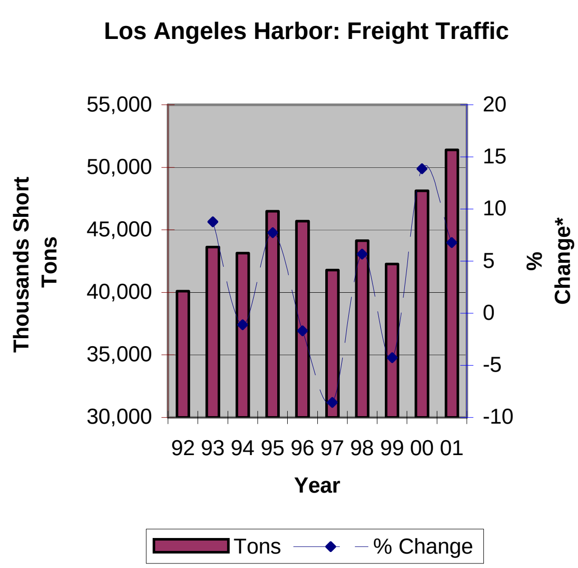
The City of Los Angeles estimates that the POLA supports over 250,000 full and part-time jobs in Southern California, and over 1.3 million nationwide. The POLA industry directly accounts for 16,360 jobs at or near the facilities, 85 percent of which are in trucking or warehousing. The primary activities at the POLA are in support of international and domestic trade. There are, however, other commercial activities, the most economically significant of these being the cruise line operations.

7.5.1 Recreational Resource Value

Just north of the POLA navigation channel, still within the San Pedro breakwater that protects the Port, are three marinas, estimated by port officials to include a total of approximately 1,300 slips for recreational boats. The Los Angeles and Cabrillo Beach Yacht Clubs are among the recreational organizations located at these marine facilities.

7.5.2 Commercial Navigation

The POLA is the world's eighth largest container port with respect to 20-foot equivalent units (TEUs). In 2001 and 2002 the POLA handled 5.18 and 6.11 million TEUs, respectively. In the year 2000 the POLA was the nation's number one port with respect to net income, amounting to nearly $84 million. The Port of Long Beach followed closely with just over $83 million, according to the Institute for Water Resources (IWR 2003).



According to the Institute for Water Resources (IWR), the POLA handled a total of 51.4 million tons in 2002. Eighty-seven percent of the tonnage derived from foreign trade, and just over two-thirds of the foreign trade was in imports. The Port's top trading partners include Japan, China, Taiwan, South Korea, and Ecuador.

The graph above depicts the change in freight traffic at Los Angeles Harbor between 1992 and 2001. The annual tonnage figures have an average absolute value percentage change of around 6 percent, indicating relatively stable traffic flows over the period. The variation in annual tonnage is slightly higher than that for two other sampled ports on the Atlantic and Gulf Coasts (Baton Rouge−5 percent; Lake Charles−3.1 percent). The three-year moving average demonstrates the generally stable and overall upward trend of tonnage through the Port.

According to the IWR, non-tow vessel traffic at the POLA in 2001 amounted to around 19,600 trips including inbound and outbound vessels. Foreign commerce accounted for around 2,100 of the inbound trips, and domestic commerce comprised just less than 10,000 of the inbound. Importantly though, vessel trips for foreign commerce represented the vast majority of large vessels calling the Port; accounting for 90 percent of vessels with drafts greater than 6.7 meters.

Besides commercial trade, the POLA is a very important center for commercial cruise and sportfishing outfits. In total, twelve cruise lines call the POLA. The POLA owns the largest passenger facility on the West Coast–the World Cruise Center. According to the POLA, in recent years more than one million passengers annually have traveled via the Cruise Center. The Cruise Center is leased to a consortium of five cruise lines, including Carnival, Cunard, Norwegian, Princess, and Royal Caribbean. The majority of cruises are bound for popular Mexican coastal cities. The POLA also serves as an intermediate stop for additional cruises to and from various parts of the world. The POLA has two passenger terminals that can accommodate up to three full-size cruise vessels simultaneously.

In addition to the large cruise ships that call the POLA, there are also local ferry services that operate between the POLA and Catalina Island. According to the Catalina Island Chamber of Commerce there are two ferry operators working out of San Pedro that serve Catalina Island. One of the operators, Catalina Express, is the proprietor of the vessel Catalina Jet, which is the second largest catamaran built in the U.S., with a length of 44 meters and a width of 12 meters. It is the fastest commercial passenger vessel on the West Coast, and includes three decks, snack and beverage service, and a full bar. Total passenger capacity is 450, and the vessel makes several departures per day with a reduced winter schedule between October and March. In addition to the high-speed catamaran, there is a lower priced, more traditional catamaran that makes multiple trips daily.

Located along the POLA's navigation channel is the Ports O' Call Village, a New England-style seaside village encompassing fifteen acres of shops, restaurants and attractions. Ports O' Call is the departure point for narrated Harbor Cruises, which from January through March include Whale Watching Cruises. Commercial Sport and barge fishing boats also depart from this location.

7.5.3 Projected Dredging/Sediment Removal & Disposal Costs

For the POLA, as detailed in Section 2.3.1 of this report, the total maintenance dredging volume between the years 1978 and 2002 was around 2 million m^3. It follows that the average annual maintenance dredging volume over this period was around 85,000 m^3. Over that period another approximately 58 million m^3 has been dredged as part of capital improvement projects at the POLA. As stated in Section 3.3.1 of this report, taking into account the POLA's expectations for the annual dredge volume over the next five years, USACE estimates the POLA's annual volume of contaminated dredge material to be between 44,000 and 85,000 m^3 over the next twenty years.

Actual average unit dredge and disposal data was not available from the POLA, but USACE Coastal Engineers indicate that a reasonable estimate of the unit cost, using data and prices from similar USACE dredge and disposal circumstances, is around $\$11/m^3$. In general, the total actual cost of dredging and disposal is highly variable because it depends on several factors including the level of contamination of the material, the dredge method, and the distance of the disposal site from the dredge location. Given, however, that POLA officials have indicated they will likely be able to accommodate all of their dredge material on-site, the total unit cost can be expected to be relatively stable over the next 20 years and less uncertain as compared to the dredging and disposal costs for Marina Del Rey and the LARE.

Importantly, the ability of the POLA to accommodate the placement of contaminated material as part of land expansion or capital improvement projects is at least somewhat dependent on the future growth in trade at the POLA, which is, of course, tied to economic growth and international trade patterns. As with the other sites in the Study Area, dredge and disposal costs would increase significantly in the event that the contaminated material from maintenance dredging had to be disposed at an upland site, as opposed to being contained at the POLA. As an example, and as stated previously with regards to maintenance activity at Marina Del Rey, the 2003 FS estimates that the unit cost for dredging and disposal of contaminated material, with disposal at an upland facility, could be as much as $\$150/m^3$, not including administrative and other general costs.

Employing unit cost estimates for upland disposal developed in the 2003 FS (USACE 2003b), Table 7-4 shows that as the percentage of contaminated material disposed at an upland location ranges from zero to one-hundred, the annual dredge and disposal cost, holding all else constant and excluding mobilization, demobilization, and administrative and design costs, ranges from approximately $0.5 million to $12.7 million. The table combines the range of expected dredge volumes with the possible percentages of upland disposal of contaminated sediment, resulting in a wide range of cost for the different scenarios. For example, under the least cost scenario, only 44,000 m^3 are dredged per year (88,000 per event), and all of the contaminated material is disposed of at a local site of opportunity – for example, either at a Port landfill or the NEIBP. The highest cost scenario assumes all the dredge material is shipped to the ECDC landfill, at a cost of $150/$m^3$.

7.6 Long Beach Harbor

According to Port officials, the POLB directly and indirectly supports nearly 30,000 jobs in the City of Long Beach and nearly 1.4 million jobs across the nation. The POLB contributes approximately $5.6 billion annually in state and local tax revenues.

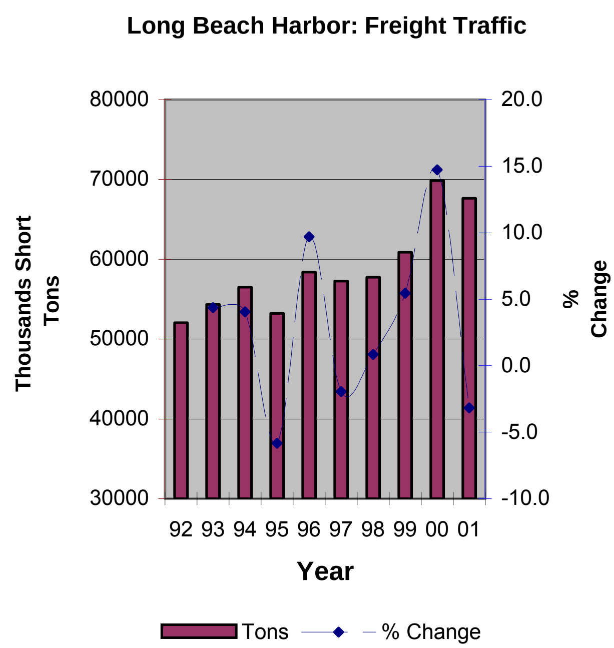
7.6.1 Recreational Resource Value

As this appendix considers the POLB and the LARE separately, and given that nearly all of the recreational resource value in the area encompassing both locations can be more appropriately assigned to the areas designated as within the LARE, no recreational resources will be assigned to the POLB.

7.6.2 Commercial Navigation

The POLB is the United States' second busiest port, and the world's twelfth busiest container cargo port. If combined, the POLB and POLA would be the world's third-busiest port complex, after Hong Kong and Singapore. In 2002, the POLB handled nearly 65 million metric tons of cargo, equivalent in value to $89 billion. This volume of cargo is almost exactly the average annual tonnage handled between the years 1998 and 2002. In 2002, revenues, while ten percent higher than in 1998, were down 10 percent from the five-year period's high of $98.2 billion. According to the POLB, container throughput has increased by 175 percent since 1990.

The chart above shows the POLB's freight traffic between the years 1992 and 2001, as recorded by IWR. By this measure, activity at the Port declined three years within the 10-year period of analysis. The three-year moving average of tonnage increased or remained practically stable over the whole decade. The average of the absolute value of the percentage change was 5.5 percent, which is slightly lower than the variation in POLB tonnage variation, and in-line with the tonnage variation at other non-Pacific Coast harbors sampled.



The Harbor Department reports that most cargo categories increased in trade volume in the fiscal year (FY) 2002. Containerized cargoes represented around two-thirds of the tonnage revenues, and the year included a record number of TEUs, increasing nearly 5 percent over 2001. The trend in the direction of containerized goods flow at the POLB followed the regional trend; inbound and outbound loaded containers increased and decreased by about 5 percent, respectively. This brought the overall ratio of inbound to outbound loaded containers to 2.7 to 1. Most other cargo types showed small increases in FY 2002, including liquid bulk cargo, which is the second largest category with over 31 million metric tons during the year.

East Asian trade accounts for more than 90 percent of the shipments through the POLB. The POLB's top trading partners (and 2002 trade value) are: China/Hong Kong ($35.6 billion), Japan ($18.1 billion), and South Korea ($9.2 billion) and Malaysia ($3.7 billion). More than 4.5 million TEUs moved through the POLB in 2002.

Leading imports by tonnage are: petroleum, salt, electric machinery, machinery, furniture, vehicles, chemicals, steel products, and toys. By value the leading exports are: machinery, electric machinery, vehicles, toys, clothing, furniture, shoes, and plastics and medical equipment. According to IWR, non-tow vessel traffic at the POLB in 2001 amounted to just over 16,500 trips including inbound and outbound vessels. Foreign commerce accounted for around 2,000 of the inbound non-tow trips, and domestic commerce comprised just over 6,100. Importantly though, vessel trips for foreign commerce represented the vast majority of large vessels–87 percent of vessels with drafts greater than 6.1 meters.

7.6.3 Projected Dredging/Sediment Removal & Disposal Costs

For the POLB, as detailed in Section 2.3.2 of this report, the total volume of maintenance dredge material between the years 1976 and 2003 was just less than 2 million m^3. It follows that the average annual maintenance dredging volume over this period was just over 71,000 m^3. Over that period another approximately 13 million m^3 has been dredged as part of capital improvement projects at the POLB. As stated in Section 3.3.2 of this report, taking into account the POLB's expectations for the annual dredge volume over the next four years, USACE estimates the POLA's annual volume of contaminated dredge material to be between 31,000 and 71,000 m^3 over the next twenty years.

As with the POLA, actual average unit dredge and disposal data was not available from the POLB, but USACE Coastal Engineers indicate that a reasonable estimate of the unit cost, using data and prices from similar USACE dredge and disposal circumstances, is around $\$11/m^3$. In general, the total actual cost of dredging and disposal is highly variable because it depends on several factors including the level of contamination of the material, the dredge method, and the distance of the disposal site from the dredge location. Given, however, that POLA officials have indicated they will likely be able to accommodate all of their dredge material on-site, the total unit cost can be expected to be relatively stable over the next 20 years and less uncertain as compared to the dredging and disposal costs for Marina Del Rey and the LARE.

Importantly, the ability of the Port to accommodate the placement of contaminated material as part of land expansion or capital improvement projects is at least somewhat dependent on the future growth in trade at the POLB, which is, of course, tied to economic growth and international trade patterns. As with the other sites in the Study Area, dredge and disposal costs would increase significantly in the event that the contaminated material from maintenance dredging had to be disposed at an upland site, as opposed to being contained at the POLB. The 2003 FS also estimates that the unit cost for dredging and upland disposal of contaminated material could be as high as $150/m^3.

Employing unit cost estimates for upland disposal developed in the 2003 FS (USACE 2003b), Table 7-4 shows that as the percentage of contaminated material disposed at an upland location ranges from zero to one-hundred, the annual dredge and disposal cost, holding all else constant and excluding mobilization, demobilization, and administrative and design costs, ranges from approximately $0.3 million to $10.7 million. The table combines the range of expected dredge volumes with the possible percentages of upland disposal of contaminated sediment, resulting in a wide range of cost for the different scenarios. For example, under the least cost scenario, only 31,000 m^3 are dredged per year (62,000 per event), and all of the contaminated material is disposed of at a local site of opportunity – for example, either at a Port landfill or the NEIBP. The highest cost scenario assumes all the dredge material is shipped to the ECDC landfill, at a cost of $150/m^3.

7.7 Los Angeles River Estuary

7.7.1 Recreational Resource Value

At the mouth of the Los Angeles River are located both Rainbow Harbor and Long Beach Shoreline Marina. The Long Beach Shoreline Marina opened in 1982 and has 1,844 slips for recreational boaters. It is located in the heart of downtown Long Beach and is home to, among others, the Shoreline Yacht Club. Rainbow Harbor is located next to the Aquarium of the Pacific. The Harbor is home to both commercial and recreational vessels, and has 103 slips available. As of October 2003 there were zero slips available at either of the harbors within the LARE.

7.7.2 Commercial Navigation

Rainbow Harbor, located at the LARE, offers a wide range of commercial boating services, including sportfishing, day cruises, harbor tours, and service to Catalina Island. According to the Catalina Island Visitors Bureau, there are two operators providing passenger service to the Island from the Estuary's docks. Both the Catalina Express and the Catalina Explorer operate from docks located within the LARE.

7.7.3 Projected Dredging/Sediment Removal & Disposal Costs

For the LARE, as detailed in Section 2.3.3 of this report, the total volume of material from maintenance dredging between the years 1979 and 2001 was just over 1.2 million m^3. It follows that the average annual maintenance dredging volume between 1990 and 2001 was around 86,000 m^3 (172,000 m^3 per event). Maintenance dredging was undertaken approximately every two years over the past decade. USACE and the City of Long Beach expect the annual maintenance dredging volume at this site over the next 20 years to be around 86,000 m^3.

As in the case of Marina Del Rey, it is important to note that the total cost of dredging and disposal of the LARE is highly variable because it depends, among other things, on the volume and level of contamination of the material and the location of the various disposal sites. Using historic dredging records for Marina Del Rey as cited in the 2003 FS indicates that ocean or beach disposal costs for *clean material* range from approximately \$4/m^3 to as high as \$31/m^3 in 2004 dollars. The 2003 report also estimates that the unit cost for dredging and disposal of *contaminated material* could be upwards of \$150/m^3 for material that needed to be shipped to an upland disposal site. Whether the contaminated material would have to be disposed of at an upland location, however, depends on the availability of sites of opportunity, such as local port projects that could accept the contaminated material as landfill. USACE Operations estimates that, on average, 30 percent of the material dredged from the LARE classifies as contaminated.

While upland disposal of contaminated dredge material does not appear to be imminently necessary, according to USACE Coastal Engineers, it may very well be that the ability to dispose of material in the medium and long-term future at local sites of opportunity will be diminished to an extent that makes some level of upland disposal necessary (for example, when further port expansion becomes infeasible given the location of the existing breakwater). In the event that all of the contaminated sediments must be disposed of at an upland landfill (the ECDC Landfill in Utah is assumed), the annual real total dredge and disposal cost per event could be nearly \$3 million (assuming ocean disposal of all clean material at \$19/m^3 and upland disposal of contaminated material, which is assumed to constitute 30 percent of the dredge volume, at \$150/m^3 plus administrative and other general costs). This estimate effectively serves as an upper bound of the cost of dredging and disposal at the harbor, given that it is likely that at least some portion of the contaminated material would be able to be disposed in a less costly manner, depending on the available sites of opportunity and the degree of material contamination.

Employing unit cost estimates for upland disposal developed in the 2003 FS (USACE 2003b), Table 7-4 shows that as the percentage of contaminated material disposed at an upland location ranges from zero to one-hundred, the annual dredge and disposal cost, holding all else constant and excluding mobilization, demobilization, administrative, design, and contingency costs, ranges from approximately \$1.0 million to \$4.6 million. The Table 7-4 combines the expected dredge volume with the possible percentages of upland disposal of contaminated sediment, resulting in a range of costs for the different scenarios. For example, under the least cost scenario, all of the 86,000 m^3 are disposed of at a local site of opportunity; none of the contaminated sediment is shipped upland for disposal. The highest cost scenario assumes all the contaminated sediment (assumed to constitute 30 percent of the total volume of sediment dredged) is shipped to the ECDC landfill, at a cost of \$150/m^3. Finally, it should be noted that Section 3.3.3 of this report states that in may not be possible to separate the clean material from the contaminated, in which case the percent contaminated would be 100 percent, instead of the 30 percent that is assumed here.

7.7.4 Projected NED Impacts to Passenger Ferry Service to/from Queensway Marina

Importantly, when evaluating the NED impacts of federal action or inaction, only those impacts that represent a change in net national economic development are considered. That is, a federal interest in project exists when the project makes a net contribution to the national output of goods and services, expressed in monetary units. In accordance with ER 1105-2-100, the change in net income to the owners/operators of commercial vessels is considered an NED impact. Importantly, the NED impact discussed below is based on short-term shoaling of the marina entranceway. At the time of writing, Catalina Express officials had not yet responded to requests for data on seasonal passenger numbers and ferry capacity. It is believed that this information is necessary for a more detailed description (and quantification) of the regional and/or national economic impacts of shoaling at the Queensway Marina. The potential economic impacts of shoaling of areas beyond the Queensway Marina (for example, at Rainbow Harbor) were not considered here.

Out of the Queensway Marina in downtown Long Beach, the Catalina Express offers departures to Catalina Island eight times per day, all year round. The company operates out of three locations in the ports of Long Beach and Los Angeles, and one location in Dana Point. The company operates a total of seven vessels from these locations and serves approximately 1.2 million passengers per year. According to Catalina Express officials, there are two vessels departing from the Catalina Landing location and two from the area adjacent to the Queen Mary. They have operated at the Queen Mary location since 1989 and at the Catalina Landing site since 2000. The Catalina Landing site is the most popular departure and destination point, according to Catalina Express officials, because of the availability of parking and the proximity of the terminal to downtown Long Beach.

The buildup up of sediment in the area adjacent to the Queensway Marina creates the potential that a significant storm event could shift the material in such a way as to prevent the transit of all watercraft into and out of the marina. Dredging of the affected areas following such an event would, according to USACE Coastal Engineers, take anywhere from a few weeks to more than a month.

According to USACE Coastal Engineers, a significant storm and resultant shoal event is most likely to occur in the non-summer months, namely October through April. Given that this is outside of the high season for ferry travel, and given that there are numerous alternative locations in the local area from which Catalina passengers can arrive and depart, the economic impact of a sudden, short-term shoal event at the entrance to the Queensway Marina is not expected to be significant. That is, it appears that the vast majority of both confirmed and prospective passengers would be able to be accommodated by either Catalina Express at a different location, or one of the other ferry operators in the area. That being said, there will ostensibly be, however minor, some additional costs incurred to those passengers that arrive to or depart from a non-optimal location; costs in the form of, for example, fuel or additional time spent in transit. There would also likely be some income loss to Catalina Express, but because the operator would be able to adjust operating expenses, it appears likely that losses would be relatively minor. A storm and resultant storm event during the summer months would, however, likely have at least marginally more significant economic impacts given the higher passenger numbers during those months.

8 REFERENCES

ABC (Aquatic Bioassay and Consulting Laboratories Inc.). 1997. The Marine Environment of Marina del Rey Harbor July 1996 – June 1997. Prepared for the County of Los Angeles Department of Beaches and Harbors.

Allen, L.G. 1991. The Fish Populations Inhabiting Lower Marina Del Rey Harbor and Ballona Channel from July 1990 to April 1991.Technical Report for MacGuire Thomas Partners.

Atwood, J. L. and P. R. Kelly. 1984. Fish Dropped on Breeding Colonies as Indicators of Least Tern Food Habits. Wilson Bulletin 96:34–47.

Barnett, A. M., and A. E. Jahn. 1987. Pattern and Persistence of a Nearshore Planktonic Ecosystem off Southern California. Continental Shelf Research 7:1-25.

Blunt, C.E. 1980. California Coastal Marine Resource Atlas. State of California, Resource Agency, California Department of Fish and Game (CDFG).

Brewer, G. D. 1976. Resuspended Sediment Elutriate Studies on the Northern Anchovy. In Marine Studies of San Pedro Bay, California. Part II, Potential Effects of Dredging on the Biota of Outer Los Angeles Harbor. Edited by D. F. Soule and M. Oguri. Prepared for Allan Hancock Foundation and Office of Sea Grant Program, University of Southern California, Los Angeles.

Brewer, G. D. 1983. Fish Spawning in the Los Angeles and Long Beach Harbors: Comparison with Shallow Open Coast Habitats off Southern California. Prepared for NOAA, National Marine Fisheries Service, Environmental Assessment Branch, Los Angeles Harbor Department Agreement No. 190.

Brittan, M., A. Albrecht, and J. Hopkirk. 1963. An oriental goby collected in the San Joaquin River delta near Stockton, California. California Department of Fish and Game (CDFG) 49(4):302-304.

California Department of Finance. *California Statistical Abstract*, 13-15. Demographic Research Unit. 2003.

California Department of Motor Vehicles (DMV). 2003. Vessel Registration Reports, 2003. http://www.dbw.ca.gov/VesselReg.htm.

California Department of Parks and Recreation. 1992. Dockweiler State Beach General Plan. Chambers, 2003. Draft EIR/EIS for the Ballona Creek Sediment Control Management Plan. Prepared for the U.S. Army Corps of Engineers, Los Angeles District. Chambers Group, Inc. March.

California Department of Transportation (DOT). 2003. http://www.dot.ca.gov/hq/tpp/offices/ote/lac.pdf.

California Employment Development Department. (to be completed in final (p112))

California Office of Environmental Health Hazard Assessment. 2003. California Ocean Fishing Regulations Book.

CDFG (California Department of Fish and Game). 1981. Determination of the Status of the Los Cerritos wetlands.25 pp.

CDIP (Coastal Data Information Program). 2003. Wave Database.

Chambers Group. 1998. Preliminary Draft Dredge Material Management Plan Programmatic Environmental Impact Statement/Report for Harbors/Marinas in the Los Angeles Region. Prepared for the U.S. Army Corps of Engineers, Los Angeles District. September 1998.

Chelton, D.B. and R.E. Davis. 1982. Monthly Mean Sea Level Variability along the West Coast of North America. Journal of Physical Oceanography, 12:757-784.

Childs, H.E. Jr. 1993. Where Birders Go in Southern California. Los Angles Audubon Society.

City of Los Angeles. 2003. 2003 City of Los Angeles Economic and Demographic Information.

City-data.com. 2003. http://www.city-data.com/city/Marina-del-Rey-California.html.

CSULB (California State University, Long Beach). 2003. CSULB Economic Forecast Predicts Significant Improvement by 2004. *This Week @ the Beach*. May 19, 2003. http://karl.papubs.csulb.edu/news-events/story.cfm?hackid=71

Dailey, M.D., J.W. Anderson, D.J. Reish and D.S. Gorsline. 1993. The Southern California Bight: Background and Setting. In Ecology of the Southern California Bight: A Synthesis and Interpretation. University of California Press. Berkeley, CA.

Dawson, J.K. and R.E. Pieper. 1993. Zooplankton in M.D. Dailey, D.J. Reish, and J. W. Anderson Ecology of the Southern California Bight. University of California Press.

DiGiacomo, P. M. and B. Holt. 2003. Circulation in the Southern California Bight. Research Notes. California Institute of Technology.

DMJM. 1984. Santa Monica Pier Reconstruction Feasibility Report. Prepared for the City of Santa Monica.

The Economist. 2003. Engine Trouble. October 2, 2003. http://www.economist.com/displaystory.cfm?story_id=2101440

Economy Efficiency Commission. 2003. http://eec.co.la.ca.us/present/pres0403a.htm

EQA and MBC (Environmental Quality Analysts and Marine Biological Consultants). 1978. Marine monitoring studies, Long Beach Generating Station. Final report 1974-1978. Prepared for Southern California Edison Company. December.

Eschmeyer, W.N., E.S. Herald, and H. Hammann, eds. 1983. A Field Guide to Pacific Coast Fishes of North America. Houghton Mifflin Co., Boston. 366 pp.

Flick, R.E. and A. Badan-Dangon. 1989. Coastal Sea Levels during the January 1988 Storm off the Californias. Shore and Beach, Vol. 57, No. 4.

Forney, K.A. and J. Barlow. 1998 Seasonal patterns in the abundance and distribution of California cetaceans, 1991-92. Mar.Mamm.Sci. 14(3):460-489.

Gill, S., J.R. Hubbard, and W.D. Scherer. 1998. Updating the National Tidal Datum Epoch for the United States. Proceedings of the Marine Technology Society Annual Conference. Baltimore, MD.

Graham, N.E., and W.B. White. 1988. The El Nino Cycle: A Natural Oscillator of the Pacific Ocean Atmospheric System. Science 240: 1293-1302.

Haaker, P. 1979. Two asiatic gobiid fishes, *Tridentiger trigonocephalus* and *Acanothogobius flavimanus*, in southern California. Bulletin of the Southern California Academy of Science 78:56-61.

Hales, L.Z. 1980. Littoral Processes Study, Vicinity of Santa Ana River Mouth from Anaheim Bay to Newport Bay, Final Report, U.S. Army Corps of Engineers, Waterways Experiment Station, Tech. Report HL-80-9, Vicksburg, Mississippi, 107 p.

HEP (Harbors Environmental Projects). 1976. Environmental investigations and analyses, Los Angeles-Long Beach Harbors 1973-1976. Submitted to the U.S. Army Corps of Engineers. December.

HEP (Harbors Environmental Projects). 1979. Marine Studies of San Pedro Bay, California, Part 16, Ecological Changes in Outer Los Angeles-Long Beach Harbors Following Initiation of Secondary Waste Treatment and Cessation of Fish Cannery Waste Effluent. Allan Hancock Foundation and Office of Sea Grant Programs, Institute of Marine and Coastal Studies, University of Southern California.

HEP (Harbors Environmental Projects). 1980. The Marine environment in Los Angeles and Long Beach Harbors during 1978, Marine Studies of San Pedro Bay, CA, Part 17. Edited be D. F. Soule and M. Oguri. June.

Hickey, B.M. 1992. Progress in Oceanography, Vol. 30: 37-115.

Hickey, B.M. 1993. Physical Oceanography. In Ecology of the Southern California Bight: Synthesis and Interpretation. University of California Press. Berkeley, CA.

Hicks, S.D., and L.E. Hickman, Jr. 1988. United States Sea Level Variations through 1986. Shore and Beach. July.

Hoffman, J., D. Keyes, and J. Titus. 1983. Projecting Future Sea Level Rise. Government Printing Office. Washington, D.C.

Holt, H. 1990. A Birder's Guide to Southern California. American Birding Association.

Horn, M. A., and L. G. Allen. 1981. A Review of Synthesis of Ichthyofaunal Studies in the Vicinity of Los Angeles and Long Beach Harbors, Los Angeles County, California. Final report. Prepared for U.S. Fish and Wildlife Service.

Ingle, J.C. Jr. 1966. The Movement of Beach Sand. Development in Sedimentology. Vol. 5. Elsevier, NY.

IWR (Institute for Water Resources). 2003. *NDC Publications and U.S. Waterway Data CD*. Volume 9.

Jackson, G.A. 1986. Physical Oceanography of the Southern California Bight. In Lecture Notes on Coastal and Estuarine Studies. R.W. Eppley, Ed. Springer-Verlag, New York, NY.

Jones, B., M.A. Noble, and T.D. Dickey. 2002. Hydrographic and Particle Distributions over the Palos Verdes Continental Shelf: Spatial, Seasonal and Daily Variability. Continental Shelf Research. 22: 945-965. Elsevier Science Ltd.

Keane Biological Consulting. 1999. Breeding Biology of the California Least Tern in Los Angeles Harbor, 1998 Breeding Season. Final Report. Prepared for the Los Angeles Harbor Department.

Keane Biological Consulting. 2002. Draft Report: Breeding Biology of the California Least Tern in Los Angeles Harbor, 2002 Season.

Keane, K. 1997a. Foraging Study of the California Least Tern in Los Angeles Harbor, 1996 Breeding Season. Report to the Los Angeles Harbor Department.

Keane, K. 1997b. Breeding Biology of the California Least Tern in Los Angeles Harbor. Report to the Los Angeles Harbor Department.

Kerr, R.A. 1988. La Nina's Big Chill Replaces El Nino. Science, 241:1037-1038.

Kleppel, G.S., E. Manzanilla. 1980. Phytoplankton Abundance and Distribution in Santa Monica Bay. W. Bascom ed., Coastal Water Research Project Biennial Report 1979 – 1980. Southern California Coastal Research Project.

Kurtz, E.S. 1977. Southern California Weather for Small Boaters. Western Region Pamphlet. National Weather Service.

LACDPW (Los Angeles County Department of Public Works). 1991. Hydrology Manual.

LAEDC (Los Angeles County Economic Development Corporation). 2003. Los Angeles County Profile. http://laedc.org/data/about_LA_county/la_profile.shtml.

LAHD (Los Angeles Harbor Department). 1984. Draft Supplement II Environmental Impact Report for Wharf and Backland improvement at Berths 225-229, Port of Los Angeles. February.

LAHD (Los Angeles Harbor Department). 1997. Draft Environmental Impact Report, Channel Deepening Project, Port of Los Angeles.

LAHD (Los Angeles Harbor Department). 1999 Pier 400 Container Terminal and Transportation Corridor Project. Draft Supplemental Environmental Impact Report. SCN 98031135. ADP No. 980107-003. January.

Landrum and Brown. 1996. Sediment Budget, Transport and Shoreline Evolution Study, LAX Master Plan - EIR/EIS Ocean Oriented Study.

Lee, A.C. 1993. Sources and Relative Fluxes for Foreshore Sand from Point Arguello to the United-States Mexico Border: Fourier Grain-Shape Analysis. Ph.D Thesis. University of Southern California.

Lee, A.C. and Osborne, R.H. 1995. Relative Fluxes of Sand for Southern California Beaches: Fourier Grain-Shape Analysis. Shore and Beach, Vol. 63, No.3.

Lee, H.J., M.A. Noble, and J. Xu. 2003. Sediment Transport and Deposition Processes near Ocean Outfalls in Southern California. In: Contaminated Sediments: Characterization, Evaluation, Mitigation/Restoration, and Management Strategy Performance. ASTM STP 1442. ASTM International, West Conshohocken, PA.

Lewis, R.D. and K.K. McKee. 1989. A Guide to the Artificial Reefs of Southern California. State of California Department of Fish and Game.

LAEDC (Los Angeles County Economic Development Corporation). (to complete in final).

LAEDC (Los Angeles County Economic Development Corporation). 2003. (to complete in final).

The Los Angeles Business Journal, 2002. (to complete in final).

Los Angeles County Department of Regional Planning. . 2000. 2000 Los Angeles County Demographic Profile. http://planning.co.la.ca.us/rsrch_LACountyProfile.pdf

Lu, Y. 1992. Fourier Grain-Shape Analysis of Beach Sand Samples and Associated Sedimentary Processes, Dockweiler and El Segundo Beaches, Santa Monica Bay, Southern California. Ph.D Thesis. University of Southern California.

Massey, B. W. 1974. Breeding biology of the California Least Tern. Proceedings of the Linnaean Society of New York 72:1–24.

Massey, B.W. and J.L. Atwood. 1981. Application of Ecological Information to Habitat Management for the California Least Tern. Progress Report No. 3. October 1981. U.S. Fish and Wildlife Service.

Massey, B.W. and J.L. Atwood. 1984. *Application of Ecological Information to Habitat Management for the California Least Tern*. Progress Report No. 6. October 1984. U.S. Fish and Wildlife Service.

Marine Advisers. 1965. Preliminary Report on Wind and Waves at the Proposed Cabrillo Marina, San Pedro, California. Marine Advisers, Inc.

MBC (MBC Applied Environmental Sciences). 1984. Outer Long Beach Harbor – Queensway Bay Biological Baseline Survey. Prepared for the Port of Long Beach.

MBC (MBC Applied Environmental Sciences). 1999. Biological Characterization.

MBC (MBC Applied Environmental Sciences). 2003. Physical and Biological Monitoring at Golden Shore Marine Reserve Long Beach, California Year 5 (2002). Final Report. Prepared for the City of Long Beach.

MEC (MEC Analytical Systems). 1988. Biological Baseline and an Ecological Evaluation of Existing Habitats in Los Angeles Harbor and Adjacent Waters. Volumes I to III. Prepared for the Port of Los Angeles.

MEC (MEC Analytical Systems). 1993. San Dieguito Lagoon Restoration Project biological baseline study, March 1992 - May 1993. Draft technical memorandum submitted to Southern California Edison. Sections 1-6.

MEC (MEC Analytical Systems). 1999. Port of Los Angeles special study. August. Prepared for the Port of Los Angeles.

MEC (MEC Analytical Systems). 2002. Ports of Long Beach and Los Angeles Year 2000 Biological Baseline Study of San Pedro Bay. Prepared by MEC Analytical Systems Inc. for the Port of Long Beach Planning Division. June 2002.

Merkel and Associates. 2001. Long-Term Monitoring and Pilot Vegetation Program for the Batiquitos Lagoon Enhancement Project. Quarterly Report, January through March, 2001.

Miller, D.J. and R.N. Lea. 1972. Guide to the Coastal Marine Fishes of California. California Department of Fish and Game Bulletin No. 157. 249 p.

National Marine Fisheries Association. 1991. Southwest Region/Southwest Fisheries Science Center Administrative Report SWR-98-02

Navigation Data Center. USACE record. http://www.iwr.usace.army.mil/ndc

NCDC (National Climatic Data Center, National Oceanic and Atmospheric Administration). 2003. Climate-Radar Data Inventories.

NOAA (National Oceanic and Atmospheric Administration). 2000a. Tidal Datums and Their Applications. NOS CO-OPS 1.

NOAA (National Oceanic and Atmospheric Administration). 2000b. Distribution and abundance of marine mammals at San Clemente Island and surrounding offshore waters: results from aerial and ground surveys in 1998 and1999.

NOAA (National Oceanic and Atmospheric Administration). 2003. Bench Mark Sheets.

Noble, M.A., H.F. Ryan, and P.L. Wiberg. 2002. The Dynamics of Subtidal Poleward Flows over a Narrow Continental Shelf, Palos Verdes, CA. Continental Shelf Research, 22: 923-944. Elsevier Science Ltd.

Nowak, Ronald M. 1991. Walker's Mammals of the World. Gray Whale. vol 2. The Johns Hopkins University Press, Baltimore.

NWS (National Weather Service, National Oceanic and Atmospheric Administration). 2001. Southern California Climate Averages.

NWS (National Weather Service, National Oceanic and Atmospheric Administration). 2003. Santa Ana Winds.

Ocean Disposal Database. U.S. Army Corps of Engineers (Corps), Research and Development Center, Waterways Experiment Station, Environmental Laboratory. http://www.wes.army.mil/el/odd/odd.html

Page, G.W., F.E. Bidstrup, R.J. Ramer, and L.E. Stenzel. 1986. Distribution of wintering snowy plovers in California and adjacent states. Western Birds 17(4):145-170.

POLB (Port of Long Beach). 2000. Final Environmental Impact Report and Application Summary Report – Piers G and J Marine Terminal Development.

Pier 400 Consultants. 1993. Pier 400 Dredging and Landfill Design, Wave Climate Analysis. Pier 400 Design Consultants, Inc.

Reid, R.O. 1990. Tides and Storm Surges. Handbook of Coastal and Ocean Engineering. J. B. Herbich (ed.).

The Research Team. 2001. Summary Report on Expenditures Module. Prepared for The Southern California Beach Valuation Project, December 2001.

Ryan, Joe. Personal Communication. U.S. Army Corps of Engineers, Los Angeles District.

SCCWRP (Southern California Coastal Water Research Project). 1993. 1992-1993 Annual Report.

SCCWRP (Southern California Coastal Water Research Project). 2003. Watershed-Based Sources of Contaminants to San Pedro Bay and Marina del Rey: Patterns and Trends. E. Stein, Ackerman, D., and Schiff, K. Prepared for Los Angeles CSTF. Technical Report #413. October 13, 2003.

SCOSC (Southern California Ocean Sudies Consortium). 1980. Biological field surveys for the West Channel/Cabrillo Beach recreational complex. Final report. Submitted to the Port of Los Angeles.

SCOSC (Southern California Ocean Sudies Consortium). 1982. Baseline Biological Survey for the Environmental Impact Report for the Terminal Island Dry Bulk Handling Terminal and Related Landfills in Outer Los Angeles Harbor, California.

Scripps Institute of Oceanography. 1995. Dramatic Drop in Zooplankton Reported off California Coast. Press Release, March 3, 1995.

Seymour, R.J., R.R. Strange III, D.R. Cayan, and R.A. Nathan. 1984. Influence of El Ninos on California's Wave Climate. Proceedings, 19th International Conference on Coastal Engineering. Houston, TX.

SMBRP (Santa Monica Bay Restoration Project). 1994. State of the Bay 1993. Monterey Park, CA.

Soule, D. F. and M. Oguri. 1976. Marine Studies of San Pedro, California. Part 14. Prepared for Allan Hancock Foundation of Office of Sea Grant Programs, University of Southern California, Los Angeles.

Soule, D.F and M. Oguri. 1977. The Marine Ecology of Marina del Rey Harbor, California Marine Studies of San Pedro Bay. Part 13. Allan Hancock Foundation and Office of Sea Grant Programs.

Soule, D. F. and M. Oguri. 1979. Ecological changes in Outer Los Angeles-Long Beach Harbors following initiation of secondary waste treatment and cessation of the fish cannery waste effluent. In Marine Studies of San Pedro Bay, California. Part 16. Allan Hancock Foundation, Sea Grant Program.

Soule, D.F. M. Oguri and B.H. Jones. 1991. The Marine Environment of Marina del Rey October 1989 to September 1990 Harbors Environmental Projects, University of Southern California.

Soule, D.F. M. Oguri and B.H. Jones. 1992. The Marine Environment of Marina del Rey October 1990 to September 1991 Harbors Environmental Projects, University of Southern California.

Soule, D.F. M. Oguri and B.H. Jones. 1996. The Marine Environment of Marina del Rey October 1994 to September 1995 Harbors Environmental Projects, University of Southern California.

The Southern California Beach Valuation Project 12/16/2001. Summary Report on Expenditures Module.

State of California. 2000. Long Term Economic Forecast for California Couties – Los Angles County.

State of California Department of Transportation Office of Transportation Economics. 2000. http://www.dot.ca.gov/hq/tpp/offices/ote/lac.pdf

Stephens, J.S., Jr., D.F. Soule, D. Pondella and P. Morris. 1991. Marina del Rey as a Fish Habitat: Studies of the Fish Fauna Since 1977 in Proceedings to a Symposium on the Marine Environment. Southern California Sea Grant.

Stopford, Martin. 2002. Is the Drive For Ever-Bigger Containerships Irresistible? Lloyds List Shipping Forecasting Conference, April 26, 2002.

Strange, R.R., N.E. Graham and W.C. O'Reilly. 1993. A Hindcast of Extreme Wave Events at Los Angeles Harbor. Pacific Weather Analysis.

SWQCB (California State Water Quality Control Board). 1965. An Oceanographic and Biological Survey of the Southern California Mainland Shelf. Publication No. 27. Sacramento, CA.

Thornberg, Christopher. 2003. UCLA Anderson Forecast. http://eec.co.la.ca.us/present/pres0403a.htm

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1979. Feasibility Report: Ballona Creek Channel and Sawtelle-Westwood Channel Watershed, Los Angeles County, California.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1980. Plans and Specifications for Dredging and Outfall Sewer at Los Angeles Harbor, Los Angeles, California DACW09-80-B-0030.

USACE (U.S. Army Corps of Engineers). 1983. Coastal Storm Damages: 1983. Planning Division.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1985. Hydrologic Data Inventory Southern California Coastal Zone Ragged Point (San Luis Obispo County) to Mexican Border. CCSTWS.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1986. Oral History of Coastal Engineering Activities in Southern California.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1988a. Feasibility Report for Storm Damage Reduction, Redondo Beach – King Harbor Area, Los Angeles County, CA.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1988b. 1982-1983 Shoreline Position Study, San Diego Region. CCSTWS 88-4.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1988c. Santa Barbara County Beach Erosion and Storm Damage Reconnaissance Study, Preliminary Final Report.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1989. Santa Monica Breakwater, Los Angeles County, CA, Reconnaissance Report.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1990. Sediment Budget Report Oceanside Littoral Cell. CCSTWS 90-2.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1991. State of the Coast Report San Diego Region. CCSTWS 91.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1994. Los Angeles and Long Beach Harbors Model Enhancement Program, Effects of Wind on Circulation in Los Angeles- Long Beach Harbors. CERC-94-7. U.S. Army Engineer Waterways Experiment Station.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1995. Marina del Rey and Ballona Creek, CA, Final Reconnaissance Report.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1995. Santa Monica Breakwater, Santa Monica, California. Appendix A: Coastal Engineering.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1996a. Los Angeles River Estuary Navigation Channel Alternatives.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1996b. Nearshore Hydrodynamic Factors and Wave Study of the Orange County Coast. CCSTWS 96-3.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 1998. Marina del Rey and Ballona Creek Feasibility Study Dredged Material Management Plan F3 Report.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 2000a. Budget of Sediment Analysis. CCSTWS.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 2000b. Marina del Rey and Ballona Creek Feasibility Study, Dredged Material Management Plan Alternative Analysis Report, F4 Main Report.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 2002a. Los Angeles Regional Dredged Material Management Plan Pilot Studies Appendix A – Evaluation of Aquatic Capping Alternative. November 2002.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 2002b. Los Angeles Regional Dredged Material Management Plan Pilot Studies Appendix D – Evaluation of Sediment Blending Alternative. November 2002.

USACE (U.S. Army Corps of Engineers, Los Angeles District). 2002c. Marina del Rey and Ballona Creek Feasibility Study Sediment Control Management Plan Draft Feasibility F4 Main Report.

USACE (U.S. Army Corps of Engineers, Los Angeles District). March 2003. Zone of Siting Feasibility Study Draft Report.

USACE (U.S. Army Corps of Engineers, Los Angeles District) and LAHD (Los Angeles Harbor). 1984. Appendices for Los Angeles/ Long Beach Harbor Channel Improvements and Landfill Development.

USC (University of Southern California) - Harbors Environmental Projects. 1976. Environmental investigations and analysis of Los Angeles-Long Beach Harbors, 1973 - 1976. Contract No. DACW09-73-0112 for U.S. Army Corps of Engineers, Los Angeles District. Published by Allan Hancock Foundation, USC, Los Angeles, CA. 737 p.

Wiberg, P.L., D.E. Drake, C.K. Harris, and M.A. Noble. 2002. Sediment Transport on the Palos Verdes Sehlf over seasonal to Decadal Time Scales. Continental Shelf Research, 22: 987-1004. Elsevier Science Ltd.

WRCC (Western Regional Climate Center). 2003. Precipitation Summary, California. Desert Research Institute.