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California Least Tern Foraging Ecology in Southern California

A Review of Foraging Behavior Relative to Proposed Dredging Locations

Kathy Keane and Lawrence J. Smith

May 2016

Environmental Laboratory

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A Review of Foraging Behavior Relative to Proposed Dredging Locations

Kathy Keane

Keane Biological Consulting
2892 North Bellflower Boulevard, Suite 480
Long Beach, CA 90815

Lawrence J. Smith

U.S. Army Engineer District, Los Angeles
915 Wilshire Boulevard, Suite 930
Los Angeles, CA 90017

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U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road, Vicksburg, MS 39180-6199

Abstract

The California least tern (*Sternula antillarum browni,* hereafter CLT), one of three subspecies of the Least Tern, nests along the west coast of North America. Foraging occurs in bays, lagoons, estuaries, tidal marshes, river mouths, ponds and lakes, as well as in offshore deep-water habitats by plunge-diving for fish. Fifty species of prey fish have been identified as potential CLT prey.

The CLT, listed as endangered by the federal and California Endangered Species Acts, is afforded protection at its nesting sites in California. The relative importance of various foraging areas and foraging habitats near CLT nesting sites has not been evaluated, nor has official protection been designated to any CLT foraging areas, aside from seasonal limits on dredging sites recommended by the U.S. Fish and Wildlife Service (USFWS).

The U.S. Army Corps of Engineers (Corps) Los Angeles District conducts maintenance dredging along the California coast to ensure navigational access. Some of these sites are within foraging distance of CLT nesting areas. Dredging activities were generally limited to periods outside the CLT nesting season (April 15 to September 15) in order to avoid potential adverse effects on CLT foraging due to turbidity.

This report summarizes the results of a literature review on studies and observations of CLT foraging and studies on the behavior of CLT forage fish in turbidity plumes. Results suggest that dredging activities may not substantially alter CLT foraging activity and seasonal restrictions on dredging near active CLT nesting sites provide no protections to this species and are not warranted.

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Preface

The authors would like to thank the following individuals for their assistance with the completion of this study. First, the authors gratefully acknowledge Mohammed Chang, U.S. Army Corps of Engineers, Los Angeles District (SPL), for funding this study, and Jodi Clifford, SPL, for report and contract reviews and support.

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The authors sincerely thank Dr. Ralph Appy, formerly with the Los Angeles Harbor Department, and Dr. Tom Johnson, formerly of the Port of Long Beach, for contracting California Least Tern (CLT) foraging studies for many years in the Los Angeles Harbor (see Table 1 of this report) and Long Beach Harbor (1997 through 2002). The USACE Los Angeles District is appreciated for requesting and contracting the Marina del Rey CLT foraging study — the study conducted during dredging and discussed in this report. Finally, the authors wish to express their gratitude to CLT researchers who provided KBC with mentoring for CLT studies — in particular, with CLT foraging survey experience during studies conducted in the 1980s: Dennis Minsky, Barbara Massey, Dr. Charles Collins, Jack Fancher, and the late Dr. Robert Cimberg. Their guidance laid the groundwork for continuing this work.

When this publication was completed, Dr. Beth Fleming was Director of the ERDC-EL; COL Bryan S. Green was Commander of ERDC; and Dr. Jeffery Holland was Director of ERDC.

Acronyms

ANOVA	Analysis of variance
CCW	Corps civil works facilities
CDFW	California Department of Fish and Wildlife (formerly California Department of Fish and Game)
CLT	California Least Tern
CLTNS	CLT Nesting site
CSWH	Cabrillo Shallow Water Habitat Area
DDO	Dredging and disposal operations
DWB	Individual docks, wharves and berths
KBC	Keane Biological Consulting
LT	Least Tern
MDR	Marian Del Ray
POLA	Port of Los Angeles
POLB	Port of Long Beach
RBH	Recreational Boat Harbor or marina
SPL	U.S. Army Corps of Engineers, Los Angeles District
SWHA	Shallow Water Habitat Area
USFWS	U.S. Fish and Wildlife Service
VBNS	Venice Beach CLT Nesting Site

1 Introduction

The California least tern (CLT) (*Sternula antillarum browni*) is one of three subspecies of least tern, although recent genetic studies found little variation among the subspecies (Whittier et al. 2006). The CLT nests along the west coast of North America, from Baja California, Mexico, north to the San Francisco Bay area (United States Fish and Wildlife Service (USFWS) 1985). CLT establish nesting colonies on sandy soils with little vegetation — typically on beaches, salt flats, estuarine islands, and man-made areas of dredged material (Keane et al. 2010).

The CLT was listed as endangered by the U.S. Secretary of the Interior in 1970 (USFWS 1973) and the California Department of Fish and Game in 1971 (CDFG 1976) due to a population decline resulting from loss of habitat (Craig 1971, Cogswell 1977). The CLT Recovery Plan, which has not been updated since 1985, included an appendix listing major feeding areas used from 1969 and 1977 and concluded that CLT "foraging, roosting, and wintering habitat must be preserved and properly managed" (USFWS 1985). However, aside from foraging studies at localized areas and summarized in this report, the relative importance of various foraging areas and habitats near CLT nesting sites has not been evaluated (Keane Biological Consulting (KBC) 2003a, KBC 2003b), nor has official protection been designated to any CLT foraging areas (USFWS 1985).

The CLT has been reported to forage in shallow waters of bays, lagoons, estuaries, tidal marshes, river mouths, ponds and lakes (Thomson et al. 1997). However, a significant amount of foraging also occurs offshore in deep-water habitats (KBC 2003a). CLT forage throughout the day by flying over the water and diving or plunging for fish (Thompson et al. 1997).

CLTs feed in both saltwater and freshwater habitats on small (10 cm or less) prey fish, including northern anchovy (*Engraulis mordax*), topsmelt (*Atherinops affinis*), jacksmelt (*A. californiensis*), shiner perch (*Cymatogaster aggregata*), rough silversides (*Membras martinica*), flat croaker (*Leiostomus xanthurus*), deep-body anchovy (*Anchoa compressa*) or slough anchovy (*A. delicatissima*), among other species (Atwood and Kelly 1984). CLT are also known to eat freshwater species, including killifish (*Fundulus parvipinnis*) and mosquito fish (*Gambusia affinis*) (Atwood and

Kelly 1984). At least 49 species of potential forage fish have been identified from fish dropped at 13 CLT nesting sites (Atwood and Kelly 1984).

Atwood and Minsky (1983) conducted the first systematic CLT foraging studies near three CLT nesting sites. Their study concluded that 75% of CLT foraged within 1.2 km (0.75 mile) of nesting sites, but foraging also occurred up to 3 km (1.86 miles) distant, although anecdotal observations have been documented of CLT several miles from shore during the nesting season.

The U.S. Army Corps of Engineers (Corps) conducts regular maintenance dredging and other activities at several locations along the California coast to ensure navigational access. Some of these areas are within foraging distance of CLT nesting areas. However, the USFWS asserts that turbidity resulting from dredging can negatively affect CLT foraging success by decreasing visual detectability of fish (USFWS 1999 *in* H.T. Harvey 2012). The California Department of Fish and Wildlife also identified turbidity as a potentially negative effect on CLT foraging success (CDFG 1998 *in* H.T. Harvey 2012).

In the San Francisco Bay (Bay) area, impacts of dredging activities on CLT foraging are minimized by adherence to the provisions of a programmatic Biological Opinion regarding the long-term management strategy for placement of dredged material in the Bay (USFWS 1999). Proponents of proposed dredging projects in the Bay area need not consult with the USFWS but simply submit applications for dredging and disposal projects through a Dredged Material Management Office (DMMO), which, depending on the project location and potential species presence, provides a “work window” of dates during which the project may take place.

However, in central and southern California (from Morro Bay to the U.S. border with Mexico), no programmatic Biological Opinion exists. All dredging and disposal activities are generally limited to periods outside the CLT nesting season (the nesting season is designated as beginning April 15 and ending September 15, although the actual nesting period varies among sites and years) to avoid potential effects on CLT foraging. The studies summarized in this report examined available information on the extent of CLT foraging near areas that may require dredging or other activities by the Corps in order to determine whether current seasonal limits on dredging or other Corps activities are appropriate and necessary.

2 Methods

At the request of the Corps Los Angeles District, KBC compiled and reviewed existing information on CLT foraging in the following locations that support Corps civil works facilities listed below:

- Morro Bay[1]
- Santa Barbara[1]
- Ventura Harbor[1]
- Channel Islands Harbor[1]
- Port Hueneme[1]
- Marina del Rey[1]
- King Harbor[1]
- Port of Los Angeles[2]
- Port of Long Beach[2]
- Los Angeles River Estuary[1, 2]
- Anaheim Bay[1]
- Offshore Surfside-Sunset Beaches[3]
- Lower Newport Bay[2]
- Upper Newport Bay[2]
- Oceanside Harbor[1]
- Offshore Solana Encinitas Beaches[3]
- Mission Bay[1]
- San Diego Bay[2]
- Offshore Imperial Beach[3]

KBC also reviewed existing information on CLT foraging in the following locations that support Corps Regulatory functions:

- Individual docks, wharves, berths in all of the above areas
- Individual recreational boat harbors along the coast (i.e., the city of Long Beach Shoreline Marina and Alamitos Bay, Marine Stadium, Dana Point, San Clemente).

KBC has reviewed previous CLT foraging studies as part of other documents, including KBC (2003b), which examined results of foraging

[1] Channel dredging with beach nourishment or near-shore disposal.

[2] Channel dredging with ocean disposal.

[3] Dredging offshore; borrow site generally deeper than 20 feet with beach nourishment nearby.

surveys in the Los Angeles Harbor from 1994 through 2002. These were reviewed once again for this report. KBC acquired and reviewed more recent foraging studies conducted near other Southern California CLT nesting sites. We also requested information on May 11, 2009 and March 4, 2011 through the CLT Yahoo list server, which allows contact with all individuals working with CLT throughout California, and reviewed all available foraging information provided from those contacts.

Although this report focuses on CLT studies conducted in southern California, the authors also reviewed and summarized foraging studies conducted in the San Francisco Bay area that included data on CLT foraging in turbidity plumes and foraging distances from CLT nesting sites. In addition, foraging studies conducted in areas not associated with Corps civil works facilities (CCW) were reviewed for an overview of CLT foraging ecology, and so that CLT tendencies to forage in habitats near CCW could be inferred for areas where no foraging data were available. Finally, although data on the relative occurrence of potential CLT prey fish within active dredging areas as compared to areas outside active dredging were not available, the authors reviewed ichthyological studies on the behavior of fish within turbidity plumes to evaluate the potential for fish within such plumes to become CLT prey.

3 Results

California Least Tern Foraging Studies Conducted Near CCWs

Table 1 summarizes the foraging studies reviewed for each of the CCW. Some studies are further discussed below, or later in this report under "Studies of Bird Behavior during Dredging Operations."

California Least Tern Foraging Studies conducted at locations outside of CCWs

A foraging study was conducted in 1978 near the Huntington Beach CLT nesting site, located at the mouth of the Santa Ana River, to quantify the daily and seasonal use of nearby foraging areas (Collins et al. 1979). Ten survey stations included the open ocean, river mouth, marsh channels, and freshwater ponds. Surveys were conducted for 15 minutes each hour, six to eight hours per day, over four census periods extending from the beginning of the nesting season through CLT departure. Open ocean areas were more heavily used than other areas, particularly later in the CLT nesting season, although an increase in the use of marsh channels was observed during peak chick hatching (Collins et al. 1979).

Another foraging study was conducted in 1980 and 1981 near the Huntington Beach CLT nesting site, as part of Atwood and Minsky (1983), summarized in Table 1 for Marina del Rey and Oceanside Harbor. The Venice Beach, Huntington Beach, and Santa Margarita River nesting areas were selected for the study, since they had supported the highest numbers of nesting CLT since 1978, and the Venice Beach and Huntington Beach sites had also produced approximately 41% of CLT fledglings from 1978-1981. All potential CLT foraging areas within a five-mile radius of the nesting sites were identified, and survey stations that allowed quick observations of foraging CLT were designated. Surveys extended for 90 minutes on four dates in 1980 and six dates in 1981. The Huntington Beach area included 10 offshore stations; the remainder were associated with the Santa Ana River and associated salt marsh areas, aside from one survey station within the marina of Lower Newport Bay. This station supported 7% of total foraging on one survey date in July 1980 but little foraging activity otherwise. Eight of the ten open ocean survey stations supported over 75% of all foraging observations for both years combined (Atwood and Minsky 1983).

Table 1. Summary of California Least Tern Foraging Studies near Corps Civil Works Locations.

Corps Civil Works Location	Name of, and Distance and Direction to, nearest CLT Nesting Site(s)	Reference(s) and Methods for Studies Conducted	Potential Maximum CLT Foraging at One Time *	Summary of Results or Expected Level of Foraging if No Studies Available
Morro Bay (Figure 1)	Oceano Dunes, 25 miles south. Other sites > 30 miles south.	No studies	37	CLT foraging is expected to be infrequent, based on distance (see Section 3.5) to nearest nesting site.
Santa Barbara Harbor (Figure 2)	Coal Oil Point 10 miles north of Santa Barbara	No studies	0 (1 nest 2008, 1 nest 2011)	Little to no CLT foraging expected, based on distance to nearest nesting site (see Section 3.5) and use (1 nest during 2 of 5 years 2008 - 2012).
Ventura Harbor (Figure 3)	2.5 miles north of McGrath State Beach	No studies	57	CLT foraging expected to be moderate based on 57 average CLT nests 2008 - 2012.
Channel Islands Harbor (Figure 3)	McGrath State Beach 4 miles north and Ormond Beach 6 miles south	No studies; anecdotal observations reported by A. Sanders 2011.	57 48	Only anecdotal observations, but foraging expected to be minimal given distance to nesting sites (see Section 3.5) and relatively low nest numbers (57 and 48 average nests, respectively, at McGrath and Ormond Beach 2008-2012).
Port Hueneme (Figure 3)	Ormond Beach 4 miles south, and Pt Mugu Naval Air Warfare Center (NAWC) 10 miles south	No studies; anecdotal observations reported by A. Sanders[1] and T. Keeney[2]	48 681	Anecdotal evidence that CLT presumably nesting at Ormond Beach forage in Ormond Lagoon, Oxnard Industrial Drain, J Street drain and Port Hueneme, and in drainage ditch paralleling the coast inland from dunes from Port Hueneme to Point Mugu. Anecdotal observations near Pt Mugu nesting site documented CLT foraging in tidal creeks but most often carrying fish from immediately off-shore or along the coastal strand south of nesting site.
Marina del Rey (Figure 4)	Venice Beach directly north of marina mouth	Pestana 1988. One survey before nesting and one survey early nesting at Ballona Lagoon & Ballona Creek.	286	Based on direction of CLT arrival at nesting site, 3.4 times more fish per hour were delivered to nest site from Ballona Lagoon than from Ballona Creek, but this likely varies year to year. No surveys of ocean foraging.

[1] Personal Communication. A. Sanders. 2011.

[2] Personal Communication. T. Keeney. 2011.

Corps Civil Works Location	Name of, and Distance and Direction to, nearest CLT Nesting Site(s)	Reference(s) and Methods for Studies Conducted	Potential Maximum CLT Foraging at One Time *	Summary of Results or Expected Level of Foraging if No Studies Available
Marina del Rey, continued (Figure 4)	Venice Beach directly north of marina mouth	Atwood and Minsky 1983. Surveys 1980-81 for 90 min at 20-minute survey stations including open ocean, marina & Ballona Creek. Study also surveyed foraging near Huntington Beach and Camp Pendleton nesting sites.	286	75% of all foraging activity occurred in the ocean offshore of the Venice Beach nesting site on 9 of 10 surveys. At Huntington Beach and Camp Pendleton, the majority of foraging was also observed in near-shore ocean near major river mouths rather than estuaries, lagoons, freshwater lakes or coastal rivers. 75% of foraging within 0.75 miles of nesting site. (Further discussed in Other Studies).
		KBC 1998a, KBC 2001a. Fourteen 20-minute surveys at 4 survey stations in Ballona Wetlands and in Marina del Rey at US Coast Guard station.	280	Minimum of 90% of foraging dives at Marina del Rey USCG station. NO OCEAN SURVEY STATIONS WERE INCLUDED.
		KBC 2013[1]. Study in 2012 to 1) document dredging effects on CLT foraging and 2) record & compare foraging dives during dredging and no dredging in same areas, 12 dredge survey stations.	280	Foraging activity inconsistent during surveys due to CLT nest site abandonment. Results comparable for only 5 of 12 dredge areas (but sample sizes too small for statistical analysis since dredging extended for longer periods at some survey stations than others): two supported more dives during dredging, two during non-dredging, and one had similar dive numbers for the 2 periods. 153 CLT (14% of the total) foraging dives recorded within dredge areas during dredging, generally within 100 ft of the dredge.
King Harbor (Figure 4)	Venice Beach 9 miles north; LA Harbor 12 miles southeast.	No studies.	286	Given the distance to nearest nesting site (see Section 3.5), little to no CLT foraging is expected.
Port of Los Angeles (POLA) (Figure 5)	Pier 400, within Los Angeles Harbor and within 2 miles of foraging locations in the	Massey and Atwood 1984. Anecdotal observations of foraging from various locations.	280	Activity concentrated in shallow water, particularly adjacent to the CLT nesting site on Pier 300.

[1] Further discussed in this report in Studies of Bird Behavior During Dredging Operations

Corps Civil Works Location	Name of, and Distance and Direction to, nearest CLT Nesting Site(s)	Reference(s) and Methods for Studies Conducted	Potential Maximum CLT Foraging at One Time *	Summary of Results or Expected Level of Foraging if No Studies Available
Port of Los Angeles (POLA), continued (Figure 5)	Outer Harbor and within 2 – 3 miles of foraging locations in Inner Harbor	Cimberg 1987. First systematic foraging study in L.A. Harbor. 14 survey stations including Cabrillo Beach and breakwaters. 20 min weekly surveys May-Aug 1986-1987.	280	Foraging dives most frequent east & south of Pier 300 nesting site (500 CLT foraging dives recorded during one survey); also frequent along San Pedro and Middle breakwaters.
	Pier 400, within Los Angeles Harbor and within 2 miles of foraging locations in the Outer Harbor and within 2 – 3 miles of foraging locations in Inner Harbor	KBC 1996. Weekly surveys 1994 – 1996 near Pier 300 nesting site and Cabrillo Beach, 20 min per survey station.	280	Foraging activity highest east & south of the Pier 300 nesting site and at the Seaplane Lagoon and off Cabrillo Beach.
		KBC 1998b, 2000a, 2000b. Foraging surveys around perimeter of Pier 400 in 1998, 1999 & 2000. Same methods as above.	280	Foraging activity concentrated in different locations around Pier 400, new CLT nesting site as of 1997, each of the 3 years.
		KBC 1997, 1998c, 1999a, 2000c. Twice-weekly 20-minute foraging surveys at 3 survey stations in POLB and at 2 POLA comparison stations.	280	Highest foraging activity at shallow water habitat near Pier 300 (P300 SWHA), 1.5 miles from new Pier 400 nesting site, although CLT no longer nest at Pier 300.
		KBC 2003a. Three consecutive years of foraging studies at 18 to 29 locations in Inner and Outer Harbor including Cabrillo Shallow Water Habitat (CSWH), once weekly for 20 min from CLT arrival to departure.	280	Majority of foraging dives at a P300 SWHA (50% of all dives in 2003), although CLT no longer nesting at Pier 300, for 2 of 3 yrs & within Pier 400 elbow 3rd yr. Shallow water habitats (<20 ft deep) supported a higher % of foraging dives than Harbor deep-water habitats. High numbers of transit flights over breakwater and harbor entrance suggest substantial foraging in ocean outside harbor. Few foraging dives at the CWSH; provided as mitigation for CLT foraging for loss of other shallow-water habitats.

Corps Civil Works Location	Name of, and Distance and Direction to, nearest CLT Nesting Site(s)	Reference(s) and Methods for Studies Conducted	Potential Maximum CLT Foraging at One Time *	Summary of Results or Expected Level of Foraging if No Studies Available
POLA, continued (Figure 5)	Pier 400, within Los Angeles Harbor and within 2 miles of foraging locations in the Outer Harbor and within 2 – 3 miles of foraging locations in Inner Harbor.	KBC 2003b. Report compiled & analyzed studies summarized above and provided scores for raw data to determine extent of foraging during dredging & disposal operations (DDO) and potential DDO effects on CLT foraging in POLA.	280	Study contracted after DDO completed, limiting conclusions regarding DDO effects on CLT foraging. However, anecdotal observations of CLT foraging within & adjacent to DDO turbidity plumes suggest DDO may not substantially alter CLT foraging. A comparison between foraging dive data collected before/during (1994-1996) and after (2001-2002) DDO was possible for five survey stations (others not consistently surveyed) showed an average of 537% more foraging dives per minute after DDO (K. Keane, post-report calculation).
		KBC 2003c. Experiment to determine CLT foraging use in event of oil spill. Three portable pools with mosquito fish provided near Pier 400 nesting site. Included surveys at 3 preferred foraging areas (per above study) to evaluate whether foraging frequency declined when pools available.	280	44 foraging dives at pools over 480 minutes indicates low use of alternate prey source. Foraging frequency at preferred foraging areas did not change when pools available. P300 SWHA the preferred foraging area of 3 surveyed. Approx.8 transit flights/min observed toward breakwaters, suggesting substantial ocean foraging.
Port of Long Beach (POLB) (Figure 5)	Pier 400 in POLA, minimum 1 mile east of POLB western boundary. See above. No CLT nesting documented in POLB.	KBC 1997 & KBC 1998c. Twice weekly surveys for 20 min at 3 survey stations in POLB West Basin, formerly shallow water but now deep water for container ships.	280	Only 17 total foraging dives recorded in 1997, followed by 306 in 1998, suggesting that foraging area importance can change from year to year.

Corps Civil Works Location	Name of, and Distance and Direction to, nearest CLT Nesting Site(s)	Reference(s) and Methods for Studies Conducted	Potential Maximum CLT Foraging at One Time *	Summary of Results or Expected Level of Foraging if No Studies Available
POLB (continued) (Figure 5)	Pier 400 in POLA, minimum 1 mile east of POLB western boundary. See above. No CLT nesting documented in POLB.	KBC 2005. Summarizes reports for 7 yrs of surveys (1999 - 2005) at POLB SWHA east of Pier 400 provided as mitigation for loss of West Basin. Included surveys at Pier 300 SWHA & Navy Mole for comparison. Methods as described above.	280	Total foraging dives at mitigation area minimal until 2005 but mean foraging dives per acre were only slightly higher at than the West Basin (above study). Highest level of foraging by far was at P300 SWHA, even though CLT were no longer nesting at this location.
		MEC 2002. Not a foraging study but a series of baseline surveys over one year of water quality, benthic resources, algae, fish, birds and marine mammals throughout Long Beach & LA Harbors. Foraging CLT recorded when observed.	280	Highest northern anchovy numbers recorded in August 2000 at POLB survey station LB3 in West Basin. Highest ichthyoplankton (fish fed to CLT chicks) abundances at the POLB SWHA. CLT observed Inner Harbor but primarily at P300 SWHA & east of Pier 400 nest site.
		SAIC 2010. A repeat of above study. Foraging CLTs were recorded when observed.	280	Highest biomass of shallow water (beach-seine) fish in April at Pier 400, and mean abundance of northern anchovy highest at Pier 300 SWHA, although biomass for anchovy and other beach seine fish was lowest in April (when CLT arrive) and highest in January. Most previous studies show higher numbers in summer, but this seasonal trend was less apparent during this study. Fish species diversity lower than previous studies. Foraging CLT observed in Inner Harbor but primarily at Cabrillo Beach, P300 SWHA & near Pier 400 nesting site.

Corps Civil Works Location	Name of, and Distance and Direction to, nearest CLT Nesting Site(s)	Reference(s) and Methods for Studies Conducted	Potential Maximum CLT Foraging at One Time *	Summary of Results or Expected Level of Foraging if No Studies Available
Los Angeles River Estuary (Figure 6)	Pier 400 in the Los Angeles Harbor, 4 miles southwest	Chambers 2000. A total of 35 pre-dredging surveys May–Sept 2000 at 5 survey stations in proposed dredging area to determine level of CLT foraging. Twice weekly surveys for 20 min.	280	Infrequent foraging activity except late June—mid July (fledgling period) & primarily at the proposed dredge stockpile area, Station 5, which was not used for stockpiling during dredging which occurred in August 2001 when most CLT had departed the area and primarily occurred in Station 1 near the river mouth where no CLT foraging was observed during the 35 surveys. No CLT monitoring occurred during dredging but turbidity was monitored.
Anaheim Bay (Figure 6)	Seal Beach Naval Weapons Station, less than 1 mile northeast	KBC 1999b. Surveys of foraging seabirds during DDO in November 1999; no CLT foraging studies conducted as this was a winter study.	189	No observable differences in shorebird foraging behavior at beach disposal site or of seabirds at dredging site.
Offshore Surfside-Sunset Beaches (Figure 6)	Seal Beach Naval Weapons Station, minimum 1.5 miles northwest; Bolsa Chica nesting sites 3 to 4 miles southeast	KBC 1999c & 2001b. Two a.m. and 2 p.m. surveys per week for 10 min at 3 survey stations along shoreline. 2001 report compares 1997 surveys (MEC 1997) during beach nourishment, with 1999 & 2000, post nourishment.	189 278	The survey station at which beach nourishment activities were occurring (near-shore sand deposition and resultant turbidity) supported more foraging dives in 1997, when sand deposition was occurring, than in 2000, when it was not, during both morning and evening surveys. 1999 surveys occurred too late to analyze (contract logistics delayed 1999 surveys until July).
Lower Newport Bay (Figure 7)	Upper Newport Bay site 3 miles north, Huntington Beach 2 miles north	No studies	23 391	CLT foraging expected to be infrequent, given number of nests in Upper Newport Bay (7 to 10 in 2009, 13 in 2010)
Upper Newport Bay (Figure 7)	Upper Newport Bay at northern end of bay	No studies	13	CLT foraging expected to be infrequent, given average of 13 nests per year 2008-2012.
Oceanside Harbor (Figure 8)	Santa Margarita River (SMR) Camp Pendleton nesting sites, minimum 0.5 miles north	Minsky 1982. 16 a.m. & 4 p.m. surveys from 30 survey stations at Camp Pendleton, SMR & Oceanside Harbor in 1982	1696	Foraging primarily in near-shore ocean near (i.e., within 2 miles) of nesting sites. Foraging in Oceanside Harbor/marina > 16% one survey but averaged 5.4% of total foraging and was concentrated in outer harbor, harbor mouth & boat turning basin entrance.

Corps Civil Works Location	Name of, and Distance and Direction to, nearest CLT Nesting Site(s)	Reference(s) and Methods for Studies Conducted	Potential Maximum CLT Foraging at One Time *	Summary of Results or Expected Level of Foraging if No Studies Available
		Minsky 1984. Sixteen a.m. & 16 p.m. surveys at 31 survey stations of near-shore ocean off Camp Pendleton nesting sites, and in SMR and Ocean-side Harbor in 1982.	1696	Near-shore ocean survey stations supported 68% morning & 75% evening of total foraging, compared with total foraging at Oceanside Harbor/marina of 9% morning and 10.5% evening.
		Atwood and Minsky 1983. Foraging recorded at 29 survey stations including offshore of SMR nesting sites, Oceanside Harbor, within SMR, and at inland freshwater lakes.	1696	Near-shore ocean stations supported 68.7% of total foraging, highest at SMR mouth. Non-ocean habitats supported little foraging. Foraging dives not recorded; thus, relative importance of foraging areas difficult to document. (Further discussed in Other Studies).
		KBC 2001c & KBC 2002. Twice weekly surveys for 20 min at 14 stations: 4 in Harbor, 6 from beach near nest sites, 3 at SM river, one at San Luis Rey River.	1696	Oceanside Harbor supported low levels of foraging compared with near-shore and offshore ocean areas and within the Santa Margarita River estuary.
Offshore Solana and Encinitas Beaches (Figure 9)	Batiquitos Lagoon 6 miles north, Mission Bay 14 miles south	No studies: distance from Batiquitos limits foraging potential.[1]	< 1 due to distance to nesting sites	CLT foraging is expected to be infrequent, based on distance to nearest nesting site (see Section 3.5). At Batiquitos Lagoon, anecdotal observations indicate that CLTs nesting within western lagoon forage more frequently in the ocean than lagoon, while those at eastern nesting sites forage more within the lagoon.

[1] Personal Communication. S. Wolf. 2009.

Corps Civil Works Location	Name of, and Distance and Direction to, nearest CLT Nesting Site(s)	Reference(s) and Methods for Studies Conducted	Potential Maximum CLT Foraging at One Time *	Summary of Results or Expected Level of Foraging if No Studies Available
Mission Bay (Figure 10)	Several nesting sites directly adjacent to waters of Mission Bay including Mariner's Point, FAA Island, North Fiesta Island.	ERC 1989. 33 survey stations in Mission Bay including San Diego River channel and river mouth, and 2 near-shore ocean stations north of channel. Fifty-four 10-minute. counts at each station during 1989 nesting season.	141	Prior to hatching, highest total foraging (dives + flights) at Mission Bay Channel & Fiesta Bay. Afterward, foraging highest at SD River Channel & near-shore ocean at river mouth. Dives most frequent in shallow water of Northern Wildlife Preserve & areas with > 25% eelgrass. Near-shore ocean aside from river mouth not used extensively but number of transit flights suggest ocean foraging beyond near-shore.
Mission Bay (Figure 10) (continued)	Several nesting sites directly adjacent towaters of Mission Bay including Mariner's Point, FAA Island, North Fiesta Island	SRA 1994. Same methods as for ERC (1989) above w 2 survey station changes; surveys in 1992 & 1993.	141	Results similar to 1989, although foraging activity higher at near-shore ocean 1992-1993. Authors state "offshore foraging behavior observed may be artificially low due to the limited offshore area visible from the beach," and transit flights that would have documented foraging beyond the shore areas were not recorded. Statistical analyses found that 4 stations supported high foraging levels during all 3 years: those near nest sites & in the San Diego River Mouth. At survey stations near nesting sites, a total of 1,351 and 892 foraging observations recorded in 1993 and 1992, respectively, over 54 10-minute surveys, but data included foraging searches as well as plunge-dives (only 150 and 500 dives, respectively.
		KBC 2010. Not a foraging study; monitored middle jetty repair for turbidity effects on CLT foraging, 5 days in May 2010.	141	Most observations were transit flights over the work area, but 2 CLT observed foraging within work area. No effects noted as a result of the ongoing construction.

Corps Civil Works Location	Name of, and Distance and Direction to, nearest CLT Nesting Site(s)	Reference(s) and Methods for Studies Conducted	Potential Maximum CLT Foraging at One Time *	Summary of Results or Expected Level of Foraging if No Studies Available
San Diego Bay (Figure 10)	Many nesting sites concentrated around the Bay: Lindbergh Field, US Navy sites, Chula Vista WR, and Tijuana River 2 – 3 miles south	Copper 1987. Methods unknown; study unavailable.	1811	Near-shore ocean areas not used extensively, per citation of this study in ERC 1989.
		Baird et al. 1997. Transects via small boat within & outside Bay, and observations from Delta Beach nesting site, assumed foraging location based on flight direction after hatching.	1811	Ocean foraging more frequent than bay foraging, particularly along shoreline adjacent to nesting site. Within the bay, areas north of Coronado Bridge (within 2 miles of Coronado nesting sites) used most frequently. Information on direction that adults return to nesting with fish can be used as a predictor for breeding success.
		Baird et al. 2010. 2009 surveys for foraging flocks within and outside bay, at upwelling areas, and "vector" surveys along directions CLT return to nesting sites.	1811	CLT foraged most frequently not in potential DDO areas such as the mouth of the bay but in inlets and mooring areas and along shorelines near nesting sites, 2) within 400 m offshore of nesting sites and 3) offshore (outside the bay) up to 24 km in upwelling areas.
Offshore Imperial Beach (Figure 10)	San Diego Bay sites within 10 miles north, Tijuana River 2.75 miles south	No studies	1811	Foraging expected to be occasional to frequent given proximity to Tijuana River nesting sites, which supported 253 average nests 2008-2012.
DWB Port of Los Angeles (Figure 5)	Pier 400, Port of Los Angeles; see POLA	See Port of Los Angeles	635	Foraging most frequent at Pier 300 SWHA. Less frequent foraging also observed along berths and wharves of Inner Harbor during KBC 2001-2003 surveys, during MEC 2002 and SAIC 2010 surveys.
DWB Port of Long Beach (Figure 5)	Pier 400, Port of Los Angeles, see POLB	See Port of Long Beach studies above.	635	Foraging observed along berths and wharves of Inner Harbor during MEC 2002 and SAIC 2010 surveys.
DWB Mission Bay (Figure 10)	See Mission Bay above	See Mission Bay studies detailed above.	179	None observed near docks, wharves, or berths, but foraging levels expected to be similar to nearby foraging areas.

Corps Civil Works Location	Name of, and Distance and Direction to, nearest CLT Nesting Site(s)	Reference(s) and Methods for Studies Conducted	Potential Maximum CLT Foraging at One Time *	Summary of Results or Expected Level of Foraging if No Studies Available
DWB San Diego Bay (Figure 10)	See San Diego Bay above	Merkel and Associates. 2002. Sixteen 30-minute surveys May-August 2002 at three survey stations: 1) fuel pier Pt Loma, 2) NAS North Island wharf 700A, 3) Naval Station San Diego Pier 14.	1431	Highest foraging activity including the most dives was in open water of Station 3 (see stations described to the left). However, 2002 was a very poor CLT productivity year, so results may not be applicable to other years.
RBH LA Inner Harbor (Figure 5)	See POLA above.	MEC 2002 and SAIC 2010. Anecdotal observations of foraging CLT during 20 biological baseline surveys in 2000 and 2008-2009.	280	No CLT observed in 2000, one observed in 2008 near recreational marina. However, Survey Station 26, western arm of Inner Harbor (see KBC 2003a), supported 6th highest percent of foraging dives of 18 survey stations in 2003.
RBH Shoreline Marina Long Beach (Figure 5)	See LA River. Pier 400 nesting site 4.5 miles southwest	No studies.	280	CLT foraging is expected to be infrequent, based on distance of nearest nesting (see Section 3.5).
RBH Alamitos Bay Long Beach (Figure 5)	Seal Beach Wildlife Refuge NASA Island 2.5 miles east and Pier 400 nesting site 7.2 miles southwest.	No studies.	280	CLT foraging expected to be occasional, based on distance of nearest nesting (see Section 3.5) and results from study summarized below (the Marine Stadium connects to Alamitos Bay).
RBH Marine Stadium Long Beach (Figure 5)	Seal Beach Wildlife Refuge NASA Island 3.5 miles east and Pier 400 nesting site 7 miles southwest.	EDAW 2007: Twice weekly 20-minute surveys June 16 to August 27, 2004 at Colorado Lagoon and Marine Stadium.	189 280	Foraging behavior rare at Colorado Lagoon and occasional at Marine Stadium and expected to be rare other years due to distance to nearest nesting sites (see Section 3.5).
RBH Huntington Harbour (Figure 6)	Bolsa Chica sites 1.5 miles southeast; Seal Beach site 1 mile north	No studies.	278 181	Foraging expected to be occasional-to-frequent given the proximity of nesting sites and number of nests.

Corps Civil Works Location	Name of, and Distance and Direction to, nearest CLT Nesting Site(s)	Reference(s) and Methods for Studies Conducted	Potential Maximum CLT Foraging at One Time *	Summary of Results or Expected Level of Foraging if No Studies Available
RBH Dana Point (Figure 7 and 8)	White Beach Camp Pendleton > 18 miles southeast	No studies.	0	Foraging expected to be rare given distance to nearest nesting site (see Section 3.5)
RBH San Clemente (Figure 8)	White Beach Camp Pendleton > 15 miles southeast	No studies.	0	Foraging expected to be rare given distance to nearest nesting site
RBH Mission Bay (Figure 10)	See Mission Bay above	See Mission Bay studies detailed above	141	Surveys did not include marinas but the survey station just outside a marina had highest foraging dives, while 2 other survey stations near marinas had low foraging activity.

* based on 1) average for CLT nest numbers reported to CDFW for 2008 -2012 at nesting sites within 10 miles of Corps Civil Works locations. Each nest supports a pair of CLT, but while one is foraging, the other attends the nest, and 2) expected distances from nearby nesting sites that CLT are expected to forage (see Section 3.5)

Acronyms:

CLT - California Least Tern

CDFW – California Department of Fish and Wildlife (formerly California Department of Fish and Game)

DDO – Dredging and disposal operations

POLA – Port of Los Angeles

POLB – Port of Long Beach

DWB - individual docks, wharves and berths

RBH - Recreational Boat Harbor or marina

SWHA - Shallow Water Habitat Area

CSWH - Cabrillo Shallow Water Habitat Area

In addition to studies in areas under jurisdiction of the Corps Los Angeles District, KBC evaluated a study conducted in the vicinity of CLT nesting site at Alameda Point, Alameda, CA. A four-year CLT foraging study was conducted from 2002 through 2005 as part of an agreement among the USFWS, the Corps, and the Port of Oakland for the Oakland Harbor Deepening Project (TetraTech 2006). The study included several components—chick provisioning (frequency and types of fish brought to chicks by parents), collection of dropped fish at the nesting site, purse seining, neuston net sampling, and beach seining—which will not be summarized in this report. However, the study also included weekly observations for three hours of CLT foraging at four survey stations. Foraging CLT numbers were highest at Alameda Point South and the Seaplane Lagoon, which were closer to the nesting site than other stations. Findings were consistent with a previous study in the Oakland Harbor (del Nevo and Malamma 1997), which found CLT foraging concentrated near the nesting site and little foraging within harbor areas. Although the dredging project created new shallow water habitats, no increase in foraging of these areas was noted during the study (TetraTech 2006). This study is further discussed in the next section with respect to CLT foraging within areas associated with dredging activity.

Studies of Bird Behavior during Dredging Operations

Current dredging projects scheduled to occur in Southern California generally avoid the CLT nesting period (designated by the USFWS as April 15 to September 15) or to implement Best Management Practices (BMPs) for controlling turbidity, per the USFWS, even though no specific studies have been conducted to document the link between dredging-related turbidity and observed effects on CLT foraging.

Three surveys (KBC 1999b) at the opening of Anaheim Bay (entrance to the Seal Beach Wildlife Refuge, the Seal Beach Naval Weapons Station, and Huntington Harbour) conducted in 1999 examined the behavior of pelicans, gulls, and terns before and during dredging and beach disposal operations but the study was conducted in the winter when CLT were not present. California brown pelicans (*Pelicanus occidentalis*), Caspian terns (*Sterna caspia*) and elegant terns (*Sterna elegans*) were observed foraging near the dredging and beach disposal operations, and more birds were present following beach disposal operations than during the pre-disposal survey (KBC 1999b).

Anecdotal observations of CLT foraging within turbidity plumes have been documented by the author and during foraging studies. For example, KBC (2003a) documents that Station 1 had a higher mean for foraging dives in 2003 than the previous two years, despite the fact that active dredging and construction of a new fill area were occurring at the south end of the station during June and July. Successful foraging dives were observed here both in turbid water and immediately adjacent to construction equipment (KBC 2003a). In addition, CLT foraging dives were observed during dredging in the Los Angeles River in 2001 within turbid waters alongside an operating clamshell dredge and alongside a dredge barge as it was maneuvered away after disposal activities.[1] CLT foraging dives were observed in turbid waters during a dredging operation in San Diego Bay near a clamshell dredge.[2]

As part of beach nourishment activities following dredging of the Anaheim Bay entrance, CLT foraging surveys were conducted along the shore of Sunset Beach in 1997 (during beach nourishment) and 1999 (following beach nourishment). Station 2, the location of 1997 dredging activity, supported higher numbers of foraging activities than the other two stations during all surveys (KBC 2001b). An analysis of variance (ANOVA) showed that differences between mean foraging dives for Stations 2 and 3, and for Stations 2 and 1, were statistically significant ($p < 0.05$), but differences between means for Stations 1 and 3 were not. Although Station 2 is somewhat closer to the Seal Beach CLT nesting site than the other two stations, the proximity factor cannot explain the substantial difference in foraging activity (e.g., 52 foraging dives at Station 2 over 28 surveys, compared with seven and one foraging dives for Stations 1 and 3, respectively). If only foraging dives, and not foraging flights and transit flights, were higher at Station 2, it may be possible to conclude that more frequent dives were required because dives in turbid waters were less successful in yielding prey fish. However, averages for other foraging activities in 1997 were generally higher at Station 2 as well, suggesting that CLT were regularly using Station 2 for foraging during beach nourishment deposition, and that they were doing so successfully (KBC 2001b).

As part of the Oakland Harbor Deepening Project (TetraTech 2006), CLT foraging was recorded during weekly surveys in 2004 and 2005 at three

[1] Personal Communication. L. Smith.

[2] Personal Communication. B. Hoffman.

locations, including areas where active dredging was occurring. Secchi disc readings ranged from 0.5 to 1.3 meters in 2004 and 0.3 to 1.7 meters in 2005. Thus, CLT should have had clear surface waters, since they are known to dive to a depth of only about 15 cm (0.15 meters) (Thompson et al. 1997). The greatest number of CLT foraging dives was recorded when no dredging material was disposed. However, low numbers of CLT dives were also recorded during other days of dredge disposal when turbidity readings, via Secchi disc, were similar to readings during no dredge disposal. Terns were observed diving on prey during active sediment deposition activities in 2005 (TetraTech 2006). The authors concluded that even if the deposition of dredged material had adversely affected CLT foraging, given the plume's small surface area, and what appeared to be rapid dissipation of turbidity, placement of dredged material did not appear to affect areas outside the one foraging area in Middle Harbor (TetraTech 2006).

Anecdotal information indicates that turbidity resulting from dredging activity may range from localized (<50 ft) to widespread areas (>500ft) depending on water/wind patterns (KBC 2003b). However, during three years of foraging studies in the Los Angeles Harbor, CLT were observed conducting foraging dives near dredging activity at stations 1, 7, & 26 — even directly into turbid waters (KBC 2003a). It has been hypothesized that turbidity plumes may form a "curtain" of silt causing small fish to aggregate near the edge of plumes (KBC 2003b). KBC (2003b) concluded that additional data are necessary to understand the relationship among turbidity plumes, behavior of CLT prey fish, and CLT foraging behavior.

KBC monitored dredging activities at Marina del Rey (MDR) during the CLT nesting season at the nearby Venice Beach CLT nesting site (VBNS) in 2012 (KBC 2013). CLT nesting at the VBNS forage over the nearby ocean, Ballona Creek, and Ballona Lagoon as well within MDR (Atwood and Minsky 1983). The Corps had determined, in accordance with the Endangered Species Act, that the project would not affect CLT. The Corps proposed monitoring as part of the Section 7 consultation process with the USFWS. Thus, dredge monitoring at MDR included CLT foraging surveys. However, all CLT nesting attempts at the VBNS in 2012 failed due to egg depredation by American crows (*Corvus brachyrhynchos*), similar to the previous three years and several prior years (KBC 2013). Nevertheless, KBC designed the study to 1) document any observable effects of dredging and associated activities on CLT foraging behavior such as turbidity, and 2) to record CLT foraging behavior within the 12 areas where the dredge

was operating and compare it with foraging behavior in comparison to areas where no dredging was occurring (KBC 2013).

KBC designed the study to 1) document any observable effects of dredging and associated activities on CLT foraging behavior such as turbidity, and 2) to record CLT foraging behavior within the 12 areas where the dredge was operating and compare it with foraging behavior in similar control areas where no dredging was occurring (KBC 2013).

Foraging behavior was monitored during dredge operations two to three times weekly, three hours in the morning and two in the evening. Only one turbidity incident, defined as visual evidence of turbidity beyond 100 ft of the dredge, was observed during 52 morning and 52 evening surveys, when the anchor of a support boat beyond the dredge area generated a turbidity plume that dissipated quickly.

CLT foraging surveys documenting foraging dives within the active dredge area, inactive dredge areas, and comparison areas, were conducted when CLT were present in the area, from May through August (some CLT remained in the area despite abandonment of the nesting site in mid-June (KBC 2013)).

During all morning surveys, a total of 1,066 CLT dives were recorded, including 153 dives (44%) within the six comparison areas (four of these were in near-shore ocean habitat preferred by CLT, per previous foraging surveys) and 153 (14% of the total) within dredge areas during dredging, generally within 100 ft of the dredge. Evening survey data were insufficient (too few CLT dives) for analyses (KBC 2013).

KBC was unable to survey some dredge areas when no dredging was occurring, since comparison foraging surveys (when and/or where no dredging was occurring) were conducted only when dredging was not occurring in the adjacent area, and frequently it was. That fact, combined with inconsistent CLT activity in the MDR area due to nesting site abandonment, resulted in foraging data that were sufficient at only five dredge areas for comparison between dredging versus non-dredging periods. Of these, results were inconsistent: two supported more foraging dives during dredging, two during non-dredging, and one had similar numbers of dives for the two periods, although because of unsuccessful nesting, CLT numbers in the MDR area varied between each comparison.

Surveys at only one of the five areas were conducted during periods of similar CLT numbers in the MDR area, based on CLT presence at the nesting site, and this area supported 2.6 times more dives during dredging than non-dredging, although the sample size was small. This suggests that, for CLT, the presence and numbers of CLT at the nesting site is a more important predictor of CLT foraging activity than the presence or absence of dredging activity (KBC 2013).

CLT foraging activity recorded during 2012 surveys at MDR would likely be higher when the VBNS supports successful nesting, particularly within MDR. Higher foraging levels were recorded within MDR during the chick phase of nesting during the most recent foraging surveys (Atwood and Minsky 1983).

Studies of Prey Fish Behavior

The following discussion summarizes studies conducted on fish behavior in turbid waters, such as those that can result in the vicinity of dredging activities. Fish actively seek out or avoid turbid waters for a number of reasons, including predator avoidance and food resources, and this pattern is observed for juvenile as well as adult fish (Cyrus & Blaber 1987a).

While turbid waters may provide refuge from predation by piscivorous fish, the response of fish to turbid waters while feeding may increase the potential they will be detected by avian predators. Mous (2000) reported that smelt (*Osmerus eperlanus*) aggregate within the top of the water column when in turbid water, and occur at much deeper levels when the water is clear. Cyrus and Blaber (1987b) also showed that juvenile fish presumably occupy surface waters to take advantage of available light when turbidity results in darkness at lower depths and utilize deeper water when light reaches further due to water clarity.

Johnston and Wildish (1982) found a similar pattern in an experimental setting. While examining the relationship of suspended sediment concentrations and forage visibility in herring, they found that as suspended sediment concentrations were artificially increased, herring larvae moved high into the upper, illuminated portion of the water column. These observations suggest that foraging success of plunge-diving birds could in fact be enhanced by increased turbidity.

In the immediate vicinity of dredging operations suspended sediment concentrations may be sufficiently high to displace fish. Elevated turbidity, resulting from dredging operations, may in some cases also enhance foraging for CLT in areas where suspended sediment concentrations are sufficiently dissipated; by concentrating larval fish seeking cover from aquatic predators and by forcing fish to the surface where they would be more readily accessible to avian predators (Johnston and Wildish 1982).

Studies of California Least Tern Foraging Distances

As noted in Table 1, several studies have documented CLT foraging within a given distance of the nesting site (e.g., Minsky 1982, Atwood and Minsky 1983). During the Oakland Harbor study, all foraging CLT were within 3.5 miles of the Alameda nesting site in 2003; in 2004, 91% of CLT were within 3.5 miles of and 98% were within 4 miles of the nesting site (TetraTech 2006). There were no other colonies reported for the southern portions of the Bay in 2003 and 2004 (Marschalek 2005, Patten 2003); thus, the authors concluded that observed CLT were from the Alameda Point colony. Anecdotal observations of CLT several miles from shore have been reported; for example, Baird et al. (2010) recorded CLT foraging up to 24 km from nesting sites in San Diego Bay. However, based on the above studies, the majority of foraging apparently occurs within four miles of CLT nesting sites.

Studies of Direct and Indirect Effects of Dredging on CLT Nesting and Foraging

A literature review of CLT nesting and foraging behavior by H.T. Harvey and Associates (2012) was conducted "as a means for evaluating uncertainties with regard to the scientific foundation on which dredging restrictions are based." The purpose of the review was to evaluate the potential effects of future dredging projects in the San Francisco Bay on CLT nesting and foraging within the Bay.

The review summarized available information on CLT biology, ecology, and predators in the first four sections; Section 5 is entitled "Known Effects of Dredging on Least Terns," which is relevant to this report and begins with a discussion of noise effects on CLT. The authors state that, though little information available in reviewed literature, noise generated by dredging activities could adversely affect CLT nesting nearby by causing flushing off nests and by hindering the ability of CLT to communicate with

other members of the colony. Such communications are necessary for courtship and for warning other colony members regarding the presence of potential predators. However, the authors later conclude that the ambient noise levels near CLT nesting sites in the San Francisco Bay are not likely to result in a "significant increase in cumulative (noise) impacts unless the dredging operations were to take place immediately adjacent to the colony (H.T. Harvey and Associates 2012).

In response to the H.T. Harvey and Associates (2012) report, the author of this report attempted to obtain data collected on noise levels generated by dredging operations and no such data were available. The U.S. Army Engineer Research and Development Center's Coastal Hydraulics Laboratory (no date) measured construction noise levels at 50 and 200 feet from several CLT nesting sites, including the Santa Margarita River, Batiquitos Lagoon, and Tijuana Estuary. Ambient noise levels at the nesting sites during no construction averaged 52 to 68 decibels (dB). Construction noise levels 50 feet from nesting sites averaged 75 dB but at 200 feet averaged 65 dB, similar to ambient levels. The type of construction was not described, but a noise impact analysis by Mestre Greve Associates (1985) cited by Giroux and Associates (1996) measured 64 decibels (dB) at 200 feet from an active clamshell dredge at Upper Newport Bay, similar to ambient levels measured at nesting sites.

The Coastal Hydraulics Laboratory measurements were not accompanied by data on CLT behavioral responses to various noise levels, nor were other studies on that subject available. However, CLT responses to higher-than-ambient noise levels will likely vary among nesting sites, with CLT nesting in relatively remote locations such as Ormond Beach (just north of Point Mugu NAWC but more than 1.5 miles northwest of its runways and otherwise surrounded by agricultural fields) likely to be less tolerant of noise than CLT at the Huntington Beach nesting site adjacent to Pacific Coast Highway, at the Los Angeles Harbor nesting site adjacent to harbor container terminal operations, or at Santa Margarita River and San Diego Bay nesting sites adjacent to occasional to frequent military operations.

Finally, the lead author of this report, who possesses over 30 CLT nesting seasons of experience monitoring CLT behavior, has observed high tolerance to noises such as nearby truck traffic, hazing of CLT predators with shotgun blasts, and construction of new container terminals. Sudden loud noises such as the clanging of the dredge clamshell against the dredge

barge or scow[1] may result in flushing of some CLT from nests closest to the noise, but the author has observed that the birds return following sudden loud noises far more quickly than they do when a potential predator visits the nesting site. For example, the lead author has observed CLT leaving nests to chase a gull until it is well beyond the nesting site boundary, and the entire CLT colony depart from nests for several minutes in response to the arrival of a peregrine falcon (Falco peregrinus). Nevertheless, to account for possible CLT flushing from nests due to sudden noises associated with dredging activities, this report recommends a 300-foot buffer between dredging activities and active nesting sites (200 ft, per the Coastal Hydraulics Laboratory data, plus 100 ft to allow for sudden loud noises.

The H.T. Harvey and Associates (2012) report also concludes that noise due to dredging may result in CLT avoidance of foraging areas, and that the birds may have to "fly significantly farther to alternate foraging locations," resulting in "increased energetic output." However, the MDR study discussed above (KBC 2013) found no apparent avoidance of active dredging areas by CLT, and the foraging studies discussed in Table 1 indicate that several foraging locations are available near nesting sites.

Finally, the H.T. Harvey (2012) study suggested that CLT communicating when foraging within the dredging area may hinder the ability of fledglings to follow their parents and learn to forage, and the ability of adults to communicate during courtship. These conclusions are based upon the assumption that the dredge barge occupies a majority of the waters over which CLT nesting nearby may fly court, forage, and teach foraging skills to fledglings. The foraging studies summarized in Table 1 of this report and discussed within the text above indicate that this assumption is incorrect. The studies that included survey stations of near-shore ocean waters indicate that offshore foraging is more frequent than foraging in bays, marinas, rivers, estuaries and non-marine bodies of water. Thus, several square miles of potential foraging habitat are generally available within the vicinity of a CLT nesting site.

As an example of the size of dredge operations with respect to available foraging habitat, Figure 11 shows the dredge barge near the Venice Beach CLT nesting site. The clamshell dredge barge used at Marina del Rey in

[1] The dredge clamshell generally deposits dredged materials into a vessel called a scow, which, when full, transports the material to approved disposal sites, sometimes beach nourishment sites, sometimes sites offshore.

2012 is 200 ft long by 60 ft wide and uses two dump scows (one at a time), 248 ft long by 48 ft wide.[1] Various support vessels (tugboats, crew boats, and tow boats to move the dredge—Figure 12), although not present continually, occupy another 4,000 square ft, for a total area of approximately 28,000 square ft, or 0.10% of a square mile. Considering the several square miles of foraging habitat available to CLT nesting at Venice Beach, based on data from Atwood and Minsky (1983) that 60% of all foraging occurs within 2 miles of the nesting site, dredge operations occupy a negligible area of available foraging habitat for any nesting site near ocean foraging habitat.

In addition, the H.T. Harvey (2012) conclusions fail to consider the fact that CLT can detect the presence of another CLT by sight as well as by sound, and the ability of courting birds, or adults flying with fledglings, to shorten the distance between one another so that calls can be heard. Finally, the author of this report has observed, during many years of foraging studies, CLT plunge dives within areas of high noise including pile driving, jet skis, and power boats, suggesting that when a CLT is actively foraging, noise levels are of little consequence.

The H.T. Harvey and Associates (2012) study also includes an extensive discussion about the potential effects of turbidity on CLT and other tern species and on CLT prey species. The authors of that report acknowledge that "the relationship between water clarity and foraging mode and success has been studied to some extent, [but] the conclusions are mixed." Their document provides additional citations but little information regarding turbidity that is additional to what is summarized in Section 3.3 of this report.

[1] Personal Communication. Lawrence Smith.

4 Discussion and Recommendations

Aside from the MDR study (KBC 2013), no CLT foraging studies comparing foraging activity during dredging and non-dredging periods have been conducted. The majority of CLT foraging studies have been conducted in the Los Angeles Harbor, Mission Bay and San Diego Bay, and most of these are a minimum of eight years old. For many of the locations that support Corps Civil Works (CCW) projects from Morro Bay to Imperial Beach, no systematic CLT foraging studies have been conducted. However, the relative importance of areas that may require maintenance dredging with respect to other potential foraging areas can be inferred from the results of other studies in similar locations and habitats.

Several anecdotal observations of CLT diving within and adjacent to turbidity plumes generated by dredging and disposal operations (DDO) suggest that DDO may not substantially alter foraging activity, but the short-term and long-term effects of DDO on CLT foraging have not yet been scientifically determined.

1. Do existing data on CLT foraging suggest that CCWs support CLT preferred foraging habitat such that the ability of CLTs nesting nearby to find sufficient prey may be compromised? No. See the following bullet points.

    - CLT forage in a wide variety of habitats near their nesting sites, including open ocean, river mouths, harbors, bays and estuaries. However, foraging studies that include open ocean survey stations, just offshore from nesting sites and beyond, have found that the majority of CLT foraging occurs in the open ocean rather than in harbors, bays, estuaries, river mouths and marinas where potential DDO areas are located. In addition, far more ocean foraging likely occurs than is possible to document, due to the difficulty in detecting CLT foraging over a large area of ocean and the expense of conducting multiple observations from a boat.
    - CLT have been observed foraging adjacent to nesting sites as well as up to 24 miles from the nearest nesting site (Baird 2010). Thus, although CLT may forage within CCW during dredging operations, the potential dredge impact area (the actual dredge barge and potential area of turbidity 100 ft around the dredge) represents a miniscule part of available foraging habitat in the vicinity of DDO.

- CLT foraging studies in the Los Angeles Harbor documented foraging at 26 different areas in the harbor, and although some of these areas were used far more frequently than other stations, this three-year study indicates that CLT forage in several areas. In addition, the frequency of transit flights over the breakwater suggests a substantial amount of ocean foraging. Since DDO operations are localized, and CLT forage widely, CLT foraging should not be adversely affected by DDO operations.
- High levels of CLT foraging have been recorded in some survey locations: 542 dives during one 20-minute survey at the Port of Los Angeles Pier 300 SWHA (Stations 1 and 2—KBC 2003a), and 1,391 total foraging observations over 54 10-minute surveys in 1993 at Mission Bay Dana Basin (Station 14—SRA 1994). However, these single observations indicate that these areas—and likely others—occasionally support large schools of prey fish for CLT and/or are important since they are close to nesting sites (see last bullet item regarding protection of these areas) but not necessarily that these areas are consistently important for CLT foraging.

2. Do existing data suggest that CLT foraging may be adversely affected by dredging activities? No. See the following bullet points.

   - Although sufficient data on CLT foraging dives in DDO areas during active dredging and during periods of non-dredging are lacking for a statistical comparison, CLT foraging within turbidity plumes (KBC 2003b) or during active sediment deposition (TetraTech 2006) resulting from dredging or beach disposal operations has been documented on several occasions. In addition, 153 LT foraging dives were recorded in dredging areas, many within 100 ft of the active dredge, during 2012 surveys at MDR (KBC 2013), suggesting that CLT foraging activities are minimally affected by dredging activities.
   - Dredging activities during the CLT nesting season are not expected to affect CLT foraging to the extent that CLT parents are unable to find sufficient prey fish for themselves and their young. However, the majority of studies summarized in this report are more than eight years old (Table 1), and CLT nest numbers, and thus the levels of CLT foraging, have changed for some areas (e.g., Los Angeles Harbor). A need still exists for foraging studies with sufficient data

to compare levels of foraging under otherwise similar conditions and locations during dredging and non-dredging periods.

- CLT can flush from nests as a result of disturbances such as sudden noises and visits by predators. They may return to nests after fractions of minutes to several minutes later, depending on the type of disturbance. For example, frequent visits to the nesting site by a peregrine falcon can cause them to abandon a nesting site for several hours (author personal observation). CLT susceptibility to disturbances varies with the stage of the nesting cycle (they are more skittish, for example, during chick hatching) and the frequency and type of other disturbances. Thus, it is difficult to develop scientifically valid recommendations for distances in feet or meters at which DDO should remain from CLT nesting areas during the nesting season, in order to ensure no affect. However, the Coastal Hydraulics Laboratory (no date) data that showed noise levels at nesting sites 200 ft from construction were similar to ambient noise levels, and this report would recommend such a buffer between active dredging activities and an active CLT nesting site but that would not take into account potential flushing from nests due to sudden noises resulting from DDO. Although such noises were infrequent during monitoring of Marina del Rey dredging project, a 300-foot buffer between the dredge barge and active CLT nesting sites is believed to be sufficient to minimize flushing disturbances. Restrictions to DDO should therefore be limited to dredging operations that occur within 300 ft of CLT nesting sites and to sediment placement operations that occur within 200 ft of CLT nesting sites. Otherwise, seasonal restrictions on dredging near active CLT nesting sites provide no protections to this species and are not warranted.

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Appendix A: Maps

Figure 1. CLT nesting site (CLT NS) near Corps Civil Works (CCW) locations in San Luis Obispo County.

Figure 2. CLT nesting site (CLT NS) near Corps Civil Works (CCW) locations in Santa Barbara County.

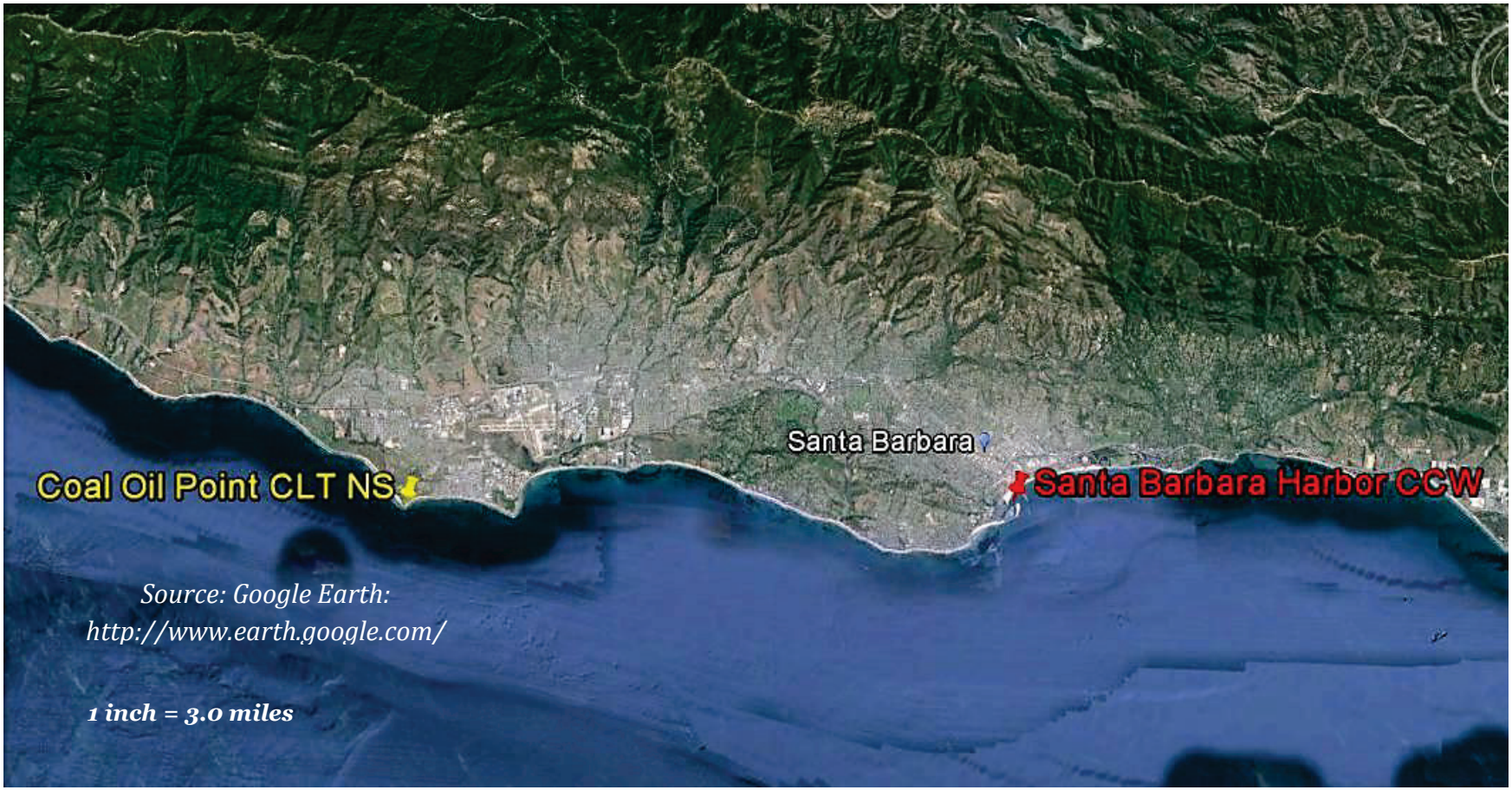

Figure 3. CLT nesting sites (CLT NS) near Corps Civil Works (CCW) locations in Ventura County.

Figure 4. CLT nesting sites (CLT NS) near Corps Civil Works (CCW) locations in northern Los Angeles County.

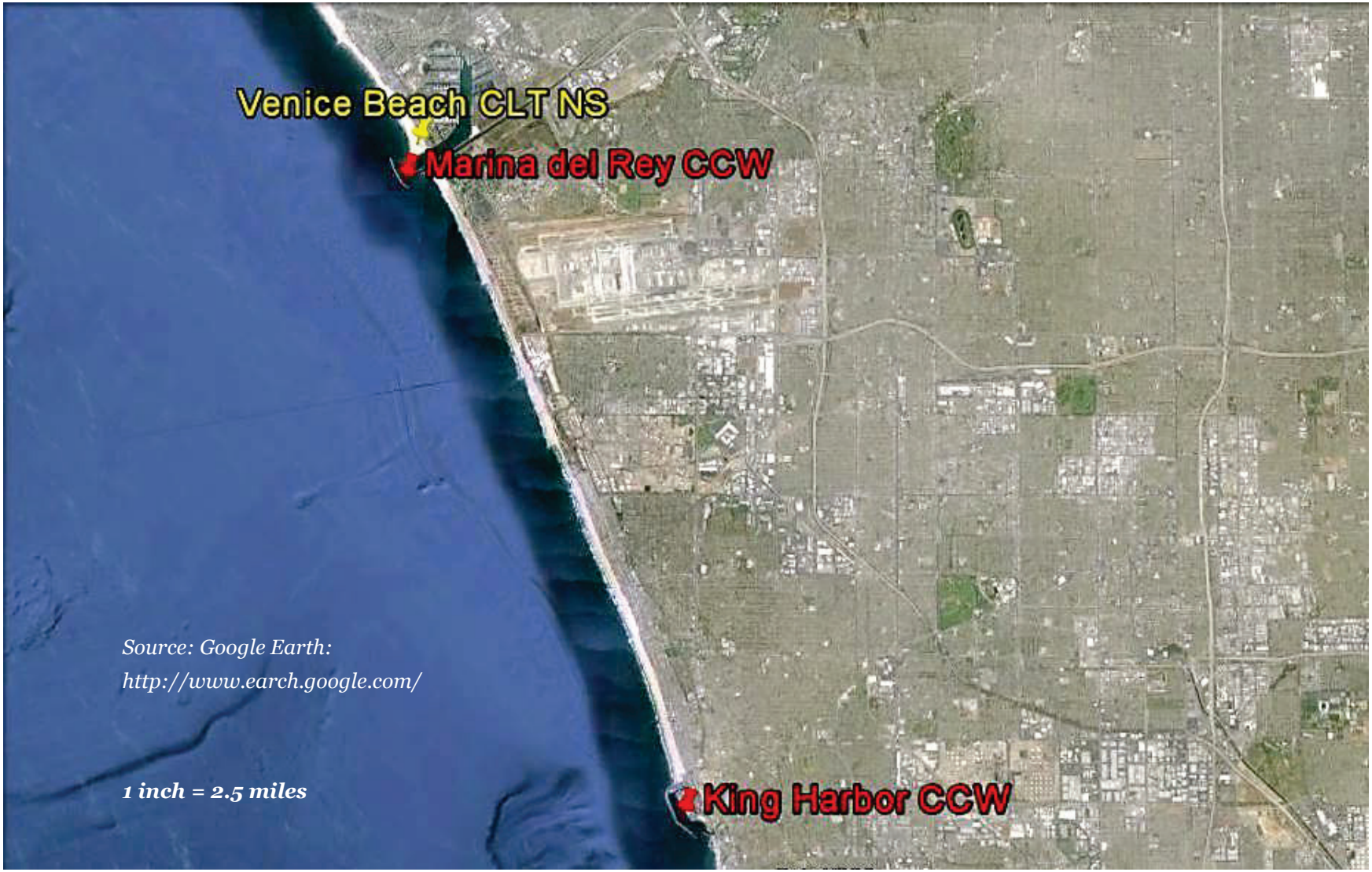

Figure 5. CLT nesting sites (CLT NS) near Corps Civil Works (CCW) locations in southern Los Angeles County.

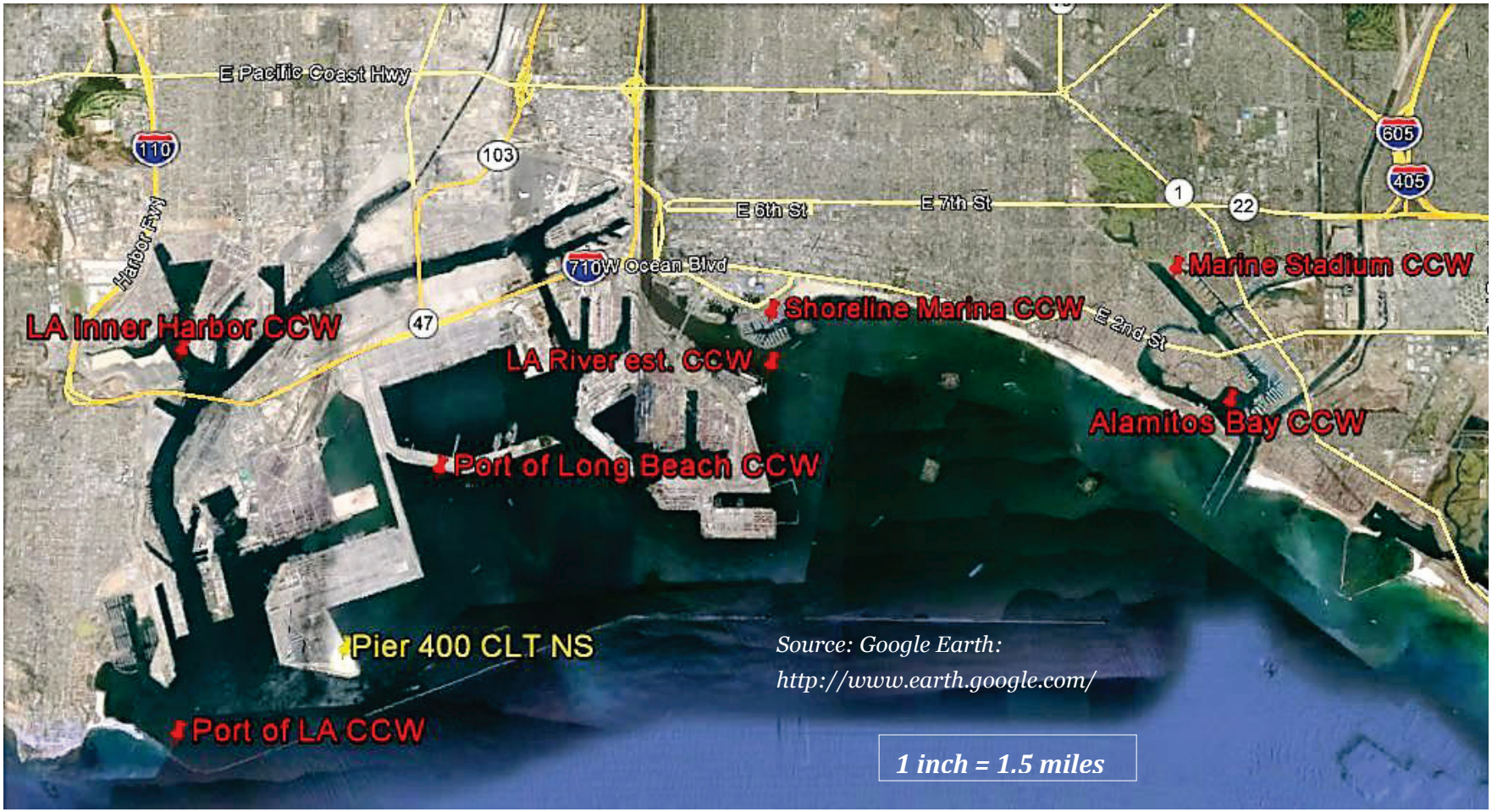

Figure 6. CLT nesting sites (CLT NS) near Corps Civil Works (CCW) locations in northern Orange County.
*("Offshore Surfside-Sunset Beaches CCW" is shown as a polygon; Bolsa Chica nesting sites are numbered NS1, NS2, NS3 and South Tern Island (STI)

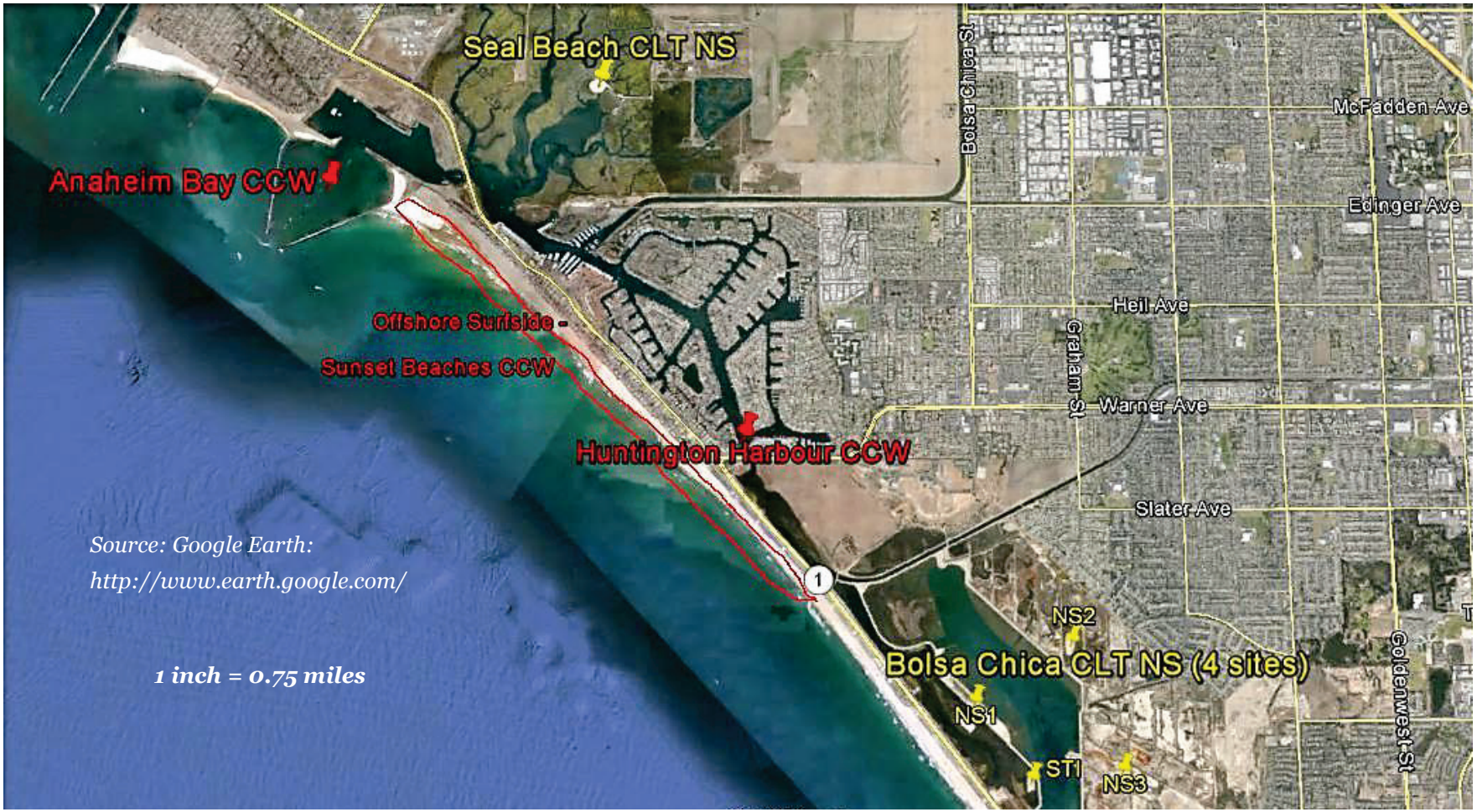

Figure 7. CLT nesting sites (CLT NS) near Corps Civil Works (CCW) locations in southern Orange County.
*(New Least Tern Nesting Island at Upper Newport Bay, created in 2007, was unused by CLT as of the 2013 nesting season)

Figure 8. CLT nesting sites (CLT NS) near Corps Civil Works (CCW) locations in northern San Diego County.

Figure 9. CLT nesting sites (CLT NS) near Corps Civil Works (CCW) locations in central San Diego County.

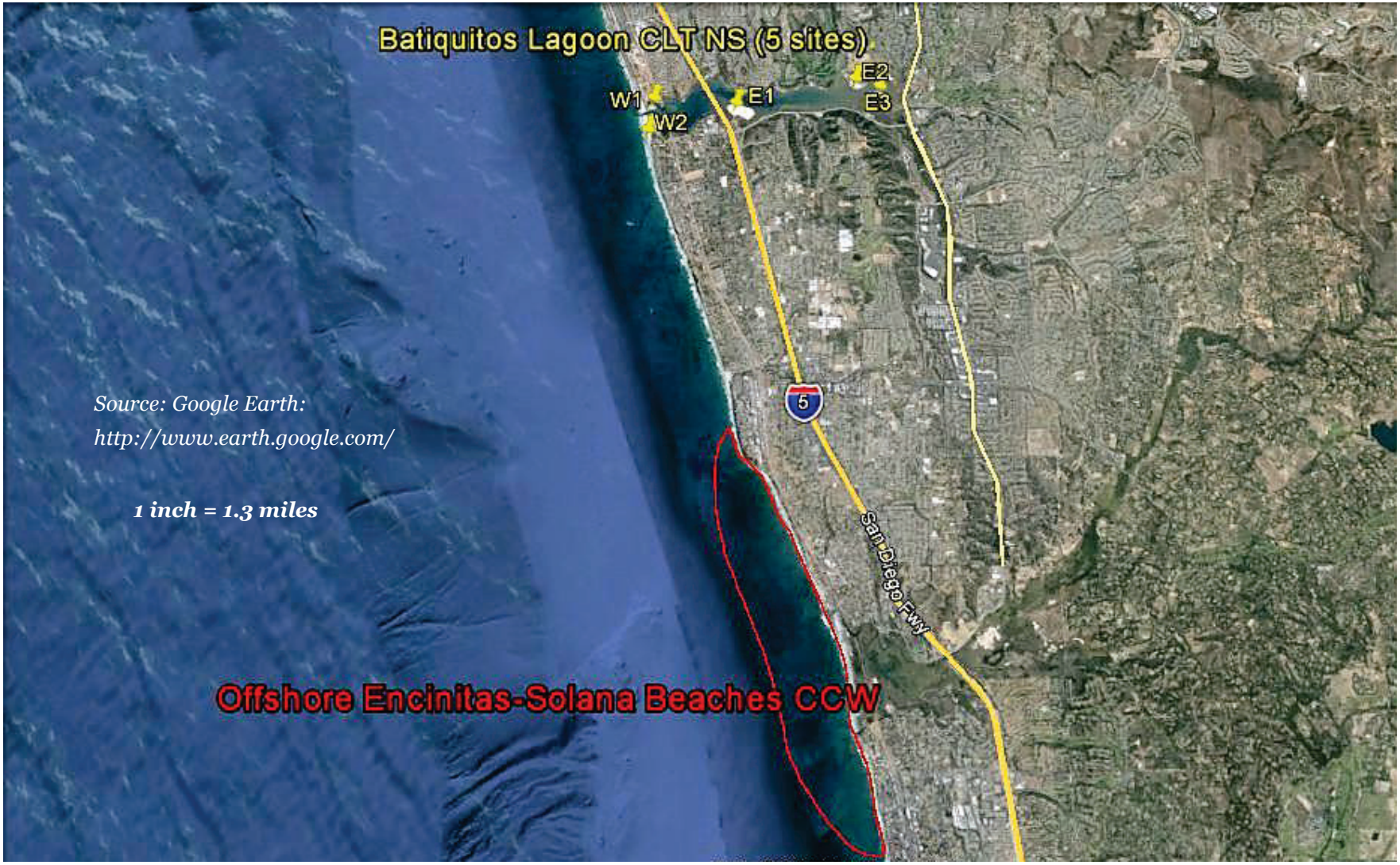

Figure 10. CLT nesting sites (CLT NS) near Corps Civil Works (CCW) locations in South San Diego County.

Figure 11. Available foraging habitat in the vicinity of the Venice Beach CLT nesting site (red dot in channel is dredge and disposal barges; pink teardrops designate two-mile distance from the Venice Beach nesting site).

Figure 12. Dredge Barge, Scow (foreground left) and Tugboat, Marina del Rey, April 30, 2012.

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Keane Biological Consulting
2892 North Bellflower Boulevard, Suite 480
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U.S. Army Engineer District, Los Angeles
915 Wilshire Boulevard, Suite 930
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14. ABSTRACT

The California least tern (*Sternula antillarum browni,* hereafter CLT), one of three subspecies of Least Tern, nests along the west coast of North America. Foraging occurs in bays, lagoons, estuaries, tidal marshes, river mouths, ponds and lakes, as well as in offshore deep-water habitats by plunge-diving for fish. Fifty species of prey fish have been identified as potential CLT prey.

The CLT, listed as endangered by the federal and California Endangered Species Acts, is afforded protection at its nesting sites in California. The relative importance of various foraging areas and foraging habitats near CLT nesting sites has not been evaluated, nor has official protection been designated to any CLT foraging areas, aside from seasonal limits on dredging sites recommended by the U.S. Fish and Wildlife Service (USFWS).

The U.S. Army Corps of Engineers (Corps) Los Angeles District conducts maintenance dredging along the California coast to ensure navigational access. Some of these sites are within foraging distance of CLT nesting areas. Dredging activities were generally limited to periods outside the CLT nesting season (April 15 to September 15) in order to avoid potential adverse effects on CLT foraging due to turbidity.

This report summarizes the results of a literature review on studies and observations of CLT foraging and studies on the behavior of CLT forage fish in turbidity plumes. Results suggest that dredging activities may not substantially alter CLT foraging activity and seasonal restrictions on dredging near active CLT nesting sites provide no protections to this species and are not warranted.

15. SUBJECT TERMS

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Foraging ecology in Southern CA

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