FINAL REPORT

Experiment to Protect Least Terns during an Oil Spill at the Port of Los Angeles Pier 400 Least Tern Nesting Area,

2006 Least Tern Nesting Season

by

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ABSTRACT

The California Least Tern, a small seabird that nests at more than 30 protected nesting sites along the California coast from San Francisco Bay to the U.S.-Mexico border, is federally and state-listed as an endangered species. It forages for small (three inches in length or less) bait fish such as anchovies and topsmelt that it obtains from near-shore waters, harbors, bays and estuaries.

The California Least Tern (CLT) population has recovered from its pre-listing numbers of less than 600 to well over 6,000 nesting pairs. However, nesting is highly concentrated at only a few nesting sites. Thus, an oil spill near one of these sites could result in substantial CLT mortality. In light of this fact, the California Department of Fish and Game Office of Oil Spill Prevention and Response (CDFG-OSPR) requested a study that could determine whether CLT could be lured away from preferred foraging areas with the use of an artificial food source (fish-stocked pools). Anecdotal evidence of CLT use of such pools stocked with mosquito fish has been observed in previous years.

Thus, CDFG-OSPR contracted with Keane Biological Consulting (KBC) to design and conduct an experiment at the Los Angeles Harbor CLT nesting site to answer the following questions:

1) Does the creation of an artificial food source attract CLT to the extent that their foraging is reduced at known, preferred foraging areas?
2) How much is CLT foraging at known, preferred foraging areas reduced?
3) Can CLT be lured away from known, preferred foraging areas for three consecutive days?
4) Will the experiment work with a simple backyard pool, such as can be quickly purchased at a local department store?
5) Will the experiment work using readily available fish (e.g. mosquito fish or anchovies from bait barges?)
6) How many pools and how many fish are needed to feed a specified number of CLT?

Results of the experiment are summarized below:

1) some CLT will use the pools and successfully obtain fish from the pools.
2) the pools with clear water were not as attractive to CLT as those with a heavy growth of green algae. Little foraging was observed over the pools where, to humans, the fish were clearly visible. Perhaps the fish don't see the terns as predators as easily if the water is murky and thus don't swim to the bottom of the pool with terns overhead. However, although only one CLT dive was observed in the non-murky pool, little CLT interest (hovering above the pool) was observed, so the dark color of the water or background may be a factor.
3) Size matters. There was more interest in the large (10-ft diameter) murky pool than the smaller (8-ft diameter) murky pool.

4) the intensity of foraging never exceeded more than about 5 dives per a 10-minute period. Thus, in the event of an oil spill, they would not be successful in diverting large numbers of CLT away from oil spill areas. However, during an oil spill in preferred foraging areas which in turn affects the availability of CLT prey, it's possible the pools would become more heavily used.

Thus, regarding the above questions:

1) Does the creation of an artificial food source attract CLT to the extent that their foraging is reduced at known, preferred foraging areas (PFAs)? NO
2) How much is CLT foraging at reduced at PFAs? NOT NOTICEABLY
3) Can CLT be lured away from PFAs for three consecutive days? NO
4) Will the experiment work with a simple backyard pool that can be easily and quickly purchased at a local department store? YES, BUT OTHER OPTIONS SHOULD BE EXPLORED IN FUTURE STUDIES
5) Will the experiment work using readily available fish (e.g. mosquito fish) YES (or anchovies from bait barges)? WE DID NOT TRY ANCHOVIES BECAUSE THEY ARE NOT AS READILY AND CONSISTENTLY AVAILABLE
6) How many pools and how many fish are needed to feed a specified number of CLT? UNKNOWN. However, if each CLT requires approximately 20 fish per day (this is an estimate—energetic needs of CLT have not yet been studied) and there are 900 pairs (or 1800 individuals) of CLT nesting at the Pier 400 nesting site, approximately 16,000 fish per day would be required to artificially feed CLT at that nesting site, prior to chick hatching.

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1.0 INTRODUCTION

1.1 California Least Tern Nesting

The California Least Tern (*Sternula*[1] *antillarum browni*[2]), listed as endangered under the federal Endangered Species Act in 1970 and the California Endangered Species Act 1971, is a small, colonially-nesting seabird that breeds from April through August in several coastal locations from San Francisco, California to Baja California, Mexico (Massey 1974). The California nesting population has increased from approximately 60 nesting pairs at listing to over 7,000 pairs in 2006 (CDFG unpublished data).

California Least Tern (CLT) breeding occurs at over 36 nesting sites in California, including the Los Angeles Harbor (LAH), the study site for this experiment (Figure 1). The LAH is the location of one of only two CLT nesting sites in Los Angeles County, while there are over twenty sites in San Diego County, six in Orange County and five in Ventura County. The Los Angeles Harbor Department, manager of the LAH, is required, per a Memorandum of Agreement with the United States Fish and Wildlife Service (USFWS), California Department of Fish and Game (CDFG), to protect a 15-acre nesting site for CLT.

Along with the statewide increase, CLT numbers at the LAH grew substantially following the creation of a new nesting site at Pier 400 (Figure 1), a 565-acre container terminal completed in 2005. Prior to 1997, the LAH annual nesting population averaged 42 pairs (4.3% of the California population) but thereafter averaged 556 pairs (9.3%), and in 2006, nearly 18% of the California CLT population nested at the LAH (Keane 2006). The CLT population is otherwise highly concentrated, with the majority nesting at just seven of the approximately 36 nesting sites statewide (Figure 2).

1.2 California Least Tern Foraging

The CLT feeds 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*) and Slough Anchovy (*A. delicatissima*) anchovies, among other species (Atwood and Kelly 1984). CLT are also known to eat freshwater species including Killifish (*Fundulus parvipinnis*) and mosquito fish (*Gambusia affinis*) (U.S. Fish and Wildlife Service [USFWS] 1980).

The CLT prefers shallow-water habitats (< 20 ft.) such as bays, lagoons, estuaries, tidal marshes, river mouths, ponds and lakes (Thompson et al. 1997); however, results of KBC surveys (KBC 2004) and this study indicate a significant amount of foraging also occurs offshore in deep-water habitats. CLT forage throughout day, searching for prey while flying or hovering 1–10 m above water, then quickly plunges to surface but does not fully submerge. It normally plunge-dives and grasps prey with open mandibles, then rises above water after capturing prey to manipulate and swallow food in flight (Burroughs 1966).

[1] The genus name for Least Tern was recently changed by the American Ornithologist's Union from *Sterna*.
[2] Scientific names are provided only after the first mention of the common name in this document.

Figure 1. Los Angeles Harbor and Location of Pier 400 California Least Tern Nesting Site

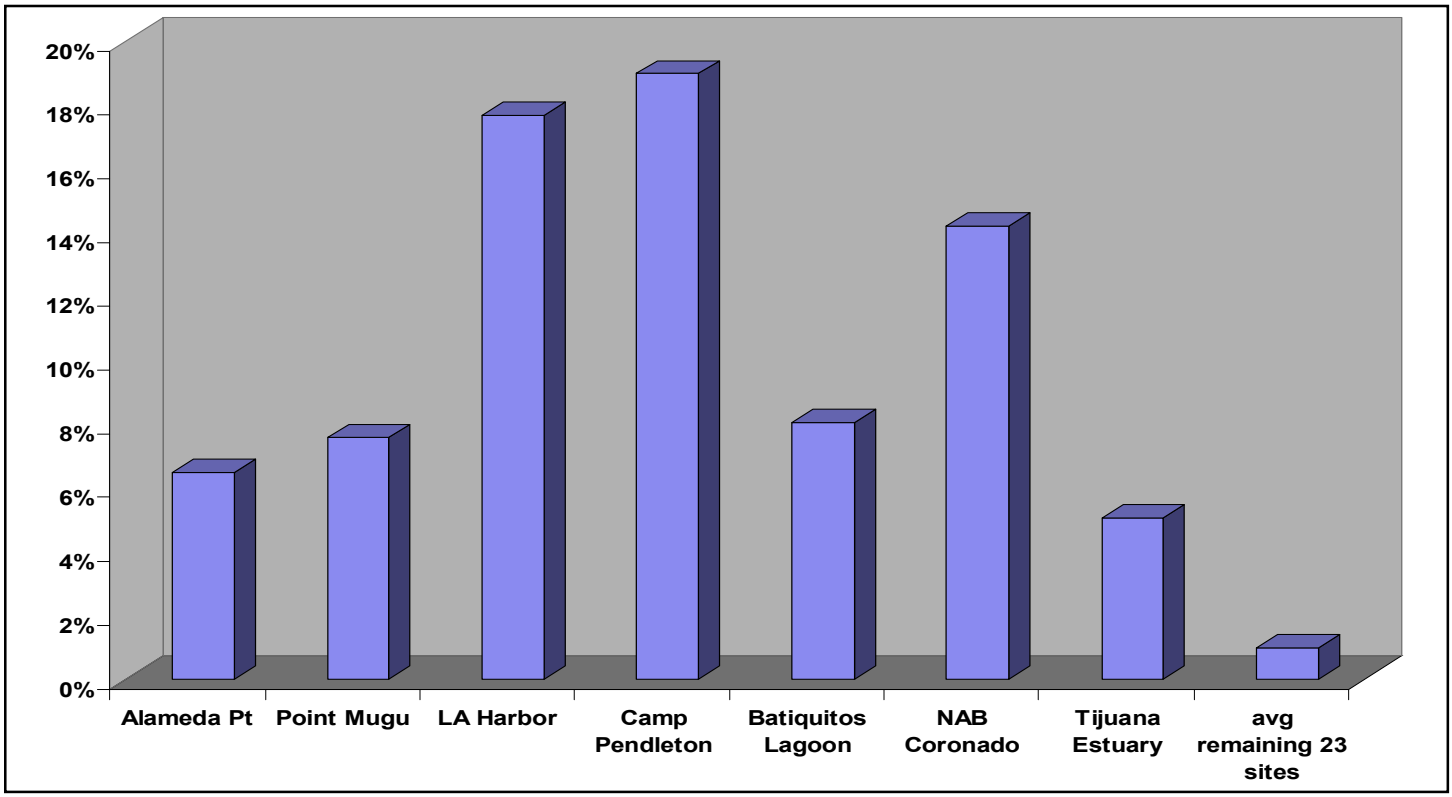

Figure 2. Percent of Total Statewide California Least Tern Nesting Population in 2005

In the early 1980's, Atwood and Minsky (1983) conducted foraging studies near three CLT nesting sites in southern California including Camp Pendleton, Venice Beach and Huntington Beach. Their study concluded that CLT foraging occurred up to 3 km from the nesting site but that 75% of foraging occurred within 1.2 km of nesting sites. Aside from that study, although CLT nest numbers and reproductive success have been quantified since 1973, other foraging studies were infrequent and seldom followed systematic data-collection methods.

During cursory surveys in the LAH during 1977, CLT were observed feeding in several locations (Atwood et al. 1977). More comprehensive surveys initiated in 1982 and repeated in 1984 and 1985 indicated that foraging activity was concentrated in shallow water, particularly east of and adjacent to the CLT nesting site located at that time on Pier 300 (Figure 1), with little activity in deeper, more distant water (Massey and Atwood 1984). The results of these studies and of foraging studies conducted elsewhere are summarized in Keane (1988).

In 1986 and 1987, the first study to systematically document foraging throughout the LAH was conducted (Cimberg 1987). It sampled 14 locations and found that foraging dives were most frequent east and south of the Pier 300 nesting site. Foraging dives were also frequent within 100 m of the San Pedro and Middle breakwaters.

A three-year study at four to eight CLT foraging locations in the LAH was conducted from 1994 through 1996, which revealed that foraging activity was highest east and south of the Pier 300 nesting site and at the Seaplane Lagoon and Cabrillo Beach (Keane 1996). Foraging surveys in 1998 through 2000 were limited to areas around the perimeter of Pier 400, where CLT had begun nesting in 1997; they no longer nested at Pier 300 (Keane 2000). Foraging activity was concentrated in different locations around Pier 400 each of the three years.

CLT foraging studies were also conducted from 1997 through 2005 for the Port of Long Beach located adjacent to and east of the LAH. These studies included two comparison locations in the LAH. Results indicated the highest level of foraging by far was in the shallow water adjacent to Pier 300, even though CLT were no longer nesting at this location (Keane 2005).

During the 2001, 2002 and 2003 CLT nesting seasons, KBC conducted weekly surveys at 18 to 27 sites throughout the LAH. Results of these surveys indicate that over 50% of CLT foraging dives occurred at the shallow water habitat area adjacent to Pier 300; however, foraging dives also occurred in deep water habitats. In addition, high numbers of transit flights over the breakwaters suggest that a substantial proportion of CLT foraging occurs outside the harbor in the open ocean (Keane 2004).

1.3 Purpose and Need for Experiment

During the 2004 Spill of National Significance (SONS) Drill in Long Beach and San Diego, California, oil industry personnel and representatives from the California Department of Fish and Game (CDFG) and USFWS discussed the above-described facts of CLT nesting and foraging. They recognized that, because the population is heavily concentrated, even a moderate sized spill could result in oiling and subsequent mortality to large numbers of CLT.

KBC has attempted in the past to haze CLT from construction areas to deter them from nesting; these attempts were unsuccessful; thus, in the event of an oil spill at or near Los Angeles Harbor, hazing CLT from spill locations would not be an option. In addition, as indicated by the findings of Keane (2004), CLT forage extensively in the open ocean as well as at many other locations, and foraging areas may extend over several square miles of open water. Therefore, even if methods were developed to successfully haze CLT from foraging areas, a future oil spill may cover a large area of potential foraging habitat prior to containment, and it may be improbable to haze CLT from the entire area.

In light of the above information, this experiment was designed to lure CLT to artificial foraging areas rather than to discourage CLT foraging at potential spill locations. In the 1970s, while conducting research on the foraging habits of CLT, Paul Kelly observed an unusual phenomenon. At Bolsa Chica Wetlands, Orange County Vector Control was preparing to treat an area with mosquito fish. They placed a cattle trough (round, about 14-feet in diameter, metal sided, approximately 2 to 3 feet deep), filled with water and fish, in close proximity to the Bolsa Chica CLT nesting site. The CLT discovered the food source immediately and began diving into the trough for fish. Many CLT fed from the trough for the next two days. Other larger terns nesting at Bolsa Chica (Caspian Tern [*Sterna caspia*] and Elegant Tern [*Sterna elegans*]) did not utilize the trough.

Subsequent to this observation, supplemental feeding of CLT was attempted in the late 1970's during construction adjacent to the Santa Ana River mouth, just south of the Huntington Beach CLT nesting site. A depression approximately 20 feet in diameter and 2 to 3 feet deep was created with a bulldozer on some nearby flats, lined with black plastic and filled with water and mosquito fish. Again, CLT discovered the food source and several were observed diving into the artificial pool for mosquito fish.

Other studies conducted by wildlife rehabilitator Meryl Faulkner, a wildlife rehabilitor in San Diego, have also shown that CLT fledglings will forage in artificial pools (Meryl Faulkner, pers. comm.).

Thus, considering the fact that the CLT population is heavily concentrated in a few nesting sites and that an oil spill near one of these nesting areas could result in substantial mortality or at least in declines in CLT reproductive success, the CDFG Office of Oil Spill Prevention and Response (OSPR) requested that KBC design and conduct an artificial feeding experiment at a CLT nesting site. The goals of the experiment are to determine whether:

1) artificial feeding pools can be quickly obtained and deployed (filled with water and stocked with fish that will survive a minimum of three days, in numbers sufficient to feed CLT for three hours a day for three days) with minimal disturbance to nesting CLT;

2) CLT forage in artificial the pools to the extent it can be concluded that they may be successfully lured away from oil-contaminated waters in the event of a future oil spill near a CLT nesting site during the nesting season.

2.0 STUDY METHODS

2.1 Foraging Surveys at Preferred Foraging Areas

KBC established three survey stations at known, preferred CLT foraging areas (PFAs) in the LAH, based on three years of surveys KBC conducted at 18 to 27 stations in the LAH, as discussed in Section 1.2. These areas, which supported the highest number of CLT foraging dives during the surveys, were the **Pier 300** shallow water habitat, the **inner elbow of Pier 400**, and the southeastern shore of Pier 400 **east of the nesting site** (labeled "F" in Figure 3).

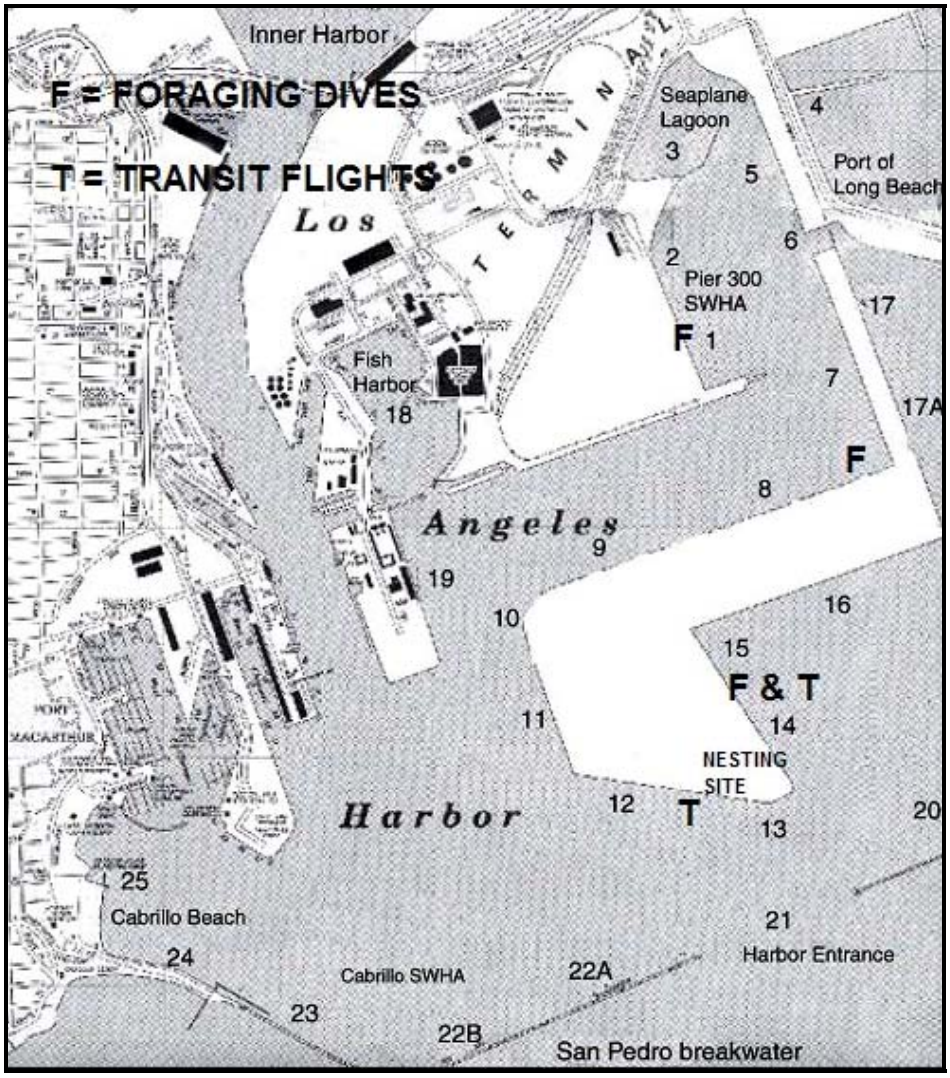

Figure 3. Preferred Foraging Area Stations and Transit Flight Stations

PFA vantage points were designed to include potential foraging habitat within view of the observer, reliable station access was established, and KBC biologists who have conducted the previous CLT foraging surveys were used to conduct the surveys. Foraging data sheets were prepared and instructions on how to complete the sheets were provided to each biologist.

The KBC study plan included a statistically valid number of CLT foraging surveys at PFAs prior to, during and following the supplemental feeding experiment so that the frequency of CLT foraging prior to, during and after the experiment could be statistically compared. It was hoped that statistical comparisons would demonstrate that CLT foraging dives were less frequent at PFAs during, as compared with prior to and after, the supplemental feeding program.

Three days of surveys prior to the experiment were conducted for two hours each day, beginning at 6 am. Each survey was 10 minutes in length, with a five-minute break in between each survey to ensure statistical independence and to minimize observer fatigue. Thus, a total of 24 separate 10-minute surveys at each of the PFA's was conducted prior to the experiment.

During each 10-minute survey at the PFA's, the number of foraging dives (plunge into water to capture prey) were recorded. No attempt was made to determine whether foraging dives were successful, as the fact that prey is often consumed quickly limits the ability to observe whether prey was captured. Foraging dives were recorded only if the bird hit the water; aborted dives were not counted. The survey time, observer, and weather variables were also recorded. Observations of other birds in the study area and other notes were recorded in the "Comments" column on the data sheet.

In addition to foraging surveys at the PFA's, the number of transit flights (direct flight one destination to another) were recorded at two locations adjacent to the nesting site (labeled "T" in Figure 3). One location was located just outside the eastern boundary of the nesting site (**east of nesting site**), and transit flights from the nesting site toward foraging areas to the east (such as in Long Beach Harbor) were counted here. The second location was the rip-rap south of the nesting site (**south rocks**), and transit flights from the nesting site toward foraging areas to the south (near the breakwater and beyond) were recorded here. The transit flight surveys were also 10-minutes in duration. Only CLT flying away from the nesting site were recorded so that foraging attempts would not be over-estimated by also counting CLT returning to the nesting site.

As discussed above, KBC hoped to continue foraging surveys at the PFAs and transit flight surveys during and following the experiment, and that data from the both the foraging surveys and transit surveys could be used to calculate and statistically compare among the mean number of foraging flights before, during and after the experiment, and among the mean number of transit flights before, during and after the experiment. We anticipated that mean foraging dives at PFAs and and mean transit flights from the nesting site would decline during the experiment due to an increase in foraging at the fish-stocked pools by at least some CLT, and that they would subsequently increase once again following the experiment.

However, as further discussed in the Results section, very few foraging attempts at the pools were observed during the experiment; thus, foraging surveys and transit surveys were continued during the experiment but surveys after the experiment were cancelled, and the infrequency of foraging at the pools rendered statistical comparisons unnecessary.

Data from each foraging and transit survey were entered into a Microsoft Excel 2000 spreadsheet, and the mean number of foraging dives and foraging terns for all surveys prior to the experiment and during the experiment were calculated for each of the PFAs. Data for transit flights were handled similarly.

We had planned to analyze the data using parametric statistics so that for each of the PFAs, means for foraging dives before the experiment could be statistically compared using paired t-test with means for foraging dives during the experiment. We hoped that such analyses would show a statistically significant difference in means due to a reduced number of foraging dives at the PFAs during the experiment as CLT shifted their preferred foraging to the pools. Similarly, we had hoped that means for transit flights conducted prior to the experiment would also be statistically higher than the means for transit flights during the experiment. However, as stated above, because of the limited extent of CLT foraging observed in the pools during the experiment, no statistical analyses were conducted.

2.2 Planning the Experiment

Telephone conversations and emails among KBC, the California Department of Fish and Game office of Oil Spill Prevention and Response (OSPR), the Port of Los Angeles (POLA), and representatives assigned to CLT protection and management with the United States Fish and Wildlife Service (USFWS; Jack Fancher) and the California Department of Fish and Game (CDFG; Lyann Comrack) were conducted to allow all interested parties to assist with design of the experiment, and to ensure, following finalization of the experimental design, that consensus was obtained. Coordination with biologists that monitor the CLT site at Pier 400 was not necessary since KBC has been monitoring this nesting site for the past 15 years and is aware of prime locations at and near the nesting site where pools can be quickly deployed with minimal disturbance to nesting CLT. KBC is also aware of preferred CLT foraging areas in the harbor. KBC also discussed supply of mosquito fish () by Orange County Vector Control, which agreed to supply mosquito fish without cost to us. KBC also ordered all experimental supplies including fish, water pumps, fish pools, covers for the fish pools, fish food, etc. The experiment was designed to answer the following questions:

1) Does the creation of an artificial food source attract CLT to the extent that their foraging is reduced at known, preferred foraging areas?
2) How much is CLT foraging at known, preferred foraging areas reduced?
3) Can CLT be lured away from known, preferred foraging areas for three consecutive days?
4) Will the experiment work with a simple backyard pool, such as can be quickly purchased at a local department store?
5) Will the experiment work using readily available fish (e.g. mosquito fish or anchovies from bait barges?
6) How many pools and how many fish are needed to feed a specified number of CLT?

Because mosquito fish provide a lower caloric value than anchovies, because of the high energy needs of CLT chicks, and because of high chick mortality at Pier 400 in 2004 and 2005, KBC proposed that the experiment be conducted prior to chick hatching to minimize any experimental affect on survival of CLT chicks. In addition, because female CLT also have high energy needs during egg laying, we proposed that the experiment should begin at the end of peak egg-laying. Thus, the experiment was initiated in early June, prior to chick hatching, which began the 9th of June, and following peak egg-laying, which occurred the week of May 20 (Keane 2006).

2.3 Setting up the Experiment

KBC determined, and obtained consensus among interested parties discussed in Section 2.2, that the best location to place pools for the experiment was along the sandy road east of the fenced nesting site. This area is accessible by vehicle from a locked gate and thus convenient for placement of pools, filling the pools with water and delivery of mosquito fish. However, because a few CLT had nested here during previous years, KBC placed chick fencing face down in an area approximately 40 feet long and 20 feet wide where we planned to place the pools.

KBC and other interested parties debated the potential for using anchovies rather than mosquito fish since previous studies indicate they are the preferred prey item and because they have a higher caloric value than mosquito fish. However, salt water is more difficult to obtain than freshwater, and although it can be created from a kit, the primary reason we decided not to use anchovies was because of their inconsistent availability. During our LAH-wide surveys from 2001-2003, we visited LAH bait barges once weekly and interviewed the proprietors regarding the availability of anchovies. Some weeks, no anchovies were available at all; at other times, large anchovies (three inches in length or greater) were available but CLT-sized anchovies (less than three inches) were low in number or not available at all. Thus, we decided to use mosquito fish, which we knew from anecdotal evidence discussed above that CLT will take as prey.

Thus, KBC obtained three Clear-Water@ wading pools, each eight feet in diameter and 18 inches deep, from K-Mart (Figure 4a). The had a light blue bottom which would allow for good visibility of mosquito fish. The Port of Los Angeles provided a water truck operated by Reyes Construction which filled the pools with freshwater (Figure 4b). As instructed by Orange County Vector Control, we then placed dechlorinator into each pool, per the amount and instructions provided on the bottle (Figures 4c and 4d).

The next morning, Orange County Vector Control District (OCVCD) arrived to stock the pools. We had hoped to install standing covers (tarps mounted on poles to allow air flow over the pools but render them invisible to CLT) to prevent depletion of fish in the pools by foraging terns prior to the experiment, and to remove the pool covers immediately prior to the experiment. However, because no CLT foraging was observed at the pools, covers were not applied.

Another larger (10-ft-diameter, 24 inches deep) Clear-Water@ pool was added due to the lack of CLT foraging over the small (eight-ft diameter) pools, and a floating pool created from an inflatable raft purchased at Sports Authority was tethered to riprap east of the nesting site when no CLT foraging over the larger pool was observed. Water from the water truck, dechlorinator and fish were added to these pools per methods discussed above.

We fed the fish each day with goldfish food purchased at a local pet store, per the recommendation of OCVCD. At the end of the experiment, OCVCD returned to retrieve surviving mosquito fish.

Figure 4a. ClearWater Pools Dechlorinator

Figure 4c.

Figure 4b. Filling the Pools

Figure 4d. Adding Dechlorinator

Figure 4e. Adding Mosquito Fish to the Pools

FIGURE 4. SETTING UP THE EXPERIMENT, SMALL POOLS

2.4 Conducting the Experiment

The morning of the fourth day of the project (following the three days of pre-experiment foraging surveys), biologists were deployed at the PFAs and transit flight stations and at the pools. Cell phones and/or hand-held short-wave radios were used to maintain contact among all biologists so that surveys can begin simultaneously. It was anticipated that once CLT begin foraging at the pools, foraging surveys would begin at the pools (similar to surveys prior to the experiment, eight 10-minute surveys would be conducted each of the three days of the experiment as well as at the PFAs and transit flight stations. Pools were to be covered prior to and following the experiment. Pools would not be covered during the five-minute break periods between the surveys so that CLT do not become confused about the availability of supplemental food. Pools were to be restocked with fish if necessary.

However, no CLT activity over the pools was observed during Day 1 of the experiment. We thus added two more pools, a larger pool 10 feet in diameter and three feet deep with a lighter bottom (Figure 5a), and an offshore pool (Figure 5b) and filled them with fresh water, dechlorinator and mosquito fish similar to the methods discussed above.

Figure 5a. Large Pool

Figure 5b. Offshore Pool

3.0 RESULTS AND DISCUSSION

As discussed above, no CLT foraging dives were observed over the two[3] eight-foot pools (small pools) pool during Day 1. No CLT foraging dives were observed at the small pools or at the newly-placed 10-foot (large) pool during Day 2 or at the offshore pool, which was subsequently stolen. However, on Day 3, when all three pools had become murky with green algae, one CLT was observed hovering over one of the small pools (Figure 6) and a total of four foraging dives into this pool was recorded over the course of eight 10-minute surveys on Day 3.

Orange County Vector Control assured us that the presence of algae would not affect the survival of mosquito fish. We suspected that algae may be a factor in CLT foraging at the pools (Figure 7); thus, we emptied one of the smaller pools and refilled it with freshwater and mosquito fish. Thereafter, we had three types of pools: one small pool murkey with algae, one large pool murky with algae and one small clear pool.

Over the following six days, we continued observations of CLT foraging dives for eight 10-minute surveys each day at the pools, for a total of 48 surveys. Results were as follows:

Table 1. CLT Foraging Dives at Experimental Pools

Treatment>	Small murky	Small clear	Large murky
TOTAL	12	1	31
PERCENT of TOTAL	32.4%	2.7%	83.8%
MEAN (foraging dives per 10-minute survey)	0.17	0.02	0.58

In summary, a total of 44 CLT foraging dives (a minimum of seven successful) were recorded at the pools over 480 minutes. The highest number of foraging dives (31, or 83.8% of the total) was observed at the large pool (Figures 8a and 8b). Whether or not this was because the pool provided a wider area of potential foraging habitat or because of some other factor is not clear. The large pool was murky with algae similar to the small murky pool; thus, the presence of algae was likely not a factor in foraging preference between the small murky pool (Figure 8) and large murky pool. However, it is apparent that the murkiness enhanced the suitability of foraging habitat, since only one dive was recorded at the small, clear pool. We hypothesized that this is because, although mosquito fish were very visible with the backgrounds of the large and small pools, CLT were also visible as potential predators to the mosquito fish when the pools were clear. This is supported by the fact that mosquito fish would swim to the other side or the bottom of the pool when people approached the edge of the pool. Thus, it is our conclusion that CLT did not forage at the clear pools because they were aware that fish would be unavailable as prey.

[3] One of the smaller pools developed a leak and was not replaced; thereafter, a total of three pools (two small (8-ft diameter) pools and one large (10-ft diameter) pool) were used.

Figure 6. Dive into Small Pool

Figure 7. Algae Growth in Small Pool

Figure 8a and 8b. Foraging Dives into Large Pool

Tables 2a and 2b summarize results of surveys at the PFAs before and during the experiment:

Table 2a. CLT Foraging Dives at PFAs Before Experiment

PFA (see Figure 3)>	Pier 300	Pier 400 elbow	East of Nesting Site
TOTAL	464	86	85
PERCENT of TOTAL	73.07%	13.54%	13.39%
MEAN (foraging dives per 10-minute survey)	19.33	3.58	3.54

Table 2b. CLT Foraging Dives at PFAs During Experiment

PFA (see Figure 3)>	Pier 300	Pier 400 elbow	East of Nesting Site
TOTAL	**171**	**132**	**46**
PERCENT of TOTAL	49.0%	37.8%	13.2%
MEAN (foraging dives per 10-minute survey)	7.13	5.50	1.92

Although the total number of foraging dives recorded at PFAs declined during the experiment, foraging at the pools cannot explain this decrease (see Table 1). It is likely that chick hatching was beginning during this time, and CLT were shifting foraging closer to other areas (see below).

Tables 3a and 3b summarize results of surveys at transit flight stations before and during the experiment:

Table 3a. CLT Transit Flights Before Experiment

Transit Flight Station (see Figure 3)>	South Rocks	East of Nesting Site
TOTAL	629	148
PERCENT of TOTAL	81.0%	19.0%
MEAN (transit flights per 10-minute survey)	26.21	6.17

Table 3b. CLT Transit Flights During Experiment

Transit3 Flight Station (see Figure 3)>	South Rocks	East of Nesting Site
TOTAL	1277	137
PERCENT of TOTAL	90.3%	9.7%
MEAN (transit flights per 10-minute survey)	53.21	5.71

The total number of transit flights over the south rocks toward the LAH breakwaters and beyond during the experiment were nearly twice the total before the experiment, indicating that CLT shifted foraging to areas offshore during this period, likely because of a change in availability of potential prey items outside the LAH and/or near LAH breakwaters. The difference cannot be explained by CLT chick hatching, since only 30 chicks had hatched by the third day of the experiment.

No other species (Elegant Tern, Caspian Tern, or gulls) showed any interest in the pools throughout the entire survey period, despite periodic flyovers.

In summary:

1) Some CLT will use and successfully obtain fish from the pools.
2) The pools with clear water were not as attractive to CLT as pools with a heavy growth of green algae.
3) Size matters. There were more CLT dives into the large (10-ft diameter) murky pool than the smaller (8-ft diameter) murky pool.
4) The intensity of foraging never exceeded more than four dives per 10-minute survey. Thus, in the event of an oil spill, the pools would not be successful in diverting large numbers of CLT from oil spill areas. However, if the oil spill is in a PFA and it affects the availability of CLT prey, it's possible the pools would become more heavily used.

4.0 RECOMMENDATIONS

Given the fact that little CLT foraging was observed at the pools, other methods need to be developed to lure CLT away from foraging at an area affected by an oil spill. One idea, if the spill is not extensive, is to use tethered Peregrine Falcons (*Falco peregrinus*) provided by licensed falconers on vessels or buoys at the oil spill. CLT are known to leave their nesting sites in response to the presence of a Peregrine Falcon; whether or not this would work at foraging areas remains unknown.

Another idea is to try the feeding experiment once again but to try:

1) a larger pool, perhaps one created using a depression created by a construction vehicle and lined with plastic tarp;
2) a pool stocked with anchovies rather than mosquito fish. Perhaps anchovies eggs could be obtained several months prior to the experiment, hatched and raised to the point they are of sufficient size for CLT prey.

5.0 ACKNOWLEDGEMENTS

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