State of California
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Department of Fish and Game

A BREEDING STUDY OF THE CALIFORNIA LEAST TERN[1/]

1971

by

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ABSTRACT

A small colony of California least terns (Sterna albifrons browni) was observed daily at Sunset Aquatic Regional Park, Huntington Beach, Orange County, California, during the 1971 nesting season. Courtship, egg laying, incubation of eggs, care and feeding of young and vocalization of adults were all documented. Also recorded were demography of the colony, number of nests, clutch size, weights and measurements of eggs, and length of incubation. Colony contained 23 nests, fifty-three eggs were laid and forty-two (80 percent) hatched. All chicks were banded immediately after hatching and their movements, physical development and behavior were recorded until fledging. After fledging, observation of juveniles and adults continued until birds left the area in early August. Percentage of juveniles successfully fledged was 33 to 50 percent. Basic requirements of the least tern for successful nesting are discussed and recommendations made for their protection.

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RECOMMENDATIONS

To assure reproduction and survival of the California least tern, it is recommended that:

1) A California least tern sanctuary be established at Sunset Aquatic Regional Park, Orange County, California.

2) A management plan be developed for the sanctuary, which will provide measures to protect and enhance the California least tern.

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INTRODUCTION

Sterna albifrons is a worldwide species with many recognized races. In Europe it was called the little tern and was first described in the 18th century (Vroeg's Catalogue 1764). It is called the least tern in North America. The subspecies which breeds in California is the California least tern (Sterna albifrons browni). This race winters in South and Central America and comes north to breed on the west coast beaches of the United States and Mexico. Historically, the birds have bred on uninhabited beaches from Moss Landing, Monterey County to Southern Baja, California, Mexico, adjacent to estuaries with a good supply of small fish. The great increase in California's human population in this century, with concomitant use of beaches and estuaries, has had a serious impact on the least tern. Numbers of nesting pairs have dropped sharply and many traditional breeding sites are no longer used. In 1970, the bird was declared endangered by the Secretary of the Interior and included on his listing of endangered species. In 1971, the California Fish and Game Commission also declared it an endangered species. Since there is a lack of life history information on the California least tern, this study was undertaken to determine breeding biology, reproductive success and make recommendations for their protection and preservation.

METHOD

Birds were studied from time of arrival in late April to departure in mid-August. Courtship behavior, egg laying, incubation period, hatching, care of chicks up to fledging, and behavior of fledged juveniles were closely observed and documented. All chicks in a colony were banded and their physical development followed by recapturing them during the prefledging period. Survival rate was calculated and reasons sought for the success or failure of the colony in rearing young. Tape recordings of the repertoire of calls, and a photographic record of the breeding cycle was made.

STUDY AREA

In 1970, a group of 75-100 pairs of least terns nested at Sunset Aquatic Regional Park in Huntington Beach, Orange County, California. Park is primarily a marina on filled land at the northwest end of Huntington Harbor, and abuts the Seal Beach Naval Weapons Station (Figure 1). Approximately one-half of the park acreage is still undeveloped, and consists of fill sand dredged from the bottom of Anaheim Bay (Figure 2). Bare sand, plus excellent fishing in the channels of Anaheim Slough in the naval weapons station apparently attracted the terns to this area (Figure 3). The area where terns nested in 1970 was approximately 15 acres (Figure 4). The colony was divided into roughly three equal groups: 1) one-third nested on Site A, a 5 acre island on the northwest end, connected to the rest of the park by a causeway; 2) one-third chose Site C, a section where a small colony nested in 1969 (Collins, personal communication), and 3) the last group to nest used Site B, a newly filled portion of the park between Sites A and C.

In 1970, the Orange County Board of Supervisors, through the Department of Harbors, Beaches and Parks, provided some protection for the colony upon request by erecting a sand berm around the periphery of the mainland nesting area Figure 4, Sites B and C). During the spring of 1971, a fence and gate were put across the causeway to the island (Site A) to permanently protect the ternery.

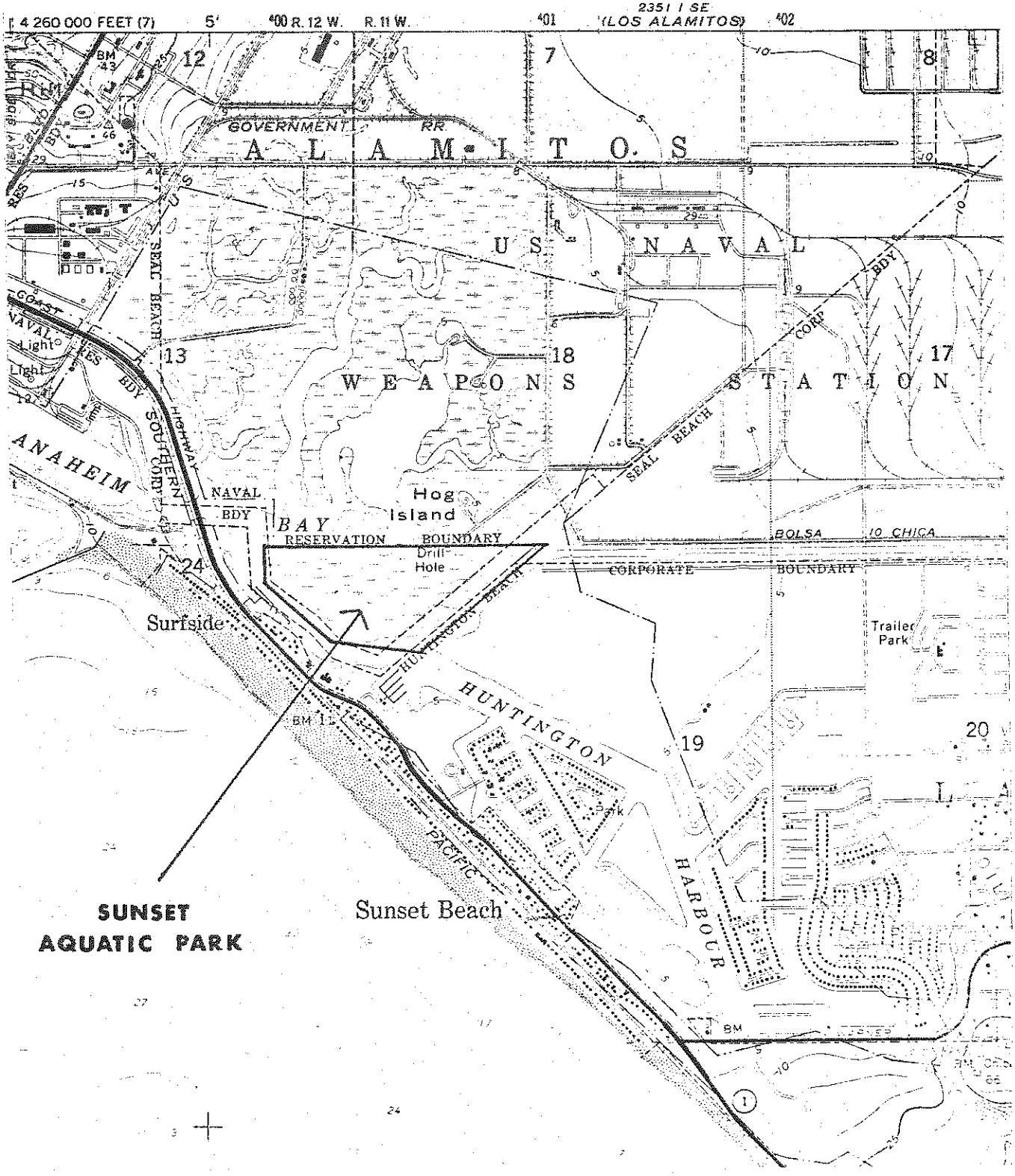

FIGURE 1. Map showing location of Sunset Aquatic Regional Park, Huntington Beach, Orange County, California, site of the California least tern nesting colony.

FIGURE 2. Tern nesting area at Sunset Aquatic Regional Park with Seal Beach Naval Weapons Station shown in background.

FIGURE 3. Tidal channels in Anaheim Bay, adjacent to nesting grounds, provide feeding areas.

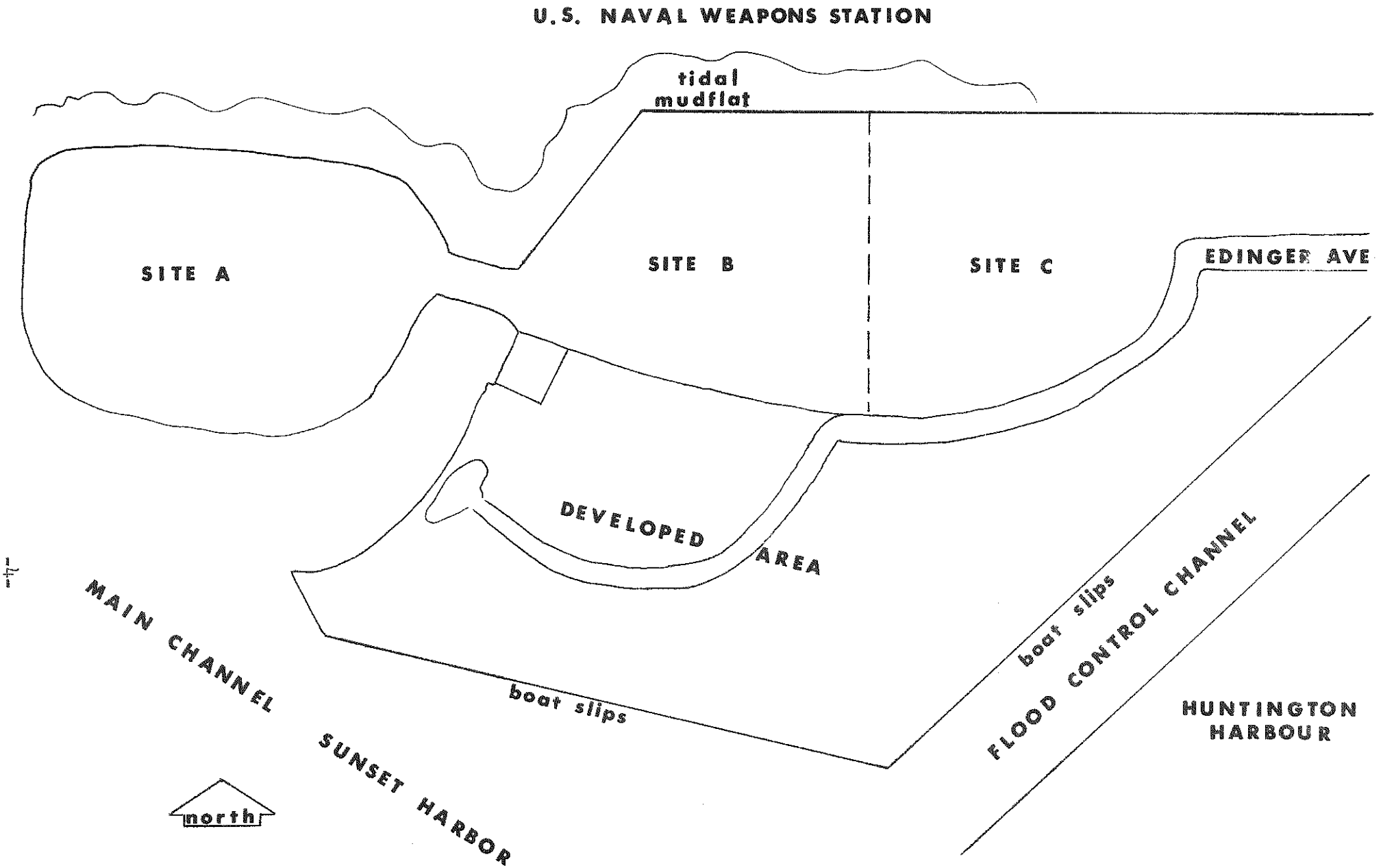

FIGURE 4. Sunset Aquatic Regional Park showing California least tern nesting sites in 1969, 1970 and 1971.

I had planned to focus attention on just one section of the ternery in 1971, assuming the birds followed 1970 nesting pattern, and observe 20-30 nesting pairs in detail. As it happened, total number of nests in the colony this year was 23, all on Site B. This portion of land was built up with sand dredged in the winter of 1970 and had dried sufficiently for nesting when terns arrived that spring, although it was not thoroughly dry. However, by spring 1971, the character of the terrain had changed rather markedly. The sand was quite dry on 2/3 of the area and small clumps of Russian thistle (Salsola kali) were scattered over the area. The other mainland nesting area, Site C, which contained 24 nests in 1970, was overgrown with ice plant (Mesambryanthemum nodiflorum) in 1971 and apprently was not suitable for nesting. The island, Site A, was rendered unacceptable by the presence of a male burrowing owl (Speotyto cunicularia) which took up residence there last winter. Terns were unable to chase him away and would not nest while he was there. By the time I realized he was causing a serious problem and persuaded him to leave by digging out his burrow, it was too late. New nests continued to appear on the mainland site, but terns did not nest on the island at all. Time for selecting nesting sites had apparently passed.

The following study results document the 1971 California least tern breeding season at Sunset Aquatic Regional Park from April 25 to August 13. During this period, the colony of 23 nests was kept under close observation from the first nesting activities to desertion of the nesting grounds.

RESULTS

Breeding Biology

Courtship

During the last week in April, least terns began to arrive from their wintering grounds in Central and South America. Birds were seen resting and preening on mud flats at low tide at Bolsa Slough behind Bolsa Chica State Beach, and at Sunset Aquatic Regional Park; they were also seen on buoys and boats in the Long Beach marina and over the waterways, where they were heard more readily than seen. Courtship had already begun by the time they arrived and aerial preliminaries were in evidence. Courtship flights consisted chiefly of the 'fish flight' and 'aerial glide', courtship displays common to many species of terns (Marples 1934, Palmer 1941, Davis 1968). During this period the birds rarely landed. It was very difficult at this stage to tell where they would eventually settle to breed. Much of the courtship took place very high in the air, and when the terns landed, it was on mudflats below high tide line. During the second week in May, birds began to land in groups of two and three on their chosen nesting ground, often with one of the pair or trio carrying a fish. The ground phase of courtship was then observed. There was feeding of the female by the male, the male flying off 3-4 times in 10 minutes and returning with a fish. Copulation has been reported by Tompkins (1959) to take place away from ternery before nesting begins and this was the case here. Two nests with one egg each were found on May 24 before copulation was ever observed on the ternery. After that date, during the entire egg-laying period, copulation, preceeded by 'posturing' and the 'parade' as described by Davis (1968), was seen often on the nesting ground.

Roosting

Roosting areas, which have been described by Davis (1968) could not be found at Long Beach, Seal Beach, or Huntington Beach. It remains a mystery where terns were spending the night roosting during the early period of courtship.

Nest Selection and Egg Data

Twenty-three tern nests at Sunset Aquatic Regional Park were scattered over a 5-acre area. Minimum distance between nests was 10 feet, and most were more widely spaced. There was no pattern in the arrangement of nests, they seemed to be quite random in nest site selection. All but 5 were simple scrapes in sand, the exceptions were hollows lined with small bits of shell (Figure 5 & 6). There was one 1-egg nest, 14 with 2 eggs, and 8 with 3 eggs. Mean weight ($\pm$2 Standard Errors) of 43 eggs weighed on June 12, 1971 was 7.93 grams $\pm$0.21. Length and width on these same eggs averaged 30.92 mm. $\pm$0.4 X 23.34 mm. $\pm$0.36.

Egg Laying

The first egg was laid on May 24, 1971. Average clutch size for 23 nests was 2.3 eggs. Eggs in each clutch were laid on consecutive days with one exception where two days elapsed between eggs. There were two instances in which a third egg appeared in a nest half way through the incubation period, examples of intraspecific egg parasitism. One of these eggs was brooded along with the parents' own eggs but did not hatch when the other two did. After 4 days of attempting to brood the egg and take care of the hatchlings, the egg was abandoned. There was a well developed embryo inside. In the other case, the day following the appearance of the third egg, the nest contained only two eggs again. Since both the two remaining eggs in the clutch hatched at the expected time, it appears the adult rejected the alien egg.

Incubation and Nest Disturbance

Incubation began after the first egg was laid. Both parents participated in this chore, as they did in all others pertaining to care of eggs and young. During the incubation period, brooding birds were easily disturbed by intrusion onto the breeding grounds and would all take wing sounding alarm calls, then fly over and mob the intruder. This behavior is common to many species of terns and has been well described by Marples (1934) and Palmer (1941). There were also times when terns showed alarm which had no apparent cause. This was also described by Marples (1934). People, gulls, other summering tern species and jack rabbits were the most common causes for alarm. On rare occasions, dogs, a black tern, burrowing owl, sparrow hawk, white-tailed kite, and loggerhead shrike disturbed the tempo of life in the ternery. Birds quickly settled on their eggs after chasing off the intruder(s). Species which were tolerated without any reaction were the horned lark, snowy plover and killdeer, which nested on or near the ternery, and cliff swallows which regularly swooped in low over the ground catching insects.

Hatching

The first egg hatched on June 15, 1971, 21 days after it was laid. Hatching of 2-egg clutches usually took place on successive days, although there were instances of two chicks hatching on the same day, or two days elapsing between hatchings. In 3-egg clutches it was most common for two eggs to hatch on the same day, either a day before or after the third egg. Average incubation period

FIGURE 5. Shell-lined nest with two least tern eggs.

FIGURE 6. Typical least tern nest--two eggs laid in a shallow scrape in the sand. Eggs hatched on consecutive date.

was 22 days, the period varied from 20 to 23 days with one exception. One 2-egg nest was observed for 28 days before hatching occurred. Since the nest was found with two eggs already in it, the date of the laying of the first egg was not known, and the length of incubation was therefore more than 28 days.

Total number of eggs laid was 53, of which 42 (80%) hatched successfully. Hatching failures were due to several causes. Three nests with two eggs each were abandoned early in the incubation period for reasons unknown. Eggs from these nests were taken after five days of observation in order to be sure they were abandoned, and frozen for chemical analysis. Three nests had one egg each which failed to hatch along with other eggs in the clutch, and were abandoned after a few days of further incubation by adults. Chicks from these nests left the nest one to two days after hatching, and it was impossible for parents to attend them and brood eggs simultaneously. **The conflict between the drive to brood eggs and to feed and protect the young chicks was apparent, but the chicks won every time. One of these nests was the** example of parasitism mentioned previously. The other two nests had clutches of two eggs each; one egg in one nest was infertile, the other nest contained an egg with an embryo in an early stage of development. Other hatching failures were due to a broken egg in one instance and death of a chick in the pipping stage in another. All other eggs hatched successfully. There was no egg predation.

Prefledging Period

Eggs usually hatched in the morning, and the sun dried the chicks' feathers within an hour. One of the parents brought a very small fish for the first feeding of the chick within three hours after hatching (Figures 7 & 8). For the first few days, parents were kept extremely busy, catching fish for their offspring, especially if there were three in a clutch.

All of the chicks which hatched were banded on the left leg with U. S. Fish and Wildlife Service aluminum bands. A strip of yellow plastic tape was put over the bands of 22 chicks when they were five days old or more, in order to increase the chance of seeing banded birds after they were fledged.

After hatching, the chicks stayed in the nest only one to two days. They were able to stagger about very soon after their feathers dried (Figure 9). From the second day on, the chicks wandered freely around the ternery and beyond. There was no territorial defense against them by adult terns, as there is in colonies of other tern species (Marples 1934, Palmer 1941). Chicks were seen to wander within two feet of an adult brooding eggs without any reaction from the adult. The first chick to leave the nesting grounds went over the berm on the east side of the ternery at the age of seven days. From that time on, chicks wandered as far as 1/2 mile east of the ternery, where the flood control channel stopped them. Later on, chicks as young as two days were found off the ternery, after the first adventurous spirit had shown the way. Parents followed, sometimes herding their young to safety by means of landing and calling, then fluttering or walking in the direction they wished the chicks to follow. Siblings stayed reasonably close together. Chicks were not brooded by adults after a few days.

During the prefledging period, the actions of parents against intruders was even more vehement than during the incubating period. Adults would dive at the offender, and when just overhead would defecate with marvelous accuracy on target to the accompaniment of a harsh scream. Young chicks would flatten in place immediately on hearing the parents' alarm call, and remain immobile until the 'all clear' was sounded (Figure 10). Older chicks (10+ days) were more likely to run from the intruder, and flatten only when danger got too close, often

FIGURE 7. California least tern with a brood of three chicks.

FIGURE 8. California least tern parent feeding chick.

FIGURE 9. California least tern chick several hours after hatching, weight 4.5 grams.

FIGURE 10. Three California least tern chicks 'frozen' to immobility in the nest at the approach of an intruder.

under a clump of Russian thistle or a bit of flotsam. Either of these methods of escape was exceedingly effective. Immobility plus cryptic coloration made the chicks practically invisible.

Feeding

During one 2-hour period of observation from a blind, I watched a brood of three chicks, age one and two days old, being fed five times by the parents. It was not possible to distinguish one chick from another to determine whether they were all getting food. But they had all been banded and weighed just before the blind was set up, and were reweighed after two hours and five feedings. Each chick had gained from 0.2 to 0.6 grams, indicating they had all received food.

Size of the fish brought by the parents increased as the chicks grew, and within a week fish appeared to be the same size as those eaten by the parents. The smallest fish picked up on the ternery was 4 cm. long and 0.4 cm. high and was brought in to feed a two day old chick. Fish picked up during the courtship period (adult food) were from 4 cm. to 9 cm. in length, and 1.6-2.0 cm. high. It was sometimes difficult for a chick to swallow a rather long fish, and the feat had to be accomplished in stages. If a fish was dropped, it was usually left where it lay, and it is from such fish that I have identified species which were used for food. Once a parent presented a fish to a fledged juvenile which dropped it, picked it up again and ate it. This particular fish was wriggling, which may be why it was dropped during the exchange, and perhaps also why it was picked up again.

Three species of fish were picked up at the ternery; 1) northern anchovy (Engraulis mordax), 2) shiner perch (Cymanogaster aggregata), and 3) topsmelt (Atherinops affinis).

Postfledging Period

A few days before fledging, youngsters did wing exercises and made short, low flights just above the ground before actually flying.

Two flying juveniles were seen on July 5, 1971, twenty days after the first two eggs in the colony hatched. There is good evidence that these birds were actually from those first hatched eggs. Banded chicks had been caught repeatedly during the prefledging period and were known to have reached the age of 15 days. It is reasonable to assume that these were the juveniles seen flying on July 5. After July 5 there were more fledged juveniles every few days, but there was no way of knowing the age at which they were first flying. Once airborne, young birds were never caught again.

Further evidence that 20 days of age is the fledging period comes from the fact that no chick older than that was ever caught on the ground.

After fledging, aerial skills were developed rapidly. Sixteen days after the first juveniles were fledged at Sunset Aquatic Regional Park, two young birds with yellow bands on their left legs were seen with accompanying parents on the bank of the San Gabriel River, four miles north of the ternery. Although skilled at flying, young were still being fed by parents. Flying young continued to be fed by parents as long as they remained in the area. During this period, flying juveniles could be seen learning to fish in the estuary. Rarely

were they successful. Their high-pitched two or three note call would identify them clearly in a group of mixed adults and juveniles. Terns, parents and young, continued to use the ternery for roosting, especially at night, through August 6. On this date, several fledged juveniles without bands, obviously from some other colony, were on the nesting grounds along with banded young that were raised there. These young wanderers were accompanied by their parents. On August 11 there were no least terns on the grounds, although several juveniles flew over, calling. On the evening of August 13 the ternery was deserted; there were many Forster's and Caspian terns on the mudflats, but no least terns were either seen or heard. A quick check of other places in Huntington Beach and Long Beach where they have been breeding or roosting indicated there were no least terns in the area.

Calls

Adult least terns have several alarm calls, for various degrees of fright, and are similar to those described by Wolk (1954) for Sterna albifrons antillarum at Jones Beach, New York. The mildest call may be phonetically given as 'zwreep'. In a state of greater agitation, the birds will give a rapid series of high-pitched 'kit-kit-kit' sounds. When most distraught and mobbing an intruder, the birds will dive and at the low point of the arc emit a harsh scream, written by Wolk as 'krowkgh!', accompanied by defecation. The melodius 'fish flight' call is a four-note call which I hear as 'ki$_{\text{dee}}$, ki$^{\text{dee}}$', so written to show the descending-ascending nature of the call. Almost invariably, a bird carrying a fish, for whatever reason, will use this vocalization. It is probably the same call described by Davis as 'kee-zink, kee-zink!'. A variant of this call, lower in pitch and throatier in quality, is used to 'talk to' young when on the ground. Within a few days after fledging, the juveniles can be heard sounding a high-pitched, two or three note call.

These are the major calls heard during the breeding season. These calls plus variants and lesser used calls, have been recorded on tape and will be transcribed to sonograms for more detailed analysis.

Growth Rate and Survival

Banding of newly hatched chicks proved an excellent method for keeping track of them. It provided information in four categories; 1) general pattern of growth of chicks 2) feather development and color during the prefledging period, 3) survival data on individual clutches and 4) success of the breeding colony.

Growth of Chicks

Weight of chicks shown in Table 1 and Figure 11 combines data gathered in 1970 and 1971 at Sunset Aquatic Regional Park.

TABLE 1

Growth Rate of California Least Tern Chicks
Sunset Aquatic Regional Park, 1970-71

Days After Hatching	Number of Chicks Weighed	Weight in Grams (± 2 Standard Error)
0	77	5.93 ± 0.09
1	67	7.13 ± 0.15
2	32	8.42 ± 0.24
3	15	9.36 ± 0.53

(Table Continued)

Days After Hatching	Number of Chicks Weighed	Weight in Grams (± 2 Standard Error)
4	13	13.81 ± 0.55
5	7	13.35 ± 1.09
6	7	17.64 ± 0.75
7	12	22.92 ± 0.92
8	5	24.80 ± 1.46
9	5	30.00 ± 1.97
10	8	29.43 ± 1.59
11	11	31.86 ± 1.12
12	8	33.13 ± 1.22
13	3	34.33 -
14	9	36.67 ± 0.75
15	8	39.62 ± 0.73
17	5	38.40 ± 0.93
18	2	37.50 -
20	2	40.50 -

Chicks increase in weight rapidly, doubling by the fourth day of age, tripling by the sixth. At fifteen days weight stabilizes between 35 and 40 grams. There were only two chicks captured at age 18 and 20 days, enough of a sample to indicate the growth rate curve but not sufficient for statistical analysis. Weight of adult least terns has not been well documented. One bird, banded as a chick at Huntington Beach State Park in 1963, was retrapped there six years later on a nest by Collins (personal communication) and weighed 47.2 grams.

Feather Development and Color

Newly hatched chicks, once dry are covered with down feathers of mottled beige and brown. Coloring is cryptic, affording excellent camouflage when they flatten immobile on the ground in the presence of danger.

First contour feathers to appear are the primaries, sheaths are evident by the third day after eggs hatch. The humeral feather tract and the secondary feathers of the alar tract soon follow, and begin to erupt from their sheaths when the chicks are five days old. Back feathers are next, the remiges lag behind. On chicks 12 days old the alar tract feathers are half way out of the sheaths and the capital tract has begun erupting. At 15 days of age the chicks flight feathers are four-fifths erupted, the tail is still in pin feathers. All feather tracts of chicks at this age are either in pin feathers or erupted. Tail feathers are well developed by the eighteenth day, and black feathers which form the eye mask have appeared in the lores. Juvenile birds are well covered with contour feathers at this age.

After fledging, juvenile plumage can be used to differentiate young from the adult in a mixed age group of birds. The juvenile has a brown-flecked cap color, only the eye mask is black; whereas, the adult has a black cap and mask and a triangle-shaped white patch on the forehead. Secondary coverts and back feathers on the juvenile are mottled brown and white, the adult's are uniform grey. The juvenile's bill is dark, the adult's yellow with black tip. Young bird's legs are bright orange like the adult's. Adult plumage is illustrated in Figure 12.

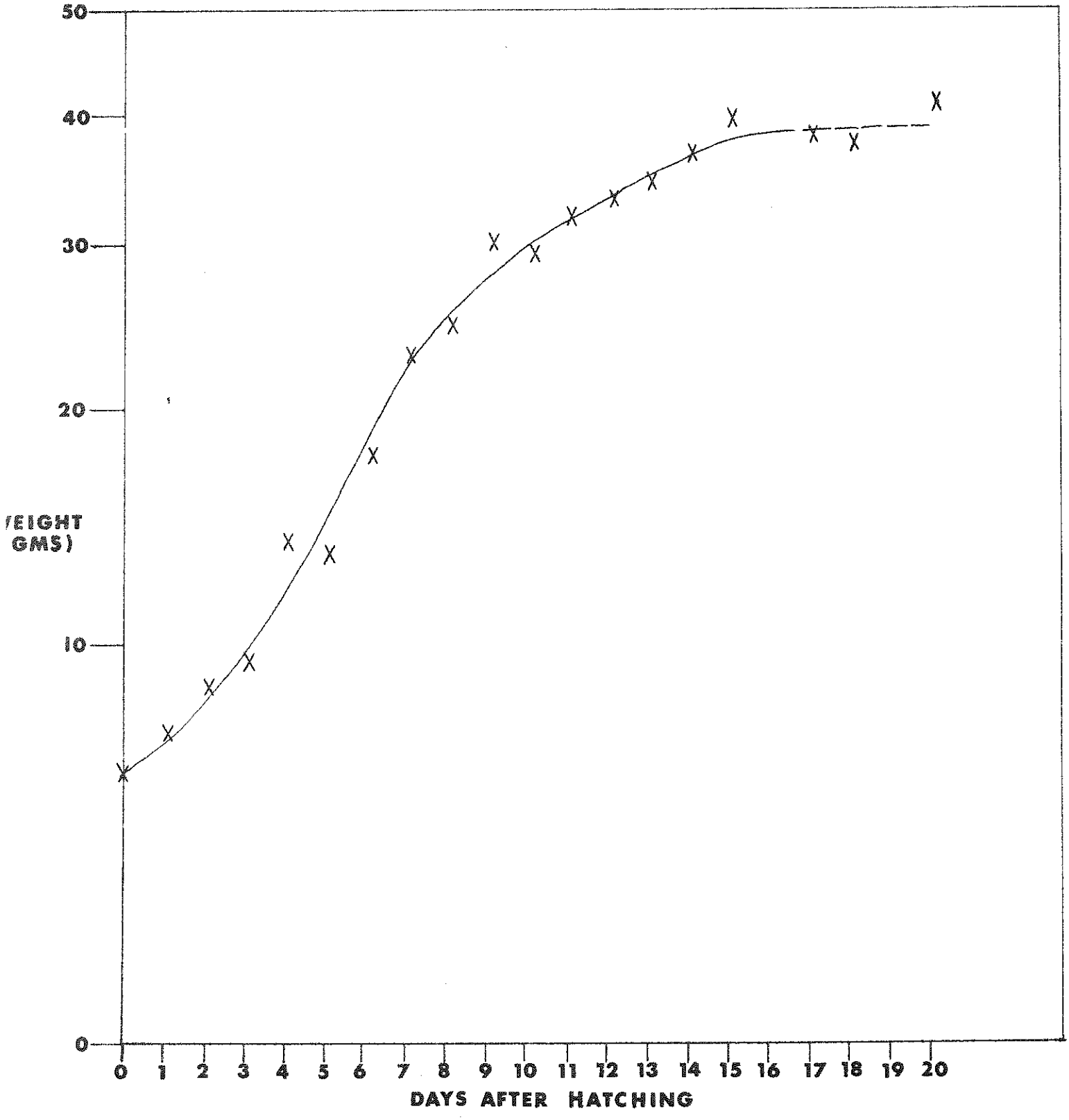

FIGURE 11. California least tern growth rate, Sunset Aquatic Regional Park, Huntington Beach, California, combined data for 1970-71.

FIGURE 12. Adult California least tern.

The egg tooth, which in the common tern (Sterna hirundo) is gone by the sixth day after hatching (LeCroy and Collins 1972), persists in the least tern for about two weeks as a dark nub on the tip of the upper mandible.

Survival Data on Individual Clutches

Because of the difficulty in capturing chicks, records are not complete as to how many siblings survived in a brood. A reasonable estimate was obtained. Chicks from 14 of the 23 nests were recaptured at ages of seven days or more. Analysis of growth data showed that chicks captured at one week of age were found again at later dates up to the age of fledging in all but two instances. It was therefore assumed that the first week after hatching was the critical period, and those chicks which survived this period would probably live to fledge. Using seven-day survival as a standard, success of individual clutches could be measured (Table 2).

Analysis of the survival data of siblings yielded unexpected information. It had been my impression, before careful scrutiny of growth data, that only one chick was surviving from most clutches. This turned out to be true for all but the three-egg clutches. Of the 14 nests from which week-old chicks were recaptured; three had hatched just one chick, and all survived; six nests produced two hatchlings each, and of this group five had but a single survivor

TABLE 2

Nesting Success of California Least Tern Colony
Sunset Aquatic Regional Park, 1971

Nest No.	No. of Eggs	No. Hatched	No. Survivors[1/]
1	2	1	1
2	1	1	1
3	3	2	1
4	2	1	1
5	2	0	
6	2	0	
7	3	3	1
8	3	3	3
9	3	3	2
10	2	2	1
11	3	3	2
12	3	2	1
13	3	3	3
14	2	1	
15	2	0	
16	2	2	2
17	4	2	1
18	3	3	
19	2	2	
20	2	2	1
21	2	2	
22	2	2	
23	2	2	
TOTAL	53	42	21

[1/] Chicks known to survive 7 days or more.

and the other managed to fledge both chicks; but the five broods with three chicks each showed quite a different survival pattern. From two nests, all three of the chicks reached the age of 12 days or more, and from two other nests, two out of three chicks survived. The fifth clutch of three had just one survivor. In all, 11 chicks probably fledged from five 3-egg nests; and 10 from the remaining nine nests which were successful in fledging chicks. There is no doubt that in this colony this year, three-egg clutches were far more fruitful in terms of fledglings than either one or two-egg clutches.

Success of the Breeding Colony

Fledging success was measured by two methods; 1) counting chicks surviving the first seven-day period after hatching which would probably live to fledge; and 2) counting actual number of fledged juveniles seen at the nesting ground during the brief period after most of the young have fledged and before they begin to wander.

Fifty percent of chicks hatched in this colony were recaptured at seven days of age or older (Table 2). It should be noted that a seven-day survival figure for a colony is neither easy nor practical to obtain. It can only be done with banded chicks and with a large daily effort expended for several weeks on catching the fast moving youngsters.

Juveniles stayed in the vicinity of the nesting grounds for several weeks after fledging, and both adults and juveniles came in to roost for the night. It was possible to get close enough in the evening to see bands on the fledglings and to ascertain that the young were from the Sunset Aquatic Regional Park colony.

Hatching spanned the period between June 15 and July 23, with most of the eggs hatched by June 28 (34 out of 42). Most chicks which survived were therefore airborne by July 18. On the evening of July 19, fourteen banded fledged juveniles were seen on the ternery with a group of adults, the largest number seen at any one time.

Forty-two chicks had hatched at this colony. Survival calculated on the number of fledged juveniles seen was thus 33 percent.

On July 21, 1971, two days after the high count, a pair of juveniles from the Sunset Aquatic Regional Park colony was seen resting on the bank of the San Gabriel River, as noted above, and two days later were seen there again. Also on that date, an unbanded fledged juvenile was seen at the Sunset Aquatic Regional Park ternery, roosting with banded young hatched there. After July 19 the number of juveniles at the ternery could not be used as an index for survival.

Fledging success was found to have a probable lower limit of 33 percent and upper limit of 50 percent based on the number of chicks hatched. A more stringent method of calculating success of the breeding colony, based on the number of eggs laid, was found to range between a minimum of 26 percent and a maximum of 40 percent.

Percentage of survival was higher this year than last, even though the colony at Sunset Aquatic Regional Park was one-third as large. Records for the 1970 breeding season show that 37 chicks reached the age of seven days or more out of 110 hatched (34 percent) and 15 fledged juveniles were seen at one time (14 percent).

Reports of survival from other least tern colonies in the United States have shown considerable range. Hardy (1957) judged survival to be 3.6 percent of eggs hatched in a small colony of Sterna albifrons athalassos, the interior subspecies at Bell Island on the Missouri River. Hagar (1937) observing the eastern race, Sterna albifrons antillarum, at Plymouth Beach, Massachusetts in 1935-36, judged survival to be 9 percent. This figure was based on the number of eggs laid and there was tremendous predation by rats before hatching (74 percent of the eggs destroyed). Survival of hatchlings was 35 percent. At this colony 820 eggs were laid, 212 hatched and 75 fledged. At Camp Pendleton, California, a large colony was under observation in 1971. Swickard (personal communication 1971) counted 192 fledged juveniles on August 5, 1971 from a total of 426 eggs hatched. This minimum survival figure of 45 percent is the highest reported.

Chemical Analysis of Eggs

Thin egg shell "syndrome" is affecting several species of fish-eating birds, and is attributed to ingestion of pesticide residues. Based on hatching success, this does not appear to be a problem for the California least tern at this time. Abandoned eggs collected at two tern colonies in 1970 and three colonies in 1971 were checked for chemical residues by the California Department of Fish and Game (Table 3).

Significant amounts of pp'DDE were found in eggs in the Orange County area. What effects this may have on least terns is not known. No tissue samples were available for analysis.

DISCUSSION

To nest successfully, the California least tern requires three conditions; 1) a large expanse of open sand as a nesting area, 2) an estuary adjacent to ternery with a good supply of small fish, and 3) freedom from disturbance and predation.

Nesting Area

Birds' preference in terms of surface on which to nest is a sand-shell beach with little or no plant cover. This was the character of nesting sites of former colonies at Huntington Beach, Playa del Rey and Redondo Beach. In searching out new breeding sites, least terns select the same kind of surface, such as at Sunset Aquatic Regional Park and Mission Bay, San Diego County, for examples. Both these sites are man-made, created with sand-fill.

Plant cover is not desired on a nesting site. In 1969 and 1970, least terns nested on newly created sand-fill at Sunset Aquatic Regional Park where there was either little or no plant growth. By 1971 one section was overgrown with ice plant and terns did not nest there. The rest of the nesting grounds is now reaching the same condition, and will have to be cleared of vegetation if the area is to be acceptable to terns in 1972.

In 1971, two small colonies were found in extremely unlikely places. One was north of Warner Avenue east of Pacific Coast Highway in Huntington Beach next to the main channel in Huntington Harbor. The other was on the north side of the San Gabriel River, just east of the Pacific Coast Highway in Long Beach, on an abandoned trash dump. Ground surface in both these places was dirt and much of it a fine powder made by cyclists. This kind of nesting terrain is

TABLE 3

RESULTS OF CHEMICAL ANALYSIS
CALIFORNIA LEAST TERN EGGS
1970-71

COLONY LOCATION	YEAR	SAMPLE	WEIGHTS (GRAMS)	PERCENT LIPIDS	RESIDUES EXPRESSED AS UG/GM SAMPLE				
					PP'DDE	OP'DDT	PP'DDD	PP'DDT	TOTAL
HUNTINGTON BEACH STATE PARK, ORANGE CO.	1970	EGG	6.1	15.3	86.90	*	9.63	6.79	103.32
SUNSET AQUATIC REGIONAL PARK, ORANGE CO.	1970	EGG	5.4	17.0	105.29	*	4.99	3.52	113.80
SUNSET AQUATIC REGIONAL PARK, ORANGE CO.	1970	EGG	6.4	10.2	270.76	*	4.20	5.95	280.91
SUNSET AQUATIC REGIONAL PARK, ORANGE CO.	1970	YOLK	2.6	47.2	355.55	*	18.94	20.02	404.51
SUNSET AQUATIC REGIONAL PARK, ORANGE CO.	1971	EGG	6.8	13.8	58.87	*	5.68	2.67	67.22
SUNSET AQUATIC REGIONAL PARK, ORANGE CO.	1971	EGG	6.2	17.7	41.65	*	4.15	2.93	48.73
SAN GABRIEL RIVER, ORANGE COUNTY	1971	EGG	5.5	15.2	116.43	*	5.24	3.70	125.37
BAY FARM ISLAND, ALAMEDA COUNTY	1971	YOLK	5.7	--	4.30	2.07	7.82	3.41	17.60

* LESS THAN 0.01 PPM.

unusual for terns, but they apparently chose it in preference to sandy spots where there was too much plant cover. Chicks caught here had heavy encrustations of dirt at the base of the upper mandible after the salt glands began functioning. They were also 'grubby' in appearance. However, some juveniles were fledged from both these colonies despite severe obstacles. Alkali flats were chosen as nest sites at Camp Pendleton, San Diego and Bair Island, San Francisco Bay. In these instances, the nesting grounds were adjacent to waterways, and the fishing apparently good.

Food Supply

The availability of a food supply is probably the most critical factor in determining the choice of nesting grounds. Least terns, the world over, nest very close to a food supply (Marples 1934). For the California least tern it is necessary to be adjacent to a saltwater estuary. Extensive marsh in the Seal Beach Naval Weapons Station fills this need for birds nesting at Sunset Aquatic Regional Park. Elsewhere, the shallow, tidal mouths of the San Gabriel and Santa Ana Rivers have substituted for natural estuaries. The birds, as noted above, have nested on dirt where it is next to a good fishing spot. Every colony reported by Craig (1971) is located next to a waterway.

Disturbance and Predation

Protection from unwanted interference during the breeding season is the third necessity, and the easiest one to control. Pedestrians, cyclists and dogs all disturb terns. Many people who wander onto an unfenced nesting area and are mobbed by terns think they are being attacked without provocation and react accordingly by throwing stones or flicking beach towels at diving birds. This is done through ignorance. Once the situation is explained, most people are immediately understanding and cooperative. Fencing plus an educational program through signs should be effective in most cases.

An area which is to be made a sanctuary must be large enough to meet the birds' needs. At Huntington Beach State Park, a very small fenced sanctuary of about an acre (200' x 250') was proven inadequate. The colony there has declined drastically; 10 years ago there were 51 nests (Davis 1968), in 1969 there were 25 (Collins personal communication), in 1970 I found 12 and this season only eight pairs nested. Huntington Beach State Park gets heavy use by people during the summer. Birds fly off nests when people appraoch within 100 feet. Huge weekend crowds keep the birds constantly agitated and off their nests. When the chicks begin wandering, they cannot go far in safety. Even under these extremely adverse conditions, a few juveniles have successfully fledged every season. In 1971, six of the eight nests were outside of the fenced sanctuary. Temporary snow fencing was put around two of them, but the other four nests were scattered over too large an area to protect. Those chicks which survived retreated into the sanctuary and more or less stayed there until fledged. To be effective, the fenced and protected area at Huntington Beach State Park should be quadrupled in size, at the very least. At Camp Pendleton in 1971 a protected area 150' x 1500' was ample for the needs of a large colony.

The high degree of success which the breeding colonies at Sunset Aquatic Regional Park and Camp Pendleton achieved in 1971, quite certainly reflect the protection afforded these two sites. At Sunset Aquatic Regional Park, disturbance by people and dogs was minimal. Protective berm and fencing around the area, surveillance by the Orange County Harbor Police, who maintain 24-hour watch at the park, and myself, were most effecitve in protecting the colony.

At Camp Pendleton, the traditional nesting grounds on the beach have in recent years been used for tank maneuvers. This spring, Swickard fenced an area 150' x 1500', using saw horses and rope, and posted signs. These measures secured the colony against disturbance.

Presence of predators on the nesting grounds will keep the terns from laying, or do great damage to a colony if nesting does occur. In 1971 a burrowing owl prevented terns from nesting in one area at Sunset Aquatic Regional Park. At Mission Bay, 14 pairs of wings of adult least terns were found in front of a burrow of a family of owls (Craig, personal communication). It would be worthwhile to check all known nesting grounds for burrowing owls before the terns arrive, and arrange for their removal. Hagar (1937) blamed rats for destroying 3/4 of the eggs at Plymouth Beach, Massachusetts in 1935. There has been no problem with rats at Sunset Aquatic Regional Park in either 1970 or 1971, at least in terms of egg destruction. There are obviously predators which were responsible for the disappearance of young chicks during the prefledging stage. But the high survival rate this year would indicate that predation has not seriously menaced the colony.

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