ATTACHMENT 25

Colonial Seabirds and the Western Snowy Plover Nesting in South San Diego Bay 1993

Prepared by

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INTRODUCTION

San Diego Bay has been subjected to severe development pressures by the U.S. Navy, San Diego Port District and a number of commercial enterprises including marinas. The importance of this area for migrating waterfowl, shorebirds, and seabird breeders has been suspected but information on these subjects is generally out-of-date, is extremely limited in scope, or unavailable. During 1993, the Bay and Estuary Program within the Carlsbad Field Office of the U.S. Fish and Wildlife Service undertook a three-part investigation: 1) a year-long census of bird use of south San Diego Bay (Western Salt Works property), 2) a year-long census of water bird use of middle San Diego Bay, and 3) a nesting survey for colonial breeding birds of the Western Salt Works (Salt Works) property. It is the intention of the Bay and Estuary Program to inform local, State, and Federal agencies as well as private enterprise of the existing coastal wetland resources of this area and promote their conservation. In addition, these studies will provide current biological information to the Division of Wildlife Refuges for their evaluation during consideration of a wildlife refuge within the southern portion of San Diego Bay. This report presents the 1993 results of an intensive nest monitoring study of colonial seabirds as well as the western snowy plover (Charadrius alexandrinus nivosus), a Federally listed threatened species, breeding at the Salt Works located in south San Diego Bay.

HISTORICAL PERSPECTIVE

Reports of nesting Caspian terns (Sterna caspia) at the Salt Works dikes have been noted as early as 1941 at which time a breeding colony of 78 pairs was present (Sechrist in Unitt 1984). In May 1953, the occurrence of an estimated 100 nests and 250 adults was published by Emblem (1954). It was not until the mid 1960's that a comprehensive nesting study was conducted. In 1965-66 a total of 382 and 351 nests were documented, respectively, and the overall breeding population was estimated to be 350 pairs (Kirven 1969). The peak number of nesting Caspian terns reported ranged from 400 to 450 pairs during the early 1980's (Sowls et al. 1980, Schaffner 1982).

Documented nesting by royal terns (Sterna maxima maxima) has changed little over the years. Carter et al. (1994) compiled available data for nesting terns in San Diego Bay and estimated 2 breeding pairs of royal terns in 1991. Both the elegant (Sterna elegans) and royal tern were initially reported as nesting in small numbers (one royal tern nest and 31 elegant tern nests) at the Salt Works in 1959 (Gallup and Bailey 1960). By 1981, the number of nesting elegant terns had increased to 861 pairs (Schaffner 1982). During the 1990 breeding season the elegant tern was noticeably absent from the Salt Works (McCaskie 1990). Although nesting resumed in 1991, only 250 breeding pairs were estimated (Carter et al. 1994).

The first report of black skimmer (Rynchops niger niger) nesting was an individual pair in 1976 and by 1988 the breeding population had increased to a minimum of 200 pairs (Carter et al. 1994). Initial nesting at the Salt Works by 3 pair of gull-billed terns (Sterna nilotica vanrossemi) was confirmed in 1987

(McCaskie 1987). In subsequent years, the gull-billed tern breeding population increased reaching a high of 27 pairs in 1991 (Carter et al. 1994).

Most of the knowledge available regarding the numbers of breeding colonial birds at the Salt Works is based on infrequent visits and sporadic counts excluding the work by Kirven (1969) and Schaffner (1982) both of whom conducted extensive nest searches and were able to monitor hatching success of caspian and elegant terns. Information on the reproductive success of black skimmers and gull-billed terns up to this point has been lacking. It is the intention of this investigation to provide estimates on the breeding population, hatching success, and nest distribution of the caspian tern, royal tern, elegant tern, gull-billed tern, and black skimmers which nested at the Salt Works during 1993. In addition, nest searches were also conducted to determine the reproductive status of the western snowy plover. Although 16 breeding pairs were previously reported at the Salt Works during a statewide survey (Page and Stenzel 1981), the availability of data regarding breeding pairs and reproductive success are virtually non-existent for this location.

STUDY AREA

The Salt Works is situated at the southern portion of San Diego Bay bordering the cities of Chula Vista and Imperial Beach (Figure 1). The basic operation of this facility is to extract sea salt from the Bay water by means of solar evaporation. The plant was constructed at the turn of the century and is comprised of a network of earthen dikes which separate a series of evaporation ponds. The dikes which have been constructed from dredged material vary in width from 2-10 meters and range from approximately 1-2.5 meters in height above the water level. Depending on the amount of erosion, dike banks may be vertical or gently sloping. The substrate of the perimeter dike road is gravel over compacted silt while the inner dikes are mostly composed of a soft powdery silt. Large salt crystal deposits can also be found along several of the inner dikes. For the most part, vegetation is sparse along the tops of the dikes but several areas have substantial vegetative cover.

METHODS

Monitoring of the Salt Works dikes began on 15 March 1993 and continued through 13 September. Areas were searched an average of two times per week with a total of 52 visits. Nest searches were conducted between the hours of 0800 and 1130. Duration of visits varied and were dependent on number of nests needed to be checked, temperature, wind condition, and number of chicks located on individual dikes. Dikes were arbitrarily numbered and systematically searched by two to three biologists with occasional assistance from volunteers. Subgroup designations were assigned by relative time of nest establishment and or discovery. In the context of this study, subgroups represent discrete concentrations of nests which for the most part were synchronously established. New nests were consecutively marked and numbered with wooden tongue depressors with the exception of elegant tern nests which occurred in such high density that stakes could not be utilized to determine nest location. For all species, excluding western snowy plovers, the large

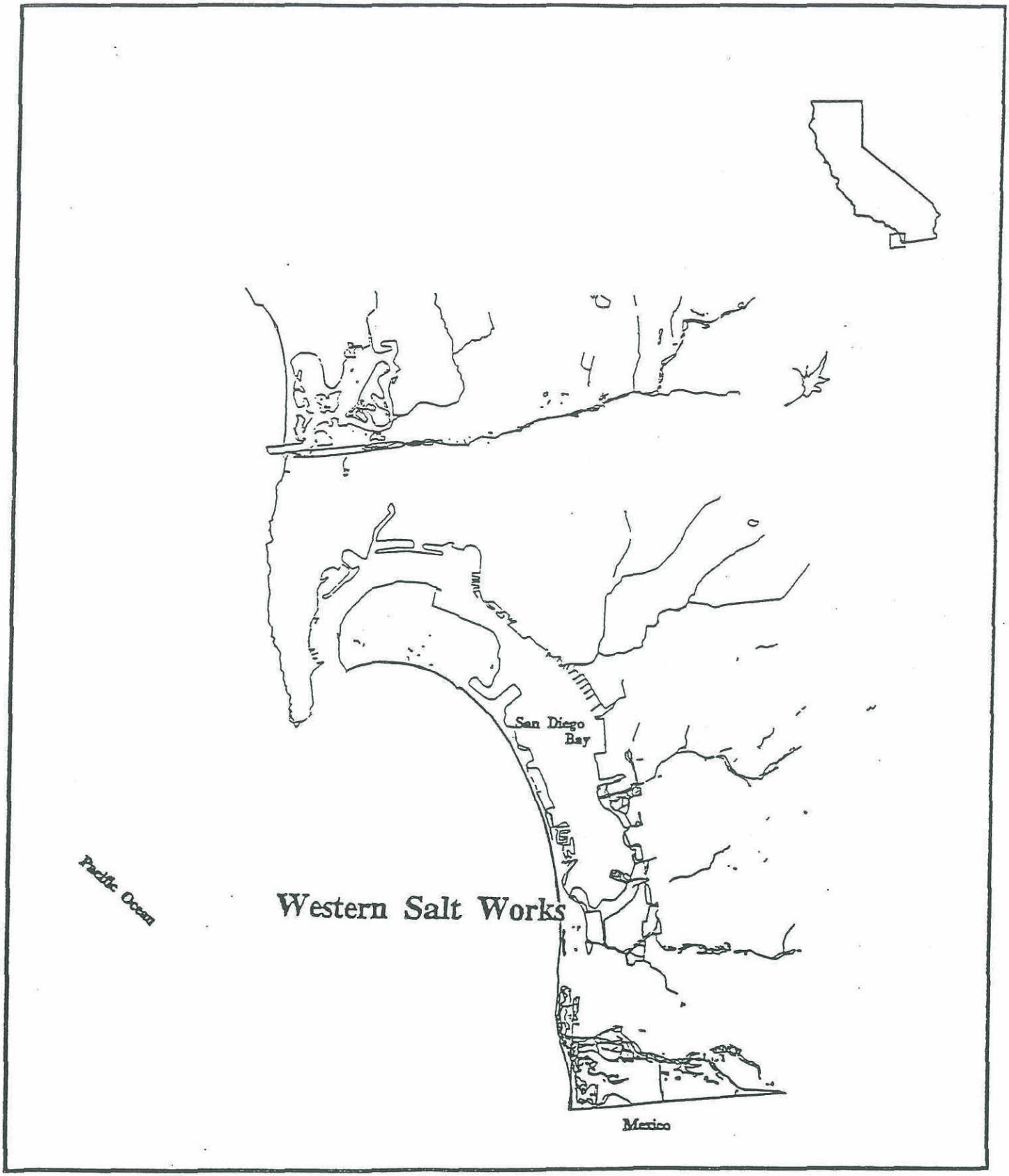

Figure 1. Location of the Western Salt Works, south San Diego Bay, California.

end of each egg was marked with their corresponding nest number. On subsequent visits the status of each nest was updated to reflect egg disposition and record the number of chicks present. Categories used to determine nest status were as follows:

active - nest that showed sign of adult attendance

hatched - nest in which chick(s) were present in a nest scrape or nests which had been previously active, were vacant at the expected hatch date, and showed no sign of predation or disturbance

preyed upon - nest with visible evidence of predator activity at the nest scrape from which some or all of the eggs were missing

abandoned - nest in which eggs were no longer being attended prior to the termination of the incubation period

unhatched - nest that was tended beyond the incubation period or which had produced hatched egg(s) and still had egg(s) remaining.

flooded - nest that had been inundated by water

damaged - nest containing eggs that appeared to be indented or cracked

unknown - nest for which the disposition of eggs could not be determined

RESULTS AND DISCUSSION

Caspian Tern

Assuming adults renested after nest failure, a minimum estimate of 280 pairs of caspian terns nested at the Salt Works in 1993. Nests were distributed along three dikes and within nine subgroups (Figure 2). A distinction was made between subgroup A and AA because nest establishment reoccurred after a substantial time had elapsed from the initial group of egg layers. Nests were first initiated on dikes I and V during mid-April. Dike II had the largest number of subgroups but overall subgroup G located on dike V contained the highest number of nest initiations (n=133). Caspian terns nested among elegant terns in subgroups B through F. In general, nest construction consisted of a simple shallow scrape in the dirt. Plates 1-2 depict caspian tern nests.

Nest placement along the dikes of the Salt Works during 1993 appears to be similar to that of previous investigations with most of the nesting occurring on the outermost dikes (Kirven 1969, Schaffner 1982). Although 1993 had the highest number of subgroups, the number of dikes utilized was slightly lower than in other years (Table 1). Areas where nesting had occurred in the past but were not utilized by caspian terns in 1993 include the perimeter road (between dikes I and VII), dike VI, and dike VII. Of the available nest distribution data, dike II has been consistently used by nesting caspian terns during all three studies.

A total of 382 nests were initiated in 1993 of which 237 complete clutches hatched (Table 2). Egg laying commenced on or about 19 April and continued through 12 July. The number of eggs within individual nest scrapes ranged from one to three with a mean clutch size of 1.82±.46.

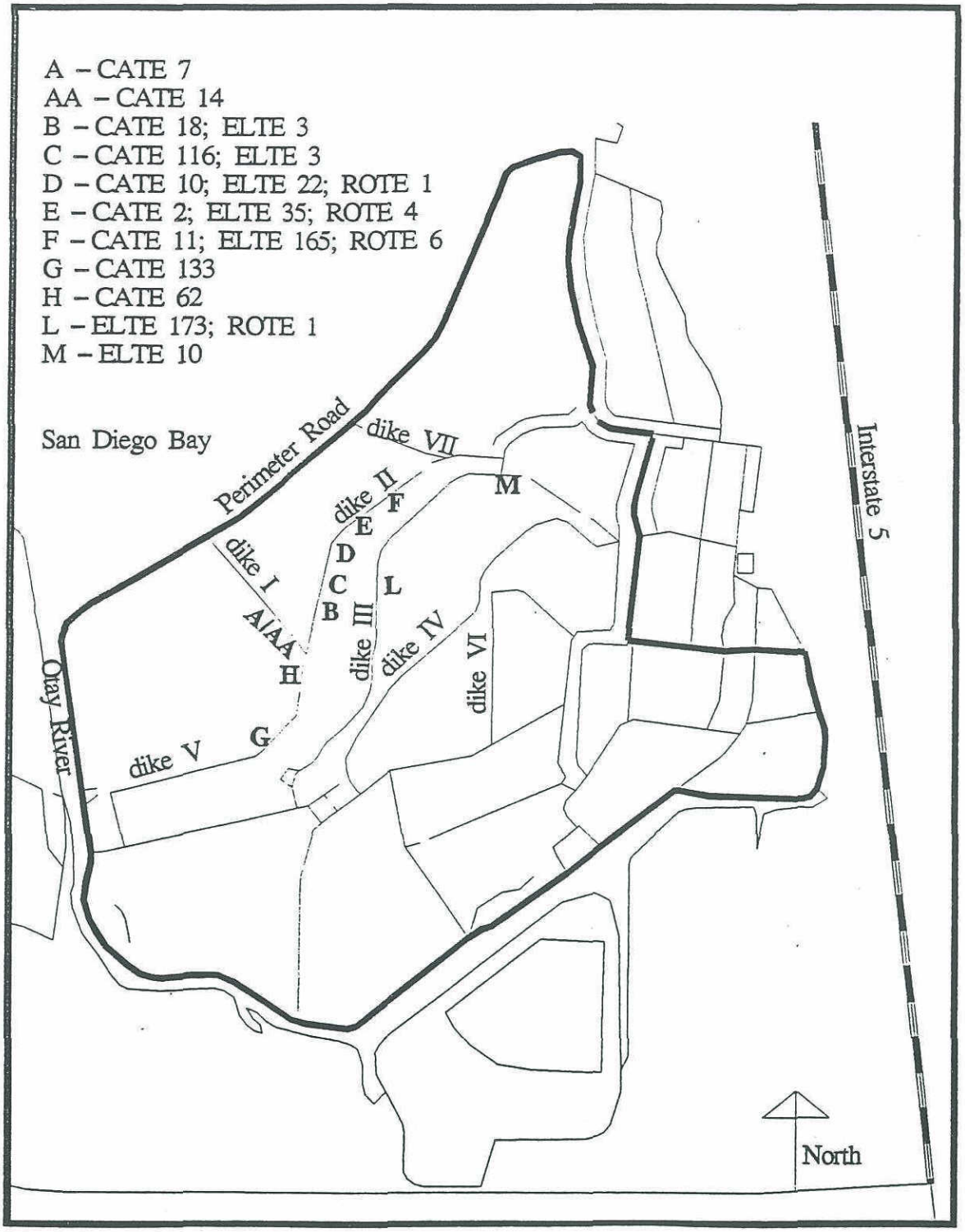

Figure 2. Nest distribution of caspian terns (CATE), elegant terns (ELTE), and royal terns (ROTE) and the number of nests that occured at each location (letter indicates subgroup).

Plate 1. Caspian tern adult brooding a chick on dike II.

Plate 2. Caspian tern nest with chicks on dike II.

Table 1. Nest distribution of caspian terns and elegant terns relative to the dikes (Kirven 1969, Schaffner 1982, this study).

	I	II	III	IV	V	VI	VII	Perimeter road	Total
Caspian Terns									
#subgroups									
1993	2	5	-	-	2	0	0	0	9
1981	-	*	-	-	1	-	2	*	4
1980	-	*	-	-	*	-	*	-	3
1966	1	2	-	1	-	1	-	3	8
1965	1	1	-	1	-	1	-	1	5
#nests									
1993[a]	24	157	-	-	195	-	-	-	382
1981	-	35	-	-	159	-	170	45	409
1980	-	*	-	-	*	-	*	-	400
1966	41	31	-	139	-	12	-	128	351
1965	72	80	-	80	-	51	-	99	382
Elegant terns									
#subgroups									
1993	-	3	2	-	-	-	-	-	5
1981	-	3	-	-	1	-	3	1	8
1980	-	2	-	-	8	-	1	-	11
1966	2	1	-	3	-	-	-	-	6
1965	1	1	-	1	-	-	-	1	4
#nests									
1993	-	328	183	-	-	-	-	-	511
1981[b]	-	418	-	-	102	-	289	115	924
1980[b]	-	162	-	-	474	-	112	-	758
1966	15	2	-	60	-	-	-	-	77
1965	4	12	-	49	-	-	-	32	97

*Caspian terns nested along these dikes but the number of subgroups and/or nests were not reported.
[a]Locations of six nest were not recorded.
[b]Does not include experimental nests (Schaffner 1982).

Table 2. Fate of caspian tern nests at Western Salt Works.

	Full clutch	Partial clutch
Nests hatched	237	43
Nest unhatched	4	24
Nests abandoned	15	6
Nests preyed upon	35	13
Nest damaged	2	6
Nest unsuccessful after pipping	2	7
Nests flooded	3	-
Nests of unknown outcome	30	9
Total nests	382[a]	

[a]Disparate nest totals are a result of nests having multiple outcomes.

Overall hatching success for eggs of known outcomes was 77.3% (Table 3) and ranged from 0% in subgroup A to 100% in subgroup E (Table 4).

Table 3. Fate of caspian tern eggs at Western Salt Works.

	N	%[a]
Eggs laid	677	-
Eggs hatched	481	77.3
Eggs unhatched	29	4.7
Eggs abandoned	29	4.7
Eggs preyed upon	61	9.8
Eggs damaged	8	1.3
Eggs unsuccessful after pipping	9	1.5
Eggs flooded	5	0.8
Eggs of unknown outcome	55	8.1[b]

[a]Percentage of eggs with known outcomes.
[b]Percentage of total eggs laid.

Mean clutch size was down slightly in 1993 from the 2.08 (Kirven 1969) and 2.22 (Ohlendorf et al. 1985) reported from previous years. Hatching success was also down from 1966 (81.3%) but was higher than the 66% reported for 1981 in which 22.7% of the eggs failed to hatch and 4.6% died in hatching (Ohlendorf et al. 1985). In this study, 4.7% of the total eggs with known outcomes failed to hatch after incubation and 1.5% were unsuccessful after pipping.

While previous studies reported no or minimal predator problems, the greatest impact to hatching success in 1993 appeared to be predation. Of the 141 eggs which were known to have not produced chicks, predation caused 43% of hatching failures and was responsible for the total destruction of subcolony A. Predation accounted for only 15% of hatching failures in 1981 (Ohlendorf et al. 1985). Egg predation was predominate in the early and latter parts of the 1993 nesting season and occurred within all subgroups except E and F. Numerous eggs were found with large puncture holes and the contents removed while in other instances the egg content remained oozing on the ground. This type of evidence has been linked to gulls who will puncture as many eggs as possible while adults are off their nests so they may return at their leisure to eat the contents (Buckley and Buckley 1972). Schaffner (1982) reported predation at the Salt Works by western (Larus occidentalis) and ring-billed gulls (Larus delawarensis) and during 1991 an unidentified predator destroyed 62 eggs (Carter et al. 1994). Although predation did not occur within subgroup F, it is interesting to note that the proportion

Table 4. Fate of caspian tern eggs by subgroup in 1993.

sub group	# nests[a]	egg laying dates	total eggs	unknown[b]	# Eggs (% of known outcomes within subgroups)						
					hatched	unhatched	predated	damaged	abandoned	unsuccessful pip	flooded
A	7	4/19-5/10	11	-	-	-	11 (100)	-	-	-	-
AA	17	6/24-7/12	25	2 (8.0)	14 (60.9)	2 (8.7)	3 (13.1)	1 (4.4)	2 (8.7)	1 (4.4)	-
B	18	4/22-6/3	32	-	24 (75.0)	3 (9.4)	4 (12.5)	1 (3.2)	-	-	-
C	116	5/6-7/1	199	20 (10.1)	149 (83.3)	4 (2.3)	14 (7.8)	3 (1.7)	7 (3.9)	-	2 (1.1)
D	10	4/26-5/10	20	-	16 (80.0)	1 (5.0)	1 (5.0)	-	2 (10.0)	-	-
E	2	4/29-4/29	4	-	4 (100)	-	-	-	-	-	-
F	11	4/22-5/6	21	-	14 (66.7)	-	-	-	7 (33.3)	-	-
G	133	4/19-7/12	246	14 (5.7)	189 (81.5)	14 (6.1)	18 (7.8)	2 (0.9)	3 (1.3)	5 (2.2)	1 (0.5)
H	62	4/19-6/17	110	10 (9.1)	71 (71.0)	5 (5.0)	10 (10.0)	1 (1.0)	8 (8.0)	3 (3.0)	2 (2.0)

[a] Six nest locations were not recorded.
[b] Percent of total eggs in subgroup.

of abandoned caspian nests was higher than in any other subgroup (Table 4). The higher rate of abandonment at this location was most likely a result of the establishment of 170 elegant tern nests. Caspian tern eggs have been known to be displaced by elegant terns (Schaffner 1982).

Chick mortality was estimated at 29.3% and was basically confined to nestlings for which the cause of death could not be determined. Chick mortality was 33.9% in 1966 and also occurred predominately in the preambulatory stage. The elevated mortality rate in 1966 may have been a result of higher numbers of 3 egg clutches. Kirven reported higher mortality rates for 3 egg clutches (3 chick broods) than for one or two egg clutches. Only thirteen 3 egg clutches were laid in 1993. In previous studies no caspian tern chicks were preyed upon (Kirven 1969, Schaffner 1982), although 100 elegant tern chicks were mauled by a "pair of stray dogs" in 1982 (Schaffner 1985). During this investigation chick predation was documented on 17 June 1993 along dike II. Twenty-three caspian tern chicks beyond the preambulatory stage were found dead. Six of the chicks had obvious external signs of trauma and canine tracks were observed over the entire length of dikes I and II.

In general, the overall breeding population of caspian terns increased over a period of 40 years (1940-1980) as breeding colonies shifted west from interior locations and intrinsic growth occurred within the coastal population (Gill and Mewaldt 1983). The Salt Works followed this general trend as nesting increased and then stabilized at approximately 400 pairs by 1981. In recent times a decrease in the breeding population within the south San Diego Bay colony has occurred. Carter et al. (1994) reported a 18% decline from 1980 to 1991 and in this study a decrease of 32% is estimated from the same time period. The reasons for the declines are uncertain but may be attributed to food supply, predation, and or human disturbance (Carter et al. 1994). One or more of these factors may have resulted in a shift of the Salt Works breeding population to other areas such as Bolsa Chica Ecological Reserve Orange County, California aproximately 70 km upcoast. Bolsa Chica first experienced nesting by caspian terns in 1986 and whose numbers have since increased (Collins et al. 1991, Carter et al. 1994).

Royal Tern

Royal terns initiated nests among nesting elegant terns on dikes II and IV within subgroups D-F and L (Figure 2). A total of 13 one egg nests were observed in 1993 (Table 5). Egg laying coincided with the formation of elegant tern subgroup

Table 5. Summary of royal tern nesting success at Western Salt Works.

	N	%[a]
Nest initiations	13	-
Eggs laid	13	100
Eggs hatched	10	90
Eggs preyed upon	1	10
Eggs of unknown outcome	2	15[b]

[a]Percentage of eggs with known outcomes.
[b]Percentage of total eggs laid.

establishment. Only a single egg located in subgroup D was documented as being preyed upon. It had a similar puncture hole as those found in numerous caspian tern eggs.

Sporadic reports spanning from 1959 through 1991 have estimated only one to two royal tern pairs nesting at the Salt Works (Gallup and Bailey 1960, Unitt 1984, Schaffner 1985, McCaskie 1985, Carter et al. 1994). The minimum number of breeding royal terns in 1993 was estimated at 10 pairs of which 3 were assumed to have renested. This represents a substantial increase over what had been previously recorded.

Elegant Tern

Elegant terns nested along dike II among nesting caspian and royal terns and on dike III among black skimmer nests (Figure 2). Subgroup M also contained nesting gull-billed terns. The two largest subgroups were F and L with 170 and 174 nest initiations respectively. Nest placement appeared to vary between dikes. Eggs located on dike II were laid on the ground in shallow scrapes. Nests in subgroup L were found atop crystal iceplant (Mesembryanthemum nodiflorum) while in subgroup M adults arranged bones lying about the dike into a circular pattern where they deposited their egg. Plates 3 and 4 illustrate the different nest placements and depict elegant tern nesting at the Salt Works.

With the exception of the nesting which occurred in 1993 along dike III, elegant terns were consistently found in association with nesting caspian terns for this investigation and for the 1965-66 and 1980-81 breeding seasons (Kirven 1969, Schaffner 1982, 1985; Table 1). Although caspian terns were absent from subgroups L and M, black skimmers and Forster's terns nested heavily along dike III as well as several gull-billed terns. Elegant terns are known to nest in association with other members of the Laridae family which respond more aggressively to potential predators (Evans 1973, Schaffner 1982). It is surmised that the presence of breeding caspian terns, who exhibit aggressive predator mobbing behavior, may have facilitated initial nesting by elegant terns at the Salt Works.

Egg laying commenced on or about 19 April and extended through 10 June with the peak of nest initiations occurring during the week of 10 May. Overall, 511 elegant tern nests were initiated. A total of eleven 2 egg clutches and 500 one egg clutches were produced (mean = 1.02 ± 0.15) . Hatching success varied from 0% in subgroup B to 100% within subgroup M (Table 6). Overall hatching success for eggs with known outcomes was 77.1% with unhatched eggs (9.1%) and abandoned eggs (7.9%) being the major cause of nest failure. Egg predation was minimal and accounted for only 3.4% of the overall known nest outcomes. A summary of elegant tern hatching success is provided in Table 7.

Elegant terns are extremely synchronous egg layers (Kirven 1969, Schaffner 1982). During 1993, 38% of the total nest initiations occurred within a one week period. By contrast, only 20% of caspian nests and 21% of black skimmer nests were established during their respective intervals

Plate 3. Elegant tern nests located on dike II.

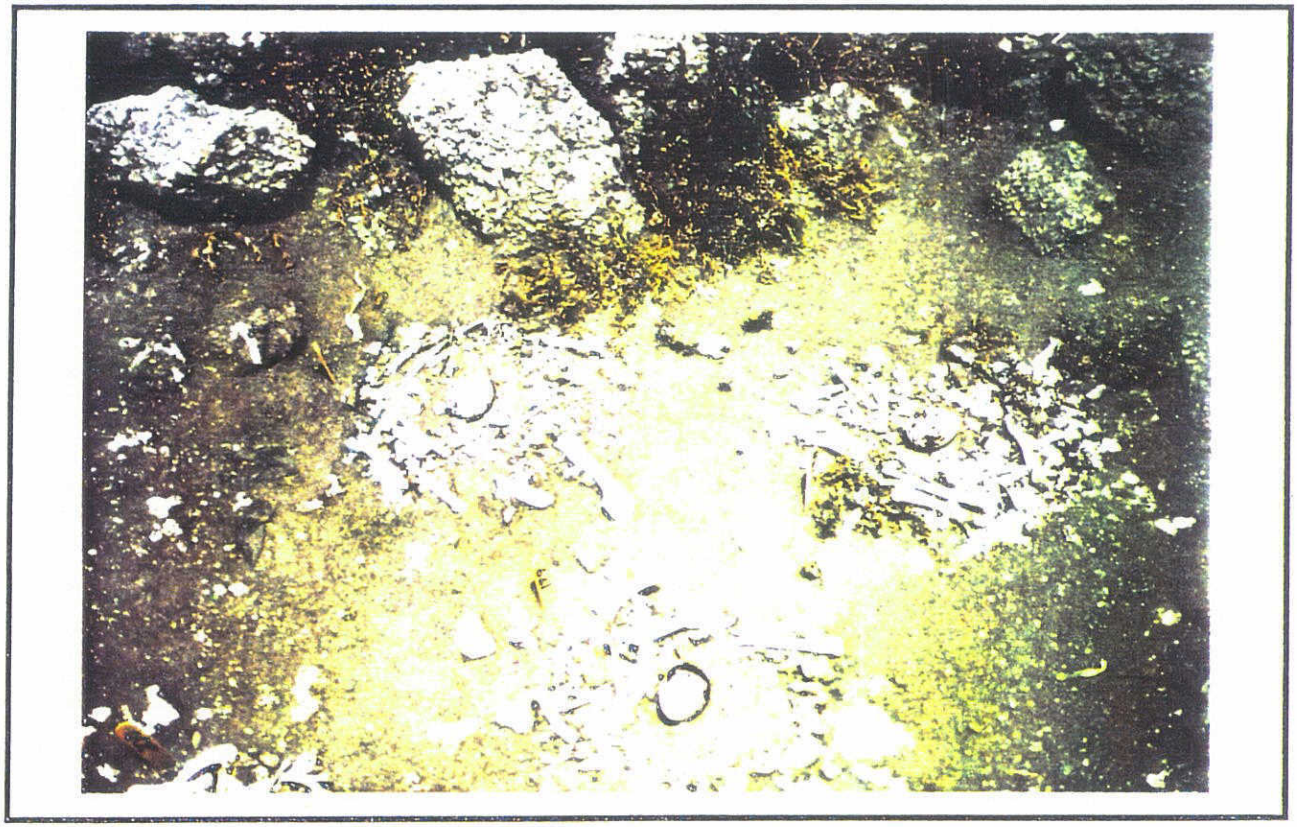

Plate 4. Elegant tern nests located in subgroup M.

Table 6. Fate of elegant tern eggs by subgroup in 1993.

sub group	# nests	egg laying dates	total eggs	unknown[a]	# Eggs (% of known outcomes)					
					hatched	unhatched	predated	damaged	abandoned	unsuccessful pip
B	3	4/19-4/19	3	-	-	-	3 (100.0)	-	-	-
C	3	5/13-5/17	3	-	1 (33.3)	1 (33.3)	1 (33.3)	-	-	-
D	122	4/26-6/10	127	33 (26.0)	76 (80.9)	5 (5.3)	5 (5.3)	3 (3.2)	4 (4.3)	1 (1.1)
E	35	4/29-5/24	35	7 (20.0)	22 (78.6)	2 (7.2)	4 (14.3)	-	-	-
F	165	5/3-5/27	170	34 (20.0)	106 (78.0)	7 (5.2)	-	2 (1.5)	21 (15.5)	-
L	173	5/6-6/3	174	41 (23.6)	99 (74.5)	22 (16.6)	1 (0.7)	3 (2.3)	7 (5.3)	1 (0.7)
M	10	5/6-5/24	10	-	10 (100.0)	-	-	-	-	-

[a] Percent of total eggs in subgroup.

Table 7. Fate of elegant tern eggs at Western Salt Works.

	N	%[a]
Nest initiations[b]	511	-
Eggs laid	522	100
Eggs hatched	312	77.2
Eggs unhatched	37	9.1
Eggs abandoned	32	7.9
Eggs preyed upon	14	3.4
Eggs damaged	8	2.0
Eggs unsuccessful after pipping	2	0.5
Eggs of unknown outcome	115	22.0[c]

[a]Percentage of eggs with known outcomes.
[b]Total one egg clutch=500; two egg clutch=11
[c]Percentage of total eggs laid.

of peak egg laying (Figure 3). The 1993 clutch size for elegant terns was consistent with 1966 (1.14) and 1980-81 (1.02). Hatching success during the 1993 breeding season was similar to that observed by Kirven (1969) in 1966. Schaffner (1986) reported a higher hatching success for both 1980 (88.0%) and 1981 (86.7%). However, the 1980 estimate excluded 112 nests which were preyed upon and if recalculated to include those nests, would result in a hatching success (approximately 75%) similar to that which occurred during this investigation. Although the rate of abandonment was lower in 1993 than had been previously reported (Schaffner 1986), the proportion of unhatched elegant tern eggs increased from 1981 (Schaffner 1982).

Documented chick mortality for elegant terns was extremely low in 1993. Chicks were found dead in only two instances; one during the canine predation on 17 June and another dead at the scrape. Although the incidence of chick predation was also low in 1966 (only 6 reported deaths), over 100 elegant tern chicks were killed by stray dogs in 1982 (Schaffner 1985).

The number of breeding pairs for 1993 is estimated between 312 and 427. Since Schaffner (1982) documented renesting by elegant terns after the loss of their first clutch, the minimum 1993 estimate for breeding pairs assumes all nests which did not produce young or whose disposition could not be determined renested during the breeding season. The maximum number was estimated assuming that unknown outcomes actually produced chicks since there was some difficulty in this study associating recently hatched elegant terns with a specific nest number.

The maximum breeding population of elegant terns at the Salt Works occurred in 1981-1982 when over 800 pairs were reported (Schaffner 1986). In 1983, the population decreased to 437 pairs which closely paralleled the 1979 estimate of 450 pairs (Schaffner 1986). Elegant terns did not nest at the Salt Works in 1990 however, 250 pairs returned to breed in the following year (Carter et al. 1994). Although there appears to have been an increase in the number of nesting pairs relative to 1991, the estimated range for the breeding population in 1993 represents an approximate 50-60% decline from the peak breeding population of the early 1980's.

Gull-billed Tern

An estimated 10 pairs of gull-billed terns nested at the Salt Works in 1993. Gull-billed terns nested in two general locations.

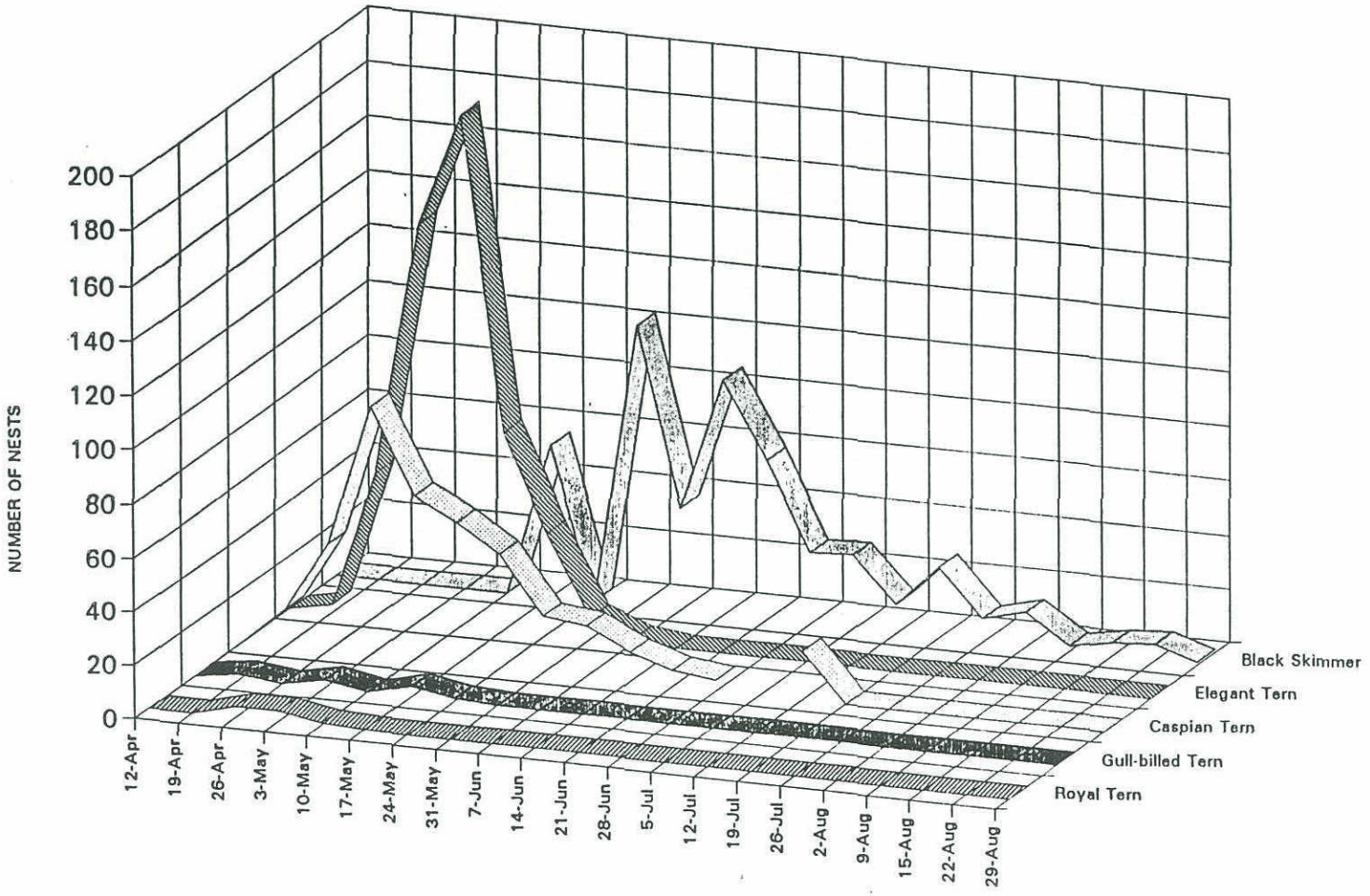

Figure 3. Weekly nest initiations for individual species of terns at the Salt Works in 1993. (note: Caspian tern data not complete for week of July 5)

Seven nests were located in subgroup M at the northeastern end of dike III which also contained nesting elegant terns and black skimmers (Figure 4). The other four nests were located on dike IV also along the northeastern end (Plate 5). Egg laying commenced on 19 April and the last nest was initiated on 24 May. Average clutch size for gull-billed terns was 2.18 ±0.39 and hatching success was 79.2% (Table 8). One nest was partially preyed upon and another 2 egg clutch was totally lost to an unknown predator.

Gull-billed terns are a relatively recent addition to the larid species nesting at the Salt Works (McCaskie 1987) which represents one of only two breeding locations in California. Initial growth in the number of nesting pairs occurred subsequent to the 1987 report of 3 pairs (McCaskie 1987) to a peak of 27 pairs in 1991. The 1993 estimate represents a decline of 63% from that peak. Population declines have also been reported at the other California nesting location, the Salton

Table 8. Summary of gull-billed tern hatching success at Western Salt Works.

	N	%
Nest initiations[a]	11	-
Eggs laid	24	100
Eggs hatched	19	79.2
Eggs unhatched	2	8.3
Eggs preyed upon	3	12.5

[a]Total two egg clutch=9; three egg clutch=2

Plate 5. Gull-billed tern nest located on dike IV.

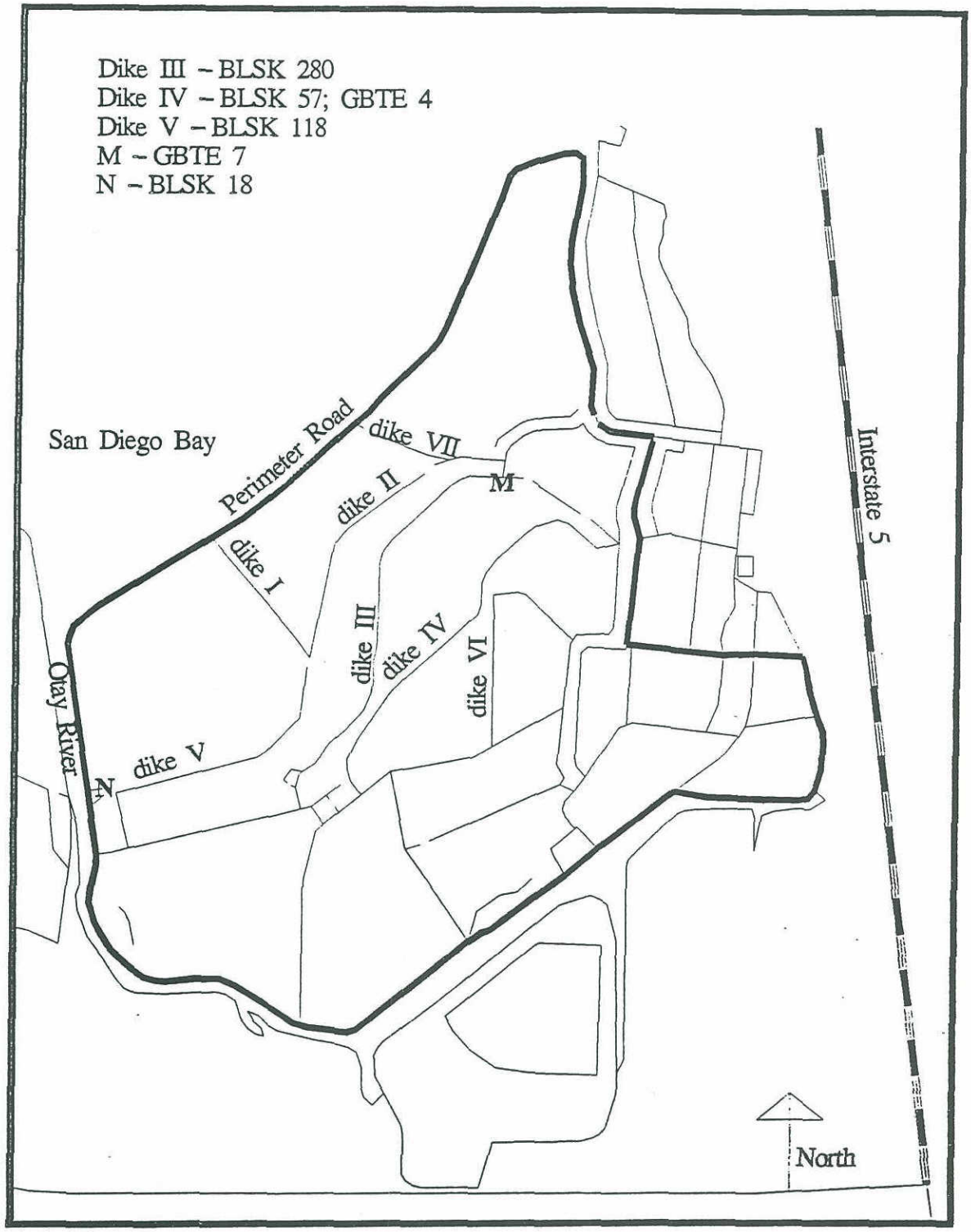

Figure 4. Nest distribution of black skimmers (BLSK) and gull-billed terns (GBTE) and the number of nests that occured at each location.

Sea, where gull-billed terns have been nesting since 1927 (Pemberton 1927, Carter et al. 1994). Between 1991 and 1993 the Salton Sea breeding population has remained between 100-120 pairs (K. Molina pers. com.)

Black Skimmer

Assuming adults renested after nest failure, a minimum estimate of 326 breeding pairs of black skimmers nested at the Salt Works in 1993. Nests were distributed along the entire length of dikes III, IV and V with only two small distinct subgroups forming at location N and M (Figure 4). The majority of nests (n=280) were located on dike III. All nests were placed on bare ground but the amount of vegetation within close proximity of the nest varied (Plate 6 and 7).

A total of 473 nests were initiated. Egg laying commenced on 20 May and continued through 30 August. This protracted egg laying period is in high contrast to the other nesting larids of the Salt Works (Figure 3). The number of eggs within individual black skimmer nests ranged from one to five eggs with a mean clutch size of 2.89 ±0.82. Hatching success varied with location and ranged from 24.5% within subgroup N to 100% within subgroup M (Table 9). Overall hatching success for eggs of known outcomes was 68.9%. A summary of black

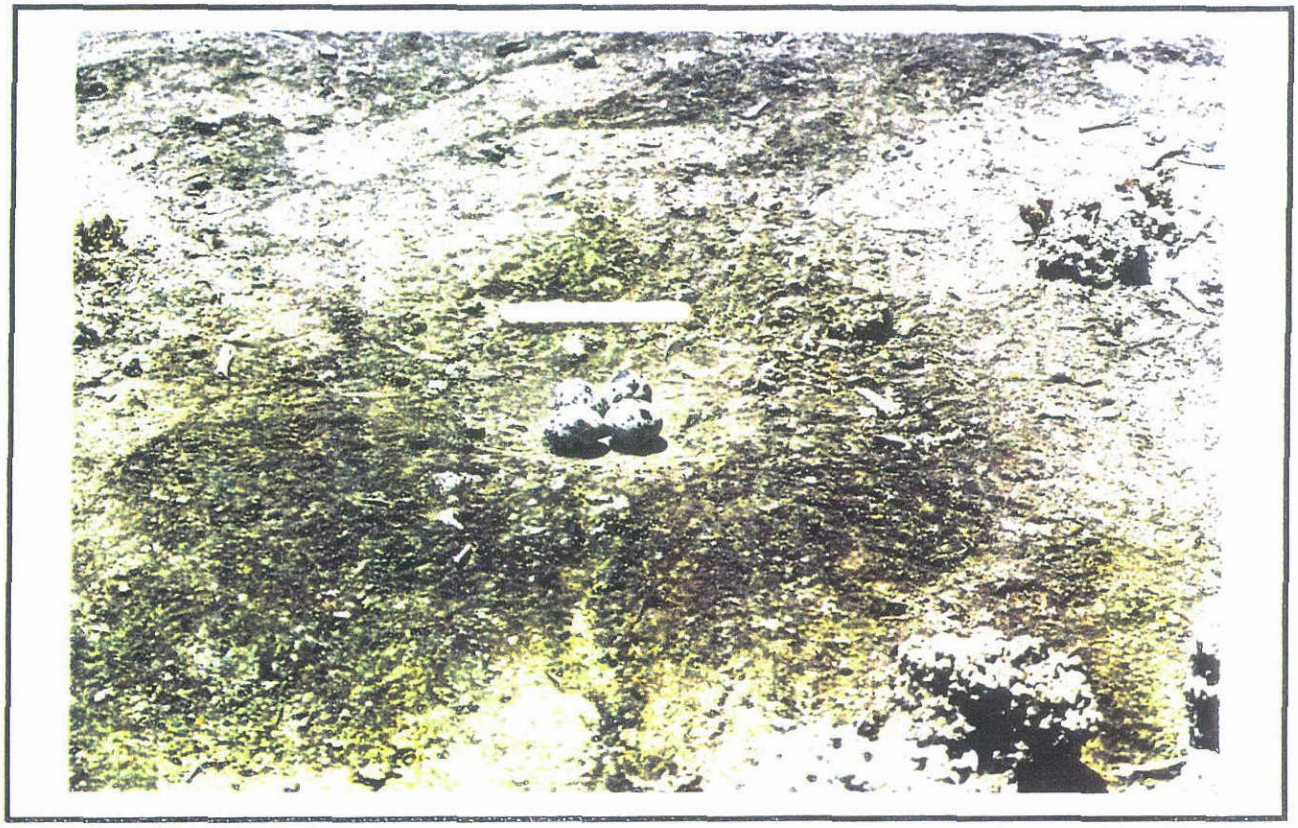

Plate 6. Black skimmer nest located on unvegetated portion of dike V.

Table 9. Fate of black skimmer eggs by location in 1993.

location	# nests	egg laying dates	total eggs	unknown[a]	# Eggs (% of known outcomes within subgroups) hatched	unhatched	predated	damaged	abandoned	unsuccessful pip	mud encrusted
Dike III	278	5/20-8/23	811	47 (5.8)	541 (70.8)	43 (5.6)	31 (4.1)	17 (2.2)	30 (3.9)	6 (0.8)	96 (12.6)
Subgroup M	2	5/20-6/21	8	-	8 (100)	-	-	-	-	-	-
Subgroup N	18	6/14-8/2	48	3 (6.3)	11 (24.5)	-	24 (53.4)	3 (6.7)	-	-	7 (15.6)
Dike IV	118	5/20-8/30	320	23 (7.2)	204 (68.7)	24 (8.1)	29 (9.8)	20 (6.7)	10 (3.4)	6 (2.0)	4 (1.3)
Dike V	10	4/26-5/10	20	-	16 (80.0)	1 (5.0)	1 (5.0)	-	2 (10.0)	-	-

[a] Percent of total eggs at each location.

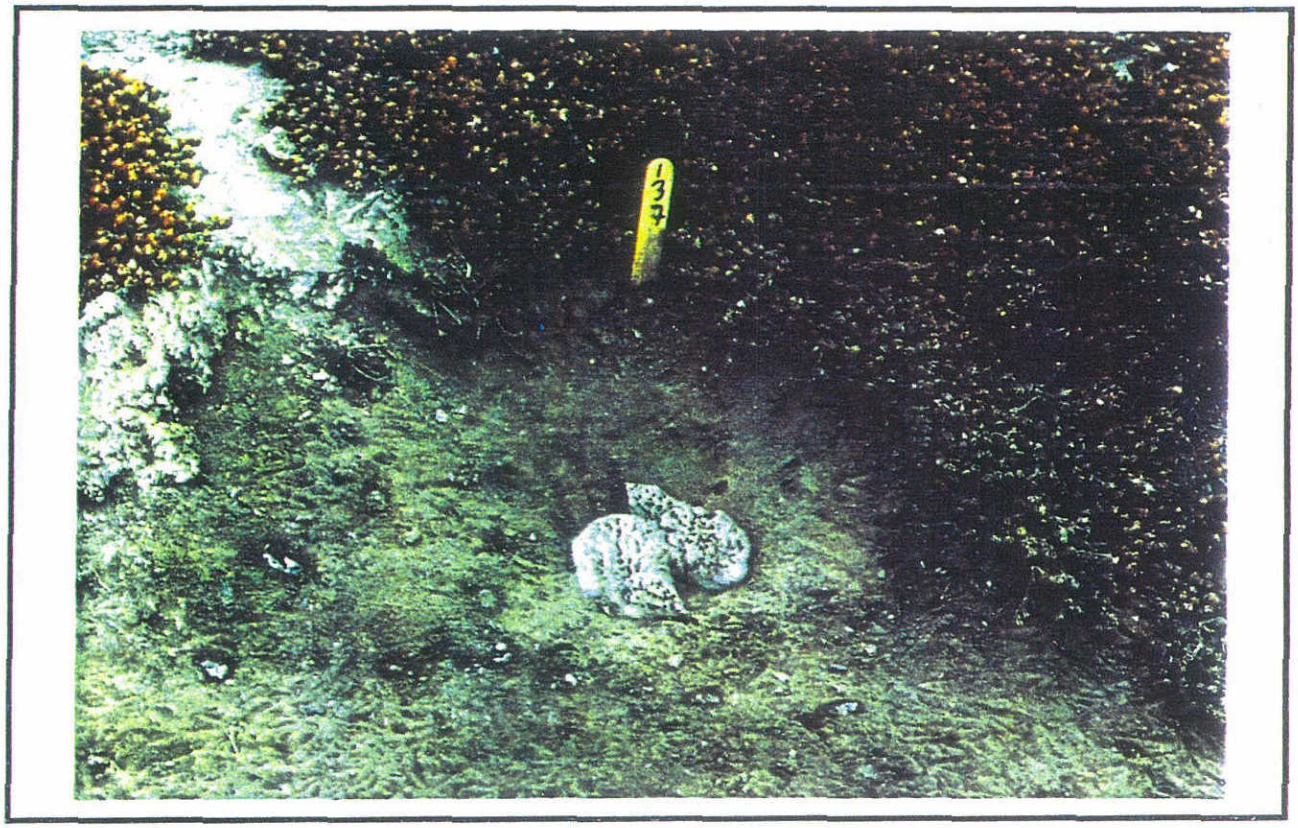

Plate 7. Black skimmer nest located on the vegetated portion of dike III.

skimmer hatching success is provided in Tables 10 and 11.

Prior information regarding nesting success of black skimmers at the Salt Works is unavailable for comparison however, published data for colonies located on the east coast exhibited greater clutch sizes and higher rates of hatching success. Clutch sizes and hatching success were reported for colonies located in New York and Virginia where 88% and 78.6% of eggs hatched and clutch sizes equaled 3.7 and 3.55 respectively (Erwin 1977, Safina and Burger 1983). The lower clutch size at the Salt Works may be attributed to the number of renesting adults as suggested by White et al. (1984) who noted a reduction in the number of eggs laid on successive nesting

Table 10. Fate of black skimmer nests at Western Salt Works.

	Full clutch	Partial clutch
Nests hatched	238	88
Nests unhatched	5	50
Nests abandoned	22	7
Nests preyed upon	30	29
Nests with damanged egg	5	29
Nests unsuccessful after pipping	-	11
Nests encased in mud	30	12
Nest of unknown outcome	23	18
Total nests	473[a]	

[a]Disparate nest totals are a result of nests having multiple outcomes.

Table 11. Fate of black skimmer eggs at Western Salt Works.

	N	%[a]
Eggs laid	1349	-
Eggs hatched	877	68.9
Eggs unhatched	75	5.9
Eggs abandoned	51	4.0
Eggs preyed upon	101	7.9
Eggs damaged	43	3.4
Eggs unsuccessful after pipping	13	1.0
Eggs encased in mud	113	8.9
Eggs of unknown outcome	76	5.6[b]

[a]Percentage of eggs with known outcomes.
[b]Percentage of total eggs laid.

attempts by black skimmers.

Hatching success at the Salt Works was most affected by weather and predation, especially along dike III. After the heavy rains on 5 June, the powdery silt of the dikes turned into a thick paste which encrusted 113 black skimmer eggs cementing them to the ground. The majority of these soil encrusted eggs (8.9% of the total eggs) were eventually abandoned by the adults and subsequently, some were destroyed by predation after abandonment. Predation of eggs not abandoned as a result of the rain also reduced black skimmer productivity. In subgroup N, approximately 54% of the eggs were depredated most likely as a result of the subgroups peripheral location to other nesting larids, direct access to the perimeter road where feral dogs were known to travel, and the small size of the subgroup (Figure 2 and 4). Eggs were found with punctures and bite marks. Another cause of nest failure was the 43 eggs which appeared to be crushed or indented as a result of adults leaving the nest or turning eggs (Plate 8). These "damaged" eggs were not specific to any one nesting location within the Salt Works and were also documented within nesting black skimmer colonies at the Salton Sea (pers. com. K. Molina). In 1981, egg shell thickness for caspian terns breeding at south Bay was reported as significantly lower than those prior to 1947 (Ohlendorf et al. 1984). In addition, caspian tern eggs were found to contain high levels of DDE which was suspected as the cause of the eggshell thinning found during that year. A sample of the indented black skimmer eggs was collected from the Salt Works to allow measurement of eggshell thickness and future contaminant analysis.

Chick mortality for black skimmers was approximately 11%. Most of the documented mortalities were of unknown cause and almost half were associated with nestlings, although predation of larger chicks was evident especially towards the end of the breeding season. Carcasses of black skimmers near fledging were found with the body cavity eaten out and wings still attached while in other instances only sets of detached wings were located. Black skimmer chicks also appeared prone to developing mud balls on their bills and feather tips (Plate 9) but only one death was attributed to this condition.

Prior estimates of black skimmer breeding adults range from one pair on the initial discovery of black skimmer nesting at the Salt Works to over 200 pairs in 1988 (McCaskie 1976, McCaskie 1988, Carter et al. 1994). In 1993, black skimmer nesting

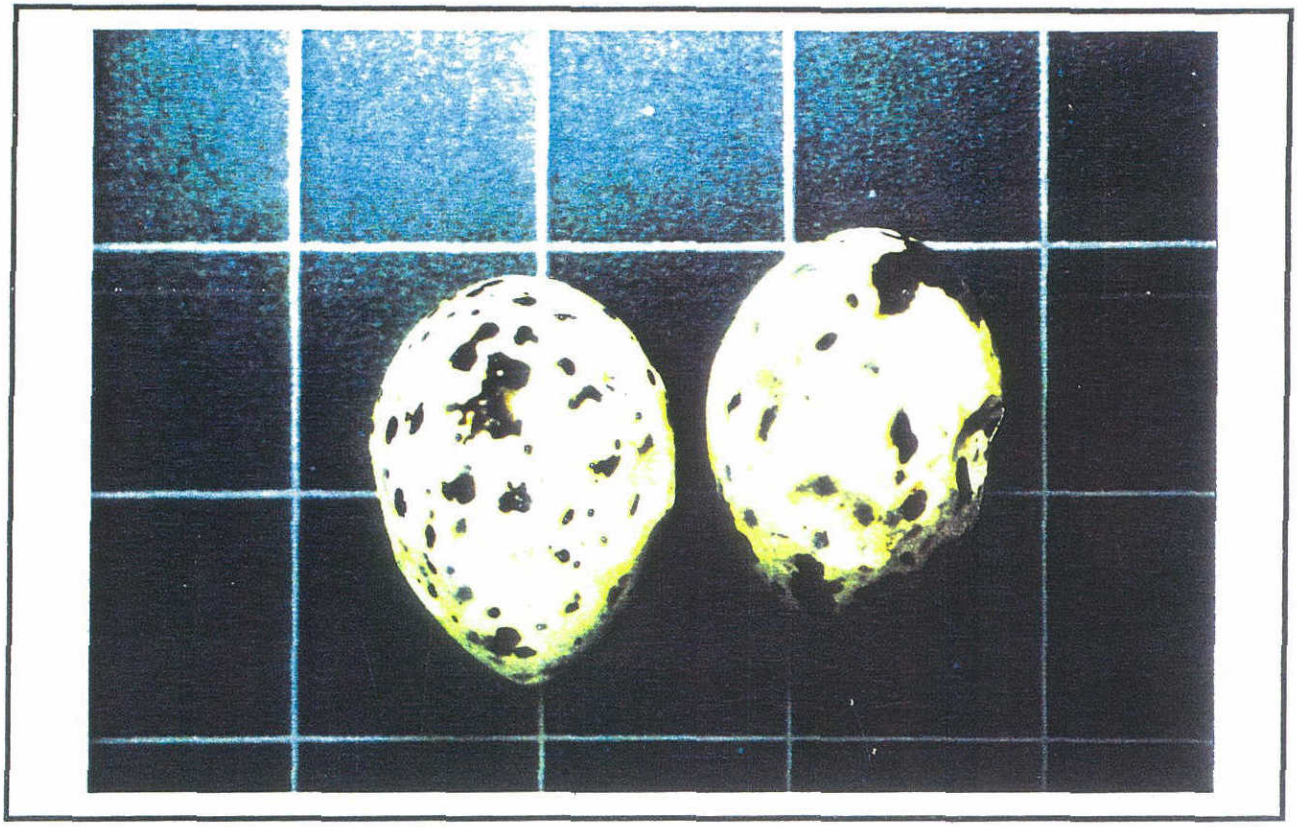

Plate 8. Black skimmer eggs which were damaged by incubating adult.

Plate 9. Black skimmer chick with mud balls on feathers.

pairs increased 50% from 1988 and represent a high count for breeding at this location.

Western Snowy Plover

Nine western snowy plover nests were initially documented at the Salt Works during 1993 (Table 12). Egg laying commenced on or about 25 March and the last nest was found on June 8 with a completed 3 egg clutch. An additional nest is believed to have been initiated after two pre-fledged chicks were observed on 12 August, the last marked nest having hatched on 25 June. Nests were located along the sides of the perimeter road and along dikes III and IV (Plate 10). It is interesting to note that two nests were located in the exact same nest scrape atop a salt crystal, the first nest having successfully produced 3 chicks. All

Table 12. Summary of snowy plover nesting success at Western Salt Works.

	N	%
Nest initiations	10	-
Eggs laid[a]	27	100
Eggs hatched	16	59.3
Eggs unhatched	2	7.4
Eggs preyed upon	8	29.6
Eggs abandoned	1	3.7

[a]Since the last marked nest hatched on 25 June, an additional nest was believed to be initiated when 2 pre-fledged snowy plover chicks were seen on 12 August. This nest is excluded from the egg data.

Plate 10. Snowy plover nest located atop a salt crystal deposit on dike III.

marked nests were three egg clutches. Two nests both located on dike IV were fully preyed upon. A second nest had two eggs removed by an unidentified predator and the remaining egg was abandoned. Both unhatched eggs were found in an individual nest which also produced a single chick.

During this investigation, a minimum of 7 breeding pairs were estimated which assumes adults renested after losses from predation. This represents a decline of 56% from the 1978 survey conducted during May which reported 16 breeding pairs (Page and Stenzel 1981). The coastal population of the western snowy plover has recently been Federally listed as a threatened species (Fish and Wildlife Service 1993). Population declines have resulted from loss of habitat, human disturbance, and predation.

INCIDENTAL OBSERVATIONS

In the course of this investigation, incidental observations were made regarding other species nesting at the Salt Works. Between 26 April and 10 June, 510 Forster's tern (Sterna forsteri) nests containing 1246 eggs were recorded (Plate 11). Predation of at least 30 Forster's tern nests was documented. Feral dogs had been seen along the dikes and canid tracks were found at several nests. Forster's tern nests were also susceptible to fluctuating water levels. Nests located at the base of the perimeter road along the Bay side were subjected to high tides and were believed to have been flooded. Crushed or indented eggs similar to those which occurred in black skimmer eggs were also present in several Forster's tern nests.

The Federally listed endangered California least tern (Sterna antillarum browni) has been known to nest at the Salt Works for many years. The number of nesting pairs at this location has fluctuated from zero to 60 pair between 1968 and 1992 (Craig 1971, Fancher 1992, Obst and Johnson 1992, Caffrey 1993). During the 1993 breeding season, a total of 62 nests were initiated (Caffrey 1994).

Thirty-four double-crested cormorants (Phalacrocorax auritus albociliatus) nests were counted on the abandoned barge located near dike V. An additional 19 nests were documented among nesting caspian terns on dike II (Plate 12). Nesting by double-crested cormorants is believed to have been initiated at the Salt Works when the barge was abandoned some 6 years ago. Nesting along the dikes has not been reported prior to this investigation.

In addition to breeding seabirds and western snowy plovers, the Salt Works provided nesting habitat for several other species including black-necked stilts (Himantopus mexicanus mexicanus), American avocets (Recurvirostra americana), and killdeer (Charadrius vociferous vociferous).

GENERAL DISCUSSION

The sequence in which the Salt Works was colonized by colonial nesting seabirds began with what is believed to be a population shift of caspian terns from inland lakes and freshwater marshes to coastal areas in response to significant habitat modification (Gill and Mewaldt 1983). The Pacific coast population of caspian terns continued to grow especially

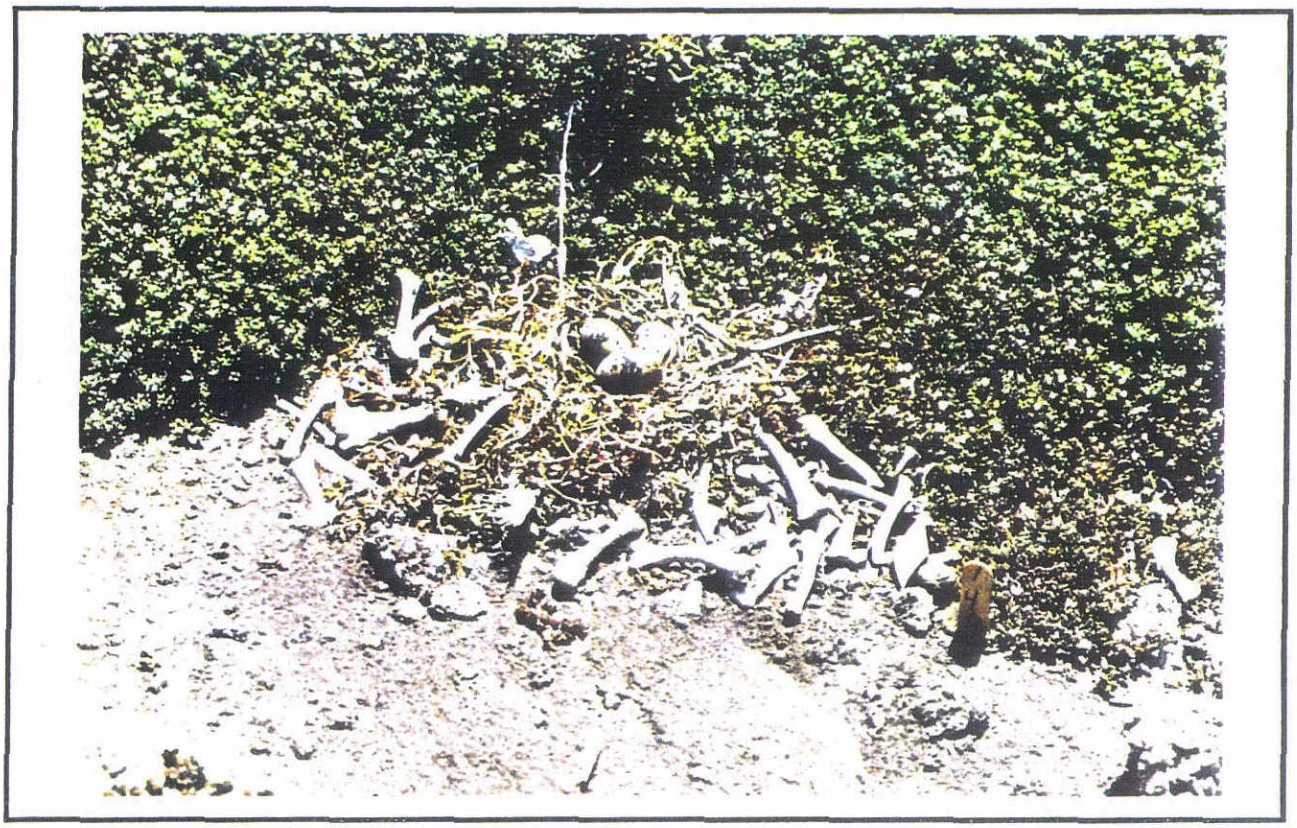

Plate 11. A Forster's tern nest.

Plate 12. Double-crested cormorant nest located on dike II.

during the early 1940's when new breeding colonies were established including the colony at the Salt Works. The nesting population at the Salt Works increased after its initial inception and by 1980 had stabilized at approximately 400 pairs. In the period between 1975 and 1980, the Salt Works accounted for 60.8% of the breeding caspian terns in coastal California (Carter et al. 1994). Report of declines in breeding pairs initially occurred in 1991 with a further decrease observed for 1993. In recent times, 19.1% of the coastal California breeding adults occur at this site. This decline has occurred in light of increases in the overall coastal breeding population (Carter et al. 1994). As previously stated, declines at the Salt Work may be explained in part by the possible shift of breeding adults to the Bolsa Chica Ecological Reserve. From previous banding records, the Salt Works colony has proven to be a "seed source" for new caspian tern colonies to the north and has contributed to the nesting population of already existing colonies (see Gill and Mewaldt 1983).

Elegant terns at the Salt Works represent an expansion of this species breeding range from the nearest active colony at Isla Raza, Mexico some 600 km south of San Diego. The Salt Works is one of only two elegant tern breeding colonies located in the United States. The initial expansion of this species to the Salt Works occurred soon after the 1957-1958 El Niño-Southern Oscillation and a subsequent increase in northern anchovy (Engraulis mordax) populations off the coast of southern California (Schaffner 1986). The shift in the elegant tern's primary forage species, the relatively isolated nature of the Salt Works dikes, and the existing colony of caspian terns apparently facilitated the establishment of the elegant tern breeding colony in south San Diego Bay. Concurrent with the caspian tern population, the elegant tern breeding colony at the Salt Works increased and peaked in the early 1980's. Recent surveys indicate a substantial decline in the elegant tern breeding population at the Salt Works. This decline coincides with an increase of elegant terns nesting at Bolsa Chica where this species began breeding in 1987 one year following initial nesting by caspian terns (Collins et al. 1991). As with the caspian terns, it is possible that the decline in elegant terns nesting at south Bay may be attributed to a shift in the breeding population but why these movements may be occurring is uncertain.

In contrast to the caspian and elegant terns, the breeding population of royal terns and black skimmers at the Salt Works exhibited an increase during 1993. Royal terns nest at only two locations along the Pacific coast where the overall breeding population has ranged between two and ten nesting pairs. The expansion of this species breeding range into California may be indicative of changes in the nearshore fish fauna (see Schaffner 1985). Black skimmers have also expanded their breeding range. This species breeds at primarily three locations in California. Although the nesting population of black skimmers has increased, black skimmers experienced the lowest hatching success of the seabirds monitored at the Salt Works during this investigation.

The dikes of the Western Salt Works provide habitat for a distinctive assemblage of nesting species of which many are

considered sensitive. The coastal population of the western snowy plover has been Federally listed as threatened and is a State Species of Special Concern. The elegant tern is a Federal Candidate (Category 2) for listing as well as a State Species of Special Concern. Both the gull-billed tern and black skimmer are also considered State Species of Special Concern. During this investigation 1900 nests and over 3800 eggs were documented for tern species alone. The importance of the Western Salt Works as a significant breeding ground for colonial seabirds and Federally listed species cannot be over emphasized.

Immediate consideration should be given to providing additional protection to the Salt Works seabird colonies. The Salt Works not only represents an important breeding ground but it is an important contributor to the biodiversity of San Diego Bay. In order to ensure continuation of this site as a seabird breeding area emphasis should be placed on pro-active management, continued monitoring of nesting seabirds and the western snowy plover, and further ecological studies. Pro-active management would include securing the perimeter fencing of the Salt Works facility to deter entry by feral animals and potential human disturbance, possible amendment of dike substrates to facilitate drainage, and removal of feral animals and injured gulls to prevent predation on ground nesting birds. Monitoring of the nesting population and hatching success is important to understand general population trends and can provide information indicative of local environmental conditions. Long term investigations including banding studies should be initiated in order to provide information regarding the relationship of the Salt Works colony to other locations and identify possible shifts in breeding populations. Further research into the ecology of individual species, identification of foraging areas, monitoring of the local prey base, and the investigation of possible contaminant problems would provide information for future management considerations.

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