POPULATION STATUS AND BREEDING BIOLOGY OF BLACK SKIMMERS AT THE SALTON SEA, CALIFORNIA

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Black Skimmers (*Rynchops niger*) are widely distributed along the eastern and southern coasts of North America. Along the western coast their distribution is more restricted, ranging from Mexico north to southern California (American Ornithologists' Union 1983, Collins and Garrett 1996); a few pairs have nested recently in coastal northern California (Yee et al. 1995, Layne et al. 1996). The ecology, reproductive biology, and behavior of Black Skimmer populations along the Atlantic coast and Gulf of Mexico have been the subject of numerous investigations (Erwin 1977, 1979, Loftin 1982, Custer and Mitchell 1987, Quinn 1989, 1990, Burger and Gochfeld 1990) and have been reviewed by Gochfeld and Burger (1994). The potential effects of environmental contaminants on these populations have also been described in several recent publications (Blus et al. 1980, White et al. 1984, King et al. 1986, King 1989, and Burger and Gochfeld 1992). Except by Schew and Collins (1990, 1991), little information has been published on the Pacific coast breeding populations. Black Skimmers nesting at the Salton Sea, a large interior saline basin in extreme southern California, have received only cursory attention since the establishment of breeding in 1972 (McCaskie et al. 1974, Grant and Hogg 1976, Grant 1978). This unique interior population is well established, having persisted for nearly 25 years. In this paper I describe the nesting habitat, population trends, phenology, clutch size, and hatching success of Black Skimmers nesting at the Salton Sea during the 1990s.

STUDY AREA AND METHODS

The Salton Sea lies within the Colorado Desert of Riverside and Imperial counties in southeastern California (Figure 1). Covering only a portion of the bed of ancient Lake Cahuilla and at an elevation of 84 m below sea level, the Salton Sea measures some 48 km in length and 15 km across its greatest width. Today this closed, saline basin is maintained primarily by an influx of agricultural and industrial tailwater. Setmire et al. (1993) estimated over one million acre-feet of water to enter the Salton Sea annually through an extensive system of drains that either terminate directly into the sea or flow into it via the Alamo and New rivers. The Whitewater River at the north end similarly directs agricultural waste water and storm runoff from the Coachella Valley into the sea. Several minor natural drainages that provide relatively fresh seasonal flows to the basin are San Felipe Creek and Wash along the western perimeter and Salt Creek along the eastern shore. Maximum sea surface elevations occur in spring, while minimum elevations occur in the fall. During the last decade, the mean sea elevation has been 69.2–68.7 m below sea level (Imperial Irrigation District). Hagar and Garcia (1988) reported maximum salinity levels for the Salton Sea to be about 44 parts per thousand; water near river mouths is fresher. Sea surface temperatures may consistently exceed 30° C from spring through fall (Carpelan 1961). Frequently following hot, windless days in summer, the oxygen in the water is depleted, periodically killing fish. The Imperial Valley receives virtually no rainfall in summer and minimal cloud cover (Ermak et al. 1976). Daily ambient temperatures commonly exceed 40° C throughout the nesting season, thus characterizing the Salton Sea as one of the harshest environments in which waterbirds nest (Grant 1982).

To determine nesting phenology and reproductive success, I surveyed traditional and other suitable breeding sites for evidence of nesting at weekly intervals beginning in mid-March of each year. I observed colonies from a distance until I believed incubation was well advanced. During visits to the colony, I marked nests individually, as encountered, with a section of PVC tubing 10–15 cm long and a numbered plastic tag. Nest contents and their condition were recorded on each visit. To minimize colony disturbance and

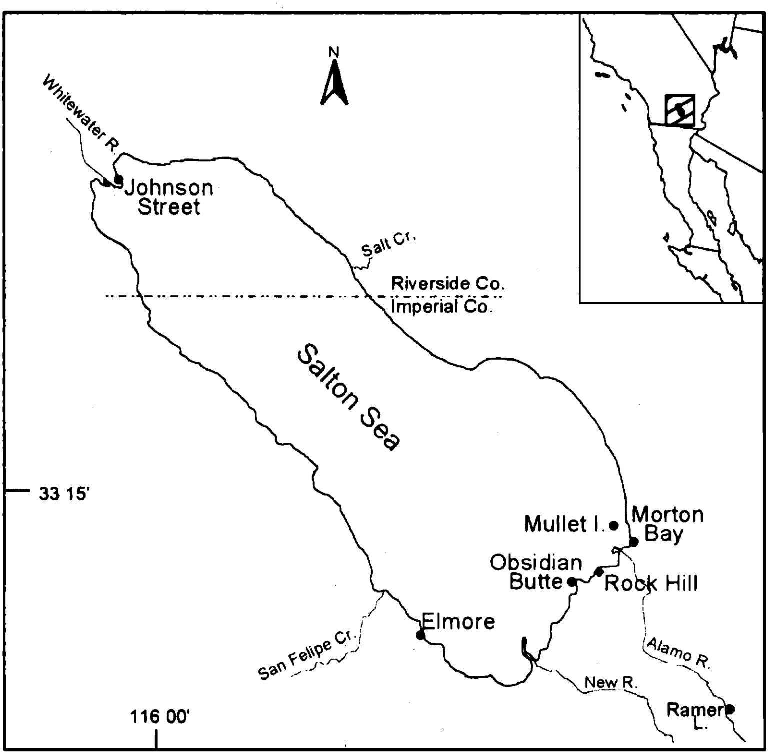

Figure 1. Black Skimmer nesting localities around the Salton Sea.

possible abandonment, I visited colonies at weekly or near-weekly intervals. Because all colonies (except at Rock Hill) are on private lands, and mammalian predators including skunks (*Mephitis mephitis*), coyotes (*Canis latrans*), raccoons (*Procyon lotor*), and feral cats (*Felis catus*) are abundant, I refrained from isolating nests within enclosures. Mean clutch sizes for each year were compared by means of a Kruskal–Wallis test. Single-egg clutches were excluded from these analyses as they were likely incomplete. A clutch was considered successful when at least one egg hatched. Hatching was determined on subsequent visits by the presence of young and relatively immobile chicks and a corresponding reduction in clutch size. This cautious approach contributed to the large number of nests of unknown fate in all years. Beginning in 1993, I marked young with U.S. Fish and Wildlife Service stainless steel bands and Darvik plastic color bands to distinguish annual cohorts.

RESULTS

Colony Sites and Utilization

Skimmers have established colonies at both the north and south ends of the sea. Although they are known to have nested at other more ephemeral or poorly defined sites, they used seven locations (Figure 1) from 1991 to 1995. With the exception of Mullet Island, all sites are less than 1000 m^2 in area. Except where otherwise noted, skimmers have nested at all sites since the initiation of this study.

The Johnson Street site, near the Whitewater River mouth, consists of two parallel and two perpendicular remnants of earthen levees, isolated from the shoreline by rising sea surface elevation. The skimmers here usually nest on compacted earth at the levee plateaus, which rise several meters above sea level. The height of these plateaus affords protection against wind-generated wave action and inundation of nests. Mullet Island (Figure 2), with relatively high relief and large areas for nesting, lies 2.5 km north of the Alamo River mouth. Skimmers use the bare earthen slopes and terraces. Nests are placed upslope from barnacle beaches at 3–4 m from the water's edge. Morton Bay is an eroded impoundment near the Alamo River. The substrates of both of its low-lying nesting islets consist of highly silty clay soils. A nearly continuous perimeter levee provides some protection from wave action and inundation of the colony site. Near Rock Hill, a series of small flat earthen islets within a freshwater impoundment was first available for nesting in 1995. Located within the Salton Sea National Wildlife Refuge, Rock Hill is the only colony site under active management (control of water level and protection from disturbance). Adjacent to Obsidian Butte is a low-lying nearshore site consisting of a rocky perimeter and an interior nesting beach composed of crushed barnacle. This islet is often completely inundated during high winds. Ramer Lake, a California Department of Fish and Game recreation area, lies 5 km southeast of the Salton Sea shoreline and adjacent to the Alamo River. Here, skimmers nest on small man-made

Figure 2. Aerial view of Mullet Island. Alamo River mouth in background.

Photo by Kathy Molina

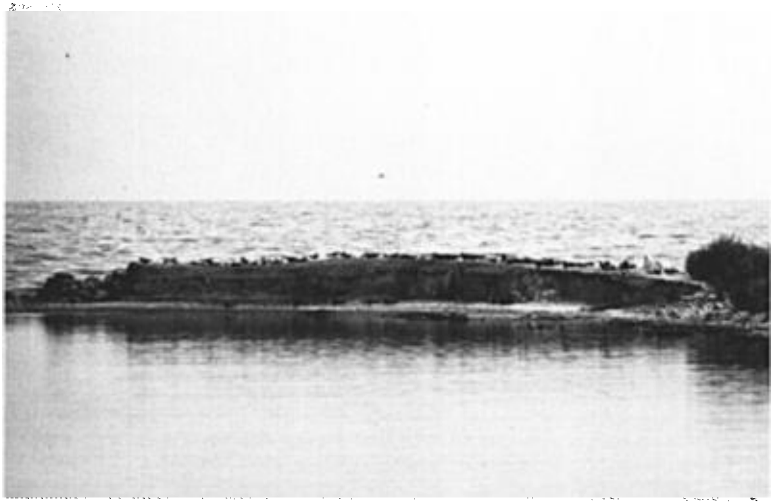

Figure 3. Black Skimmer nesting habitat near Elmore Ranch on western shoreline, Salton Sea, 1992.

Photo by Kimball Garrett

compacted earth islets. They first colonized Ramer Lake in 1995, although these islets had been formed three years earlier. The potential for the colony to be disturbed is high owing to heavy levels of recreational use. The colony at Elmore Ranch (Figure 3), on the southwest shore of the sea, lies on a single earthen levee remnant that is highly susceptible to wave action, erosion, and inundation.

To examine site fidelity, I report the pattern of colony occupation for 1991 through 1995. Black Skimmers did not use any single site continuously throughout the study period. Johnson Street and Morton Bay had the highest rates of occupation (Figure 4). The Ramer Lake and Rock Hill sites are omitted from Figure 4 because the former site's population was small and because the latter was available only one year. Successful colony sites, those that did not experience widespread desertions or nest failures, were reused the following year 82% of the time. Failed colony sites were still reoccupied in the following year 33% of the time.

During the same 5-year period, the sites of earliest nesting were also inconsistent (Figure 4). The novel Rock Hill site was occupied immediately after the creation of nesting islets in 1995. Rates of earliest occupation are distributed almost evenly among three of the five sites, suggesting low site fidelity.

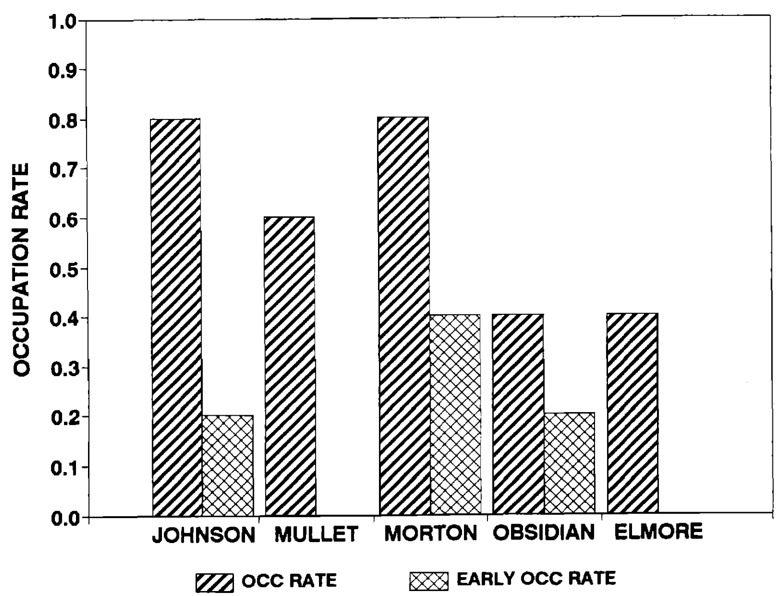

Figure 4. Occupation rates (diagonal bars) and rates of earliest occupation (hatched bars) for five long-standing Black Skimmer nesting sites around the Salton Sea, 1991–1995. Excludes Ramer Lake and Rock Hill sites.

Population Size

McCaskie and Suffel (1971) first described the appearance of Black Skimmers at the Salton Sea in the summer of 1968; the nesting of five pairs was documented in 1972 (McCaskie et al. 1974). Based on data published in *American Birds* and from this study, the trend in breeding population size over the last 23 years (Figure 5) is a dynamic one. Peak numbers of pairs occurred in 1987 and again in 1995. Although skimmers nested in 1979, an estimate of the number of pairs is not available. Black Skimmers were thought not to be breeding at the Salton Sea from 1980 to 1984.

Phenology

Black Skimmers begin arriving at the Salton Sea in early to mid-April, with 3 April being the earliest arrival date during this study period; numbers increase through June. Skimmers form loose aggregations and often roost at locations that later serve as nesting sites. Colony sizes range from 10 to several hundred pairs; colonies consisting of 50-200 pairs are most common. With few exceptions, Black Skimmers nested near nesting Gull-billed (*Sterna nilotica*) and/or Caspian terns (*S. caspia*).

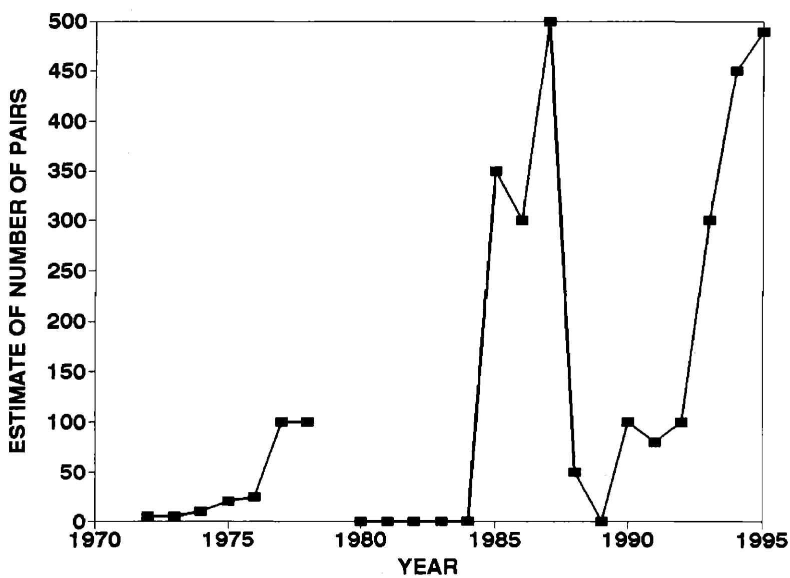

Figure 5. Trend in the number of breeding pairs of the Black Skimmer at the Salton Sea, 1972–1995, based on data from *American Birds* and the present study. Skimmers were present at the Salton Sea in 1979 and probably nested, but an estimate of the number of pairs is not available. Skimmers were scarce from 1980 to 1984 and in 1989 and were believed not to be breeding in those years.

Although egg-laying generally commences in late May and continues through late August (Figure 6), a well-defined peak of nest initiation extends from late June and late July. Every year, there has been a small wave of nest initiations in September, suggesting renesting attempts of adults or perhaps first attempts of younger birds.

Hatching commences in mid-June and continues through early September with a peak in late July and August. Fledging first occurs by late July or early August and continues through October. Nesting sites frequently serve as post-breeding roosts until adults and young begin dispersing to wintering grounds in September and October. Reports of Black Skimmers from the Salton Sea in winter are few; however, observations of several juveniles in late December and of birds in early March suggest that some skimmers overwintered in 1995–1996 along with an unusually large number of Brown Pelicans (*Pelecanus occidentalis*), perhaps in response to abundant food supplies.

Reproductive Parameters

The mean clutch size for Salton Sea skimmers (Table 1) ranged from 2.97 eggs in 1994 to 3.29 eggs in 1995. Mean clutch size was significantly lower in 1994 than in 1993 and 1995 (Kruskal-Wallis, $p < 0.001$).

To determine hatching success (Table 2), I monitored the outcome of over 200 nests each year from 1993 to 1995. The proportion of nests with

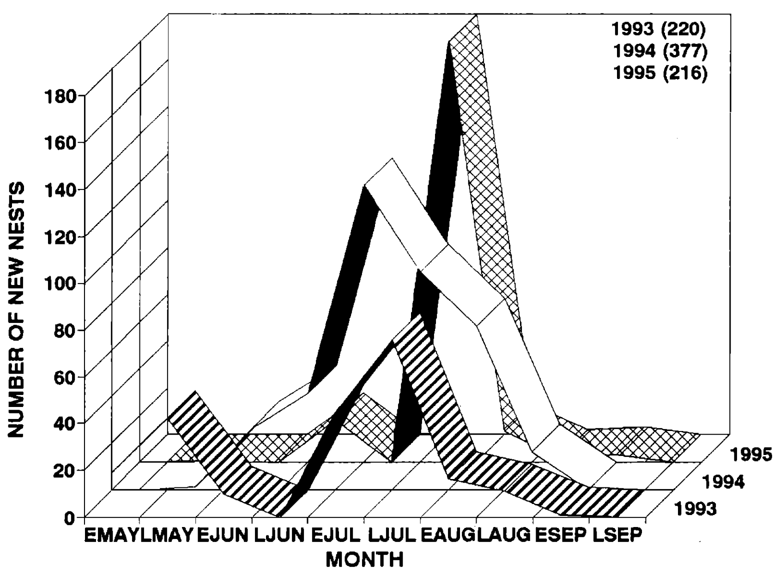

Figure 6. Pattern of Black Skimmer nest initiation at the Salton Sea, 1993–1995. See text for methods. Sample sizes for each year in parentheses upper right.

Table 1 Clutch sizes of Black Skimmers Nesting at the Salton Sea, 1993–1995

	1993	1994	1995[a]
Mean	3.15	2.97[b]	3.29
Standard deviation	0.64	0.65	0.65
Range	2–4	2–5	2–6
Sample size	209	354	185

[a]Ramer Lake colony excluded since first visited after hatching.

[b]Mean differs from all others, $p < 0.001$, Kruskal–Wallis.

known fate among the total nests monitored ranged from 56% to 76%. The number of successful nests reported, therefore, is a minimum value. The hatching success for nests of known fate was highly variable from year to year, ranging from 27% in 1994 to 71% in 1993.

In 1993 and 1994 large colonies at Morton Bay experienced complete hatching failures despite continual attendance of nests throughout the season. A large proportion of clutches were found cemented to the bottom of the bare scrape. Here the substrate consisted of silty clay and many embedded eggs also had dents and cracks. My attempts to dislodge clutches often resulted in damage to the eggs. In 1995 Johnson Street also experienced a widespread nesting failure. This failure differed from the failures at Morton Bay in that eggs remained movable within the scrape and exhibited little cracking or denting.

Since 1993, 622 young Black Skimmers have been banded at the Salton Sea. With constant effort over the last three seasons, I banded 228 young in 1993, 90 in 1994, and 304 in 1995. Quantitative information on annual fledging success is limited.

Since 1993 I have observed a few juveniles with defective wing development characterized by loss of primary feather shaft integrity and by a possible rotation of the wrist joint (Figure 7). I estimated this condition to occur in 1–2% of the banded juveniles annually.

Table 2 Measures of Black Skimmer Hatching Success at the Salton Sea, 1993–1995

	1993	1994	1995
Total nests monitored	219	377	225
Nests of known fate (% of total)	139 (63%)	211 (56%)	171 (76%)
Successful nests	99	57	113
Failed nests	40	140	58
Percent success	71%	27%	66%

Figure 7. Black Skimmer near fledging age with feather/wing deformity (at right) at Obsidian Butte, 1994.

Photo by Kimball Garrett

DISCUSSION

The variation in nest-site fidelity of Salton Sea Black Skimmers is characteristic of populations nesting in dynamic environments (Burger 1982). Fluctuating sea levels may affect low-lying sites near shore, by either inundation or by enhancing connectivity to the mainland (and increasing susceptibility to predation) during a drop in sea level. Morton Bay and Obsidian Butte were not used in 1995, a year when the level reached a 20-year maximum. Levees protecting the low-lying islets of Morton Bay were breached early in the season, and the nesting beaches of Obsidian Butte were inundated by wind-generated wave action through most of the nesting season.

The immediate colonization of novel nesting sites and the subsequent reoccupation of some previously unsuccessful sites suggests that optimal nesting habitat is limited at the Salton Sea. Black Skimmers formed a large colony of some 400 pairs at the Rock Hill impoundments in Salton Sea National Wildlife Refuge for the first time in 1995. Colonization of Rock Hill is significant in that it is the only site actively managed for colonial ground-nesting birds. Also in 1995, skimmers established a small colony of about 10 pairs at Ramer Lake, a popular recreation area managed by the California

Department of Fish and Game; it is the first documented colony of Black Skimmers nesting away from the Salton Sea's perimeter.

Because estimates of population size since the early 1970s have been generated primarily from casual observations rather than from focused censuses, one may ask whether these numbers accurately reflect the true population. Several factors may explain this pattern of fluctuating population size at the Salton Sea. A graph of sea level versus the skimmer population (Figure 8) suggests an inverse relationship between these two variables during the late 1970s and early 1980s. The rapid and constant rise in sea level may have rendered many existing low-lying sites unsuitable for nesting. During the increase of sea level in the 1990s, however, the relationship between the two variables was positive. This change may be explained by a decrease in disturbance from recreational fishing and a resultant shift to novel nesting habitat. Red Hill Marina is the single most important boat launching ramp at the south end of the Salton Sea and is only 3 km from Mullet Island. Colonization of Mullet Island by larids was not documented until 1992, although the island has been continuously isolated since at least the early 1950s. Local folklore describes Mullet Island as an anchorage popular with fishermen. A comparison of the marina's activity from 1987 through 1994 (Figure 9) and the population of nesting skimmers demonstrates an inverse relationship between population size and the

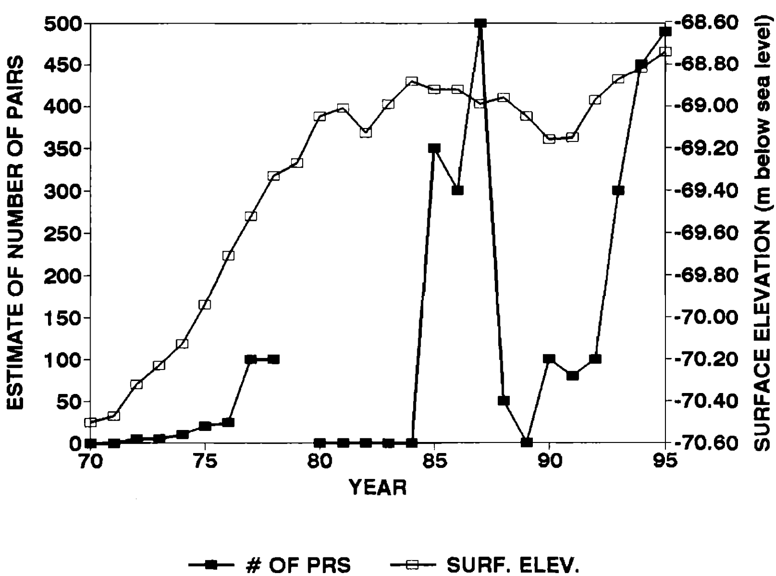

Figure 8. Number of breeding pairs of the Black Skimmer (filled squares) and Salton Sea surface elevation in June (open squares), 1972–1995. Sea-surface elevation data from Imperial Irrigation District.

number of boat launches. The popularity of the sportfishery peaked in 1988, declined precipitiously the following year, and has continued to decline since. The diminished sportfishery, resulting in decreased levels of disturbance at or near Mullet Island, suggests a plausible explanation for the skimmers' increase despite rising sea level.

The nesting schedule of Salton Sea skimmers is similar to that reported for coastal California (Schew and Collins 1991) and for some Gulf of Mexico and Atlantic coast populations (Stewart and Robbins 1958; Portnoy 1977) but differs markedly from peak nest initiation periods of late April and May observed in Virginia (Erwin 1977) and in south Texas (Custer and Mitchell 1987).

The mean clutch sizes I observed are similar to those reported earlier for this population (Grant and Hogg 1976) and to those reported from coastal California (Stadtlander 1994) but slightly lower than those reported for Gulf of Mexico populations (Custer and Mitchell 1987).

Reports of hatching success among North American Black Skimmer populations are highly variable (Gochfeld and Burger 1994). The low mean clutch size coupled with low hatching success and lowered abundance of young for banding indicate that 1994 was a highly anomalous year. The poor reproductive output in 1994 may imply a prolonged period of poor

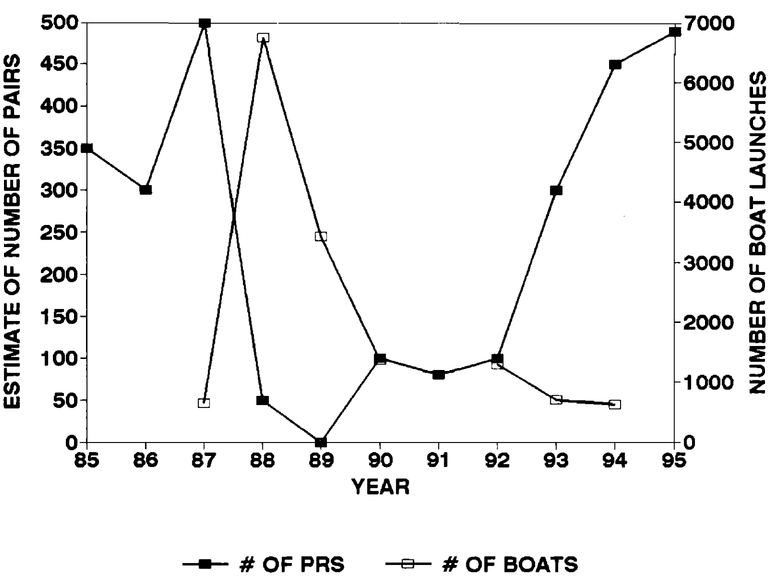

Figure 9. Number of breeding pairs of the Black Skimmer (filled squares) and number of boats using the Red Hill Marina boat ramp (open squares), 1987–1995. Number of boat launchings not available for 1991. Based on data from Imperial County Department of Recreation.

food availability; however, the role of contaminant-induced reproductive depression, operating just below threshold levels, is still unclear and can not be ruled out.

Quantitative information on the foraging behavior and diet of Black Skimmers at the Salton Sea is lacking. The Salton Sea fishery is a simple one, with marine game species, the Orangemouth Corvina (*Cynoscion xanthulus*), Sargo (*Anisostremus davidsonii*) and Bairdiella (*Bairdiella icistia*) initially stocked. Tilapia (*Tilapia* sp.) have since been introduced into irrigation ditches (Setmire et al. 1993) and are abundant inshore. Small tilapia are often observed dropped at nests. These and small Bairdiella are occasionally regurgitated by chicks during handling. The comprehensive investigation of the biota of the Salton Sea during the 1950s by Walker et al. (1961) is now somewhat outdated, and few recent studies of the Salton Sea fishery have been published. Matsui et al. (1992) recently examined the reproduction of Bairdiella in the Salton Sea and reported abnormal embryonic development in addition to reproductive decline. The relationship of developmental deformities and diminished reproduction to factors of salinity, temperature, and contaminants is unclear. Fewer and smaller corvina, a highly prized game species, are currently being caught by fishermen. Diminished public use since 1990 suggests that the vitality of the sportfishery has declined significantly.

The large-scale failures observed at Morton Bay in 1993 and 1994 may be related to the apparent immobilization of eggs within the bare nest scrape, possibly preventing proper embryonic development. Grant (1978) has previously described the behavior of foot and belly soaking by Black Skimmers and Gull-billed Terns nesting at the Salton Sea. By cementing the eggs to the ground, this behavior adaptive to heat stress and the transport of moisture to the nest and eggs may actually be detrimental to reproductive success when the birds nest on substrates like that at Morton Bay. Gull-billed Terns have nested successfully at this site during most years of this study. Because Gull-billed Tern nests are lined with flotsam and debris, their clutches have been unaffected by the stickiness of these clay soils when moistened. Immobilization of clutches, as well as eggshell weakening and other contaminant-induced reproductive impairment, may have contributed to these large scale failures.

Setmire et al. (1993) reported elevated levels in DDE and selenium in some Salton Sea biota, and Platter (1976) reported significant eggshell thinning for the Snowy (*Egretta thula*) and Cattle Egrets (*Bubulcus ibis*) nesting there. Preliminary analyses of eggshell quality (unpubl. data) for Salton Sea Black Skimmers are difficult to interpret because pre-DDT clutches from California do not exist. Comparisons of Black Skimmer clutches over a wide geographic range within North America before and after the ban on DDT do not demonstrate consistent thinning (White et al. 1984, Blus and Stafford 1980, King et al. 1991). Some studies of Black Skimmers in Texas during the late 1970s and 1980s (White et al. 1984, King et al. 1991) reported decreases in eggshell thickness but demonstrated no significant relationship between residue levels and eggshell quality and reproductive success. The results of studies examining the relationship of contaminants, eggshell thinning, and reproductive success in other larid species are also mixed. Fox (1976) demonstrated eggshell thinning and a correlation with DDE levels in Common Terns (*Sterna hirundo*) in Alberta, Canada, in addition to differences in amino acid composition and pore area between the shells of eggs that hatched and of those that failed to hatch. Ohlendorf et al. (1985) documented eggshell thinning for Caspian Terns in San Diego but found no clear relationship between eggshell thickness and DDE residues. Fox (1976) reported intra-clutch variation in eggshell thicknesses due to laying sequence and suggested that this natural variation may mask any contaminant-induced variability. Future investigation may help resolve geographic trends and response to contaminants.

Several studies of east-coast tern populations (Gochfeld 1971, Hays and Risebrough 1972) reported feather deformities during the early 1970s at rates similar to that observed in Black Skimmers from the Salton Sea and coastal California (C. T. Collins pers. comm.). Polychlorinated biphenyls, chlorinated dioxins, and heavy metals have been implicated in these studies. Curiously, I have rarely recovered dead chicks near fledging age with this condition. Hays and Risebrough (1972) and my own observations suggest new feather growth after subsequent handling of some affected birds. If parents continue to provision these juveniles, the damaged primaries may be replaced and ultimately fledging may proceed. Continued surveillance, however, is warranted.

Little information is available on the dispersal and wintering patterns of the Salton Sea breeding population of Black Skimmers. The current presumption is that most of this population moves south through the Gulf of California and winters in western Mexico. Gazanniga's (1995, 1996) study of the wintering behavior of resident California coastal populations suggests that Salton Sea birds are generally absent from coastal wintering flocks. However, banded Salton Sea skimmers are rarely but regularly observed along the coast. Such observations were usually made in late winter or early spring and involved birds in their first or second winter. Studies of east-coast Black Skimmers (Gochfeld and Burger 1994) suggest that few first-year birds return to natal colonies. During casual observations at one Salton Sea colony, 5 of 72 (7%) banded young of the year were resighted the following year.

SUMMARY

Black Skimmers nesting at the Salton Sea now form one of the largest nesting populations in western North America, numbering nearly 500 pairs in 1995. This unique inland population varies widely in population size, habitat availability, and reproductive success. Nesting in one of the harshest environments in North America, it may be subject to enormous physiological stress. The increasing salinity and pollutant levels of the Salton Sea also contribute to the uncertain future of these and other piscivorous birds residing there. These baseline demographic data and a maturing banded population provide the foundation upon which more detailed studies of the ecology and physiology of this interesting population of Black Skimmers can be based.

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