Roosting Brown Pelicans at San Nicolas Island, California, 1972-2006

Phillip J. Capitolo[1,*], Harry R. Carter[2,3], Deborah L. Jaques[4], Gerard J. McChesney[3,7], William R. McIver[3,8], Thomas W. Keeney[5] and Grace Smith[6]

[1]University of California, Institute of Marine Sciences, 100 Shaffer Road, Santa Cruz, CA, 95060, USA

[2]Carter Biological Consulting, 1015 Hampshire Road, Victoria, BC, V8S 4S8, Canada

[3]Humboldt State University, Department of Wildlife, Arcata, CA, 95521, USA

[4]Pacific Eco Logic, 375 3rd Street, Astoria, OR, 97103, USA

[5]U.S. Army Corps of Engineers, Planning Division, Environmental Resources Branch, 915 Wilshire Boulevard, Los Angeles, CA, 90017, USA

[6]U.S. Navy, NAWCWD Range Sustainability Office, 575 "I" Ave. Suite 1, Point Mugu, CA, 93042, USA

[7]Current Address: U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, 1 Marshlands Road, Fremont, CA, 94555, USA

[8]Current Address: U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, 1655 Heindon Road, Arcata, CA, 95521, USA

[*]Corresponding author; E-mail: phil.capitolo@gmail.com

Abstract.—To assist long-term protection of roost sites, roosting patterns of California Brown Pelicans (*Pelecanus occidentalis californicus*) at San Nicolas Island (SNI), California, were assessed for the 1972-2006 period. SNI was used for roosting year-round, with most birds likely from nearest primary breeding colonies (Santa Barbara and Anacapa islands) within the Southern California Bight subpopulation. Among non-El Niño years, monthly diurnal counts varied, but ranged from less than 100 birds during the breeding season to approximately 1,000 during fall. Influxes from the large Gulf of California subpopulation also occurred on occasion, best demonstrated by prolonged increased numbers during strong El Niño conditions in 1972-1973, possibly reflecting delayed or skipped breeding and increased prey availability near the outer California Channel Islands. The peak estimate of 13,500 night-roosting pelicans was on 16 November 1972 during these El Niño conditions. Most pelicans roosted diurnally on the north shore, reflecting close proximity to main foraging areas. Diurnal roost patterns did not appear affected by introduced feral cats (*Felis catus*) and Island Foxes (*Urocyon littoralis dickeyi*). The single, major night roost shifted 4 km from Cormorant Rock Area (used 1972-1992) to Vizcaino Point by 2006, following reduction of human disturbance in 1992-1996. Vizcaino Point and Cormorant Rock Area should be designated as "key, long-term roosts" that merit additional protection. *Received 25 July 2011, accepted 14 March 2012.*

Key words.—Brown Pelican, disturbance, El Niño, nesting, *Pelecanus occidentalis*, roosting, San Nicolas Island, Southern California Bight.

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The California Brown Pelican (*Pelecanus occidentalis californicus*; hereafter, pelican) was federally-listed as endangered by the U.S. Fish and Wildlife Service (USFWS) in 1970 and state-listed as endangered by the California Fish and Game Commission in 1971. Its breeding range currently extends to the northern Channel Islands in the Southern California Bight (SCB; ~30-34° N; including northwestern Baja California, Mexico), but more than 80% of breeding pelicans occur at colonies in the Gulf of California (GOC) and farther south. In the U.S. portion of the SCB, primary breeding colonies have occurred at Anacapa and Santa Barbara islands; in the Mexico portion of the SCB, at Coronado, Todos Santos, and San Martin islands (Gress and Anderson 1983; Anderson *et al.* 2007; F. Gress, unpubl. data; Fig. 1). Non-breeding distribution regularly extends north to Washington state, and in small numbers to British Columbia (Jaques 1994). Reproductive failure primarily due to impacts from organochlorine pollution (especially from the pesticide dichlorodiphenyltrichloroethane [DDT]) was the main factor that led to population decline and colony losses from the 1940s to the 1970s. Ma-

Figure 1. Location of San Nicolas Island in the northern portion of the Southern California Bight. Nearby primary breeding colonies for California Brown Pelicans (*Pelecanus occidentalis californicus)* occurred at Anacapa, Santa Barbara, Coronado, and Todos Santos islands.

jor declines at breeding colonies in the SCB, where DDT levels were highest, were a main impetus for listing the subspecies as endangered (Gress and Anderson 1983). Great reduction of organochlorine pollution, along with protection and monitoring of breeding colonies, aided recovery. In 2009, the subspecies was removed from both federal (USFWS 2009a) and California-state lists of endangered species (see Burkett *et al.* 2007).

The U.S. recovery plan for pelicans also recognized the need for protection and assessment of important roost sites throughout the breeding and non-breeding ranges (Gress and Anderson 1983). Pelicans have wettable plumage (Rijke 1970) and require diurnal terrestrial roost sites with low levels of disturbance in proximity to foraging areas, where they can dry and maintain feathers, rest, and sleep (Schreiber and Schreiber 1982). Because pelicans return to shore and are typically inactive at night (Briggs *et al.* 1981; Croll *et al.* 1986), nocturnal roost sites with sufficient buffers from mammalian predators and little disturbance also are essential habitat (Jaques and Strong 2003).

Since the 1980s, assessments (mostly unpublished) have been made for certain roosting areas in California (Mugu Lagoon [Jaques *et al.* 1996; Capitolo *et al.* 2003]; Vandenberg Air Force Base [D. Robinette, unpubl. data]; Elkhorn Slough [Jaques and Anderson 1988]; South Farallon Islands [ongoing monitoring; Richardson *et al.* 2003]), Oregon (East Sand Island; Wright *et al.* 2007), and Washington (Willapa Bay and Gray's Harbor; D. Jaques, unpubl. data). These assessments have been important for identifying factors affecting key roost sites and methods for protection of roost sites. Most roost sites, though, have been infrequently examined, usually only during large-scale coastal surveys (e.g. Jaques 1994; Jaques *et al.* unpubl. data).

In this paper, we provide a summary of pelican roosting patterns in 1972-2006 at San Nicolas Island (SNI), the outermost of the Channel Islands, to assist ongoing efforts by the U.S. Navy (USN) to protect pelican roosts from disturbance. USN has managed SNI since 1933 and has operated an airfield and other base facilities there since 1944. Point Mugu Naval Air Station has overseen SNI since 1947. Roost site protection at SNI began in the early 1980s, increased in the early 1990s, and was further identified as an objective in an Integrated Natural Resources Management Plan completed in 2005. Long-term patterns and protections of roosting pelicans at SNI can also help guide efforts to protect key roost sites in other areas. With federal delisting and loss of protections for roosting areas, a plan for monitoring pelican roost sites throughout California has been proposed (USFWS 2009b), but remains to be implemented.

METHODS

SNI is approximately 15 km long and 6 km wide, has a peak elevation of 277 m, and lies approximately 120 km southwest of Los Angeles, California (Fig. 1). Sandy beaches and low, rocky shelves characterize the coastal terrace, with extensive sand dunes at the northwest end (Vizcaino Point area). A central plateau gently slopes to the coastal terrace on the northwest, north and east sides of SNI, whereas steep slopes and cliffs occur on the south side (Martz 2005). Likewise, shallower waters (<100 m) extend far off the northwest to northeast sides (8-15 km) and deeper waters (>350 m) are reached within 5 km of the south side.

Aerial Photographic Surveys

Aerial photographic surveys, conducted for various research and management purposes by several organizations in 1975-2006 (Table 1), were the principal means

Table 1. Aerial photographic and ground-based surveys of roosting California Brown Pelicans (*Pelecanus occidentalis californicus*) at San Nicolas Island, California, 1972-2006.

	Aerial	Ground			
Year	Diurnal	Diurnal	Night	Survey Organization[1]	Data Source
2006	6/29; 9/25; 9/27; 11/13	9/25-9/27	9/25-9/27	UCSC & PEL	PJC & DLJ, unpubl. data
2002	1/14	—	—	HSU & USGS	HRC, unpubl. data
2001	1/16; 6/18; 7/16; 9/10	—	—	HSU & USGS	HRC, unpubl. data
2000	1/11; 4/19; 5/24; 6/12; 7/11; 9/11	—	—	HSU & USGS	HRC, unpubl. data
1999	5/17; 6/14; 9/13	—	—	HSU & USGS	HRC, unpubl. data
1998	4/13; 5/20; 6/16	—	—	HSU	HRC, unpubl. data
1997	5/20; 6/23	—	—	HSU	HRC, unpubl. data
1996	6/17	—	—	HSU	HRC, unpubl. data
1995	5/25; 6/22	—	—	HSU	HRC, unpubl. data
1994	5/20; 6/21	X	—	HSU	HRC, unpubl. data
1993	6/9; 6/21; 9/30	X	—	CCR, HSU & USN	Jaques *et al.* (1996); DLJ & HRC, unpubl. data
1992	5/15; 6/10; 6/17; 8/19; 9/26	X	7/23-8/23	CCR, HSU & USN	Jaques *et al.* (1996); DLJ & HRC, unpubl. data
1980	10/28	—	—	UCSC	Briggs *et al.* (1983)
1975-1978	Monthly	—	—	UCSC & UCI	Briggs *et al.* (1981)
1972-1975	—	—	X	USN & USFWS	D. W. Anderson, unpubl. data

[1]Abbreviations: CCR (Crescent Coastal Research); HSU (Humboldt State University); PEL (Pacific EcoLogic); UCI (University of California, Irvine); UCSC (University of California, Santa Cruz); USFWS (U.S. Fish and Wildlife Service); USGS (U.S. Geological Survey); and USN (U.S. Navy).

for determining island-wide diurnal roost counts because they facilitated timely and complete inspections of the entire shoreline. In 1992-2006, we conducted 36 surveys of SNI, with counts for all individual roosts and age ratios for most. In 1980, Briggs *et al.* (1983) conducted one survey of SNI on 28 October. In 1975-1978, Briggs *et al.* (1981) conducted 21 monthly surveys of SNI. Only total island counts were available for 1975-1980.

In 1992-2006, each aerial survey was completed within one hour, such that little or no movement of pelicans between roosts likely occurred. Surveys generally occurred near midday, but timing varied due to many factors. Roosts were photographed by two observers while a third observer recorded data. All surveys were conducted from twin-engine, high-wing aircraft at altitudes of 500'-1000' (150-305 m) above sea level and airspeeds of approximately 100 knots (185 km/h). In 2006, digital single lens reflex (SLR) cameras were utilized, while 35 mm SLR cameras with slide film were used earlier. Close-up photographs were taken with 200 or 300 mm telephoto lenses and overview photographs were taken with 50 mm or zoom lenses. Counts from individual images were summed to determine total counts for each roost site; borders of adjacent areas were identified to prevent double-counting. Pelicans with much white head plumage, silver-grey upper back feathers and wing coverts, and/or dark bellies were categorized as "adult", whereas pelicans with brown heads and/or white bellies were categorized as "immature". Immature pelicans likely included most birds up to about two years old, including birds with small amounts of white mottling on the head but with white bellies (referred to as "WW1"s; see Gress and Anderson 1983; Schreiber *et al.* 1989). Age was categorized as "unknown" in cases of poor photo quality or use of distant overviews for counting when roost coverage with close-ups was incomplete.

Ground Surveys

Ground-based surveys, conducted in fewer years than aerial surveys (Table 1), were used to determine night roost locations and counts, and provide additional information on diurnal roost use. In 2006, surveys were scheduled for late September, when peak numbers were expected. Night roost surveys focused on both Cormorant Rock Area and Vizcaino Point (Fig. 2). At Cormorant Rock Area, pelicans were counted in flight as they departed (dawn) or arrived (dusk), but the roost site itself could not always be seen. At Vizcaino Point at dusk, roosting pelicans were counted until shortly after sunset; arrivals thereafter were added to the last roost count to determine a minimum dusk total. At Vizcaino Point at dawn, pelicans could be counted as they departed from the roost beginning about 30 min before sunrise; these numbers were added to a later count of birds remaining at the roost to determine a minimum dawn total. Most but not all roosting areas of Vizcaino Point could be seen from our vantage point. Limited diurnal roost surveys also were conducted from Daytona Beach to Pirate's Cove.

From April 1992 to September 1994, diurnal roosts of all seabird species were counted during other studies. Most observations were in April-August of roosts near Brandt's Cormorant (*Phalacrocorax penicillatus*) colonies at Vizcaino Point and Cormorant Rock Area; no surveys occurred in October-December. Other roosts around the north and south shores were surveyed less often by driving and walking the shorelines, respectively. Because these data did not provide complete island-wide counts, only high counts are reported here. Also in 1992, night roost surveys were conducted, first at Vizcaino Point on 23 July, and thereafter focusing on Cormorant Rock Area through 23 August.

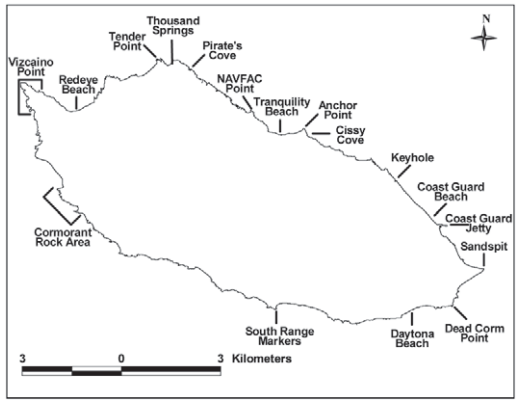

Figure 2. California Brown Pelican roost sites at San Nicolas Island, California, 1992-2006.

From 16 November 1972 to February 1975, numbers of night-roosting pelicans at Cormorant Rock Area were assessed by USN at the request of D. W. Anderson.

RESULTS

Abundance Patterns

Numbers of pelicans roosting at SNI were typically highest in late summer and fall, with additional increases during short- and long-term influxes. Highest counts from aerial surveys were approximately 1,000 birds in September 2006 (Table 2), October 1980, and September 1977. Three other aerial survey counts of >500 pelicans occurred in September-October 1975-1978. More than 1,000 birds were estimated night-roosting from 5 to 23 August 1992, with an influx to approximately 2,500 birds mid month (Table 3). A more prolonged influx was noted in 1972-1973, when the peak estimate of 13,500 night-roosting pelicans occurred on 16 November 1972 and several thousand birds remained into January 1973 (Fig. 3). In January, two marked pelicans from the GOC subpopulation were observed.

Table 2. Total counts of California Brown Pelicans at San Nicolas Island, California, 1992-2006, from aerial photographic surveys of diurnal roosts. Percentage immature in parentheses, when known.

Year	January	April	May	June	July	August	September	November
1992			153	478(3)				
				106		320	576(4)	
1993				76(3)				
				185			86(18)	
1994			1	9				
1995			1	16				
1996				47				
1997			127	106				
1998		495	42	435				
1999			4(0)	4(25)			71(4)	
2000	4(0)	26(8)	204(20)	124(36)	92(32)		85(7)	
2001	9(11)			83(5)	17(6)		318(38)	
2002	48(29)							
2006				87(24)			677(24)	
							910(23)	211(12)

Table 3. Night-roost counts of California Brown Pelicans at Vizcaino Point and Cormorant Rock Area, San Nicolas Island, California, in 1992 and 2006. ND = No Data.

Date	Survey Period	Vizcaino Point	Cormorant Rock Area
23-Jul-92	Dusk	0	ND
24-Jul-92	Dawn	ND	756
5-Aug-92	Dusk	ND	1,020
6-Aug-92	Dawn	ND	679
14-Aug-92	Dusk	ND	2,494
15-Aug-92	Dawn	ND	2,081
23-Aug-92	Dawn	ND	1,265
26-Sep-06	Dawn	ND	>44
26-Sep-06	Dusk	>400	>27
27-Sep-06	Dawn	>620	ND

Numbers were usually lowest from January through June. Counts in January 1974, the year after the prolonged 1972-1973 influx, were <50 birds, similar to January counts from aerial surveys in 2000-2002 (Table 2).

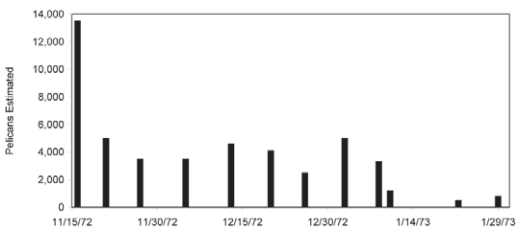

Figure 3. Estimated numbers of California Brown Pelicans night-roosting at Cormorant Rock Area, San Nicolas Island, 16 November 1972 to 29 January 1973, during strong El Niño conditions.

After January, counts were mostly <150 birds in aerial surveys in April-July 1992-2006 (Table 2), <250 birds in aerial surveys in March-July 1975-1978, and 200-300 birds at night roosts in February-mid July 1973. However, higher counts near 500 birds occurred in January 1977-1978, and April-June 1992 and 1998 (Table 2).

Among months with two aerial surveys (N = 3; Table 2), higher counts were 34% to 351% greater than lower counts. Among aerial surveys with age ratios, immatures were present in highest proportion (38%) in September 2001 (mean 15% ± 12% SD, N = 22; Table 2).

Diurnal Roost Locations

Of all pelicans counted from aerial surveys in 1992-2006, 85% (N = 6,233) roosted at several sites along the north shore from Vizcaino Point to Sandspit on low coastal bluffs, points and beaches (Fig. 2). One man-made structure, Coast Guard Jetty, was occasionally used by small numbers. Sandspit (75% of surveys) and Vizcaino Point (67% of surveys; N = 36) were used most frequently. The largest individual roost (626 birds) was on 27 September 2006 at Cissy Cove-Keyhole (not including Keyhole). Other north shore roost sites with high counts ≥ 100 pelicans were: Vizcaino Point (337 birds); Sandspit (209 birds); and Keyhole (120 birds).

Ground surveys in 1992-1994 also indicated high roost use on the north shore. High counts ≥ 100 pelicans were recorded at: Redeye Beach (400 birds); Cissy Cove-Keyhole (250 birds); Sandspit (236 birds); Vizcaino Point (208 birds); Coast Guard Beach (206 birds); Tranquility Beach (150 birds); Coast Guard Jetty (125 birds); Anchor Point (124 birds); and NAVFAC Point (100 birds). On the south shore, a high count of 331 pelicans occurred at Cormorant Rock Area on 26 September 1992. Highest counts at other south shore sites were: Dead Cormorant (or SE Pellet) Point (38 birds); Daytona Beach (69 birds); and South Range Markers (28 birds). The region between South Range Markers and Cormorant Rock Area was least used, with <20 pelicans detected on few surveys.

Nocturnal Roost Patterns

Vizcaino Point (2006). In 2006, the major night roost was at Vizcaino Point (Table 3). On 26 September, pelicans began arriving steadily at Vizcaino Point by 18.10 h, about 40 min before sunset, counts increasing from 77 pelicans at 18.00 h to >400 at 19.00 h. Arrivals more than 20 min after sunset could not be counted accurately. The next morning, first departures were noted approximately 20 min before sunrise, and nearly 400 pelicans had departed by 20 min after sunrise.

Cormorant Rock Area (2006, 1992, 1972-1975). In 2006, only small numbers night-roosted at Cormorant Rock Area (Table 3). On 26 September, 44 pelicans had departed by one hour after sunrise. At dusk, 27 pelicans had arrived by 15 min after sunset, with the first arrival noted 40 min before sunset. In 1992, Cormorant Rock Area was identified as the major night roost by direction of travel of pelicans departing Vizcaino Point near dusk on 23 July. On 5 August at dusk, 63% of pelicans arrived after sunset. The 6 August dawn estimate was 33% lower, suggesting many birds remained out of view or had departed before first light. Night-roosting numbers approximately doubled by 14 August followed by a return to lower numbers by 23 August. In 1972-1975, Cormorant Rock Area was the only identified night-roost (Fig. 3).

DISCUSSION

In 1972-2006, SNI was used year-round mostly by adult pelicans for both diurnal and nocturnal roosting. Island totals were typically in the hundreds, lowest during the breeding season (January-June) and highest in fall, but the peak estimate in 1972 indicated that many thousands of pelicans can occur at SNI during migration or periods of increased prey availability near the island. Counts also were variable, however, likely due to daily or even hourly potential changes in roosting numbers and only single monthly aerial surveys in most years. Most diurnal roost use occurred on the north shore, and the single major night roost shifted 4 km from Cormorant Rock Area in 1972-1975 and 1992 to Vizcaino Point in 2006.

During the breeding season, pelicans roosting at SNI likely included some birds on foraging trips from nearby primary breeding colonies in the SCB. Nearest primary breeding colonies were: 1) Santa Barbara Island (~50 km from SNI; hundreds to low thousands of pairs after 1985, nesting having resumed in 1980 after an absence of about 30 years); 2) Anacapa Island (~80 km from SNI; thousands of pairs since 1979, and hundreds prior); and 3) Coronado Islands (>200 km from SNI; several hundred to rarely low thousands of pairs) (Gress 1995; Anderson *et al.* 2007; F. Gress, unpubl. data). Information on foraging trip distances of individual pelicans in the SCB is lacking, but the ecologically similar Peruvian Pelican (*Pelecanus thagus*) has been shown to range at least 80 km from a breeding colony (Zavalaga *et al.* 2011). However, because the proportion of breeding-age pelicans that breeds each year can vary greatly (Anderson and Gress 1983), non-breeding adults from nearby colonies also may have stayed at SNI for extended periods.

Increased numbers in fall likely reflected post-breeding dispersal of pelicans primarily from SCB colonies in most years. Along the mainland coast of California, increases in numbers of pelicans typically occur in late summer and early fall as GOC birds disperse northward, followed by similar influxes in

early winter during the return movement to GOC colonies (Anderson and Anderson 1976; Briggs *et al.* 1981, 1983; Jaques 1994; Jaques *et al.* 1996; Capitolo *et al.* 2003). Use of SNI by several thousand pelicans over an extended period in 1972-1973 apparently reflected offshore movements of GOC birds, based on sightings of marked individuals and counts that far surpassed the hundreds of pelicans then breeding at all SCB colonies combined. Much lower typical fall counts at SNI suggested that GOC birds migrated closer to the southern California mainland in most years. Source colonies of pelicans can be determined by sightings of banded individuals, but pelicans have not been banded at northern SCB colonies since 1996; some banding continues at GOC colonies (F. Gress, pers. comm.).

Offshore movements of GOC birds in 1972-1973 and other atypical high counts at SNI were likely related to effects of El Niño events on local and regional prey availability in the SCB and timing, extent and success of breeding at SCB and GOC colonies (Anderson and Anderson 1976; Ainley *et al.* 1988). Strong El Niño conditions were in effect during the prolonged attendance by thousands of pelicans in November 1972 to January 1973 and may have led to poor prey availability in most wintering areas on the mainland coast. In 1973, pelicans mostly failed to breed at GOC colonies (Anderson *et al.* 1982). Higher counts at SNI in January 1977 and 1978 may have reflected poor prey conditions that led to reduced or later onset of breeding during moderate El Niño conditions. In 1977, Gress and Anderson (1983) estimated that only 19% of breeding-age pelicans in the northern SCB attempted to breed. Higher counts in April-July 1992 and 1998 may have reflected early dispersal from northern SCB colonies after nest abandonments during strong El Niño conditions (Gress 1995; Jaques *et al.* 1996).

Predominant use of diurnal roost sites along the north shore apparently reflected selection of suitable roosting habitat closest to foraging areas (Briggs *et al.* 1981; Gress and Anderson 1983). Pelican distribution at sea often is associated with warm, shallow water (Briggs *et al.* 1981) and pelicans typically forage in waters less than 150 m deep (Briggs *et al.* 1983), habitat that is extensive off the northwest to northeast sides of SNI.

Anthropogenic and natural disturbances, which can lead to roost site abandonment, increased energy expenditure from flushing (i.e. departing from or relocating within a roost by flight), and use of less favorable roost sites (Gress and Anderson 1983; Jaques and Strong 2002), apparently did not have long-term impacts on diurnal roost patterns. Most ground access by people to coastal areas occurs on the north shore, but disturbance levels were likely reduced in the early 1990s when USN restricted locations and timing of recreational activities in coastal habitats. Potential impacts to pelicans from weapons system testing activities near the west end of the island have not been assessed, but Harbor Seals (*Phoca vitulina*) and California Sea Lions (*Zalophus californianus*) are frequently disturbed during missile launches (Holst *et al.* 2005). Island Foxes (*Urocyon littoralis dickeyi*), introduced at least approximately 5,000 years ago (Vellanoweth 1998; Rick *et al.* 2009), and feral cats (*Felis catus*), introduced by 1952 (Hanson *et al.* 2010), pose little or no predation threat to roosting pelicans (see Anderson *et al.* 1989), but may flush pelicans on occasion. Predation on Brandt's Cormorant and Western Gull (*Larus occidentalis*) eggs by Island Foxes and possibly feral cats was well documented at SNI in 1991-1996 (McChesney 1997; H. Carter, unpubl. data). Feral cats were removed from SNI in 2009 to benefit breeding seabirds and other island natural resources (Hanson *et al.* 2010).

In contrast to diurnal roost patterns, long-term night roost patterns were impacted by anthropogenic disturbance. The shift of the major night roost suggested Vizcaino Point had become a higher quality night roost than Cormorant Rock Area after USN removed buildings, closed roads to all motorized and pedestrian traffic, and limited research activities at Vizcaino Point in 1992-1996. Establishment of roads at Vizcaino Point in the late 1960s to support missile testing operations may have caused an earlier shift of the major night roost from Vizcaino Point

to Cormorant Rock Area before 1972. Vizcaino Point is closer than Cormorant Rock Area to main foraging areas off the north shore and its aspect likely allows greater visual detection of formation of seabird feeding flocks. Island Fox distribution, distance from missile launch sites, and other factors may also contribute to night roost quality. Buffer from mammalian predators and human disturbance is especially important at night, when pelicans typically are inactive and have reduced ability to detect potential predators (Jaques and Strong 2003). Further reflecting increased protection of Vizcaino Point, breeding Brandt's Cormorants and California Sea Lions have become more widely distributed there since 1992-1996.

Nesting by pelicans at SNI has never been confirmed, but may occur in the future, given long-term roost use, recent removal of feral cats, and increased protection of roosting habitat. Nesting reported in 1945 (Rett 1947) and 1968 (Hunt *et al.* 1979) likely reflected observations of pelicans roosting on abandoned Brandt's Cormorant nests (D. W. Anderson, pers. comm.). Small pelican colonies (low 100s of pairs) have occasionally formed at other nearby islands adjacent to long-term roost sites, including at Scorpion Rock (off Santa Cruz Island; 1972-1975), Prince Island (off San Miguel Island; 2006), and San Clemente Island (2011) (Gress and Anderson 1983; Anderson *et al.* 2007; D. Garcelon, F. Gress, P. Capitolo and M. Lowry, unpubl. data). However, Island Foxes do not occur at most islands where pelicans have nested (only at San Clemente Island) and may prevent pelicans from nesting at SNI.

Management Implications

Increased protection of pelican roosting habitat at SNI has been provided by USN since the early 1990s. Long-term use of diurnal roosts on the north shore over time can be expected with enforcement of current safeguards, but long-term regulations should be developed. Vizcaino Point and Cormorant Rock Area are especially important diurnal- and nocturnal-roosting habitat (and possible breeding habitat), and should be designated as "key long-term roosts" that merit added protection from human disturbance. For long-term management purposes at SNI, diurnal roost sites can be effectively monitored with periodic aerial surveys, but nocturnal roost site monitoring requires specialized ground-based surveys. Night roost habitat preference shown by pelicans after release from human disturbance provides insight for needed efforts to protect night roost sites in other areas (Jaques and Strong 2003; Wright *et al.* 2007). Successful, long-term management of diurnal and nocturnal roosting habitat at SNI can help guide protection of key roost sites throughout the breeding and non-breeding ranges, especially needed given federal delisting and loss of protections for roosting areas (e.g. USFWS 2009b).

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Most aerial surveys in 1997-2006 were conducted with pilots from CDFG (Air Services, Sacramento and

Hemet), including W. Burnett, T. Evans L. Heitz, R. Morgan, R. van Benthuysen and J. Veal. Aerial surveys in 1992-1996 and certain surveys in 1997-2006 were conducted with pilots from Aspen Helicopters (Oxnard, California), including B. Hansen and J. Drust.

Ground survey data in 1972-1975 were collected by R. E. Lust. Unpublished data and discussions were provided by D. W. Anderson, R. Dow, F. Gress, S. Schwartz and W. Townsend. An anonymous reviewer provided comments on the manuscript.

LITERATURE CITED

Ainley, D. G., H. R. Carter, D. W. Anderson, K. T. Briggs, M. C. Coulter, F. Cruz, J. B. Cruz, C. A. Valle, S. I. Fefer, S. A. Hatch, E. A. Schreiber, R. W. Schreiber and N. G. Smith. 1988. Effects of the 1982-83 El Niño-Southern Oscillation on Pacific Ocean bird populations. Proceedings of the International Ornithological Congress 19: 1747-1758.

Anderson, D. W. and I. T. Anderson. 1976. Distribution and status of Brown Pelicans in the California Current. American Birds 30: 3-12.

Anderson, D. W. and F. Gress. 1983. Status of a northern population of California Brown Pelicans. Condor 85: 79-88.

Anderson, D. W., F. Gress and K. F. Mais. 1982. Brown Pelicans: Influence of food supply on reproduction. Oikos 39: 23-31.

Anderson, D. W., J. O. Keith, G. R. Trapp, F. Gress and L. A. Moreno. 1989. Introduced small ground predators in California Brown Pelican colonies. Colonial Waterbirds 12: 98-103.

Anderson, D. W., C. J. Henny, C. Godinez-Reyes, F. Gress, E. L. Palacios, K. Santos del Prado and J. Bredy. 2007. Size of the California Brown Pelican metapopulation during a non-El Niño year. Open-File Report 2007-1299, U.S. Geological Survey, Reston, Virginia.

Briggs, K. T., D. B. Lewis, W. B. Tyler and G. L. Hunt, Jr. 1981. Brown Pelicans in southern California: Habitat use and environmental fluctuations. Condor 83: 1-15.

Briggs, K. T., W. B. Tyler, D. B. Lewis, P. R. Kelly and D. A. Croll. 1983. Brown Pelicans in central and northern California. Journal of Field Ornithology 54: 353-373.

Burkett, E. E., R. J. Logsdon and K. M. Fien. 2007. Report to the California Fish and Game Commission: Status review of California Brown Pelican (*Pelecanus occidentalis californicus*) in California. California Deptartment of Fish and Game, Wildlife Branch, Nongame Wildlife Program Report 2007-04.

Capitolo, P. J., R. J. Young, H. R. Carter, W. R. McIver and T. W. Keeney. 2003. Roosting patterns of Brown Pelicans at Mugu Lagoon, California, and other nearby roosts in 2002. Unpublished Report, Humboldt State University, Department of Wildlife, Arcata, California and Naval Base Ventura County, Natural Resources Point Mugu, California. http://www.darrp.noaa.gov/southwest/amtrader/pdf/Appendices_C-E.pdf, Appendix D, accessed March 2012.

Croll, D. A., L. T. Ballance, B. G. Wursig and W. B. Tyler. 1986. Movements and daily activity patterns of a Brown Pelican in central California. Condor 88: 258-260.

Gress, F. 1995. Organochlorines, eggshell thinning, and productivity relationships in Brown Pelicans breeding in the Southern California Bight. Unpublished Ph.D. Dissertation, University of California Davis, California.

Gress, F. and D. W. Anderson. 1983. A recovery plan for the California Brown Pelican. U.S. Fish and Wildlife Service, Portland, Oregon. http://ecos.fws.gov/docs/recovery_plan/830203b.pdf, accessed March 2012.

Hanson, C. C., K. J. Campbell, J. E. Bonham, B. S. Keitt, A. E. Little and G. Smith. 2010. The removal of feral cats from San Nicolas Island: Methodology. Pages 72-78 *in* Proceedings of the 24th Vertebrate Pest Conference (R. M. Timm and K. A. Fagerstone, Eds.). University of California, Davis, California.

Holst, M., J. W. Lawson, W. J. Richardson, S. J. Schwartz and G. Smith. 2005. Pinniped responses during Navy missile launches at San Nicolas Island, California. Pages 477-484 *in* Proceedings of the 6th California Islands Symposium (D. K. Garcelon and C. A. Schwemm, Eds.). National Park Service Technical Publication CHIS-05-01, Institute for Wildlife Studies, Arcata, California.

Hunt, G. L., Jr., R. L. Pitman, M. Naughton, K. Winnett, A. Newman, P. R. Kelly and K. T. Briggs. 1979. Distribution, status, reproductive ecology, and foraging habitats of breeding seabirds. *In* Summary of marine mammal and seabird surveys of the Southern California Bight area, 1975-1978. U.S. Department of Interior, Bureau of Land Management, Los Angeles. Available from: NTIS, Alexandria, Virginia; Product Code PB81248205.

Jaques, D. L. 1994. Range expansion and roosting ecology of non-breeding California Brown Pelicans. Unpublished M.S. thesis, University of California, Davis, California.

Jaques, D. L. and D. W. Anderson. 1988. Brown Pelican use of the Moss Landing Wildlife Management Area: Roosting behavior, habitat use, and interactions with humans. Unpublished Report, California Department of Fish and Game, Sacramento, California. nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=47828, accessed March 2012.

Jaques, D. L. and C. S. Strong. 2002. Disturbance to Brown Pelicans at communal roosts in southern and central California. Unpublished Report, Crescent Coastal Research, Astoria, Oregon. http://www.darrp.noaa.gov/southwest/amtrader/pdf/at_brpe_report_2002.pdf, accessed March 2012.

Jaques, D. L. and C. S. Strong. 2003. Brown Pelican night roost sites on the southern California coast. Unpublished Report, Crescent Coastal Research, Astoria, Oregon. http://www.darrp.noaa.gov/southwest/amtrader/pdf/at_brpe_report_2003b.pdf, accessed March 2012.

Jaques, D. L., C. S. Strong and T. W. Keeney. 1996. Brown Pelican roosting patterns and responses to

disturbance at Mugu Lagoon and other nonbreeding sites in the Southern California Bight. National Biological Service, Technical Report No. 54, Tucson, Arizona.

Martz, P. C. 2005. Prehistoric settlement and subsistence on San Nicolas Island. Pages 65-82 *in* Proceedings of the 6th California Islands Symposium (D. K. Garcelon and C. A. Scwemm, Eds.). National Park Service Technical Publication CHIS-05-01, Institute for Wildlife Studies, Arcata, California.

McChesney, G. J. 1997. Breeding biology of the Brandt's Cormorant on San Nicolas Island, California. Unpublished M.Sc. Thesis, California State University, Sacramento, California.

Rett, E. Z. 1947. A report on the birds of San Nicolas Island. Condor 49: 165-168.

Richardson, T. W., P. Pyle, R. Burnett and P. Capitolo. 2003. The occurrence and seasonal distribution of migratory birds on Southeast Farallon Island, 1968-1999. Western Birds 34: 58-96.

Rick, T. C., C. R. Torben, J. M. Erlandson, R. L. Vellanoweth, T. J. Braje, P. W. Collins, D. A. Guthrie and T. W. Stafford, Jr. 2009. Origins and antiquity of the Island Fox (*Urocyon littoralis*) on California's Channel Islands. Quaternary Research 71: 93-98.

Rijke, A. M. 1970. Wettability and phylogenetic development of feather structure in water birds. Journal of Experimental Biology 52: 469-479.

Schreiber, R. W. and E. A. Schreiber. 1982. Essential habitat of the Brown Pelican in Florida. Florida Field Naturalist 10: 9-17.

Schreiber, R. W., E. A. Schreiber, D. W. Anderson and D. W. Bradley. 1989. Plumages and molts of Brown Pelicans. Los Angeles County Natural History Museum, Contributions in Science, Number 402.

U.S. Fish and Wildlife Service. 2009a. Endangered and threatened wildlife and plants; Removal of the Brown Pelican (*Pelecanus occidentalis*) from the Federal List of Endangered and Threatened Wildlife. Federal Register 74 (220) 59444-59472.

U.S. Fish and Wildlife Service. 2009b. Draft post-delisting monitoring plan for the Brown Pelican. U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. http://ecos.fws.gov/docs/species/doc2621.pdf, accessed March 2012.

Vellanoweth, R. L. 1998. Earliest Island Fox remains on the southern Channel Islands: Evidence from San Nicolas Island, California. Journal of California and Great Basin Anthropology 20: 100-108.

Wright, S. K., D. D. Roby and R. G. Anthony. 2007. Responses of California Brown Pelicans to disturbances at a large Oregon roost. Waterbirds 30: 479-487.

Zavalaga, C. B., G. Dell'Omo, P. Becciu and K. Yoda. 2011. Patterns of GPS tracks suggest nocturnal foraging by incubating Peruvian Pelicans (*Pelecanus thagus*). PLoS ONE 6(5): e19966.