PEREGRINE FALCON MONITORING ON THE CALIFORNIA CHANNEL ISLANDS, CALIFORNIA, 2018

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INTRODUCTION

American peregrine falcons (*Falco peregrinus anatum*; hereafter peregrines) historically were common residents on all the California Channel Islands (Willett 1912, Howell 1917, Kiff 1980), although the highest number of reported nests in a single year was 15 (Kiff 1980, 2000). Because peregrines and their nests are less conspicuous to casual observers than are other raptors historically found on the Channel Islands, such as bald eagles (*Haliaeetus leucocephalus*) and osprey (*Pandion haliaetus*), historical estimates of the number of peregrines on the islands were almost certainly too low (Kiff 1980) and could have been 30 or more pairs (Hunt 1994).

Peregrine numbers plummeted across much of the northern hemisphere starting in the late 1940s (Hickey and Anderson 1969). Peregrines were at their lowest numbers in the 1960s and early 1970s, at which time they were extirpated from the eastern United States and across the Midwest and reduced to a few hundred pairs in the western United States and Mexico (U.S. Fish and Wildlife Service 2003). Approximately 100 peregrine eyries in California were producing young each year until at least the mid-1940s, with more than a third of the verified or suspected peregrine nest sites occurring within 10 miles of the ocean, including the Channel Islands (Herman et al. 1970). By 1970, the number of breeding peregrines had dropped by at least 95% in California (Herman et al. 1970, Herman 1971). It appears that nests along the southern coast suffered the earliest reductions and the peregrine population on the Channel Islands was drastically reduced or extirpated by 1955 (Herman et al. 1970), with the last reported sighting of a probable Channel Islands breeding adult occurring on Anacapa Island in 1949 (Kiff 1980).

Overwhelming evidence indicated that declines in peregrines and other bird species feeding higher on the food chain were a result of the effects of DDE, a metabolite of DDT, on egg hatchability (Kiff 1980, Mesta 1999, Kiff 2000). The apparent source of the DDT pollution in the Southern California Bight was eventually traced to the Montrose Chemical Corporation's manufacturing plant in Torrance, California. Between 1947 and 1961, an estimated 37 to 53 million liters of DDT-contaminated acid sludge, containing 348-696 metric tons of DDT, was disposed at an ocean dump site 16 km northwest of Catalina Island (Chartrand et al. 1985). In addition, an estimated 1800 metric tons of DDT was discharged from the Joint Water Pollution Control Plant outfall, 3.3 km offshore of Palos Verdes Peninsula (Chartrand et al. 1985).

Peregrines were listed as endangered in 1970 under the Endangered Species Conservation Act of 1969, and later under the Endangered Species Act of 1973 (Mesta 1999). Populations

rebounded following restrictions on the use of organochlorine pesticides in Canada and the United States (banned in 1970 and 1972, respectively) and successful management activities, including the reintroduction of captive-bred and relocated peregrines (Mesta 1999). Between 1983 and 1998, the Santa Cruz Predatory Bird Research Group (SCPBRG) released 37 peregrines on the Channel Islands (12 on San Miguel, 17 on Catalina, 4 on Santa Rosa, and 4 on Santa Cruz; Latta 2012). The first pairs with young were seen on Anacapa and Santa Cruz islands in 1989 and 1990, respectively (Hunt 1994). During a 1992 survey, Hunt (1994) located 9 active eyries on 4 of the Channel Islands. Peregrines were removed from the Endangered Species list in 1999, at which time breeding targets for the Channel Islands (5 pairs) and the Pacific Coast (185 pairs) had been greatly exceeded (Mesta 1999). Ten years later, peregrines were removed from the State of California's list of Endangered and Threatened Animals (California Department of Fish and Game 2011).

After a successful lawsuit against Montrose Chemical et al. for damage caused by the release of DDTs and PCBs into the Southern California Bight, the Montrose Settlements Restoration Program (MSRP) was created to implement restoration projects aimed at restoring natural resources that were directly or indirectly harmed by DDT and PCB contamination. The final consent decree for the Montrose case stated that "the Trustees will use the damages for restoration of injured natural resources, including bald eagles, peregrines and other marine birds, fish and the habitats upon which they depend" (Montrose Settlements Restoration Program 2012). The Montrose Settlements Trustee Council (MSTC) was created to oversee the settlement monies and is composed of representatives of Federal and State agencies that have interests in the Southern California Bight: National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service (FWS), National Park Service (NPS), California Department of Fish and Wildlife (CDFW), California State Lands Commission, and the California Department of Parks and Recreation.

Since the conclusion of peregrine survey efforts in the early 1990s, there were limited surveys conducted on the Channel Islands and the distribution and extent of breeding pairs was not known. Under Phase 1 of MSRP's Restoration Plan, the MSTC contracted with the SCPBRG to conduct a peregrine falcon survey and monitoring project in 2007. The goal of that monitoring effort was to assess the current status of peregrines on the Channel Islands and determine whether their recovery was still being affected by on-going contamination in the local food web

(Montrose Settlements Restoration Program 2005). The 2007 survey located 27 occupied territories on 5 of the 8 islands, but also found that DDE contamination still appeared to be reducing peregrine falcon reproductive success (Latta 2012).

Under Phase 2 of the MSRP Restoration Plan, peregrine surveys were to be conducted at 5-year intervals (Montrose Settlements Restoration Program 2012), although the survey scheduled for 2012 was delayed until 2013. After the Institute for Wildlife Studies (IWS) conducted surveys on all 8 Channel Islands in 2013, the MSTC agreed to our proposal to institute annual surveys through 2017 to gain more information on population demography and important population parameters, such as survival, immigration and emigration. As part of that effort, IWS located 45 occupied territories in 2013, 48 in 2014, 48 in 2015, 46 in 2016, and 51 in 2017, with at least 2 territories on each island (Sharpe 2014, 2015, 2016, 2017, 2018). During 2018, we conducted surveys and monitoring on a subsample of the islands due to funding and personnel cuts. This report summarizes the results of the 2018 field season.

STUDY AREA

The California Channel Islands are composed of eight islands located off the coast of southern California (Fig. 1). All of the Channel Islands are subject to a Mediterranean climate regime characterized by cool, wet winters and warm, dry summers (Coonan and Schwemm 2009). The northern Channel Islands, which are composed of San Miguel Island, Santa Rosa Island, Santa Cruz Island, and Anacapa Island are located approximately 20 to 44 km off the coast of Ventura and Santa Barbara counties (Junak et al. 1995) and are a tightly clustered group with no more than 9.6 km separating adjacent islands (Moody 2000; Fig. 1). The southern Channel Islands, which are composed of San Nicolas Island, Santa Barbara Island, Santa Catalina Island, and San Clemente Island, are located 32-79 km from the mainland (Junak et al. 1995) and are more remote and scattered than the northern islands, with the closest islands (Santa Catalina and San Clemente Islands) separated by 34 km (Moody 2000; Fig. 1). We did not survey San Miguel or San Nicolas islands in 2018.

Santa Rosa Island (hereafter Santa Rosa) is the second largest of the Channel Islands and is owned by the NPS (Fig. 1). The island is approximately 24 x 16 km and encompasses about 217 km^2 with a central mountain range reaching an elevation of approximately 475 m (Junak et al. 1995, Rick 2009). The central highland is dissected by drainages; a relatively gentle marine

terrace occurs north of the highland, whereas steep, deeply incised drainages comprise much of the south portion of the island (Coonan and Schwemm 2009).

Santa Cruz Island (hereafter Santa Cruz) is the largest of the 8 Channel Islands and is owned by the NPS (eastern 24% of the island) and The Nature Conservancy (TNC; western 76% of the island). The island measures about 38 km long by 12 km wide at its widest point (Fig. 1), encompassing approximately 249 km^2 with a maximum elevation of 753 m (Junak et al. 1995).

Anacapa Island (hereafter Anacapa), which is composed of 3 islets (East, Middle, and West Anacapa; Fig. 1) is owned by the NPS. The island encompasses approximately 2.8 km^2,

Figure 1. California Channel Islands located off the coast of southern California, USA.

spanning about 8 km from end to end and reaching a maximum elevation of 283 m (Junak et al. 1995).

Santa Barbara Island (hereafter Santa Barbara), owned by the NPS, is located 62 km from the nearest point on the mainland and 38 km east of its nearest neighboring island, Santa Catalina Island (Fig. 1). With an area of only 2.6 km^2 it is the smallest of the Channel Islands. It has a series of low terraces, with small peaks at the north and south ends of the island (high point at 193 m) and is bound by sheer cliffs on much of the north, west, and part of the south sides of the island (Drost and Junak 2009).

Santa Catalina Island (hereafter Catalina), located 34 km south of Long Beach, California, is owned primarily by the Santa Catalina Island Conservancy (~90%). The island is 34 km long, 0.8 to 13.0 km wide, and has an area of 194 km^2, 80 km of coastline, and maximum elevation of 648 m (Junak et al. 1995; Fig. 1).

San Clemente Island (hereafter San Clemente), owned by the U.S. Navy, is the southernmost of the Channel Islands, located approximately 92 km off the coast of California (Fig. 1). The island is 143 km^2, about 34 km long, and has a high point of 610 m (Willey 1997). It is characterized by a series of marine terraces on the west side and a steep escarpment on the east side (Kaiser et al. 2009).

METHODS

Permitting

Our peregrine research activities were covered by multiple state and federal permits. IWS has a Memorandum of Understanding and Scientific Collecting Permits (Permit #s SC-2485 [Peter Sharpe] and SC-0932 [David Garcelon]) with the CDFW to conduct peregrine research on the Channel Islands, a banding permit (# 21564) from the United States Geological Survey's Bird Banding Laboratory (BBL) allowing us to band peregrines with both federal and auxiliary leg bands and draw blood, and a research permit from the Santa Catalina Island Conservancy (Permit 12-014). Our Migratory Bird Treaty Act permit (#MB95076A-0) allowed us to collect feathers, failed eggs, and eggshells at nests.

Survey Method

We used a survey method similar to that used by the National Park Units in the Northern Colorado Plateau Network (NCPN), as described by Daw et al. (2006). The protocol involved monitoring potential nesting areas for up to 4 hours, normally the maximum time between eyrie visits/exchanges at the ledge (Daw et al. 2006), with a minimum of 3 visits to each known territory between February and June. The NCPN protocol allows for the use of recorded vocalizations to elicit vocal or behavioral responses from territorial birds, which has been found to increase the likelihood of detection and decrease the amount of time required to detect many bird species (Johnson et al. 1981, Anderson 2007, Barnes et al. 2012). Although call-broadcast

surveys have typically been used for forest-dwelling raptors (Kimmel and Yahner 1990, Watson et al. 1999), they have also been used for non-forest raptors (Balding and Dibble 1984).

The call-broadcast technique we incorporated into our survey protocol was developed by Barnes et al. (2012) to survey for peregrines in the Lake Mead National Recreation Area. The 10-minute survey protocol begins with a 3-min passive observation period, followed by a 30-sec broadcast period, a 1-min observation period, a second 30-sec broadcast period, and a final 5-min passive observation period. We loaded recorded peregrine vocalizations (Stokes Field Guide to Bird Songs: Western Region; Time Warner Trade Publishing, New York, NY), which were converted to mp3 format to be compatible with a digital game caller (FOXPRO NX4, FOXPRO Inc., Lewiston, PA). The vocalizations consisted of 5 sec of the 'cack' alarm call, immediately followed by 10 sec of the 'eechup' call from an adult female peregrine (described in Linthicum 1996), which were looped to produce 30 sec of continuous calling. During the call-broadcast a surveyor rotated up to 360° (depending on terrain, habitat, and broadcast location) in order to evenly project the sound around the broadcast point and the broadcast was discontinued immediately when a responding peregrine was detected.

We used the 4-hr passive observation and/or the 10-min call-broadcast protocol, depending on where and when we were conducting the survey, as described below. We did not conduct surveys or monitoring during periods of heavy rain, heavy fog, or severe cold. The general protocol called for not conducting surveys or monitoring during periods of sustained high winds greater than 25 km/h (~15 miles/hour). However, the Channel Islands can have long periods of high winds, which would have made it impossible to conduct any surveys for a week or more. Therefore, when there were high winds we attempted to conduct most surveys/monitoring on leeward sides of the islands. If it was necessary to survey during high winds, we did not include the survey in the minimum of 3 surveys required to determine that a territory was unoccupied.

Surveying Historic Nesting Areas

IWS biologists began surveying territories for activity in February 2018. All territory locations on the Channel Islands that had been confirmed during our 2013-2017 surveys (Sharpe 2014, 2015, 2016, 2017, 2018) were uploaded into Garmin eTrex 20 GPS units (Garmin International Inc., Olathe, KS) to assist in locating the known territories on each island. We

added satellite imagery (BirdsEye Satellite Imagery™, available through Garmin Basecamp™) onto each GPS unit for ease of orienting in relation to geographic features.

Initial surveys at each historic territory generally included a 10-min call-broadcast survey, followed by up to 4 hours of passive observations if no peregrines were detected. If any peregrines were detected, we would return at approximately 1-month intervals for further monitoring (see Monitoring Active Territories below). If no pair was detected, we usually returned at least 2 more times at approximately 1-month intervals to verify that the territory was inactive.

Surveying for New/Unknown Territories

We used the 10-min call-broadcast method to conduct ground-based and boat surveys for new or unknown peregrine territories on the islands. Although peregrine habitat typically contains tall cliffs (50+ m) to serve as perching and nesting sites (Johnsgard 1990), we did not assume that those were the only places that peregrines would nest on the islands. In other studies, peregrines have been found nesting on the ground (Hickey and Anderson 1969, Pagel et al. 2010) and in tree nests of other raptors and in tree cavities (Campbell et al. 1977). Because peregrine nests have historically been found far inland in canyons on Santa Rosa (Pemberton 1928), we surveyed for peregrines both along the coastal bluffs and cliffs and in interior portions of the islands. Call-broadcast locations during a single day were generally ~1 km apart, although they could be more closely spaced if required for adequate coverage in areas of high topographic relief that may have minimized the distance at which the broadcast could be heard by peregrines (e.g., opposite sides of a steep ridge, along a coastline with many harbors or prominent points) or where ocean noise impacted our ability to hear responding peregrines. We used GPS units to record our daily survey routes, call-broadcast locations, and sightings of peregrines. We revisited areas with potential peregrine habitat at approximately monthly intervals to determine whether birds had gone undetected or had occupied an area after a previous survey.

Monitoring Active Territories

We attempted to visit occupied territories at monthly intervals to estimate the chronology of the breeding season. We refined estimates of lay and hatch dates by aging the chicks using photos and descriptions in Clum et al. (1996) and Moritsch (1983) with an assumed incubation

period of 33 days (Linthicum 1996). We only used the 10-min call-broadcast about 1 time per month at active territories, if needed, to minimize the chance that the birds would become acclimatized to the recorded vocalizations. We observed peregrines and potential or known nest sites from a distance of 150-1500 m using 20-60x spotting scopes and binoculars. Distances to peregrines or nest sites were estimated using a distance measuring function on our GPS units.

On each visit to an active territory we recorded data on weather conditions, time, observer location, peregrines observed, and behavior of any adult and chicks. To standardize behavioral observations made during these visits, we used the definitions and descriptions in Linthicum (1996). For most territories with chicks, we made our last visits when chicks were ≥28 days of age to determine success (see Terminology below).

Nest Entry and Banding

We entered active nests either when the chicks were approximately 21-28 days of age. The recommended age range for banding is 21-35 days (Heinrich 1996), but we lowered the upper age limit to minimize the likelihood of chicks jumping from the eyrie. We evaluated each eyrie prior to entry to determine the safest anchoring technique(s) and route of entry. In some cases, we did not band the chicks when a nest entry was not safe for the birds and/or the biologists. For eyries that were only visible from a distant location, a biologist remained at the observation point and used a handheld radio to help direct the climbing team to the eyrie. Chicks were placed in a small duffle bag and carried to the top of the nest cliff for processing in most cases, although a few eyries were large enough for 2 climbers to enter and band chicks without removing them.

Peregrines exhibit reverse size dimorphism and we were able to determine the sex of each chick primarily based on weight, overall size, and the breadth of the tarsi (Burnham et al. 2003, J. Barnes, personal communication). We attempted to band chicks when they were at least 21 days old, at which time they had developed sufficiently so that differences in the size of the tarsus was evident (Craig and Enderson 2004). Males were fit with a USFWS lock-on #6 band on the left leg and a black anodized aluminum band with silver alphanumerical characters (Acraft Sign & Nameplate Co., Edmonton, Alberta, Canada) on the right leg, and females were banded with a USFWS lock-on #7A band on the right leg and an Acraft band on the left leg. If there was any question as to the sex of the birds, then we used the female bands (Heinrich 1996,

Gustafson et al. 1997). We collected approximately 0.5 cc of heparinized whole blood from most chicks for future DNA and/or contaminants analyses.

During nest entries, we collected eggshell fragments and addled eggs prey remains. Samples were labeled and delivered to the Western Foundation of Vertebrate Zoology (WFVZ; Camarillo, CA) for determination of shell thickness. We enhanced nest ledges, if necessary, by removing sharp stones or adding suitable substrate to reduce the chance of eggs breaking in the nest in the future.

Eggshell Measurements

René Corado (WFVZ) measured the thickness of eggshells using 2 methods. Method 1, referred to as the René Corado "RC" method, used a measuring device consisting of a thin gauge wire mounted to a digital gauge (Starrett Gauge; 0.00005 mm resolution) fixed to a mounting bracket with a moveable bottom plate. For whole eggs, 10 shell measurements were taken around the equator of each egg (not at the poles because more calcium is deposited at the ends), where there is no visible debris, both with and without the membrane, as applicable. If a membrane was no longer attached to the shell at the equator, then measurements were taken without membrane, but an average membrane thickness was measured separately and provided. For samples that contain only eggshell fragments, usually only 1-2 measurements were taken on each fragment. To ensure that the egg fragments actually belong to the species in question, only those fragments that could be clearly identified as Peregrine eggshells were measured.

Method 2, referred to as the Sam Sumida "SS" method, used a Federal mechanical gauge (0.01 mm resolution; Mahr, Providence, Rhode Island, USA) attached to the same mounting bracket and pin used in Method 1, to allow for comparison with historical measurements taken by Sam Sumida and the WFVZ prior to 2003. Method 2 used the same procedure as described for Method 1, except for the change in the gauge, and a tapping of the raising and lowering arm of the mounting bracket.

Percent eggshell thinning was calculated by comparing measured eggshell thickness with the standard pre-DDT peregrine eggshell thickness in California of 0.364 mm (Kiff 1994) using the equation N% = [1-(thickness/0.364)] x 100 (Latta 2012).

Terminology

There are a variety of definitions used to describe peregrine occupancy and nesting success, but we followed the guidelines in the 2003 Monitoring Plan for the American Peregrine falcon (U.S. Fish and Wildlife Service 2003), as defined below.

Occupied Territory: A territory where either a pair of peregrines is present (2 adults or an adult/subadult mixed pair), or there is evidence of reproduction (e.g., incubation, brooding, eggs or young, food delivery to an eyrie). We considered a territory occupied if there was evidence of occupancy on 2 or more visits to a territory.

Nest Success: The proportion of occupied territories on the Channel Islands in which 1 or more young $\geq$ 28 days old was observed, using the aging guidelines in Clum et al. (1996).

Productivity: The number of young observed at $\geq$ 28 days old per occupied territory, averaged across the Channel Islands.

We further categorized occupied territories based upon the following breeding stages (see Linthicum 1996 for further descriptions).

Courtship: Behavior indicative of pair bonding, such as cooperative hunting, adult prey exchanges, copulation, or ledge courtship displays.

Incubation: Adult observed in incubation posture (low horizontal position) or inferred to be incubating based upon behavior (for eyries that were not visible). The female does most of incubation, but the male will bring her food several times per day and relieve her at incubation. During incubation, there is generally an adult present at the eyrie, except when disturbed or for short periods on warm days.

Nestling: Chick(s) present. May be able to see chicks, hear begging, or see adults in what appears to be feeding. Generally, only females brood and feed nestlings. An adult brooding young nestlings (< 7 days old) can look a lot like incubation, so we waited for a prey delivery to the eyrie to confirm that chicks were present.

Fledgling: When young reach $\geq$ 28 days old.

We classified the breeding activity of occupied territories as either successful, unsuccessful, or none as described below.

Successful: A pair produced 1 or more nestlings that survived until at least 28 days of age.

Unsuccessful: A pair that engaged in prolonged courtship or copulating that either did not produce eggs or failed during the incubation or nestling stage (chicks < 28 days old).

None: Pair present, but no or minimal signs of courtship observed.

Data Management

Data were entered into island-specific Excel files that were shared via the cloud-based file storage program Dropbox. We combined the weekly data into a master database and the field notebooks were kept on each island as backup records. We downloaded data from our GPS units to the free Garmin Basecamp™ program weekly, which allowed us to evaluate which areas needed additional surveys and to share data among our biologists.

RESULTS

Surveying and Nest Monitoring

We surveyed 41 historic peregrine territories on the Channel Islands and located 1 previously unknown territory (Table 1). We confirmed occupancy in 38 territories, with at least 2 occupied territories on each island surveyed (Figs. 2 and 3, Table 1). Survey summaries for each island and territory are provided below.

Santa Rosa Island

Surveys began on Santa Rosa on 14 February and continued monthly through 11 June. We surveyed 12 previously known territories on Santa Rosa and confirmed occupancy in 9 (75%) of them (Fig. 5). We did not locate any new territories. Notably, courtship behavior and/or incubation was observed at 5 of the 9 occupied territories but all 5 failed to fledge young.

MC16 Carrington Point: We confirmed the presence of a pair in the historic Carrington Point territory (Fig. 5) on 14 March. The pair were confirmed incubating on 8 May but had failed by our next visit on 7 June.

MC27 Lime Point: We confirmed a pair in the historic Lime Point territory (Fig. 5) on 14 March. The birds were incubating by 11 May near the 2015 eyrie location on a coastal cliff. This cliff

Figure 2. Occupied peregrine falcon territories on the northern Channel Islands in 2018.

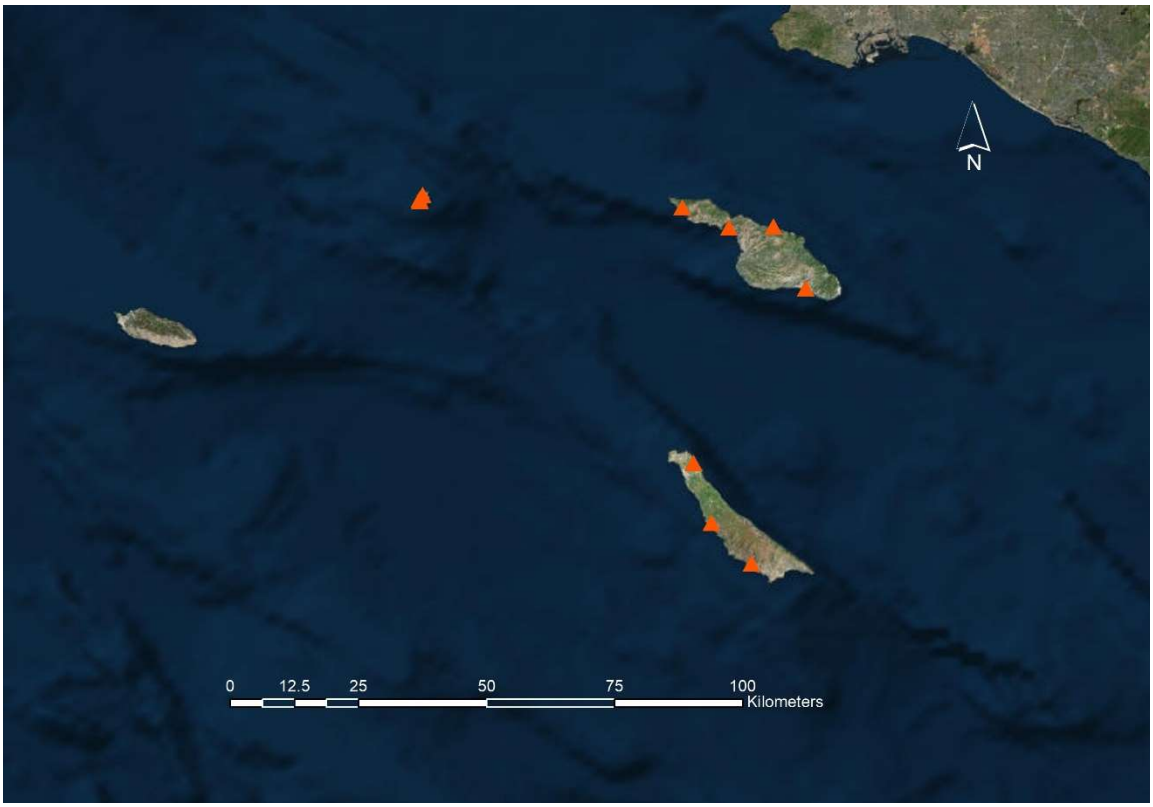

Figure 3. Occupied peregrine falcon territories on the southern Channel Islands in 2018.

Table 1. Status and breeding activity observed at peregrine falcon territories surveyed on the California Channel Islands in 2018.

Island/ Territory Name	State Code[b]	Territory Type	Occupancy Status	Breeding Activity	# Chicks Hatched	# of Fledglings	Notes (see report text for more details)
Santa Rosa							
Carrington Point[a]	MC16	Historic	Occupied	Unsuccessful	?	0	Failed during incubation/nestling stage
Lime Point[a]	MC27	Historic	Occupied	Unsuccessful	?	0	Failed during incubation/nestling stage
Water Canyon	MC31	Historic	Occupied	Unknown	.	.	No known nesting
Bee Rock Canyon	MC34	Historic	Occupied	Unknown	.	.	No known nesting
Orr's Camp	MC35	Historic	Unknown	Unknown	.	.	No adults seen
Trancion[a]	MC50	Historic	Occupied	Unsuccessful	?	0	Failed during incubation/nestling stage
Krumholtz	MC51	Historic	Occupied	Unknown	.	.	No known nesting
Soledad[a]	MC55	Historic	Occupied	Unsuccessful	?	0	Failed during incubation/nestling stage
Bonn Point	MC65	Historic	Occupied	Unknown	.	.	Unable to monitor regularly
Chickasaw Canyon	MC66	Historic	Unknown	Unknown	.	.	Did not monitor regularly
Sandy Point	MC67	Historic	Occupied	Unknown	.	.	No known nesting
Gnoma	MC76	Historic	Unknown	Unknown	.	.	No adults seen
Santa Cruz							
Gherini Knife Edge[a]	MC18	Historic	Occupied	Successful	2	2	Did not band chicks
Laguna	MC19	Historic	Occupied	Unknown	.	.	Could not confirm nesting
West End[a]	MC20	Historic	Occupied	Successful	1	1	Did not band chick
Sea Lion[a]	MC30	Historic	Occupied	Successful	1	1	Banded chick on 6/22
Black Point[a]	MC38	Historic	Occupied	Unsuccessful	1	0	Failed during nestling stage
Arch Rock[a]	MC45	Historic	Occupied	Unsuccessful	?	0	Failed during incubation/nestling stage
Valley Anchorage[a]	MC46	Historic	Occupied	Successful	2	1	Did not band chicks
Cavern Point	MC52	Historic	Occupied	Unknown	.	.	Could not confirm nesting
Bowen Point[a]	MC53	Historic	Occupied	Successful	2	2	Did not band chicks
Pelican Bay[a]	MC60	Historic	Occupied	Unsuccessful	.	.	No known nesting
Punta Diablo	MC61	Historic	Occupied	Unknown	.	.	Could not confirm nesting
Punta Gorda[a]	MC62	Historic	Occupied	Unsuccessful	0	0	Failed during incubation stage
San Pedro West[a]	MC63	Historic	Occupied	Successful	2	2	Did not band chicks

Table 1. Continued.

Island/ Territory Name	State Code[b]	Territory Type	Occupancy Status	Breeding Activity	# Chicks Hatched[c]	# of Fledglings[c]	Notes (see report text for more details)
Santa Cruz (continued)							
West Point South	MC64	Historic	Occupied	Successful	2	2	Did not band chicks
East Smuggler's[a]	MC77	Historic	Occupied	Successful	2	2	Did not band chicks
Del Norte	MC81	Historic	Occupied	Successful	2	2	Did not band chicks
Anacapa							
West Anacapa	MC21	Historic	Occupied	Unknown	.	.	Could not determine nesting status
Middle Anacapa	MC43	Historic	Occupied	Successful	2	1	Did not band chick
Cathedral Cove[a]	MC54	Historic	Occupied	Successful	3	2	Banded chicks on 5/20
Lighthouse	MC91	New	Occupied	Unknown	2	?	Unable to confirm fledge
Santa Barbara							
Signal Peak	MC33	Historic	Occupied	Successful	2	2	No regular monitoring
North Peak	MC71	Historic	Occupied	Successful	3	3	First known nesting in this territory
North Signal Peak	MC72	Historic	Occupied	Unknown	.	.	No known nesting
Santa Catalina							
Silver Peak	MC75	Historic	Occupied	Unknown	.	.	No known nesting
Lone Tree	MC78	Historic	Occupied	Unknown	.	.	No known nesting
Seal Point	MC88	Historic	Occupied	Unknown	.	.	No known nesting
San Clemente							
Cave Canyon[a]	MC59	Historic	Occupied	Successful	4	4	Did not band chicks
Wilson Cove[a]	MC89	Historic	Occupied	Unsuccessful	1	0	Failed during chick rearing stage

[a]Territory included in calculations of productivity
[b] Designated by the California Department of Fish and Wildlife (CDFW)
[c]Minimum number

was heavily used by nesting Brandt's (*Phalacrocorax penicillatus*) and pelagic (*P. pelagicus*) cormorants as well as western gulls (*Larus occidentalis*). The nest had failed by 7 June.

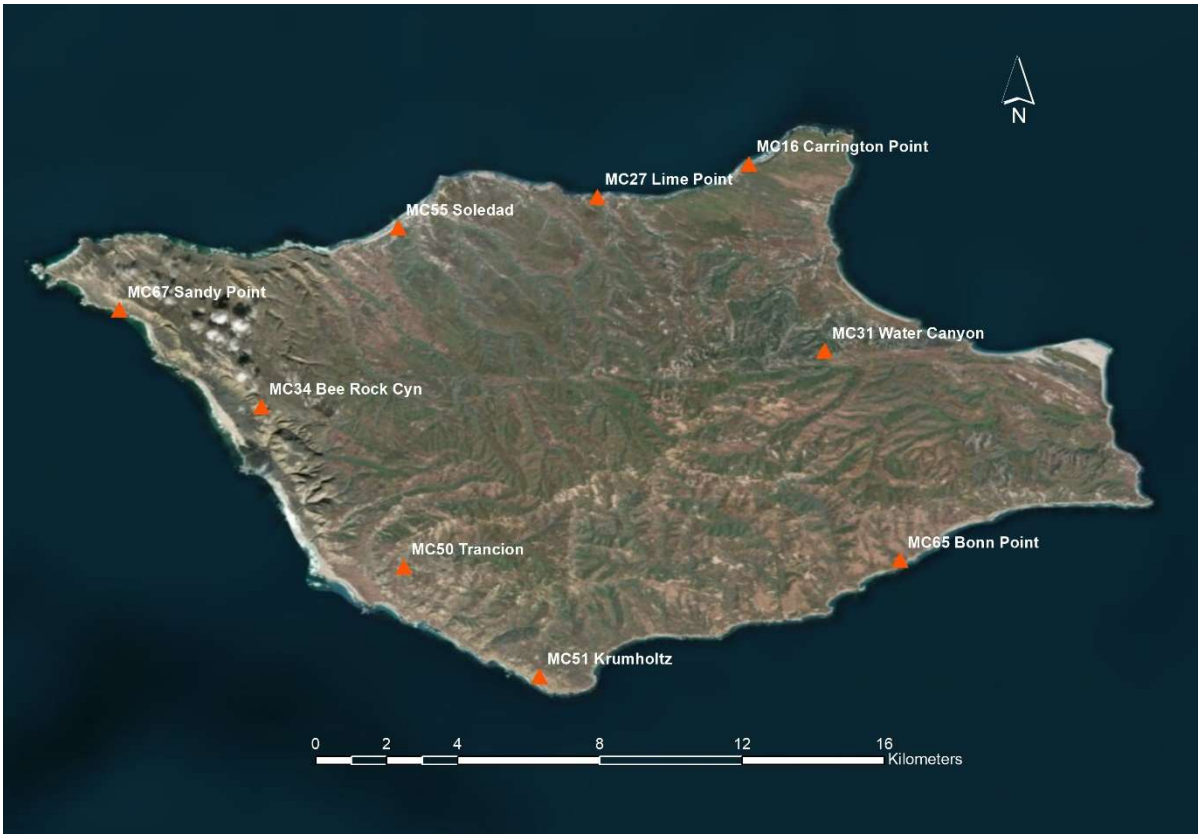

Figure 5. Peregrine falcon territories on Santa Rosa Island, CA, 2018.

MC31 Water Canyon: We confirmed a pair in the historic Water Canyon territory (Fig. 5) on 16 March. We observed the pair on surveys on 11 May and 9 June, but did not document any evidence of a nesting attempt.

MC34 Bee Rock Canyon: We confirmed a pair in the historic Bee Rock Canyon territory (Fig. 5) on 15 May, at which time behavior was consistent with the pair having recently failed. We observed the pair visiting an obvious scrape on a ledge several times though there were no eggs present. A follow-up survey on 11 June found no signs of breeding activity.

MC35 Orr's Camp: We surveyed the historic Orr's Camp territory (Fig. 5) and neighboring areas 3 times between 18 March and 13 May and were unable to document the presence of any

peregrine falcons. This territory is particularly time-consuming to survey because of recent road closures by the NPS, so we were unable to complete 3 4-hour surveys to determine that the territory was unoccupied.

MC50 Trancion: We confirmed a pair in the historic Trancion territory (Fig. 5) on 17 March. The birds were incubating on 9 May, but had failed by 6 June.

MC51 Krumholtz: We surveyed the historic Krumholtz territory (Fig. 5) 3 times between 17 March and 9 May. We confirmed a pair was present on all 3 of our surveys. The 9 May survey included a close inspection of the 2017 eyrie location and found that there was no active eyrie present in the area.

MC55 Soledad: We confirmed a pair in the historic Soledad territory (Fig. 5) on 14 February. The pair were incubating at the 2016 eyrie location on 13 May. Our next survey on 11 June found that the nesting attempt had failed. Close examination of the eyrie from above the cliff confirmed that it was no longer active.

MC65 Bonn Point: We confirmed a territorial female on 15 March and then observed a pair on 14 April. Our final visit on 12 May documented a female vocalizing at the observer but not defending a particular eyrie location.

MC66 Chickasaw Canyon: We surveyed the historic Chickasaw Canyon territory (Fig. 5) on 17 March and 6 June. One peregrine was observed moving through the territory on 17 March, but it was likely a bird from the nearby Krumholtz territory. We did not complete 3 separate 4-hour surveys at this historic territory to say reliably that it was unoccupied.

MC67 Sandy Point: We confirmed a pair in the historic Sandy Point territory (Fig. 5) on 18 March. Two subsequent surveys on 14 April and 12 May found no sign of active nesting at any of the historic locations.

MC76 Gnoma: We detected no peregrines during surveys on 15 March, 14 April, and 10 May. This territory is time-consuming to survey because of recent road closures by the NPS. For this reason, we were only able to survey 3 times, 1 month apart, and for durations considerably less than the 4-hour minimum required to determine that the territory was unoccupied.

Santa Cruz Island

Surveys began on Santa Cruz on 2 February and continued monthly through 10 July. We surveyed 17 historic territories of which 16 were occupied (Fig. 6).

MC18 Gherini Knife Edge: We confirmed a pair was present and incubating in the historic Gherini Knife Edge territory (Fig. 6) on 11 March. An unknown number of nestlings had hatched by 27 April and by 27 May there were 2 nestlings over 35 days old.

MC19 Laguna: We documented an adult male caching prey and building a scrape on 3 April. An adult female was seen on 26 May, but there was no evidence of nesting as of our last visit on 21 June.

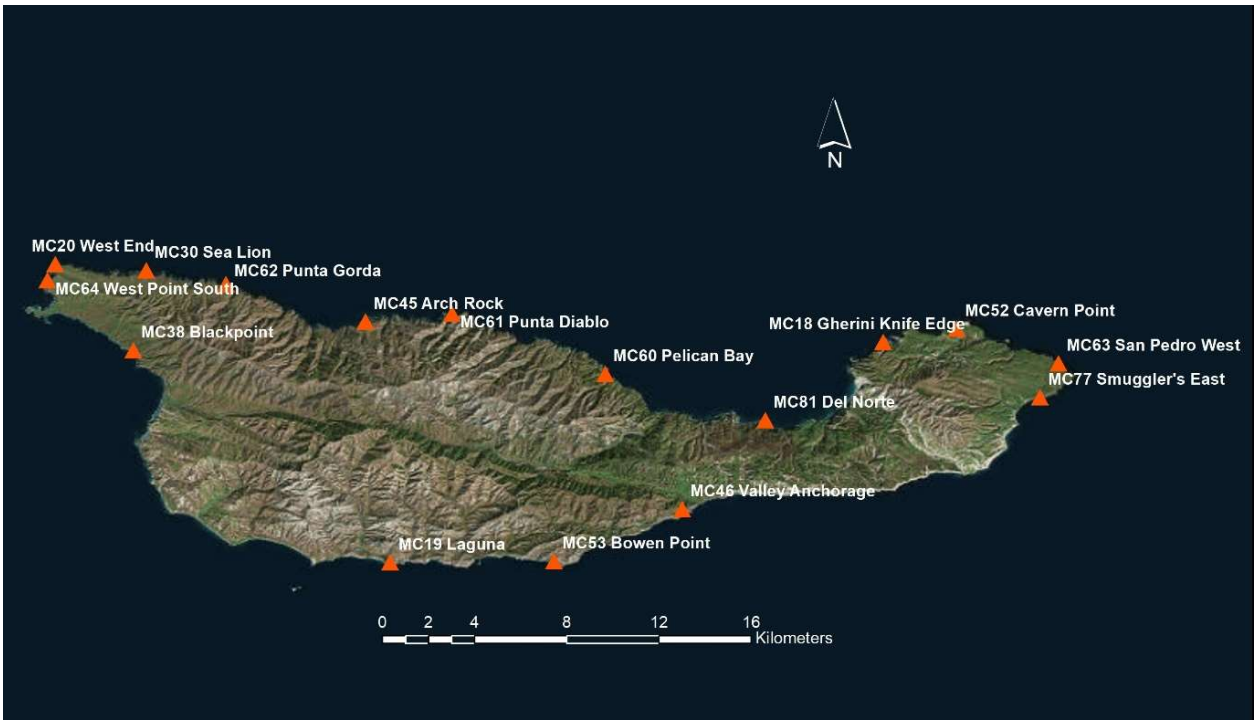

Figure 6. Peregrine falcon territories on Santa Cruz Island, CA, 2018.

MC20 West End: We confirmed a pair exhibiting courtship behavior in the historic West End territory (Fig. 6) on 4 March. On 25 May, there was one nestling approximately 7 days old. It was still present on our last visit on 22 June and estimated to be about 35 days old.

MC30 Sea Lion: We confirmed a pair exhibiting courtship behavior in the historic Sea Lion territory (Fig. 6) on 3 April. There was 1 nestling less than 3 days old on 25 May. We entered the eyrie on 22 June to band the chick and to collect shell fragments and an addled egg for analyses (Table 2, Appendix I). The bird had fledged by our last visit on 9 July.

Table 2. Summary of peregrine falcon banding on the California Channel Islands, CA in 2018.

Island/Territory Name	Sex	Age (days)	USGS Band #	Color Band	Wt. (g)
Santa Cruz					
MC30 Sea Lion	Male	25	1156-16878	29/AE	655
Anacapa					
MC54 Cathedral Cove	Female	20	1947-21690	58/AE	825
MC54 Cathedral Cove	Female	20	1947-21691	08/AN	840

MC38 Black Point: We confirmed that a pair was present in the historic Black Point territory (Fig. 6) on 3 April. There was a nestling present on 25 May, which we estimated was 10-14 days old. We returned on 22 June, but the eyrie was empty, no adults or fledgling were seen in the area, and close approach to the eyrie did not elicit a defensive response. It is likely that this nesting attempt failed.

MC45 Arch Rock: We observed courtship behavior from a pair in the historic Arch Rock territory (Fig. 6) on 2 April. They were incubating by 25 April, but had failed by 23 May.

MC46 Valley Anchorage: We confirmed a pair exhibiting courtship behavior in the historic Valley Anchorage territory (Fig. 6) on 3 April. They were incubating by 28 April and we confirmed 2 10-day-old chicks in the nest on 25 May. On 21 June, there was only 1 nestling about 29-31 days old. We returned on 9 and 10 July to confirm fledging, but no birds were seen in the area. Given the age of the nestling on our previous visit, it is likely that it had fledged and moved to another area.

MC52 Cavern Point: We confirmed a pair in the historic Cavern Point territory (Fig. 6) on 12 March. On 27 April, we located the pair making courtship displays at a new eyrie location. We observed activity at the eyrie on 27 May, but it was inactive by 24 June. We could not confirm whether there was a nesting attempt.

MC53 Bowen Point: We confirmed a pair incubating in the historic Bowen Point territory (Fig. 6) on 3 April. They had an unknown number of nestlings less than 1 week old on 28 April. We confirmed 2 fledglings on 26 May.

MC60 Pelican Bay: We confirmed a pair in the historic Pelican Bay territory (Fig. 6) on 3 March. They were exhibiting courtship behavior on 24 April and were present through 22 May, but do not appear to have nested.

MC61 Punta Diablo: We confirmed a pair in the historic Punta Diablo territory (Fig. 6) on 3 February. They were observed throughout the season, occasionally defending the area from bald eagles that were nesting nearby. The pair seemed to be focused primarily on the cliff east of the historic eyrie locations, but we were unable to confirm any breeding attempt.

MC62 Punta Gorda: We confirmed a pair exhibiting courtship behavior in the historic Punta Gorda territory (Fig. 6) on 2 April. The pair was incubating by 25 April, but the nesting attempt had failed by 23 May.

MC63 San Pedro West: We confirmed a pair in the historic San Pedro West territory (Fig. 6) on 3 April. On 26 April, the pair were incubating and had 2 nestlings about 25 days old on 27 May. We confirmed both birds had fledged by 25 June.

MC64 West Point South: We confirmed a pair exhibiting courtship behavior in the historic West Point South territory (Fig. 6) on 3 February. We were unable to confirm nesting during multiple visits in March and April, but confirmed 2 fledglings on 25 May.

MC77 East Smuggler's: We confirmed a pair exhibiting courtship behavior in the historic East Smuggler's territory (Fig. 6) on 28 February. We confirmed incubation on 26 April and there were 2 nestlings 31-33 days old present on 24 June. Both had fledged by 8 July.

MC81 Del Norte: We located a pair in the historic Del Norte territory (Fig. 6) on 14 March. We saw no evidence of nesting on 2 April or 22 May, but found 2 fledglings on 25 June.

MC90 Pozo: We did not locate any peregrines during 3 surveys in April and May.

Anacapa Island

We conducted 2 surveys of Anacapa from our boat on 24 May and 19 June. We located pairs in 3 of the 4 historic territories (Fig. 7) and found a new territory on the south side of East Anacapa.

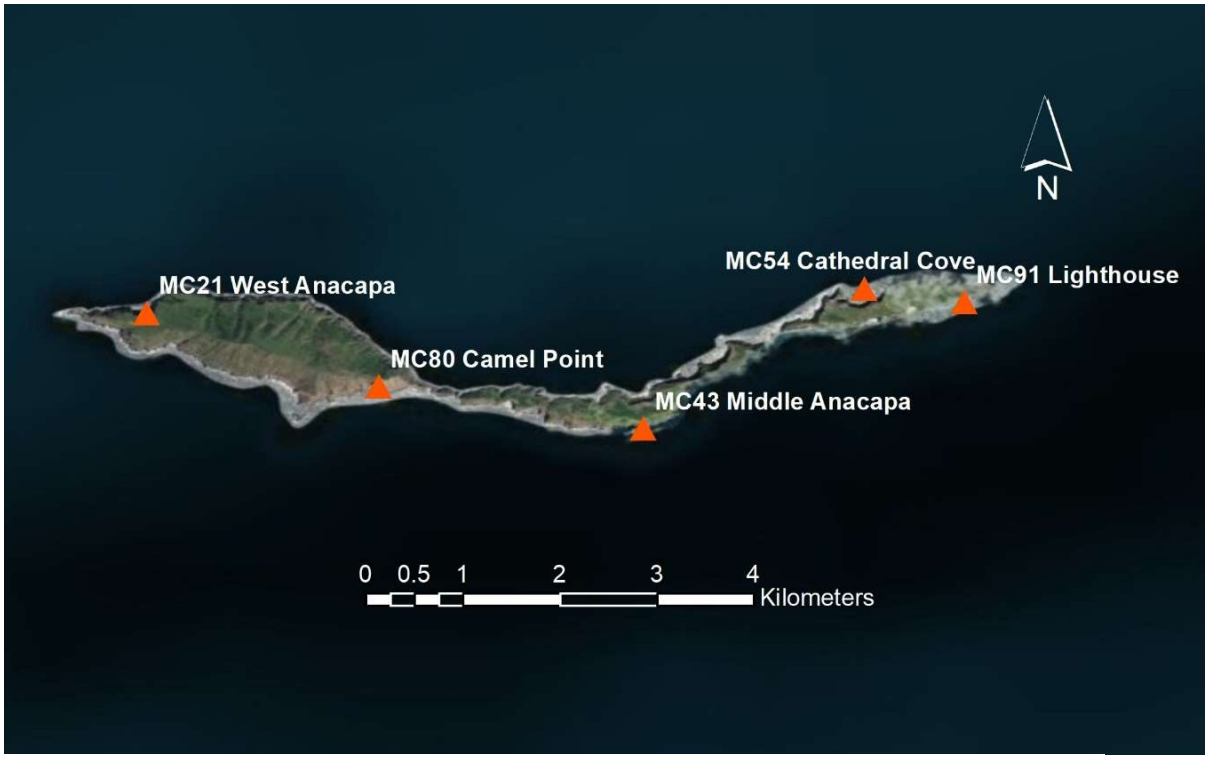

Figure 7. Peregrine falcon territories on Anacapa Island, CA, 2018.

MC21 West Anacapa: We confirmed a pair incubating at an alternate location to the historic West Anacapa territory (Fig. 7) on 24 May. We were unable to confirm the presence of nestlings on 19 June, although the pair was still present.

MC43 Middle Anacapa: We located the Middle Anacapa pair (Fig. 7) with at least 2 nestlings of indeterminate age on 24 May. We confirmed 1 fledgling on 19 June.

MC54 Cathedral Cove: We monitored the Cathedral Cove nest site (Fig. 7) via a live web cam established in early 2017. They laid eggs on 24, 26, and 29 March. Two chicks hatched on 30 April and 1 hatched on 1 May. A western gull removed 1 nestling from the eyrie on 4 May. We entered the eyrie on 20 May to band the chicks and to collect prey remains and eggshell fragments (Table 2, Appendix I).

MC80 Camel Point: We were only able to survey this territory once on 4 May. We did not document any activity.

MC91 Lighthouse: We discovered this territory on 20 May after banding the Cathedral Cove nestlings. From the water, we located the eyrie and identified 2 nestlings approximately 3 weeks old. We returned 19 June but did not observe any fledglings in the area.

Santa Barbara Island

Jim Howard with the California Institute of Environmental Studies, conducted surveys of Santa Barbara for us this season. Pairs were located in each of the 3 historic territories and no new territories were discovered (Fig. 8).

MC33 Signal Peak: Two birds were exhibiting courtship behavior in the historic Signal Peak territory (Fig. 8) on 16 April. Both birds were present on 10 May and the male exhibited territorial defense, but we could not confirm a nesting attempt. Our last survey was on 10 June, at which time there were 2 fledglings present.

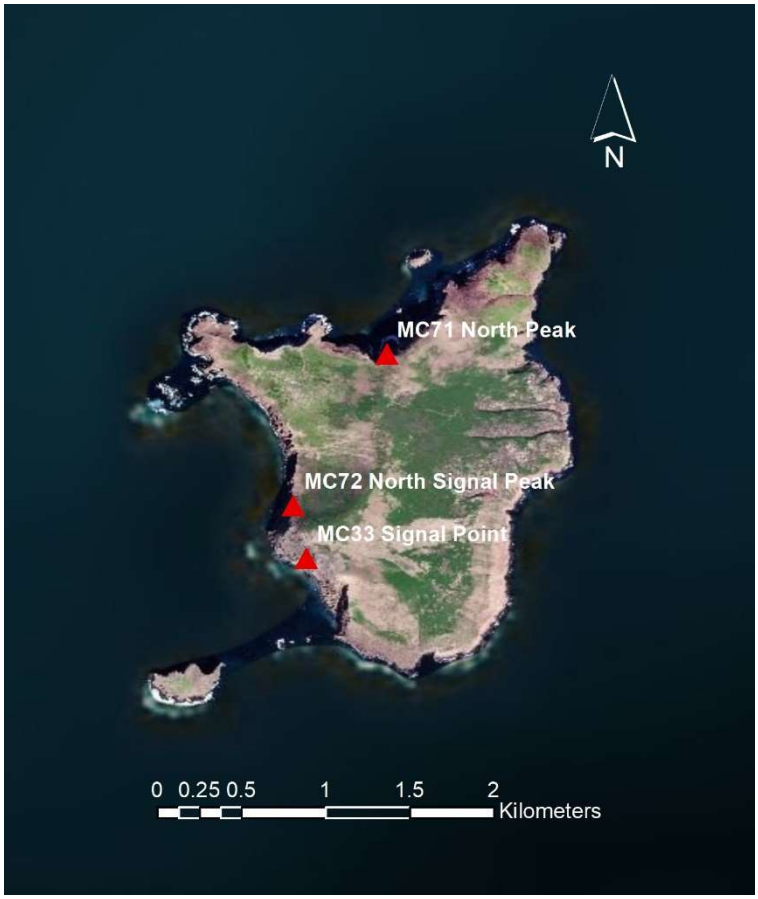

Figure 8. Peregrine falcon territories on Santa Barbara Island, CA, 2018.

MC71 North Peak: We confirmed a pair in the historic North Peak territory (Fig. 8) on 14 March. The pair was incubating 4 eggs on 24 April. At least 2 chicks were present on 7 May and 3 fledglings were seen on 10 June.

MC72 North Signal Peak: We confirmed a pair in the historic North Signal Peak territory (Fig. 8) on 14 March, 24 April, 11 May, and 10 June. There was no evidence of a nesting attempt.

Santa Catalina Island

We surveyed 4 previously identified territories on the island and confirmed pairs present in each territory (Fig. 9).

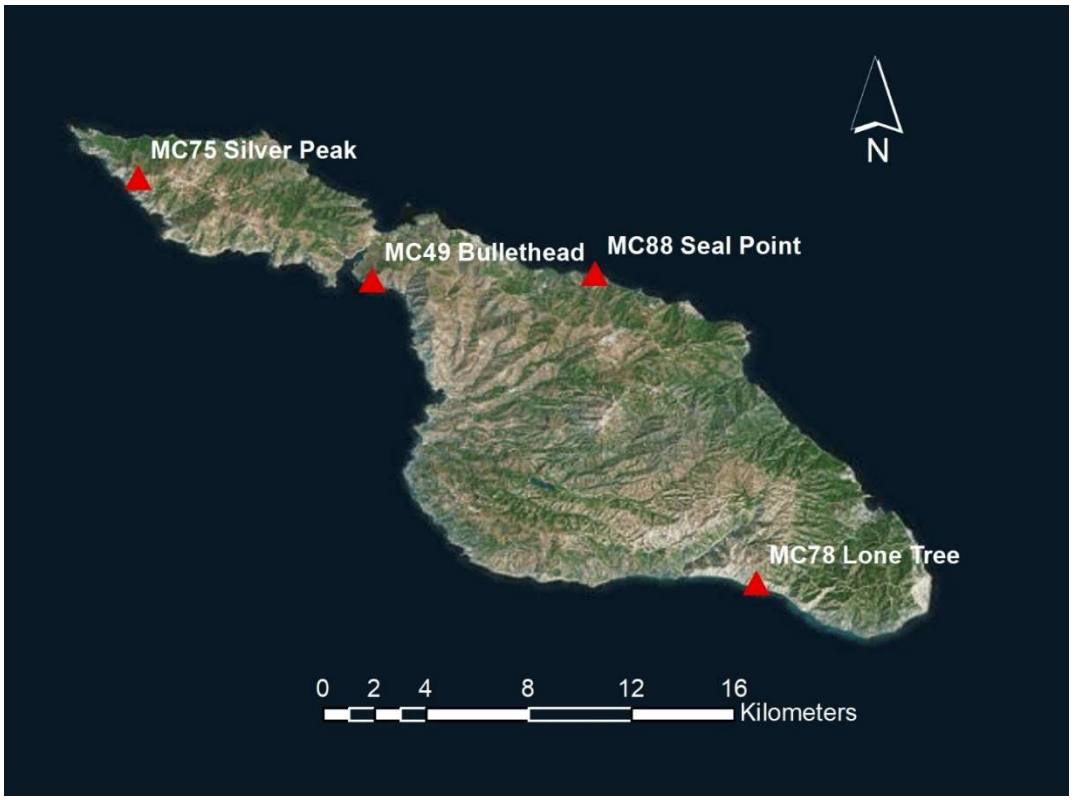

Figure 9. Peregrine falcon territories on Catalina Island, CA, 2018.

MC49 Bullethead: We have not located a pair in the historic Bullethead territory (Fig. 9) since our surveys began in 2013, but a pair was present on 6 March. Only 1 adult was seen on 20 March and 16 May and there was no evidence of a nesting attempt.

MC75 Silver Peak: We confirmed a pair in the historic Silver Peak territory (Fig. 9) on 27 February. Fog obscured the cliffs on our 3 April survey, but both adults were heard. There was no activity on 9 April or 16 May.

MC78 Lone Tree: We confirmed a pair in the historic Lone Tree territory (Fig. 9) on 5 and 27 March, but there was no activity on 8 June. We did not determine whether there was any nesting attempt.

MC88 Seal Point: We confirmed a pair in the historic Seal Point territory (Fig. 9) on 28 February, but no birds were seen on 6 March. We were unable to return to this territory for additional surveys.

San Clemente Island

We surveyed 3 historic territories on the island (Fig. 10) and confirmed breeding attempts in 2 of the territories.

MC59 Cave Canyon: We confirmed a pair incubating in the historic Cave Canyon territory (Fig. 10) on 20 April. Three nestlings about 24 days old were seen on 20 May. Four nestlings about 32-36 days old were seen on our last visit on 3 June.

Figure 10. Peregrine territories on San Clemente Island, CA, 2018.

MC79 Seal Cove: We were only able to survey the historic Seal Cove territory (Fig. 10) on 19 May and no peregrines were seen.

MC89 Wilson Cove: We located a pair in the historic Wilson Cove territory (Fig. 10) on 21 April. We suspected that there were nestlings present on 8 May based upon behavior. Nestlings

still appeared to be present on 21 May, but the nest had failed by 17 June

Resightings

In 2018, we received sighting reports on the mainland for 4 peregrines that we had banded as nestlings on the islands.

A female banded in 2016 at the Punta Gorda territory on Santa Cruz (Band #1947-21675) was seen in La Jolla, CA on 13 April, 7 May, 27 May, 1 June, and 16 September.

A female banded in 2013 at the Cathedral Cove territory on Anacapa (Band #1947-21612) was found with a broken wrist and taken to Project Wildlife in San Diego, CA.

A male banded in 2014 at the Laguna territory on Santa Cruz (Band #1156-16831) was seen at Torrey Pines State Reserve, La Jolla, CA.

A male banded in 2017 at the Krumholtz territory on Santa Rosa (Band #1156-16872) was seen at the Bolsa Chica Ecological Reserve, Orange County, CA on 18 September and 5 November.

Eggshell Measurements

We collected eggshell fragments and 1 addled egg from 2 territories on 2 islands in 2018 (Table 4, Appendix I). Percent eggshell thinning, compared to peregrine eggs from pre-1947 in California, ranged from 17.9% to 35.2%% using the "RC" method, and 13.6% to 36.7% using the SS method (Table 4).

Productivity

At least 23 chicks are known to have hatched on the Channel Islands in 2018, of which 22 (96%) are known to have survived to ≥28 days of age. We calculated productivity based upon 18 pairs that were monitored from early in the breeding season (i.e., courtship, incubation) and for which we know the outcome of the breeding season (see Table 1). Seventeen pairs (94%) laid eggs, 11 pairs hatched at least 1 chick, and 9 pairs successfully produced at least 1 chick ≥28 days of age. Minimum productivity was 0.94 fledglings per occupied territory, and 1.9 fledglings per successful nesting attempt.

Table 4. Measurements of peregrine falcon eggs and eggshell fragments collected from nests on the California Channel Islands in 2018.

	Clutch Means (RC[a])		Clutch Means (SS[b])		
Island/Territory	Eggshell Thickness (mm)	% Thinning	Eggshell Thickness (mm)	% Thinning	Notes
Santa Cruz Island					
MC30 Sea Lion	0.236	35.2	0.230	36.7	Measured from 4 small fragments with membrane
MC30 Sea Lion	0.293	19.5	0.300	17.6	10 measurements around equator of addled egg
Clutch Mean	0.264	27.5	0.265	27.2	
Anacapa Island					
MC54 Cathedral Cove	0.299	17.9	0.315	13.6	Measured from 10 fragments with membrane thickness added

[a]René Corado Method
[b]Sam Sumida Method

DISCUSSION

The once-extirpated peregrine population on the Channel Islands has undergone a strong recovery since initial reintroduction work in the 1980s and 1990s. Our 2013-2017 surveys identified 45-51 occupied territories, which exceeded Hunt's (1994) estimate of approximately 30 territories for historical periods. Due to our funding cuts for the 2018 field season, we were unable to survey as many islands as in previous years, but still located 38 occupied territories.

The northern Channel Islands continue to be the stronghold for Channel Island peregrines, which is likely due to a higher seabird diversity (Carter et al. 1992, Takekawa et al. 2004) and more cliffs with ledges and potholes for peregrine nesting (Hunt 1994; P. Sharpe, personal observations), as compared to the southern Channel Islands. In other peregrine populations, density of peregrine territories appears to be positively correlated with availability of food resources, with higher densities generally occurring in association with large seabird or shorebird colonies (Ratcliffe 1980). This is likely the case with the peregrines on the Channel Islands.

Nest success (50%) and productivity (0.94 fledglings/occupied territory) in occupied territories with known outcomes was lower in 2018 than in any of the previous 5 years, which was driven largely by the lack of any known productivity on Santa Rosa Island. Over the 5 previous breeding seasons that IWS monitored peregrines on the Channel Islands (2013-2017), nest success averaged 64% and productivity has been 1.39 chicks/occupied territory. Nest success and productivity on the Channel Islands is similar to that in the Pacific Region in 2003 (65% and 1.45 chicks/occupied territory), but slightly lower than the 2003 national average of 71% and 1.64 chicks/occupied territory (Green et al. 2003). More recent studies reported nest success of 77-78% and 1.8 chicks/occupied territory found in Colorado, Montana, Wyoming, and Idaho (Enderson et al. 2012, Moulton 2012). Nest success and productivity can vary greatly between years, so continued monitoring will allow us to better estimate long-term reproductive averages and trends in the peregrine population on the Channel Islands.

The potential impact of DDE on the productivity of peregrines on the Channel Islands is a continuing concern. Historically, peregrine populations with eggshell thinning exceeding 17% were either declining or extirpated (Peakall and Kiff 1988), but populations with average thinning below 14.5% appeared normal (Fyfe et al. 1988). Eighteen clutches collected on the

Channel Islands from 1988-1993 had 19.8% thinning (Kiff 1994) and mean eggshell thinning was 18.3% in 2007 (Latta 2012), 12.4% in 2013 (Sharpe 2014), 14.4% in 2014 (Sharpe 2015), 10% in 2015 (Sharpe 2016), 22.6% in 2016 (Sharpe 2017), and 30% in 2017 (Sharpe 2018). Mean clutch eggshell thinning from the 2 eyries we entered in 2018 was 20.4% (SS Method). If this level of thinning is characteristic of the other peregrine territories, it could help explain the lower productivity observed in 2018. The higher thinning observed during the past 3 seasons could be an indication of contaminate or other problems, so it is important to conduct regular monitoring of the peregrines on the Channel Islands to determine if the population begins to decline.

We continue to locate new breeding territories on both the northern and southern Channel Islands and believe that the peregrine population will continue to expand into currently unoccupied breeding habitat. Although nesting density is high on the northern Channel Islands and the levels of productivity appear sufficient to maintain the population, factors such as juvenile/adult survival and emigration/immigration rates play an important role in population persistence. Annual population monitoring and banding of young could help us gain an understanding of these population parameters for the Channel Island peregrines and help determine whether contaminants or other issues are negatively impacting the population.

During the 2019 season, we plan to survey Santa Cruz, Santa Rosa, San Nicolas, Santa Catalina, and Anacapa with a similar effort as in 2018. We will rely primarily on the call-broadcast protocol for the rapid assessment of areas with suitable habitat outside of known territories, as has been done in other studies (Klinger and Tomlinson 2010), and we recommend its use in peregrine population monitoring, especially when time and/or personnel are limited.

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Appendix I. Samples collected in 2018.

Sample ID	Island[a]	Territory	Sample Type	Collection Date	Notes
18-MC54-SF-1	Anacapa	Cathedral Cove	Shell Fragments	5/20/2018	Collected from eyrie
18-MC54-WB-1	Anacapa	Cathedral Cove	Whole Blood	5/20/2018	Collected from 1947-21690
18-MC54-WB-2	Anacapa	Cathedral Cove	Whole Blood	5/20/2018	Collected from 1947-21691
18-MC54-PR-1	Anacapa	Cathedral Cove	Prey Remains	5/20/2018	Collected from eyrie
18-MC30-AE-1	Santa Cruz	Sea Lion	Addled Egg	6/22/2018	Collected from eyrie
18-MC30-SF-1	Santa Cruz	Sea Lion	Shell Fragments	6/22/2018	Collected from eyrie
18-MC30-WB-1	Santa Cruz	Sea Lion	Whole Blood	6/22/2018	Collected from 1156-16878
18-MC30-PR-1	Santa Cruz	Sea Lion	Prey Remains	6/22/2018	Collected from eyrie