Nest Monitoring of Xantus's Murrelets at Anacapa Island, California: 2008 annual report

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Incubating Xantus's Murrelet in Landing Cove Nest #4 at East Anacapa Island on 1 May 2008

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Final Report – December 2008

Suggested Citation: Whitworth, D.L., H.R. Carter, A. Bailey and F. Gress. 2008. Nest monitoring of Xantus's Murrelets at Anacapa Island, California: 2008 annual report. Unpublished report, California Institute of Environmental Studies, Davis, California (prepared for the American Trader Trustee Council and Channel Islands National Park). 32 p.

EXECUTIVE SUMMARY

- In 2008, the ninth year of Xantus's Murrelet (*Synthliboramphus hypoleucus*) nest monitoring and the sixth year of post-eradication monitoring was conducted at Anacapa Island, California. With primary support from the American Trader Trustee Council and Channel Islands National Park, a monitoring program was initiated in 2000 to provide baseline data on reproductive success and population size prior to the eradication of Black Rats (*Rattus rattus*) from Anacapa Island in 2000-02. In 2003-08, nest monitoring was used post-eradication to examine murrelet breeding effort, reproductive success, and colony expansion in sea caves and other sample plots.

- In 2008, highest nest occupancy (60%) and highest nesting effort (n = 31 clutches) occurred since monitoring was initiated at Anacapa Island.

- Hatching success at Anacapa remained high in 2008 (83%), although for the second consecutive year some difference in hatching success between sea caves (89%) and the other plots (73%) was evident.

- Although no new nest sites were established in sea caves in 2008, murrelets continued to expand their nesting distribution in other habitats previously occupied by rats. Three new nests (1 site in Rockfall Cove and 2 sites in Landing Cove) were established in cliff, shoreline and offshore rock habitats, where none were known prior to 2003.

- The mean nest initiation date in 2008 was 13 April (± 20 d), with nests initiated as early as 15 March and as late as 29 May. Timing of breeding in 2008 was 19-37 days earlier than in 2004-07, but 1-10 days later than in 2000-03.

- Post-eradication (2003-08) hatching success has averaged 82% (range = 69-89%) compared to just 44% (range = 22-86%) during the pre-eradication period (2000-02).

- Mammalian depredation has been nearly eliminated as a cause of nest failure at Anacapa since the removal of rats. Nearly half (48%) of all pre-eradication nests were depredated by rats, but only 3% of nests were depredated post-eradication, presumably by endemic Deer Mice (*Peromyscus maniculatus anacapae*).

- In 2008, nest site competition with Pigeon Guillemots (*Cepphus columba*) was a significant cause of murrelet nest failure at Anacapa. Since 2003, guillemots have disturbed four active murrelet nests, usurping two active and two inactive murrelet nest sites in the process. Nest site competition with Cassin's Auklets (*Ptychoramphus aleuticus*) may also occur in the future as at least three auklet nests have been established at Anacapa since 2003.

- Colony growth in sea caves appears to have leveled off in 2005-08, with little variation in nest occupancy (52-58%) and nesting attempts (n =16-19 clutches). In contrast, greatly increasing numbers of nests have been observed in other plots from 2003 (2 clutches) to 2008 (12 clutches), with nest occupancy in these sites increasing markedly from 17% to 71%.

- Eradication of rats has led to improved hatching success and colony growth. While rat depredation was likely the primary factor impacting the murrelet colony over the last century, population recovery may occur slowly because of the naturally low reproductive rates of *Synthliboramphus* murrelets, and annual variation in nesting effort, hatching success, and survival to breeding age. In certain years (e.g., 2004), natural factors can greatly reduce nesting effort and hatching success.

- Annual nest monitoring is currently scheduled to continue at least through the 2010 breeding season. Extensive nest searches of currently non-monitored upper-island areas are planned after the breeding season in 2009 or 2010. Continued nest monitoring beyond 2010 is desirable to best document continued recovery of Xantus's Murrelet at Anacapa Island, currently one of only two colonies of this state-threatened species that are monitored annually for reproductive success.

INTRODUCTION

In February 1990, the *American Trader* oil spill occurred off Huntington Beach, California, killing about 3,400 seabirds (ATTC 2001, Carter 2003). With funds from the litigation settlement in 1998, the American Trader Trustee Council (ATTC), in collaboration with Channel Islands National Park (CINP), developed a restoration program to enhance seabird breeding habitat on Anacapa Island, California, by eradicating non-native Black Rats (*Rattus rattus*) (ATTC 2001, Howald et al. 2005). The Xantus's Murrelet (*Synthliboramphus hypoleucus*) was identified as the species expected to benefit most from the Anacapa Island Restoration Program as the murrelet colony apparently had been severely impacted by rats since at least the early 1900s (Hunt et al. 1979, Carter et al. 1992, McChesney and Tershy 1998, McChesney et al. 2000, Whitworth et al. 2003a). The ATTC determined that rat eradication would assist murrelet population recovery and prevent possible loss of this important colony. In December 2004, Xantus's Murrelet was listed as threatened by the California Fish and Game Commission and the expected recovery of the Anacapa murrelet colony was considered a significant step toward increasing the probability of maintaining viable populations in California (Burkett et al. 2003). Xantus's Murrelet currently is listed as a candidate species under the federal Endangered Species Act.

Island Conservation and CINP successfully eradicated rats from Anacapa Island in two phases: a) East Anacapa in December 2001; and b) Middle and West Anacapa in November 2002 (Howald et al. 2005). While non-native introduced predators had been eradicated from several murrelet breeding islands in Baja California and southern California over the past 30 years (Hunt et al. 1979, McChesney and Tershy 1998, Keitt 2005), little effort has been made prior to 2000 to document the benefits of predator eradication for murrelets or other seabirds. In 2000, the ATTC sponsored Humboldt State University and Hamer Environmental (with collaboration by Channel Islands National Marine Sanctuary and California Institute of Environmental Studies) to design and implement a Xantus's Murrelet Monitoring Program for Anacapa Island. The primary goals of this monitoring program were: a) to determine baseline levels of population size indices and reproductive success prior to eradication; and b) to measure expected increases in murrelet population size and reproductive success after eradication. Innovative population monitoring techniques (including nest monitoring in sea caves, nocturnal spotlight surveys of at-sea congregations, and radar monitoring) were employed in 2000-03 to provide reliable indices of murrelet population size and reproductive success for measuring changes over time (Whitworth et al. 2003a,b,c; 2005a; Hamer et al. 2005).

In 2004, the ATTC decided that baseline data collection was completed for the Xantus's Murrelet population monitoring program but lower-cost annual long-term monitoring was still needed to provide information on key demographic parameters and the general progress of population increases prior to later more extensive studies that would better determine actual large-scale changes in population size and distribution. The California Institute of Environmental Studies (CIES; with collaboration by Channel Islands National Marine Sanctuary) was funded to continue nest searches and monitoring in sea caves and other nesting habitats at Anacapa Island. In 2004-08, this work has provided standardized data to: a) measure nesting effort, hatching success, and nest depredation rates; and b) detect expansion of the colony into habitats previously occupied by rats. Monitoring efforts in 2008 marked the ninth consecutive year of Xantus's Murrelet nest monitoring at Anacapa Island and the sixth year of monitoring since eradication. In this report, we present the results of 2008 nest monitoring with comparison to previous years.

METHODS

Study Area

Anacapa Island is the easternmost and smallest of the northern four California Channel Islands and is located 15 km southwest of Ventura (Fig. 1). It is comprised of three small islets (West, Middle, and East; Figs. 2 and 3) separated by narrow channels that are sometimes exposed at low tide. The island chain is approximately 7.5 km long and is surrounded by 17.5 km of steep, rocky cliffs punctuated with over 100 sea caves (Bunnell 1993; Figs. 2 and 3). West Anacapa is the largest (1.7 km^2) and highest (284 m) of the three islets (Fig. 2), followed by Middle Anacapa (0.6 km^2, 99 m; Fig 3), and East Anacapa (0.5 km^2, 73 m; Fig. 3). Anacapa Island is managed by CINP which maintains quarters for staff and facilities for campers on East Anacapa, but the rest of the island chain is uninhabited. Surrounding waters out to 9.7 km (6 miles) are managed by CINMS, out to 4.8 km (3 miles) by California Department of Fish and Game, and out to 1.6 km (1 mile) by CINP. The Anacapa Marine Reserve is located off the north side of East and Middle Anacapa and the Anacapa Island Marine Conservation Area is off the north side of West Anacapa.

Field Logistics

In 2008, we used the CINMS research vessel *Shearwater* (Santa Barbara, CA) and the private charter vessel *Retriever* (Ventura, CA) for transportation to Anacapa Island and accommodations while at the island. Field work was conducted by staff from CIES (D. Whitworth, A. Bailey) and CIES subcontractor Carter Biological Consulting (H. Carter, P. Hébert). Access to sea caves and other sample areas was performed in a 3.8 m Zodiac® inflatable craft powered by 15-25 hp outboard engines. Boats and personnel were supplied with all required safety equipment.

Nest Monitoring

In May-July 2008, we conducted nest searches and monitoring in 10 sea caves previously monitored in 2000-07 (Figs. 2 and 3). Caves were named by Bunnell (1993). All potential nesting habitats in sea caves were searched using hand-held flashlights during each visit. Sea caves were checked every two weeks from 1 May to 14 July. Only sites which were active on the penultimate check were checked during the last visit on 14 July.

With reduced funds and extended nesting beyond June in 2004-07, nest monitoring was changed from a weekly schedule used in 2001-04 to a biweekly schedule in 2005-08. In 2000, nest checks were conducted every 2-3 weeks due to limited funding. We now consider biweekly checks to be the most efficient long-term monitoring schedule for obtaining adequate data at Anacapa Island with available time, funds, and boat support. While biweekly checks result in less exact data at some nests for estimating breeding phenology, the accuracy of hatching success is not affected (usually determined by presence of 1-2 hatched eggshell fragments after evidence of full-term incubation).

Systematic efforts to survey potential murrelet nesting areas in cliff, shoreline and offshore rock habitats began in 2003 and were continued and expanded in 2004-08 (Figs. 2 and 3). Using methods similar to sea cave nest monitoring, areas were thoroughly searched as follows: 1) cliffs in Landing Cove on East Anacapa (2003-08); 2) Cat Rock off West Anacapa (2003-08); and 3) Rockfall Cove on the south side of Middle Anacapa (2005-08). Previously tagged sites in these plots were checked biweekly as for sea cave sites. More extensive nest searches of sample areas were conducted 1-2 times during the breeding season after egg laying had progressed substantially in most sea caves. By monitoring some areas outside of sea caves, we aimed to detect when murrelets began colonizing nesting areas that previously were not used, apparently due to presence of rats. In 2008, limited time prevented nest searches along shoreline areas on the south side of Middle Anacapa near East Fish Camp that were searched in 2004-06, although no monitored sites are currently located in this area.

Monitored nest sites were identified as suitable crevices or sheltered sites, containing an incubating or brooding adult or other evidence of past or present murrelet breeding (i.e, whole unattended eggs, broken or hatched eggshell fragments, or eggshell membranes). During the first visit of the year, each cave was carefully inspected and any remaining eggshell fragments from the past breeding season were collected to avoid possible confusion with previous nesting efforts. During subsequent biweekly visits to sea caves, we recorded contents for each tagged nest (e.g., empty nest, one or two unattended eggs, incubating or brooding adult, abandoned eggs, broken or hatched eggshell fragments) and searched for new nest sites. Incubating adults were observed briefly with a small flashlight but were not handled or prodded to reduce the possibility of nest abandonment due to researcher disturbance.

<u>Hatching Success</u> – As in past years, hatching success was determined as the percent of nesting attempts (i.e., each clutch of 1-2 eggs laid) that successfully hatched at least one egg. Successful hatching was usually indicated by observations of chicks or freshly hatched eggshell fragments (identified by dried or bloody membranes which had separated from eggshells; Fig. 4) at the nest site. A Yates corrected Chi-square analyses for a 2 x 2 contingency table (χ^2) was used to examine differences in the frequency of hatched nests between pre-eradication and post-eradication periods.

As in past years, failed nesting attempts were classified as depredated or abandoned. However, in light of the considerable numbers of broken and ejected eggs caused by Pigeon Guillemots (*Cepphus columba*) in 2007-08, "usurped nests" were included as a potential nest fate and data for all nests from 2000-07 were re-evaluated for consistency among years (*see Discussion*). The usurped nest fate applied to any murrelet clutch disturbed by Pigeon Guillemots whether or not the site was used by guillemots for nesting. Depredated nests were usually identified by the presence of broken eggshells in or near the site prior to hatching. Depredated eggshells usually had signs of depredation by rats (larger bite marks on shell edges or greater crushing of eggshells) or mice (smaller bite marks on shell edges with little or no crushing; Fig. 5). However, it was not clear if depredated eggs were taken from active nests or after abandonment. Nesting attempts were considered abandoned when whole unattended eggs were observed on at least two consecutive nest checks. Because egg neglect is known for Xantus's Murrelets, unattended eggs were not removed until after three or more nest checks to ensure that eggs were definitely abandoned. Nests with unknown nest fates were excluded from calculations of hatching success and rates of depredation and abandonment.

<u>Nest Occupancy</u> - In 2008, nest occupancy in sea caves was calculated for each year as the percentage of total monitored nest sites found in 2000-08 (regardless of when the site was first tagged) in which at least one egg was laid. Potential nest sites were not tagged until some evidence of nesting was observed, but because all habitats in sea caves were thoroughly searched each year, we believe that untagged sites in caves could reliably be considered unoccupied prior to tagging. This technique increases comparability of occupancy rates among years. Using this method, calculated occupancy rates in sea caves for a particular year will decrease as the murrelet population increases and new monitored sites are added, but occupancy rates will more reliably reflect growth of the murrelet population. Estimates of nest occupancy over the entire island were calculated as for sea caves. However, systematic nest searches in cliff, shoreline, and offshore rock plots began in different years (*see above*) and the total number of monitored sites used to calculate occupancy differed among years.

Two single eggs were found in open locations unsuitable for nesting (in Lava Bench #1 Cave in 2005 and Lonely at the Top Cave in 2008). These eggs were treated as nesting attempts for calculations of hatching success those years, but locations were not considered potential nest sites and were not included in analyses of nest occupancy. Inspection of locations indicated exposure to light and predators and that eggs could not have rolled out of or been moved from a nearby hidden nest. For nest fate determinations, we assumed that these eggs were abandoned immediately at or shortly after laying.

<u>Timing of Breeding</u> - A range of possible clutch initiation dates (i.e., laying date of the first egg of the clutch) was estimated for each nest by subtracting an estimated period of time from the date of reliable evidence of laying or hatching of the first egg of the clutch, such as: 1) one unattended egg prior to the laying of the second egg (i.e., between 1-7 days since laying); 2) "chicks in nest" (i.e., between 0-3 days since hatching); 3) "fresh hatched eggshell fragments" (i.e., 3-7 days since hatching); or 4) the first date in a series of repeated checks with incubating birds (i.e., 1-14 days since laying). The number of days subtracted took into account: a) mean time between the laying of two eggs in a clutch is 8 days; b) mean time between clutch completion and start of incubation is 2 days; c) mean incubation period is 34 days (range = 27- 44 days); and d) mean time from hatching to nest departure is 2 days

(Murray et al. 1983). By placing mean nest initiation dates in 10-day blocks each year, we partly accounted for error in the estimation of mean initiation date for each nest. However, with biweekly nest checks in 2005-08, slightly greater error was involved in this process than with weekly nest checks in 2001-04.

RESULTS

Nest Monitoring in 2008

Nesting Effort and Occupancy - In 2008, we monitored a total of 48 nest sites, including 31 sites in 10 sea caves and 17 sites in other plots (Table 1). A total of 31 nesting attempts (19 clutches laid in sea caves and 12 in other plots) were recorded in 29 sites (17 sites in sea caves and 12 in other plots). Separate clutches laid by different pairs were recorded in Refuge Cave Nest #1 (*see below*), while a nesting attempt (single egg) in an unsuitable nest site in Lonely at the Top Cave was included in analysis of breeding effort and hatching success, but the site was not tagged and was excluded from calculations of occupancy. We suspect the laying of this egg in an open site was caused by depredation of the adult male of a breeding pair just prior to clutch initiation (*see Discussion*). Nesting was observed in: a) 90% (n = 10) of monitored sea caves; b) eight nests in cliffs at Landing Cove; and c) four nests in rocky scree in Rockfall Cove (Table 1).

A total of three new nests were found in 2008 (Table 2), all in plots outside of the sea caves, including two new sites on the Landing Cove cliffs and one new site in Rockfall Cove. Occupancy of monitored sites was 60% over the entire island (n = 48; Table 2), with 55% (n = 31) in sea caves (Table 3) and 71% (n = 17) in other plots (Table 4).

The second clutch laid in Refuge Cave Nest #1 likely was a nesting attempt by a different pair. The second clutch was laid soon after hatching of the first clutch, presumably while the first pair was raising chick(s) at sea. Replacement clutches have yet to be documented at Anacapa Island but have been noted occasionally at Santa Barbara Island and the Coronado Islands (Murray et al. 1983; Whitworth et al. 2008a).

A single Cassin's Auklet (*Ptychoramphus aleuticus*) nest was found in Landing Cove in 2008, where an auklet of undetermined age was observed in a deep crevice on all three monitoring checks in May. Although an egg was not seen, this auklet was likely incubating. Auklets rarely stay in nest sites during the day (especially later in the breeding season) unless an egg or small chick is present. However, this site was difficult to monitor and hatching or fledging success could not be determined. Another auklet also may have nested in Landing Cove Nest #6 where guano and odor were detected at the crevice entrance. This second site also was too deep to observe an adult, egg or chick with a flashlight. Auklet nests on Rat Rock found in 2003-05 could not be monitored again in 2008 because of nesting Brandt's Cormorants (*Phalacrocorax penicillatus*) above these sites.

Nesting Success - Hatching success was 83% over the entire island (n = 30; Table 2), with 89% in sea caves (n = 19; Table 3) and 73% in other plots (n = 11; Table 3). Calculations of hatching success did not include Landing Cove Nest #10 where monitoring activities resulted in falling rocks that crushed a clutch of two fresh but unattended eggs. Hatched eggshells were observed in all 25 successful sites, although one site (Landing Cove Nest #2) contained one hatched and one depredated eggshell (Fig. 5). This depredated egg likely was scavenged by mice after the family group departed from the nest. Brooding adults with chicks were observed in three sites. Dead chicks were not observed in or near any nest sites and all chicks were assumed to have successfully departed from the nest.

Excluding the nest disturbed by monitoring activity, only five failed nests (17%; n = 30) were recorded at Anacapa in 2008 (Tables 1 and 2). Two nests (7%) failed due to abandonment, another two nests (7%) were usurped by Pigeon Guillemots, and one nest (3%) was assumed to have been depredated by endemic Deer Mice (*Peromyscus maniculatus anacapae*).

One of the abandoned clutches was a single egg was laid in an open site on the cave floor in Lonely at the Top Cave. This egg was found less than one meter from a site (Nest #3) that had hatched in both 2006 and 2007. The site was not active in 2008, but the unsexable carcass of a raptor-depredated murrelet was found within a meter of this site two weeks prior to discovery of the abandoned egg. We suspect the abandoned egg was laid in an unsuitable nest site after the female of the pair "recognized" depredation of the male mate. The other abandoned site was a single egg in Landing Cove Nest #5. This egg was likely abandoned shortly after lay due to Western Gulls that established a nest at the entrance to the crevice site before the murrelet pair had commenced incubation.

The two murrelet nests usurped by Pigeon Guillemots were: a) a two-egg clutch in Keyhole Cave Nest #2 (Fig. 6); and b) a two egg clutch in Landing Cove Nest #7. An incubating murrelet was observed in the latter nest on 1 May, but on 12 May a guillemot flushed from the crevice when we approached and found two murrelet eggs ejected from the nest. We replaced the eggs in the nest, but a single egg was found ejected from the site on the next check. We assumed the nest was likely usurped by guillemots, although guillemot nesting was not directly observed nearby.

The only depredated nest (Landing Cove Nest #4) in 2008 was assumed to have been depredated by endemic Deer Mice. An incubating murrelet was present in the narrow crevice on 1 May (*see cover photo*), but the site was empty on 12 May. Although broken eggshell fragments were found in a shallow crevice on a ledge less than 1 meter below the site on 12 May, these fragments could not have fallen onto the lower ledge from Nest #4. We assumed the eggs had been depredated by mice and moved into the shallow crevice below, even though bite marks were not evident on the eggshell fragments.

Timing of Breeding - Murrelet clutches were initiated over 75 days between 15 March and 29 May, with a mean nest initiation date of 13 April (± 20 d; Table 5, Fig. 7). Peak egg laying occurred in early April, although relatively high numbers of nests were initiated from mid-March through late April. Only four nests were initiated in May.

Inter-Annual Comparisons in Sea Caves (2000-08)

Nesting Effort and Occupancy – In 2008, we recorded the highest number of nesting attempts in sea caves (n = 19 clutches), matched only in 2005. However, nesting effort and nest occupancy in sea caves appears to have leveled off in 2005-08 (Figs. 8-9), as the number of occupied sites and nesting attempts has varied within narrow ranges (16-18 sites; 52-58% occupancy; 16-19 nesting attempts) since 2005. For the first time since monitoring began in 2000, no new nest sites were discovered in sea caves in 2008 (Table 3). In 2004-07, about 1-

3 new sites per year were found in sea caves. In 2003, the first murrelet breeding season after eradication, a higher increase of 8 sites occurred over 2002 (Table 3).

Post-eradication, the number of monitored sites in sea caves has increased 94% from 16 sites in 2002 to 31 sites in 2008 (Table 3). The mean annual number of nesting attempts has increased 58% between pre-eradication years (2000-02; mean 10.3 nests/year) and post-eradication years (2003-08; mean 16.3 nests/year). Nest occupancy was consistently low pre-eradication (range 29-35%), but has increased markedly post-eradication (range 35-58%; Table 3).

Nesting Success - In 2008, we recorded the highest number of hatched nests (n = 17) and hatching success (89%; also in 2007) since monitoring began, although hatching success has been consistently high (range 73-89%) since 2002 (Table 3; Fig. 10). Overall hatching success (excluding nests with unknown fates) in sea caves post-eradication (84%; n = 96) has been much higher ($\chi^2 = 16.12$, $P < 0.0001$) than pre-eradication (44%; n = 27).

Post-eradication nest failures in sea caves (n = 15 failed nests) have been attributed to nest abandonment (67%), Pigeon Guillemot nest disturbance (20%) and mammalian (i.e., mouse) depredation (13%). In contrast, nest failures pre-eradication (n = 15 failed nests) were due primarily to depredation by rats (87%), with only two (13%) failed nests due to abandonment (Table 3). Abandoned nests have occurred consistently since 2001 (range = 5-20%), with 1-3 abandoned nests each year (Table 3). Single usurped nests in sea caves (all attributed to Pigeon Guillemots in Keyhole Cave; *see Discussion*) occurred in 2003, 2007 and 2008. The only depredated nests documented in sea caves post-eradication both occurred in 2004: a) a depredated adult and egg (perhaps scavenged after the adult was killed) in Lonely at the Top Cave Nest #1; and b) a broken egg in Nest #1 at Lave Bench Cave #2.

Colony Expansion (2003-08)

Post eradication (2003-08), a total of 42 nesting attempts (including one clutch in a site destroyed by a landslide in winter 2004-05) in 17 monitored sites were found during nest searches in plots outside of sea caves, where none were known prior to 2003 (Table 4). The number of monitored sites in these plots has increased from two sites in 2003 to 17 sites in 2008, while nesting effort has increased from two clutches in 2003 to 12 clutches in 2008. Nest occupancy in sites outside sea caves increased steadily from 17% to 71% over this period (Fig. 9). Colony expansion has been more evident in the Landing Cove and Rockfall Cove plots, where the number of monitored sites increased from one site in 2003 to 11 sites in 2008, and from two sites in 2005 to 5 sites in 2008, respectively. In contrast, the Cat Rock plot has remained at only one monitored site since 2003, and this site was not occupied in 2008 after being active in four of the last 5 years.

Overall hatching success in these plots has been 78%, with only 22% failed (n = 41 nests). Hatching success has been higher at Cat Rock (100%) and Rockfall Cove (90%), compared to Landing Cove (73%), but low sample sizes preclude statistical testing of any differences. Nest failures in plots outside sea caves (n = 9 failed nests) have been due primarily to abandonment (67%), with only two depredated or scavenged nests (22%) and one nest usurped by Pigeon Guillemots (11%). Both depredated clutches occurred in the same site (Landing Cove Nest #4) in 2007 and 2008.

Timing of Breeding (2000-08)

The overall mean nest initiation date over the past nine breeding seasons was 23April (± 17 d) with annual mean nest initiation dates ranging from 30 March (± 11 d) in 2000 to 20 May (± 29 d) in 2007 (Table 5). The earliest individual lay date occurred in 2002 (7 March) and the latest in 2007 (8 July). The widest range of lay dates within a single year occurred in 2007 (112 days), while the narrowest range of lay dates occurred in 2000 (29 days).

Nesting in Individual Sites

Since 2000, nesting has been noted at least once in all but one (i.e., Nest #2 marked in Refuge Cave in 1994) monitored site. Four sites in sea caves had nest attempts every year from 2000 to 2008, while one site was active 8 years (Table 6). These five sites (3 in Moss Cave and one each in Lava Bench Cave #2 and Respiring Chimney Caves) together accounted for 16% of monitored sites in sea caves, but 46% of all hatched nests documented in sea caves from 2000 to 2008.

Excluding three new sites found in 2008, 14 sites have been active each year since nesting was first documented in those sites (Table 6), including sites active each of the last 9 years (4 sites), 6 years (one site), 5 years (one site), 4 years (3 sites) and 3 years (one site). Four of 6 new sites established in 2007 were also active in 2008.

DISCUSSION

Xantus's Murrelet Recovery at Anacapa Island

Further strong evidence of continued improvement in reproductive success and colony growth was obtained at Anacapa Island in 2008, six years after eradication of Black Rats in December 2002. Highest nest occupancy (60%) and numbers of nests (n = 31 clutches) were observed since monitoring began in 2000. Pre-eradication and post-eradication comparisons in sea caves continued to provide convincing evidence of beneficial effects of rat eradication, with hatching success of Anacapa murrelets nearly doubling from 44% pre-eradication (2000-02) to 84% post-eradication (2003-08). In addition, egg depredation has been almost entirely eliminated as a cause of nest failure. The improvement in hatching success was particularly striking in Refuge Cave on Middle Anacapa where all four pre-eradication clutches failed, whereas all nine post-eradication clutches hatched.

Continued colony expansion outside sea caves demonstrated that murrelets are gradually responding to improved breeding conditions. Outside sea caves, murrelets seldom attempted to breed prior to eradication, but the number of murrelet nests found in Landing Cove from 2003-08 and in Rockfall Cove from 2005-08 has increased steadily each year. Meanwhile, the first documented Cassin's Auklet nest in Landing Cove provided evidence of improved breeding conditions for other vulnerable crevice nesting species in the absence of rats.

Most of the increase in numbers of murrelet nests found and monitored at Anacapa post-eradication occurred outside sea caves. The maximum number of clutches laid in sea caves from 2004-08 (n = 19 clutches in 2005 and 2008) represented only a 27% increase compared to 2003 (n = 15 clutches in the first post-eradication breeding season). Outside sea caves, we documented much greater increases in the number of clutches laid over the same period (2 clutches in 2003 compared to 12 in 2008). Similar colony expansion and increase in numbers of nesting murrelets, auklets and perhaps Ashy Storm-petrels (*Oceanodroma homochroa*) may be occurring in suitable cliff, shoreline and upper-island habitats throughout Anacapa, but greater research and monitoring effort (involving spotlight surveys, radar surveys, mist-net captures, and expanded nest searches) are needed to document such expansion in areas that are not currently monitored.

Only 24 failed nests have been recorded at Anacapa Island in six years of post eradication monitoring, compared to 15 failed nests in three pre-eradication years. Most (67%) post-eradiation failed fates were classified as abandoned and in recent years a slight increase in the number of abandoned nests has occurred at the Anacapa Island. Although one clutch in Landing Cove was impacted by monitoring activity in 2008, researcher disturbance has had minimal effects on breeding success at Anacapa. Adult murrelets were never observed in 13 (72%) of 18 abandoned nests found in 2000-08 and we have yet to cause any incubating adults to flush during monitoring.

The post-eradication period of high hatching success at Anacapa may be a temporary phase as the island returns to a natural equilibrium following the removal of rats. Nest failure rates may increase as the natural relationships are established between murrelets, the re-introduced Deer Mouse population (eradicated concurrently with rats in 2001-02), plant communities (alternate food sources for mice), avian predators, and nest competitors. Although overall hatching success at Anacapa was again high in 2008, some difference was noted between sea caves (89%) and other plots (73%), as also noted in 2007. Protected sea caves may constitute better breeding habitat where hatching success is enhanced by reduced avian and mammalian depredation (Whitworth et al. 2008a). Considering the almost total lack of documented nesting outside sea caves prior to rat eradication, Anacapa sea caves likely served as refugia that permitted the survival of the murrelet colony during the period when rats occupied the island (McChesney et al. 2000).

Nest Fates at Anacapa Island

Hatched Nests - Determination of Xantus's Murrelet nest fates at Anacapa Island is easiest for successful nest sites, where hatched eggshell fragments usually remain in the site for several weeks or months after family groups depart. Hatched eggshell fragments were found in all 25 hatched sites in 2008, and 98% of hatched sites from 2000-08 (n = 125). In two sites where hatching was assumed without evidence of hatched eggshell fragments (i.e., deep crevice sites in Landing Cove and Aerie Cave in 2007), incubating murrelets were documented for a minimum of 40 days after estimated nest initiation dates. We suspect that hatched eggshells were not visible in these sites because the birds had moved them farther back in the crevice and out of view. As a matter of protocol, whenever possible we removed hatched eggshell fragments from sites after chicks departed the nest to reduce confusion with any following clutches in that or future years. Fragments can persist for several months or years if not removed. In fact, hatching of three very late nesting efforts (one each in 2004, 2005 and 2007) was not confirmed until hatched eggshell fragments were found the following breeding season.

Unknown Nest Fates – In contrast, assessing fates for nests with missing eggs can be a more difficult process, with multiple interpretations often possible from available data. Missing eggs could result from egg predation by mammalian predators (i.e., rats prior to 2003 or mice), egg ejection by inter- or con-specific nest competitors, and displacement of eggshell fragments caused by murrelet activity in cramped crevices. Determining nest fates has been particularly problematic for five nests in 2000-03 where the inconclusive monitoring data has been interpreted using different criteria (*see below*). All five nests contained no definitive evidence of either hatched or broken eggs after relatively long periods of documented incubation (minimum 20-36 days). Original fates assigned to these nests in annual reports (Whitworth et al. 2002a,b, 2004a) differed from a reassessment (Whitworth et al. 2005a) where certain fates were lumped together in order to increase sample sizes and demonstrate potential impacts of rats using all data that likely reflected rat depredation. However, to achieve more consistent assessments of nest fates at Anacapa Island between years, we again assessed monitoring data for all sites (2000-08) using the following criteria: a) unknown nest fates were assigned to all nests where long-term incubation was observed but egg(s) went missing; and b) hatched eggshells must be present in fully visible crevices for a site to be considered hatched. In this current reassessment, we considered the available data for these five sites to be inconclusive and reclassified the nest fates as unknown:

- Lava Bench Cave #1 Nest #1 (2000) – near full-term incubation was documented (incubating adults observed for a minimum of 36 days) but no hatched eggshells were found after an extended period between the last two monitoring checks (over two months). We originally concluded that this nest hatched and this fate did not change during the first reassessment. However, the presence of a depredated egg near the site during the incubation period suggested that site could have been depredated, thus nest fate was changed to unknown in the second reassessment.

- Moss Cave Nest #3 (2000) – less than full-term incubation was documented (incubating murrelets observed for a minimum of 20 days) for this late nest, but no hatched eggshells were found in July (more than two months after the previous check). We originally concluded that data were insufficient to reliably determine nest fate but later concluded during the first reassessment that the lack of hatched eggshells presumably reflected removal by rats and nest fate was reclassified as depredated. During this second reassessment, nest fate was returned to unknown fate.

- Moss Cave Nest #1 (2001) – near full-term incubation was documented (fresh eggs or incubating murrelets observed for a minimum of 36 days), but no eggshell fragments were found. We originally concluded that data were insufficient to reliably determine nest fate but, in the first reassessment, the lack of hatched eggshells presumably reflected removal by rats and nest fate was reclassified as depredated. During the second reassessment, data were again judged inconclusive to confirm nest fate.

- Moss Cave Nest #3 (2001) – close to full-term incubation was documented (incubating adults observed for a minimum of 24 days), but a single dead chick was found within eggshell fragments. We originally concluded that data were insufficient to determine whether the egg had hatched or was broken by predators prior to hatch. In the first reassessment, fates of nearby nests and lack of definitely hatched eggshells was assumed to reflect depredation by rats. During this second reassessment, data were again judged inconclusive to confirm nest fate.

- Aerie Cave Nest #2 (2003) – close to full-term incubation was documented (two eggs and incubating adults observed for 26 days), but on subsequent visits only one intact egg was found. We originally concluded that available data were insufficient to reliably determine nest fate. In the first reassessment, the intact egg led us to conclude that the clutch had been abandoned and the second egg removed by murrelets or mice. In this second reassessment, we have reclassified nest fate as unknown because depredated or hatched eggshell fragments could have been removed from the site.

The main consequences of these reevaluated nest fates were: a) an increase in the number of clutches with unknown nest fates that were excluded from analyses of hatching success; and b) possible understating of the degree of predation by rats. Most changes (4 of 5) applied to pre-eradication nests, but had only a small effect on measures of pre-eradication hatching success (44% versus 42% previously) or depredation level (48% versus 52% previously). In any case, pre-eradication depredation rates were underestimated because many depredated eggs not associated with known nest sites were found in sea caves but were excluded from analyses of hatching success and numbers of nest sites. Changing the fate of one 2003 clutch from abandoned to unknown did not affect the post-eradication abandonment rate (12%).

<u>Usurped Nests</u> - In light of several broken and ejected eggs caused by Pigeon Guillemots in 2008, we added usurped nests as a potential nest fate and reexamined 2000-07 data for all nests to identify sites likely disturbed by guillemots. Our reassessment resulted in nest fates changed from depredated to usurped for two clutches:

- Keyhole Cave Nest #1 (2003) - two eggs observed in Nest #1 in early to mid-May were broken and ejected in late May, after which a single guillemot egg was laid in the site, indicating usurping by Pigeon Guillemots rather than depredation was the most likely nest fate.

- Keyhole Cave Nest #2 (2007) - broken murrelet eggs were found outside the site on two occasions. The site was located less than one meter from a relatively open Pigeon Guillemot nest along the cave wall, suggesting usurping by guillemots rather than depredation for nest fate.

Changing fates of these two clutches from depredated to usurped had little effect on post-eradication nest depredation rates (3% versus 4% previously). For all nests in 2000-08, Pigeon Guillemots have: a) disturbed three active murrelet clutches (2003, 2007, 2008) and usurped two sites in Keyhole Cave; b) usurped two previously used murrelet sites in Aerie Cave (Nests #1-2) without disturbing active clutches; and c) disturbed an active murrelet clutch in Landing Cove in 2008 without yet usurping the site (Nest #7). Currently, nesting Pigeon Guillemots have not affected murrelet breeding in other monitored areas at Anacapa. However, colony expansion by guillemots and other crevice nesting species (i.e., auklets and storm-petrels) at Anacapa might result in an increase in nest site competition and usurping of murrelet sites in the near future. The establishment of Cassin's Auklet nests in Landing Cove in 2008 and Rat Rock in 2003 indicated a developing potential for overlap in breeding habitats and future nest site competition between murrelets and auklets. To date, no storm-petrel nests have been located on Anacapa Island but birds have been documented visiting the island (Hamer and Meekins 2000; Carter et al. 2008).

Future Murrelet Monitoring at Anacapa

In fall 2007, the ATTC and CINP decided to continue funding for Xantus's Murrelet nest monitoring by CIES through the 2010 breeding season. Continuation of the current nest monitoring program in sea caves and selected shoreline plots is desirable for continued standardized documentation of improved breeding conditions at Anacapa Island during the early period of colony restoration. Identifying resources for continuing the Anacapa monitoring program beyond 2010 is also desirable. Although, the Xantus's Murrelet is a California state threatened species, Anacapa and Santa Barbara Islands are currently the only southern California colonies with ongoing murrelet monitoring programs. Two Santa Barbara Island nest plots (Cat Canyon and Nature Trail) have been monitored since 1975 and have provided most long-term knowledge of breeding biology of this species (Murray et al. 1983, Drost and Lewis 1995, Schwemm and Martin 2005). However, numbers of active sites in these plots have been declining and the Nature Trail plot has not been accessible for monitoring since 2004 when Brown Pelicans (*Pelecanus occidentalis*) began nesting at this location. We suggest that long-term monitoring also should occur at Anacapa Island, both to continue to monitor restoration success and as a substitute for Santa Barbara Island for long-term knowledge on breeding biology of the species.

A more extensive survey of accessible upper island, cliff and shoreline habitats of East, Middle and West Anacapa is also being planned for 2009 or 2010. Most upper island areas have not been searched since 1997 (McChesney et al. 2000) and an update is needed on the extent to which crevice-nesting species (e.g., Xantus's Murrelets, Cassin's Auklets, and Ashy Storm-Petrels) are now using these previously unoccupied habitats. To prevent disturbance to surface-nesting Brown Pelicans, Double-crested Cormorants (*Phalacrocorax auritus*), and Brandt's Cormorants surveys of upper habitats at Middle and West Anacapa will be conducted in the fall as done in 1997 (McChesney et al. 2000). These surveys will primarily involve extensive searches for eggshell fragments in accessible habitats.

ACKNOWLEDGMENTS

Funding for Xantus's Murrelet nest monitoring work at Anacapa Island in 2008 was provided to the California Institute of Environmental Studies by the American Trader Trustee Council (S. Hampton, J. Boyce, and C. Gorbics) and Channel Islands National Park (K. Faulkner). We are extremely grateful to: a) Captain D. Carlson and Co-Captain B. Willhite who provided most vessel support in 2008 aboard the private charter vessel *Retriever*; and b) excellent captains and crew of the R/V *Shearwater* (L. Moody, T. Shinn, B. McDuffy, C. Lara and D. Carlson) operated bythe Channel Islands National Marine Sanctuary (CINMS) for additional vessel support. Additional in-kind support, permits, and assistance were provided by CINMS (C. Mobley and D. Lipski), Channel Islands National Park (K. Faulkner and T. Coonan), California Department of Fish and Game (E. Burkett), and Carter Biological Consulting. We greatly appreciated field assistance from P. Hébert, S. Bailey, D. Carlson, B. Willhite, and I. Austin.

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Table 1. Number of monitored nests and nest fates for Xantus's Murrelets at Anacapa Island in 2008.

Sea Cave/ Plot	Monitored Sites	Occupied Sites	Nesting Attempts	Hatched Nests	Depredated Nests	Abandoned Nests	Usurped Nests
Refuge	5	2	3[a]	3	0	0	0
Lava Bench #1	3	1	1	1	0	0	0
Lava Bench #2	1	1	1	1	0	0	0
Respiring Chimney	3	2	2	2	0	0	0
Lonely at the Top	3	1	2[b]	1	0	1	0
Confusion	0	0	0	0	0	0	0
Pinnacle	5	3	3	3	0	0	0
Moss	4	4	4	4	0	0	0
Aerie	5	2	2	2	0	0	0
Keyhole	2	1	1	0	0	0	1
Sea Cave Total	31	17	19[ab]	17	0	1	1
Cat Rock	1	0	0	0	0	0	0
Rockfall Cove	5	4	4	4	0	0	0
Landing Cove	11	8	8	4	1	1	2[c]
Plot Total	17	12	12	8	1	1	2
Anacapa Total	48	29	31	25	1	2	3

[a]Nesting efforts by different pairs occurred in one site in Refuge cave.
[b]A single egg on cave floor was considered a nesting attempt for calculations of hatching success but was not tagged and was excluded from occupancy analyses (*see methods*).
[c]Includes one clutch destroyed by falling rocks during monitoring activities and classified as a nest with an unknown fate for calculations of hatching success (see Tables 1 and 3).

Table 2. Breeding indices for Xantus's Murrelets (all monitored sites) at Anacapa Island pre- and post-eradication.

	Pre-Eradication				Post-Eradication						
	2000	2001	2002	**2000-02**	2003	2004	2005	2006	2007	2008	**2003-08**
Tagged Sites	13	15	16	**16**	26	29[a]	36	39	45	48	**48**
Potential Sites	31	31	31	**31**	43	44	48	48	48	48	**48**
Occupied Sites (Occupied/Potential)	9 29%	11 35%	10 32%	**32%**	17 40%	13 30%	25 52%	23 48%	27 56%	29 60%	**48%**
Nest attempts	7(9)[c]	9(11)[c]	11[b]	**27(31)[c]**	16(17)[c]	13	27[b,d]	22(23)[b]	29[d]	30(31)[b,c,d]	**137(140)[c]**
Hatched (Hatched/Nest attempts)	6 86%	2 22%	4 36%	**12** **44%**	14 88%	9 69%	24 89%	18 82%	23 79%	25 83%	**113** **82%**
Depredated (Depredated/Nest attempts)	1 14%	6 67%	6 55%	**13** **48%**	0	2 15%	0	0	1 3%	1 3%	**4** **3%**
Abandoned (Abandoned/Nest attempts)	0	1 11%	1 9%	**2** **7 %**	1 6%	2 15%	3 11%	4 18%	4 14%	2 7%	**16** **12%**
Usurped (Usurped/Nest Attempts)	0	0	0	**0**	1 6%	0	0	0	1 3%	2 7%	**4** **3%**
Unknown Fate	2	2	0	**4**	1	0	0	1	0	1	**3**

[a]Includes one tagged site found in 2004, but destroyed by a landslide in winter 2004-05 and excluded from later analyses of nest depredation and abandonment.
[b]Nesting attempts by different pairs of adults occurred in one site in 2002, one site in 2005, two sites in 2007 and one site in 2008 (*see methods*).
[c]Nests with an unknown fate (including one site disturbed by monitoring activity in 2008) were included in occupancy analyses but excluded from calculations of hatching success in 2000, 2001, 2003, 2006 and 2008.
[d]Eggs on cave floor (one in 2005 and one in 2008) in marginal nest sites were considered nesting attempts for calculations of hatching success but were not tagged and were excluded from occupancy analyses (*see methods*).

Table 3. Breeding indices for Xantus's Murrelets (sea caves) at Anacapa Island pre- and post-eradication.

	Pre-Eradication				Post-Eradication						
	2000	2001	2002	**2000-02**	2003	2004	2005	2006	2007	2008	**2003-08**
Tagged Sites	13	15	16	**16**	24	25	27	28	31	31	**31**
Potential Sites	31	31	31	**31**	31	31	31	31	31	31	**31**
Occupied Sites (Occupied/Potential)	9 29%	11 35%	10 32%	**32%**	15 48%	11 35%	17 55%	16 52%	18 58%	17 55%	**51%**
Nest attempts	7(9)[c]	9(11)[c]	11[a]	**27(31)**[c]	14(15)[c]	11	19[a,b]	15(16)[c]	18	19[a,b]	**96(98)**[c]
Hatched (Hatched/Nest attempts)	6 86%	2 22%	4 36%	**12 44%**	12 86%	8 73%	16 84%	12 80%	16 89%	17 89%	**81 84%**
Depredated (Depredated/Nest attempts)	1 14%	6 67%	6 55%	**13 48%**	0	2 18%	0	0	0	0	**2 2%**
Abandoned (Abandoned/Nest attempts)	0	1 11%	1 9%	**2 7 %**	1 7%	1 9%	3 16%	3 20%	1 6%	1 5%	**10 10%**
Usurped Usurped/Nest Attempts)	0	0	0	**0**	1 7%	0	0	0	1 6%	1 5%	**3 3%**
Unknown Fate	2	2	0	**4**	1	0	0	1	0	0	**2**

[a]Nesting attempts by different pairs of adults occurred in one site in 2002, one site in 2005 and one site in 2008 (*see methods*).
[b]Eggs on cave floor (one in 2005 and one in 2008) were considered nesting attempts for calculations of hatching success but were not tagged and were excluded from occupancy analyses (*see methods*).
[c]Nests with an unknown fate in 2000, 2001, 2003 and 2006 were included in occupancy analyses but excluded from calculations of hatching success.

Table 4. Breeding indices for Xantus's Murrelets (plots outside sea caves) at Anacapa Island post-eradication.

	2003	2004	2005	2006	2007	2008	**2003-08**
Tagged Sites	2	4[a]	9	11	14	17	**17**
Potential Sites	12	13	17	17	17	17	**17**
Occupied Sites (Occupied/Potential)	2 17%	2 15%	8 47%	7 41%	9 53%	12 71%	**43%**
Nest attempts	2	2	8	7	11[b]	11(12)[c]	**41(42)**[c]
Hatched (Hatched/Nest attempts)	2 100%	1 50%	8 100%	6 86%	7 64%	8 73%	**32** **78%**
Depredated (Depredated/Nest attempts)	0	0	0	0	1 9%	1 9%	**2** **5%**
Abandoned (Abandoned/Nest attempts)	0	1 50%	0	1 14%	3 27%	1 9%	**6** **15%**
Usurped (Usurped/Nest Attempts)	0	0	0	0	0	1 9%	**1** **2%**
Unknown Fate	0	0	0	0	0	1[c]	**1**

[a]Includes one tagged site found in 2004, but destroyed by a landslide in winter 2004-05 and excluded from later analyses.
[b]Nesting attempts by different pairs of adults occurred in two sites in 2007 (*see methods*).
[c]Clutch destroyed by falling rocks during monitoring activities in 2008 was classified as a nest with an unknown fate and included in occupancy analyses but excluded from calculations of hatching success.

Table 5. Timing of breeding for Xantus's Murrelet nests at Anacapa Island in 2000-08.

Year	Mean Initiation Date	Standard Deviation	Range (Dates)	Range (Days)	No. of Nests
2000	3 April	11	17 March - 24 April	38	9
2001	13 April	13	30 March - 5 May	36	11
2002[a]	10 April	16	7 March - 2 May	56	11
2003	11 April	12	27 March - 5 May	39	17
2004	2 May	21	6 April - 2 June	58	11
2005[a]	2 May	14	11 April - 2 June	52	26
2006	17 May	24	8 April – 20 June	73	22
2007[a]	20 May	29	18 March – 8 July	112	29
2008[a]	13 April	20	15 March - 29 May	75	30

[a]Includes both initiation dates for nests with two clutches in the same site.

Table 6: Use of specific monitored Xantus's Murrelet nest sites in sea caves on Anacapa Island in 2000-08. Hatched clutches are indicated by ⚫; abandoned clutches by 🔴; depredated clutches by 🔵; usurped clutches by 🟢; and unknown fate by ⚪.

Cave or Plot	Nest #	2000	2001	2002	2003	2004	2005	2006	2007	2008	Years Active
Refuge	1		🔵				⚫	⚫	⚫	⚫⚫	5
	3			🔴							1
	4	🔵	🔵								2
	5						⚫	⚫	⚫	⚫	4
Lava Bench 1	1	⚪		🔵	⚫	⚫	⚫(🔴[1])	⚪			6
	2								⚫	⚫	2
	3								🔴		1
Lava Bench 2	1	⚫	🔵	🔵	⚫	🔵	⚫	⚫	⚫	⚫	9
Respiring Chimney	1	⚫	⚫	🔵⚫	⚫	⚫	⚫⚫	⚫	⚫	⚫	9
	2		🔴	🔵	⚫		🔴				4
	3		🔵					⚫	⚫	⚫	4
Lonely at the Top	1				⚫	🔵					2
	2				⚫	⚫	⚫	⚫	⚫	⚫	6
	3							⚫	⚫	(🔴[1])	2
Pinnacle	1		⚫							⚫	2
	2				⚫	🔴	⚫	⚫	⚫		5
	3				⚫		🔴				2
	4					⚫	⚫	🔴		⚫	4
	5								⚫	⚫	2
Moss	1	⚫	⚪	⚫	⚫	⚫	⚫		⚫	⚫	8
	2	⚫	🔵	⚫	🔴	⚫	⚫	⚫	⚫	⚫	9
	3	⚪	⚪	⚫	⚫	⚫	⚫	⚫	⚫	⚫	9
	4				⚫		⚫	⚫	⚫	⚫	5
Aerie	1	⚫	🔵	🔵							3
	2				⚪						1
	3				⚫	⚫	⚫		⚫	⚫	5
	4						⚫	🔴			2
	5	⚫		🔵				🔴	⚫	⚫	5
Keyhole	1				🟢						1
	2						⚫	⚫	🟢	🟢	4

[1]Abandoned egg on cave floor near site was included in calculations of hatching success only (*see methods*).

Table 7: Use of specific monitored Xantus's Murrelet nest sites in shoreline, cliff and offshore rock plots on Anacapa Island in 2000-08. Hatched clutches are indicated by ●; abandoned clutches by 🔴; depredated clutches by 🔵; usurped clutches by 🟢; and unknown fate by ⚪. Shaded cells indicate years monitoring was not conducted in those plots.

Plot	Nest #	2000	2001	2002	2003	2004	2005	2006	2007	2008	Years Active
Landing Cove	1				●						1
	2					●	●	●	●🔴	●	5
	3						●	●		●	3
	4						●		🔵●	🔵	3
	5						●			🔴	2
	6						●	●	●		3
	7							●	●	🟢	3
	8							🔴			1
	9								🔴	●	2
	10									⚪	1
	11									●	1
Rockfall Cove	1						●			●	2
	2						●	●	●	●	4
	3								🔴		1
	4								●	●	2
	5									●	1
East Fish Camp	1					🔴	Site Destroyed				1
Cat Rock	1				●		●	●	●		4

Figure 1. Breeding range of the Xantus's Murrelet indicating locations of confirmed breeding islands, based on surveys in 1991-2007 (H.R. Carter and D.L. Whitworth, unpubl. data).

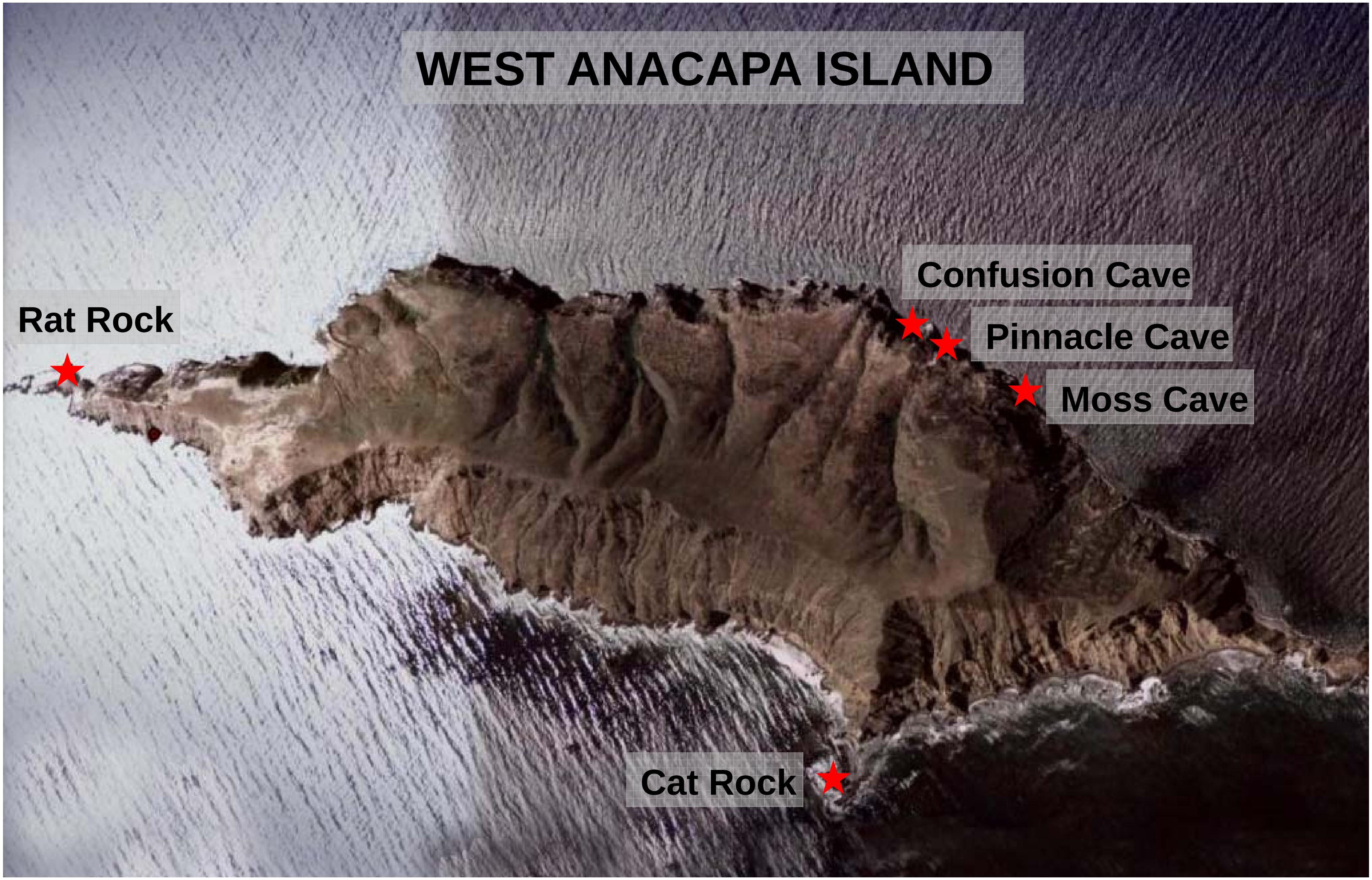

Figure 2. Satellite photograph of West Anacapa Island illustrating locations of sea caves and other areas where Xantus's Murrelet monitoring has been conducted from 2000-08.

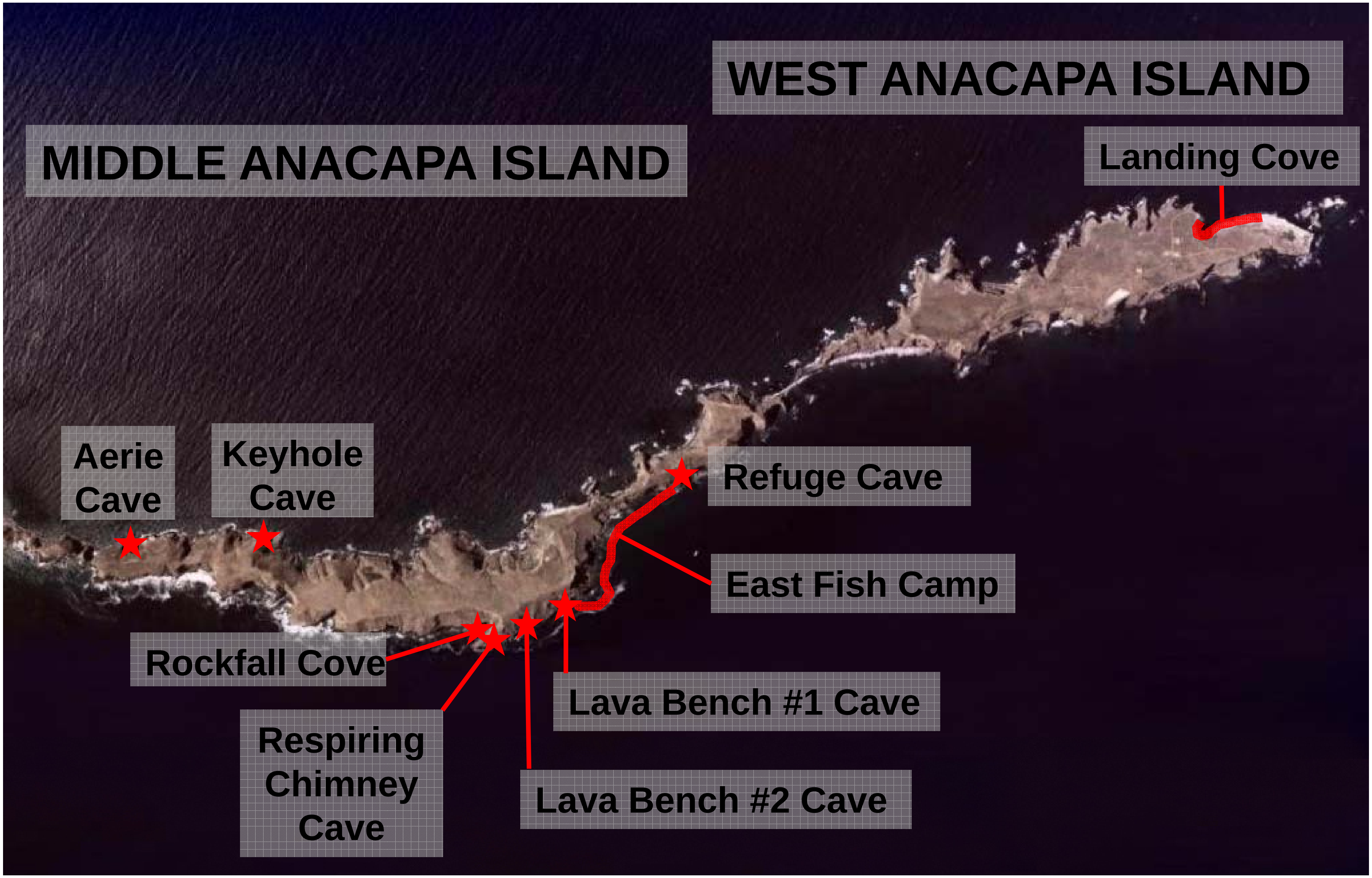

Figure 3. Satellite photograph of East and Middle Anacapa Islands illustrating location of sea caves and other areas where Xantus's Murrelet monitoring has been conducted from 2000-08.

Figure 4. Hatched eggshells at Respiring Chimney Cave Nest #1 on 29 May 2008, illustrating characteristic dried or bloody membranes which separate from the eggshell (Photo by D.L. Whitworth).

Figure 5. Hatched and depredated eggshells at Landing Cove Nest #2 on 12 May 2008, illustrating dried membrane which separated cleanly from the hatched eggshell (bottom), and mouse bite marks and yolk on the depredated eggshell (top). (Photo by D.L. Whitworth).

Figure 6. Adult Pigeon Guillemot in incubating posture in Keyhole Cave Nest #2 on 12 May 2008, with two ejected Xantus's Murrelet eggs visible. (Photo by D.L. Whitworth)

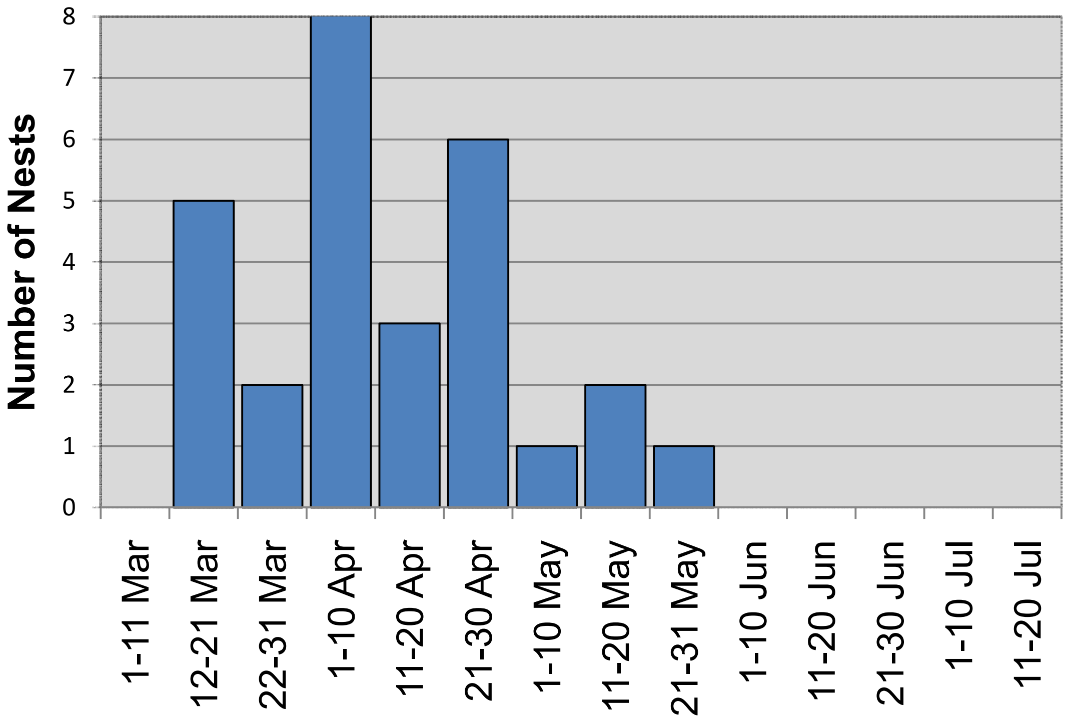

Figure 7. Distribution of clutch initiation dates for Xantus's Murrelets at Anacapa Island in 2008.

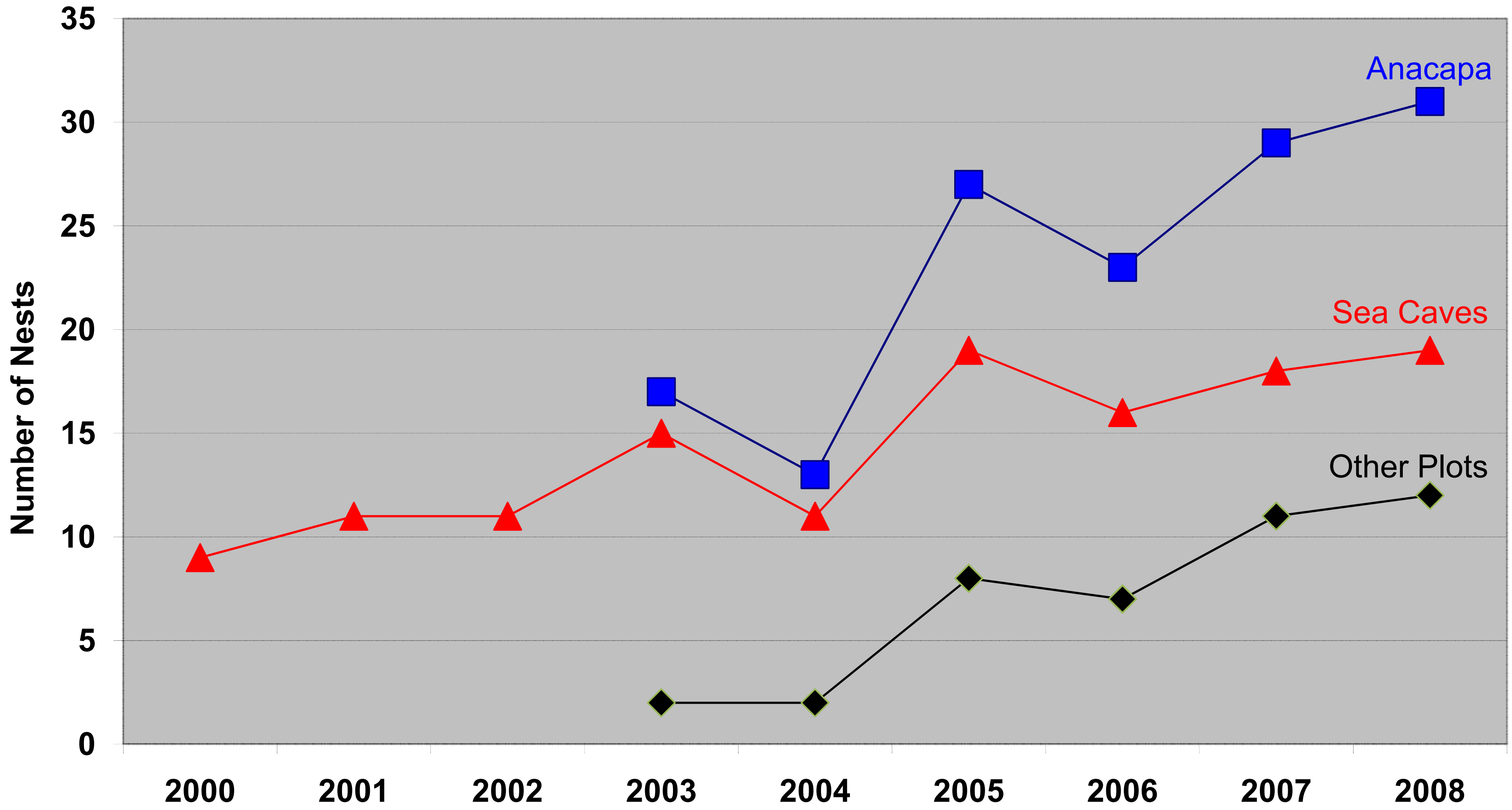

Figure 8. Numbers of Xantus's Murrelet nests initiated in sea caves, other plots, and all monitored sites at Anacapa Island, 2000-08.

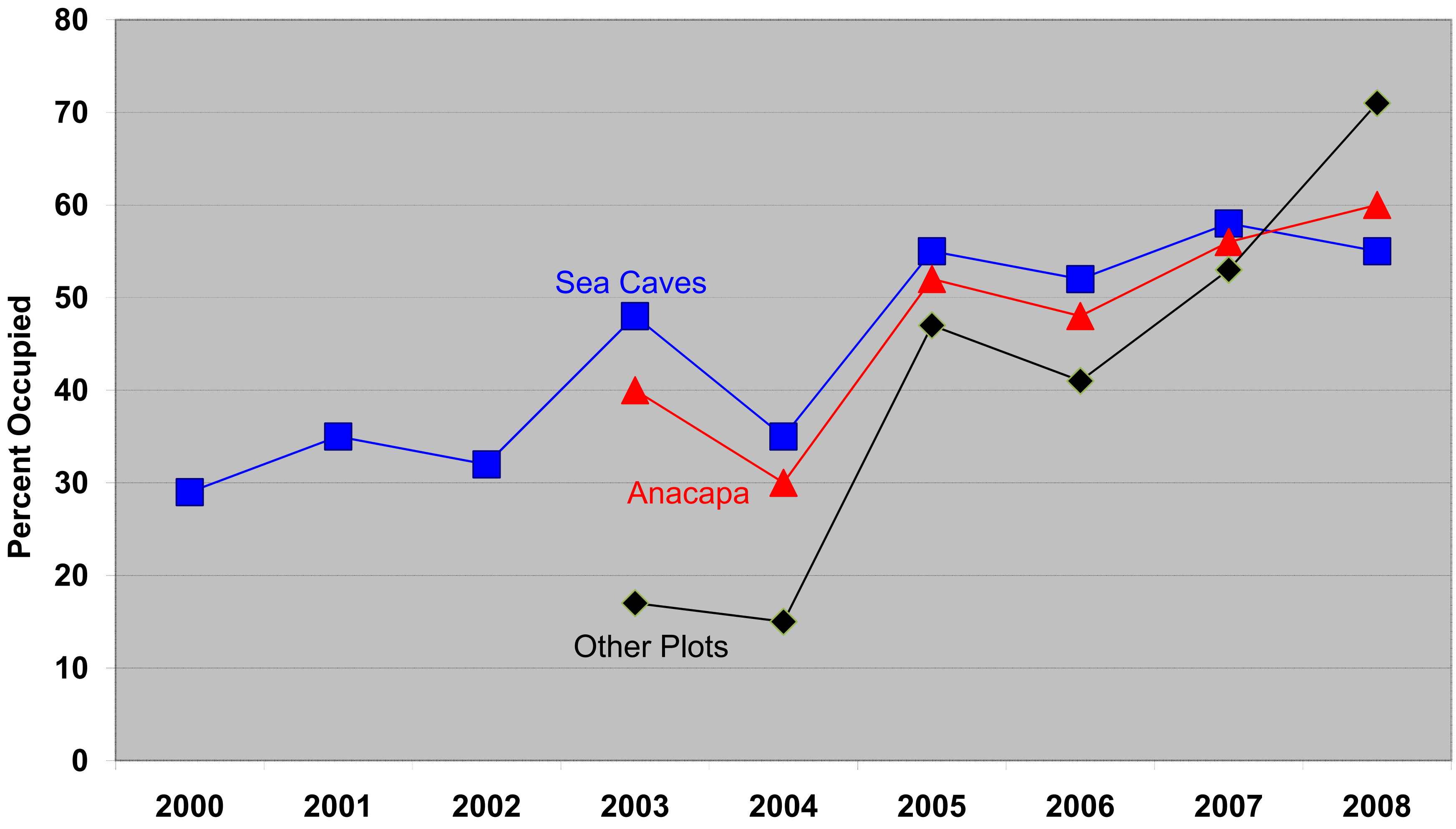

Figure 9. Xantus's Murrelet nest occupancy in sea caves, other plots, and all monitored sites at Anacapa Island, 2003-08.

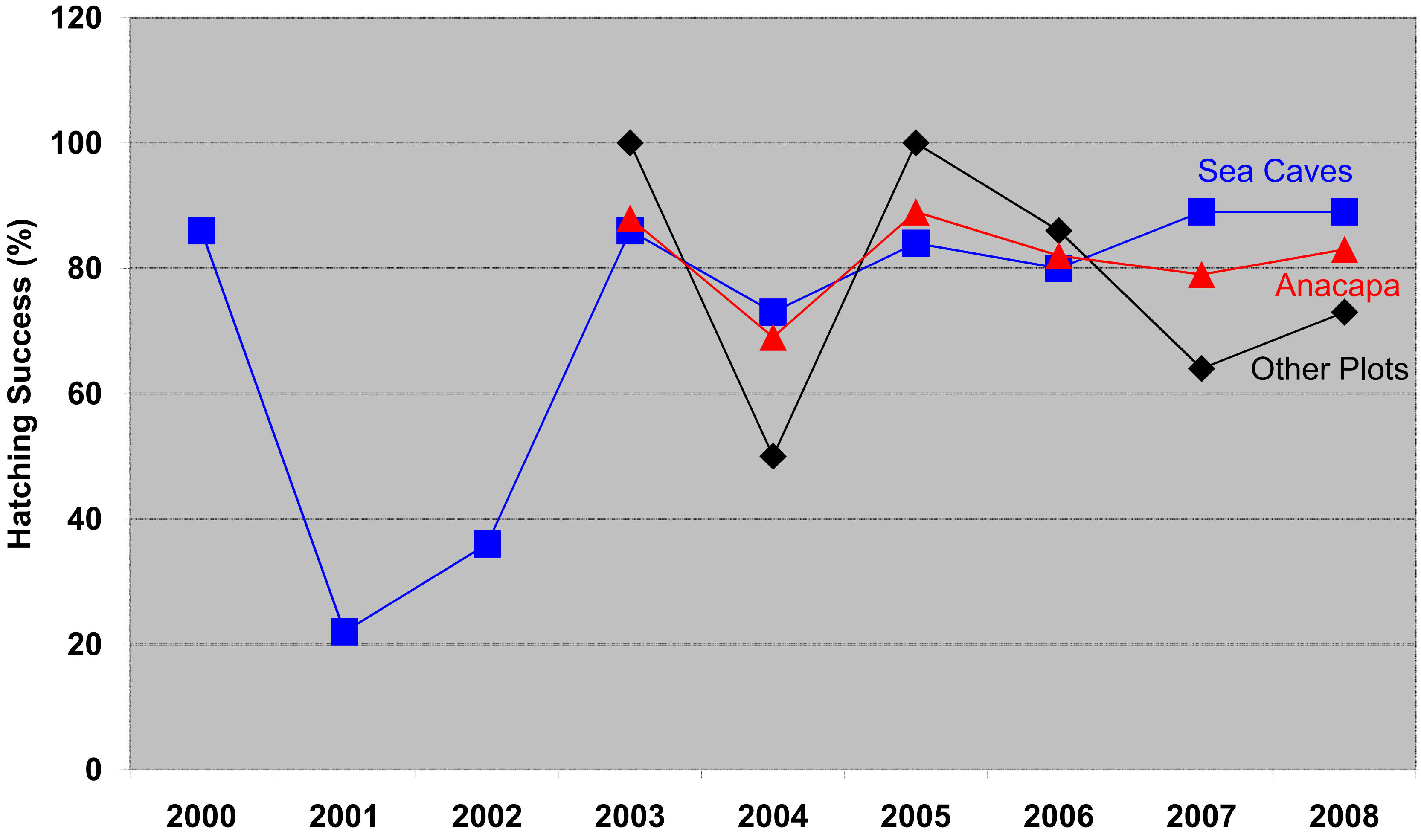

Figure 10. Hatching success for Xantus's Murrelets in sea caves, other plots, and all monitored sites at Anacapa Island, 2003-08.