Status Review of Xantus's Murrelet in California
Report to the Fish and Game Commission
November 14, 2003

Introduction

Petition History

On April 16, 2002, the Fish and Game Commission (Commission) received a petition from the Pacific Seabird Group (PSG) to list the Xantus's Murrelet (*Synthliboramphus hypoleucus*) as a threatened species under provisions of the California Endangered Species Act (CESA). The proposed listing included both subspecies of the Xantus's Murrelet, *S.h. scrippsi* and *S.h. hypoleucus*. The Commission reviewed the petition for completeness, and pursuant to Section 2073 of the California Fish and Game Code (FGC), referred the petition to the Department of Fish and Game (Department) on April 25, 2002, for evaluation. The Department had a 90-day period to review the petition and make one of the two following findings:

- Based upon the information contained in the petition, there was sufficient evidence to indicate that the petitioned action may be warranted and the petition should be accepted and considered; or
- Based upon the information contained in the petition, there was not sufficient evidence to indicate that the petitioned action may be warranted, and the petition should not be accepted and considered.

The Department requested a 30-day extension to complete the evaluation and recommendation. At the Commission meeting on June 20, 2002, in South Lake Tahoe, the Department received the extension for consideration of the petition.

The Department found that the information in the petition was sufficient to indicate the petitioned action may be warranted, and recommended the Commission accept the petition. At the Commission meeting in Santa Barbara on October 23, 2002, the Commission received the Department's evaluation report, recommendation, and public testimony, and the petition was accepted by the Commission. On November 15, 2002, the Commission published a Notice of Findings in the California Regulatory Notice Register declaring Xantus's Murrelet a candidate species, thereby starting the candidacy period and the one year status review process. A candidate species is defined as a native species or subspecies of bird, mammal, fish, amphibian, reptile, or plant the Commission has formally noticed as being under review by the Department for addition to either the list of endangered species or the list of threatened species. The Commission also adopted a special order pursuant to FGC Section 2084 to provide for incidental take under specific circumstances of Xantus's Murrelet during the candidacy period.

Department Review

This report, pursuant to FGC Section 2074.6, details the Department's review and recommendations to the Commission regarding the proposed listing of the Xantus's Murrelet as a threatened species under CESA. The discussion and analysis set forth below is based on the best scientific information available. The Department's recommendation about whether the petitioned action is warranted is also addressed. Further, this status review identifies habitat that may be essential to the continued existence of the species and suggests management activities and other recommendations for recovery of the species.

The Department contacted affected and interested parties, invited comment on the petition, and requested any additional scientific information that may be available, as required under FGC Section 2074.4. The Department produced a public notice (Appendix A1) and distributed it by mail on March 2, 2003, to as many affected and interested parties as was practicable. Appendix A2 contains a list of individuals, organizations, and agencies contacted. Newspapers that published the public notice on March 2, 2003 are shown in Appendix A3.

In an attempt to obtain and review all available information on Xantus's Murrelets, Department staff contacted various scientists and researchers outside the Department for all available information. Information collected by and provided to the Department by the scientific community is vital to the completeness of this review. In addition, the Department provided a draft version of its status review to several qualified experts for Peer Review. The list of scientific experts and their Peer Review comments to the Department regarding Xantus's Murrelet are shown in Appendix B.

All four peer reviewers supported the Department's recommendation for listing the Xantus's Murrelet as a threatened species. We considered all of the peer review comments received, and most of their comments have been incorporated into this report. In some cases, we were unable to incorporate the information or respond to particular questions, because we needed more information in order to properly address the issue at hand, or discussion with experts was needed before definitive conclusions could be drawn. Additionally, there are some areas where additional research is needed before definitive conclusions can be drawn.

Finally, the Commission and Department received two letters commenting on the listing petition and the status of the Xantus's Murrelet as a candidate species under CESA (Appendix C).

Life History

The Xantus's Murrelet (murrelet) is a member of the family Alcidae, which includes murres, puffins, guillemots, and the extinct Great Auk (*Pinguinus impennis*).

Most members of the alcid family are black above and white (or light brown/black) below, and they are sometimes referred to as "penguins of the north" due to similarities with penguins, both in plumage characteristics and excellent diving ability. Their legs are set far back on their body, giving them an upright stance on land, and making walking awkward. In flight, their wingbeats are rapid and shallow. However, they are swift underwater, using their wings to propel themselves forward in search of prey, a trait known as "pursuit diving".

Alcids are known to be long lived, and to have a low reproductive rate, laying only 1-2 eggs per clutch (depending on the species), and usually not breeding until 3-4 years old or more. The average life span of many alcids is over ten years (Gaston and Jones 1998). Xantus's Murrelets have thus far been documented to live up to 15 years old in the wild (Carter et al. 1992). Age of first breeding and adult survival rates (from year to year) are unknown for the Xantus's Murrelet. Population parameters from a closely related species, the Ancient Murrelet (*S. antiquus*), have been used in population modeling (Sydeman et al. 1998).

A low reproductive rate, as is the case with most alcids, can make it difficult for populations to recover quickly from impacts. This will be discussed more fully in the Population Trend section of this report.

Alcids are known to have high fidelity to their breeding colonies, meaning they often return to breed at the same "colony" where they were born (breeding islands or offshore rocks). Another term for this trait is "philopatry", defined as the tendency of an organism to stay in or return to its home area. Additionally, once the birds begin breeding, they sometimes return to the same specific nest site year after year. Colony fidelity has been demonstrated for the Xantus's Murrelet from studies conducted on Santa Barbara Island (Hunt et al. 1979, Murray et al. 1983). The murrelets were even observed following a consistent path to their nest site (Drost and Lewis 1995).

The Xantus's Murrelet is a small alcid, measuring only 23-25 cm (9-10 inches or less) from tip of bill to tip of tail. An adult bird fits easily into the outstretched hand of an adult human. They are cleanly marked, black above and white below in breeding plumage (Figure 1). Though they molt into a winter plumage, it is not distinct from breeding coloration except by close inspection (Drost and Lewis 1995). Murrelets weigh approximately 167 g (6 oz.) (Murray et al. 1983). Their small body size makes them vulnerable to a broad array of predators.

During daylight hours, murrelets spend most of the time foraging and resting at sea. After dusk and before dawn, during the breeding season, they congregate and vocalize on the waters below their island nesting areas (Murray et al. 1983). Their nesting activities are nocturnal, and they limit all land-based activities, except incubation, to hours of darkness.

Murrelets typically begin arriving in the vicinity of breeding colonies in December and January (Murray et al. 1983, Gaston and Jones 1998). During this time, birds engage in courtship activities on the water and irregularly make nocturnal visits to nest sites (as early as two months before laying eggs but usually during the two to three weeks before egg-laying). Egg-laying is unsynchronized but typically peaks from mid-March to mid-April (Gaston and Jones 1998).

Timing of nesting is variable between years, with egg-laying recorded as early as mid-February and as late as mid-June. Relaying has been reported for birds that lost their first eggs. By the end of July, murrelets are uncommon on or near the islands, as adults with newly hatched young disperse rapidly from breeding areas (Hunt et al. 1979, Murray et al. 1983).

The murrelet has a typical and maximum clutch size of two eggs, which are laid about eight days apart. The two-egg clutch constitutes 45% of the adult female's weight. The first egg is left unattended in the nest until the second egg is laid. Incubation begins after the second egg is laid, and lasts an average of 34 days (range 27-44 days, Murray et al. 1983). Both sexes share incubation duties, and mates relieve one another every two to four days. Eggs are sporadically left unattended during incubation while the adults forage at sea, a condition known as "egg neglect". This leaves the eggs vulnerable to predation by mice and rats.

Murrelet chicks are highly precocial (newly hatched young are covered with down and fully active), and fledge (leave the nest) at 1-2 days after hatching. Their coloration matches the adult pattern (Figure 2).

These secretive alcids nest primarily in rock crevices or small caves along or near cliff ledges (Figures 3a and 3b), but also under shrubs and ground vegetation, and occasionally under man-made debris (Hunt et al. 1979). They can also be found nesting in sea caves along the shore of some islands. There is no evidence that Xantus's Murrelets dig their own burrows (Drost and Lewis 1995).

Chick departures occur exclusively at night, presumably to reduce predation by gulls. Chicks are normally escorted from the nest by both parents on the night of departure. Parents typically lead the chicks down the slope for a short distance before flying out to sea. Left on their own, the chicks make their way directly to the cliff edge where they jump, or get blown off the cliff into the surf below. The chicks may be guided to sea by calls from their parents or other murrelets. The family unit moves rapidly away from the nesting island (perhaps to help reduce gull predation), and remains together at sea for an unknown time (Hunt et al. 1979, Murray et al. 1983).

Intensive studies on the murrelet did not begin until 1975, and two landmark studies covered the period of 1975-1979 (Hunt et al. 1979, Murray et al. 1983). Prior to that time, researchers were primarily interested in breeding

distribution and relative numbers, taxonomic status, and the collection of eggs, young, and adult birds for scientific study and museum specimens. However, the field notes and publications from this early work provide important baseline information to help assess the current status of the murrelet.

The closest relative ("congener") to the Xantus's Murrelet is Craveri's Murrelet (*Synthliboramphus craveri*) that nests in southern Baja California and the Gulf of California (Jehl and Bond 1975). However, little is known of this southern murrelet. Ancient Murrelets are another closely related small alcid; they also nest on the ground in burrows or rocky areas, lay 2 eggs, and have precocial young (Gaston and Jones 1998, and others). Ancient Murrelets nest on offshore islands in the western Pacific Ocean from Japan and eastern Siberia, to Alaska and British Columbia. These murrelets have been well studied for many years, thus, they provide an important key to better understanding the life history of the secretive, and lesser-studied Xantus's Murrelet. Another closely related alcid is the Japanese Murrelet *(S. wumizusume*). This endangered species has a small population size, restricted range, and many similar threats in Japan.

Food habits of the murrelet are discussed in the Threats/Oceanographic and Prey Changes section of this report.

Range and Distribution

A number of studies have documented the range and distribution of the murrelet, including both subspecies, *S.h. scrippsi* and *S.h. hypoleucus* (Jehl and Bond 1975, Hunt et al. 1979, Winnett et al. 1979, Briggs et al. 1987, Carter et al. 1992, Drost and Lewis 1995, Howell and Webb 1995, Keitt 2000, McChesney and Tershy 1998, McChesney et al. 2000, Whitworth et al. 2000, Spear et al. 2003, Whitworth et al. 2003a and others). Breeding season distribution has been more intensively studied than the non-breeding season, and nesting colonies have been more intensively studied than the at-sea aspects of murrelet range and distribution.

Range and Distribution of the Two Subspecies

The two subspecies differ in facial plumage, bill size, and range (Jehl and Bond 1975, Drost and Lewis 1995). The *S.h. scrippsi* subspecies breeds from the northern Channel Islands south to the San Benito Islands, in Baja Mexico, while *S. h. hypoleucus* breeds primarily at Guadalupe Island and the San Benito Islands off Baja (Figure 4). Some murrelets on the San Benito Islands exhibit an intermediate plumage type between these two subspecies (Jehl and Bond 1975). A recent study of murrelets at the San Benito Islands provides the following, based on at-sea captures of birds at night (Whitworth et al. 2003a): 1) All three plumage types (*S.h. scrippsi, S. h. hypoleucus,* intermediate) were captured in March 2002; 2) Proportions of each

plumage type in the captured samples (61%, 32%, and 7%, respectively) were not dissimilar from proportions in museum specimens (47%, 38%, and 15%, respectively) examined by Jehl and Bond (1975), with *S.h. scrippsi* predominant, and the intermediate plumage type relatively rare; and 3) The 2002 captured sample indicated that the morphological differences between subspecies persist at the San Benito Islands where the two races occur together.

However, there is some evidence that *S.h. hypoleucus* breeds in the Channel Islands in small numbers. A nest site of *S.h. hypoleucus* was found on Santa Barbara Island (Winnett et al. 1979), and *S.h. hypoleucus* have been captured on the water at night during the breeding season as follows: a) 1 bird near Scorpion Anchorage at Santa Cruz Island on 9 July 1994; and b) 2 birds near Seal Cove at San Clemente Island on the nights of 12-13 May 1994 and 3-4 May 1996 (H.R. Carter, unpubl. data). Additionally, *S.h. hypoleucus* occurs in U.S. waters in the fall, at least in some years.

Worldwide Distribution

The worldwide breeding range of the Xantus's Murrelet is restricted to the Channel Islands and the west coast of Baja California, Mexico. All California colonies of murrelets are located in the Channel Islands (Figure 4). Xantus's Murrelets have a geographically restricted breeding range of only 12 nesting islands scattered along 500 miles of coastline (Figure 4).

Importance of Santa Barbara Island

Santa Barbara Island, the smallest of the Channel Islands, is the most important colony for Xantus's Murrelet in California at this time. Fifty-one percent of the California Channel Islands population of murrelets utilizes this small island of only 2.6 km^2 (1 square mile) in size. The next largest breeding colony, Anacapa Island, is located 64 km (40 miles) to the northwest of Santa Barbara Island. In the past, numbers of breeding Xantus's Murrelets at Anacapa Island may have been equal to or larger than Santa Barbara Island (McChesney et al. 2000). These islands are discussed in detail in the Population Trend and Threats sections of this report.

At-sea Distribution

Post breeding and winter distribution covers a large geographic area (Figure 5) (Jehl and Bond 1975, Briggs et al. 1987, Drost and Lewis 1995, Karnovsky et al. 1996, Gaston and Jones 1998:207, Whitworth et al. 2000, Spear et al. 2003 and others). The most recent summary of murrelet distribution at-sea is described in Spear et al. 2003, and summarized here. In general, during the breeding season, murrelets that nest in the Channel Islands are concentrated in the Southern California Bight, though the degree of overlap with birds from the Coronados Islands needs more study.

During the non-breeding season, murrelets (presumably from both Baja colonies and the Channel Island colonies) are more dispersed, and occur primarily from northern California to southern Baja California. The area of highest concentration during the non-breeding season was off northern Baja California from about 28°N to 31°N. Moderate numbers were noted off the Oregon coast, decreasing to lower numbers up to northern Vancouver Island, British Columbia.

Similar to the findings of Briggs et al. (1987) and Karnovsky et al. (1996), Xantus's Murrelets were most abundant over the upper continental slope, and at distances of 25-150 km (16-93 miles) from shore. When dispersed from breeding areas, murrelets also preferred warmer, lower salinity waters characteristic of the California Current. This pattern was consistent within any given year regardless of large scale conditions (Spear et al. 2003).

Other Factors Affecting Range and Distribution

The Island Fox (*Urocyon littoralis*), state-listed as threatened, is present on the six larger Channel Islands, but does not occur on the two small islands, Anacapa and Santa Barbara. Most historic accounts of murrelet breeding locations in the Channel Islands refer to Anacapa and Santa Barbara islands. Island foxes eat a wide variety of foods, including insects and berries, and are also known to eat birds and bird eggs (Laughrin 1977: 59). Thus, it appears the presence of the fox limits the distribution of the murrelets to some extent (Hunt et al. 1979, H.R. Carter, pers. comm.). On islands where foxes and murrelets are found, for example, Santa Cruz and San Miguel, the murrelets nest in steep cliffs or on offshore rocks that foxes cannot access. In general, seabird biologists infer that foxes limit the distribution of murrelets in the Channel Islands (Hunt et al. 1979, Sowls et al. 1980, Drost and Lewis 1995). Studies in Alaska and British Columbia also show that introduced foxes have a major impact on the survival of ground-nesting seabirds (Bailey and Kaiser 1993).

Hunt et al. (1980:454) stated: "*Another factor of paramount importance affecting the distribution and numbers of seabirds breeding in the Channel Islands is the presence of the Island Fox...Generally, all of the marine birds breeding in the Bight nest on the small, fox-free islands of Santa Barbara and Anacapa or are crowded onto tiny rocks and islets offshore of the other main islands*". There was only one exception noted by Hunt et al. (1980), and that was relative to gulls and cormorants on San Nicolas Island. However, Xantus's Murrelets are not known to breed on San Nicolas Island.

Abundance

There are a number of studies that contain a comprehensive overview of the murrelet, and emphasize the current rarity of the species on a worldwide scale (Jehl

and Bond 1975, Hunt et al. 1979, Hunt et al. 1980, Drost and Lewis 1995, Gaston and Jones 1998).

The Xantus's Murrelet is a rare species with a limited breeding range. In fact, it is one of the rarest seabirds in the North Pacific. A recently published book on the alcid family concurs with this assessment (Gaston and Jones 1998), and other scientists have also concurred and recommended formal protection measures (Drost and Lewis 1995, Sydeman et al. 1998). In this report, the term "rare" is used in the familiar dictionary meaning of the term ("seldom occurring or found, uncommon") and not in any legal context or conclusion under state law.

Bent (1919) found that the Xantus's Murrelet "... *is now well known as a fairly common bird about the rocky islands from southern California along the west coast of Lower California at least as far as Magdalena Bay.*" He quotes A. Howell to describe the population status of the species:

"*A few years ago [about 1908] they were very rare...[at Los Coronados Islands], but at present they are almost abundant. Their case is somewhat similar on Santa Barbara and Anacapa Islands, California, for at the latter place during May, 1913, Mr. van Rossem found them to be fairly common. Hence it would seem that the species is increasing in numbers at the northern end of its range.*" It is quite likely that egg collectors were becoming more familiar with what time of year and in what habitats to find murrelet eggs at the Los Coronados, Santa Barbara, and Anacapa Islands, such that true population increase may not have been occurring at this time.

An important reference containing information on the historic population levels of California's bird populations is the classic Grinnell and Miller's (1944) "The Distribution of the Birds of California." In this reference, the Xantus's Murrelet is described as "*fairly common*" to even "*common, locally.*" Bailey (1921) refers to the species as "... *frequently seen in the Santa Barbara Channel at all seasons.*"

The quote by Howell, that murrelets are "increasing" shortly after the turn of the century (at Los Coronados and Anacapa), and the Grinnell and Miller (1944) reference to murrelets being "fairly common" to even "common", stand in contrast to more current scientific publications that conclude murrelets are rare and declining. Therefore, the Department believes a decline of some unknown magnitude occurred, from historic levels, and more recently from the mid 1970s to the present.

The Department has reviewed the available information on murrelet abundance and concludes that the Xantus's Murrelet is a rare or uncommon species, with only 3,460 breeding birds under California's jurisdiction (Tables 1 and 2). For comparison, the Marbled Murrelet (*Brachyramphus marmoratus*), another alcid in California (which nests in old-growth trees) is listed under both the California and federal endangered species acts, as endangered and threatened, respectively. The Marbled Murrelet was

both state and federally listed in 1992. At that time, the population in California was estimated at approximately 2,000 birds, based on limited survey effort. Marbled Murrelets are currently estimated to number from 3,500-6,400 birds in northern California and southern Oregon, based on a statistically rigorous at-sea sampling protocol; smaller populations exist in central California (USFWS 1997, Bentivoglio et al. 2001, USFWS 2003). Marbled Murrelet populations in California continue to decline due to a wide variety of impacts, including two recent oil spills in northern California (California Department of Fish and Game 2001).

The Department believes there is sufficient scientific information to indicate the Xantus's Murrelet is now a rare or uncommon species that has declined from historic population levels. The evidence for decline from "common" and "abundant" to "rare" will be discussed in detail in the Population Trend section, below.

Population Trend

Population trend information for Xantus's Murrelets from the Channel Islands to Mexico has been described by various researchers (Howell 1910, Jehl and Bond 1975, Hunt et al. 1979, Hunt et al. 1980, Murray et al. 1983, Everett and Anderson 1991, Carter et al. 1992, Drost and Lewis 1995, Gaston and Jones 1998, McChesney and Tershy 1998, Sydeman et al. 1998, Keitt 2000, McChesney et al. 2000, Wolf et al. 2000). The Department has reviewed this information and finds sufficient scientific information to indicate population decline has occurred and continues at present. Additional information on population trend that was evaluated by the Department is discussed below and in the Threats section of this report.

There is evidence for population declines from historic levels at breeding sites for the murrelet in Mexico (for example, due to feral cat (*Felis catus*) predation on the Coronados), and for Anacapa and Santa Barbara Islands in the Channel Islands. Numerous non-native mammals that have occupied known murrelet nesting islands throughout their range are identified in Table 2 in the petition. Studies throughout the world have documented that non-native predators, particularly rats (*Rattus* sp.) and cats can have negative effects on seabird populations (Moors and Atkinson 1984, Everett and Anderson 1991, Springer et al. 1993, Burger and Gochfeld 1994, Bertram 1995, Seto and Conant 1996, McChesney and Tershy 1998, Drever and Harestad 1998, Seto et al. 2001, Sowls and Rauzon 2001, Keitt 2000, Keitt et al. 2002, in review). The Department believes that murrelets have declined from this unnatural pressure for which they have not evolved effective defenses. A prominent book on the alcid family supports this conclusion:

"…. the effects of mammalian predators, introduced either deliberately or accidentally, have probably had a much greater impact on auk populations world-wide"; "Those that have been most affected by our activities are the southern murrelets: …Xantus' …all at present endangered or threatened in one way or another".; "It is

certain that the majority of auk populations are smaller, in many cases much smaller, than they would have been a few centuries ago" (Gaston and Jones 1998:18-19).

The exact magnitude of the murrelet population declines cannot be determined because the early studies on murrelets were primarily natural history trips, consisting of field notes and specimen collection (early naturalists often collected eggs, chicks, and adults for museum specimens). Such specimens are labeled and catalogued in natural history museums and educational institutions, and provide historical background on the occurrence and abundance of many species. Published notes in reputable scientific journals also exist to cross reference with the specimen collections. In this way, biologists can discern that a particular notation on the absence of a species may not be valid, because the visit did not occur at the right time of year, or proper time of day to document a particular species. Careful reading and interpretation of such published notes is important to draw the proper conclusions.

Early naturalists did not approach wildlife population assessment from a statistical perspective. Their main goal was to describe the distribution and relative abundance of native animals, and to document new species. Therefore, the interpretation of historic population declines is based on scientific reasoning, analysis of facts, and best available scientific information.

Historical Context for Santa Barbara Island Murrelet Population Trend

Santa Barbara Island has received the most study, and because most (51%) Xantus's Murrelets in California now nest there, the following background is important to put population dynamics and decline into the proper context. One conclusion that can be drawn from looking at the historic accounts is that the murrelet population has been unstable due to perturbations brought on by humans. Alcid reproduction may vary year to year due to fluctuations in food supply, but their island nesting sites normally remain stable and are often relatively predator free in a natural state (as in rocky offshore islands utilized by Common Murres (*Uria aalge*)). Introducing non-native predatory mammals (cats and rats) into such an environment, and coupling that impact with non-native grazing mammals (sheep, rabbits, goats), is a recipe for instability and population decline (Burger and Gochfeld 1994). Many seabird populations do not normally undergo drastic population swings, but it appears murrelets on Santa Barbara Island have, due to human influences. The Department has prepared a timeline of human impacts on Santa Barbara Island (Figure 6), and the associated impacts to native vegetation and wildlife species.

Effects of humans (including introduced mammals) on island nesting species can be dramatic, for example, a Cassin's Auklet (*Ptychoramphus aleuticus*) colony was nearly extirpated from the island by feral cats by 1908, and has never recovered (Howell 1917:22, Hunt et al. 1979, H. R. Carter, pers. comm.). Cassin's Auklets are small, nocturnal, burrow-nesting alcids with some similarities to murrelets; however,

these auklets usually excavate their own burrows. Grinnell found them breeding in large numbers on Santa Barbara Island in 1897: "*The southwest side of the mesa from the top of the bluff to the summit of the hill was crowded with their burrows*" (Grinnell *in* Hunt et al. 1979). Another observer in 1897 noted: "*In a field of malva weed hundreds of burrows contain auklets sitting upon their single white eggs*" (Britton *in* Hunt et al. 1979). But by May of 1908, no signs of the species were seen (Howell *in* Hunt et al. 1979). A later trip to the island in 1911 revealed only bones and feathers of auklets all over the island, and the observer stated: "*...concluded that they had been exterminated by the cats with which the island is infested*" (Willett *in* Hunt et al. 1979). In 1991, auklets persisted in small numbers on the offshore islet of Sutil Island near the southwest end of Santa Barbara Island and in bluffs at Elephant Seal Point (Carter et al. 1992). Recently, auklets have not been found at either location and may no longer breed at Santa Barbara Island (H. R. Carter, pers. comm., via J. Adams and P. Martin, pers. comm.). Vegetation and soil changes from non-native grazing mammals and past agricultural practices likely led to a large historical decline with no chance for natural recovery.

Another species that suffered from the changes induced by humans was the federally endangered Santa Barbara Island Song Sparrow (*Melospiza melodia graminea*), known only from Santa Barbara Island, and officially declared extinct in 1983 by the U.S. Fish and Wildlife Service (Fed. Register Vol. 48, No. 198, Oct. 12, 1983). Since the 1959 fire which severely altered most of the island, no sparrows had been observed (Figure 6). The sparrows were known to be closely affiliated with the native giant tree-sunflower shrubs (*Coreopsis gigantea*) on the island (Sumner *in* Stewart et al. 1974). The coreopsis shrubs were heavily damaged by the 1959 fire. One observer described the fire effects as follows: "*It burned nearly all the vegetation from the water's edge on the east shore of the island to the crest of the ridge where it was halted by the strong winds from the west slope...Two-thirds of the island was denuded right down to mineral soil...*" (Sumner in Stewart et al. 1974).

It has been well documented that sheep (Schuyler 1993), goats (Coblentz 1980), and rabbits (Sumner 1959; Appendix D in this document) have modified the native vegetation on various Channel Islands. On Santa Barbara Island, these changes have probably reduced nesting opportunities for murrelets through reduction in shrub cover. The change in vegetation may also have caused an increase in deer mouse numbers on Santa Barbara Island (Murray et al. 1983); the petition made note of this as well (see Threats section for discussion on deer mice (*Peromyscus maniculatus* sspp.). Seeds of the introduced grasses on Santa Barbara Island are an important food source for the native deer mice (Murray et al. 1983).

The population of murrelets on Santa Barbara Island has apparently never fully recovered from a drastic decline caused by feral cats. Between 1897 and 1908, cats were introduced onto Santa Barbara Island. There is little data on the size of the murrelet population prior to the introduction of cats, but Sumner *in* Sowls et al. (1980)

states: *"At one time large colonies of auklets and murrelets were present on the island, but none have been recorded in recent years and it is supposed that they have been exterminated by these feral cats".* It is very unlikely that Xantus's Murrelets were extirpated but their population was likely reduced and limited to habitat with low cat predation.

In summary, it appears that murrelets (and auklets) were fairly abundant prior to European settlement and the introduction of sheep, goats, cats, and rabbits. A decline then began due to vegetation changes induced by the non-native grazers, intensive agricultural practices, and abnormal predation levels by cats. A slight recovery of murrelets may have occurred on Santa Barbara Island once the cats and rabbits were reduced and removed. However, both cats and rabbits were not entirely eliminated from Santa Barbara Island until some time in the late 1970s (Stewart et al. 1974, Hunt et al. 1979, Drost and Lewis 1995). Rats are not documented to have been introduced onto Santa Barbara Island, as noted in Table 2 of the petition.

More Recent Evidence for Population Decline at Santa Barbara Island

Hunt et al. (1979) conducted field work on Xantus's Murrelets at Santa Barbara Island from 1975 to 1978. They surveyed for murrelet nests in "accessible" areas during the breeding season, with extrapolation to inaccessible areas. They also conducted at-sea surveys on vessels to count murrelets along transects radiating out from Santa Barbara Island. Similarly, in 1991, Carter et al. (1992) conducted nest searches on Santa Barbara Island to document potential nest sites and extrapolate to other inaccessible areas; this work did not include at-sea surveys. Carter et al. (1992) surveys were undertaken in an effort to assess murrelet population size in 1991 but methods probably were only roughly comparable to those used earlier by Hunt et al. (1979, 1980). It is difficult to assess exactly how comparable these methods were due to poor description of count methodology used in the 1970s (Carter et al. 1992).

Sydeman et al. (1998) reviewed the work of both previous researchers (Hunt and Carter), made some adjustments to the occupancy correction factors used in 1991 (note: these adjustments may or may not be valid), and derived a smaller number of breeding birds than Carter et al. (1992; Table 1).

Further, Sydeman et al. (1998) conducted a population viability analysis for the Santa Barbara Island population and concluded: *"Xantus' Murrelets on SBI declined by as little as 2.51% ... or more than 5.29 % ... per year from 1977 to 1991."* The report also states *"This population is in danger of extinction and should be considered endangered. Given current population parameters and predation rates, the population faces a 30% probability of reaching quasi-extinction within 20 years under the most favorable scenario...."* He derived population parameters from the Ancient Murrelet, because most population parameters for Xantus's Murrelets are not known. The

Department considers this approach reasonable due to many similarities between the two species. Appropriate caveats were included in the Sydeman et al. (1998) analysis.

An important aspect of the Sydeman et al. (1998) population viability analysis is the determination that a reduction in adult mortality alone is unlikely to produce a stable murrelet population. Instead, they noted, improvement in reproductive success (reduction in egg predation) would also be required to produce a stable population. Factors affecting adult, chick, and egg survival were discussed earlier, and are further discussed in the Threats section of this report.

The Department has carefully reviewed this information for Santa Barbara Island, along with more current information not included in the petition (Humboldt State University (HSU), unpubl. data; National Park Service (NPS), unpubl. data). The Department finds that murrelet populations have declined on Santa Barbara Island, possibly up to 72% from 1977-1991 (from 3,000 to 847 breeding birds), as presented in Sydeman et al. (1998:45). But due to the difficulties discussed above relative to safely accessing nest sites and determining occupancy rates, and based on more recent murrelet survey work that will be discussed below, it appears more likely that the population declined to a lesser degree during this period (approximately 30%).

We consider the following statements by Carter et al. (1992) to be important, relative to the earlier, higher population estimates by Hunt et al. (1979): "*In either case, the population is much smaller than previously reported.*" and "*We consider the current population size to be very low.*" For Santa Barbara Island proper, excluding the two offshore rocks, Carter et al. (1992) estimated 1,402 breeding birds. This is in contrast to the wide range of breeding murrelets (2,000-10,000) reported in Hunt et al. (1979) (Table 1). The estimate from the Hunt et al. (1979) effort was later revised to 3,000 breeding murrelets for Santa Barbara Island, or 3,180 if both offshore rocks are included (Hunt et al. 1980).

Carter et al. (1992) also mentioned that the murrelet population may have been stable between 1977 and 1991, but a later publication with Carter as a lead author (Carter et al. 2000) states: "*...a 1991 survey found lower numbers of murrelets than in the 1970s*" and cites Carter et al. (1992). When questioned on this point, H.R. Carter (pers. comm., July 2002), stated that he believed the data indicated a decline had occurred, though the exact magnitude could not be determined.

Department review of this information by both Hunt and Carter indicates both parties made their best attempts to accurately survey this secretive seabird. This is based on the amount of detail and documentation that is contained in both reports. However, techniques to estimate population size were different, estimates may not be fully comparable, inter-annual variability may be involved, and earlier techniques were not well described (Carter et al. 1992). We agree with Carter that the at-sea work conducted by Hunt is difficult to extrapolate to population size given the many

assumptions that must be made; however, the at-sea data does provide useful information in a relative degree to the nest site based population estimates. As noted by Carter et al. (1992), one extrapolation presented in the Hunt et al. (1979) document was for 20-21 March 1976, where 103 murrelets were counted on the water from a research vessel, on murrelet survey transects near Santa Barbara Island. Hunt et al. (1979) then used this number to extrapolate to the rest of the ocean environment surrounding the island, where vessel based surveys did not occur. From that method, he derived an estimate of 2,741 murrelets; these numbers likely served as a check for Hunt et al. (1979) to narrow the range of the murrelet population estimate for the island.

Apparently, Murray et al. (1983) used the higher end population estimates from Hunt et al. (1979), and stated 6,000-10,000 murrelets bred at Santa Barbara Island during the 1976-1978 breeding seasons. No detailed methods were provided as to how this estimate was obtained, except for the following: "*We searched all accessible areas each year for murrelet nests. In 1978 we measured distances to nearest conspecific neighbors and to the ocean at all study sites for which we could safely reach the cliff edge and/or nearest neighbor.*" It appears that because Hunt was a co-author on the Murray et al. (1983) paper, the consensus was to utilize the higher population estimate based on the 1976-1978 field work. However, it appears doubtful that up to 10,000 breeding murrelets could occupy an island as small as Santa Barbara under the existing state of modified/reduced native vegetation and high deer mouse and predator abundance. That would be seven-fold greater than the 1,402 breeding birds estimated by Carter et al. (1992). While 10,000 murrelets may be feasible for pre-European influence, a population decline from 10,000 to 1,402 does not appear likely given the relatively short 14 year time span between 1977 and 1991. Therefore, it seems reasonable to rely on the 1977 estimate of 3,000 breeding birds (Hunt et al. 1979, Hunt et al. 1980), and to contrast it with the estimate of 1,544 breeding birds from Carter et al. (1992). As noted in the petition, the 1,544 breeding bird estimate for 1991 includes Shag Rock and Sutil Island, the large rocks just offshore from Santa Barbara Island (Table 1).

Because the two island nest count methods are not directly comparable between 1977 and 1991, two other population indicators are important, and corroborate a population decline, as discussed below.

Nest Site Occupancy at Santa Barbara Island

Nest site monitoring work on murrelets is conducted yearly at two nest plots on Santa Barbara Island, Nature Trail and Cat Canyon (Figures 7-9). This intensive effort to monitor breeding success provides an important data set to help assess population status, as noted in the petition. Biologists visit each marked nest site in the two study areas approximately once per week to check nest status (Wolf et al. 2000) (Figure 3b). This work is ongoing, and has been conducted annually since 1985 by NPS biologists and contract biologists. Based on this field work, nest site occupancy rates at the

monitored nest plots on Santa Barbara Island have been declining since 1985 (Figure 10a). In general, occupancy rates fluctuated between 35 and 70 percent up until the mid 1990s, and have since declined to 30 percent or less (Wolf et al. 2000, P. Martin, NPS, draft, unpubl. data). The Department has conducted a statistical analysis (linear regression) on this data which indicates a statistically significant negative trend at both study sites ($p<.05$). The results of another statistical test (ANCOVA) indicates that the slopes (negative trend lines) between the two sites are not significantly different ($p<.05$) from each other, and that percent occupancy is significantly higher ($p<.05$) in the Cat Canyon site. This indicates both sites are moving in a similar negative trend downward, and the statistical model predicts a continued pattern of decline. Transformation of the data (two arcsine square root) to stabilize variances also results in a statistically significant ($p<.05$) negative trend at both study sites (Figure 10b).

In the Nature Trail study area, shrubs have been in decline which is rendering the habitat unsuitable for murrelets due to lack of cover at nest sites (Ingram and Jory-Carter 1997, Wolf et al. 2000). Thus, one would expect a decline in occupancy rates. This, however, is not the case with the Cat Canyon site where most of the monitored nests are in cliff/crevice habitat types (Wolf et al. 2000, H.R. Carter, pers. comm.). Cat Canyon is also located further from potential human disturbance sources, compared to the Nature Trail site which is located near the NPS visitor center. What happens to the displaced birds from the Nature Trail site is unknown. Most alcids have high colony site fidelity, and Xantus's Murrelets have shown evidence of this as well, as noted in the petition (Murray et al. 1983). Thus, they may not breed until suitable sites become available or they may be forced to seek nesting sites elsewhere. Also, some of the nesting adults could have died from various mortality factors.

Productivity Measures for Murrelets on Santa Barbara Island

Another indicator of population decline is productivity, a measure of nest success. Productivity at Santa Barbara Island averaged 0.81 hatchlings (murrelet chicks) per adult pair from 1983 -1995; summarized by Sydeman et al. (1998). This productivity measure is low compared to the Ancient Murrelet, a species very similar to the Xantus's Murrelet. Ancient Murrelets average 1.44 to 1.69 chicks/pair (Gaston and Jones 1998). Craveri's Murrelets also have higher productivity estimates ranging from >1 - 1.5 (DeWeese and Anderson 1976, Tershy *in* Gaston and Jones 1998). However, work on Craveri's Murrelets has been very limited, and the data are not directly comparable to Xantus's Murrelets because standard techniques with adequate sample sizes have not been used. The Department considers the low productivity for Xantus's Murrelets to be of concern, especially when compared to Ancient Murrelets. Further studies are needed in this regard. More recent estimates of productivity for Xantus's Murrelets need to be evaluated once they become available.

For the Ancient Murrelet, productivity values of 1.44 - 1.69 are sufficient to maintain a stable population, even with high adult mortality. In fact, in order to survive

in the face of high adult mortality, a high reproductive rate is needed, and requires the potential to rear more than one offspring per year (Gaston 1990). Gaston (1990:1009) cites three studies indicating that the Ancient Murrelet has the highest adult mortality (or lowest estimated annual survival) that has been observed for any other alcid, or any other pelagic seabird. The Department believes Xantus's Murrelet populations are subject to similar population growth constraints. The population viability analysis (Sydeman et al. 1998) and the actual field data collected on Xantus's Murrelets, as discussed above, provides scientific support for this conclusion. Additional supporting information is contained in the Threats section of this report.

Recent Studies at Santa Barbara Island

Recent work in the Channel Islands by HSU researchers has led to revised population estimates for all of the Channel Islands. These detailed maps are the result of different types of survey effort over a number of years as described in Figures 11 through 18. Changes in sampling techniques did not substantially change the estimated number of murrelets on Santa Barbara Island or the other Channel Islands.

Additionally, H. R. Carter and others returned to Santa Barbara Island during the 2001 breeding season to reassess the nesting population of murrelets, and provide a comparison to the 1991 effort by Carter et al. (1992). This large nest plot monitoring study occurred outside of, but also included a part of one NPS nest plot (Nature Trail), and showed 14% lower numbers of active nests when comparing 1991 to 2001 (Whitworth et al. 2003c).

Population Trend on Anacapa Island

Based on the information summarized below, the Department finds evidence of population reduction of murrelets at Anacapa Island from historic levels. There is sufficient scientific information to indicate that higher densities of murrelets existed under more pristine conditions, prior to the introduction of non-native mammalian predators (rats and cats). This finding is supported by the extensive but *unoccupied* habitat that is present on Anacapa (McChesney et al. 2000). The majority of this habitat has not been utilized by the birds due to the presence of rats. This situation is only beginning to change at this time due to the recent (2001-2002) implementation of a rat eradication program (some degree of rat control also occurred in several years during the 1980s through NPS efforts). Xantus's Murrelets did not evolve with rats or cats, thus, they have few behavioral defenses against them. The historical and current condition of Anacapa Island is briefly discussed below.

In the past, Xantus's Murrelets were considered "not uncommon" on Anacapa Island (Howell 1917). Two separate papers, Hunt et al. (1979) and McChesney et al. (2000) listed the many documented egg collections for this species from Anacapa

Island by early egg collectors, thus providing evidence of former abundance of murrelets. These egg sets were collected up until 1929. There is the possibility that additional eggs were collected and were never reported, because egg collecting was a form of scientific investigation and hobby during that era.

As was noted previously, it is also well documented by present day seabird biologists that non-native mammals can have serious impacts on nesting seabirds (see previous discussion under Population Trend, and also the Threats/Non-native mammals section of this report). Thus, it is reasonable to conclude that murrelet populations (and nesting success) have declined considerably on Anacapa Island due to impacts from non-native mammalian species including sheep, cats, rats, and rabbits. Impacts from these non-native species include vegetation loss, ecological changes in vegetation type, disruption of predator/prey guilds, burrow destruction, and predation (Banks 1966, Bakker 1971, Hunt et al. 1980, Murray et al.1983, Burger and Gochfeld 1994, Bertram 1995, McChesney and Tershy 1998, Keitt 2000, and others).

Black rats (*Rattus rattus*), were introduced to Anacapa sometime between the mid-1800s and early 1900s, and became common and widespread. In 1963 and 1964, the black rat was described as "abundant" on portions of Anacapa Island (Banks 1966).

A small number of cats that were present on West Anacapa Island between the 1930s and mid-1970s likely impacted murrelets and other seabirds (McChesney and Tershy 1998). Cats have been documented as effective predators of many different seabird species; one example of their abilities is noted here (W. Everett, pers. comm., June 2002):

"*A couple of years ago Mark Rauzon and I were working at a large Sooty Tern (Sterna fuscata) colony out on Wake Atoll. We went out late one night and counted over 10 feral cats marauding through the colony attacking birds. The next morning we counted 300 killed terns, and another 35 or so that had been mauled and were unable to fly. They were just slowly dying in the tropical sun. I had to euthanize them rather than let them suffer.*"

On Guadalupe Island, cats were known to prey on both the Guadalupe Storm-Petrel (*Oceanodroma macrodactyla*) and the Leach's Storm-petrel (*Oceanodroma leucorhoa)*, and cat predation is mainly blamed for the extinction of the endemic Guadalupe Storm-Petrel, last seen in 1912 (Jehl and Everett *in* McChesney and Tershy 1998). Additional evidence on the effects of cat predation on seabirds is cited in McChesney and Tershy (1998).

A comprehensive review of non-native predators and seabird colonies concludes: "... *alien predation has been the key factor in the reduction or extinction of more seabird populations in historic times than any other factor.*" (Moors and Atkinson 1984). Another paper on seabird distribution and predation pressure resulted in a

similar conclusion (Springer et al. 1993): *"All of the murrelets and auklets nest only on islands and inaccessible mainland capes, probably to escape terrestrial mammals. Also, they nest underground to escape avian predators. These strategies proved successful until terrestrial mammals were introduced to many of the islands."*

An extensive rat removal project for Anacapa Island was initiated recently with the first poison bait drop occurring in December 2001 on East Anacapa Island, and the second occurring in November 2002 on Middle and West Anacapa. This project is one aspect of the American Trader oil spill restoration plan, and is designed to benefit murrelets and other seabirds (American Trader Trustee Council 2001). Monitoring for murrelet population changes to assess the success of the rat removal program is occurring, and preliminary results indicate a slight increase in the number of nesting murrelets, and an increase in nest success (Hamer et al. 2003, Whitworth et al. 2003b). Thus, it appears murrelets can respond with increased reproductive effort when non-native rats are removed from nesting colonies.

The PSG petition noted the following (page 9): *"Based on the low murrelet populations currently found at many islands, it appears that, over the years, impacts to murrelets have been great. Although recent and planned eradication efforts likely will lead to increases in murrelet numbers, the murrelet's low reproductive rate (mean = 0.813 hatchlings per pair at Santa Barbara Island; Sydeman et al. 1998) and high philopatry (if they are like most other alcids) likely will lead to slow natural recovery."* As was noted earlier in this report, research studies support colony fidelity (philopatry) for the Xantus's Murrelet, similar to other alcids (Hunt et al. 1979, Murray et al. 1983).

The Department finds there is sufficient scientific evidence of murrelet population reduction at Anacapa Island from historic levels. This is supported by recent research indicating substantial suitable but unused habitat, evidence of rat predation on murrelet eggs in accessible and relatively inaccessible habitats, and past evidence of larger numbers of murrelets at Anacapa Island (McChesney et al. 2000, Whitworth et al. 2003; H.R. Carter, pers. comm.). More recent research also supports this conclusion (Hamer et al. 2003, Whitworth et al. 2003b). Further discussion on rat impacts can be found in the Threats/Non-native mammals section of this report.

Population Trend in Mexico

A striking illustration of probable population decline is presented in the petition on page 6 and reads as follows:

"At Los Coronados Islands, Howell (1910) considered murrelets abundant on all 4 islets, and an abundance of murrelet eggs collected by numerous observers (now mostly at the Western Foundation of Vertebrate Zoology, Camarillo, California) in the early – to mid-twentieth century also indicated a very large colony there. By 1989-1990, R. Pitman (pers. comm.) roughly estimated this colony was reduced to only 10% of

potential because of feral cat predation". Mr. Pitman is a noted marine biologist who conducted the early murrelet work with G. Hunt and others (Hunt et al. 1979, Hunt et al. 1980). Another researcher believes the level of decline is somewhat overstated because even in 1995 there were indications of fairly large numbers of murrelets associated with the Coronados Islands (H.R. Carter, pers. comm.). However, Carter concurs that cats did indeed reduce murrelet numbers at the Coronados, though precise estimates of the decline are not available.

Research efforts in Mexico by the Island Conservation and Ecology Group (ICEG) and others have been fairly substantial (Jehl and Bond 1975, Everett and Anderson 1991, McChesney and Tershy 1998, Keitt 2000). Recent work was conducted by HSU and ICEG in spring 2002 at the San Benitos Islands (Table 2; Whitworth et al. 2003a). In general, populations are still under threat from introduced mammals and human disturbance, and population declines have been inferred (Jehl and Bond 1975, McChesney and Tershy 1998, Keitt 2000). In some cases, as at Todos Santos, ICEG personnel removed predators, but residents soon brought them back to the island (Keitt 2000). Currently, there is very little evidence of nesting at Todos Santos, San Martin, and San Geronimo (Table 2; McChesney and Tershy 1998, Keitt 2000). Additionally, there is no evidence of murrelet nesting activity at Natividad, San Roque, or Asuncion Island, and murrelets may never have bred there. Current population estimates are needed for Guadalupe Island. The world population size may be much smaller than currently thought, if only small numbers of murrelets occur at Guadalupe Island.

In spring 2002, HSU researchers noted hundreds of murrelets present in the waters around the Coronados while conducting spotlight surveys (Table 2; H. R. Carter and D. Whitworth, unpubl. data). As noted above, some murrelet recovery may have occurred after cat removal, but these large numbers also indicate the population was not severely reduced. If concerted conservation actions can be implemented on these islands, the potential for substantial population increase exists at the Coronados.

Population Trend Summary

The Department has carefully reviewed the scientific information described above. We believe there is sufficient scientific information to indicate population decline has occurred and continues at present, from the Channel Islands to Mexico.

Xantus's Murrelet numbers have declined substantially from historic levels, though the exact magnitude of the decline is not known and has not been quantified (however, the Department believes it could be quantified based on a series of assumptions and known information). Currently, the best available scientific information from more recent studies indicates a decline of approximately 30%, and possibly up to 72%, from 1977 to 1991, and a 14% decline in active nest sites between 1991 and 2001 on Santa Barbara Island (Hunt et al. 1979, Carter et al. 1992, Sydeman

et al. 1998, Whitworth et al. 2003c). More recent studies and unpublished information from the National Park Service indicates the decline is continuing (Figure 10b; NPS, P. Martin, draft unpubl. data, Wolf et al. 2000). Compared to historical accounts, murrelet populations have also declined substantially on Anacapa Island.

We also researched other plant and wildlife species on the Channel Islands in order to document indications of detrimental habitat change that may have led to population declines in Xantus's Murrelets. The Department believes that the substantial influence of humans and associated non-native species (cats, rats, rabbits, goats, and sheep) provides strong evidence of habitat change, increased predation rates, and land use practices that negatively affected Xantus's Murrelets. This is most noticeable on Santa Barbara Island where more information exists. Other species negatively affected by the land use changes induced by humans include Cassin's Auklets, Santa Barbara Island Song Sparrow, and an endangered plant, the Santa Barbara Island live-forever (*Dudleya traskiae*) (Figure 6).

One source of uncertainty between the mid 1970s and 1991 population estimates of the Xantus's Murrelet on Santa Barbara Island results from the difficulties of surveying for a small nocturnal species nesting in steep, difficult-to-access terrain. Differences in the field techniques also make direct comparisons difficult. However, the declining nest site occupancy rates over a 19 year time period noted for Santa Barbara Island (Figure10b) provides a compelling case for population decline. Additionally, since 1994, several new survey techniques have been utilized by HSU, including vocalization surveys, spotlight surveys, and ornithological radar surveys (Figures 11-18). These intensive studies have helped discover the full extent of the breeding distribution of the Xantus's Murrelet in the Channel Islands but newer methods have not provided data at Santa Barbara Island that were inconsistent with the 1991 estimate. The Department is currently working with researchers to determine the best method(s) to utilize for assessing population size and monitoring murrelets in the Channel Islands.

Factors Affecting the Ability of the Population to Survive and Reproduce

Growth and decline of wildlife populations are driven by survival and mortality rates of adults, subadults, and juveniles, and reproductive success. Therefore, it is clear that threats which cause high adult mortality (for example, rat predation and oil spills), and high nest failure (for example, rat and deer mice predation on eggs), directly affect the ability of the population to survive and reproduce. The threats to murrelets are discussed in detail, below, in the Threats section of this report. Some additional factors affecting the murrelet population are first briefly summarized.

Small Population Size and Island Environments

The murrelet breeding population is highly concentrated. About 82% of the world population breeds on only five islands/island groups (Santa Barbara, Anacapa, Los Coronados, San Benitos, and Guadalupe). Figure 4 depicts the extremely limited breeding range of the murrelet on a worldwide scale. This level of concentration, along with small world population size (4,970 - 11,650 breeding birds), makes the species more vulnerable to localized catastrophes. Additionally, island environments are especially vulnerable to catastrophic influences. We provide the following quotes as supporting scientific information relative to population effects and catastrophes:

"The relatively small land areas of islands result in small populations of organisms that tend to be more vulnerable to extinction than those on continents" (MacArthur and Wilson *in* National Research Council 1995:30).

"*Because island biotas already have lost so many populations and species and land resources are so limited, conservation programs on islands face an extraordinary challenge to maintain conditions that will allow the long-term survival of existing species*" (National Research Council 1995:39).

"*Catastrophes are extreme forms of environmental variation that suddenly and unpredictably reduce the population size.*" Additionally, "*... it is clear that, on the basis of chance alone, larger populations will have an increased likelihood of some individuals surviving this type of event*" (National Research Council:131).

The latter quote refers to *natural* catastrophes. In the case of the murrelet, an example could include a series of El Niño oceanographic events, coupled with large winter/spring storm events that could reduce or disperse fish and zooplankton prey. This would negatively affect murrelet nest success and survival due to inadequate energy reserves. An *unnatural* example would include significant oil spill mortality that would suddenly reduce population size.

In summary, scientific principles indicate that murrelets are especially vulnerable to extinction due to small population size. This is partly due to the uniqueness of their island environments (small geographic land area). This condition naturally leads to a lower likelihood of surviving catastrophic events. Human induced impacts (cat and rat predation, habitat modification, oil spill mortality, artificial light pollution) only exacerbate the problem and ultimately affect the ability of the population to survive and reproduce.

Human-altered Nature of Murrelet Nesting Sites

There are numerous non-native mammals that affect the ability of murrelets to survive and reproduce (Moors and Atkinson 1984, Burger and Gochfeld 1994,

McChesney and Tershy 1998). A careful review of the scientific literature makes it clear that murrelets have existed, and in some places continue to exist in highly altered ecosystems where natural processes have been disturbed (for example, Santa Barbara Island, see Figure 6). Though murrelets still exist at all known historical colonies, their numbers probably are greatly reduced from historic levels (see earlier discussion under Population Trend).

A further example of the human-altered nature of the Channel Islands ecosystem is the declining population of Island Foxes from excessive Golden Eagle (*Aquila chrysaetos*) predation. In an effort to protect the foxes, the Golden Eagles are being removed, because they did not historically nest on the Channel Islands. Bald Eagles (*Haliaeetus leucocephalus*) are being reintroduced, and their presence should restrict Golden Eagles, thus reducing Golden Eagle predation on foxes and allowing for fox recovery. The Bald Eagle was eliminated as a breeding bird on the Channel Islands, as was the Peregrine Falcon (*Falco peregrinus)*, due to the effects of DDT contamination (see discussion on peregrines in Threats section of this report).

Two other seabirds, the Tufted Puffin (*Fratercula cirrhata*) and the Common Murre have also been impacted on the Channel Islands, for reasons not well understood. Common Murres and Tufted Puffins have only recently returned to the Channel Islands in very small numbers (H.R. Carter, pers. comm.). Human impacts are suspected to have played a role in the decline of these two alcids (Hunt et al. 1979, Hunt et al. 1980).

Summary

The Department believes there is sufficient scientific information to indicate that many factors are negatively affecting the ability of the population to survive and reproduce. Additionally, as was noted earlier, the murrelet is naturally limited from occupying or expanding to the larger Channel Islands (San Miguel, Santa Cruz, Santa Catalina, and San Clemente) due to the presence of the Island Fox.

Threats

Threats to the murrelet have been divided into major and minor categories to help identify their degree and immediacy. Four major threats (non-native mammals, oil pollution, native predators, and artificial light pollution), and four minor threats (human disturbance at colonies, oceanographic and prey changes, disturbance and mortality from military operations, and bycatch in fisheries) have been identified and are discussed below. At this time, there is no information to suggest disease or competition are significantly affecting murrelet population viability, though these aspects of murrelet life history have not been well studied.