DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 17

[Docket No. FWS–R7–ES–2013–0099; 4500030113]

Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition To List Kittlitz's Murrelet as an Endangered or Threatened Species

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Notice of 12-month petition finding.

SUMMARY: We, the U.S. Fish and Wildlife Service (Service), announce a 12-month finding on a petition to list the Kittlitz's murrelet (*Brachyramphus brevirostris*) as an endangered or threatened species and to designate critical habitat under the Endangered Species Act of 1973, as amended (Act). After a review of the best available scientific and commercial information, we find that listing the Kittlitz's murrelet is not warranted at this time. However, we ask the public to submit to us any new information that becomes available concerning threats to the Kittlitz's murrelet or its habitat at any time.

DATES: The finding announced in this document was made on October 3, 2013.

ADDRESSES: This finding is available on the Internet at *http://www.regulations.gov* at Docket Number FWS–R7–ES–2013–0099. Supporting documentation we used in preparing this finding is available for public inspection, by appointment, during normal business hours at the U.S. Fish and Wildlife Service, Juneau Fish and Wildlife Field Office, 3000 Vintage Blvd., Suite 201, Juneau, AK 99801. Please submit any new information, materials, comments, or questions concerning this finding to the above street address.

FOR FURTHER INFORMATION CONTACT: Bill Hanson, Field Supervisor, Juneau Fish and Wildlife Field Office (see **ADDRESSES**); by telephone at 907–780–1160; or by facsimile at 907–586–7099 *mailto:.* If you use a telecommunications device for the deaf (TDD), please call the Federal Information Relay Service (FIRS) at 800–877–8339.

SUPPLEMENTARY INFORMATION:

Background

Section 4(b)(3)(B) of the Act (16 U.S.C. 1531 *et seq.*), requires that, for any petition to revise the Federal Lists of Endangered and Threatened Wildlife and Plants that contains substantial scientific or commercial information that listing the species may be warranted, we make a finding within 12 months of the date of receipt of the petition. In this finding, we will determine that the petitioned action is: (1) Not warranted, (2) warranted, or (3) warranted, but the immediate proposal of a regulation implementing the petitioned action is precluded by other pending proposals to determine whether species are endangered or threatened, and expeditious progress is being made to add or remove qualified species from the Federal Lists of Endangered and Threatened Wildlife and Plants. Section 4(b)(3)(C) of the Act requires that we treat a petition for which the requested action is found to be warranted but precluded as though resubmitted on the date of such finding, that is, requiring a subsequent finding to be made within 12 months. We must publish these 12-month findings in the **Federal Register**.

Previous Federal Actions

We received a petition dated May 9, 2001, from the Center for Biological Diversity, Coastal Coalition, Eyak Preservation Council, Lynn Canal Conservation, Inc., and Sitka Conservation Society, requesting that the Kittlitz's murrelet be listed as an endangered or threatened species and critical habitat be designated. Included in the petition was supporting information regarding the species' taxonomy and ecology, historical and current distribution, status, and potential causes of decline. We acknowledged receipt of the petition in a letter to the Center for Biological Diversity, dated June 7, 2001. In that letter we stated that, due to funding constraints in Fiscal Year 2001, we would not be able to begin processing the petition at that time, but would request the appropriate funding for Fiscal Year 2002. We also stated that emergency listing of the Kittlitz's murelet was not warranted at that time.

On June 13, 2002, we received a 60-day notice of intent to sue from the Center for Biological Diversity alleging a violation of section 4 of the Act for failure to complete 90-day and 12-month findings on the petition.

On May 4, 2004, we published a candidate notice of review (CNOR) in the **Federal Register** (69 FR 24876) in which the Kittlitz's murrelet was included in the *Summary of New Candidates.* In this document, we indicated that listing of the Kittlitz's murrelet under the Act was warranted but precluded rangewide, and we assigned a listing priority number (LPN) of 5 to this species. The LPN of 5 reflected non-imminent threats of high magnitude for this species. On May 11, 2005 (70 FR 24870) and September 12, 2006 (71 FR 53756), we retained Kittlitz's murrelet in our CNORs with a LPN of 5.

On December 6, 2007, we published an annual CNOR in the **Federal Register** (72 FR 69034) that included a notice of change in LPN for the Kittlitz's murrelet, elevating it from a 5 to a 2 to acknowledge that threats facing this species were of high magnitude and imminent. The CNORs in 2008 (73 FR 75176, December 10, 2008), 2009 (74 FR 57804, November 9, 2009), and 2010 (75 FR 69222, November 10, 2010) continued to assign a LPN of 2 to Kittlitz's murrelet.

On July 12, 2011, the Service reached a multi-district litigation settlement agreement with the Center for Biological Diversity that requires the Service to review and address the needs of over 250 species, including the Kittlitz's murrelet, included in a CNOR published in the **Federal Register** on November 10, 2010 (75 FR 69222). The Kittlitz's murrelet was included in the settlement, requiring the Service to submit a proposed rule or not-warranted finding to the **Federal Register** by September 30, 2013.

On October 26, 2011, the CNOR (76 FR 66370) included a notice of change in listing priority for the Kittlitz's murrelet, downgrading the LPN from a 2 to an 8 because we determined through a reassessment of the threats that their magnitude was moderate (not high) and threats were imminent.

In Fiscal Year 2012, the Service initiated work on the listing evaluation of the Kittlitz's murrelet, as stated in the November 21, 2012 CNOR (77 FR 69994).

This document addresses our requirements under the multi-district litigation settlement agreement.

Species Information

This document constitutes a 12-month finding on the May 9, 2001 petition to list the Kittlitz's murrelet as an endangered or threatened species.

The petitioners requested the Kittlitz's murrelet be listed as an endangered or threatened species and we confirm that this species is a listable entity under the Act. Because we find that listing the Kittlitz's murrelet rangewide is not warranted, as explained below in the Finding section, we conducted further analysis to evaluate any potential distinct population segments (DPS) or significant portion(s) of the range (SPR) within the range of the Kittlitz's murrelet exist that may require listing. However, we did not identify any

populations of the Kittlitz's murrelet that meet the definition of DPS or SPR (see appropriate sections below).

Taxonomy and Species Description

Kittlitz's murrelet (*Brachyramphus brevirostris;* Vigors 1829) is a member of the Alcidae or auk family. *Brachyramphus* murrelets are unusual because unlike the rest of this diverse family of seabirds that nest in colonies, they nest solitarily. There are two additional species within the genus, the marbled murrelet (*B. marmoratus;* Gmelin 1789) and the long-billed murrelet (*B. perdix;* Pallas 1811; Friesen *et al.* 1996a, p. 360). The distributions of marbled murrelet and Kittlitz's murrelet overlap in Alaska and the distribution of the long-billed murrelet overlaps with the Kittlitz's murrelet in portions of eastern Russia (Friesen *et al.* 1996b, p. 682). All three species generally are similar in appearance, but physical and genetic differences among them are well documented (Pitocchelli *et al.* 1995, pp. 239–248; Friesen *et al.* 1996a, pp. 363–365; Friesen *et al.* 1996b, pp. 681, 685–687; Day *et al.* 1999, p. 2). Kittlitz's murrelets are heavier (8.3 ounces [oz] (236 grams [g])) (Kissling, Service, 2007–2012, unpublished data), and have larger heads, longer wings and tails, and smaller bills than do marbled murrelets (7.7 oz [219 g]) (Pitocchelli *et al.* 1995, pp. 241–245; Kuletz *et al.* 2008, pp. 91–95; Kissling, unpublished data). Long-billed murrelets are distinctly larger than both Kittlitz's and marbled murrelets, have a longer bill than them, and have a white eye ring (Friesen *et al.* 1996b, p. 681).

Mitochondrial DNA (mtDNA) sequences and restriction fragment analysis show significant differentiation among the three species (Pitocchelli *et al.* 1995, pp. 244–247; Friesen *et al.* 1996a, pp. 364–366; Friesen *et al.* 1996b, pp. 683–687). Analysis of allozymes further strengthens the evidence that these murrelets are separate species (Friesen *et al.* 1996a, pp. 361–365). In addition, nuclear introns and cytochrome *b* gene sequencing showed no evidence of recent hybridization between marbled and Kittlitz's murrelets (Pacheco *et al.* 2002, pp. 179–180).

The Kittlitz's murrelet has been considered a single panmictic population (with random mating of individuals within a breeding population) for lack of any evidence to suggest otherwise, but several recent studies suggest that there is strong population genetic structure in this species (MacKinnon 2005, pp. 18, 24–25; Birt *et al.* 2011, pp. 47–49; Friesen and Birt 2012, pp. 6–9). Intra-specific analyses of genetic data (allozymes, cytochrome *b* gene, control region of mtDNA, and nuclear DNA) indicate that there are two strongly differentiated genetic groups: one in the western Aleutian Islands and the other in the Gulf of Alaska (Friesen *et al.* 1996b, p. 686; MacKinnon 2005, pp. 18, 24–25; Birt *et al.* 2011, pp. 47–49; Friesen and Birt 2012, pp. 6–9). Birt *et al.* (2011, pp. 46, 49) concluded that gene flow between these two groups has been very limited for an extended period of time and that the genetic structure probably is due to historical fragmentation of populations; however, this study was based on limited sample sizes within and among populations of Kittlitz's murrelet (53 individuals from three study sites; n=15 from Attu, n=18 from Kachemak Bay, n=20 from Glacier Bay).

Friesen and Birt (2012, pp. 9, 16) expanded the study to include 301 individuals from nine study sites in coastal Alaska ranging from Glacier Bay in the south to Barrow in the north; results supported the previous findings of strong genetic structure in the Kittlitz's murrelet, resulting in an eastern group (Glacier Bay to Kodiak Island) and a western one (Adak, Agattu and Attu islands) that probably diverged from one another a long time ago (547,428 years ago; 95 percent confidence interval [CI]=131,000 to 896,000; confidence intervals are a range of values defined so that there is a specified probability that the value of a parameter lies within it) (Friesen 2013, in litt.). In addition, there are two contact zones where Kittlitz's murrelets have mixed ancestry from both groups; those contact zones are located between Atka and Unalaska islands in the eastern and central Aleutian Islands and in northern Alaska, although the sample size from this latter area was small (n=9) (Friesen and Birt 2012, pp. 10, 16).

Importantly, results from the expanded genetic study suggest that there are low levels of contemporary movement between the two groups and that Kittlitz's murrelets from the two groups can and do interbreed and that offspring are viable and fertile (Friesen and Birt 2012, p. 10). Therefore, birds within the two groupings (eastern and western) do not constitute separate species because genetic connectivity still exists (Friesen and Birt 2012, p. 10). Further, although a comprehensive, comparative study has not occurred yet, there are no documented differences in morphology (e.g., plumage, size) or behavior of Kittlitz's murrelets from the eastern and western genetic groups or across their range (Day *et al.* 1999, pp. 2, 20; Day 2013, in litt.). Both groups have sufficient levels of intra-specific genetic variation and do not have evidence of a genetic bottleneck (Friesen and Birt 2012, pp. 17–18; Kissling 2012, in litt.). To date, there have been no genetic analyses comparing Kittlitz's murrelets from Russia with those from North America (preliminary laboratory work has been initiated but was not completed at the time of writing of this finding). We recognize the two genetic groupings (eastern and western), but do not consider these groups to meet the definition of a DPS (see below).

Distribution

The range of the Kittlitz's murrelet encompasses a vast area from the Russian Far East (northern Okhotsk Sea, Bering Sea coast, and coast of the Chukchi Sea in northern Chukotka as far to the northwest as Cape Schmidt) across to the Aleutian Islands and southeastern Alaska, and north to northwestern Alaska (Day *et al.* 1999, pp. 3–6; Artukhin *et al.* 2011, p. 29). Nests have been recorded throughout nearly the entire at-sea range. Seasonal shifts in distribution are discussed below. There is no reliable information to suggest that the historical range of the Kittlitz's murrelet is substantially different than the current range.

Habitat and Life History

In this section, we describe seasonal shifts in distribution and habitats used, molting cycles, foraging and nesting characteristics, and the demography of the Kittlitz's murrelet.

The Kittlitz's murrelet typically spends its entire annual cycle in marine waters within and adjacent to Alaska and eastern Russia, generally moving offshore (maximum observed 106 miles [mi] (170 kilometers [km]) from shore) during the non-breeding months (August–March or April) and nearshore (within 3.4 mi [5.5 km] from shore) during the breeding season (April–August) with some latitudinal variation. Low numbers of adult Kittlitz's murrelets also have been observed during the breeding season on freshwater lakes (Savage 2013, in litt.; Walsh 2013, in litt.). The seasonal appearance, increase, and disappearance of Kittlitz's murrelets during systematic surveys at sea during the breeding season (Klosiewski and Laing 1994, pp. 55, 83; Kendall and Agler 1998, p. 55; Kuletz *et al.* 2003a, pp. 17–20; Robards *et al.* 2003, pp. 92, 100, 104; Kissling *et al.* 2007, pp. 2167–2168; Kuletz *et al.* 2008, pp. 21–22, 53–54) demonstrate that murrelets move inshore near to known breeding areas in south-coastal Alaska beginning in March or April, peak in densities in late

June and early July, and leave these areas rapidly, but asynchronously in late July to mid August. Post-breeding movements of murrelets in late July and August are westward to nearshore waters of Kodiak Island and along the Alaska Peninsula and Bristol Bay, then northward to the Bering and Chukchi seas and even extending, in a few cases, into the Beaufort Sea, where birds may remain until about late October when their pre-basic molt is complete (Day *et al.* 2011, pp. 57–59; Madison *et al.* 2012, p. 1). At-sea surveys have documented the regular occurrence of Kittlitz's murrelets from August through October in offshore waters between Cape Peirce and north of Nunivak Island, and north of the Bering Strait from Cape Lisburne to the western Beaufort Sea (Kuletz, Service, 2006–2012, unpublished data). In November, as sea ice builds in the Chukchi and Beaufort seas, Kittlitz's murrelets begin to move south into the Bering Sea where they probably winter until late February or early March (Day *et al.* 1999, p. 7; Kuletz and Lang 2010, pp. 39–43; Day *et al.* 2011, p. 59). However, records of winter sightings in southeastern, south-central, and western Alaska (Klosiewski and Laing 1994, p. 83; Kendall and Agler 1998, pp. 55–56; Day *et al.* 1999, pp. 4–5; Day 2006, pp. 208–209; Stenhouse *et al.* 2008, p. 61) indicate that some individuals are year-round residents in these areas. Annual movements of Kittlitz's murrelets in eastern Russia, the Aleutian Islands, and northern Alaska remain poorly known, although limited satellite-tag data indicate that Kittlitz's murrelets in the central Aleutians follow the same northward post-breeding migration to the Bering and Chukchi seas as those birds tagged in the Gulf of Alaska do (Madison *et al.* 2012, p. 1).

The winter range of the Kittlitz's murrelet is poorly known (Day *et al.* 1999, pp. 4–5). Recent information from icebreaker-based at-sea surveys indicates that open water leads (fractures in sea ice caused by wind drift or ocean currents) and polynyas (a large area of open water surrounded by sea ice), primarily south of St. Lawrence Island, between Nunivak and St. Matthew islands, and east of the Pribilof Islands, may be important wintering areas (Kuletz and Lang 2010, pp. 40–43; Kuletz, unpublished data). Most Kittlitz's murrelets encountered during early spring surveys in the sea ice were in pairs (Kuletz and Lang 2010, p. 40). The exact winter distribution of Kittlitz's murrelets in the Bering Sea probably shifts with respect to dynamic changes in open leads and polynyas (Kuletz, unpublished data), which tend to form consistently near the large Bering Sea islands and some coastal areas (Niebauer *et al.* 1999, p. 34). The winter range of the species in eastern Russia is largely unknown, but observations have been reported from the Kamchatka Peninsula and the Kuril Islands in the Russian Far East south to northern Japan (Flint *et al.* 1984, pp. 156–157; Brazil 1991, p. 164; but see Carter *et al.* 2011, p. 8). A few birds also have been observed during late winter in the Sireniki polynya of southern Chukotka and the western Bering Sea in Russia (Konyukhov *et al.* 1998, p. 325; Shuntov 2000, pp. 97–98).

During the summer breeding season, Kittlitz's murrelets usually, but not exclusively, are associated with glacially influenced waters, especially those with floating ice, in south-coastal Alaska, where large numbers aggregate (Isleib and Kessel 1973, p. 100; Kendall and Agler 1998, p. 58; Day *et al.* 2000, p. 109; Arimitsu *et al.* 2011, p. 18; Hoekman *et al.* 2011, p. 40; Kissling *et al.* 2011, p. 7; Kuletz *et al.* 2011a, pp. 102–103; Kuletz *et al.* 2011b, pp. 90–92; Piatt *et al.* 2011, p. 70; Arimitsu *et al.* 2012, p. 18). The exact reasons for this association are unclear, but hypothetical explanations exist. This pattern of at-sea distribution simply may reflect an adaptation for nesting on unvegetated scree slopes or nunataks (isolated peaks of rock projecting above the surface of inland snow or ice) often associated with tidewater glaciers, which are selected because these areas are thought to be predator-free (Piatt *et al.* 1999, p. 12; Kissling *et al.* 2012, p. 1; Lawonn 2012, pp. 21, 94–95). Their association with tidewater glaciers also may reflect foraging preference and efficiency in glacial-affected water (Day *et al.* 2003, pp. 681, 686; Kuletz *et al.* 2003b, p. 138; Allyn *et al.* 2012, pp. 244–245; Arimitsu *et al.* 2012, pp. 14, 18). In addition, strong nest area and site fidelity may cause these birds to return to the same area (Piatt *et al.* 1999, p. 11; Kaler *et al.* 2010, p. 18; Lawonn 2012, pp. 82, 88; Kenney and Kaler 2013, p. 73; Kissling, unpublished data), but it is unknown if the same birds are using a particular area annually or if site characteristics make the area suitable to breeding pairs.

The Kittlitz's murrelet has two distinct plumages in its annual cycle and therefore undergoes two molts per year: a full, pre-basic molt in fall (September–October) and a partial, pre-alternate molt in spring (April–May) (Day *et al.* 1999, pp. 18–19). During the pre-basic molt, individuals transition from their mottled, cryptic plumage of the breeding season to the sharply contrasting black and white plumage of the non-breeding season. The pre-basic molt replaces of the wing, tail, and body feathers, whereas the pre-alternate molt replaces only the body feathers. Although Sealy (1977, p. 467) reported that in the pre-basic molt wing feathers grow synchronously rendering a flightless period (2–4 weeks) for the bird, Pyle (2009, p. 222) found that Kittlitz's murrelets undergo a non-synchronous molt, either sequentially or in blocks, perhaps to avoid an extended flightless period, and probably prolonging the pre-basic molt period.

Foraging

Because little research on the Kittlitz's murrelet has occurred during the winter, information about foraging and other life-history characteristics are based primarily on observations made during the spring, summer, and fall. Kittlitz's murrelets tend to forage as single birds or in small groups, but seldom in mixed-species feeding flocks (Day and Nigro 2000, pp. 8–10, 12). Most foraging occurs during the day (Day *et al.* 1999, p. 9; Madison *et al.* 2010, p. 1), especially in the morning (Day and Nigro 2000, p. 5). They pursue and capture prey underwater by using wing-propelled ''flight'' and consume prey either at the surface or underwater (Day *et al.* 1999, p. 9; Day and Nigro 2000, p. 9).

The Kittlitz's murrelet appears to be a flexible forager with a diet that varies considerably among seasons but is fairly specialized within a season (Hatch 2011, pp. 25–26, 35; Allyn 2012, p. 102). Although Kittlitz's murrelets are considered to be piscivorous, they also eat zooplankton throughout the entire annual cycle (Day *et al.* 1999, p. 9), more so than for the closely related marbled murrelet (Hobson *et al.* 1994, p. 795; but see Day *et al.* 1999, p. 10). In the pre-breeding season, Kittlitz's murrelets feed on low-trophic-level prey such as macrozooplankton and larval fishes and gradually transition to consuming larger proportions of higher-trophic-level prey (planktivorous fishes) as the breeding season commences (Hatch 2011, pp. 24–25; Allyn 2012, p. 102). During the breeding season, Kittlitz's murrelets feed on a combination of macrozooplankton (36–44 percent of their diet) and schooling fishes such as Pacific capelin (*Mallotus villosus*), Pacific sand lance (*Ammodytes hexapterus*), juvenile Pacific herring (*Clupea pallasi*), and juvenile walleye pollock (*Theragra chalcogramma*) (Sanger 1983, p. 692; Hobson *et al.* 1994, p. 795; Day *et al.* 1999, p. 9; Day and Nigro 2000, pp. 11–13; Kuletz *et al.* 2003a, pp. 23, 28; Agness 2006, p. 119; Kuletz *et al.* 2008, p. 26; Hatch 2011, p. 47; Kaler *et al.*

2011, p. 15; Allyn 2012, p. 102; Lawonn 2012, pp. 27–28). By the post-breeding period they feed almost exclusively on these high-lipid fish, consuming only small proportions (4–9 percent) of zooplankton (Hatch 2011, p. 47; Allyn 2012, pp. 100–101). In the northern Bering and Chukchi seas, a variety of small arctic fishes and large zooplankton are abundant (Eisner *et al.* 2013, pp. 97–102) and presumably are consumed by Kittlitz's murrelets in the fall and winter. Based on a comparison of stable isotopes (carbon and nitrogen) from recently captured murrelets and museum specimens, these seasonal foraging patterns have been consistent over the past century (1911–2009) (Hatch 2011, p. 27).

During nesting, Kittlitz's murrelets carry a single whole fish at a time to their chick. Adult fish-holding murrelets often stage on the water before returning to their nest to deliver the fish to the chick; therefore, chick diet has been inferred by identifying these fishes held in the bill of adults on the water and by directly monitoring food deliveries to chicks at nest sites. The proportion of fish held in bill by adults on the water that is identified to species is low (21–23 percent) (Agness 2006, p. 116; Kuletz *et al.* 2008, p. 26) because of the difficulty for the observer to do so at a distance and under at-sea conditions. This method is useful, however, in areas where it is difficult to monitor nests directly such as in glacial-dominated landscapes, where Kittlitz's murrelets have been observed on the water holding primarily sand lance and capelin, and to a lesser extent Pacific herring and Pacific salmon (*Oncorhynchus* spp.) (Agness 2006, p. 124; Kuletz *et al.* 2008, p. 26). In contrast to the low identification rate of fish held by murrelets on the water, most fish (70–85 percent) delivered to chicks at monitored nests have been identified to species (Naslund *et al.* 1994, p. 46; Lawonn 2012, p. 27–28; Kaler 2012, in litt.; Kissling, unpublished data). Pacific sand lance is the fish species delivered most commonly to chicks (57 percent of identified deliveries) and occurs in chick diet in all areas where nests have been monitored (n=33 nests; western Aleutians and Kodiak islands and Kachemak and Icy bays) (Naslund *et al.* 1994, p. 46; Lawonn 2011, pp. 27–28; Kaler 2012, in litt.; Kissling, unpublished data). Although significant geographic variation exists (see *Nesting,* below), the remainder of chick diet is composed of hexagrammids (23 percent; kelp greenling [*Hexagrammos decagrammus*] and Atka mackerel [*Pleurogrammus monopterygius*]), capelin (10 percent), gadids (5 percent; Pacific cod [*Gadus macrocephalus*]) and rockfish (*Sebastes* spp.), smelt (2 percent; Osmeridae family) and Pacific herring (1 percent) (Naslund *et al.* 1994, p. 46; Lawonn 2011, pp. 27–28; Kaler 2012, in litt.; Kissling, unpublished data). In both methods used to determine chick diet, it is not known if there is bias associated with fish identification due to size of the prey item, but this is certainly possible.

Small schooling fishes that are oily, such as sand lance and capelin, are thought to be favored for chick meals because of their high lipid, and therefore energy, content (van Pelt *et al.* 1997, p. 1395; Anthony *et al.* 2000, p. 75; Litzow *et al.* 2004, p. 1150). Capelin, in particular, is hypothesized to be an important prey species for Kittlitz's murrelets in glacially-affected waters because this fish species occurs in cold, turbid marine waters close to tidewater glaciers (Arimitsu *et al.* 2008, p. 137). Chicks eating oily fishes receive more calories and grow faster (Ostrand *et al.* 2004, p. 69), resulting in fewer foraging trips for parents, when high-energy fishes are fed to chicks than when lower-energy fishes such as walleye pollock or rockfishes, are fed to chicks (Hatch 2011, pp. 74–77, 103–104). Therefore, a change in the availability of high-energy forage fishes during the breeding season could affect the reproductive success of Kittlitz's murrelets (van Pelt *et al.* 1997, p. 1393; Anderson and Piatt 1999, p. 117; Becker *et al.* 2007, pp. 276–278; Österblom *et al.* 2008, pp. 967–974).

Several studies have described marine habitat use of Kittlitz's murrelets in the breeding season by associating murrelet distribution with marine biotic and abiotic factors in areas where glaciers exist (Day and Nigro 2000, pp. 8–9; Day *et al.* 2003, pp. 685–694; Kissling *et al.* 2007, p. 2168; Kuletz *et al.* 2008, p. 24–27; Allyn *et al.* 2012, pp. 240–242; Arimitsu *et al.* 2012; pp. 12–14; Renner *et al.* 2012, pp. 2035–2039). Generally, Kittlitz's murrelets prefer to forage in shallow (less than 196 feet [ft] (60 meters [m])), glacially affected waters (Kuletz *et al.* 2008, p. 37) often with some floating ice (Day and Nigro 2000, pp. 6, 8; Day *et al.* 2003, pp. 686, 694; Kuletz *et al.* 2003b, pp. 136, 139), but it is not known whether ice occurrence is biologically meaningful to murrelets. Arimitsu *et al.* (2012, p. 18) postulated that the presence of ice may instead serve as a proxy to other factor(s), such as outflow of sediment-laden freshwater from glacial streams and a downstream increase in the availability of certain near-surface prey (e.g., euphausiids). Kuletz *et al.* (2003b, p. 139) hypothesized that the undersides of icebergs and pack ice may increase prey abundance and availability to murrelets, perhaps due to the presence of sea ice algae and its role in primary production (Grebmeier *et al.* 2006, p. 339). Other studies have positively associated Kittlitz's murrelets with highly turbid waters (Day *et al.* 2003, p. 685; Renner *et al.* 2012, pp. 2038–2039), often with a clear, cold freshwater lens at the surface less than 32 ft (10 m) in depth (Kuletz *et al.* 2008, p. 37; Allyn *et al.* 2012, p. 233); in fact, Day *et al.* (2003, p. 695) suggest that the eyes of Kittlitz's murrelets are large to increase their ability to forage in highly turbid water. This species prefers marine waters with sea surface temperatures of 37–48 degrees Fahrenheit (F) (3–6 degrees Celsius) (Day *et al.* 2003, p. 685; Day *et al.* 2011, p. 59; Allyn *et al.* 2012, p. 242). Kittlitz's murrelets are often associated with areas of localized upwelling that are generally created by the interaction of landscape features, such as submerged marine sills, shoreline, hanging and tidewater glaciers, and strong tidal currents (Day and Nigro 2000, p. 5; Kuletz *et al.* 2003b, p. 139; Kissling *et al.* 2007, p. 2171; Allyn *et al.* 2012, pp. 244–245; Arimitsu *et al.* 2012, p. 10), but not tidal height (Allyn 2012, p. 101). It is not known to what extent the distribution of Kittlitz's murrelet depends on these marine habitat conditions for foraging efficiency or prey availability in a given year. However, it is logical to assume that daily, weekly, monthly and annual variability in Kittlitz's murrelet population density at a location may be due, at least in part, to corresponding variability in prey abundance.

Kittlitz's murrelets probably switch among prey types between seasons or years depending on availability, as do marbled murrelets (Ostrand *et al.* 2004, p. 73; Becker *et al.* 2007, p. 274). High-lipid forage fishes are expected to represent higher-quality prey for seabirds than are zooplankton because the fishes' larger size should result in more energy gained per unit of effort spent foraging (Norris *et al.* 2007, p. 876), although macrozooplankton are not necessarily of lower caloric value than fishes (Vermeer and Cullen 1982, p. 35; Davis *et al.* 1998, p. 151; Hedd *et al.* 2002, pp. 229–230). Janssen *et al.* (2009, p. 36) reported that in some years female marbled murrelets producing eggs early in the breeding period had a higher proportion of low-trophic-level prey in the pre-breeding diet than did murrelets not producing eggs, signifying that low-trophic-level prey may not

necessarily equate to low-quality prey. Thus, the substantial amount of marine invertebrates in the Kittlitz's murrelet diet coupled with their prey-switching abilities, may buffer self-feeding adults from annual and seasonal variation in the availability or quality of high-energy forage fishes (Anderson and Piatt 1999, p. 117; Robards *et al.* 2003, p. 2; Litzow *et al.* 2004, p. 1149; Arimitsu 2009, pp. 33–36, 45).

Nesting

The Kittlitz's murrelet is a dispersed-nesting seabird (i.e., does not nest in colonies like most marine foragers) that often nests in remote, rugged areas and therefore little information on their nesting ecology existed until recently. Until 1999, only 19 confirmed Kittlitz's murrelet nests had been described, 17 in Alaska and 2 in Russia (Day *et al.* 1999, pp. 25–26). In 2005, a nest was opportunistically discovered on Agattu Island, at the western end of the Aleutian Islands (Kaler 2006, p. 3). Since that time, a number of different studies have been initiated, owing to increasing interest in their conservation status, that have greatly added to our knowledge about the nesting and breeding behavior of this species. On Agattu Island, an additional 86 active nests have been found and monitored (Kaler, Service, 2008–2011, unpublished data), 9 nests have been found on Adak Island (Kenney 2012, in litt.; Kenney and Kaler 2013, p. 74), 75 have been found on Kodiak Island (Corcoran and Mackey, 2012, p. 1; Lawonn 2012, p. 10), and 35 have been found in the glaciated landscape around Icy Bay (Kissling, unpublished data). To date, 234 Kittlitz's murrelet nests have been found in Alaska (n=230; 98 percent) and Russia (n=4; 2 percent) (Felis, U.S. Geological Survey, 2013, unpublished data).

Based on these recent efforts, some generalities can be made about nesting habitat and nest site selection of the Kittlitz's murrelet. Their nesting habitat is characterized by sparsely vegetated or unvegetated scree-fields, talus slopes, barren ground, and cliff and rock ledges in the coastal uplands and mountains, often in the vicinity of glaciers or in historically-glaciated areas (Day *et al.* 1983, pp. 267–269; Day 1995, pp. 271–273; Konyukhov *et al.* 1998, p. 322; Piatt *et al.* 1999, p. 8; Kaler *et al.* 2009, p. 366; Lawonn 2012, pp. 83–87; Kissling, unpublished data). Rangewide, barren areas, which are characterized by bare rock, gravel, sand, silt or clay with little or no ''green'' vegetation present appear to be the preferred nesting habitat the Kittlitz's murrelet owing to disproportionate use relative to availability (Kaler *et al.* 2009, p. 366; Lawonn 2012, pp. 90, 101–102; Felis, unpublished data; Kissling, unpublished data). In parts of this species' range, such as Kodiak Island, where mammalian predators exist, the Kittlitz's murrelet appears to avoid nesting near vegetated edges (Lawonn 2012, pp. 90, 101). Dwarf shrub and herbaceous habitats occasionally are used by nesting Kittlitz's murrelets, especially in the Aleutian Islands where nests are positively associated with orange crustose lichens (*Xanthoria* spp.) (Kaler *et al.* 2009, p. 366; Kenney and Kaler 2013, pp. 73–74), and where this habitat type is abundant. Nesting habitat of the Kittlitz's murrelet is located adjacent to or associated with glaciers and persistent snow only in south-coastal Alaska where these land cover classes currently exist. Generally, the amount of vegetative cover within a 25-m radius of nest sites is least in glaciated areas of south-coastal Alaska (3 percent) (Kissling, unpublished data), moderate on Kodiak Island (9 percent) (Lawonn, p. 102) and northern Alaska (14 percent) (Felis, unpublished data) and greatest in the Aleutian Islands (51 percent) (Kaler *et al.* 2009, p. 366). Despite variation in percent of vegetative cover near nests among these study sites, Kittlitz's murrelets consistently nest in the least vegetated areas available on the landscape within a particular area (Lawonn 2012, p. 90; Kaler, unpublished data; Kissling, unpublished data), presumably to maximize the safety of the nest from predators.

Although the amount of vegetative cover appears to drive nest site selection for the Kittlitz's murrelet both within areas and across their range, other characteristics may also be important. Many of these factors, such as elevation, slope, distance to ocean, aspect, substrate, and local climate, however, often are correlated with low vegetative cover. For example, unvegetated or sparsely vegetated areas tend to occur at higher elevations and on steeper, windward-facing slopes. Moreover, the variation in these attributes across the species' range makes it difficult to draw generalizations about their importance. For example, nests have been found from 0.1 to 45.7 mi (0.2 to 73.5 km) from the ocean, on slopes 0–66 degrees, and at elevations between 419 and 7,378 ft (128 and 2,249 m) above sea level. In general, nests located on the steepest slopes and at the highest elevations occur in south-coastal Alaska, whereas those farthest from the ocean are located in northern Alaska (Felis, unpublished data), but this may reflect overall differences in habitat available. Nest orientation is similarly uninformative at the rangewide scale; based on 196 nests with documented aspect, 50 (26 percent) faced north, 56 (29 percent) faced east, 40 (20 percent) faced south and 50 (26 percent) faced west (Day *et al.* 1999, 25–26; Lawonn 2012, p. 84; Kaler, unpublished data; Kissling, unpublished data; summarized by Felis, unpublished data), suggesting that nest site aspect is not relevant (Kaler *et al.* 2009, p. 366) or is locally driven (e.g., on Kodiak Island) (Lawonn 2012, pp. 83–84). The importance of small- and medium-sized rocks (roughly 2.0– 11.8 inches [in]) (5–30 centimers [cm]) at and near nests has been reported at several study sites (Day *et al.* 1983, p. 267; Kaler *et al.* 2009, p. 366; Lawonn 2012, p. 89; Kissling, unpublished data).

Similar to that of the marbled murrelet, much of the behavior and life history of the Kittlitz's murrelet appears to have evolved around predator avoidance, particularly during nesting (Nelson and Hamer 1995, p. 66). While most alcids avoid predators by nesting in inaccessible areas (burrows, crevices) or on open rock ledges and protect their young by nesting in large colonies or by guarding them, the Kittlitz's murrelet places its nest in habitats expected to support low numbers of predators, disperses nests across the landscape, and relies on cryptic coloration and behavior to avoid predator detection. On the mainland in south-coastal Alaska, nunataks appear to be favorable habitats presumably because of their isolation from terrestrial predators (Kissling, unpublished data). On Kodiak Island, the median within-year nearest neighbor distance was found to be 1,128 ft (range=42–5,085 ft) (344 m; range=13–1,550 m) (Lawonn 2012, p. 83). In addition to site selection, murrelets have a variety of morphological and behavioral characteristics to minimize detection by potential predators (summarized by Nelson and Hamer 1995, p. 66).

A single egg is laid in a nest scrape composed of sand- and pebble-sized rocks (more typical in northern Gulf of Alaska) or plant matter (moss and lichens; common in western Aleutian Islands) at the base of a large rock or on a cliff ledge (Day *et al.* 1983, p. 267; Piatt *et al.* 1994, p. 55; Piatt *et al.* 1999, p. 11; Day 1995, pp. 271–273; Kaler *et al.* 2009, p. 366; Lawonn 2012, pp. 81–82; Kaler 2012, in litt.; Kenney and Kaler 2013, p. 73; Kissling, unpublished data). The egg is colored pale-green, olive-green, or blue-green with brown mottling, ranging from speckling to streaking (Day *et al.* 1983, pp. 265–266; Piatt *et al.* 1994, p. 55; Kaler *et al.* 2009,

p. 367). Across their range and within areas, egg laying is highly asynchronous, with records ranging from 6 May through 17 July (Day 1996, p. 435; Kaler *et al.* 2009, pp. 366–367; Corcoran and Mackey 2012, p. 10; Lawonn 2012, p. 21; Kissling, unpublished data). There is some evidence that Kittlitz's murrelets attempt to renest when a nest fails (Kaler and Kenney 2008, p. 16; Kenney and Kaler 2013, p. 73; Kissling, unpublished data).

The duration of incubation is approximately 30 days (Day *et al.* 1999, p. 14; Kaler *et al.* 2009, p. 365). Both parents incubate the egg, and loss of a parent can mean failure of the nest (Kissling, unpublished data). Mean hatching dates range from 6 July in Icy Bay (Kissling, unpublished data), to 8 July on Kodiak Island (Corcoran and Mackey 2012, pp. 10–11; Lawonn 2012, pp. 21, 47), and to 17 July on Agattu Island (Kaler, unpublished data); these are consistent with the known or expected hatching dates by geographic region presented by Day *et al.* (1996, p. 435), which range from 14 June in southeastern Alaska to 28 July in the Chukchi Sea. Like the marbled murrelet, Kittlitz's murrelet chicks are semiprecocial and are brooded for approximately 48 hours (Nelson and Hamer 1995, p. 66; Lawonn 2012, pp. 23–24). This short period of brooding requires that thermoregulatory capability be developed quickly after hatching so that the chick can remain unattended and have minimal parental care other than food deliveries.

The chick is fed fish for 21–40 days post-hatch at a rate of 1–12 times per day with considerable variation among individual nests, study areas, and years (Day *et al.* 1999, p. 15; Kaler *et al.* 2011, p.15; Lawonn 2012, p. 51; Kissling, unpublished data). Both adults feed the chick throughout the day and night (Day *et al.* 1999, p. 15; Kaler *et al.* 2011, p. 16; Kissling, unpublished data), but most meal deliveries occur in the early morning within a 4-hour period around sunrise (Lawonn 2012, p. 26). Similar to those of the marbled murrelet, Kittlitz's murrelet chicks maintain their camouflaging down until just prior to fledging (Nelson and Hamer 1995, p. 60; Kaler *et al.* 2009, p. 367). When they fledge, chicks are 40–60 percent of adult body mass, but their wing length is nearly adult-sized (Day *et al.* 1983, p. 272; Kaler *et al.* 2009, pp. 368–369; Lawonn 2012, p. 60). Their initial flight from the nest to the ocean can be short from island nests (Kaler *et al.* 2009, p. 371; Lawonn 2012, p. 101), or much longer from mainland nests that have been recorded as far as 46 mi (74 km) from the ocean (Day *et al.* 1983, p. 272). Russian scientists have speculated that newly-fledged Kittlitz's murrelets stage on upland glacial lakes before departing for the ocean, but this hypothesis has not been substantiated (Kuletz *et al.* 2008, p. 13), although low numbers of adult Kittlitz's murrelets have been observed on freshwater lakes during the breeding season (Savage 2013, in litt.; Walsh 2013, in litt.). There also is the possibility that fledglings fly downslope to the nearest river from an inland site and use the river as transportation or orientation to the ocean, but this behavior has not been documented (Day *et al.* 1983, p. 272).

Demography

Although demographic data are sparse, Kittlitz's murrelets exhibit life-history characteristics that are similar to other alcids, such as fairly long lifespan (assumed to be approximately 15 years), delayed reproductive maturity (assumed to be approximately 3 years of age), intermittent breeding (i.e., they do not appear to breed annually), and low rates of reproduction (Bessinger 1995, p. 385; De Santo and Nelson 1995, pp. 36–37; Begon *et al.* 1996, pp. 494–496; Day *et al.* 1999, p. 16; Gaston 2004, pp. 164–167). This life-history strategy depends on the survival of at least a few offspring and recruitment of those offspring into the adult breeding population to maintain population stability. Generally, for a species with this life history strategy, changes in mortality rates of reproductively capable adults have greater population-level effects compared to those of juvenile or sub-adult birds and to changes in reproductive rates; in contrast, for a species that is shorter lived, produces more offspring, and matures at an earlier age, changes in reproductive rates tend to drive population-level effects (Ricklefs 1977, p. 467–468; Roff 1992, p. 45; Beissinger 1995, p. 390).

Reproductive Performance. Assessing reproductive effort and performance of the Kittlitz's murrelet is particularly challenging because of their non-colonial and purposefully cryptic nesting behavior. Low reproductive success has been both suggested (Day and Nigro 2004, pp. 91–94) and documented in Kittlitz's murrelets (Kaler *et al.* 2009, p. 369; Lawonn 2012, pp. 29–30; Kaler, unpublished data; Kissling, unpublished data). Because nesting behavior and nesting success have been monitored for only a few years (since 2006) and only in a few locations, it is unclear whether this low rate of nesting success is typical for the Kittlitz's murrelet, a species in which a breeding pair needs to produce offspring only infrequently, or whether one or more environmental parameters have changed, causing decreased breeding effort or increased egg and chick mortality.

In total, 206 active nests of the Kittlitz's murrelet have been monitored, nearly all of which were discovered as part of studies initiated since 2006 on Agattu and Kodiak islands and Icy Bay (south-coastal Alaska) (Naslund *et al.* 1994, p. 46; Kaler *et al.* 2009, p. 363; Lawonn 2012, p. 10; Corcoran and Mackey 2012, p. 1; Kenney 2012, in litt.; Kaler, unpublished data; Kissling, unpublished data). The majority of these nests (74 percent) failed; only 23 percent successfully fledging a chick; the nest fate was not able to be determined at 3 percent of the nests. Overall, most of the nest failures were attributed to depredation of the egg or chick (31 percent) and death of the chick (starvation, exposure or disease; 29 percent), followed by unknown cause (21 percent), abandonment (14 percent), accident (3 percent), and parent mortality (2 percent). When analyzed collectively, estimates of daily nest survival (± standard error [SE]; standard error is a measure of variability in the data) at the three locations where nests where regularly monitored were slightly higher in Icy Bay (0.979±0.005) than at Kodiak and the Aleutian islands (0.968±0.003) (see *Factor A* discussion for more details on this analysis). Across the 55-day nesting period, these daily nest-survival rates extrapolate to estimates of nesting success of 0.307 and 0.166, respectively. Nest observations from the three locations where nests were regularly monitored are summarized below, as well as observations of juveniles at sea.

Aleutian Islands—Since 2005, 96 active Kittlitz's murrelet nests have been found in the Aleutian Islands (Agattu=87 and Adak=9) (Kaler *et al.* 2009, p. 366; Kenney 2012, in litt.; Kenney and Kaler 2013, p. 74; Kaler, unpublished data). Nests were found using searches conducted on foot owing to the low, scrubby vegetation and rolling hills (Kenney and Kaler 2013, pp. 73–74). From 95 nests of known fate, 18 chicks successfully fledged (19 percent apparent nesting success; range among years=6–44 percent) (Kenney 2012, in litt.; Kaler, unpublished data), and the fate of one chick was unknown because researchers left the island before its fate was determined (Kaler *et al.* 2009, p. 369). Of the 77 failed nests, the apparent cause of nest failure was chick death due to starvation and exposure (40 percent), depredation of egg or chick (25 percent), unknown cause (21 percent), failure of eggs to

hatch followed by abandonment (12 percent), or accident (2 percent). Kaler *et al.* (2011, p. 17) could not definitively assign the causes of chick mortality to either exposure or starvation because multiple factors including diet, weather, and provisioning rates by adults were likely contributors. Fledglings in the Aleutian Islands were approximately 50 percent of the adult body mass (Kaler *et al.* 2009, pp. 368, 370–371). This percentage is lower than that calculated for marbled murrelets (58–70 percent) (Kuletz and Marks 1997, p. 423; Nelson and Hamer 1995, p. 60; Kissling, unpublished data) and for Kittlitz's murrelets that fledged from Kodiak Island (58 percent) (Lawonn 2012, p. 60) and Icy Bay (63 percent) (Kissling, unpublished data), but is greater than a Kittlitz's murrelet fledgling found on the Kenai Peninsula (40 percent) (Day *et al.* 1983, p. 272). The low fledging weight in the Aleutian Islands was most likely due to the poor quality (i.e., low lipid content) of prey delivered to chicks, which included mostly hexagrammids (40 percent of deliveries at 10 nests monitored), sand lance (36 percent), and gadids and rockfish (24 percent), and was reflected in the high prey delivery rates at nests in the Aleutians (9.8 fish per day) (Kaler, unpublished data), which was nearly double the rates observed in the northern Gulf of Alaska (Lawonn 2012, pp. 27, 55; Kissling, unpublished data).

South-central Alaska—In 1994, one active Kittlitz's murrelet nest was opportunistically found and monitored using a remote video camera on Red Mountain near Kachemak Bay (Naslund *et al.* 1994, p. 46; Piatt *et al.* 1994, p. 55). The chick fledged and the nest was deemed to be successful (Naslund *et al.* 1994, p. 46).

In 2006, an active nest that contained a live Kittlitz's murrelet nestling was found opportunistically on Kodiak Island, although the fate of this nest was not confirmed (Stenhouse *et al.* 2008, p. 59). Since then, 74 additional nests have been found by systematically searching areas of apparently suitable habitat on foot in a pre-defined study area (Corcoran and Mackey 2012, p. 1; Lawonn 2012, p. 21). Of these 74 nests, 16 chicks fledged from 71 nests (23 percent apparent nesting success) and nest fate of 3 nests was unknown. The overall annual nest survival rate (number of chicks fledged per nesting pair) was 0.0933 (95 percent CI = 0.0067 to 0.2991) between 2008 and 2011, almost certainly below 30 percent nesting success (Lawonn 2012, p. 30). Nest failures were most commonly caused by depredation (54 percent), followed by chick death (25 percent) and abandonment (20 percent); one nest failed for unknown reasons (Corcoran and Mackey 2012, p. 3; Lawonn 2012, p. 59). The red fox (*Vulpes vulpes*) was the only identified nest predator (13 of 15 predation events recorded; two unidentified predators) (Corcoran and Mackey 2012, p. 3; Lawonn 2012, pp. 30–31). In 2011 and 2012, nine dead chicks found in nest scrapes of monitored nests were necropsied, and all were in fair to good body condition, suggesting that nutritional health was not responsible for their death (Shearn-Bochsler *et al.* 2013, p. 1). However, at least six of these chicks had high levels of saxitoxin, a neurotoxin produced by certain species of dinoflagellates, in their gut and/or liver, which is believed to have caused the death of these chicks immediately after consuming sand lance (Shearn-Bochsler *et al.* 2013, p. 1). Chick meal delivery rates (±1 standard deviation [SD]; standard deviation is a measure of variability in the data) averaged 4.6 (±0.8) fish per day or 117 (±37) fish from hatching to fledging of the chicks with sand lance being the most common prey delivered (92 percent of deliveries), followed by capelin (8 percent) and a few herring and salmonids (*Oncorhynchus* spp.) (Lawonn 2012, pp. 27–28, 55). On Kodiak Island, the mean number of days to fledging (±SD) was 24.8 (±2.3) days (Lawonn 2012, p. 55), or lower than that for nests monitored at Agattu Island (30.6±5.6 days) (Kaler, unpublished data), despite comparable apparent nesting success at these study sites where similar methods were used to locate and monitor Kittlitz's murrelet nests.

Southeastern Alaska—In contrast to Kodiak, Adak, and Agattu islands, the terrain in southeastern Alaska is characterized by steep mountains, icefields, and glacial fjords usually with thick vegetation along the near shore areas precluding nest searching efforts by foot. Thus, from 2007 to 2012, 35 Kittlitz's murrelet nests have been located in Icy Bay by tracking 24–44 radio-marked birds throughout each of the six breeding seasons (Kissling, unpublished data). Thus, this is the only study site where some reproductive measures, such as breeding propensity and adult body condition prior to breeding, are available and where nest locations are seemingly unbiased because all habitats within the study area were available to the marked birds for nesting (as opposed to searching a specified area that consists of presumably suitable nesting habitat). The mean proportion of radio-marked murrelets that attempted to nest annually was 0.18 (range=0.03–0.43 across all years), but because weather and logistics precluded daily aerial tracking, it is possible that early failed breeders were not detected and that this estimate of breeding propensity is biased low. Therefore, Kissling (unpublished data) used a combination approach to estimate breeding propensity that includes quantifying levels of vitellogenin (an egg-yolk precursor protein expressed only in females), brood patch development (necessary for incubation in both sexes), and radio-telemetry (following Peery and Henry 2010, p. 2417). Using the combination method, the proportion of murrelets attempting to breed was 0.87 (range=0.75–1.00), which is probably biased high because brood patches can be an unreliable indicator of reproductive status (McFarlane Tranquilla *et al.* 2003, p. 112). It is difficult to reconcile the range in estimates of breeding propensity (0.18–0.87; mean=0.52; breeding propensity is defined as the probability that an after-second-year murrelet will breed in a given year), and it is impossible to determine the accuracy of either method because in glacial-dominated landscapes such as Icy Bay, alternative field methods to locate nests do not currently exist. Many adult Kittlitz's murrelets arrive in Icy Bay paired with a mate and in apparently good body condition, suggesting perhaps that certain environmental cues may be required for breeding to proceed. Another possible explanation for the variable breeding-propensity rate is that there is a capture, handling, or radio-transmitter effect on individual Kittlitz's murrelets; however, several lines of evidence, including few juveniles observed at sea and good reproductive performance of radio-marked marbled murrelets (see below), suggest that this possible issue is not significant.

Because most (86 percent) nests in Icy Bay were not accessible due to the dangerous terrain, nest fate often was inferred (following Bradley *et al.* 2004, pp. 321–322), but nests occasionally (n=5) could be monitored with video or still cameras. Apparent nesting success across all years combined was 40 percent (14 of 35 nests). Causes of failure were largely unknown (71 percent of failed nests) because most of the nests were inaccessible, but of those where cause of failure could be determined or inferred, three failed due to parent mortality (predation) during incubation, two failed due to unstable terrain (i.e., a rockfall), and one egg was abandoned. Despite the small sample sizes, successful nests (n=14) were

located closer to the ocean (median distance=5.6 mi [9.0 km]) than failed nests (n=21; median distance=15.0 mi [24.1 km]); the elevation of nests did not affect nest fate (4,226 ft [1,288 m] for successful nests and 4,718 ft [1,435 m] for unsuccessful nests). Prey deliveries averaged 3.0 fish per day (n=2 nests) and consisted primarily of sand lance (58 percent) and capelin (21 percent) with smaller amounts of smelt (9 percent), herring (6 percent) and snake prickleback (*Lumpenus sagitta;* 6 percent). The mean number of days to fledging (±1 SD) at 9 nests was 23.7 (±3.5) days, or comparable to nests monitored at Kodiak Island.

In addition to Kittlitz's murrelets, researchers captured and radio-marked marbled murrelets in 2011 (n=7) and 2012 (n=9) in Icy Bay to compare reproductive performance between the two closely related species (Kissling, unpublished data). Across both years, 11 of 16 (69 percent) radio-marked marbled murrelets attempted to nest (two actually renested successfully), and 9 of 13 nests were successful (69 percent apparent nesting success). Marbled murrelet nests were located at lower elevations (median elevation=1,368 ft [417 m]) and closer to the ocean (median distance=2.9 mi [4.7 km]) than were Kittlitz's murrelet nests (4,291 ft [1,308 m] and 8.8 mi [14.2 km], respectively). Both breeding propensity and nest success of marbled murrelets were far greater than that for Kittlitz's murrelets using the same techniques in the same study area. Although the sample sizes are small, these results are important for two reasons: (1) It is unlikely that there was a capture, handling or radio-transmitter effect negatively biasing the poor reproductive measures of Kittlitz's murrelets, assuming that Kittlitz's and marbled murrelets would respond similarly; and (2) despite their similar life histories, Kittlitz's murrelets were consistently outperformed reproductively by marbled murrelets in Icy Bay, suggesting perhaps that forage-fish abundance was not limiting the nesting success of Kittlitz's murrelets. Possible reasons for the differences in reproduction of the two species are reduced foraging efficiency of Kittlitz's murrelets, availability of suitable nest sites, carry-over effects from the non-breeding period (Sorensen *et al.* 2009, p. 464), or increased energetic costs of Kittlitz's murrelets to access nests at higher elevations and farther from the ocean (Hatch 2011, pp. 86–87).

Juveniles at sea—Juvenile and adult Kittlitz's murrelets are readily distinguishable in hand owing to plumage characteristics, and usually, the presence of an egg-tooth in juveniles (Kissling, unpublished data); however, these identification markers are not easily observed at a distance at sea, especially in August when fledglings arrive on the water and adults begin their concurrent pre-basic molt (Kuletz *et al.* 2008, p. 34). This complication may prevent the accurate estimation of juvenile abundance and ratios of juveniles to adults, both of which have been used as indices to annual reproductive success of marbled murrelets (Beissinger 1995, pp. 391–392; Kuletz and Kendall 1998, pp. 450–455; Beissinger and Peery 2007, pp. 297–298; Kuletz *et al.* 2008, p. 85).

Day and Nigro (2004, pp. 91–93) suggested that reproductive success in Kittlitz's murrelets may be very low based on the near absence of juvenile birds in late summer surveys in Prince William Sound. In 3 combined years of at-sea surveys conducted between 15 July and 15 August in 1996, 1997, and 1998, in the fjords of Prince William Sound, only a single hatch-year bird was sighted (Day and Nigro 2004, p. 91). During similar late summer surveys in Kachemak Bay from 2004 to 2007, densities of juvenile Kittlitz's murrelets varied among years (range=0.01–0.05 birds per square mile (mi^2) [0.03–0.12 birds per square kilometer (km^2)]) and were much lower than those of marbled murrelets (range=0.10–0.31 birds per mi^2 [0.27–0.79 birds per km^2]); however, juvenile to adult ratios were comparable between species ranging from 0.01 to 0.28 for Kittlitz's murrelets and from 0.02 to 0.13 for marbled murrelets, albeit with less intra-annual variation for the latter species (Kuletz *et al.* 2008, pp. 59, 85). To provide perspective, the total number of juvenile Kittlitz's murrelets recorded in the 4 years of surveys was 37 among 1,445 sub-adults and adults (Kuletz *et al.* 2008, pp. 104–107). Similarly, during surveys of nearshore waters around Kodiak Island in August 2011 and 2012, 16 juvenile and only 6 sub-adults and adult Kittlitz's murrelets were observed compared to 187 juvenile and 5,779 sub-adults and adult marbled murrelets (Corcoran 2012, p. 5). Between 2008 and 2011, only 5 juvenile to 380 adult Kittlitz's murrelets were captured in late summer in Icy Bay (Kissling, unpublished data). Thus, results of all of these studies are difficult to interpret without information on the behavior and timing of movements of both age classes of Kittlitz's murrelets in late summer and some estimates of detection errors. Fairly high ratios of juveniles to adults in Kachemak Bay and Kodiak Island suggest good reproductive performance in these areas, yet nest monitoring data on Kodiak Island indicate differently; therefore, the high ratios may reflect rapid and synchronous departure of adult Kittlitz's murrelets from these areas or post-fledging dispersal of juvenile Kittlitz's murrelets into these areas.

In Icy Bay, six juvenile Kittlitz's murrelets (1 immediately prior to fledging, 3 newly fledged, and 2 approximately 2–3 weeks post-fledgling) were captured and radio-marked in 2008–2010 (Kissling, unpublished data). All juveniles still had their egg-tooth at the time of capture. The 3 newly fledged birds were located within Icy Bay for approximately 24 hours before departing; 2 of them were not detected again, but 1 returned to Icy Bay 8 days later. The older fledglings, which were significantly heavier than the newly fledged birds, were relocated in Icy Bay for 1–3 weeks post-marking. All juveniles were relocated visually and appeared to be good swimmers and divers, although the newly fledged birds were not readily capable of flight, in contrast to the older fledglings that were excellent flyers and were indistinguishable from flying adults both in terms of flight ability and plumage. The small sample size precludes drawing definitive conclusions; however, these results suggest that most newly fledged Kittlitz's murrelets immediately depart their breeding area. After becoming proficient at foraging on their own, gaining weight and improving flight capability to avoid predators, they may return to their breeding area where they remain until the post-breeding migration begins. This possible scenario explains the differences in behavior between the newly fledged and post-fledged Kittlitz's murrelets. A better understanding of juvenile behavior after fledging would help to determine the reliability of juvenile surveys in late summer, which may be the most realistic and cost-efficient method for long-term monitoring of reproductive performance across many different study sites, as it is for marbled murrelets.

Survival. The only estimates of survival of Kittlitz's murrelets were derived from data collected in Icy Bay. Using radio-marked Kittlitz's murrelets (n=197), Kissling (unpublished data) estimated breeding season survival (60 days post-marking; approximately mid-May through mid-July) of adults greater than 1 year old to be 0.89 (SE=0.04) with little inter-annual variation (n=6 years). The primary cause of adult mortality in the breeding season in Icy Bay was predation by peregrine falcons

(*Falco peregrinus*) and bald eagles (*Haliaeetus leucocephalus*). Based on mark-recapture banding methods, annual survival (1 July to 30 June) of adult Kittlitz's murrelets was estimated to be 0.80 (SE=0.33). Although this estimate is imprecise, primarily because of low recapture rates across years (less than 8 percent), it is comparable to annual survival of marbled murrelets (0.83–0.88) estimated using similar methods (Cam et al 2003, p. 1122; Peery *et al.* 2006, p. 83). There are no estimates of juvenile survival of Kittlitz's murrelets, but estimates of annual survival of juvenile marbled murrelets range from 0.51 based on radio-telemetry (Parker *et al.* 2003, p. 207) to a proportion of adult survival (70 percent) by comparing with other alcids (Nur 1993 in Piatt *et al.* 2007, p. 55).

Population Status and Trends

In this section, we summarize information on status and trends of the Kittlitz's murrelet at the local population scale (i.e., by individual study areas) and at a broad scale across multiple populations. We also describe difficulties in estimating population size and trends of the Kittlitz's murrelet.

Estimating abundance and population trends for most alcids is simpler than for the Kittlitz's murrelet because the majority of alcids nest in colonies where birds concentrate and can be monitored in large numbers during the breeding season. In contrast, the solitary, remote, and secretive nesting behavior of the Kittlitz's murrelet makes terrestrial monitoring impractical for the purposes of estimating abundance and population trends (Drew and Piatt 2008, p. 179). Therefore, estimating abundance and the rate of change in populations of Kittlitz's murrelets has relied entirely on at-sea surveys (Day 2011, p. 2).

A handful of ornithological surveys and expeditions primarily aimed at documenting the distribution of marine birds occurred prior to 1972 (Isleib and Kessel 1973, p. 1), when systematic at-sea surveys were conducted in a few select locations in Alaska (Bailey 1977, p. 60; Klosiewski and Laing 1994, p. 5) and along discontinuous sections of shoreline in Russia (summarized in Artukhin *et al.* 2011, pp. 25–26). Since then, many surveys for marine birds, including a number of efforts specifically for the Kittlitz's murrelet, covering a wider geographic area have been conducted and, in some areas, repeated in subsequent but not necessarily continuous years. These historical and recent survey efforts have provided a tremendous amount of information on the distribution and abundance of the Kittlitz's murrelet within the areas surveyed. Nonetheless, inherent, methodological, and analytical difficulties in estimating population size and trend of this species remain, many of which are not mutually exclusive and some of which can be resolved as new information becomes available.

First, present-day populations of Kittlitz's murrelet occupy a large range and are geographically clustered, usually in remote areas that are difficult to reach and survey. Many areas of their range have not yet been systematically surveyed or are under-represented by existing survey efforts.

Second, the high at-sea spatial and temporal variation of Kittlitz's murrelets often results in wide variances associated with population estimates and therefore little power to detect trend (Kissling *et al.* 2007, p. 2168; Kirchhoff 2011, pp. 79–80; but see Drew *et al.* 2008, pp. 18, 41). Each surveyed area differs in size, which has implications for estimating abundance. Surveys attempting to encompass larger areas, such as Prince William Sound, may encompass the spatial variability of murrelets that use this area during the summer; that is, surveys may be sufficiently large to encompass the spatial variation in areas used by murrelets during a survey effort owing to daily or weekly movements by murrelets within that area. However, larger areas take longer to survey and thus must capture the temporal variability in murrelet abundance. None of the survey areas, except Icy Bay (see *Nesting* and *Demography,* above), has been accompanied by related studies of daily (or longer) movements by murrelets to help understand whether the at-sea surveys are encompassing the range of habitats used by murrelets in that area during the survey period.

Third, the Kittlitz's murrelet can be difficult to distinguish from the more common marbled murrelet during surveys, resulting in varying proportions of *Brachyramphus* murrelets identified to genus only. This issue was particularly problematic during earlier surveys (pre-2000), when there was less emphasis and training on distinguishing between the two species during surveys of all marine birds, occasionally leading to high proportions (greater than 50 percent) of unidentified murrelets (Piatt *et al.* 2011, p. 66; Day 2011, pp. 22–27; Kuletz *et al.* 2011a, p. 99; Kuletz *et al.* 2011b, pp. 87, 90) and possibly unknown proportions of misidentified murrelets (Kirchhoff 2011, pp. 80–81; Hodges and Kirchhoff 2012, p. 117; Kuletz *et al.* 2013, p. 69).

Fourth, owing to their asynchronous arrival at breeding sites, unknown fidelity to breeding areas, and movements during the breeding season, it is difficult to define both a statistical or biological population of Kittlitz's murrelets. Therefore, apparent trend in local population size of the Kittlitz's murrelet is confounded by intra- and inter-annual movements of individuals among study sites. Most Kittlitz's murrelets apparently do not breed annually (Day and Nigro 2004, p. 91; Kissling, unpublished data) and, therefore, are not restricted to a particular breeding site or at-sea areas near a breeding site every year, allowing non-breeding individuals and failed breeders to move freely to locate food during the breeding season when most surveys are conducted. While breeding birds may not be counted on surveys because they are incubating or tending to young at nests, this probably is minor because breeding propensity typically appears to be low in this species (see *Reproductive Performance,* above).

In Icy Bay, the daily emigration rate of radio-marked Kittlitz's murrelets (±SE) over a 60-day period during the breeding season was low (0.008±0.002) (Kissling, unpublished data), but no estimate of the rate of immigration exists. Similarly, the annual recapture probability of uniquely banded Kittlitz's murrelets (±SE) was low (0.08±0.03), suggesting that individuals do return to the area, but perhaps not annually (Kissling, unpublished data). These intra- and inter-annual movements complicate reliable trend estimation of local population size, especially because the timing of at-sea surveys for the Kittlitz's murrelet has not been synchronized among study sites. To illustrate an extreme example, the local population of Kittlitz's murrelet in Kachemak Bay was estimated to be 1,776 birds (SE=1,051) in 2005, but 3,277 birds (SE=1,582) in 2006, followed by a drastic reduction in 2007 to 1,086 birds (SE=931) (Kuletz *et al.* 2011b, p. 96). The documented fluctuations in local population size over the 3-year period cannot be demographically explained and therefore probably are related to intra- or inter-annual movements into or out of Kachemak Bay.

Fifth, there is not a consistent survey protocol or design used to count Kittlitz's murrelets at sea across locations and occasionally at the same location (Day 2011, pp. 6–39). Key survey and analytical procedures such as time of year and synchrony of counts across range, level of surveyor expertise and training, limitations of oceanic and climatic conditions, varying survey platforms, estimation of detection probabilities, inclusion of flying

murrelets, survey objectives (single-species versus multi-species surveys), and treatment of unidentified murrelets in population-size estimation have varied among locations and years (Hoekman *et al.* 2011, p. 35; Kirchhoff 2011, p. 78; see Day 2011 for complete review). Within a study site, many methodological issues have been addressed in recent years, but across sites, inconsistencies will remain until a comprehensive monitoring protocol is developed, accepted and implemented by researchers. Until then, our ability to detect population trend of Kittlitz's murrelet reliably, especially beyond individual study sites, is limited (Day 2011, pp. 52–57).

Recognizing all of these challenges and differences in methods across study sites, the rangewide population of Kittlitz's murrelet currently is estimated to be 33,583 birds (95 percent CI=25,620–41,546). Because some areas remain unsurveyed or have not been surveyed in many years, this estimate should be considered a minimum. The rangewide estimate was derived by summing the most recent local population estimate in all surveyed areas during the breeding season, which includes all known concentrations of Kittlitz's murrelet. These areas (and most recent survey year) include the mainland fjords of southeastern Alaska (2002) (Kissling *et al.* 2011, p. 7), Glacier Bay (2010–2012, averaged) (Hoekman *et al.* 2013, p. 15), the outer coast of southeastern Alaska from Cross Sound to Yakutat (2003–2004) (Kissling *et al.* 2011, p. 7), Yakutat Bay (2009) (Kissling *et al.* 2011, p. 7), Lost Coast extending from Manby Point (2002) to Duktoth River (2008–2009) (Kissling *et al.* 2011, p. 7), Icy Bay (2012) (Kissing, unpublished data), Kenai Fjords (2008) (Arimitsu *et al.* 2011, p. 18), Prince William Sound (2012) (Cushing, Oregon State University, 2010–2012, unpublished data), Kachemak Bay (2011) (Kuletz, Service, 2011, unpublished data), Lower Cook Inlet (1996) (Kuletz *et al.* 2011b, p. 96), Kodiak (2012) (Corcoran 2012, p. 5), southern coast of the Alaska Peninsula (2003) (Madison *et al.* 2011, p. 118), select Aleutian Islands (2004–2009) (Madison *et al.* 2011, p. 118), northern Alaska including Chukchi and Beaufort seas and Arctic Ocean (2000–2009) (Day *et al.* 2011, p. 58), eastern coast of Russia extending from the Chukotka Peninsula in the north to the southern tip of the Kamchatka Peninsula (1991–2005) (Artukhin *et al.* 2011, pp. 26–28) and the northern Sea of Okhotsk (2005–2008) (Artukhin *et al.* 2011, p. 30). Hence, this population estimate does not include numbers from Kodiak Island, most of the Aleutian Islands, and the Bering Sea, plus non-breeding birds that may be living at sea across the open northern Gulf of Alaska.

We examined trends of the Kittlitz's murrelet at the local population scale and across multiple populations. We defined a population as the birds using pre-defined study area boundaries, although there is no evidence that these individual populations are biologically separated from one another. Below, we briefly summarize available information about local population trends of the Kittlitz's murrelet in areas for which a sufficient number of years of data were available. In many cases, we were unable to draw inferences on the trend of Kittlitz's murrelet at the local population scale because of the difficulties described above and, in some cases, conflicting information within a study area. However, we did not consider this to be a limitation to our assessment because our primary interest was to determine, to the best of our ability, the status and trend of the Kittlitz's murrelet at a broad scale, as opposed to the local population scale. Therefore, we analyzed trend across multiple populations of Kittlitz's murrelet using all of the available information on local populations with at least 3 years of at-sea survey data and developed a population model that also incorporated information on reproduction and survival; these two efforts to assess the status and trend of Kittlitz's murrelet across multiple populations are also summarized below.

Local Populations

Only 7 areas have been surveyed for Kittlitz's murrelets at sea in a somewhat consistent manner in 3 or more different years between 1989 and 2012: Glacier Bay (13 surveys of 3 different designs between 1991 and 2012), Malaspina Forelands (4 surveys of one continuous transect, 1992–2009), Icy Bay (2002–2012), Prince William Sound (13 years, 1972 and 1989–2012, with a different design in 1972), Kenai Fjords (3 years, 2006–2008), Kachemak Bay (4 years, 2005–2011), and Lower Cook Inlet (5 years, 1993–1999 using two different designs). Few surveys were conducted prior to 2000, and the reliability of some of those survey data is compromised due to the methodological challenges presented above. Therefore, rates of change in local population size in the few areas where early surveys were completed (i.e., Glacier Bay, Malaspina Forelands, Prince William Sound, and Lower Cook Inlet) often rely heavily on 1–2 historical years of data.

Glacier Bay (37 percent of rangewide population estimate). Three different research teams have conducted systematic at-sea surveys for marine birds in Glacier Bay and all have employed their own survey design and protocol (Kirchhoff 2011, p. 78). Piatt *et al.* (2011, p.71) conducted surveys in 1991, 1999–2003, and 2008 and reported a local population decline of 89 percent (negative 10.7 percent per year) over this time period, but the decline was not statistically significant due to high inter- and intra-annual variance. During the 1991 surveys, a different sampling design was used that did not sample the offshore habitat randomly nor systematically, raising concern that the 1991 survey results were not comparable to data collected in 1999–2008 (Drew and Piatt 2008, p. 179; Day 2011, p. 39; Kirchhoff 2011, p. 78). However, the authors believed that they had adequately addressed discrepancies between the two designs in their analysis and that Kittlitz's murrelets, in fact, did decline in Glacier Bay between 1991 and 2008, although the decline appeared to level off after 2002 (Piatt *et al.* 2011, p. 72). Further, Drew and Piatt (2008, p. 178) tested for potential survey-based bias in both sampling designs by using spatially matched transects and concluded that the Kittlitz's murrelet population in Glacier Bay had declined by 83 percent between 1991 and 2000. During a similar time period, Lindell (2005, p. 5) conducted surveys in 1993 in Glacier Bay that were replicated in 2009 and 2010 (Kirchhoff *et al.* 2013, p. 6). When analyzed collectively with survey results completed by Piatt *et al.* (2011, p. 7), the annual rate of change was negative 2.3 percent between 1991 and 2010 and was not statistically significant (Kirchhoff *et al.* 2013, p. 10). Most recently, Hoekman *et al.* (2011, p. 35; 2013, p. 15) developed and tested a new, sophisticated survey design and protocol specifically for Kittlitz's murrelets in Glacier Bay and completed annual surveys accordingly in 2010–2012; this protocol currently is under review. The field and analytical techniques employed by Hoekman *et al.* (2013, p. 15) have resulted in much larger population estimates (2–3 times greater) of Kittlitz's murrelet compared to the more standard approaches used by other researchers (Lindell 2005, p. 5; Piatt *et al.* 2011, p. 71; Kirchhoff *et al.* 2013, p. 6). There is notable disagreement among researchers about the current population size and trend of Kittlitz's murrelets in Glacier Bay, with the disagreement about trends primarily

due to differences in survey design and protocol of the 1991 survey.

Malaspina Forelands (less than 1 percent of rangewide population estimate). The Malaspina Forelands, an area extending between Manby Point near Yakutat and Point Riou at the entrance to Icy Bay, was surveyed initially in 1992 by paralleling the coastline roughly 0.6 mi (1 km) offshore for 51 mi (82 km) (Kozie 1993, pp. 1–2). Kissling *et al.* (2011, p. 4) repeated this survey in 2002, 2008, and 2009. Results of these surveys are useful to document distribution and qualitative rates of change, but the survey design of one linear transect lacks rigor and does not lend itself to estimation of population size or trend at the scale of a study area. In the four surveys, however, the number of Kittlitz's murrelets varied dramatically ranging from 641 in 1992 to 10 (2002), 39 (2008) and 165 (2009) (Kissling *et al.* 2011, p. 7).

Icy Bay (3 percent of rangewide population estimate). Since 2002, eight at-sea surveys for marine birds targeting Kittlitz's murrelet and using the same study design and sampling methods have been conducted in Icy Bay (2002, 2005, 2007–2012; Kissling *et al.* 2011, p. 7; Kissling, unpublished data). Between 2002 and 2012, the annual rate of change of the local population was estimated to be negative 10.0 percent; this rate of decline was statistically significant (slope estimate=negative 0.10 [SE=0.03]) (Kissling, unpublished data). A population model that incorporates demographic characteristics including reproduction, survival, and abundance of Kittlitz's murrelets in Icy Bay substantiated the results of the at-sea surveys by indicating an 8 percent decline annually between 2002 and 2012, but the variance surrounding this estimate is large (Kissling, unpublished data).

Prince William Sound (4 percent of rangewide population estimate). While Prince William Sound has the longest history of survey effort (13 years), it is also subject to reliability concerns related to historical data, especially in regards to varying proportions of unidentified *Brachyramphus* murrelets, as well as impacts of the *Exxon Valdez* oil spill that occurred in March 1989. Several authors determined that there had been declines in some marine bird populations, including *Brachyramphus* murrelets, before the spill occurred (Klosiewski and Laing 1994, p. 28; Agler *et al.* 1999, p. 101). Kuletz *et al.* (2011a, p. 103) reported a decline in Kittlitz's murrelets in Prince William Sound of 18.1 percent per year between 1972 and 2007. However, interpretation of population trend in this area was complicated by three primary concerns: (1) The 1972 survey used a different survey design than the 1989–2012 surveys; (2) the 1972 survey was temporally removed from the remainder of the surveys (17 years between the 1972 survey and the next survey in 1989); and (3) the earlier surveys in 1989–1991 and 1993 had high proportions of unidentified murrelets (39–89 percent). Kuletz *et al.* (2011a, pp. 99–101) developed a population model that included the unidentified murrelets to overcome these challenges and tested the sensitivity of the model to inclusion and exclusion of the problematic years; after acknowledging the many assumptions and limitations of the analysis, the authors found negative trends for populations of Kittlitz's murrelets in Prince William Sound regardless of which years were included (p. 104). In fact, even after removing the 1972 survey, the annual rate of population change of Kittlitz's murrelets was greater (negative 30.0 percent; Kuletz *et al.* 2011a, p. 103).

Hodges and Kirchhoff (2012, pp. 118–119), however, postulated that misidentification of murrelets in 1989 and 1993 was probable. Based on a reanalysis excluding those years and including 2 additional survey years (2001 and 2009; not included by Kuletz *et al.* (2011a, p. 101) because only select fjords within Prince William Sound representing different statistical populations of murrelets were surveyed in these years), Hodges and Kirchhoff (2012, p. 119) concluded that population trend of Kittlitz's murrelet in Prince William Sound between 1989 and 2009 was not significantly different from a stable population. Kuletz *et al.* (2013, pp. 69–71) disputed the case presented by Hodges and Kirchhoff (2012, pp. 118–119), contending that the authors erred in their assumption of Kittlitz's murrelet distribution, and in including the 2001 and 2009 survey data, concluding that there was in fact a decline in the Kittlitz's murrelet in Prince William Sound between 1989 and 2007.

Cushing *et al.* (2013, p. 1) took a different approach to address the high and varying proportions of unidentified and possibly misidentified murrelets by simply reporting populations trends of *Brachyramphus* murrelets (genus level) in Prince William Sound between 1989 and 2012. There was strong evidence of an overall decline in abundance of murrelets with a mean annual rate of change of negative 5.2 percent or a 70.8 percent cumulative decrease in abundance of *Brachyramphus* murrelets over the 23-year period. This estimate of decline applies to both Kittlitz's and marbled murrelets, however, so it is difficult to draw firm conclusions about the status of Kittlitz's murrelets in Prince William Sound from this analysis. Kuletz *et al.* (2013, pp. 69–71) argued that, given the undisputed decline in *Brachyramphus* murrelets in Prince William Sound, the proportion of identified Kittlitz's murrelets to marbled murrelets should have increased if the Kittlitz's murrelet population was stable, but instead the proportion of identified Kittlitz's murrelets has declined between 1989 and 2012. However, this argument hinges on comparable identification rates of both murrelet species within and among years.

Kenai Fjords (2 percent of rangewide population estimate). Seven surveys using five different survey designs or protocols have been conducted in Kenai Fjords, prohibiting reliable estimation of local population trends of Kittlitz's murrelet. Arimitsu *et al.* (2011, p. 17) summarized earlier survey efforts for marine birds in the greater Kenai Fjords area (1976, 1986, 1989, 2002), most of which concentrated survey effort along the shoreline and did not follow a consistent survey protocol with previous surveys. Acknowledging many methodological issues associated with these surveys, density estimates of Kittlitz's murrelet increased by 55 percent between 1986 and 1989 and decreased by 90 percent between 1989 and 2002 (Arimitsu *et al.* 2011, p. 18). In 2006–2008, annual surveys for Kittlitz's murrelets were conducted while following a systematic study design and sampling protocol similar to those employed in other areas, but with only 3 years of data over a short time frame, Arimistu *et al.* (2011, p. 17) appropriately refrained from estimating local population trend and instead assessed variability of the Kittlitz's murrelet population during the 3-year period.

Lower Cook Inlet and Kachemak Bay (9 percent of rangewide population estimate). Of all areas with multiple years of surveys, Lower Cook Inlet and adjacent Kachemak Bay in the southeastern part of the inlet, are the most complex and confounding. In June 1993, Agler *et al.* (1998, pp. 255–256) completed a comprehensive, systematic survey for marine birds and mammals covering all of Lower Cook Inlet. A portion (roughly one-third) of this area was surveyed in July and August 1996–1999, but while using a different systematic sampling design (described in Kuletz *et al.* 2011b, p. 86). Kuletz *et al.* (2011b, p. 86) reanalyzed data from a 'core area' of Cook Inlet that had been

covered during both earlier survey efforts. Within the core area, numbers of Kittlitz's murrelet declined significantly by 26.2 percent per annum between 1993 and 1999, a total decline of 84 percent over the 7-year period (Kuletz *et al.* 2011b, p. 91); however, there are two primary concerns related to these surveys. First, in 1993, 82 percent of the murrelets observed were not identified to species (Kuletz *et al.* 2011b, p. 91), and second, the timing of the four surveys varied dramatically, especially between the 1993 survey (7–23 June) and the 1996–1999 surveys (14 July–16 August; p. 87), severely reducing the comparability of these surveys across years. Removing the 1993 survey from the trend analysis, numbers of Kittlitz's murrelet declined by 32 percent annually between 1996 and 1999 in the core area (Kuletz *et al.* 2011b, p. 91), although these surveys started and ended later each consecutive year (p. 87). These results may be questionable, however, given recent information that Kittlitz's murrelets from other parts of the northern Gulf of Alaska are known to move into Lower Cook Inlet in the post-breeding season (late July–August; Madison *et al.* 2012, p. 1).

Similarly, several late-summer surveys of varying sampling designs and protocols were conducted between 1988 and 2011 in Kachemak Bay (Kuletz *et al.* 2011b, p. 90; Kuletz, unpublished data), but many of these survey efforts lacked a rigorous or systematic survey design, and there are concerns about the timing of the surveys. Therefore it is difficult to draw statistical inference from their results. Between 2005 and 2007, systematic surveys of Kachemak Bay were conducted from 18 to 26 July using standard protocols (Kuletz *et al.* 2011b, p. 90), resulting in annual local population estimates ranging from 1068 to 3287 Kittlitz's murrelets, depending on the year. Based on these surveys, as well as the historical efforts, Kuletz *et al.* (2011b, p. 93) concluded that the population of Kittlitz's murrelet in Kachemak Bay was statistically stable. In 2011, the same systematic survey of Kachemak Bay was repeated, resulting in a considerably lower estimated population size of Kittlitz's murrelet (424 birds) than the previous 3 surveys completed in 2005–2007 (Kuletz, unpublished data). However, we cannot draw reliable conclusions from these data for two reasons. First, the variance associated with these local population estimates is too high to detect a trend between 2005 and 2011 (coefficient of variation [a measure of variability in the data]=52–86 percent) (Kuletz *et al.* 2011b, p. 96; Kuletz, unpublished data). Second, the rate of change in population size was not linear across the 6-year period and the range in estimates (424 to 3,287 Kittlitz's murrelets) cannot be demographically explained (Kuletz *et al.* 2011b, p. 96; Kuletz, unpublished data).

Multiple Populations

Trend analysis. We assessed change in Kittlitz's murrelet populations at a broad scale by conducting a comprehensive trend analysis that used survey data collected at multiple individual study sites (hereafter referred to as the multiple-populations trend analysis) (Lukacs and Kissling 2013, p. 27). We limited our analysis to those areas with at least 3 different years of survey data, and within a study area, we only grouped surveys that sampled similar statistical populations; no datasets were combined. We included 9 statistically-independent populations with datasets spanning from 1989 to 2012 in the multiple-populations trend analysis: Glacier Bay–A (1991, 1999–2003, 2008) (Piatt *et al.* 2011, p. 70), Glacier Bay–B (1993, 2009–2010) (Lindell 2005, p. 5; Kirchhoff *et al.* 2012, pp. 6, 10), Glacier Bay–C (2010–2012) (Hoekman *et al.* 2013, p. 15), Malaspina Forelands (1992, 2002, 2008–2009) (Kissling *et al.* 2011, p. 7), Icy Bay (2002, 2005, 2007–2012) (Kissling *et al.* 2011, p. 7; Kissling, unpublished data), Prince William Sound (1989–1991, 1993, 1996, 1998, 2000, 2004–2005, 2007, 2010, 2012) (Cushing, unpublished data), Kenai Fjords (2006, 2007, 2008) (Arimitsu *et al.* 2011, p. 18), Kachemak Bay (2005–2007, 2011) (Kuletz *et al.* 2011b, p. 96; Kuletz, unpublished data), and Lower Cook Inlet (1993, 1996–1999) (Kuletz *et al.* 2011b, p. 96).

We considered four model forms to describe and estimate population trend of Kittlitz's murrelets across multiple local populations between 1989 and 2012: constant (no change over time), linear (straight line), quadratic (line that displays concavity with a single bend either upward or downward), and linear with a change in slope (statistically referred to as a 'knot') at 2000 (Lukacs and Kissling, p.27). We tested the last model form (linear with a knot at 2000) because around this time climate regime shifts occurred in the northern Gulf of Alaska (1998–1999) and in the Arctic (2000) (Litzow 2006, p. 1386; Overland *et al.* 2008, p. 92) (see *Factor A* below for more detailed discussion on climate regime shifts) and researchers reported that Kittlitz's murrelet numbers may have stabilized in some areas shortly thereafter (Kuletz *et al.* 2011a, p. 105; Piatt *et al.* 2011, p. 73). Of the four model forms considered in the multiple-populations trend analysis, the linear model form with a knot at 2000 was the most strongly supported model (delta Akaike Information Criterion [AIC]=19.2 units; AIC is a measure of the relative quality of a statistical model for a given set of data and contending model forms; a small delta AIC [e.g., less than 2] indicates model uncertainty).

Results of the multiple-populations trend analysis demonstrated that the population of Kittlitz's murrelet declined significantly by 30.6 percent per annum between 1989 and 2000 (slope estimate=negative 0.31 [SE=0.09]), at which time a statistically significant change in the rate of change occurred and populations stabilized between 2000 and 2012 (slope estimate=0.38 [SE=0.13]; this slope estimate represents the positive change from negative 0.31, or a positive slope of 0.07). We then removed 3 problematic years of data due to high proportions of unidentified murrelets (1993 in Prince William Sound and 1993 in Lower Cook Inlet) and to differences in study design (1991 in Glacier Bay) and reran the analysis. Although model fit with the problematic data points removed gave a poorer fit (delta AIC=12.2), the same model (linear with a knot at 2000) was selected and estimated similar trends across all populations between 1989 and 2000 (slope estimate=negative 0.30 [SE=0.10] and between 2000 and 2012 (slope estimate=0.38 [SE=0.14]. We conclude from this analysis that Kittlitz's murrelets declined by roughly 30 percent per annum on average across multiple populations between 1989 and 2000, after which abundance stabilized. For comparison, the same analysis for the population of marbled murrelet across multiple populations indicated a stable trend from 1989 to 2012 with no change in slope at year 2000; the constant model for marbled murrelet was selected as the best model (delta AIC=3.3) when we ran the analysis with and without the three questionable data points.

For assessing status of the Kittlitz's murrelet across their range, we found that the multiple-populations trend analysis described above is more useful and rigorous than trend estimates of individual local populations; however, several drawbacks to our approach exist. First, the trend analysis included populations of Kittlitz's murrelets only from Glacier Bay in the south to Lower Cook Inlet in the north, an area that contains most of the known larger populations of the Kittlitz's murrelet (see *Local Populations,* above), but covers a small portion of their overall

range. Second, we only considered linear and quadratic shapes to the trend of multiple populations combined. Third, demographic parameters such as reproduction and survival are not considered in the trend analysis, even though these vital rates drive current and future abundance. Fourth, the trend analysis does not allow population projections into the future or estimation of extinction probabilities. To address some of these drawbacks, we developed a population model as a tool to assessing population status of the Kittlitz's murrelet at a broad scale.

Population model. Owing to the limitations of the multiple-populations trend analysis, we developed a population model to help evaluate the status of the Kittlitz's murrelet across all populations with sufficient demographic information (hereafter referred to as the multiple-populations model) (Brooks *et al.* 2004, p. 515; Johnson *et al.* 2010, p. 1084; Lukacs and Kissling 2013, p. 5). Population models are a well-established tool for evaluating population dynamics for species with limited and variable datasets, such as the Kittlitz's murrelet, by linking population size with stage-specific vital rates. A single comprehensive population model like the one we developed integrates all of the available data on abundance, survival, and reproduction; shares information from data-rich areas with data-poor areas; and predicts population size given the demographic data each year and into the future. One advantage to using this approach for the Kittlitz's murrelet is that it allowed us to include data on reproduction at Agattu and Kodiak islands and Icy Bay (see *Nesting* and *Reproductive Performance,* above) and on survival from Icy Bay (see *Survival,* above), thereby nearly doubling the spatial scope of inference compared to that of the multiple-populations trend analysis. Another advantage is that it is not purely a statistical test such as the multiple-populations trend analysis, but instead incorporates aspects of the biology of the Kittlitz's murrelet.

We included 7 local populations in the multiple-populations model: Glacier Bay, Icy Bay, Prince William Sound, Kenai Fjords, Kachemak Bay, Kodiak Island, and Agattu Island. In Glacier Bay, where multiple datasets on abundance exist, we used the dataset (Glacier Bay–A) with the most number of years of abundance estimates (Piatt *et al.* 2011, p. 70). We modeled data collected from 2000 to 2012 because only abundance was available prior to 2000, and without concurrent data on reproduction or survival, we were unable to achieve a good model fit (Lukacs and Kissling 2013, p. 6). Because our primary interest was to determine the current and future status and population dynamics of the Kittlitz's murrelet at a broad scale and few demographic data were collected prior to 2000, we did not consider the exclusion of pre-2000 data to be a major constraint to the model development or results. Reproduction was estimated as the product of breeding propensity (the proportion of birds attempting to nest in a given year) and nesting success. Following Peery and Henry (2010, p. 2417), we considered a range of values for breeding propensity (low=0.181, medium=0.526, high=0.817; see *Reproductive Performance,* above, for details) (Kissling, unpublished data) and estimated daily nest survival at Agattu and Kodiak islands (0.968) (Kaler, unpublished data; Lawonn, Oregon State University, 2008–2011, unpublished data) and Icy Bay (0.979) (Kissling, unpublished data). For areas without nesting information, we applied the estimate of nesting success from the study site most similar in landscape (e.g., glacial, non-glacial). We considered a range of values for annual adult survival (low=0.79, medium=0.89, high=0.95) (Kissling, unpublished data) and used a proportion (0.70) of adult survival as juvenile survival following Peery and Henry (2010, p. 2415) and others (McShane *et al.* 2004, p. 3–41; Piatt *et al.* 2007, p. 58).

The best-fit model for the multiple-populations model included the medium-level breeding propensity (0.526) and medium-level annual survival (0.89) and predicted an annual rate of change in multiple populations to be negative 1.7 percent but with large variance that included both a stable population and a quasi-extinction scenario (Lukacs and Kissling 2013, p. 10). The probability of extinction, with a quasi-extinction threshold defined for the purposes of this modeling exercise as less than 100 individuals per population, at 2032 (i.e., 20 years from present) was zero and at 2037 (i.e., 25 years from present) was less than 0.01 (Lukacs and Kissling 2013, p. 10; Lukacs, University of Montana, unpublished data). We were unable to model population size accurately or precisely beyond 25 years into the future because the variance increased rapidly and the model became unstable. Given the paucity of data available for the Kittlitz's murrelet, predicting future population size is challenging for any number of years and becomes more difficult with increased time, but after examining model fit and diagnostics, we determined that model predictions of population size of this species between 2000 and 2037 were informative in our assessment of the current and future status of this species.

As with all modeling exercises, there are numerous limitations and assumptions related to model structure and inputs that need to be met or evaluated to assess reliability and usefulness of the model results. Key assumptions for this type of modeling (not a comprehensive list) include: (1) The model structure accurately represented Kittlitz's murrelet population biology; (2) populations were sampled independently; (3) populations are not under density-dependent regulation; (4) estimates of reproduction and survival were appropriately applied to and representative of populations lacking those data; (5) the populations for which sufficient data exist to include in the model were representative of all Kittlitz's murrelet populations; (6) immigration and emigration rates within a population were equal; and (7) estimates of vital rates and their associated variances between 2000 and 2012 that were used in the model to predict future population size will be comparable on average to those experienced by Kittlitz's murrelets between the present time and 2037. These are reasonable assumptions to make for the purposes of this modeling exercise in the absence of more complete data on the Kittlitz's murrelet or a similar species that would allow explicit testing of each assumption.

We acknowledge that the available information on the demography of the Kittlitz's murrelet is both spatially and temporally limited and therefore, attempted to account for these data limitations in the multiple-populations model in three ways. First, we chose to use a type of model (Bayesian Integrated Population Model) that is specifically aimed to serve as a powerful statistical tool for evaluating the dynamics of populations with messy or incomplete datasets (Brooks *et al.* 2004, p. 515; Johnson *et al.* 2010, p. 1084). Second, we considered a range of values for key demographic parameters such as breeding propensity and adult survival, placing weight on empirical data derived from that population and reducing weight for data borrowed from a different population. This approach allowed the empirical data available for a specific population to have a strong influence on the model results for that population. Third, we drew on previous population modeling efforts for the congeneric marbled murrelet, recognizing that all of these efforts, including our effort for the Kittlitz's

murrelet, had different objectives and therefore used a different type of population model (Beissinger 1995, pp. 385–393; McShane *et al.* 2004, pp. 3–27–3–58; Piatt *et al.* 2007, pp. 54–67; Peery and Henry 2010, pp. 2414–2424). We also used the marbled murrelet as a proxy for some unknown or less-defined demographic parameters of the Kittlitz's murrelet. We recognize all of these limitations and assumptions of the multiple-populations model and believe that the high variance associated with most of the model input parameters and the results accurately reflects our current state of knowledge of the status of the Kittlitz's murrelet at a broad scale.

Summary of Population Status and Trends

We estimate the minimum rangewide population of Kittlitz's murrelet to be 33,583 birds (95 percent CI=25,620–41,546). In evaluating population status and trends of the Kittlitz's murrelet, we collectively considered all of the available information across all time periods, at the local population scale, and at a broad scale across multiple populations. We determined that some local populations of the Kittlitz's murrelet may have declined at some point over the last few decades (e.g., Glacier Bay, Prince William Sound, Lower Cook Inlet) and some may still be in decline (e.g., Icy Bay, Kachemak Bay). Across all populations, we conclude that there was a decline of approximately 30 percent per annum in Kittlitz's murrelets between 1989 and 2000, but since then populations appear to have stabilized or, when coupled with information on reproduction and survival, may be declining and are projected to continue to decline at a much slower rate.

Summary of Information Pertaining to the Five Factors

Section 4 of the Act (16 U.S.C. 1533) and implementing regulations (50 CFR 424) set forth procedures for adding species to, removing species from, or reclassifying species on the Federal Lists of Endangered and Threatened Wildlife and Plants. Under section 4(a)(1) of the Act, a species may be determined to be endangered or threatened based on any of the following five factors:

(A) The present or threatened destruction, modification, or curtailment of its habitat or range;

(B) Overutilization for commercial, recreational, scientific, or educational purposes;

(C) Disease or predation;

(D) The inadequacy of existing regulatory mechanisms; or

(E) Other natural or manmade factors affecting its continued existence.

In making this finding, information pertaining to the Kittlitz's murrelet in relation to the five factors provided in section 4(a)(1) of the Act is discussed below. In considering what factors might constitute threats, we must look beyond the mere exposure of the species to the factor to determine whether the species responds to the factor in a way that causes actual impacts to the species. If there is exposure to a factor, but no response, or only a positive response, that factor is not a threat. If there is exposure and the species responds negatively, the factor may be a threat and we then attempt to determine how significant a threat it is. If the threat is significant, it may drive or contribute to the risk of extinction of the species such that the species warrants listing as endangered or threatened as those terms are defined by the Act. This does not necessarily require empirical proof of a threat. The combination of exposure and some corroborating evidence of how the species is likely impacted could suffice. The mere identification of factors that could impact a species negatively is not sufficient to compel a finding that listing is appropriate; we require evidence that these factors are operative threats that act on the species to the point that the species meets the definition of an endangered or threatened species under the Act.

In making our 12-month finding on the petition we considered and evaluated the best available scientific and commercial information.

Factor A. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

The Kittlitz's murrelet is primarily a subarctic species with a broad distribution that encompasses a diversity of marine and terrestrial habitats along most of coastal Alaska and eastern Russia. This species exhibits variable habitat affinities throughout its range and its annual cycle, which makes it difficult to identify necessary habitats and potential threats to those habitats. For example, in the breeding season, the greatest densities of Kittlitz's murrelet typically are observed in glacially-influenced marine waters of south-coastal Alaska (Kuletz *et al.* 2003b, p. 136; Arimitsu *et al.* 2011, p. 18; Kissling *et al.* 2011, p. 7; Kuletz *et al.* 2011a, pp. 102–103; Kuletz *et al.* 2011b, pp. 90–92; Piatt *et al.* 2011, p. 70). There are a handful of glaciated areas in southeastern Alaska, such as Le Conte, Thomas, Dundas, and Taylor bays, where no Kittlitz's murrelets have been observed in the breeding season in recent years, although several individuals were collected historically in Le Conte Bay (Kissling *et al.* 2011, pp. 7, 9). Lower densities of this species also occur in non-glaciated marine waters of the Alaska Peninsula, Aleutian Islands (Madison *et al.* 2011, pp. 118–119), western and northern Alaska (Day *et al.* 2011, pp. 58–59) and Russia (Artukhin *et al.* 2011, pp. 26–30). Low numbers of Kittlitz's murrelet also have been observed annually during the breeding season on freshwater lakes in southwestern Alaska (Savage 2013, in litt.; Walsh 2013, in litt.). In the non-breeding season, Kittlitz's murrelets migrate to the Bering and Chukchi seas where they occupy offshore marine waters, or occur in polynyas or in open water leads within the sea ice (Madison *et al.* 2012, p. 1; Kuletz, unpublished data), but they also are observed in ice-free waters of the northern Gulf of Alaska during this period (Day *et al.* 1999, pp. 4–5; Kuletz, unpublished data). The reason for the apparent, but irregular, association with sea ice or glacial ice during specific periods in the annual cycle is not clear, nor is it known if it is biologically meaningful or is simply a proxy for an unidentified habitat feature of importance (Arimitsu *et al.* 2012, p. 18). Furthermore, it is not known whether the explanatory factor(s) occur in the marine or terrestrial habitat of the Kittlitz's murrelet, or both.

Without an understanding of the habitat requirements of the Kittlitz's murrelet, we identified, deconstructed, and assessed possible threats to the marine and terrestrial habitats currently used by this species. We then evaluated potential impacts by considering the exposure and response of Kittlitz's murrelet at the individual level and population level to each possible threat. Because the underlying mechanisms driving habitat use of the Kittlitz's murrelet are not defined, we attempted to establish links between possible threats to marine and terrestrial habitats and demographic change of Kittlitz's murrelet at the population level. Our analysis focused on possible threats to habitats occupied by Kittlitz's murrelets in the summer months because this was the time period for which the most data were available, along with the greatest number of possible identified threats and demographic bottlenecks (e.g., poor reproduction; see *Reproductive Performance,* above). We considered potential threats during the non-breeding period if sufficient information was available. Under *Factor A,* we considered climate change and

environmental contaminants as potential threats to the habitats used by the Kittlitz's murrelet.

Climate Change

Our analyses under the Act include consideration of ongoing and projected changes in climate. The terms ''climate'' and ''climate change'' are defined by the Intergovernmental Panel on Climate Change (IPCC). ''Climate'' refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term ''climate change'' thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19). Identifying likely effects often involves aspects of climate change vulnerability analysis. Vulnerability refers to the degree to which a species (or system) is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the type, magnitude, and rate of climate change and variation to which a species is exposed, its sensitivity, and its adaptive capacity (IPCC 2007, p. 89; see also Glick *et al.* 2011, pp. 19–22). There is no single method for conducting such analyses that applies to all situations (Glick *et al.* 2011, p. 3). We use our expert judgment and appropriate analytical approaches to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

Within the range of the Kittlitz's murrelet, climate change is occurring and is likely altering marine and terrestrial habitats used by this species. In Alaska, average annual Statewide air temperatures have increased by nearly 4.0 degrees F between 1949 and 2005, but decreased by 2.3 degrees F in the last decade (2000–2010) with most of the change occurring over winter (Markon *et al.* 2012, p. 11; Wendler *et al.* 2012, pp. 111–112). The recent cooling trend suggests a shift from the long-term warming trend (Wendler *et al.* 2012, p. 111), even though climate models project warming to continue in Alaska over the next century (Markon *et al.* 2012, pp. 14–21). Precipitation also increased over the last few decades, but it is more difficult to quantify (Arendt *et al.* 2009, p. 4132; Markon *et al.* 2012, p. 12). In addition, subsurface and surface waters of the North Pacific Ocean, including the Gulf of Alaska, and Bering and Chukchi seas, have warmed over the last few decades (Bograd *et al.* 2005, p. 244; Overland and Wang 2007, p. 178; Stabeno *et al.* 2007, pp. 2607–2608; Steele *et al.* 2008, p. 2; Mueter *et al.* 2009, p. 96; Hazen *et al.* 2012, p. 2). A significant part of the observed warming in Alaska occurred as a sudden, step-like change in the mid-1970s, which coincided with a major shift in atmospheric circulation patterns across a large portion of the Pacific basin, called the Pacific Decadal Oscillation (PDO) (Mantua *et al.* 1997, p. 1070). It is likely that some portion of the observed warming over the last century and recent cooling in Alaska is attributed to inherent decadal-scale variability in regional climate, like the PDO (Markon *et al.* 2012, p. 11; Wendler *et al.* 2012, p. 113), making it difficult to ascertain any amplified or accelerated impacts of natural variability or cycles from underlying long-term warming trends in Alaska. Regardless, marine and terrestrial habitats of the Kittlitz's murrelet are changing in response to climate change, and we anticipate that these changes will continue. Available information suggests that the changes may affect the Kittlitz's murrelet; however, the specific response or sensitivity of the species to these current and forecasted changes is uncertain at this time.

Loss of Glaciers

Loss of glacial volume is a phenomenon occurring on a global scale and, during the recent decades, at rates that cannot be explained by historical trends alone (Dyurgerov and Meier 2000, pp. 1406, 1410; Lemke *et al.* 2007, pp. 356–359). The primary driver of glacier change is climate (Markon *et al.* 2012, p. 45), especially temperature (Oerlemans 2005, p. 677; Arendt *et al.* 2009, p. 4132). Maritime glaciers terminating in tidewater are particularly sensitive to temperature change (Berthier *et al.* 2010, p. 93), including sea surface temperatures (Post *et al.* 2011, p. 306), and therefore have the potential to shed ice more rapidly than land-locked glaciers (Markon *et al.* 2012, p. 46). Yet, changes in individual tidewater glaciers are dominated by dynamic, complex cycles, with low-order effects occurring due to climate (Arendt *et al.* 2009, p. 4132; Post *et al.* 2011, p. 306).

At the beginning of the 20th century, many of Alaska's tidewater glaciers began to retreat (Barclay *et al.* 2006, p. 160) and in less than 100 years, major ocean inlets, such as Glacier and Icy bays, were formed by glacial recession (Molnia 2008, p. K7). The Kittlitz's murrelet presumably adjusted its distribution in order to take advantage of these newly-created habitats where they now occur in large numbers in the breeding season (Kissling *et al.* 2011, p. 7; Piatt *et al.* 2011, p. 66). Currently, within the range of the Kittlitz's murrelet, 59 major tidewater glaciers exist, all along the southern coast of Alaska (Molnia 2008, pp. K57–59), and a few very small isolated mountain glaciers or permanent snow occur on the Alaska Peninsula, select Aleutian Islands, Koryak Highlands and Kamchatka Peninsula (Artukhin et al 2011, p. 31; Arendt *et al.* 2012). The majority (68 percent) of these tidewater glaciers are in retreat, grounded (resting on the ocean floor) or at the shoal (shallow water area) (Molnia 2008, pp. K57–59). Over the last few decades, glacial ice loss has been greatest for the glaciers along the southern coast of Alaska compared to the mountain glaciers of central Alaska, Brooks Range, and Alaska Peninsula (Larsen *et al.* 2005, p. 548; Berthier *et al.* 2010, pp. 92–93; Arendt *et al.* 2009, pp. 4127–4128; Le Bris *et al.* 2011, p. 141).

Approximately 66 percent of the minimum global population of Kittlitz's murrelet is associated with glacially affected marine waters in the breeding season. Within these areas, Kittlitz's murrelets prefer highly stratified, cool, turbid marine waters near tidewater glaciers and glacial outflows, especially in the vicinity of submerged marine sills where localized upwelling occurs (Day and Nigro 2000, pp. 5, 8; Kissling *et al.* 2007, pp. 2171–2172; Allyn *et al.* 2012, p. 244; Arimitsu *et al.* 2012, p. 18). The reason that Kittlitz's murrelets use these areas is not clear, but several hypotheses have been proposed. For example, marine waters with these characteristics may provide increased abundance of high-energy forage fish, such as sand lance or capelin (Robards *et al.* 2003, p. 71; Arimitsu *et al.* 2008, p. 137; Arimitsu *et al.* 2011, pp. 15, 17–18; Renner *et al.* 2012, pp. 2037–2038), or promote greater foraging efficiency for Kittlitz's murrelets (Day *et al.* 2003, pp. 695–696; Arimitsu *et al.* 2011, p. 14; Allyn *et al.* 2012, pp. 244–245). Nutrient-rich glacial meltwater (Crusius *et al.* 2011, p. 1) forms a turbid, stratified surface layer that limits light penetration, reducing phytoplankton

growth at depth (Hood *et al.* 2009, p. 1046; Piwosz *et al.* 2009, pp. 552–554, 556) and possibly affecting vertical diel (24 hour) migration of zooplankton and fish (Abookire *et al.* 2002, p. 378; Frank and Widder 2002, p. 1189). Owing to their proportionately larger-diameter eye compared to the marbled murrelet (Day *et al.* 2003, p. 695), the Kittlitz's murrelet may specialize at foraging in these low light conditions, taking advantage of underutilized ocean space and prey. In the northern Gulf of Alaska, freshwater streams and rivers fed by glaciers and snow melt drain into the coastal ocean and create large plumes of highly turbid water (Crusius *et al.* 2011, pp. 1–2), where both zooplankton and juvenile fish abundance is greater compared to outside the plumes (McFadden *et al.* 2012, p. 1). Juvenile fish may occupy these areas to take advantage of concentrated zooplankton populations or to evade predation (McFadden *et al.* 2012, p. 1). Several studies have also suggested that the physical features and landforms (e.g., underwater sills and moraines) within glacial fjords interact with tides to concentrate prey of the Kittlitz's murrelet (Kissling *et al.* 2007, p. 2171; Allyn *et al.* 2012, pp. 244–245; Arimitsu *et al.* 2012, pp. 10–15). Yet no studies have reported greater foraging success, or subsequent productivity or survival, in glacially affected waters compared to those without glacial influence, or in fjord versus non-fjord habitats (e.g., outer coast of the Gulf of Alaska).

Any foraging advantages in glacially affected waters should be readily apparent in the breeding season when Kittlitz's murrelets concentrate in these areas and deliver whole fish singly to chicks at nests. However, nests have been found throughout this species' range, including many areas without tidewater glaciers or glacially influenced marine waters (e.g., Kodiak and Aleutian islands, northern Alaska, and Russia), and, although highly variable, chick meal delivery rates at nests monitored at glacial sites (Naslund *et al.* 1994, p. 46; Kissling, unpublished data) are not substantially different from those at non-glacial sites (Lawonn 2012, pp. 27–28, 55; Kaler, unpublished data), with one exception. Delivery rates for Agattu Island are much higher than those for all other sites, but the lack of glacial influence in the marine system alone cannot explain the unusually high rate of 10.2 fish per day, especially when compared to the moderate rate of 6.3 fish per day at nearby Adak Island (Kaler, unpublished data). Agattu Island is the only study site where rockfish and Pacific cod, low-energy-density fishes (Anthony *et al.* 2000, p. 75), have been delivered as chick meals at monitored nests (Kaler, unpublished data), likely explaining the higher delivery rates and lower fledging mass of chicks. However, there is no information to suggest that the absence of high-quality fishes in the chick diet of Kittlitz's murrelets on Agattu Island is associated with the absence of glaciers in this region. On nearby Buldir Island in the western Aleutians, chick diets of tufted puffin (*Fratercula cirrhata*) and horned puffin (*F. corniculata*) between 1988 and 2012 were consistently composed of low-quality fish (i.e., hexagrammids) with intermittent years of relatively high percentages of high-quality Pacific sand lance (Warzybok *et al.* 2013, pp. 162, 180). Therefore, although poor quality forage fish may be affecting nesting success of Kittlitz's murrelets on Agattu Island, it appears to be related to natural and regional fluctuations in forage fish abundance that cannot be attributed to the lack of glacial influence. Similarly, on non-glaciated Kodiak Island, the chick meal delivery rate (4.6 fish per day) is comparable to that estimated at glaciated sites (3–5 fish per day) (Naslund *et al.* 1994, p. 46; Kissling, unpublished data). It is possible, but extremely unlikely, that Kittlitz's murrelets nesting on Kodiak Island make the lengthy round-trip flight to forage in the glacially-affected waters of Kenai Fjords (488 mi round-trip [784 km]), Kachemak Bay (374 mi [602 km]), Lower Cook Inlet (250 mi [402 km]), or perhaps to the far less-glaciated waters of the Alaska Peninsula (31 mi [50 km]) and then return to their nests with fish. For all of these reasons, we cannot determine whether glacially affected waters are a required or advantageous (in terms of fitness) element of breeding habitat for the Kittlitz's murrelet.

In addition to chick diet, trophic level and stomach contents of adult Kittlitz's murrelets sampled in the breeding season did not differ between glaciated and non-glaciated areas (Day *et al.* 1999, p. 9). In glacial fjords of southeastern Alaska, adult Kittlitz's murrelets captured in the early breeding season (May) were heavier compared to those captured in the late breeding season (late July–August) (Kissling, unpublished data). Reduced body mass of Kittlitz's murrelets during the breeding season may be aimed at increasing flight efficiency and reducing energetic costs of transiting to and from nest sites (Hatch 2011, p. 82), but too few murrelets appear to attempt to breed annually (18 percent; see *Reproductive Performance,* above) (Kissling, unpublished data) to explain the overall change in body mass between early and late breeding periods. Furthermore, the rapid departure from breeding sites (Robards *et al.* 2003, pp. 92, 100, 104; Kissling *et al.* 2007, pp. 2167–2168; Madison *et al.* 2012, p. 1) suggest that the foraging conditions and resources in glacially-affected waters are suitable and sufficient for breeding only for a short period. Otherwise, it is reasonable to assume that murrelets would remain in the area to take advantage of locally abundant and available food prior to fall migration. Available information at this time does not suggest that foraging conditions in glacially affected waters are superior to those in marine waters without glacial influence. However, we do not conclude that a change in such conditions would lead to a population- or species-level effect on the Kittlitz's murrelet.

Another reason that the Kittlitz's murrelet occurs disproportionately in glacially influenced areas in the breeding season may be because they are seeking suitable nesting habitat on historically-glaciated scree slopes or on cliff and rock ledges of glacial cirques (steep, bowl-shaped hollow at the head of a mountain valley) or nunataks (Day *et al.* 1999, pp. 13, 25–26; Piatt *et al.* 1999, pp. 8, 12; Kissling, unpublished data). Because this species nests on the ground and chicks are mostly left unattended for 24–31 days except for periodic feeding visits by parents (Lawonn 2012, p. 55; Kaler, unpublished data; Kissling, unpublished data), these remote, barren, unproductive areas are likely selected because terrestrial predators are largely absent. The presumably forage-rich marine waters are beneficial, but may not be the primary driver concentrating Kittlitz's murrelets in these areas in the breeding season; in fact, low numbers of Kittlitz's murrelets have been observed regularly on freshwater lakes adjacent to mountainous terrain in southwestern Alaska (Savage 2013, in litt.; Walsh 2013, in litt.), suggesting that perhaps some individuals may not require marine waters solely during the breeding season. Nelson and Hamer (1995, p. 66) argue that for the marbled murrelet, and most likely the Kittlitz's murrelet, strategies to avoid predation determine much of their nesting behavior, including nest site selection. However, as mentioned above, Kittlitz's murrelets nest successfully throughout their range, and there is no conclusive evidence to suggest that nest sites near glaciers are safer than those not near glaciers.

Between 2007 and 2012, active nests of Kittlitz's murrelet were regularly monitored at three sites ranging from

heavily glaciated southeastern Alaska (Icy Bay) to the non-glaciated Aleutian Islands (Agattu and Adak islands), with Kodiak Island serving as a geographic midpoint. Apparent nest success was lowest in the Aleutian Islands (19 percent; n=95) (Kaler, unpublished data), followed by Kodiak (23 percent; n=71) (Lawonn, unpublished data) and Icy Bay (40 percent; n=35) (Kissling, unpublished data), but apparent nest success may be severely biased because unsuccessful nests are less likely to be found than are successful nests (Johnson and Shaffer 1990, p. 595). Therefore, we estimated daily nest survival using nest data collected at these three sites. We developed 10 a priori candidate models that included a combination of study area, year, nest age, nest stage, glacial group (Icy Bay=glacial, Kodiak and Agattu islands=non-glacial), and genetic group (Icy Bay and Kodiak Island=eastern, Agattu Island=western; see *Taxonomy and Species Description,* above). The best-fit model included ''glacial group,'' but model fit was poor, and the difference in daily nest survival in glacial (0.979 ± SE=0.005) and non-glacial (0.968 ± SE=0.003) sites was not statistically significant. This analysis did not specifically address nest safety or consider cause of failure, but the results do indicate that daily nest survival in glaciated areas is not statistically different when compared to non-glaciated areas.

Not only have nests of the Kittlitz's murrelet been found throughout their range, but also suitable nest habitat exists rangewide with significant portions available in areas with and without glaciers. Barren areas characterized by bare rock, gravel, sand, silt, or clay with little or no ''green'' vegetation present are used in greater proportion to their availability and appear to be the preferred nesting habitat of the Kittlitz's murrelet rangewide, although preferences vary regionally and with availability (Kaler *et al.* 2009, p. 366; Lawonn 2012, pp. 90, 101–102; Felis, unpublished data; Kissling, unpublished data). We mapped nest habitat of the Kittlitz's murrelet rangewide by using known nest locations to define regional thresholds and criteria for elevation, distance to ocean, slope, and landcover. Despite variability in suitability factors, the greatest amount of suitable nesting habitat for Kittlitz's murrelets was located in northern Alaska (10,538 mi^2 [27,292 km^2]; 8.6 percent of total land), followed by south-coastal Alaska (9,160 mi^2 [23,723 km^2]; 7.8 percent), Alaska Peninsula including Kodiak Island (6,004 mi^2 [15,511 km^2]; 18.5 percent) and the Aleutian Islands (1,715 mi^2 [4,441 km^2]; 36.8 percent) (Felis, unpublished data). The results for Russia are not comparable to the values presented here because of differences in methodology, but it appears that there may be a significant amount of suitable nest habitat for Kittlitz's murrelet in Russia (Felis, unpublished data). We did not detect a positive relationship between the amount of suitable nesting habitat and glacial extent or persistent snow. We were unable to estimate future changes in amount of suitable nest habitat as a result of climate change because the necessary land cover predictions at the appropriate spatial scale do not currently exist. We do anticipate primary succession in previously barren, ice- and snow-covered areas, as well as northward and elevational shifts in forest biomes (Beck *et al.* 2011, pp. 5–6). In addition, our mapping effort of suitable nest habitat did not take into account proximity to foraging areas (e.g., submerged marine sill), although we did consider distance to the ocean. Nonetheless, given the diversity of habitats used by this species for nesting and the seemingly large amounts of suitable nest habitat throughout its range, we conclude that the Kittlitz's murrelet is not limited by the current amount of suitable nest habitat.

For a short period following glacial retreat, thinning or subsequent isostatic rebound (uplift in ground released from the weight of glaciers), additional barren, isolated habitat is created that may be suitable for nesting Kittlitz's murrelets. However, any habitat gained probably lasts only 5–20 years before primary succession ensues, provided that the substrate is sufficiently stable, usually beginning with dwarf fireweed (*Epilobium* spp.), *Dryas drummondii* (a mat-forming dwarf shrub), and willow (*Salix* spp.), followed by alder (*Alnus sinuata*) and then Sitka spruce (*Picea sitchensis*) (Chapin *et al.* 1994, pp. 149, 151). As plants colonize the landscape, the habitat rapidly becomes unsuitable for nesting Kittlitz's murrelets, but does begin to support increasingly greater diversity and abundance of other wildlife species, such as small mammals and birds, which in turn attracts predators. Eventually, previously isolated areas of barren habitat, such as nunataks, are accessible to predators through vegetated corridors, reducing their suitability for nesting. Consequently, distance between suitable nesting and foraging habitat for Kittlitz's murrelet is expected to increase, and murrelets will likely need to nest at higher elevations where the rate of change in habitat should be slower. In contrast, the transition from barren to vegetated habitat in deglaciated areas may benefit the marbled murrelet, a species that typically nests on the mossy limbs of large trees or on cliff ledges surrounded by vegetation (Barbaree 2011, pp. 65, 71–74).

In Icy Bay, successful nests (n=14) of radio-marked Kittlitz's murrelet were located closer to the ocean (median distance=5.6 mi [9.0 km]) than failed nests (n=21; median distance=15.0 mi [24.1 km]), although elevation did not affect nest fate (4,226 ft [1,288 m] and 4,718 ft [1,435 m], respectively) (Kissling, unpublished data). Comparatively, radio-marked marbled murrelets nested (n=13 nests) at lower elevations (median elevation=1,368 ft [417 m]) and closer to the ocean (median distance=2.9 mi [4.7 km]) than Kittlitz's murrelets (4,291 ft [1,308 m] and 8.8 mi [14.2 km], respectively), and exhibited both higher breeding propensity and nest success (Kissling, unpublished data). These results suggest that in this glaciated area there is an advantage to nesting closer to the ocean and at lower elevations, most likely due to reduced energetic costs associated with delivering prey to chicks and predator avoidance (Hatch 2011, pp. 86–87). Marbled murrelets also nested in a greater diversity of habitat types in Icy Bay, including barren, shrubland, and conifer sites, compared to Kittlitz's murrelets that were restricted to barren sites. Although glacial recession and subsequent primary succession will likely reduce access to high-quality nesting habitat of the Kittlitz's murrelet in part of its range, we do not know that these ecological processes will have a population- or species-level impact on the Kittlitz's murrelet for two reasons. First, nests of this species have been found throughout its range, some in areas with considerable amounts of vegetation (e.g., average 51 percent at nest sites in Aleutian Islands) (Kaler *et al.* 2009, p. 366; Kaler and Kenney 2013, pp. 73–74), suggesting some level of adaptability to variable terrestrial conditions. Second, the Kittlitz's murrelet population has been presumably stable since 2000 despite continued loss of glaciers in south-coastal Alaska (see *Population Status and Trends,* above).

Changes in Ocean Conditions

Ocean temperatures in Alaska have increased (Bograd *et al.* 2005, p. 244; Overland and Wang 2007, p. 178; Stabeno *et al.* 2007, pp. 2607–2608; Steele *et al.* 2008, p. 2; Mueter *et al.* 2009, p. 96) and are predicted to continue to increase (IPCC 2007, pp. 45–

46; Haufler *et al.* 2010, p. 10; Hazen *et al.* 2012, p. 2). Consequently, physical and biological changes in the marine environment are expected, but the scope and magnitude of these are unknown and difficult to project. Although we do not expect direct effects to the Kittlitz's murrelet, we may observe indirect effects such as changes to their prey base, which in turn, would likely affect their survival, reproduction, and perhaps distribution.

The Kittlitz's murrelet appears to be a flexible forager with a diet that varies considerably among seasons, but is more specialized within a season. For example, nesting Kittlitz's murrelets need high-energy forage fish to deliver to chicks at nests, requiring access to both foraging areas where these prey occur and nesting habitat. Generally, however, the diet of the Kittlitz's murrelet ranges from mostly zooplankton in the winter months to predominantly fish in the summer months, although zooplankton is part of their diet throughout the entire annual cycle (Hobson *et al.* 1994, p. 795; Day *et al.* 1999, p. 9; Hatch 2011, pp. 25–26, 35; Allyn 2012, p. 102). A comprehensive diet study of the Kittlitz's murrelet has not been completed, but based on stable isotope analysis (Hobson *et al.* 1994, p. 795; Hatch 2011, p. 47; Allyn 2012, p. 102), stomach contents (Sanger 1983, p. 692; summarized in Day *et al.* 1999, p. 9), fish-holding observations (Agness 2006, p. 119; Kuletz *et al.* 2008, p. 26), fish netted below foraging Kittlitz's murrelets (Kuletz *et al.* 2003a, pp. 23, 28), and chick meal deliveries (Naslund *et al.* 1994, p. 46; Kaler *et al.* 2011, p. 15; Lawonn 2012, pp. 27–28; Kaler, unpublished data; Kissling, unpublished data), this species is known to feed on neritic macrozooplankton, such as copepods, amphipods, and euphasiids, and forage fishes, primarily Pacific sand lance, but also capelin, Pacific herring, Pacific sandfish (*Trichodon trichodon*), walleye pollock, kelp greenling, Atka mackerel, Pacific cod, and rockfish and smelt species (see *Foraging,* above, for a more complete description of diet and foraging preferences). Given the diverse diet of the Kittlitz's murrelet and its ability to forage successfully in a variety of marine habitats, and perhaps freshwater, we assume that this species has the ability to switch prey based on local availability when self-feeding, like many other seabird species, including the marbled murrelet (Litzow *et al.* 2002, p. 292; Ostrand *et al.* 2004, p. 73; Becker *et al.* 2007, p. 274; Ito *et al.* 2009, p. 282).

The collective, complex process of ocean acidification is a global problem that will intensify with continued carbon dioxide emissions and may significantly affect marine ecosystems. Oceans absorb carbon dioxide from the atmosphere and store it as carbonic acid. Since the beginning of the industrial revolution, the pH of ocean surface waters has decreased from 8.2 to 8.1 (0.1 units) (Markon *et al.* 2012, p. 40). Although this change in pH seems small, it equates to a 20 percent increase in acidity and a subsequent decrease in carbonate compounds (primarily aragonite and calcite) necessary for calcifying organisms to construct tissues such as skeletons and shells (Markon *et al.* 2012, p. 40). By 2100, ocean surface pH is expected to decrease another 0.3–0.5 units (Caldeira and Wickett 2005, p. 1). High-latitude regions are particularly vulnerable to ocean acidification because cold ocean temperatures increase the solubility of carbon dioxide and precondition the seawater to have lower calcium carbonate concentrations and saturation states compared to more temperate ocean environments (Fabry *et al.* 2009, p. 161; Mathis *et al.* 2011, p. 2; Markon *et al.* 2012, p. 40). Furthermore, in the Arctic Ocean, the carbonate mineral saturation state is expected to decrease with increasing sea ice melt (Bates and Mathis 2009, p. 2433). Although the biological effects of ocean acidification are far from clear, the ability to tolerate its apparent impacts is species-specific and varies within phyla and between closely related species (Whiteley 2011, pp. 257–258), making it difficult to generalize potential impacts to a single species, like the Kittlitz's murrelet. High-latitude planktonic and benthic calcifiers, especially pteropod snails, a common prey item for various zooplankton and fish (e.g., pollock, salmon, cod), are expected to be most affected by ocean acificiation (Fabry *et al.* 2009, p. 164). Consequently, as a top predator in the marine ecosystem, the Kittlitz's murrelet may experience alterations to underlying food webs. However, this species has a diverse diet (except when nesting), appears to have the ability to switch prey when necessary, and can forage successfully in a variety of marine habitats (see *Foraging,* above). We acknowledge that ocean acidification is occurring and is expected to continue, but, based on the best available information, we conclude that projected ecosystem changes as a result of ocean acidification are not having or will not have population- or species-level impacts on the Kittlitz's murrelet.

Variability in ocean temperatures alone can disrupt complex marine food webs by affecting the productivity or abundance of lower trophic levels, thereby influencing higher trophic levels and the balance in predator-prey relationships (Hazen *et al.* 2012, p. 2). As ocean temperatures change, we anticipate poleward shifts in distribution of species that have limited temperature ranges (Overland and Stabeno 2004, p. 309; Perry *et al.* 2005, p. 1914; Stabeno *et al.* 2007, p. 2605; Mueter and Litzow 2008, pp. 316–317; Mueter *et al.* 2009, p. 106), changes to the thermohaline circulation (part of the large-scale ocean circulation that is driven by global density gradients) (Haufler *et al.* 2010, p. 10) thereby influencing nutrient input and mixing (Mueter *et al.* 2009, pp. 99, 107), variability in the timing and magnitude of spring phytoplankton blooms (Stabeno *et al.* 2007, p. 2612; Janout *et al.* 2010, p. 13), and changes in the local abundance of forage fish (Hunt *et al.* 2002, pp. 5835–5842; Abookire and Piatt 2005, pp. 236–238; Becker *et al.* 2007, pp. 267–269). However, available information does not allow us to project the magnitude or direction of possible impacts to the Kittlitz's murrelet or its prey as a result of increased ocean temperatures, especially given additional natural processes, such as inter-annual to decadal-scale ocean variability and large-scale regime shifts.

Several climate regime shifts and subsequent community or taxomonic reorganizations have occurred in the North Pacific and Arctic oceans over the last few decades (Anderson and Piatt 1999, p. 120; Hare and Mantua 2000, p. 103; Litzow 2006, p. 1387; Brodeur *et al.* 2008, p. 108; Flint 2013, p. 59). These regime shifts often, but not always, corresponded to a change in the PDO index between a cold (negative) phase and a warm (positive) phase (Mantua *et al.* 1997, pp. 1076–1077; Litzow 2006, p. 1387). It is well-recognized that there were major atmospheric, oceanographic and ecological changes near 1976–1977 with a shift from the negative to the positive phase of the PDO (Anderson and Piatt, 1999, pp. 119–120), followed by weaker, less defined shifts in 1989 and 1998 (Litzow 2006, pp. 1390–1393; Overland *et al.* 2008, p. 92; Flint 2013, p. 61); retrospective analyses indicate that there were also North Pacific regime shifts in 1925 and 1947 (Mantua *et al.* 1997, p. 1075). It is difficult to assess impacts of these climatic regime shifts (or project them into the future) on the Kittlitz's murrelet, specifically, because we lack sufficient and reliable data (see *Population Status and Trends,*

above). In California, annual survival of marbled murrelet was positively associated with positive values (warm phase) of the PDO (Peery *et al.* 2006, p. 82). In contrast, declines in populations of marine birds, especially piscivorous (fish-eating) species, and fishes occurred in the Gulf of Alaska between 1972 and 1993, in response to a shift to a warm water regime in 1976–1977 (Piatt and Anderson 1996, pp. 725, 731; Anderson and Piatt 1999, pp. 119–120; Agler *et al.* 1999, p. 100; Litzow *et al.* 2002, p. 286). The impact of the regime shift was probably exacerbated in Prince William Sound by the *Exxon Valdez* oil spill in 1989. For some marine species, however, declines halted shortly following the 1989 regime shift (Flint 2013, pp. 61–62). Similarly, our multiple-populations trend analysis indicated that Kittlitz's murrelets declined at an average annual rate of about 30 percent across multiple populations in the Gulf of Alaska between 1989 and 2000, after which abundance appeared to have stabilized, possibly due to the minor regime shift in 1998 (see *Population Status and Trends,* above).

Undoubtedly, the Kittlitz's murrelet will respond to changes in ocean conditions, including temperature, circulation, salinity, chemistry, and other physical characteristics. Evidence suggests that this species has been resilient (able to persist), adaptable (able to adapt), or both to previous and ongoing changes in its marine habitat, or has undergone a population shift in response to environmental change, as suggested by Day (2011, p. 52). Between 1907 and 2009, mean isotopic signatures of nitrogen, an indicator of dietary trophic level, declined in feathers of Kittlitz's murrelets in the Gulf of Alaska during the pre-breeding season, but not in the post-breeding season (Hatch 2011, pp. 27, 49). These results suggest that perhaps decreased prey resources over the last century have forced Kittlitz's murrelets to fish further down the food chain, but we do not have reliable information to demonstrate a rangewide effect to this species during a similar time period. In addition, stomach contents of 48 adult Kittlitz's murrelets collected at sea between 1969 and 1996 in the North Pacific Ocean do not indicate any major shift in diet or trophic level compared to more recent information on chick and adult diet (Day *et al.* 1999, p. 9; Allyn 2012, p. 100; Kissling 2013, in litt.). So, while we fully recognize that changes in ocean conditions as a consequence of climate change play a significant role in the population regulation and abundance of prey species to the Kittlitz's murrelet, available information does not suggest that these changes are a threat to the persistence of this species for two primary reasons. First, the Kittlitz's murrelet has a diverse diet throughout the year, indicating that it can successfully forage on many different taxa, can switch prey types presumably based on local availability, and can adapt to a variety of foraging conditions across its broad range. Only nesting Kittlitz's murrelets experience prey restrictions, but there is no evidence to suggest that changes in ocean conditions as a result of climate change are limiting or will limit high-quality chick meal deliveries, thereby affecting fledging rates, in the future. Second, we do not have sufficient evidence that would allow us to determine if Kittlitz's murrelet populations or the diet of this species have fluctuated concurrently with regime shifts or ocean warming and acidification. Therefore, the weight of evidence suggests that this species can respond to changing ocean conditions by switching prey, adjusting its behavior, or potentially shifting its distribution.

Contaminated Meltwater

Climate warming and associated glacial melt may be increasing contamination of fresh and marine waters. This phenomenon has been studied most extensively in alpine freshwater catchments in Europe. Bogdal *et al.* (2009, pp. 8173–8175) used lake sediment core results to track fluxes of organochlorine contaminants (industrial chemicals and pesticides) beginning in the 1950s and found an initial peak in the 1960s–1970s corresponding to peak air emissions in Europe, decreased levels in the1980s–1990s that were attributed to emission reductions, and a second peak since the late 1990s that the authors attributed to glacial melt. Recent organochlorine inputs to the lake are similar to, or higher than, those observed in the 1960s–1970s, with recent fluxes of the pesticide dichlorodiphenyl-trichloroethane (DDT) and its metabolites exceeding past fluxes by a factor of five (Bogdal *et al.* 2009, p. 8176). In a follow-up study, Schmid *et al.* (2011, pp. 205–207) compared polycholorinated biphenyls (PCBs) and the pesticide DDT and its metabolites (DDTs) in the sediments of a glacial-fed lake to sediments in a nearby lake that lacked glacial inputs. During the past two decades, total PCB and DDT levels in the non-glacial lake sediments decreased, while those in the glacial-affected lake sediments increased, supporting the hypothesis that glaciers represent a secondary source of these pollutants (Schmid *et al.* 2011, p. 207). Similarly, in Alberta, Canada, a substantial percentage of current glacial melt originated from ice that was deposited between 1950 and 1970, when organochlorines were more concentrated in the atmosphere than they are now, or were before 1950 (Blais *et al.* 2001, pp. 410, 414–415) and the concentrations of persistent organic pollutants (POPs) were, on average, 29 times higher in the glacial stream, relative to a nearby non-glacial valley stream (Blais *et al.* 2001, p. 414).

Results of contaminant studies conducted in alpine freshwater lake systems may not be relevant or directly comparable to the physical and chemical processes associated with coastal and tide-water glaciers. In the polar coastal environment of Antarctica, cesium-137, a ubiquitous radionuclide contaminant associated with historical nuclear weapons testing, exhibited an abrupt concentration increase in recent sediments relative to older sediments (Sanders *et al.* 2010, pp. 422–423). While results are limited to a single sediment core (so extrapolation should be conducted with caution), the authors hypothesized that increased snow and ice melt from the uplands and enhanced sediment transport have resulted in net movement of cesium-137 from the coast into the marine environment. We are unaware of comparable contaminant studies from coastal ice fields or alpine glaciers in Alaska; therefore, we have no basis from which to determine the significance of glacial meltwater as a potential source of contamination to the Kittlitz's murrelet (see *Environmental Contaminants,* below).

Loss of Winter Sea Ice

Until recently, there was little information about the movements and distribution of the Kittlitz's murrelet outside of the breeding season, which is when most surveys are completed. Within the last few years, research demonstrated that individuals depart breeding sites in the Gulf of Alaska and Aleutian Islands in July and August and migrate offshore to areas in the Bering, Chukchi and western Beaufort seas, where they apparently remain until late October (Day *et al.* 2011, pp. 57–59; Madison *et al.* 2012, p. 1; Kuletz, unpublished data) (see *Habitat and Life History,* above). In November, as sea ice builds in the Chukchi and Beaufort seas, Kittlitz's murrelets begin to move south into open water of the Bering Sea where at least some individuals winter in open water leads and polynyas of the annual sea ice (Day *et al.* 1999, p. 7; Kuletz and Lang 2010, pp. 39–43; Day *et al.* 2011,

p. 59). These observations suggest that the Kittlitz's murrelet's winter distribution may be associated with winter sea ice in the Bering and Chukchi seas, which is declining rapidly and projected to continue declining (Douglas 2010, p. 1). However, to date, there has been little survey effort in the Gulf of Alaska where winter sightings indicate that some individuals are year-round residents or over winter in the ice-free waters of south-coastal Alaska (Klosiewski and Laing 1994, p. 83; Kendall and Agler 1998, pp. 55–56; Day *et al.* 1999, pp. 4–5; Stenhouse *et al.* 2008, p. 61; Kissling, personal observation). We recognize the post-breeding northward migration and the occurrence of the Kittlitz's murrelet in open leads and polynas of the Bering and Chukchi seas in the winter and spring, but the data are limited and preliminary. In addition, the variable patterns of distribution and types of habitat used make it difficult to draw conclusions about the Kittlitz's murrelet's use of non-breeding habitat. Therefore, we have no basis from which to determine whether or not the loss of winter sea ice would negatively affect the habitat of the Kittlitz's murrelet.

Summary of Climate Change

To summarize, climate change is modifying the marine and terrestrial habitats of the Kittlitz's murrelet. Although we can hypothesize about the various mechanisms by which Kittlitz's murrelets could be affected by these changes, we have not identified a causal link that is or will be causing a population- or species-level effect. Among the stressors evaluated, there are two that raise concern because they could negatively affect reproductive success of Kittlitz's murrelets, which was found to be consistently poor at sites where it was studied (see *Reproductive Performance,* above). These stressors are (1) The increasing distance between nesting and foraging habitats as a result of glacial recession and subsequent primary succession; and (2) changes in the foraging habitats due to glacial recession that could affect foraging efficiency or access to high-quality prey during chick rearing. However, the underlying mechanisms of these stressors are only working hypotheses; there is little information available to evaluate the significance of these stressors or potential implications to the Kittlitz's murrelet at the population or species level now or in the future.

Although the Kittlitz's murrelet is generally associated with glacial-influenced habitats during the breeding season, this species is broadly distributed across many areas that have been deglaciated for thousands of years, and it nests and forages successfully in a variety of habitats. There is too much spatial and temporal variation in the species' habitat use to conclude that ice is an essential part of its life history and there is no evidence to suggest that Kittlitz's murrelets in glacial-affected areas outperform those in non-glaciated areas. Their seasonally varied and diverse diet at multiple trophic levels and apparent ability to switch prey types demonstrate adaptability to interannual and decadal-scale ocean variability and changes in ocean conditions that are likely to influence prey of the Kittlitz's murrelet. Furthermore, changes in forage quality, quantity, or distribution is uncertain at this time. Although contaminated meltwater from glaciers and the loss of winter sea ice may be altering marine habitats within this species' range, we have little information to evaluate these potential threats to the Kittlitz's murrelet. Thus, available information does not suggest that possible projected changes to the marine and terrestrial habitats used by the Kittlitz's murrelet as a result of climate change will be so great as to pose a threat to the persistence of this species at the population or species level now or in the future.

Environmental Contaminants

Persistent Organic Pollutants

Kittlitz's murrelets may be exposed to contaminants from site-specific sources, including former military sites, and from global atmospheric transport, so specific sources may be distant from the location of measurement. Within the range of the Kittlitz's murrelet, we tallied 2,537 contaminated sites and spills within 62 mi (100 km) of the shoreline that occurred between 1995 and 2012, most of which primarily affected land resources (n=2,077), not marine resources (n=460) (Alaska Department of Environmental Conservation 2013a). The majority of these spills was small in volume, localized and generally associated with villages, small towns, or urban areas (e.g., heating oil tanks and lines), primarily near Anchorage and Barrow (see *Marine Oil Pollution,* below, for more detailed discussion on marine-related spills). We also reviewed mining exploration, development, and production sites in Alaska to evaluate future potential contamination (or disturbance) sites near nesting habitat of the Kittlitz's murrelet (Szumigala *et al.* 2010, pp. 10, 39, 43). Generally, spatial overlap of contaminated sites with suitable nesting habitat or known areas of marine concentrations of the Kittlitz's murrelet was low, indicating that exposure to any point-source contamination would also be low.

Nonetheless, sympatric waterbird species to the Kittlitz's murrelet are exposed to contaminants, especially POPs, including PCBs, other organocholorines, and mercury. Pelagic cormorants (*Phalacrocorax pelagicus*) and red-faced cormorants (*P. urile*) throughout the Aleutian Archipelago had greater levels of PCB, hexachlorobenzene (HCB), DDE (a DDT metabolite), and *trans*-nonachlor, all of which are persistent organochlorine contaminants, in the western Aleutian Islands compared to the eastern islands (Rocque and Winker 2004, pp. 761–762), with identified sources including former military installations (p. 764). Similarly, total PCBs were proportionally the most abundant persistent organochlorines in glaucous-winged gulls (*Larus glaucescens*), northern fulmars (*Fulmarus glacialis*), and tufted puffins at several locations within the Aleutian Islands (Ricca *et al.* 2008, pp. 314–315), again with military sites the proposed sources. Concentrations of organochlorine contaminants in tufted puffins were generally lower than other species, with the exception of one sample from East Adak near Sweeper Cove, a site of known PCB contamination (Ricca *et al.* 2008, p. 316). Collectively, these results suggest significant point sources of contamination at sites such as Adak, Amchitka, and to a lesser extent Kiska islands, all in the Aleutian Archipelago and within the range of the Kittlitz's murrelet. High concentrations of PCBs, DDE, and chlordanes in seabirds from Buldir Island, the most westerly site sampled and which lacks a point source for military pollution, suggest that atmospheric transport from Eurasian sources may also be important. For example, tufted puffins, black-legged kittiwakes (*Rissa tridactyla*), and short-tailed shearwaters (*Puffinus tenuirostris*) were exposed to recently applied DDT obtained from a distant source (Ricca *et al.* 2008, p. 320).

These persistent contaminants were also detected in Kittlitz's murrelets from Icy Bay, Alaska (Matz, Service, 2012, unpublished data), but at concentrations that are not of concern for adult mortality or reproduction. In 10 composited adult plasma samples, total PCBs were at concentrations below those associated with reduced hatching success and hatchling mass in glaucous gulls (*L. hyperboreus*), abnormal male reproductive behaviors in American kestrels (*Falco sparverius*) and glaucous

gulls (Harris and Elliott 2011, pp. 486–487), or poor adult return-to-colony in Caspian terns (*Hydroprogne caspia,* formerly *Sterna caspia*) from the Great Lakes (Mora *et al.* 1993, p. 328). On a congener basis (related chemicals), PCB congeners common in marine environments or that are environmentally persistent due to a high percentage of chlorine were detected in the majority of samples, but at very low concentrations, and the four most toxic (''dioxin-like'') individual PCB congeners were not detected. Other congeners detected in the majority of samples were also at very low concentrations. Although the best sample in which to measure DDE is eggs, plasma concentrations of Kittlitz's murrelets were very low compared to lethal levels in liver and brain concentrations in a variety of birds (summarized by Blus 2011, pp. 428–430). Similarly, concentrations of these persistent contaminants in one composite sample of livers taken from four Kittlitz's murrelet chicks found dead at nests on Agattu Island were low and not of concern (Lance, Service, 2013, unpublished data). Other POPs of emerging concern, such as polybrominated diphenyl ethers that are used as flame retardants, were not detected in Kittlitz's murrelet blood from Icy Bay, Alaska (Matz, unpublished data). In conclusion, PCBs, DDE, and other organochlorine contaminants were not detected at deleterious concentrations in plasma (n=10) or liver (n=1) of Kittlitz's murrelets from Alaska, so, with the caveat that few data are available, we find that these contaminants are currently not considered to have population- or species-level effects now or in the future.

Mercury

Mercury is a global contaminant of concern for aquatic species, including numerous seabirds (e.g., black-footed albatross [*Phoebastria nigripes*]) (Vo *et al.* 2011, p. 1). However, the toxicological significance of actual mercury concentrations in marine birds and animals is not clear, as they appear to tolerate much greater mercury concentrations than freshwater organisms due to different selenium-related detoxification abilities (Burger *et al.* 1997, p. 167; Ikemoto *et al.* 2004, pp. 402, 404). For species with high or variable selenium exposure, such as marine birds like the Kittlitz's murrelet, it is necessary to evaluate selenium concentrations and their effect on mercury toxicity to generate reliable tissue-specific mercury effect thresholds (Spalding *et al.* 2000, pp. 419–420). However, because there are too few studies that document mercury concentrations and effects in marine birds, we cautiously relied on established toxic effect levels from other, mostly freshwater, birds to assess mercury concentrations in feathers, whole blood, and eggshells of the Kittlitz's murrelet.

Threshold feather concentrations for adverse reproductive effects (including reproductive behavioral changes, reduced reproductive output and sterility; Eisler 1987, pp. 62–63) in various species' range from 5–65 parts per million (ppm) dry weight (dw), depending on the species (Burger and Gochfeld 1997, p. 164). For feather mercury concentrations, the most commonly used toxicity threshold level for potential adverse effects is 5 ppm dw, but it is highly dependent on species (Blevin *et al.* 2013, p. 6). For example, adult great skuas (*Stercorarius skua*) in the Shetland Islands had adult feather mean mercury concentrations of 7.0 ppm, with no apparent effects on survival or reproduction (Thompson *et al.* 1991, p. 678), and for the common loon (*Gavia immer*) the adverse effect threshold for adults is 40.0 ppm in feathers (Evers *et al.* 2008, p. 69). Mean feather mercury concentrations of adult Kittlitz's murrelets varied significantly with no obvious pattern among geographic areas in Alaska. In the Aleutian Islands, feather mercury concentrations averaged 2.06 ppm dw on Agattu Island, but were significantly higher at Adak Island (9.15 ppm dw) (Kenney, Service, 2007–2012, unpublished data). Similarly, in southeastern Alaska, mean feather mercury concentrations in 301 adult Kittlitz's murrelets from Icy Bay were 1.22–1.58 ppm dw (Folsom *et al.* 2009, p. 44; Kenney, unpublished data; Matz, unpublished data), but were much higher in Glacier Bay (9.00 ppm dw) (Kenney, unpublished data). Although accumulated mercury in feathers of some individual Kittlitz's murrelets, especially those at Adak Island and Glacier Bay, was relatively high, it is difficult to reconcile and interpret the large variation among individuals and study sites.

Whole blood mercury values in Kittlitz's murrelets from Icy Bay are equally inconclusive at the population level, but may raise concern for some individuals. Mean blood concentrations of Kittlitz's murrelets from Icy Bay were variable among years; in 2008–2009, concentrations averaged 0.32 ppm wet weight (ww) (Folsom *et al.* 2009, p. 44; Kenney, unpublished data), and in 2011, concentrations were 4.5 ppm ww (Matz, unpublished data), perhaps reflecting differences in prey consumed across years. For comparison, whole blood mercury concentrations of marbled murrelets in Port Snettisham, southeastern Alaska, in 2008 were 0.22 ppm ww (Folsom *et al.* 2009, p. 44). Threshold concentrations in blood for reproductive effects in adult common loons and bald eagles (*Haliaeetus leucocephalus*) were 3.00 and 6.54 ppm ww, respectively (Weech *et al.* 2006, p. 1438; Evers *et al.* 2008, p. 79). However, given the variation in whole blood concentrations of Kittlitz's murrelets among years (range across all years=0.04–15.1 ppm ww) and lack of information on selenium levels of this species, we can only tentatively conclude that blood mercury concentrations in some individual Kittlitz's murrelets from Icy Bay in some years may be at the low end of reproductive effect levels or below effect levels based on their marine status.

Adverse effect thresholds of mercury concentrations in eggshells have yet to be established, but mercury concentrations of 0.90–18.0 ppm ww in whole eggs have been associated with poor hatching success and increased chick mortality in some avian species (Eisler 1987, p. 2; Burger and Gochfeld 1997, p. 163–164). Mean mercury concentrations in eggshells collected from 20 Kittlitz's murrelet nests on Agattu Island appear to be low (0.016 ppm dw) (Kenney, unpublished data). For comparison, mercury concentrations in eggshells of Audouin's gulls (*L. audouinii*) ranged from 0.13–0.18 ppm dw and were not correlated with reproductive impairment (Sanpera *et al.* 2000, pp. 120–121).

Since the preindustrial period, human activities have increased the amount of mercury cycling in the environment by about a factor of three (Selin 2009, p. 55). If emissions of mercury into the atmosphere continue, ocean concentrations will continue to increase (Selin 2009, p. 55), possibly causing adverse effects for marine species, such as the Kittlitz's murrelet. Yet, substantial variability exists among bird species in their sensitivity to mercury, and no information exists for Kittlitz's murrelet mercury thresholds or selenium levels. Current data on mercury concentrations in feathers, blood, and eggshells of Kittlitz's murrelets are both spatially and temporally limited, but suggest that perhaps some individuals in some years may exceed commonly used adverse effects thresholds established for other bird species. However, owing to the high variability in concentration values and the apparent higher tolerance of marine species to mercury toxicity, we

find that mercury does not pose a population- or species-level threat to the Kittlitz's murrelet now or in the future.

Marine Oil Pollution

Petroleum hydrocarbons in marine waters are considered among the most potentially harmful contaminants to marine birds and their prey (Martin and Richardson 1991, p. 533). Acute and chronic exposure to oil pollution can have both direct and indirect impacts to marine birds (Yamato *et al.* 1996, p. 381; Esler *et al.* 2000, pp. 839, 844). Oiling of feathers causes loss of insulating capacity and can lead to death from hypothermia, smothering, drowning and ingestion of toxic hydrocarbons (Peterson *et al.* 2003, p. 2082). Marine birds ingest oil by preening their oiled feathers or by consuming oiled prey. Long-term or chronic effects of oiling are more difficult to document, but certainly exist, and are most likely to impact those species that are intimately associated with sediment for egg-laying or foraging (Peterson *et al.* 2003, p. 2083), such as sand lance, herring, and many prey species of the Kittlitz's murrelet. However, it is often challenging to demonstrate a population- or species-level impact to a species because pre-event baseline data are rarely available (Carter and Kuletz 1995, p. 261).

The Kittlitz's murrelet is considered highly vulnerable to marine oil pollution because this species spends most of its annual cycle at sea, forages by diving and pursuing prey, and is typically found nearshore (King and Sanger 1979, p. 234; Day *et al.* 1999, p. 9; Day and Nigro 2000, p. 5). At least 19 major oil spills have occurred within the range of the Kittlitz's murrelet since 1976 (Alaska Department of Environmental Conservation, 2013b) and some have resulted in direct mortality of individuals (Kuletz 1996, p. 781; Piatt *et al.* 2007, pp. 72–77). However, estimating total mortality of Kittlitz's murrelet is complicated by their similar morphology to the typically more common marbled murrelet, which results in a large proportion of unidentified murrelets, and their small size relative to other marine birds and mammals. In addition, due to the remoteness and exposed marine waters of Alaska and Russia, response to oil spills within the range of the Kittlitz's murrelet is often hampered by weather and lack of infrastructure.

In March 1989, the commercial oil tanker *Exxon Valdez* spilled nearly 11.6 million gallons of crude oil into the marine environment of Prince William Sound, resulting in roughly 30,000 oiled seabird carcasses found on the beaches and an estimate of hundreds of thousands of seabird mortalities in total (Piatt and Anderson 1996, p. 720). A minimum estimate of direct mortality was 8,400 *Brachyramphus* murrelets, including a minimum of 255 Kittlitz's murrelets (not including unidentified murrelets) and at least 51 definitively identified Kittlitz's murrelet carcasses (Kuletz 1996, p. 781; Piatt *et al.* 2007, p. 74). Mortality estimates of over 1,000 Kittlitz's murrelets from this spill have been reported (van Vleit and McAllister 1994, p. 5). Since the *Exxon Valdez* oil spill, 11 other major spills have occurred in the coastal waters of Alaska, but data on Kittlitz's murrelet mortalities are limited. In August 2001, the fishing tender *F/V Windy Bay* struck a reef and sank in northern Prince William Sound, creating an oil slick from hydrocarbons on board (35,000 gallons of diesel and hydraulic fuel and lube oil) (Kuletz *et al.* 2003a, pp. 57–61; Piatt *et al.* 2007, pp. 73–74). Only 7 bird carcasses were retrieved, but 6 were marbled murrelets and 4 of those were newly fledged juveniles, extrapolating to a mortality estimate of roughly 100 murrelets (Piatt *et al.* 2007, p. 74); no Kittlitz's murrelets were retrieved, but they were present in the area and could have died without being recovered (Kuletz *et al.* 2003a, pp. 57–61). In December 2004, the *M/V Selandang Ayu* spilled 500,000 gallons of fuel oil (bunker C and diesel) into Makushin Bay, Unalaska Island, in the eastern Aleutians. Only five *Brachyramphus* murrelet carcasses (two marbled and three unidentified murrelets) were recovered after this oil spill (Byrd, Service, 2004, unpublished data), although this area is frequented by Kittlitz's murrelets in the breeding season (Madison *et al.* 2011, p. 116). We are aware of only four major oil spills within the range of the Kittlitz's murrelet in Russia (Sakhalin Island, Sea of Okhotsk), and we lack any information about possible murrelet mortality as a result of those spills, all of which occurred between September and January, a period in which Kittlitz's murrelets initiated post-breeding migration or settled into their winter habitats. Oil spills in Russia are not well-documented, but probably occur frequently (Blokov 2012, p. 3). Kittlitz's murrelet mortality from fuel spills and petroleum contamination may go largely unobserved in the vast and remote waters of Alaska and eastern Russia, but lack of observed mortality from marine oil pollution does not confirm its absence. However, it is difficult to assess the impacts from these spills and others on the Kittlitz's murrelet population. An additional aspect of oil spills is the large, but temporary increase in vessel traffic in the spill area during response activities, as documented during large (e.g., *Exxon Valdez*) and small (e.g., *Windy Bay*) spills and vessel groundings alike (Kuletz *et al.* 2003a, pp. 30–31).

We examined the spatial and temporal overlap of 460 oil spills and contaminated sites that primarily impacted marine resources in coastal Alaska between 1995 and 2012, and distribution and abundance of Kittlitz's murrelet (Alaska Department of Environmental Conservation, 2013a). We identified four biologically-meaningful periods within the annual cycle of the Kittlitz's murrelet: Breeding (May–July), post-breeding (August–October), winter (November–February), and pre-breeding (March–April). We estimated relative densities of Kittlitz's murrelets at sea by marine ecoregion (n=30 in Alaska; Piatt and Springer 2007, pp. 524–525) and period (Kuletz, unpublished data; see *Population Status and Trends,* above, for information on abundance estimates). Most spills occurred during the post-breeding period (43 spills per month), followed by the winter and breeding (38 spills per month each), and pre-breeding (33 spills per month) periods. Across all periods, most (83 percent) of the spills were small, releasing less than 1,000 gallons of substance, and 78 percent consisted of non-crude oil (diesel), which is lighter and disperses more quickly than crude oil. However, there is no evidence to suggest that the immediate impact to marine birds from non-crude oil is less problematic than crude oil (Piatt *et al.* 2007, p. 73). There were 12 large spills (greater than 10,000 gallons); 8 of these consisted of non-crude oil, and 7 occurred due to grounding or sinking vessels. We concluded that there was low spatial overlap between these spills and Kittlitz's murrelet distribution in the post-breeding, winter, and pre-breeding periods, but low–moderate overlap during the breeding period, primarily in Prince William Sound and, to a lesser extent, Adak Island in the central Aleutian Archipelago.

Marine traffic within the range of the Kittlitz's murrelet is forecasted to increase in the next 25 years (Det Norske Veritas and ERM West 2010, pp. 60–61). The vessel fleet in or passing through marine waters of Alaska and eastern Russia is comprised of container vessels, bulk carriers, cargo vessels, gas and car carriers, cruise and tank ships, tugs and barges, fishing vessels, and government vessels. Cruise ships and recreational boating activity have increased and continue to increase in

the glaciated fjords of Glacier Bay (federally managed waters requiring an entry permit), Yakutat Bay, Prince William Sound and Kenai Fjords in south-coastal Alaska (Day *et al.* 1999, pp. 20–21; Jansen *et al.* 2006, p. 1186; Hoover-Miller *et al.* 2013, p. 3), where large numbers of the Kittlitz's murrelet are found in the breeding season (Arimitsu *et al.* 2011, p. 18; Kissling *et al.* 2011, pp. 7–8; Kuletz *et al.* 2011a, pp. 99–101; Piatt *et al.* 2011, pp. 68–70).

Trans-Pacific shipping routes that connect North America and Asia overlap with Kittlitz's murrelet distribution in the northern Gulf of Alaska and throughout the Aleutian Islands, most of which are part of the Alaska Maritime National Wildlife Refuge. Within a 1-year period, a minimum of 2,219 large commercial ships transited along this route, known as the North Pacific Great Circle route, with most vessels traveling offshore across the Gulf of Alaska, but nearshore along the Aleutian Islands, where most vessels cross the island chain twice during each transit (Det Norske Veritas and ERM West 2010, pp. 5–6; Kuletz, unpublished data). The nearshore portion of this popular shipping route likely presents the greatest oil exposure risk to the Kittlitz's murrelet. In the next 25 years, both westbound and eastbound traffic along the North Pacific Great Circle route are expected to increase, but the rate of increase is dependent on economic activity (gross domestic products) (Det Norske Veritas and ERM West 2010, pp. 60–61, 65). However, based on the certainty that oil spills will continue to occur in this region where high volumes of ships traverse dangerous waters, the Alaska Maritime National Wildlife Refuge is considered among the most vulnerable refuges in the country (National Wildlife Refuge Association 2005, p. 10).

Projections of shipping traffic from the Bering Sea into the Chukchi and Beaufort seas along the Northwest Passage route are highly dependent on the future of natural resource development, regional trade growth, and future commodity prices for the natural resources being developed in and around these regions (Det Norske Veritas and ERM West 2010, p. 67). A key choke point is the Bering Strait, the migratory channel between the Bering and Chukchi seas, where vessel traffic has increased in the past decade and is projected to increase as extent and duration of seasonal sea ice decreases. The marine waters near Point Barrow, which separates the Chukchi and Beaufort seas, will likely experience increased traffic, and this is an area where Kittlitz's murrelets have been observed in late summer and fall (Madison *et al.* 2012, p. 1; Kuletz, unpublished data).

Offshore oil and gas development within the range of the Kittlitz's murrelet is also projected to increase in the future. In 2012, Royal Dutch Shell Oil (Shell) initiated offshore exploration in the Beaufort and Chukchi seas with a plan to drill up to 2 and 3 wells per year in each location, respectively, but after the drilling unit *Kulluk* was driven aground near Kodiak Island in a severe storm in December 2012, Shell paused exploration in 2013, to prepare equipment and emergency plans (Shell 2013). No Kittlitz's murrelet mortalities or injuries were reported as a consequence of the *Kulluk* grounding, but Kittlitz's murrelets have been observed in the vicinity of the accident in the winter months (Stenhouse *et al.* 2008, p. 60). In Cook Inlet, oil and gas activity is also increasing, but most lease sales have occurred in the upper portion of the inlet where Kittlitz's murrelets are less abundant compared to the lower portion (Kuletz *et al.* 2011b, p. 88; Alaska Department of Natural Resources 2013a). Recently, a lease sale for geothermal energy on western Augustine Island in Lower Cook Inlet was completed (Alaska Department of Natural Resources 2013b); this is an area frequented by individual Kittlitz's murrelets during post-breeding migration (Madison *et al.* 2012, p. 1).

It is reasonable to assume that as marine traffic and oil and gas development increase, so does the risk of petroleum contamination from both accidental spills and routine vessel operation. Because the Kittlitz's murrelet distribution varies considerably among seasons, it is difficult to assess the future risk from marine oil pollution to this species, but its broad distribution and relatively low densities on the water throughout most of the year reduce the risk of population-level impacts from any single event. Spill prevention is likely the best approach to reducing acute and chronic impacts of hydrocarbon contamination to the Kittlitz's murrelet. Baseline information on seasonal distribution and abundance of the Kittlitz's murrelet has improved significantly since 2000, which should help to inform future risk and spill response planning. Worldwide, oil tankers now under construction require double hulls and older tankers will be phased out of use. In the United States, single-hulled tankers should be completely phased out and replaced with double-hulled tankers by 2015 (see *Oil Pollution Act [OPA] of 1990,* below) (Det Norske Veritas and ERM West 2010, p. 54). While we recognize that hydrocarbon exposure is a possible acute and chronic source of mortality of individual Kittlitz's murrelets throughout their range and it will likely increase in the future, we conclude that marine oil pollution alone does not threaten the persistence of the Kittlitz's murrelet at the population or species level now nor is it likely to do so in the future.

Conservation Efforts To Reduce Habitat Destruction, Modification, or Curtailment of Its Range

We are not aware of any non-regulatory conservation efforts, such as habitat conservation plans, or other voluntary actions that may help to ameliorate any potential threats to the marine or terrestrial habitats used by the Kittlitz's murrelet.

Summary of Factor A

In summary, marine and terrestrial habitats of the Kittlitz's murrelet within select parts of its range are currently being modified by climate change, including loss of glaciers and changes in ocean conditions, and environmental contaminants, but we cannot predict the response of Kittlitz's murrelet to future changes in habitat conditions. This species uses a variety of habitats across a broad range, does not have a highly specialized diet, and appears to be a flexible forager. We are not aware of habitat characteristics required by or significantly advantageous to the Kittlitz's murrelet that are currently limited or may become limited in the future. Although sites that include tidewater glaciers apparently support greater densities of Kittlitz's murrelets during the breeding season compared to non-glaciated sites, there is little evidence to support the hypothesis that glaciers (or ice) are a required feature of nesting or foraging habitat or lead to better reproductive performance or survival of the Kittlitz's murrelet. Therefore, with limited data and assumptions, we conclude at this time that there is not likely to be a population- or species-level response of the Kittlitz's murrelet to the forecasted loss of glaciers, especially given that this species currently occurs in areas without glacial influence and that population trend has been stable since 2000, despite continued loss of glaciers.

Because this species spends most of its life at sea, possible threats to the marine habitat of the Kittlitz's murrelet, especially those that reduce prey availability or foraging efficiency, are more pervasive and therefore more likely to impact the species at the population level. However, we did not

identify any measurable threats affecting the marine habitats used by this species that could have a population- or species-level impact. The Kittlitz's murrelet, like many marine species, is probably sensitive to oceanic regime shifts that occur on interannual to decadal time scales. However, we do not have sufficient years of demographic data to evaluate population-level response of the Kittlitz's murrelet to past regime shifts, nor are we able to project the frequency or magnitude of future regime shifts. We do know, however, that this species has persisted through several large-scale regime shifts in the last century, coupled with loss of glaciers, subsequent vegetation succession, ocean warming, increased environmental contaminants, and marine oil pollution. For all of these reasons, we consider the Kittlitz's murrelet to be resilient or adaptable, or both, to changes in its marine and terrestrial habitats. Thus, in the absence of an identified mechanistic link between Kittlitz's murrelet and glaciers, available information does not lead us to conclude that modifications to habitats used by the Kittlitz's murrelet as a consequence of climate change or environmental contaminants will negatively impact the viability of this species in the future.

We conclude, based on the best scientific and commercial information available, that the present or threatened destruction, modification or curtailment of its habitat or range does not currently pose a threat to the Kittlitz's murrelet, nor is it likely to become a threat to this species in the future.

Factor B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The Kittlitz's murrelet was not historically, and is not currently a bird targeted by commercial or recreational interests (Day *et al.* 1999, p. 17); overutilization from these sources is not a threat. In addition, overutilization for educational purposes has not been documented and is not considered a threat.

During the last decade, a handful of research projects on Kittlitz's murrelet were initiated in several locations, some of which involved capturing and handling juvenile and adult live birds, collecting biological data and samples, attaching transmitters, and searching for and monitoring active nests. These methods, other than nest searching, are commonly used to study marbled murrelets in British Columbia (e.g., Lougheed *et al.* 2002, p. 309; Cam *et al.* 2003, p. 1120), Washington (e.g., Bloxton and Raphael 2009, pp. 1–3), and California (e.g., Hebert and Golightly 2006, pp. 7–8; Peery *et al.* 2006, p. 78), and, in some cases, have affected survival. For example, Peery *et al.* (2006, p. 85) found that radio-marked marbled murrelets had a lower probability of surviving the year after they were marked than non-radio-marked, but banded, murrelets, suggesting a radio-transmitter effect. Radio-transmitters are known to affect other alcids by lowering reproductive success (Whidden *et al.* 2007, p. 206) and performance (Ackerman *et al.* 2004, p. 1229; summarized for all birds by Barron *et al.* 2010, p. 180), but not influencing diving behavior (Jodice and Collopy 1999, p. 1414). There is no evidence to suggest that capture and handling, radio-marking, or nest searching and monitoring has affected the reproductive performance or survival of the Kittlitz's murrelet.

Few radio-telemetry studies of the Kittlitz's murrelet have been attempted. Pilot efforts in 2004 in Glacier Bay (Romano *et al.* 2007, pp. 120–121) and in 2006 in Kenai Fjords (Arimitsu *et al.* 2010, pp. 5–6, 14–15) were successful, but transmitter retention was poor and sample sizes were limited; no capture-related injuries or mortalities were reported. In Icy Bay, 940 Kittlitz's murrelets were captured on the water (74 were later recaptured), and 271 individuals were fitted with radio-transmitters between 2005 and 2012 (Kissling, unpublished data). In 8 years of research, 2 capture-related mortalities and 12 minor injuries (e.g., bent primary) were reported (Kissling *et al.* 2010, p. 1; Kissling, unpublished data). Based on the large number of birds captured in Icy Bay, there was no relationship between lactate (a metabolite used as an index of muscle fatigue or stress) and handling or transport time, sex, capture attempt, time of year, body condition, age, or reproductive status (Kissling *et al.* 2010, p. 1). A comparison of three radio-transmitter attachment techniques (subcutaneous anchor, suture only, and waterproof tape) did not indicate differences in behavior at sea or breeding propensity of Kittlitz's murrelets (Kissling, unpublished data). In 2011 and 2012, radio-marked marbled murrelets reproductively outperformed radio-marked Kittlitz's murrelets (see *Reproductive Performance,* above), suggesting that the radio-transmitter and marking were not responsible for the poor reproductive performance of Kittlitz's murrelets observed in those 2 years; these data are further supported by the low ratio of juvenile to adult Kittlitz's murrelets captured at sea in late summer (5 juveniles to 380 adults) (Kissling, unpublished data). Unfortunately, too few radio-marked Kittlitz's murrelets were recaptured across years to compare differences in annual survival rates, as done by Peery *et al.* (2006, p. 85), but there was no acute survival effect to Kittlitz's murrelets detected 1, 3, and 5 days post-radio-marking, and a chronic effect is unlikely because transmitter retention is low (80–90 days) (Kissling, unpublished data). Similarly, radio-marked Kittlitz's murrelets were delivered to predator nests in proportion to their availability on the water and in comparable proportion to non-radio-marked murrelets, suggesting that the radio-transmitter did not increase predation rates, thereby decreasing survival of individual Kittlitz's murrelets (Lewis, Service, 2007–2012, unpublished data). In 2009 and 2011, similar radio-marking efforts to study Kittlitz's murrelets in Prince William Sound (39 captured and 12 radio-marked birds) (Allyn 2012, pp. 95–96) and Glacier Bay (47 captured and 20 radio-marked birds) (Marcella *et al.* 2012, p. 3) reported no capture-related injuries or mortalities.

Between 2009 and 2012, 35 Kittlitz's murrelets were marked with a solar-powered satellite transmitter using two techniques (double prong and suture only) in 5 different locations across coastal Alaska (Madison *et al.* 2012, p. 1). No capture-related injuries or mortalities were reported in association with this effort, and there is no evidence to suggest that the satellite transmitters affected vital rates of individual Kittlitz's murrelets, although this has not been tested explicitly.

Three research projects aimed to locate nests of Kittlitz's murrelets by searching on foot on Agattu (2006, 2008–2011) (Kaler *et al.* 2009, p. 365; Kaler, unpublished data), Adak (2010–2012) (Kenney and Kaler 2013, p. 74; Kenney, unpublished data), and Kodiak islands (2008–2012) (Corcoran and Mackey 2012, p. 1; Lawonn 2012, p. 16). After active nests were discovered, they were monitored by visiting every 3–10 days (Kaler *et al.* 2009, p. 365), in stages (Corcoran and Mackey, 2012, p. 1; Lawonn 2012, p. 19) or using remote still cameras with motion detection (Kaler *et al.* 2011, p. 4; Lawonn 2012, pp. 17–18). Five active nests were located and accessible in Icy Bay, and all were monitored using remote video cameras (Kissling, unpublished data). On Agattu and Kodiak islands, an experimental approach to test for possible adverse effects of researcher visits to active nests was employed; discovered nests were categorized as

either a control or disturbed nest (Kaler *et al.* 2011, p. 4; Lawonn 2012, p. 17). Both studies concluded that nest visitation by researchers had a negligible, if any, effect on nest success (Kaler *et al.* 2011, p. 17; Lawonn 2012, pp. 30, 38).

Conservation Efforts To Reduce Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

We are not aware of any conservation efforts or other voluntary actions that may help to reduce overutilization for commercial, recreational, scientific, or educational purposes of the Kittlitz's murrelet.

Summary of Factor B

In summary, we conclude that overutilization has not led to the loss of populations or a significant reduction in numbers of individuals of Kittlitz's murrelet. Given the relatively small number of Kittlitz's murrelets that are potentially directly affected by research activities, the lack of evidence to suggest that a measurable impact exists, and the relatively small portion of their range that is affected by researchers, we conclude that overutilization for commercial, recreational, scientific, or educational purposes is not a threat to the population of Kittlitz's murrelet, nor is it likely to become a threat in the future.

Factor C. Disease or Predation

Disease

The recent emergence of bacterial, fungal, parasitic, and viral diseases, and biotoxins has affected populations of wild birds (summarized by Friend *et al.* 2001, pp. 294–295), including many seabirds (McShane *et al.* 2004, p. 3–66). Yet, available information on disease or parasites in the Kittlitz's murrelet is limited both spatially and temporally. Until recently, the only known parasite was a cestode (*Alcataenia* spp.) in two Kittlitz's murrelets from Kodiak Island (Hoberg 1984, p. 2297). Within the last few years, four adult and nine nestling Kittlitz's murrelets were necropsied. All nine nestlings were found dead at nest sites that were being actively monitored on Kodiak Island in 2011 and 2012, and all were in fair to good body condition and nutritional status (Lawonn 2012, p. 31; Shearn-Bochsler *et al.* 2013, p. 1). Two adults were found dead from suspected raptor predation attempts in Glacier Bay (Kissling, unpublished data), one adult died during a capture-related incident in Icy Bay (Kissling, unpublished data), and one adult was found alive near Chignik with an apparent wing injury, but eventually died at a rehabilitation facility in Anchorage (Lance, unpublished data).

Because of the varying condition and preservation method of the carcasses, not all of the 13 birds were tested equally for disease or parasites, but of those tested, no viruses, infectious diseases, or pathogenic bacteria were detected. These include negative tests for West Nile virus, avian influenza viruses, and avian paramyxoviruses, including Newcastle disease (Shearn-Bochsler *et al.* 2013, p. 1; Kissling, unpublished data; National Wildlife Health Center 2012a, b, c). All 13 birds were examined for parasites, and 8 of them had evidence of parasite infections; 6 of the juveniles contained an unknown species of nematode, and 2 of the adults contained both nematodes (*Stegophorus* spp. and *Contracaecum* spp.) and cestodes (presumably *Alcataenia* spp.) (Shearn-Bochsler *et al.* 2013, p. 1; Kissling, unpublished data). These parasites are widespread and relatively common in fish-eating birds (Muzaffar and Jones 2004, pp. 130, 132–133). None of the individual parasite loads were substantial enough to have caused death, although parasites may potentially affect seabird population dynamics by selectively reducing fitness and reproductive success of individuals (Bried and Jouventin 2002, p. 284; Schreiber 2002, p. 193; Muzaffar and Jones 2004, p. 139).

A subset of the carcasses was tested for presence of biotoxins, toxic substances produced by living organisms that are a consequence of algal blooms. Specifically, eight of the nestlings collected at Kodiak Island in 2011 and 2012 were tested for saxitoxin, a neurotoxin that is naturally produced by some species of dinoflagellates (*Alexandrium* spp.) and is the cause of paralytic shellfish poisoning (PSP), and domoic acid, a neurotoxin secreted by microscopic diatoms (*Pseudonitzschia* spp.) and is responsible for amnesic shellfish poisoning (ASP) (Horner *et al.* 1997, p. 1076; Shumway *et al.* 2003, p. 2). Clinically, PSP can result in respiratory distress, muscular paralysis, and death, while ASP can lead to amnesia, coma, and death (Sumway *et al.* 2003, p. 2). Both of these biotoxins are known to kill or reduce survival of marine organisms (Nisbet 1983, p. 338; Beltran *et al.* 1997, p. 447; Lefebvre *et al.* 2000, p. 485; Shumway *et al.* 2003, pp. 5–6; Muzaffar and Jones 2004, p. 126), including the marbled murrelet (MacBean 1989, p. 134; Peery *et al.* 2006, pp. 83–84). The majority of the Kittlitz's murrelet nestlings (88 percent) tested positive for saxitoxin, but not for domoic acid (Shearn-Bochsler *et al.* 2013, p. 1). High concentrations of saxitoxin were detected in the upper gastrointestinal contents and livers of the nestlings and were likely the cause of their deaths (Shearn-Bochsler *et al.* 2013, p. 1). Based on still images taken by remote cameras at their nest sites, the nestlings were fed sand lance shortly before their deaths, and chick death occurred within 3 hours of the meal delivery (Shearn-Bochsler *et al.* 2013, p. 1). All *Brachyramphus* murrelets reported to have died from PSP were juveniles (MacBean 1989, p. 134; Shearn-Bochsler *et al.* 2013, p. 1), suggesting perhaps lower toxicity thresholds for young murrelets, although only one adult was tested (negative) to determine saxitoxin concentrations for comparison to juveniles.

Harmful algal blooms can be natural phenomena, but globally they appear to be increasing in frequency and severity in coastal areas, or at least reports of events have increased (Anderson *et al.* 2002, p. 704; Sellner *et al.* 2003, p. 383). Blooms occur when environmental conditions change to be more favorable to phytoplankton growth and are generally attributed to two factors: (1) Natural processes, such as circulation, upwelling relaxation, and river flow; or (2) anthropogenic nutrient loading (Horner *et al.* 1997, p. 1084; Sellner *et al.* 2003, p. 383). Human activities that can enhance nutrient input and stimulate harmful algal blooms in coastal waters can include aquaculture farming, agricultural and other fertilizer runoff, fossil fuel combustion, sewage and animal waste, and ballast water discharge (Anderson *et al.* 2002, pp. 706–707; Sellner *et al.* 2003, pp. 384–385; Smayda 2007, p. 602). Increased water temperatures as a result of climate change have also been identified as a possible contributor to increased frequency and intensity of toxic blooms (Horner *et al.* 1997, p. 1084; Moore *et al.* 2008, p. 3; Lewitus *et al.* 2012, p. 142).

Saxitoxin and domoic acid toxicity have been present on the western coast of North America for hundreds of years, perhaps longer (Horner *et al.* 1997, p. 1083; RaLonde and Wright 2011, pp. 5–7; Lewitus *et al.* 2012, p. 134). In Alaska, 183 incidences from 68 outbreaks of PSP on Kodiak Island, the Aleutian Peninsula, Prince William Sound, and southeastern Alaska were reported between 1973 and 2010 (RaLonde and Wright 2011, p. 5; Shearn-Bochsler *et al.* 2013, p. 1). There is less known about ASP in Alaska, but from the early 1990s to 2010, a number of incidences of domoic acid toxicity have been documented in shellfish, forage fish,

and marine mammals along the southern coast (RaLonde and Wright 2011, pp. 6–7). There is no evidence to suggest an increase in PSP or domoic acid concentrations in Alaska over the last few decades (Lewitus *et al.* 2012, pp. 141, 145–146), nor is there evidence to support anthropogenic factors as promoters of *Alexandrium* or *Pseudonitzschia* blooms or toxic events in Alaska (Lewitus *et al.* 2012, pp. 142, 148).

It is difficult to evaluate harmful algal blooms as a potential population- or species-level threat to the Kittlitz's murrelet because occurrences are unpredictable, are episodic, and appear to be localized. Furthermore, PSP-related deaths have only been documented in juveniles and the actual incidence and impacts, especially to adults at sea, may not be adequately reported. However, the results from Kodiak Island confirm that individual Kittlitz's murrelets are at risk for saxitoxin poisoning during harmful algal blooms. Because this is the only area for which Kittlitz's murrelets are known to die from PSP, it is worth noting that the greatest number of shellfish species affected and the highest concentrations of PSP across Alaska were reported from Kodiak Island (Lewitus *et al.* 2012, p. 135). For all of these reasons, based on the best available information, we conclude that harmful algal blooms are not a current threat to this species at the population or species level, nor will these blooms pose a threat in the future. There are insufficient data to assess fully the potential effects of diseases or parasites to the Kittlitz's murrelet, but based on available information, we conclude that these factors are currently not a threat to the species now or in the future.

Predation

Predation can act as a strong selective force in the evolution of prey behavior (Lima and Dill 1990, p. 619) and was likely a major factor contributing to the development of Kittlitz's murrelet behavior. Secretive nesting habits, cryptic plumage, erratic and evasive flight, and fast and deep dives help this species to avoid aerial and mammalian predators at their nests or on the water. Because this species apparently has evolved a variety of behavioral strategies to evade their predators, few apparent situations may arise that could alter predation rates and result in a population- or species-level impact to the Kittliz's murrelet. However, this is a complex issue that involves both direct and indirect relationships (Hipfner *et al.* 2011, p. 41) and therefore it can be difficult to quantify impacts beyond the individual level. For example, increases in predator abundance could result in increased predation rates on Kittlitz's murrelets, but only if those predators were specializing on or targeting Kittlitz's murrelet as prey and not taking advantage of other suitable prey species. Such increases in predator abundance may be possible if predators were able to colonize previously unoccupied space, although at some threshold, density-dependent factors would likely prevail and predator numbers would stabilize. Predator-prey relationships are multi-faceted; increases in predators do not necessarily translate to decreases in prey.

We assessed two types of predation that affect individual adult and juvenile Kittlitz's murrelets, but are often executed by a different suite of predators. We considered nest predation as an event that results in an egg or nestling being killed by a predator at the nest, and active predation to be an event that results in an adult or juvenile being killed away from the nest, but perhaps in transit to or from the nest. Likely nest predators include birds and mammals that occur or forage near the remote nest sites of the Kittlitz's murrelet (Day *et al.* 1999, p.12); confirmed nest predators of Kittlitz's murrelet eggs and nestlings are red fox (Lawonn 2012, p. 31), snowy owl (*Bubo scandiacus*) (Kaler, unpublished data), and common raven (*Corvus corax*) (Kenney 2012, in litt.). Likely active predators include raptors that have the ability to capture Kittlitz's murrelets in flight or on the water (Day *et al.* 1999, p.12); confirmed active predators are bald eagle and peregrine falcon (*Falco peregrinus*) (Arimitsu *et al.* 2010, p. 15; Allyn 2012, p. 101; Kissling, unpublished data).

Of the areas where Kittlitz's murrelet nests have been monitored regularly, nest predation appears to be a significant cause of nest failure at Kodiak Island and, to a lesser extent, the Aleutian Islands, but not in Icy Bay (see *Reproductive Performance,* above, for a full description). On Kodiak Island between 2008 and 2012, 53 percent of nest failures (29 of 55 failed nests) were attributed to depredation of egg or nestling, and red fox was identified as the nest predator at 87 percent (13 of 15 nests) of the nests monitored with cameras (Corcoran and Mackey 2012, p. 3; Lawonn 2012, pp. 30–31, 59). On Agattu Island between 2006 and 2011, only 25 percent of the nest failures (18 of 72 failed nests) was caused by depredation with the only identified predator at one nest being a snowy owl (Kaler, unpublished data), but common raven and glaucous-winged gull were implicated as the most likely nest predators because no terrestrial mammals occur on the island and these two species were commonly observed near Kittlitz's murrelet nests (Kaler and Kenney 2008, p. 15; Kaler *et al.* 2009, p. 365). In 2012, on Adak Island, depredation was confirmed at only one nest (four nests failed due to unknown causes) when a common raven removed the egg from the nest (Kenney 2012, in litt.). In Icy Bay, most of the discovered nests were not accessible to humans due to dangerous, heavily glaciated terrain and therefore were monitored remotely. Only five nests were monitored directly in this area, and no predation events were observed, but it is very unlikely that nest predation commonly occurs in Icy Bay because the majority of suitable nesting habitat is remote and isolated from most potential nest predators, perhaps contributing to nest site selection by Kittlitz's murrelets (Kissling, unpublished data). As described under *Factor B* above, possible researcher impacts did not influence predation rates observed at monitored nests. Thus, it appears that in some parts of this species' range, nest predation is a substantial factor contributing to the poor reproductive performance of the Kittlitz's murrelet, but it is difficult to put this result into broader spatial and temporal context because the available data are too limited.

Active predation on Kittlitz's murrelets is more challenging to document and quantify compared to nest predation because it is rarely observed, and, therefore, most information comes from studying the diet of probable or confirmed active predators. The diet of coastal breeding peregrine falcons is overwhelmingly dominated by alcids (e.g., auklets and murrelets), which comprise 75 percent of their diet (Beebe 1960, p. 168; White *et al.* 1973, p. 307; Nelson and Myers 1976, p. 290), and procellarids (e.g., storm-petrels and shearwaters) similar in size to the Kittlitz's murrelet (White *et al.* 2002, p. 11). In contrast, the bald eagle is a generalist predator that consumes a high proportion of fish, but supplements its diet with other types of prey (e.g., birds), especially during times of the year when fish are not locally available (Buehler 2000, pp. 9–10); in some areas, however, birds can comprise a large proportion of eagle diet (Anthony *et al.* 2008, p. 2730; summarized in Hipfner *et al.* 2011, p. 42). In Russia, probable active predators include peregrine falcon, white-tailed eagle (*H. albicilla*) and Steller's sea eagle (*H. pelagicus*) (E. Potapov, Bryn Athyn College, 2012, personal

communication), but likely only peregrine falcons prey on Kittlitz's murrelet with any frequency.

In the rapidly changing, glaciated landscape of Icy Bay, Lewis (Service, 2007–2012, unpublished data) studied the diet and movements of nesting peregrine falcons and bald eagles with the goal of quantifying the scope and magnitude of active predation on the Kittlitz's murrelet. Movements of both predators overlapped considerably with areas frequently used by Kittlitz's murrelets. Individual peregrine falcons had large foraging ranges, including somewhat regular trips into upland areas of high suitability nesting habitat of the Kittlitz's murrelet; in fact, two radio-marked Kittlitz's murrelets were found dead at great distance from the water and were likely killed while in transit to and from their nest (Kissling, unpublished data). On the other hand, bald eagle movements were relatively constricted to the coast near their nesting areas; longer movements appeared to be driven by access to salmon spawning streams. Based on 544 prey remains (i.e., parts of prey removed before or left after consumption, such as feathers, bones, hair) collected at 5 peregrine falcon nests over 6 years, Kittlitz's murrelet was the most commonly delivered prey species based on both frequency of occurrence (23 percent of prey remains) and biomass (26 percent). The biomass of Kittlitz's murrelet in peregrine falcon diet varied considerably among years (6–80 percent), which is likely partially related to sampling effort across years, but undoubtedly is also associated with annual changes in the availability of Kittlitz's murrelet, as well as differences in individual falcon hunting preferences. Conversely, bald eagles delivered very few Kittlitz's murrelets to their nests (n=6 nests between 2007 and 2012); only 3 percent of prey remains (n=56) and 1 percent of prey deliveries recorded using still cameras mounted above active nests were documented. These results are not surprising because the main seabird prey of bald eagles in Icy Bay and elsewhere includes species larger than the Kittlitz's murrelet (Hipfner *et al.* 2011, p. 42; Lewis, unpublished data). Nonetheless, within Icy Bay, it appears that peregrine falcons are the primary active predator of Kittlitz's murrelets, and, at least in some years, falcons prey on this species at rates that could have an impact to the local population, especially because the predation results in adult mortality.

The prevalence of Kittlitz's murrelet in the diet of peregrine falcons in Icy Bay may be due in part to the lack of alternative, appropriately-sized prey available to foraging falcons. In other coastal areas of Alaska, the marbled murrelet far outnumbers the Kittlitz's murrelet, and peregrine falcons likely prey on both species in proportion to their availability. Additionally, in areas where large seabird colonies exist (e.g., Kenai Fjords), peregrine falcons can select from seabirds similar in size to the Kittlitz's murrelet, such as ancient murrelet (*Synthliboramphus antiquus*), Cassin's auklet (*Ptychoramphus aleuticus*), and fork-tailed storm-petrel (*Oceanodroma furcata*). For example, in Kenai Fjords, peregrine falcon diet consisted of only 8 percent *Brachyramphus* murrelets (Phillips, National Park Service, 2012, unpublished data). In these areas, the impact to the local population of Kittlitz's murrelet from peregrine falcons would likely be much lower compared to an area like Icy Bay where few alternative prey are available. As glaciers recede, suitable cliff nesting and foraging habitat for peregrine falcons will become exposed, and falcons will likely colonize this newly created habitat, potentially having an impact on Kittlitz's murrelets that occupy the upper reaches of these fjords, but we anticipate any impact to be temporary, as alternative prey to falcons are also expected to colonize these areas (see *Factor A* discussion, above).

The peregrine falcon is a far more efficient active predator compared to the bald eagle, and therefore, in areas where they coexist, bald eagles may alter predation rates of peregrine falcons by stealing captured prey items (i.e., kleptoparasitism) (Buehler 2000, p. 9), potentially increasing the number of Kittlitz's murrelets killed. Dekker and Bogaert (1997, pp. 381–383) observed 73 peregrine falcon foraging flights from Langara Island, British Columbia; only 22 percent of those flights resulted in the falcon returning to the island with prey, and on 13 percent of those flights, a bald eagle was actively pursuing the peregrine falcon. This behavior by bald eagles appeared to result in greater kill rates of peregrine falcons in order to compensate for prey lost to theft (Dekker *et al.* 2012, p. 293). There are observations and anectodal evidence of similar interactions between peregrine falcons and bald eagles in glacial fjords of Alaska, suggesting that kleptoparasitism may be altering peregrine kill rates in these areas as well, potentially having an effect on Kittlitz's murrelets.

We know little about predation risk to Kittlitz's murrelets outside of the breeding season when at least some proportion of the global population occupies open leads and polynyas in the Bering and Chukchi seas (see *Habitat and Life History,* above). Recently, satellite tracking studies of gyrfalcons (*F. rusticolus*) and snowy owls found that these species spend considerable time during the winter months on sea ice, near polynyas, presumably preying on seabirds (Burnham and Newton 2011, p. 478; Therrien *et al.* 2011, p. 364). Because no data exist, we have no way of evaluating this potential threat to the Kittlitz's murrelet, but we assume that Kittlitz's murrelets likely experience risk of predation outside of the breeding season in addition to the actual predation during the breeding season described above.

Because predation is a natural process, it is difficult to evaluate it as a population- or species-level threat to the Kittlitz's murrelet. We considered possible changes in distribution and abundance of nest and active predators and factors potentially contributing to those changes. We focused our evaluation on bald eagles and peregrine falcons because active predation often results in adult mortality of Kittlitz's murrelets, which can have a greater immediate influence on local population stability than failed reproductive attempts (Kissing, unpublished data).

Populations of bald eagle have fluctuated over the last century due to human-caused influences (Buehler 2000, p. 1). In Alaska and British Columbia, bald eagles were targeted through an official bounty program because of their competition with fisheries (Hodges 2011, p. 7). In Alaska alone, 128,273 bounties were paid to hunters between 1917 and 1953 (Robards and King 2004, p. 158), undoubtedly reducing the population of bald eagles, but persecution of this species ended with Statehood in 1959 (Hodges 2011, p. 7). By the 1980s, eagle populations began to recover and have increased or continue to increase since then, probably reaching carrying capacity throughout much of their range that overlaps with the Kittlitz's murrelet (Zwiefelhofer 2007, p. 8; Hodges 2011, p. 10). Current distribution of bald eagles and Kittlitz's murrelets overlaps along most of south-coastal Alaska and the Aleutian Islands (Buehler 2000, p. 1). Bald eagles rarely occur along the coast north of the Alaska Peninsula, but do occur inland along rivers, where Kittlitz's murrelets are absent. There are no data to document bald eagle colonization rates of glacial fjords following glacial recession, but the best available information suggests that bald eagles inhabit these areas as suitable trees for large eagle nests become available and often nest at the leading

edge of tree line within the glacial fjord system (Lewis, unpublished data).

Peregrine falcons nest throughout the range of the Kittlitz's murrelet (White *et al.* 2002, p. 1). Since severe population declines in the mid-1900s across North America (Kiff 1988, p.126; Enderson *et al.* 1995, p.144), including some populations in Alaska (Ambrose *et al.* 1988, p. 81), peregrine falcons have recovered to what is believed to be pre-decline numbers (White *et al.* 2002, p. 2). The cause of the decline was exposure to persistent chemicals that were commonly used in parts of the winter range of the peregrine falcon (White *et al.* 2002, p. 1). Because coastal peregrine falcons in Alaska were considered to be residents, it was generally assumed that the coastal population was not impacted and did not decline; however, recent evidence indicates that at least some coastal peregrine falcons overwinter in Central or South America (Lewis, unpublished data) and therefore may have experienced the same population declines and recovery. Nonetheless, information about peregrine populations within the range of the Kittlitz's murrelet is sparse and inconsistent. Recent surveys have found peregrines nesting in many areas where Kittlitz's murrelets occur and often in close association with seabird colonies (Hughes and Sanger 1999, pp. 1–2; Shook and Ritchie 2011, p. 12). The only information available on changes in peregrine falcon numbers within the range of the Kittltiz's murrelet was collected in the glacial fjords of Icy Bay; in 1992 and 1995, despite considerable effort, no nesting peregrine falcons were located (Kozie 1993, pp. 5–6; Kozie *et al.* 1996, pp. 4–5), but between 2007 and 2012, five peregrine falcon nesting areas were occupied regularly (Lewis, unpublished data). This apparent increase may reflect overall recovery of peregrine falcons, as well as expansion into formerly unsuitable nesting and foraging habitat (e.g., recently deglaciated cliffs above open water). Regardless, we cannot project the possible implications of this anecdotal observation in Icy Bay to the Kittlitz's murrelet at the population or species level.

The distribution and abundance of nest predators may have changed locally as the result of human actions and habitat conditions. We collated data on accidental introductions and game transplants across the range of the Kittlitz's murrelet using a variety of sources (Paul 2009; Threatened Island Biodiversity Database 2013 [online]; Ebbert, Service, pers. comm.). Potential impacts to the Kittlitz's murrelet from nonnative introductions or transplants include direct predation at nests and availability of alternate prey for nest predators. Since the early 1900s, 174 introductions and transplants have occurred within the range of the Kittlitz's murrelet and most of these were fox (n=48; *Vulpes* spp.), rat (n=20; *Rattus* spp.), and rabbit (n=17; *Lepus* spp.) with the latter primarily introduced for fox food. Eradication efforts have been successful, especially on many of the Aleutian Islands, but may have had some impact on nesting Kittlitz's murrelets prior to eradication, expecially fox. We overlaid remaining nonnative species distributions with the Kittlitz's murrelet nest habitat suitability map (described in *Nesting,* above) and identified nine islands (Afognak, Kodiak, Attu, Amchitka, Adak, Great Sitkin, Atka, Unalaska, and Akutan islands) where introduced or transplanted species may be having an indirect impact to Kittlitz's murrelet, primarily by enhancing prey abundance for native species that are nest predators. For example, while red fox, a known nest predator to the Kittlitz's murrelet (Lawonn 2012, p. 31), is native to Kodiak Island, several species that it can prey upon or scavenge have been introduced, including Sitka black-tailed deer (*Odocoileus hemionus sitkensis*), red squirrel *(Tamiasciurus hudsonicus*), snowshoe hare (*Lepus americanus*), American marten (*Martes americana*), mountain goat (*Oreamnos americanus*), Roosevelt elk (*Cervus canadensis roosevelti*), reindeer (*Rangifer tarandus*), and beaver (*Castor canadensis*). Although historical and current fox population abundance are not known, it seems likely that introductions increased the carrying capacity of fox on Kodiak Island by providing additional sources of food, and this increased carrying capacity potentially has negative effects on nesting Kittlitz's murrelets. We have no data to support this hypothesis or to assess potential impacts to the local population of Kittlitz's murrelet. Unfortunately, there is no at-sea population trend information for the Kittlitz's murrelet near Kodiak Island (Madison *et al.* 2011, p. 118) or in the vicinity of other islands with relatively large number of introductions or transplants. Similarly, other human activities may have cascading consequences that can impact the Kittlitz's murrelet, such as refuse from seafood processing, which is known to attract several gull species (Yorio and Caille 2004, p. 778; Gibson and Byrd 2007, pp. 136–137; Carniel and Krul 2012, p. 61), and bald eagles (Lewis, unpublished data), but we have no information to suggest that these artificial increases in local populations of nest predators actually translate into increased predation of Kittlitz's murrelet.

Conservation Efforts To Reduce Disease or Predation

We are not aware of any conservation efforts or other voluntary actions that may help to reduce disease or predation of the Kittlitz's murrelet.

Summary of Factor C

In summary, based on the available information, we find that disease is not a threat to the Kittlitz's murrelet now or is likely to be one in the future. Biotoxins, or harmful algal blooms, are likely the cause of small numbers of mortalities of individual Kittlitz's murrelets, but we do not have information to suggest that biotoxins are having a population- or species-level impact on the Kittlitz's murrelet.

Predation is a source of mortality of Kittlitz's murrelet eggs, nestlings, and adults. Although behavioral or morphological strategies against predation have been identified for all life-history stages of this species, it is clear that predation and risk of predation is a regular occurrence. It appears that predation rates may be elevated in certain locations as a result of human actions or consequences of climate change, but negative impacts to the Kittlitz's murrelet seem to be localized. Thus, based on the information available, we find that predation in and of itself is not a threat to this species, nor is it likely to become a threat in the future.

Factor D. The Inadequacy of Existing Regulatory Mechanisms

Several laws have been passed that help maintain the quality of habitat that Kittlitz's murrelets occupy and reduce threats to those habitats. We determined that the existing regulatory mechanisms authorized by these laws are adequate for the Kittlitz's murrelet. These laws are discussed briefly below.

Oil Pollution Act (OPA) of 1990

The Oil Pollution Act of 1990 (OPA) (33 U.S.C. 2701 *et seq.*) provides enhanced capabilities for oil spill response and natural resource damage assessment by the Service. The OPA and implementing regulations require the Service to consult on developing a fish and wildlife response plan for the National Contingency Plan, provide input to Area Contingency Plans, review Facility and Tank Vessel Contingency Plans, and conduct damage assessments for the purpose of obtaining damages for

the restoration of natural resources injured from oil spills. In addition, the OPA includes provisions for the double-hulling of oil tankers; all new tankers are required to be double-hulled, and single-hulled tankers will be phased out completely and replaced with double-hulled tankers by 2015. The double-hulling provision within the OPA should reduce the likelihood of marine hydrocarbon contamination due to accidents within the range of the Kittlitz's murrelet.

Coastal Zone Management Act (CZMA)

The Coastal Zone Management Act of 1972 (CZMA) (16 U.S.C. 1451 *et seq.*) was enacted to preserve, protect, develop, and where possible, restore or enhance the resources of the Nation's coastal zone. The CZMA provides for the submission of a State program subject to Federal approval. The CZMA requires that Federal actions be conducted in a manner consistent with the State's Coastal Zone Management Plan (CZMP) to the maximum extent practicable. In 2011, the Alaska Legislature did not renew the State of Alaska's program, and it was phased out by the Alaska Department of Natural Resources. Thus, Alaska has not had an active Coastal Management Program since 2011.

Marine Protection, Research and Sanctuaries Act (MPRSA)

The Marine Protection, Research and Sanctuaries Act of 1972 (MPRSA) (33 U.S.C. 1401 *et seq.*) was enacted in part to prevent or strictly limit the dumping into ocean waters of any material that would adversely affect human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities.' The MPRSA was designed to protect the quality of marine habitats that the Kittlitz's murrelet and its prey utilize.

Migratory Bird Treaty Act

Although the Migratory Bird Treaty Act (16 U.S.C. 703 *et seq.*) prohibits, unless permitted by regulation, any take of any migratory bird, including Kittlitz's murrelet, such incidental take does occur in commercial fisheries in Alaska (Wynne *et al.* 1991, pp. 25–31; Wynne *et al.* 1992, pp. 18–19; Stehn *et al.* 2001, pp. 68–70; Manly 2007, p. 90; Manly 2009, p. 66). Murrelets do not appear to be taken by longliners, by trawlers, or within pot fisheries (Stehn *et al.* 2001, p. 71; Phillips *et al.* 2010, p. 113). However, where studies have examined seabird bycatch in nearshore gillnet fisheries in the range of Kittlitz's murrelets, *Brachyramphus* murrelets (marbled and Kittlitz's combined) comprise between 11 and 70 percent of seabird mortality from gillnets (Wynne *et al.* 1991, p. 33; Wynne *et al.* 1992, p. 49; Carter *et al.* 1995, pp. 271–275; Manly 2006 p. 31; Manly 2007, pp. 34–35; Manly 2009, pp. 31–32). Gillnet bycatch is an ongoing source of mortality to Kittlitz's murrelets (see *Incidental Take in Fisheries,* below), but Blejwas and Wright (2012, p. 14) concluded that fine scale spatial overlap of Kittlitz's murrelet distribution and commercial gillnet fishing effort was low. Gillnet fisheries in Alaska generally occur in State territorial waters. Melvin *et al.* (1999, pp. 1389–1396) reported on gear types and fishing methods that reduce such bycatch, but regulations requiring the use of bycatch reduction techniques are not currently in place.

State Regulations

In 2013, the Alaska State Legislature passed a bill to allow cruise ships to meet water quality standards at the ends of a mixing zone, as opposed to the point of discharge, relaxing water quality standards within the marine environment. However, it is unlikely that this will have a negative impact on the Kittlitz's murrelet because, considering the broad range of the species, the spatial and temporal overlap between the Kittlitz's murrelet and cruise ships is low, except in Glacier Bay National Park where the marine waters are federally managed and discharge is not allowed.

The Kittlitz's murrelet receives no special protection by the State of Alaska. On March 5, 2009, the Center for Biological Diversity (CBD) petitioned the State of Alaska to list the Kittlitz's murrelet as endangered under the Alaska Endangered Species Act (A.S. 16.20.180 *et seq.*). The petition specified that because of the species' small population size, precipitous population declines, and multiple, ongoing threats to its continued existence, the Kittlitz's murrelet should receive State-level regulatory protection. On April 9, 2009, the State rejected CBD's petition to list the Kittlitz's murrelet as endangered under the Alaska Endangered Species Act, claiming insufficient evidence to indicate that their numbers have decreased to the extent to cause endangerment.

Summary of Factor D

The laws described above reduce the likelihood of oil spills, help protect water quality in marine habitats, and prohibit take of Kittlitz's murrelet unless permitted by regulation. Through such actions, these laws provide some protection to the Kittlitz's murrelet and its habitats. As discussed in *Factors A, B, C,* and *E,* although we recognize that some of the potential stressors addressed may result in mortality of individual Kittlitz's murrelets, we have not identified any threat that would affect the species at the population or range-wide level. Therefore, we find that the existing regulatory mechanisms authorized by the laws described above are adequate for the Kittlitz's murrelet now and into the future.

Factor E. Other Natural or Manmade Factors Affecting Its Continued Existence

Recreational Effects

The Kittlitz's murrelet is rarely pursued by commercial tour boat operators or recreational vessels, but the scenic tidewater glacier habitat in which this species occurs in parts of its range is often the ultimate destination for these users. Marine and coastal tourism has increased substantially over the last few decades in many areas that have relatively dense populations of the Kittlitz's murrelet during the breeding season (see *Habitat and Life History,* above), including Glacier Bay, Yakutat Bay, Prince William Sound, and Kenai Fjords (Day *et al.* 1999, pp. 20–21; Jansen *et al.* 2006, p. 1186; Payne *et al.* 2010, p. 7; Hoover-Miller *et al.* 2013, p. 3). Motorized and non-motorized vessels can impact marine wildlife directly (e.g., injury or mortality due to collision) (Jensen and Silber 2003, p. 2; Neilsen *et al.* 2012, p. 1) or indirectly (e.g., disturbance) (Jansen *et al.* 2010, p. 1186; Schwemmer *et al.* 2011, pp. 1855–1857; Hoover-Miller 2012, pp. 8–9). It is extremely unlikely that Kittlitz's murrelets are directly impacted by vessel activity owing to their ability to flush from the water if within a vessel pathway and their skillful maneuverability during flight. In the fjords of northwestern Prince William Sound, jet-propulsion tour catamarans can travel at speeds up to 42 mi per hour (68 km per hour), ingesting water and debris down to 20 ft (6 m) below the water surface, and murrelets diving in the path of these boats may not be able to escape injury (Kuletz, pers. obs.), although it has never been documented. Indirect impacts to individuals may include increased energetic costs (Speckman *et al.* 2004, p. 33; Agness *et al.* 2013, p. 13), increased predation risk (Whittington 2008, in litt.), temporary changes to foraging habitat characteristics (Kuletz *et al.* 2003a, pp. 23, 29; Stephensen 2009, p. 22), displacement of murrelets (Kuletz 1996, pp. 777–778; Stephensen 2009, pp. 22–23; Agness *et al.* 2008, p. 352), and

reduced ability to feed (Day *et al.* 2003, p. 697).

Several studies in Alaska have attempted to understand the scope and magnitude of possible effects to Kittlitz's murrelets from vessel activity and to develop guidelines to minimize any impacts. In all areas studied, Kittlitz's murrelets and vessel traffic overlap spatially (typically within the glacial fjords) and temporally (May–July). In Prince William Sound, the number of murrelets observed on the water was negatively correlated with the number of boats in the area (Kuletz 1996, pp. 777–778; Kuletz *et al.* 2003a, pp. 23, 25) and densities of murrelets decreased between the initial and return boat transits in one of the glacial fjords of the area (Stephensen 2009, pp. 22–23). During a pilot study using focal-animal observations in two fjords of Prince William Sound, birds conducted fewer forage dives and flew away more often in the presence of boats, and flushing distance was estimated at 82–1,640 ft (25–500 m) (Kuletz *et al.* 2003a, pp. 23, 29). Because Kittlitz's murrelets tended to occupy the mid-water channels where boat traffic was greatest, there was potential for vessel disturbance during the summer months (Kuletz *et al.* 2003a, pp. 29–30). There may be a vessel density threshold beyond which murrelets may not occupy an area, as reported by Day *et al.* (2003, p. 697), but this theory has not been tested. Schoen *et al.* (2013, pp. 56–57) took a different approach and quantified spatial overlap of Kittlitz's murrelets and vessels in Yakutat Bay. The average probability of an individual Kittlitz's murrelet encountering a vessel at least once per day was extremely low (0.0097; SE=0.0031), and the proportion of the local population disturbed daily was 0.98 percent (roughly 23 individuals); for comparison, the same values for marbled murrelet were 0.0083 (SE=0.0013) and 0.83 percent (roughly 76 individuals) (Schoen *et al.* 2013, p. 59). Although all of these studies document encounters and temporary displacement of individual Kittlitz's murrelets in response to vessel activity, none provides evidence of a measurable demographic response at the individual, population, or species level. Marbled murrelets showed a tendency to swallow fish held at the surface (presumably for their chicks) when disrupted by boat traffic (Speckman *et al.* 2004, p. 33), which may have unmeasurable implications for birds raising chicks, but there is no evidence to support this supposition.

The most comprehensive and targeted studies to evaluate effects of vessel activity on Kittlitz's murrelets were conducted in Glacier Bay. Agness *et al.* (2008, p. 352) reported that nearshore densities of murrelets decreased temporally following vessel passage, but recovered within the day, concluding that vessel activity does not constitute a loss of suitable habitat for the Kittlitz's murrelet. Environmental and biological factors had more influence on density, group size, and behavior of Kittlitz's murrelets than vessel activity (Agness *et al.* 2008, p. 351). However, vessel passage, especially large, fast-moving vessels, did cause a 30-fold increase in flight behavior of Kittlitz's murrelets observed nearshore (Agness *et al.* 2008, p. 346), which resulted in a 10–50 percent increase in daily energy expenditure of individual murrelets (Agness *et al.* 2013, p. 13). Bioenergetic modeling suggested that, in the absence of vessel disturbance, Kittlitz's murrelets need to consume about 76 percent of their body mass daily, but with vessel disturbance, this increased to 83–107 percent depending on breeding status and rate of vessel passage; presumed non-breeding Kittlitz's murrelets were more likely to experience chronic increases in energy expense compared to breeding birds because they have more flexible activity budgets (Agness *et al.* 2013, p. 18). The authors concluded that Kittlitz's murrelets may have a relatively small capacity to buffer extra energy demands because they may already be functioning at their physiological limits (Agness *et al.* 2013, p. 18). A follow-up study to refine time activity budgets of Kittlitz's murrelets, especially those found offshore and in the direct path of large vessels, is currently being conducted (Marcella *et al.* 2012, p. 1). Preliminary results indicate that roughly half of all murrelets observed within 0.5 mi (0.8 km) of a vessel path were disturbed, and the proportion of birds to take flight in response to the vessel was greater than 50 percent within 656 ft (200 m) of the vessel, but declined thereafter (Marcella *et al.* 2012, pp. 7, 15). In both years of the study, mean flushing distance of Kittlitz's murrelet (2011=830 ft [253 m], 2012=1,027 ft [313 m]) was smaller than that of marbled murrelet (2011=1,158 ft [353 m], 2012=1,266 ft [386 m]), but this result could be related to species-specific identification rates (Marcella *et al.* 2012, p. 11). Neither of these studies evaluated potential energetic effects to individual Kittlitz's murrelets that are displaced by vessels multiple times per day or continually throughout the season.

Among all core areas that support Kittlitz's murrelets in the breeding season, Icy Bay is the only glacial fjord system that remains relatively free of commercial and recreational boat traffic. Perhaps coincidentally, this is the only area where Kittlitz's murrelet outnumbers marbled murrelet by a factor of at least two across all years (Kissling *et al.* 2011, p. 7; Kissling, unpublished data). This unique composition of *Brachyramphus* murrelets is very likely due to site-specific environmental conditions, not the absence of anthropogenic effects, but we cannot disregard it, especially because in nearby Yakutat Bay with moderate levels of boat traffic (Schoen *et al.* 2013, p. 59), marbled murrelet abundance is more than double Kittlitz's murrelet abundance (Kissling *et al.* 2011, p. 7).

Incidental Take in Fisheries

Globally, seabird bycatch is one of the most pervasive and immediate threats to many pelagic species, affecting 41 percent of all seabirds species listed as threatened by the International Union for the Conservation of Nature (Croxall *et al.* 2012, p. 10). Commercial, recreational, and subsistence fisheries occur in coastal Alaska and Russia within the range of the Kittlitz's murrelet. Owing to their nearshore feeding and pursuit-diving behavior to forage, murrelets are particularly susceptible to mortality in gillnet fisheries. Incidental take of Kittlitz's murrelets has been documented in the salmon gillnet fisheries in Alaska (Wynne *et al.* 1991, p. 33; Wynne *et al.* 1992, p. 49; Manly 2007, p. 33; Manly 2009, p. 4), subsistence gillnet fisheries in Russia (Artukhin 2011, p. 7; Artukhin *et al.* 2011, p. 28), and in offshore Japanese salmon drift nets (Artukhin *et al.* 2011, p. 31). No studies have aimed specifically to quantify gillnet mortality rates of Kittlitz's murrelet, so data are limited to existing observer programs, most of which are implemented to record interactions and take of marine mammals in gillnet fisheries, and consist of questionnaires distributed to fishermen and local villagers.

In Alaska, data have been collected on incidental take of marine mammals and birds in gillnet fisheries in 4 areas for 2 years each: Prince William Sound and Copper River Delta (1990, 1991), Cook Inlet (1999, 2000), Kodiak Island (2002, 2005), and Yakutat Bay (2007, 2008). Not accounting for observer effort and number of boats monitored, nine adult Kittlitz's murrelets and three unidentified murrelets were killed in Prince William Sound and Copper River Delta (Wynne *et al.* 1991, p. 33; Wynne *et al.* 1992, p. 49), zero Kittlitz's or unidentified murrelets in Cook Inlet

Inlet (Manly 2006, p. 73), one juvenile Kittlitz's murrelet near Kodiak Island (Manly 2007, pp. 27, 33), and one adult Kittlitz's murrelet and one unidentified murrelet near Yakutat (Manly 2009, pp. 29–30). Although these numbers appear to be small, only about 5 percent of the total fishing effort is typically sampled (Manly 2009, p. 3), which is likely insufficient to estimate bycatch rates of rare species. Recognizing the limitations of these data due to low sampling effort, estimated per annum incidental catch of Kittlitz's murrelets was 133 birds in Prince William Sound (Wynne *et al.* 1992, p. 48), zero in Cook Inlet (Manly 2006, p. 73), 18.1 birds (SE=16.8) near Kodiak Island (Manly 2007, p. 36), and 13.7 birds (SE=12.9) in Yakutat Bay (Manly 2009, p. 34). The high variances around the estimates for Kodiak Island and Yakutat Bay reflect both low sampling effort and the relatively low densities of Kittlitz's murrelets at sea.

In some areas, *Brachyramphus* murrelets appear to be disproportionately caught in nets of these fisheries compared to other marine birds (Wynne *et al.* 1991, p. 33; Wynne *et al.* 1992, p. 49; Manly 2009, pp. 31–32), as suggested by Day *et al.* (1999, p. 17). Combining the limited bycatch data described above with information on murrelet and fishing vessel distribution, Blejwas and Wright (2012, p. 2) completed a qualitative risk assessment by determining spatial and temporal overlap of Kittlitz's murrelets and gillnet fishing effort. Temporal overlap between Kittlitz's murrelets and gillnet fisheries was high, but the degree of spatial overlap varied by scale (Blejwas and Wright 2012, p. 14). At a coarse scale, generally within a bay, inlet, or defined set of coastline, there was moderate overlap, but at a finer scale, Kittlitz's murrelets were spatially separated from gillnet fisheries with a few exceptions (e.g., Alitak Bay near Kodiak Island, Manby Point near Yakutat) (Blejwas and Wright 2012, pp. 14–15). While this approach provided the first assessment of the potential magnitude of gillnet fishery impacts to Kittlitz's murrelets, it clearly has some limitations such as the inability to account for intra- and inter-annual variation in murrelet and vessel distribution (Blejwas and Wright 2012, p. 16), and the scope of inference is restricted to daytime hours only when surveys for murrelets were completed (Blejwas and Wright 2012, pp. 17–18). Despite these limitations and the reported low overlap of Kittlitz's murrelets and gillnet fishing effort, bycatch mortalities did occur, and, therefore, gillnets are a source of direct mortality to some individual Kittlitz's murrelets. Carter (2012, p. 3) clarified previous reports of *Brachyramphus* murrelet mortalities in gillnet fisheries in Alaska and concluded that Kittlitz's murrelets were spatially separated from concentrations of fishing boats and appeared to have greater net avoidance compared to marbled murrelets.

There are comparatively fewer data on incidental take of Kittlitz's murrelet in Russian fisheries, but mortalities have been documented (Artukhin 2011, p. 7; Artukhin *et al.* 2011, p. 28). In the Kamchatka region, marine trap nets are the primary method used in the commercial coastal salmon fishery, constituting 95 percent of the total harvest (Artukhin 2011, p. 7). Owing to the design and operation of these nets, risk of entanglement of birds is low, and, in fact, no bycatch mortality of Kittlitz's murrelets was documented during the observer program and is not considered to be a concern in this area (Artukhin 2011, p. 7). However, along the Chukotka Peninsula, different fishing gear and methods are used in the subsistence fishery near coastal villages, resulting in three Kittlitz's murrelets being caught in fishnets used by native people in 1971 (Artukhin *et al.* 2011, p. 28). It is unknown if this is a continuing occurrence in this region, but it seems likely.

In some areas, gillnet fishing can occur at all times of day and may interact with individual Kittlitz's murrelets during the night (Allyn 2012, p. 104). However, within glacial fjords and bays, Kittlitz's murrelets rapidly exit daytime locations at dusk and shift to deeper waters farther from shore where they remain throughout the night (Kissling, unpublished data). Furthermore, Kittlitz's murrelets typically forage during the day (Day *et al.* 1999, p. 9; Madison *et al.* 2010, p. 1), especially in the morning (Day and Nigro 2000, p. 5), which reduces potential for interactions between Kittlitz's murrelets and gillnets at night. Nonetheless, Carter (2012, p. 2) reported an observation from a fisherman suggesting that most *Brachyramphus* mortalities (80 percent) in gillnets occurred at night, but there is no evidence to substantiate this statement.

We know little about potential overlap of the Kittlitz's murrelet and the North Pacific high-seas driftnet fishery. Artukhin *et al.* (2011, p. 31) reported that bycatch of Kittlitz's murrelet in Japanese salmon drift nets was estimated to be about 1 bird per year (95 percent CI=0–2). Generally, offshore mortality of *Brachyramphus* murrelets is not recognized as a significant problem (Ainley *et al.* 1981, p. 803; DeGange and Day 1991, p. 253; Johnson *et al.* 1993, p. 473; Carter *et al.* 1995, p. 275), but does occasionally occur.

Conservation Efforts To Reduce Other Natural or Manmade Factors Affecting Its Continued Existence

The Service and the National Marine Fisheries Service entered into a memorandum of understanding (MOU) in June 2012 with the overall purpose to conserve migratory birds (per Executive Order 13186, ''Responsibilities of Federal Agencies to Protect Migratory Birds'') (National Marine Fisheries Service 2012, [*http://www.alaskafisheries.noaa.gov/protectedresources/seabirds/mou/eo13186_nmfs_fws_mou2012.pdf,* accessed on July 11, 2013]). Specifically, the MOU promotes a partnership between the two agencies to minimize the unintentional take of seabirds in commercial fisheries nationally and internationally. Although the primary focus is reducing bycatch of seabirds in longline gear, other gear types (e.g., gillnet fisheries) more likely to impact the Kittlitz's murrelet are also included.

We are not aware of any other conservation efforts or other voluntary actions that may help to reduce or ameliorate other natural or manmade factors that may be a threat to the continued existence of the Kittlitz's murrelet.

Summary of Factor E

To summarize, collectively, results of the vessel disturbance studies demonstrate that Kittlitz's murrelets do respond to vessels, including those at great distances from them, and that there may be increased energetic costs to individuals as a consequence, but displacement is temporary and encounter rates are low. It is challenging to assess vessel activity and disturbance as a possible threat to the Kittlitz's murrelet because there is no evidence to suggest that there are fitness impacts, such as reduced nest success or survival, affecting population(s) or even individual Kittlitz's murrelets. In addition, vessel activity is relatively limited in scope geographically and seasonally, and some individual murrelets may habituate to boat traffic (Speckman *et al.* 2004, pp. 32–33). Therefore, we conclude that vessel disturbance may be an additive stressor to some individual Kittlitz's murrelets, but we conclude that it currently does not pose a population- or species-level threat to the Kittlitz's murrelet, nor is it likely to become a threat in the future.

Commercial and subsistence gillnets are a known source of mortality of individual Kittlitz's murrelets. Although

temporal overlap of gillnet fishing and distribution of this species is high, spatial overlap is currently low (Blejwas and Wright 2012, pp. 14–15). At a coarse scale, gillnet fishing effort overlaps significantly with Kittlitz's murrelet distribution (Blejwas and Wright 2012, p. 14), but the opposite is not necessarily true; the Kittlitz's murrelet is distributed across some nearshore marine waters where gillnet fishing does not occur, including Glacier Bay (Piatt *et al.* 2011, pp. 68–69), Alaska Peninsula (Madison *et al.* 2011, p. 115), and Aleutian Islands (Madison *et al.* 2011, pp. 116–117). Furthermore, fine scale overlap of gillnet fishing and Kittlitz's murrelet distribution within a specific area is minimal (Blejwas and Wright 2012, pp. 14–15). As pursuit-divers that capture their prey underwater, Kittlitz's murrelets are susceptible to being caught in gillnets, but some aspects of their behavior and habitat use, such as moving to deeper water at night and perhaps net avoidance, may minimize their overall risk to gillnet mortality. Thus, although bycatch mortality of Kittlitz's murrelets does occur, we conclude that incidental take of indivduals in commercial, recreational, or subsistence fisheries is not a population- or species-level threat to the Kittlitz's murrelet, nor do we anticipate that it will become a threat in the future.

Cumulative Effects From Factors A through E

The Kittlitz's murrelet is faced with numerous potential stressors throughout its range and its annual cycle, but none of these individually constitutes a threat to the species now or in the future. However, more than one stressor may interact synergistically or compound with one another to impact the Kittlitz's murrelet negatively at the population or species level. Not all of the identified possible threats described above are present or are equally present across this species' range or its annual cycle (e.g., incidental take in fisheries, vessel disturbance), and, in some cases, we were not able to determine the response of this species to the stressor because we lack a mechanistic link (e.g., loss of glaciers). For some of the identified stressors, we were unable to conclude that there would be a negative response of Kittlitz's murrelet at the population or species level to those stressors or changes in the frequency and intensity of them. Yet, if multiple factors are working together to impact the Kittlitz's murrelet negatively, the cumulative effects should be manifested in a measurable and consistent demographic change at the population or species level, but we did not determine this to be the case.

Based on our analyses of population status and trend (see *Population Status and Trends,* above, for detailed summary), we concluded that Kittlitz's murrelet populations declined at about 30 percent per annum prior to 2000 and since then, the populations appear to have stabilized or may be declining and are projected to continue to decline at a gradual, slow rate. In specific areas, such as Prince William Sound and Glacier Bay, declines in the Kittlitz's murrelet have been documented (Kuletz *et al.* 2011a, p. 104; Kuletz *et al.* 2011b, p. 91; Piatt *et al.* 2011, p. 70) and disputed (Hodges and Kirchhoff 2012, p. 117; Kirchhoff *et al.* 2013, p. 10) or the reliability of data has been questioned (Day 2011, p. 51). We acknowledge that these local population declines likely occurred, but when evaluated as a whole, there is no credible evidence of a rangewide population decline in Kittlitz's murrelet since 2000, despite multiple stressors facing this species in all or parts of its range and annual cycle. Thus, the best available information suggests that cumulative effects from possible stressors described under *Factors A* through *E* above are not so great so as to pose a threat to the persistence of this species now or in the future.

Finding

As required by the Act, we considered the five factors in assessing whether the Kittlitz's murrelet is an endangered or threatened species throughout all of its range. We examined the best scientific and commercial information available regarding the past, present, and future threats faced by the Kittlitz's murrelet. We reviewed the petition, information available in our files, other available published and unpublished information, and we consulted with recognized Kittlitz's murrelet experts and other Federal, State, and tribal agencies. We also requested comments and information from all interested parties in each of our CNORs from 2004 to 2011, and in preparation for this finding. In response to our request, we received formal comments from the Alaska Department of Fish and Game and CBD. We also convened a 1-day workshop to review the methods and interpretation of results of the multiple-populations model described above (see *Population Status and Trends,* above). As part of our review, we brought together researchers with experience and expertise in Kittlitz's murrelet biology from across the Service to review and evaluate the best available scientific and commercial information thoroughly at several meetings in Anchorage, Alaska.

We considered a variety of potential threats facing the Kittlitz's murrelet and its marine and terrestrial habitats, including climate change, exposure to environmental contaminants and marine pollution, disease, changes in predation, disturbance from vessel traffic, and incidental take in fisheries. To determine if these risk factors individually or collectively put the species in danger of extinction throughout its range, or are likely to do so in the foreseeable future, we first considered if the identified risk factors were causing a population decline or other demographic changes, or were likely to do so in the foreseeable future.

Boat-based surveys for Kittlitz's murrelets on the water during the breeding season are the most efficient method for estimating population size and trend of this species. Using the most current survey data available for each study site, we estimated the current global population of Kittlitz's murrelet to be 33,583 birds (95 percent CI=25,620–41,546), which is a minimum estimate because many areas within the range of this species remain unsurveyed. Estimating population trend of Kittlitz's murrelet is difficult because populations are geographically clustered, most individuals do not breed annually and therefore can be highly mobile during the breeding season when surveys are conducted, and the species looks similar to the more common marbled murrelet. These issues, coupled with inconsistencies in survey design and analysis, have complicated the use of historical data in trend estimation of local population size. Furthermore, there are few study sites that have been surveyed regularly enough to estimate local population trends reliably. Without accounting for intra- and inter-annual movements, apparent declines have been documented in local population size of Kittlitz's murrelet in some study sites over the last two decades. When all populations with sufficient years of data are evaluated collectively, Kittlitz's murrelet abundance declined by roughly 30 percent annually between 1989 and 2000, but populations appear to have stabilized since then.

Although surveys indicate that the population of Kittlitz's murrelet stabilized between 2000 and 2012, several lines of evidence across a similar time frame suggest that reproduction of this species is poor. Both the number of birds that attempt to breed annually and the number that breed successfully are low with some variation among study sites and years. Only a few studies on

the Kittlitz's murrelet have estimated demographic parameters (e.g., breeding propensity, nest success, survival) necessary to identify key factors that may be influencing population stability and to predict future population size. We combined all demographic information available since 2000 for the Kittlitz's murrelet and concluded that populations will likely undergo a slow decline in the future of less than 2 percent annually, provided that environmental conditions and stressors remain the same on average. Using the multiple-populations model, we estimated that the probability of extinction in 25 years is less than 1 percent, but we are unable to project population size reliably beyond this timeframe. The model predictions of population size informed our assessment of the current and future status of this species along with the local populations information and our trend analysis. Therefore, based on the best available information, we find that population trend of Kittlitz's murrelet is currently either stable or possibly slightly declining.

We then identified and evaluated existing and potential stressors on the Kittlitz's murrelet. We aimed to determine if these stressors are affecting this species currently or are likely to do so in the foreseeable future, are likely to increase or decrease, and may rise to the level of a threat to the species, rangewide or at the population level. Because this species is broadly distributed across Alaska and Russia, occupying numerous habitats throughout its annual cycle, we evaluated both exposure and response of Kittlitz's murrelets to each identified stressor.

We examined several stressors that were temporally episodic, spatially localized, or both, relative to the seasonal distribution of the Kittlitz's murrelet. For some of these stressors, we have little information to assess their frequency or intensity now or in the foreseeable future or to indicate that the stressor is likely to increase in the foreseeable future. We found that disease, harmful algal blooms, incidental take in fisheries, disturbance from vessel activity, impacts from scientific research, or exposure to environmental contaminants are not threats to the Kittlitz's murrelet (see discussions under *Factors A, B, C,* and *E,* above). Although some of these stressors do result in mortality, risk, or increased energetic costs to small numbers of Kittlitz's murrelets, the best available information indicates that none of these stressors is currently having a population- or species-level effect, or is likely to do so in the foreseeable future.

Climate change is occurring and is predicted to continue, but there is substantial uncertainty in the response of the Kittlitz's murrelet to possible environmental changes as a consequence of climate change. We considered loss of glaciers and winter sea ice, increased contaminated meltwater, and changes in ocean conditions as climate change stressors that may affect the persistence of the Kittlitz's murrelet and its habitats. Of these stressors, we were unable to evaluate the significance of glacial meltwater as a source of contamination and loss of winter sea ice to the Kittlitz's murrelet because few data exist. We are unaware of any contaminant studies from coastal ice fields or alpine glaciers within the range of the Kittlitz's murrelet, and information on winter distribution and habitat use of this species is too limited and preliminary to assess potential impacts of the loss of winter sea ice on the Kittlitz's murrelet. We therefore focused our evaluation of climate change stressors to this species on the loss of glaciers and changes in ocean conditions.

Approximately 66 percent of the minimum global population of Kittlitz's murrelet occupy glacially affected marine waters during the breeding season, but we did not identify a causal link between the tidewater glaciers and persistence of the Kittlitz's murrelet. Several studies report associations between Kittlitz's murrelet marine distribution and tidewater glaciers in areas where glaciers exist, but this species is broadly distributed and occurs in areas that have been deglaciated for thousands of years. These rangewide inconsistencies in marine habitat use make it difficult to predict response of the Kittlitz's murrelet to the loss of glaciers without an identified, underlying mechanism explaining the association. We identified and evaluated many hypothetical consequences to this species and its viability due to loss of glaciers, such as changes in foraging efficiency, changes in marine productivity, and increasing distance between foraging and nesting sites, but none was supported with sufficient evidence, or the scope of inference and the available data were too limited to draw conclusions at the population or species level (see *Factor A* discussion for further details). We did not find information to indicate that Kittlitz's murrelets experience greater foraging success, or subsequent productivity or survival, in glacially affected waters compared to those without glacial influence. Thus, although most glaciers within the range of this species are currently in retreat or thinning, at this time we conclude that this change in its habitat is not likely to negatively impact the Kittlitz's murrelet at the population- or species-level because available data do not suggest that glaciers are an essential habitat feature to their life history. We concluded that this species has the ability to adapt or is resilient to changing environmental conditions, and therefore changes in glaciers should not directly threaten the viability of the Kittlitz's murrelet population.

The Kittlitz's murrelet spends most of its life at sea and therefore is subject to ongoing and forecasted changes in ocean conditions that may affect its prey base, which in turn, would likely affect its survival and reproduction. We considered potential consequences to the Kittlitz's murrelet and its prey as a result of ocean warming and acidification and decadal-scale ocean variability, or climatic regime shifts. We relied on information about the species' diet and foraging preferences, as well as population trend, to assess potential impacts to this species from changes in ocean conditions (see *Factor A* discussion).

We expect changes in ocean conditions within the range of the Kittlitz's murrelet to occur, but we cannot determine the demographic response of this species or its prey to these changes, largely owing to sparse information on diet and demographics of the Kittlitz's murrelet. Ocean warming and acidification is a global problem that will intensify with continued carbon dioxide emissions and may significantly affect marine ecosystems, especially those in high-latitude regions. As ocean temperatures change, we anticipate poleward shifts in distribution of marine species that have limited temperature ranges, changes to the thermohaline circulation, variability in the timing and magnitude of phytoplankton blooms, and changes in the local abundance of forage fish (see *Factor A* discussion for details). In addition, calcifying marine organisms, particularly pteropod snails, a common prey item for various zooplankton and fish, are expected to be most affected by increased ocean acidity and subsequent decreases in carbonate compounds. Although the frequency and intensity is unpredictable, we also assume that oceanic regime shifts will continue to occur in the North Pacific Ocean and Bering and Chukchi seas, as they have over the last century, causing subsequent community or taxonomic reorganizations. Consequently, as a top predator in the marine ecosystem, the

Kittlitz's murrelet may experience alterations to underlying food webs in the future. However, the Kittlitz's murrelet has a diverse diet, appears to have the ability to switch prey when necessary, and can forage successfully in a variety of marine and perhaps freshwater habitats (see *Foraging,* above). These are all characteristics that should facilitate adaptation and resiliency in diet and foraging preferences to changes in ocean conditions as a result of warming, acidification, and regime shifts. Nesting Kittlitz's murrelets will continue to require access to high-quality forage fish for delivery to chicks at nests, but we have little information to suggest that changes in ocean conditions in response to climate change are limiting or will limit nest success at the population or species level in the foreseeable future. Furthermore, we do not have evidence that the Kittlitz's murrelet or its diet have fluctuated concurrently with previous regime shifts or ocean warming and acidification. Thus, the best available information suggests that changes in ocean conditions do not currently put the species at risk of extinction, nor are they likely to do so in the foreseeable future.

The Kittlitz's murrelet is considered to be vulnerable to marine oil pollution because it spends most of its annual cycle at sea, forages by diving and pursuing prey, and is typically found nearshore. We anticipate marine traffic within the range of the Kittlitz's murrelet to increase, but the rate of increase is dependent on economic activity and natural resource development. As marine traffic increases, the risk of petroleum contamination from both accidental spills and routine vessel operation is also expected to increase. We assessed the spatial and temporal overlap of marine oil spills and contaminated sites since 1995, and the seasonal distribution and abundance of the Kittlitz's murrelet in order to determine the magnitude of the risk to this species from marine pollution (see *Factor A* discussion). We found that overlap was generally low, with most spills releasing small amounts of substance in localized areas at times of the year when Kittlitz's murrelet densities were relatively low. Although few in number, larger spills did occur and overlap with the distribution of the Kittlitz's murrelet, primarily during the breeding season in Prince William Sound and near Adak Island. However, the broad distribution and relatively low densities of the Kittlitz's murrelet on the water throughout most of the year reduce the risk of population-level impacts from any single event, with the exception being the 1989 *Exxon Valdez* oil spill. In addition, technological and regulatory improvements, such as the Oil Pollution Act of 1990, are likely to reduce the risk of contamination and to improve response and cleanup in the event of a spill. We conclude that exposure to hydrocarbon contamination is an acute and chronic source of mortality of low numbers of individual Kittlitz's murrelets that does not rise to the level of a threat to the persistence of this species now, nor is it likely to do so in the future.

Many life-history traits of the Kittlitz's murrelet developed to avoid predation at the nest, on the water, or in transit. We assessed predation of nestling and adult Kittlitz's murrelets by native, introduced, and transplanted predators to identify possible factors that may have resulted in changes to predation rates of the Kittlitz's murrelet. We first identified known predators and their distribution and diet across the range of the Kittlitz's murrelet, and then we evaluated local or population trend of those predators and possible factors contributing to the trend. We categorized predation events into two types: nest predation and active predation (see *Factor C* discussion).

In some parts of this species' range, nest predation by fox appears to be a significant cause of nest failure, but we have no information to indicate that fox abundance or predation rates on Kittlitz's murrelet eggs or nestlings has increased or is likely to increase in the future. Fox and their prey were introduced to many islands of coastal Alaska and likely had an effect on local populations of Kittlitz's murrelets, but over the last few decades, eradication efforts have nearly eliminated all introduced fox, thereby removing the impact to Kittlitz's murrelets. In some areas, introduced species may have had and continue to have an indirect impact to the Kittlitz's murrelet by enhancing prey abundance for native species that are nest predators such as fox. Similarly, nest sites that are currently inaccessible by terrestrial predators, may be reachable as glaciers recede and primary succession follows. While we can postulate about possible changes in rates and patterns of nest predation of the Kittlitz's murrelet, we have no credible information to support the proposition that these changes actually occurred, are occurring, or have had a population- or species-level impact to the Kittlitz's murrelet.

Active predation, when adults or juveniles are killed away from the nest site, is more difficult to quantify, but has potential to have a greater population-level impact than nest predation because it can result in adult mortality and likely occurs rangewide and year-round. Peregrine falcons and bald eagles are the only known active predators of the Kittlitz's murrelet, but the latter species likely kills far fewer individual murrelets compared to the peregrine falcon, which along the coast feeds primarily on small alcids. Populations of both of these raptor species have fluctuated over the last century due to human-caused influences (e.g., persecution, exposure to contaminants) and may be benefitting from glacial recession, although credible evidence is lacking. We found information to suggest that in at least one glacial fjord system, peregrine falcons can prey on Kittlitz's murrelets at rates that could have an impact to the local population, but any impact is likely to be localized and temporary until other alternate prey species colonize these newly created habitats. Thus, we found that predation, in and of itself, is not a population- or species-level threat to the Kittlitz's murrelet, nor is it likely to become a threat in the future.

In summary, we found that the Kittlitz's murrelet experiences stressors in its marine and terrestrial habitats throughout its annual cycle and range, but based on our consideration of the best available scientific and commercial data information we determined that the identified stressors, individually or collectively, do not pose a threat to the species at the population- or range-wide level now or in the foreseeable future. Some local populations of the Kittlitz's murrelet likely declined, but there is no identified causal link between demographic change in this species and the stressors evaluated in our assessment. Furthermore, when analyzed collectively, we found that populations of Kittlitz's murrelet are currently stable or possibly slightly declining. We acknowledge that many of the stressors facing this species are occurring, and some will likely increase in the future, but we cannot predict the demographic response of the Kittlitz's murrelet to changes in these stressors. We identified some known sources of mortality to small numbers of Kittlitz's murrelet, but most were temporally episodic, spatially localized, or both. We postulated that some life-history traits and behaviors of the Kittlitz's murrelet, such as their broad distribution and variable diet, will counterbalance or mitigate possible effects of the identified stressors, including those associated with climate

change. Based on our review of the best available scientific and commercial information pertaining to the five factors, we find that the stressors are not of sufficient imminence, intensity, or magnitude to indicate that the Kittlitz's murrelet is in danger of extinction (endangered), or likely to become endangered within the foreseeable future (threatened), throughout all of its range.

Distinct Vertebrate Population Segment

After assessing whether the species is endangered or threatened throughout its range, we next consider whether a distinct vertebrate population segment (DPS) of the Kittlitz's murrelet meets the definition of an endangered or threatened species.

Under the Service's Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act (61 FR 4722, February 7, 1996), three elements are considered in the decision concerning the establishment and classification of a possible DPS. These are applied similarly for addition to or removal from the Federal List of Endangered and Threatened Wildlife. These elements include:

(1) The discreteness of a population in relation to the remainder of the species to which it belongs;

(2) The significance of the population segment to the species to which it belongs; and

(3) The population segment's conservation status in relation to the Act's standards for listing, delisting, or reclassification (i.e., is the population segment endangered or threatened).

Discreteness

Under the DPS policy, a population segment of a vertebrate taxon may be considered discrete if it satisfies either one of the following conditions:

(1) It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.

(2) It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act.

The Kittlitz's murrelet is considered a single panmictic population, but recent studies suggest that there is strong population genetic structure in this species, resulting in at least two genetic groups. A comprehensive and targeted genetic study that adequately samples individual Kittlitz's murrelets from across their range, including Russia, at a specified time of year has not been completed. However, based on the most recent genetic analysis, there is an eastern group of the Kittlitz's murrelet, ranging from Glacier Bay to Kodiak Island in the Gulf of Alaska during the breeding season, and a western group that occupies Adak, Agattu, and Attu islands in the central and western Aleutian Archipelago during the breeding season (see *Taxonomy and Species Description,* above, for more details). There are low levels of contemporary movement among the two groups, suggesting that connectivity still exists with at least some individual Kittlitz's murrelets interbreeding and producing viable offspring. The area between Atka and Unalaska islands in the eastern Aleutians and in northern Alaska appear to be contact zones where Kittlitz's murrelets have mixed ancestry of both groups. We accept the genetic basis of the eastern and western groups of the Kittlitz's murrelet and therefore evaluated whether either group meets the definition of discreteness as described in the 1996 DPS policy.

We assessed physical, physiological, ecological, and behavioral factors of Kittlitz's murrelets in the eastern and western groups to determine the level of separation between the two genetic groups. There are no known morphological or physical differences, such as egg characteristics, plumage coloration, size, wing or tail length, bill measurements, or molt patterns, between the eastern and western groups of the Kittlitz's murrelet. Similarly, we have no information to suggest that flight, swimming and diving, sexual behavior (mate attraction, pair bonding), vocalizations, degree of socialization, or interspecific behavior is different between the two groups. Breeding phenology is slightly later in the western group compared to the eastern group, but this difference is most certainly due to the persistence of sea ice and terrestrial ice and snow in the Aleutian Islands compared to the Gulf of Alaska; in fact, phenology is most delayed in northern Alaska, where mixed ancestry of the Kittlitz's murrelet occurs. Incubation length and post-hatching parental care are similar, but length of the chick-rearing period is greater at nests monitored in the Aleutian Islands compared to nests in the Gulf of Alaska. The difference in average number of days between hatching and fledging is presumably due to quality of chick diet (see *Reproductive Performance* and *Factor A* discussion), not an ecological or behavioral difference between Kittlitz's murrelets in the western and eastern groups. Post-breeding migration timing and routes of Kittlitz's murrelets in the eastern and western groups are similar with individuals moving into the Bering and Chukchi seas in August and September. Individual Kittlitz's murrelets have not been tracked between October and May, and, therefore, we cannot evaluate possible overwinter separation of Kittlitz's murrelets by group.

The only possible ecological difference in Kittlitz's murrelets belonging to the eastern and western genetic groups is associated with nesting habitat. In the central and western Aleutian Islands, Kittlitz's murrelets nest in areas with greater amounts of vegetative cover (51 percent) compared to nests in the Gulf of Alaska (3–12 percent) and northern Alaska (14 percent). However, regardless of the region, Kittlitz's murrelets consistently nest in the least vegetated areas available on the landscape, presumably to maximize camouflage and nest safety from predators (see *Nesting* for more details). Thus, we do not know whether or not the difference in percent vegetative cover near nest sites serves as ecological separation of Kittlitz's murrelets in the western and eastern groups. Although the distribution of the genetic groups may be partially explained by the distribution of glaciers, there are several regions of genetic introgression, including the eastern Aleutian Islands and northern Alaska, as well as areas in the eastern group, like Kodiak Island, that lack glaciers. Furthermore, as mentioned above, there are low levels of contemporary movement between these two genetic groups, suggesting that genetic continuity exists.

The Kittlitz's murrelet is broadly distributed across coastal Alaska and eastern Russia where it spends its entire annual cycle, but only less than 5 percent of the minimum global population of the Kittlitz's murrelet resides in Russian waters during the breeding season. Despite the international governmental boundary essentially bisecting the distribution of this species, we have no reason to conclude that differences in control of exploitation, management of the habitat, conservation status of the species, or regulatory mechanisms exist that are significant to the listing status of the Kittlitz's murrelet.

Determination of Distinct Population Segment

We determine, based on a review of the best available information, that the western and eastern populations of the Kittlitz's murrelet do not meet the discreteness conditions of the 1996 DPS policy. Therefore, neither of these population segments qualifies as a DPS under our policy and is not a listable entity under the Act.

The DPS policy is clear that significance is analyzed only when a population segment has been identified as discrete. Since we found that the population segment did not meet the discreteness element, we will not conduct an evaluation of significance.

Significant Portion of the Range

Under the Act and our implementing regulations, a species may warrant listing if it is endangered or threatened throughout all or a significant portion of its range. The Act defines ''endangered species'' as any species which is ''in danger of extinction throughout all or a significant portion of its range,'' and ''threatened species'' as any species which is ''likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.'' The definition of ''species'' is also relevant to this discussion. The Act defines ''species'' as follows: ''The term 'species' includes any subspecies of fish or wildlife or plants, and any distinct population segment [DPS] of any species of vertebrate fish or wildlife which interbreeds when mature.'' The phrase ''significant portion of its range'' (SPR) is not defined by the statute, and we have never addressed in our regulations: (1) The consequences of a determination that a species is either endangered or likely to become so throughout a significant portion of its range, but not throughout all of its range; or (2) what qualifies a portion of a range as ''significant.''

Two recent district court decisions have addressed whether the SPR language allows the Service to list or protect less than all members of a defined ''species'': *Defenders of Wildlife* v. *Salazar,* 729 F. Supp. 2d 1207 (D. Mont. 2010), concerning the Service's delisting of the Northern Rocky Mountain gray wolf (74 FR 15123, April 2, 2009); and *WildEarth Guardians* v. *Salazar,* 2010 U.S. Dist. LEXIS 105253 (D. Ariz. September 30, 2010), concerning the Service's 2008 finding on a petition to list the Gunnison's prairie dog (73 FR 6660, February 5, 2008). The Service had asserted in both of these determinations that it had authority, in effect, to protect only some members of a ''species,'' as defined by the Act (i.e., species, subspecies, or DPS), under the Act. Both courts ruled that the determinations were arbitrary and capricious on the grounds that this approach violated the plain and unambiguous language of the Act. The courts concluded that reading the SPR language to allow protecting only a portion of a species' range is inconsistent with the Act's definition of ''species.'' The courts concluded that once a determination is made that a species (i.e., species, subspecies, or DPS) meets the definition of ''endangered species'' or ''threatened species,'' it must be placed on the list in its entirety and the Act's protections applied consistently to all members of that species (subject to modification of protections through special rules under sections 4(d) and 10(j) of the Act).

Consistent with that interpretation, and for the purposes of this finding, we interpret the phrase ''significant portion of its range'' in the Act's definitions of ''endangered species'' and ''threatened species'' to provide an independent basis for listing; thus there are two situations (or factual bases) under which a species would qualify for listing: a species may be endangered or threatened throughout all of its range; or a species may be endangered or threatened in only a significant portion of its range. If a species is in danger of extinction throughout a significant portion of its range, the species is an ''endangered species.'' The same analysis applies to ''threatened species.'' Based on this interpretation and supported by existing case law, the consequence of finding that a species is endangered or threatened in only a significant portion of its range is that the entire species shall be listed as endangered or threatened, respectively, and the Act's protections shall be applied across the species' entire range.

We conclude, for the purposes of this finding, that interpreting the significant portion of its range phrase as providing an independent basis for listing is the best interpretation of the Act because it is consistent with the purposes and the plain meaning of the key definitions of the Act; it does not conflict with established past agency practice (i.e., prior to the 2007 Solicitor's Opinion), as no consistent, long-term agency practice has been established; and it is consistent with the judicial opinions that have most closely examined this issue. Having concluded that the phrase ''significant portion of its range'' provides an independent basis for listing and protecting the entire species, we next turn to the meaning of ''significant'' to determine the threshold for when such an independent basis for listing exists.

Although there are potentially many ways to determine whether a portion of a species' range is ''significant,'' we conclude, for the purposes of this finding, that the significance of the portion of the range should be determined based on its biological contribution to the conservation of the species. For this reason, we describe the threshold for ''significant'' in terms of an increase in the risk of extinction for the species. We conclude that a biologically based definition of ''significant'' best conforms to the purposes of the Act, is consistent with judicial interpretations, and best ensures species' conservation. Thus, for the purposes of this finding, and as explained further below, a portion of the range of a species is ''significant'' if its contribution to the viability of the species is so important that without that portion, the species would be in danger of extinction.

We evaluate biological significance based on the principles of conservation biology using the concepts of redundancy, resiliency, and representation. *Resiliency* describes the characteristics of a species and its habitat that allow it to recover from periodic disturbance. *Redundancy* (having multiple populations distributed across the landscape) may be needed to provide a margin of safety for the species to withstand catastrophic events. *Representation* (the range of variation found in a species) ensures that the species' adaptive capabilities are conserved. Redundancy, resiliency, and representation are not independent of each other, and some characteristic of a species or area may contribute to all three. For example, distribution across a wide variety of habitat types is an indicator of representation, but it may also indicate a broad geographic distribution contributing to redundancy (decreasing the chance that any one event affects the entire species), and the likelihood that some habitat types are less susceptible to certain threats, contributing to resiliency (the ability of the species to recover from disturbance). None of these concepts is intended to be mutually exclusive, and a portion of a species' range may be determined to be ''significant'' due to its contributions under any one or more of these concepts.

For the purposes of this finding, we determine if a portion's biological contribution is so important that the portion qualifies as ''significant'' by asking whether *without that portion,* the representation, redundancy, or

resiliency of the species would be so impaired that the species would have an increased vulnerability to threats to the point that the overall species would be in danger of extinction (i.e., would be ''endangered''). Conversely, we would not consider the portion of the range at issue to be ''significant'' if there is sufficient resiliency, redundancy, and representation elsewhere in the species' range that the species would not be in danger of extinction throughout its range if the population in that portion of the range in question became extirpated (extinct locally).

We recognize that this definition of ''significant'' (a portion of the range of a species is ''significant'' if its contribution to the viability of the species is so important that without that portion, the species would be in danger of extinction) establishes a threshold that is relatively high. On the one hand, given that the consequences of finding a species to be endangered or threatened in an significant portion of its range would be listing the species throughout its entire range, it is important to use a threshold for ''significant'' that is robust. It would not be meaningful or appropriate to establish a very low threshold whereby a portion of the range can be considered ''significant'' even if only a negligible increase in extinction risk would result from its loss. Because nearly any portion of a species' range can be said to contribute some increment to a species' viability, use of such a low threshold would require us to impose restrictions and expend conservation resources disproportionately to conservation benefit: listing would be rangewide, even if only a portion of the range of minor conservation importance to the species is imperiled. On the other hand, it would be inappropriate to establish a threshold for ''significant'' that is too high. This would be the case if the standard were, for example, that a portion of the range can be considered ''significant'' only if threats in that portion result in the entire species' being currently endangered or threatened. Such a high bar would not give the significant portion of its range phrase independent meaning, as the Ninth Circuit held in *Defenders of Wildlife* v. *Norton,* 258 F.3d 1136 (9th Cir. 2001).

The definition of ''significant'' used in this finding carefully balances these concerns. By setting a relatively high threshold, we minimize the degree to which restrictions will be imposed or resources expended that do not contribute substantially to species conservation. But we have not set the threshold so high that the phrase ''in a significant portion of its range'' loses independent meaning. Specifically, we have not set the threshold as high as it was under the interpretation presented by the Service in the *Defenders* litigation. Under that interpretation, the portion of the range would have to be so important that current imperilment there would mean that the species would be *currently* imperiled everywhere. Under the definition of ''significant'' used in this finding, the portion of the range need not rise to such an exceptionally high level of biological significance. (We recognize that if the species is imperiled in a portion that rises to that level of biological significance, then we should conclude that the species is in fact imperiled throughout all of its range, and that we would not need to rely on the significant portion of its range language for such a listing.) Rather, under this interpretation we ask whether the species would be endangered everywhere without that portion, *i.e.,* if that portion were completely extirpated. In other words, the portion of the range need not be so important that even the species being in danger of extinction in that portion would be sufficient to cause the species in the remainder of the range to be endangered; rather, the *complete extirpation* (in a hypothetical future) of the species in that portion would be required to cause the species in the remainder of the range to be endangered.

The range of a species can theoretically be divided into portions in an infinite number of ways. However, there is no purpose to analyzing portions of the range that have no reasonable potential to be significant or to analyzing portions of the range in which there is no reasonable potential for the species to be endangered or threatened. To identify only those portions that warrant further consideration, we determine whether there is substantial information indicating that: (1) The portions may be ''significant,'' *and* (2) the species may be in danger of extinction there or likely to become so within the foreseeable future. Depending on the biology of the species, its range, and the threats it faces, it might be more efficient for us to address the significance question first or the status question first. Thus, if we determine that a portion of the range is not ''significant,'' we do not need to determine whether the species is endangered or threatened there; if we determine that the species is not endangered or threatened in a portion of its range, we do not need to determine if that portion is ''significant.'' In practice, a key part of the determination that a species is in danger of extinction in a significant portion of its range is whether the threats are geographically concentrated in some way. If the threats to the species are essentially uniform throughout its range, no portion is likely to warrant further consideration. Moreover, if any concentration of threats to the species occurs only in portions of the species' range that clearly would not meet the biologically based definition of ''significant,'' such portions will not warrant further consideration.

We evaluated the current range of the Kittlitz's murrelet to determine if there is any apparent geographic concentration of potential threats to this species. We examined potential threats from climate change, exposure to environmental contaminants and marine pollution, disease, changes in predation, disturbance from vessel traffic, and incidental take in fisheries. We found no concentration of threats that suggest the Kittlitz's murrelet may be in danger of extinction in a portion of its range. We found no portion of its range where threats are significantly concentrated or substantially greater than in other portions of its range. Therefore, we find that known factors affecting the Kittlitz's murrelet are essentially uniform throughout its range, indicating no portion of the range of the Kittlitz's murrelet warrants further consideration of possible endangered or threatened status under the Act. The best available information does not suggest that there has been a noteable range contraction of the Kittlitz's murrelet, and therefore we find that lost historical range does not constitute an important component of our analysis of whether any particular area is a significant portion of the range for the Kittlitz's murrelet.

Conclusion of 12-Month Finding

Our review of the best available scientific and commercial information indicates that the Kittlitz's murrelet is not in danger of extinction (endangered) nor likely to become endangered within the foreseeable future (threatened), throughout all or a significant portion of its range. Therefore, we find that listing the Kittlitz's murrelet as an endangered or threatened species under the Act is not warranted at this time.

We request that you submit any new information concerning the status of, or threats to, the Kittlitz's murrelet to our Juneau Fish and Wildlife Field Office (see **ADDRESSES**) whenever it becomes available. New information will help us monitor the Kittlitz's murrelet and

encourage its conservation. If an emergency situation develops for the Kittlitz's murrelet, we will act to provide immediate protection.

References Cited

A complete list of references cited is available on the Internet at *http://www.regulations.gov* at Docket No. FWS–R7–ES–2013–0099 and upon request from the Juneau Fish and Wildlife Field Office (see **ADDRESSES**).

Authors

The primary authors of this notice are the staff members of the Juneau Fish and Wildlife Field Office.

Authority

The authority for this section is section 4 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.).

Dated: September 23, 2013.

Rowan W. Gould,

Acting Director, U.S. Fish and Wildlife Service.

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