

Common Murre

Uria aalge

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GENERAL RANGE AND WASHINGTON DISTRIBUTION

The common murre is a gregarious, colonially nesting, and circumpolar seabird with a boreal, low Arctic, and northern temperate distribution (American Ornithologists' Union 1983, Nettleship and Evans 1985, Gaston and Jones 1998, Ainley et al. 2002). Based mostly on morphological differences, there have been up to eight subspecies or races described for the common murre (Storer 1952, Tuck 1961, Bédard 1985, Gaston and Jones 1998, Ainley et al. 2002), with three to six occurring in the Atlantic Ocean and two in the Pacific Ocean (*Uria aalge inornata*, *U. a. californica*).

In the Atlantic Ocean there are roughly 2,000,000 (Nettleship and Evans 1985) to as many as 9,000,000 (Gaston and Jones 1998) adult common murres breeding from the Labrador and Newfoundland coast in Canada, north to southern Greenland, Iceland, northern Norway and Spitsbergen, and south to Great Britain and the coast of Europe to Portugal (Harrison 1983, Gaston and Jones 1998, Ainley et al. 2002). In the Pacific and Arctic Oceans, common murres range from Cape Lisburne, Chukchi Sea, Siberian and Alaskan coasts of the Bering Sea, and south along the eastern and western north Pacific to Hokkaido, Japan, and Hurricane Point, central California, respectively (Sowls et al. 1978, American Ornithologists' Union 1983, Harrison 1983, Gaston and Jones 1998, Ainley et al. 2002). In the northern parts of the Pacific Ocean and throughout the Arctic Ocean, the common murre and the closely related thick-billed murre (*Uria lomvia*) may nest together in mixed colonies, making it difficult to estimate the total population of either species (Gaston and Jones 1998). Based on the work of Carter et al. (2001), U.S. Fish and Wildlife Service [USFWS] (2001), and others (e.g., Takekawa et al. 1990, Lowe and Pitkin 1996), Ainley et al. (2002) recorded nearly 5,000,000 common murres and 4,500,000 unidentified murres from California through Alaska, and Gaston and Jones (1998) added an additional 2,700,000 common murres from the Siberian Bering Sea and Kuril Island in the western Pacific Ocean.

Although common murres move away from breeding colonies after the breeding season, their winter range is essentially the same as their breeding range, but extends further south where murres are regularly found in southern California in the Pacific and Maine in the Atlantic (American Ornithologists' Union 1983). Some populations of common murres may remain resident near breeding colonies throughout the year (e.g., common murres nesting in central California; Boekelheide et al. 1990, Sydeman 1993).

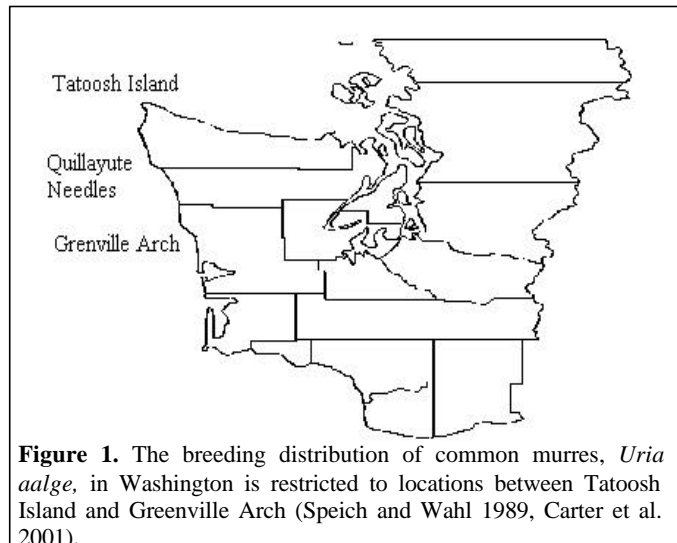


Figure 1. The breeding distribution of common murres, *Uria aalge*, in Washington is restricted to locations between Tatoosh Island and Greenville Arch (Speich and Wahl 1989, Carter et al. 2001).

Washington Colony Distribution, Attendance, and Trends

Distribution: The breeding distribution for common murres in Washington State is restricted to the outer coast from Grenville Arch (47° 18' N, 124° 17' W) to Tatoosh Island (48° 24' N, 124° 44' W) and include at least five groups of colonies or “complexes”: Point Grenville, Split-Willoughby, Quillayute Needles, Carroll-Jagged, and Tatoosh (see Figure 1; Speich and Wahl 1989, Carter et al. 2001). All colonies, except that on Tatoosh Island, are part of the USFWS National Wildlife Refuge (NWR) system (North to South: Flattery Rocks, Quillayute Needles, and Copalis NWRs) and have been aerially surveyed each year since 1979 (Wilson 1991, Carter et al. 2001). Tatoosh Island is owned by the Makah Tribe and regular ground and boat surveys of breeding common murres on the island began in 1990 (Parrish 1995), although some data on murre status were collected on the island in the 1980s (Paine et al. 1990).

Attendance¹: Data on the attendance of common murres in Washington have been recorded continuously by USFWS since 1979, when more than 31,000 birds were recorded from 12 localities (Speich and Wahl 1989, Carter et al. 2001). USFWS surveys did not include Tatoosh Island until 1994 (Carter et al. 2001), although work by University of Washington researchers estimated attendance at Tatoosh Island in 1979 to be less than 500-1000 birds (Paine et al. 1990, Parrish et al. 2001). In 2002 there were between 5,785 and 5,925 common murres in attendance at 15 NWR colonies (Wilson 2003), plus an additional 4,466 murres at Tatoosh Island (Thompson et al. 2003), for a total of over 10,000 birds. The largest colony in the state is Tatoosh Island, followed by Cake Island (Wilson 2003), both of which are in the northern part of Washington’s common murre range.

Trends: In order to better understand the population dynamics of murres in Washington through 2002, we added to the analyses of Wilson (1991) and Carter et al. (2001), and included additional data for the refuge islands (Wilson 1996, 1999, 2002, and 2003) and for Tatoosh Island (Paine et al. 1990, Thompson et al. 2003). This new dataset provides nearly continuous data for common murres in Washington from 1979 through 2002, with the following exceptions: (1) refuge colony-specific data for 1999 and 2000 were not available, although total counts were obtained from Figure 1 in Wilson (2003); and (2) continuous attendance data from Tatoosh Island were only available from 1991 through 2002 (Thompson et al. 2003), although Paine et al. (1990) plotted murre attendance for 1978, 1979, 1986, and 1988). In order to fill in the gaps, we used the plotted attendance figures for these years and extrapolated from these figures using linear regression to obtain attendance estimates at Tatoosh Island for 1987 and 1989-1990 (Figures 2, 3). Our analysis is similar to that of Wilson (2003), except we include data for Tatoosh Island, and we do not focus attention on a time period dictated by the *Tenyo Maru* oil spill. When multiple aerial surveys were conducted in a given year, we chose the median values in our analysis. Our results indicate that the common murre population in Washington appears stable over the past decade.

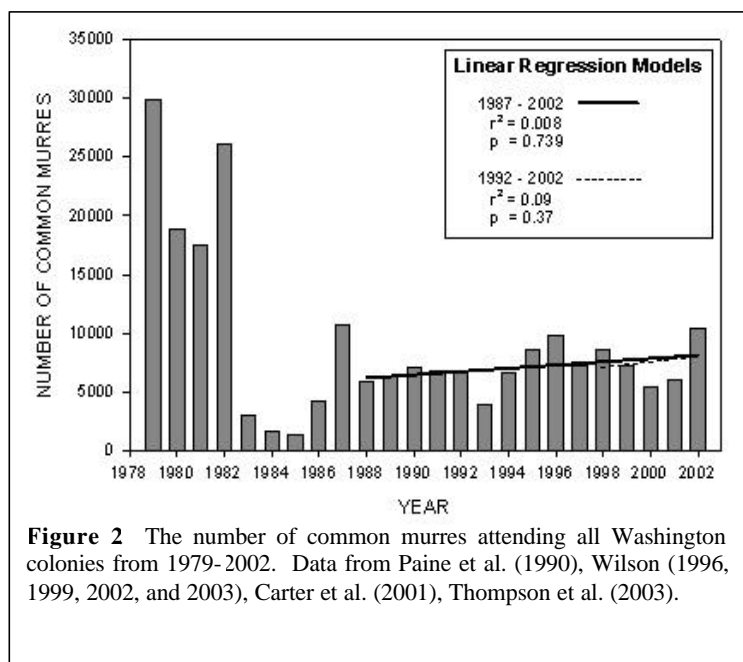


Figure 2 The number of common murres attending all Washington colonies from 1979-2002. Data from Paine et al. (1990), Wilson (1996, 1999, 2002, and 2003), Carter et al. (2001), Thompson et al. (2003).

¹ Attendance is the number of individuals counted during a colony census, and represents breeding and non-breeding birds. At the time of these censuses, the breeding population at the colony was composed of breeding birds (i.e., adults) that were at the colony and were therefore counted. Adult birds (generally the mates of the birds present at the colony) that were at-sea were not counted. The total population was composed of all juvenile, subadult, and adult birds that would or potentially would breed at the colony.

Figure 2 shows the total attendance at murre colonies from 1979 through 2002. The dramatic decline in murre attendance in 1983, as initially documented by Wilson (1991), is clearly evident. Murre numbers stayed low from 1983-1985 and began to increase through 1987. After 1987, murre numbers remained stable through 2002. If murre numbers in Washington are at “carrying capacity²” (Wilson 2003:2), this capacity is remarkably lower than that in the late 1970s and early 1980s (see below, and Parrish and Zador 2003 for discussion of common murre carrying capacity in Washington).

Carter et al. (2001) divided the murre colonies into a southern (Gray’s Harbor County, including Point Grenville and Split-Willoughby Complexes) and a northern component (Jefferson and Clallam Counties, including the Quillayute Needles, Carroll-Jagged, and Tatoosh Complexes). From 1979 through 1982, common murre attending Washington colonies in the southern areas averaged 92% of the total Washington population (Figure 3). In 1988, the dominance of the southern areas ended and by the mid 1990s the Washington murre population had shifted to the northern colonies (Figure 3). In 2002, 81% of common mures in Washington were nesting in the northern areas, with 44% at Tatoosh Island and 35% at the Quillayute Needles Complex.

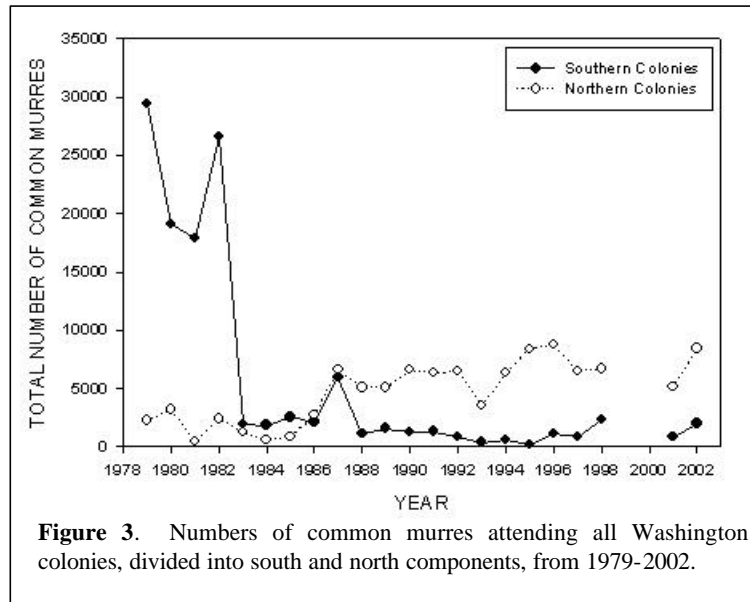


Figure 3. Numbers of common mures attending all Washington colonies, divided into south and north components, from 1979-2002.

Although murre attendance summed across all colonies (as presented in Figure 2) has been relatively stable for 15 years, attendance at individual rocks has varied (Carter et al. 2001). This is especially true at the Quillayute Needles and Carroll-Jagged Complexes, in particular Cake Rock and Carroll, Huntington, and Petrel Islands (Figure 4; see also Carter et al.

2001:Figure 2.11). In the early 1980s, Petrel Island was the predominant murre colony in the area, followed by Huntington Island from the mid 1980s through the early 1990s. The murre population at Carroll Island increased dramatically following the 1994 breeding season, but has been replaced by Cake Rock (Figure 4) as the main murre colony in the area.

Understanding trends in common murre colony attendance in Washington over the past two decades is confounded by at least two basic issues. First, as discussed above, there does not appear to be a uniform trend in colony attendance among colonies from the Quillayute Needles and Carroll-Jagged Complexes. The fact that all Washington murre colonies are within a range of 127 km (79 mi) makes these data even more perplexing. Second, counts at particular colonies generally have not been replicated in any given year, and census methods used by different researchers may differ and may not be directly comparable. Counts at common murre refuge colonies have been conducted only once per year from 1979 through 1993 (Carter et al. 2001), and single yearly counts can result in poor estimates of breeding attendance (Hatch and Hatch 1989). Censuses by other researchers often resulted in different population estimates. For example, Wilson (in Carter et al. 2001:Appendix F) estimated that only 50 common mures were in attendance on Grenville Arch during an aerial survey on June 26, 1985. However, Speich et al. (1987) provided a maximum count of 8,000 common mures on Grenville Arch for the week that included June 26, 1985, based on a combination of shore- and boat-based counts. Land, boat, and aerial surveys have the potential of sampling different parts of a colony, and therefore they may produce different results. In addition, there may be inherent hourly or daily variability in attendance at Washington colonies (Parrish 1996a, b), and censuses taken on two different days (or at two different times during the same day) may differ as a result of this variability.

² The number of individuals that the resources of a habitat can support.

At-sea Distribution

Although common murre breeding in Washington is restricted to cliffs, rocks, and islands on the outer coast, murre are found throughout the year in all marine waters of the state, including Puget Sound (Wahl et al. 1981, Briggs et al. 1992, Thompson 1997, 1999, Nysewander et al. 2001, Thompson et al. 2002, 2003). In Puget Sound, murre densities are positively correlated with distance from the shore and water depth (D. Nysewander, personal communication; Wahl et al. 1981); however, this relationship does not exist along the outer coast and in the western portions of the Strait of Juan de Fuca (Thompson 1997, 1999). The temporal and spatial patterns for the abundance and distribution of common murre in Puget Sound are highly variable (Thompson 1997, 1999, Nysewander et al. 2001). For example, population indices for common murre in the Puget Sound in July were 48,423; 9,915; 5,271; and 30,660 for 1993 through 1996, respectively (D. Nysewander, personal communication). The reason for this variability is unclear, although the timing of post-breeding dispersal of adult murre from coastal colonies is most likely an important variable. The at-sea density of common murre is highest in the fall (i.e., post-breeding, beginning late July/early August) on the outer coast (Briggs et al. 1992, Thompson 1997, 1999, unpublished data) and in Puget Sound (D. Nysewander, personal communication). The increase of murre in Washington waters following the breeding season is, in part, a result of post-breeding dispersal from colonies in Oregon (Warheit 1996, Thompson 1997, 1999), possibly California, and to a lesser extent, British Columbia and Alaska. Although murre distribution and abundance also varies substantially in time and location on the outer coast, total at-sea population estimates of murre on the outer coast were consistent in 2001 and 2002 ([mean, 95% CI] 2001: 72,840; 48,816–91,124; 2002: 74,011; 35,803–103,048; Thompson, unpublished data).

RATIONALE

The common murre is a State Candidate species. Carter et al. (2001) concluded that the common murre population dropped dramatically from approximately 26,000 in 1982 to 3,000 in 1983, coinciding with a severe El Niño-Southern Oscillation (ENSO) (Wilson 1991). This decline was mirrored at common murre colonies in California (Boekelheide et al. 1990) and Oregon (Hodder and Graybill 1985). However, unlike colonies in California and Oregon total attendance at Washington refuge colonies has not recovered to pre-1983 ENSO levels and has not exceeded 11,000 since that event. Wilson (1991) and Carter et al. (2001) suggested that the lack of recovery to pre-1983 numbers and low attendance within the NWRs may be the result of a combination of ENSOs, oil spills, gillnet mortality, and Naval disturbances at breeding colonies.

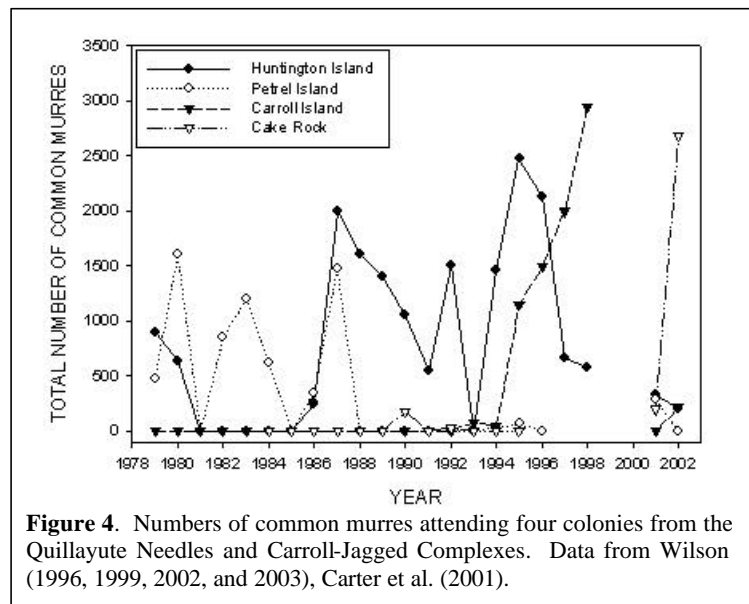


Figure 4. Numbers of common murre attending four colonies from the Quillayute Needles and Carroll-Jagged Complexes. Data from Wilson (1996, 1999, 2002, and 2003), Carter et al. (2001).

HABITAT REQUIREMENTS

Common murre require coastal cliff ledges or elevated marine terraces on islands or rocky headlands for breeding (Ainley et al. 2002). The habitat must be above the splash zone, inaccessible to terrestrial predators or pests (such as cats, rats, foxes, or raccoons), sufficiently windswept or elevated to permit takeoff and landing (Tuck 1961), and in “full ocean view” (Ainley et al. 2002:5). Common murre do not build nests, and each pair lays a single egg directly on the substrate, usually on bare rock, although on Tatoosh Island a subcolony of murre nested on soil near vegetation (salmonberry [*Rubus spectabilis*]; Parrish 1995, Parrish and Paine 1996). Common murre also require marine habitats with relatively abundant prey. Prey include Pacific herring (*Clupea harengus*), Pacific sand lance (*Ammodytes hexapterus*), northern anchovy (*Engraulis mordax*), rockfish (*Sebastes* spp.), salmon (*Oncorhynchus*

spp.), squid, and euphasids (Vermeer et al. 1987, Boekelheide et al. 1990, Ainley et al. 2002). Common murres require that breeding habitat be sufficiently close to productive foraging areas (e.g., oceanographic fronts, tidal sheers, upwelling plumes, shelf-break fronts, and runoff plumes; Ainley et al. 2002) so that repeated trips between the colony and prey sources can be made within a single day (foraging radius for common murres is approximately 60 km [37 mi]; see Ainley et al. 1991). Following the breeding season, common murres require only suitable marine habitat for foraging and resting, although murres may return to colony rocks prior to the breeding season. During this time murres are frequently seen close to shore (Ainley et al. 2002).

Diet

There have been only two detailed studies of the diet of common murres in Washington. The first study is based on the contents of the gastrointestinal tracts of common murres collected from salmon drift gill nets in the late summer and fall from 1993 through 1996 (Wilson 1998, Wilson and Thompson 1998, Lance and Thompson, in press). In this geographically limited study, common murres fed on Pacific herring (74.2 % frequency of occurrence), Pacific sandlance (45.8%), and salmonid species (21.9%). The proportion of these prey species in the diet of murres did not differ significantly between murre age classes (adult vs. subadult), gender, or among years. The mean lengths of Pacific herring and Pacific sandlance were not significantly different in the murre diet. Diet diversity within individual murres was low with most gastrointestinal tracts containing only one or two prey species. Based on the time of day in which Pacific herring and Pacific sandlance were present in murre esophagi and/or proventriculi, Wilson and Thompson (1998) and Lance and Thompson (in press) determined that murres fed most frequently on these two species at dusk (2100-2259 PST).

The second study included only the diet of chicks fed by adults at nest sites on Tatoosh Island (Parrish 1996 a, b, Parrish and Zador 2003, Thompson et al. 2003). The primary prey items fed to chicks were surf smelt (*Hypomesus pretiosus*), Pacific herring, Pacific sandlance, and eulachon (*Thaleichthys pacificus*) (Parrish and Zador 2003, Thompson et al. 2003).

LIMITING FACTORS

A variety of natural and human-induced factors can affect common murre populations. Colony attendance and reproductive success for murre populations along the west coast of North America have been affected by ENSO events (Hodder and Graybill 1985, Ainley and Boekelheide 1990, Wilson 1991). Additional natural factors that may affect murre abundance, distribution, and reproductive success include food availability, predation pressure, and the distribution of specific marine habitats (Briggs et al. 1987, 1992; Speich et al. 1987; Ainley and Boekelheide 1990; Allen 1994; Ainley et al. 1995; Parrish 1996a; Parrish and Paine 1996; Thompson 1997). Disturbance caused by aerial predators such as the bald eagle (*Haliaeetus leucocephalus*) can also negatively affect the reproductive success of breeding murres (Speich et al. 1987, Parrish 1995, 1996a, b; Parrish et al. 2001, Thompson et al. 2003; R. Lowe, personal communications).

Common murres are also vulnerable to drowning in fish-nets or becoming oiled during spills because they are gregarious on land and at sea (Burger and Fry 1993, DeGange et al. 1993, Warheit et al. 1997). In the last 10-20 years, there have been several oil spills in California, Oregon, and Washington, with two major spills in Washington resulting in substantial mortality to common murres. Murres were the most numerous seabirds affected in the *Tenyo Maru* and *Nestucca* oil spills off the coast of Washington (Ford et al. 1991, Momot 1995, *Tenyo Maru* Oil Spill Natural Resources Trustees 2000). Seabird mortality associated with gillnets in Washington and central California have shown a bias toward common murres (Takekawa et al. 1990, Erstad et al. 1994, Pierce et al. 1994, Thompson et al. 1998). Overall, in Washington, it is estimated that thousands of common murres have been killed in salmon gillnets and by oil spills (Ford et al. 1991, Momot 1995, Melvin and Conquest 1996; Warheit 1996; Melvin et al. 1997). Recreational fishing does not appear to be a threat to common murres in Washington (C. MacDonald and W. Beeghley, unpublished data); however, more research is necessary before any conclusions can be reached. The degree to which these factors affect the long-term stability of the population(s) of common murres in Washington is unknown.

Population Regulation

Population responses of a common murre colony to natural or human-induced environmental changes may depend on how that colony is reproductively linked to other colonies and how the overall population is geographically structured. There have been three studies particularly relevant to the geographic structure of common murres occurring from British Columbia south to California. First, Warheit (1996) estimated that 55–58% of common murres killed during the *Tenyo Maru* oil spill were from Washington (the remaining birds were from Oregon). These results indicate that at certain times of the year the Washington “population” of common murres is simply an association of birds from different geographic areas, and not necessarily an integrated breeding nexus. Second, Warheit (1999) stated that based on preliminary genetic analysis, there is little to no geographic structure to common murre populations from British Columbia to California, although there is a slight north-south gradient in allelic frequencies. These tentative conclusions also indicate that there is no evidence for a distinct Washington “population.” Finally, Drovetski et al. (submitted) found a lack of geographic structure to mitochondrial DNA variation among common murres from Japan, Russia, Alaska, and California, and that the history of common murres in the Pacific is highlighted by local population declines and recovery through high migration and gene flow.

The results from the two genetic analyses suggest that common murres in Washington are part of a large and integrated metapopulation that includes, at a minimum, birds from Oregon and British Columbia. However, because both studies limited the Washington samples from one locality (near Tatoosh Island), neither contributes to our understanding of the geographic structure and demographics of common murres within Washington.

There are few data available to help determine what factors (natural or human-induced) are actually “regulating” common murre populations in Washington. Common murre abundance and distribution may be determined by factors such as migration from outside Washington (as the genetic data suggests), food distribution, or bald eagle predation or disturbance. Wilson (2003) has suggested that common murres in Washington are at their carrying capacity and that growth of this population is being limited by food. Parrish and Zador (2003) looked for correlations between a series of mechanisms and several measures of murre demographics and foraging behaviors. They concluded that although a central Oregon colony of murres (Yaquina Head) may be near carrying capacity, Washington colonies “probably exist well below carrying capacity,” and at Tatoosh Island eagle predatory pressure is affecting several demographic parameters (Parrish and Zador 2003:1054). Without additional data on potential regulating factors, it is impossible to predict how a particular colony or population will be affected by events such as gillnet or oil spill mortality. In addition, without more inclusive data on common murre demographic parameters throughout Washington (such as survival, reproductive success, or dispersal from colonies in addition to Tatoosh Island) or information about common murre food habits and potential effects of climate change on prey distribution and abundance, it is difficult to design a comprehensive management or restoration plan for common murres in Washington.

MANAGEMENT RECOMMENDATIONS

To successfully manage the population(s) of common murres in Washington, additional baseline data are needed. Therefore, the following management recommendations consist of two parts. First, we will outline the priority research recommendations. Second, we list direct management activities that should be or have been implemented for the conservation of the breeding and at-sea populations of common murres in Washington.

Research and Monitoring Recommendations

- 1) *Breeding distribution and phenology, and reproductive success*: Tatoosh Island, and to a lesser extent Point Grenville (Thompson et al. 2003) are the only areas in Washington where definitive data have been collected on the basic reproductive parameters of common murres. Therefore, there are no extensive data on breeding phenology, reproductive success, or factors affecting reproductive success (e.g., food availability) available from murre colonies south of Tatoosh Island. This information is important to understanding the demographics of common murres in Washington and for implementing effective management programs.

- 2) *Geographic structure of population*: There are at least two aspects of the geographic structure of common murre populations in Washington that are important in designing management plans.
 - a) Dispersal: The connectivity among colonies is based on the degree to which birds hatched in an area disperse to another area. If the dispersal rate among several areas is high, these areas function as one population, and natural recovery following a disturbance may be relatively quick due to the influx of immigrants. In these cases, management activities need to be directed at the population, rather than an individual colony. However, if a colony or area is isolated and few or no birds disperse to or from the colony, management activities need to be directed at the colony or area because recovery following disturbance must be through local recruitment and natal philopatry (i.e., birds that hatch at a colony and return to that colony to breed). Data on dispersal can be collected directly through the observation of banded birds and indirectly through genetic analyses of individuals from colonies throughout a particular geographic range. At this time our entire knowledge of the genetic structure of common murres from British Columbia to California is based on only four colonies.
 - b) Identification of origin of birds: If common murres are geographically structured either within Washington or between Washington and other regions along the west coast, particular morphological or genetic markers may exist that can identify a bird from a specific colony or region. If such markers exist, it may be possible to identify the areas of origin (e.g., Washington versus Oregon) for common murres killed in oil spills or fishing nets in Washington marine waters (e.g., Warheit 1996, Edwards et al. 2001).

- 3) *Survival rates*: Adult and juvenile survival are important parameters in understanding the demographics of common murre populations (Nur et al. 1994). Although there are data on the survival rates for common murres from both the Atlantic and Pacific oceans (Hudson 1985, Harris and Wanless 1988, 1995; Sydeman 1993), no data are currently available from any Washington colony. Obtaining data on survival rates requires banding individual birds.

- 4) *Sources of mortality*: Researchers (Parrish 1996a, b; Parrish and Paine 1996; Parrish et al. 2001) studied the effects of eagle disturbance on survival and reproductive success of common murres on Tatoosh Island. This type of study should be conducted at other murre colonies in Washington, as was attempted at Point Grenville (Thompson et al. 2003). To better understand the effects of fishing bycatch mortality and oil spills on common murres in Washington, more data are needed on the number of individuals killed each year in all types of fishing gear (including recreational fishing) and in oil spills (including small-scale but chronic spills). Systematic and wide-ranging beach bird surveys are essential to document baseline mortality rates for marine birds in Washington. The Coastal Observation and Seabird Survey Team initiated such a comprehensive coastwide program in 1999 (Hass and Parrish 2000).

- 5) *Fisheries bycatch mortality*: More research is required to further reduce the number of birds killed in all kinds of fishing gear.
 - a) Pingers: Melvin et al. (1997) conducted experiments on the use of audio devices (i.e., pingers) attached to gillnets as a method to reduce the rate by which seabirds become entangled. We recommend that new experiments be conducted on the use of pingers on 20 mesh nets.
 - b) Recreational fishery activities: Based on one year of data, it appears that bycatch of common murres in recreational fishing lines are minimal (C. MacDonald and W. Beeghley, personal communications). Nevertheless, a more comprehensive, multi-year, and systematic study needs to be implemented to effectively evaluate this potential problem.
 - c) Monitoring: Comprehensive monitoring of the at-sea distribution of common murres in Puget Sound, Strait of Juan de Fuca, the outer coast, and along the Oregon coast needs to be implemented and maintained; monitoring and surveying have been or are currently being conducted on Tatoosh Island (Paine et al. 1990, Parrish 1995) and on all colonies managed by USFWS (Speich et al. 1987, Wilson 1991, Briggs et al. 1992, Carter et al. 2001). These data should be used to determine seasonal murre abundance that might influence the regulation of a particular gillnet fishery. This information will also help determine potential injury from oil spills occurring in particular places at specific times of the year.

- 6) *Food habits*: Short- and long-term changes in food resources for common murres can result from factors such as ENSO events, Pacific Decadal Oscillation (Mantua et al. 1997, Minobe 1999), overfishing, and global climate change. Food shortages resulting from ENSO events have been documented to be associated with large die-offs of common murres in Washington (Good et al. 1999). Management plans must be designed that

incorporate this information. Detailed analysis of food habits for common murres in Washington is limited for most sites. Comprehensive studies of common murre food habits and foraging ecology are needed and should combine information gathered both at sea and at breeding colonies. These studies need to be long-term, multiyear endeavors, and should include analyses on diet, adult foraging rates, chick diet at nest sites, and information about the marine food web (in particular, the abundance, distribution, and life history of the primary prey species, and how these prey species might be affected by climate change). This type of comprehensive analysis was initiated in 2001 (Thompson et al. 2003), but the *Tenyo Maru* Oil Spill Trustee Committee terminated funding for this project after two years.

- 7) *Spatial factors affecting murre distribution*: As described in the Trends Section above, common murres have shifted their Washington distribution to the north (Figure 3), and have experienced irregular attendance at the Quillayute Needles and Carroll-Jagged Complexes (Figure 4). These spatial patterns are unmistakable and may relate to differences in local terrestrial and marine environments. Differences in factors such as food availability, human and eagle disturbance, and rates of predation need to be examined.

Direct Management Actions and Recommendations

- 1) *Reduce bycatch of common murres in Washington drift gillnets*: A considerable amount of research has been conducted in Washington to determine the degree to which seabirds, in particular common murres, are caught in non-treaty salmon drift gillnets (Erstad et al. 1994, 1996; Pierce et al. 1994; Thompson et al. 1998). In addition, researchers (Melvin and Conquest 1996, Melvin et al. 1997) have developed procedures to reduce seabird bycatch in drift gillnets. Because thousands of murres are potentially killed by gillnets each year (Thompson et al. 1998), specific management activities to reduce this mortality are warranted. The Washington Fish and Wildlife Commission adopted procedures and commercial fishing regulations designed to reduce the bycatch of seabirds, particularly common murres and rhinoceros auklets, in gillnets (Washington Department of Fish and Wildlife 1997). These regulations set the following gillnet design standards and timing restrictions to reduce mortality associated with gillnets:
- Net design**: The monofilament line in the first 20 meshes below the corkline of nets must be replaced with #12 white twine which is more visible to diving birds. Melvin et al. (1997) showed that the 20 mesh nets (but with thicker #18 white twine) significantly reduced seabird bycatch without significantly reducing fishing efficiency.
 - Length of season**: The Department of Fish and Wildlife was authorized to end the 1997 sockeye and pink salmon gillnet fisheries in northern Puget Sound (Areas 7/7a) when the number of seabirds in the fishing area became abundant in order to eliminate common murre bycatch. This authority should be extended to future years.
 - Fishing hours**: The Commission eliminated early morning (change-of-light period) and most night fishing to reduce the time in which fishers would be unable to see and thereby avoid flocks of birds; the designated open fishery was from 1.5 hours after sunrise to midnight.
 - Educational programs**: Although the Commission's new regulations did not require the implementation of educational programs, the Commission's goals may be best met through programs designed to instruct the commercial fishing fleet in Washington on how best to avoid encountering seabirds.
- 2) *Reduce effects from oil spills*: Oil spills are usually accidents and as such are difficult to plan and manage. Nevertheless, activities can be employed to reduce the probability and negative effects of an oil spill. The Washington Departments of Ecology and Fish and Wildlife are addressing the following:
- Spill prevention through vessel and facility inspections
 - Coordinated spill response and injury assessment
 - Restoration planning and implementation
 - Oiled wildlife rescue capabilities
 - Industry and coast guard drills and geographic response plans to enhance spill response activities
- 3) *Reduce human disturbance at breeding colonies*: Human disturbance through activities such as kayaking, boating, or aircraft overflights can disturb nesting common murres and affect local recruitment and productivity (Speich et al. 1987, Parrish 1996b, Warheit et al. 1997). As provided in the *Nestucca* oil spill restoration plan (Momot 1995), the USFWS will inform citizens about the sensitivities of seabird breeding colonies at NWR sites in Washington through brochures and signs/posters displayed prominently at commercial, private, and

public boat launches and marinas, and in refuges and parks. These brochures and signs will also inform the public that it is illegal to harass seabirds and to enter onto a NWR island without proper authorization. The *Tenyo Maru* Oil Spill Trustee Committee has implemented a similar program in Oregon and the Cape Flattery – Tatoosh Island area in Washington (*Tenyo Maru* Oil Spill Natural Resources Trustees 2000). Finally, although the use of brochures and signs promises to reduce disturbance at specific colonies, other factors such as aircraft ceiling violations over specific common murre colonies (e.g., Tatoosh Island; Parrish 1996b) need to be addressed through a combination of educational programs and enforcement of existing laws and regulations.

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KEY POINTS

Habitat Requirements

- Requires for breeding coastal cliff ledges or elevated marine terraces on islands or rocky headlands that are inaccessible to terrestrial predators.
- Lays a single egg directly on the substrate, usually on bare rock.
- Requires breeding habitat to be sufficiently close to productive foraging areas.
- In the eastern Pacific, preys upon Pacific herring, Pacific sandlance, northern anchovy, rockfish, salmon, squid, and euphasids.
- In Washington, chicks are fed surf smelt, Pacific herring, Pacific sandlance, and eulachon by adults at the nest site.
- Dietary diversity of individual murrelets tends to be low.
- Requires only suitable marine habitat for foraging and resting following the breeding season. However, murrelets may return to colony rocks prior to the breeding season.

Management Recommendations

Research and Monitoring Recommendations

- Collect data on breeding phenology, reproductive success, and factors affecting reproductive success in Washington to support the implementation of more effective management programs.
- Gather comprehensive data to determine the rate of dispersal among colonies to better focus management efforts. Identification of genetic markers to track the origin of individual murrelets is also important.
- Collect survival data to more accurately understand murrelet demographics in Washington.
- Conduct comprehensive surveys to better understand the effects of various sources of mortality (e.g., natural mortality, bycatch, oil spills).
- Carry out additional research and monitoring efforts that will help identify ways to further reduce the number of birds killed in fishing gear.
- Develop and conduct comprehensive studies of murrelet food habits and foraging ecology. These studies should combine information gathered both at-sea and at breeding colonies.
- Examine spatial factors affecting murrelet distribution. Differences in factors such as food availability, human and eagle disturbance, and rates of predation need to be examined.

Direct Management Actions and Recommendations

- Replace the monofilament line in the first 20 meshes below the corkline of nets with #12 white twine which is more visible to diving birds. 20 mesh nets (but with thicker #18 white twine) significantly reduced seabird bycatch without significantly reducing fishing efficiency.
- Extend the Fish and Wildlife Commission's authority to end certain fishing seasons when the number of seabirds in a fishing area becomes abundant.
- Design programs to instruct commercial fishing fleets on how to best avoid seabird bycatch.
- Resource agencies should continuously improve their capabilities to reduce the effect of oil spills through various means (e.g., vessel and facility inspections, coordinated spill response and injury assessments, restoration, wildlife rescue).
- Reduce human disturbance at breeding colonies caused by activities such as kayaking, boating, or aircraft overflights.