Marbled Murrelet *(Brachyramphus marmoratus)*
CA, OR, WA DPS

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Washington Fish and Wildlife Office
Lacey, WA

5-YEAR REVIEW

Species reviewed: Marbled Murrelet (*Brachyramphus marmoratus*)

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5-YEAR REVIEW
Marbled Murrelet (CA, OR, WA DPS) / *Brachyramphus marmoratus*

GENERAL INFORMATION

Species: Marbled Murrelet (CA, OR, WA DPS)
Date listed: October 1, 1992
FR citation: 57 FR 45328
Classification: Threatened
Critical habitat: Designated May 24, 1996 (61 FR 26257); Revised October 5, 2011 (76 FR 61599); Affirmed August 4, 2016 (81 FR 51349)

Methodology used to complete the review: In accordance with section 4(c)(2) of the Endangered Species Act of 1973, as amended (Act), the purpose of 5-year reviews is to assess each threatened species and endangered species to determine whether its status has changed and whether it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants. To evaluate the status of the marbled murrelet, we (the U.S. Fish and Wildlife Service [Service]) used the Species Status Assessment (SSA) framework (Service 2016, entire), which uses the concepts of resiliency, redundancy, and representation to assess viability. We reported our findings in a Species Biological Report (SBR).

The SBR (Service 2024, entire) was developed by a writing team from the Service's Washington Ecological Services Office, with review and input from the Service's species experts across the listed range. The SBR represents our evaluation of the best available scientific information, including species ecological needs, factors influencing the species and the current condition of the species. Independent peer reviewers and partner representatives reviewed the SBR before it was used as the scientific basis to support our 5-year review decision-making process.

FR Notice citation announcing the species is under active review:
U.S. Fish and Wildlife Service. 2022. Initiation of 5-year status reviews for 167 species in Oregon, Washington, Idaho, Montana, California, Hawaii, Guam, and the Northern Mariana Islands. Federal Register 87:28031-28034. May 10, 2022.

REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) policy

The marbled murrelet was listed in 1992, prior to implementation of the Service's 1996 Distinct Population Segment (DPS) policy. In 2009, we determined that the murrelet population in Washington, Oregon, and California meets the policy standards of discreteness and significance and is therefore a valid DPS (Service 2009, pp. 3-12). We affirmed this finding in 2019 (Service 2019, pp. 3-10). There is no new information to indicate that the listed DPS does not continue to meet those policy standards. Therefore, we consider the Washington, Oregon, and California population of marbled murrelet to be a valid DPS.

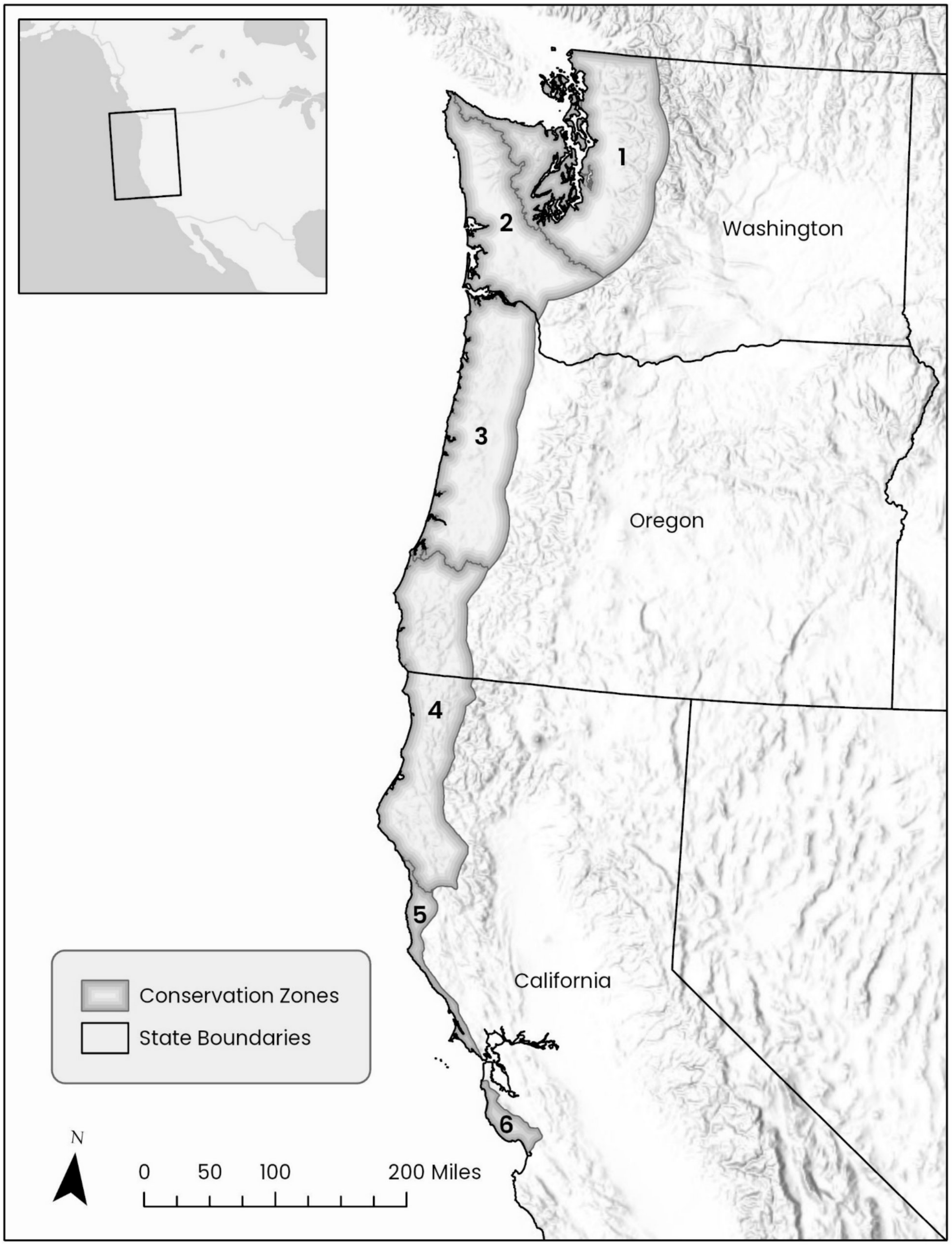

Figure 1. Marbled murrelet Conservation Zones

Updated Information and Current Species Status

The species' life history traits, habitat, and distribution have been previously well-described and are summarized in the SBR (Service 2024, pp. 5-9). Briefly, the marbled murrelet is a small seabird that typically forages in shallow nearshore marine waters and nests in coastal forests that contain older trees, typically up to 89 km (55 miles) inland (Raphael et al. 2018, p. 301). Murrelets do not construct nests, but instead lay a single egg on naturally occurring nesting platforms in large, older-aged trees (Nelson 1997, p. 17). Both parents commute between foraging and nesting habitat to incubate the egg and provision the chick.

Species Ecological Needs

All life stages of the murrelet are dependent upon the presence of adequate nesting habitat, adequate foraging habitat, and connectivity between the two. Adequate nesting habitat, comprising large coniferous trees, large diameter platforms covered in moss and other detritus, overhead cover, and access routes, provides for the establishment of nests and the successful rearing of nestlings. Adequate foraging habitat provides sufficient energetic and nutritional resources to support essential functions, including growth, locomotion, and reproduction. Adequate foraging and nesting habitats must occur within daily commuting distance to allow for foraging by adults while they incubate their egg and rear their chick. These individual resource needs influence the population size and growth rate, which contributes to population resiliency and ultimately to the redundancy and representation of the species.

Since completion of our previous 5-year status review, more information has become available about the relationship between nesting and foraging habitats, and their influence on murrelet movement and distribution. Use of these disparate habitats is not independent; for successful chick rearing, foraging and nesting areas must occur within daily commuting distance of one another to allow for continued foraging by adults while they incubate their egg and rear their chick. Accordingly, murrelet abundance at sea during the breeding season is correlated with the presence of good-quality nesting habitat in the adjacent terrestrial environment (Raphael et al. 2015, p. 20; Lorenz et al. 2016, p. 1; Raphael et al. 2016 p. 101; Pastran et al. 2021, p. 1), while terrestrial sites are most likely to be occupied by murrelets when they occur in areas with more old forest that are closer to high-quality foraging areas (Betts et al. 2020, p. 7). During poor foraging years, which are associated with low nesting propensity, terrestrial features are not the primary drivers of marine habitat use (Garcia-Heras et al. 2024, p. 7).

Demographics and Trends

Murrelet population abundance and trends are estimated through a standardized, coordinated sampling effort within the Northwest Forest Plan (NWFP) area (Conservation Zones 1 through 5) (Figure 1), and a comparable effort in Conservation Zone 6. The most recent population estimate for the entire NWFP area was approximately 19,000 murrelets in 2022 (McIver et al. 2024, p. 4). The annual rate of change between 2001 and 2022, derived from this estimate, is not statistically significant (P-value ≤ 0.05) at the scale of the NWFP area (McIver et al. 2024, pp. 4, 20) (Table 1). While population size is not changing in a detectable way across the NWFP area, population trends vary by conservation zone and by state, with murrelet decreases in the north (Conservation Zones 1 and 2) apparently offset by murrelet increases farther south (Conservation Zones 3 and 4). Outside of the NWFP area, in Conservation Zone 6, surveys indicated an

estimated population size of 397 murrelets, with no trends in abundance detected for the 1999 to 2022 time frame (Felis et al. 2022a, p. 3-4) (Table 1).

Table 1. Estimated long-term abundance trend for murrelets, by conservation zone. Asterisk (*) indicates statistically significant annual rate of change (P-value ≤ 0.05) (McIver et al. 2024, p. 20; Felis et al. 2022b, pp. 3-5).

Conservation Zone(s)	Period of analysis	Annual rate of change (percent)	95% Confidence interval	Standard error
Zones 1-5 (NWFP Area)	2001-2022	0.0	(-0.8 to 0.8)	
Washington	2001-2022	–4.1*	(-5.2 to -3.0)	
Oregon	2000-2022	1.7	(0.8 to 2.7)	
California (NWFP portion only)	2000-2023	3.6	(2.2 to 5.1)	
Zone 1	2001-2022	–4.6*	(-6.4 to -2.7)	
Zone 2	2001-2023	–3.5*	(-5.8 to -1.0)	
Zone 3	2000-2022	1.6*	(0.03 to 2.9)	
Zone 4	2000-2023	2.8*	(1.3 to 4.4)	
Zone 5	2000-2021	1.5	(-7.1 to 11.7)	
Zone 6	1999-2022	0.01		0.009

Reproductive success, or productivity, is low for murrelets within the listed range. Telemetry-based studies indicate that fecundity rates, calculated from estimates of nesting attempts and nesting success, range from 0.021 to 0.063 (Peery et al. 2004, p. 1094; Service 2024, p. 54). At-sea survey-based methods indicate that juvenile-to-adult ratios range from 0 to 0.067 (Strong 2022, p. 17; Strong 2023, p. 17). Date-corrected juvenile-to-adult ratios, which account for adults that are still incubating eggs and chicks that are not yet fledged at the time of the survey, range from 0 to 0.091 (Lorenz and Raphael 2018, pp. 206, 211; Felis et al. 2022a, p. 4). Each of these estimates is well below the level thought to be necessary to maintain a stable population; demographic modeling, historical records, and comparisons with similar species all suggest that murrelet population stability requires fecundity to be between 0.20 and 0.46 or juvenile-to-adult ratios to be between 0.15 and 0.3 at the end of the breeding season (Beissinger 1995, p. 390; Beissinger and Peery 2007, p. 302; Service 1997, p. B-13). Even the lower end of these ranges is substantially higher than estimates of productivity for any of the conservation zones. Although estimates obtained from telemetry studies and uncorrected juvenile ratios are prone to underestimation, the magnitude of difference between observed rates and required rates indicates that the murrelet reproductive rate is likely insufficient to maintain stable population numbers throughout all the species' listed range.

There are several uncertainties associated with at-sea survey results and other available demographic data. First, these abundance estimates do not reflect the abundance of the local breeding population. Rather, they include both locally breeding and non-breeding birds, as well as transient birds (McIver et a. 2021, p. 26). They also do not account for movement of murrelets

among conservation zones or between the U.S. and Canada, which confounds interpretation of changes in abundance over time, particularly at the conservation zone scale (McIver et al. 2021, p. 26; Loehle et al. 2023, pp. 23-27). Because murrelets are highly mobile and respond to changes in both the marine and terrestrial environments (Raphael et al. 2015, p. 17), reported trends may not reflect meaningful changes in demographic metrics, especially at a local scale. In addition, observed low reproductive rates are at odds with the apparently stable population size. Nevertheless, at-sea abundance estimates represent the best available information relative to murrelet population size, and are a valuable tool for assessing status, particularly at the range-wide scale.

Current Viability

We used the conservation principles of resiliency, redundancy, and representation to assess the viability of marbled murrelet within its listed range, as described in the SBR (Service 2024, pp. 1-2). We evaluated population resiliency at the conservation zone scale, using a condition category model (Figure 2) where we computed a metric of resiliency based on the unweighted mean of three available demographic metrics (abundance, trend in abundance, and productivity). For the first metric, we used the range of at-sea abundance estimates for the last six years (2018 to 2023). For the second metric, we categorized long-term trend according to whether it represents a declining, stable/ambiguous, or increasing populations. We incorporated the third demographic metric, productivity, by considering what the available information indicates about murrelet reproductive potential more broadly. A detailed description of our methodology is available in the SBR (Service 2024, pp. 54-57).

Metric	**Condition Scoring**			
Abundance	Abundance >5000 murrelets (3 points)	Abundance 500-5000 murrelets (2 points)	Abundance 200-500 murrelets (1 point)	Abundance <200 murrelets (0 points)
Trend in Abundance	Evidence of a long-term population increase (3 points)	No evidence of a long-term population trend (2 points)	Evidence of a long-term population decrease (1 point)	
Productivity	Juvenile ratios > 0.3; Overall fecundity > 0.46 (3 points)	Juvenile ratios 0.15-0.3; Overall fecundity 0.20-0.46 (2 points)	Juvenile ratios < 0.15; Overall fecundity < 0.20 (1 points)	

Figure 2. Condition category model used to assess current resiliency of marbled murrelets, at the conservation zone scale.

Population resiliency ranges from moderate to very low (Table 2). It is highest in the central portion of the range, in Conservation Zones 3 and 4, and lower in in the northern and southern portions of the range, in Conservation Zones 1, 2, 5, and 6. Within our analytical framework, low

resiliency is a result of small population size and/or declining trend, coupled with poor productivity.

Table 2. Murrelet resiliency by conservation zone.

Conservation Zone	Abundance Range 2018-2023	Trend in Abundance	Productivity	Resiliency
Zone 1	3,143-3,843	Decreasing	Low	Low
Zone 2	1,018-1,657	Decreasing	Low	Low
Zone 3	8,249-8,414	Increasing	Low	Moderate
Zone 4	5,132-6,822	Increasing	Low	Moderate
Zone 5	42	No trend	Low	Very low
Zone 6	266-408	No trend	Low	Low

To evaluate species redundancy, we considered the number and distribution of populations relative to the scale of anticipated catastrophic events. To evaluate representation, we considered the breadth of genetic and ecological diversity found within a species. This evaluation indicates that murrelets within the listed range continue to have the ability to withstand catastrophic events (redundancy) and have some ability to adapt to changes in their physical and biological environments (representation). The species continues to occupy its historical range in Washington, Oregon, and California. Given their current widespread distribution, we do not expect that the species will face extinction as a result of one or more catastrophic events. While catastrophic events such as fire and marine heatwaves are currently present on the landscape, may result in deleterious effects to murrelets and their habitat, and are likely to increase in the future, we do not expect that the scope and scale of these events will cause extinction of the species within its listed range. Similarly, the genetic and ecological diversity found with the species indicates that murrelets have at least some capacity to adapt to changing physical and biological conditions. However, this adaptive capacity may be limited for changes that develop rapidly.

Threats Analysis

When analyzing influence factors, we distinguish between factors that have negative impacts (threats) and those that have positive impacts (conservation measures). Additionally, we consider whether the impacts are of sufficient scope and magnitude that they affect not only individual murrelets, but also rise to level of having population-level effects. Although we considered both historical and potential future threats, for the purposes of our threats analysis and evaluation of species' status, we only include influence factors that are currently having a population-level effect.

When the species was listed in 1992, loss and modification of suitable nesting habitat due primarily to timber harvest (Factor A) was identified as the primary threat facing the species. Gill-net fisheries in Washington (Factor E), predation (Factor C), and oil spills (Factor E) were identified as secondary threats. It was also determined that existing regulatory mechanisms (Factor D) were inadequate to ensure the survival of the species. Threats that currently have a population-level effect include timber harvest (Factor A), fire (Factor A), predation (Factor C),

coastal and nearshore development (Factor E), and climate change (Factor E). Existing regulatory mechanisms (Factor D) remain inadequate to fully protect remaining nesting habitat. Additional threats to the species include tree disease (Factor A), wind events (Factor A), toxic contaminants (Factor E), net entanglement (Factor E), oil spills (Factor E), energy generation (Factor E), and Highly Pathogenic Avian Influenza (Factor C). However, the best available information does not indicate that these additional threats currently act on the species at the population level. Therefore, they are not included in our evaluation of status.

Timber Harvest

Timber harvest includes a range of activities such as removal of trees and operation of heavy equipment, which can change the structure and availability of nesting habitat and result in elevated sound levels and visible human activity near nests. The loss and modification of nesting habitat reduces site availability and displaces murrelets with site fidelity, and can have several impacts on murrelets, including nest site abandonment, delayed breeding, failure to initiate breeding in subsequent years, and failed breeding due to increased predation risk at a marginal nesting location (Divoky and Horton 1995, p. 83; Raphael et al. 2002, p. 232). These outcomes reduce nesting success, which ultimately influences recruitment of juvenile birds into the local population (Raphael et al. 2002, pp. 231-233).

Historical timber management during the 20th century significantly reduced the area of potential murrelet habitat in Washington, Oregon, and California (Perry 1995, p. 382). As of 2017, there were approximately 8.1 million ha (20 million acres) of lands capable of supporting forest within the NWFP area. However, only about 7 percent of those lands are currently considered nesting habitat (Lorenz et al. 2021, pp. 2-3, 25). Loss of nesting habitat, primarily due to commercial timber harvest, is implicated in the historical decline of murrelets (57 FR 45328, October 1, 1992). Although loss of nesting habitat due to timber harvest has slowed considerably since the time of listing, these losses continue, with a net loss of 8,436.5 ha (20,847 acres; 1.38 percent) of murrelet nesting habitat across all ownerships within the NWFP area (Conservation Zones 1 through 5) between 1993 and 2017 (Lorenz et al. 2021, pp. 29-30). Timber harvest is the leading attributable cause of nesting habitat loss in each of Conservation Zones 1 through 4, and accounts for approximately 71 percent (63,065.1 ha; 155,837 acres) of gross nesting habitat loss across Conservation Zones 1 through 5, with the majority of losses occurring on nonfederal lands (Lorenz et al. 2021, pp. 33, 43-44). Most of the murrelet nesting habitat in Conservation Zone 6 is found in state parks or other public lands, where logging has not occurred (Halbert and Singer 2017, p. 1). Timber harvest has not been identified as a major contemporary threat or source of nesting habitat loss in Zone 6 (Halbert and Singer 2017, p. 30).

While there are no clear predictions for what magnitude of harvest is likely to occur across the listed range in the future, 96 percent of the nesting habitat loss attributed to timber harvest between 1993 and 2017 occurred on nonfederal lands (Lorenz et al. 2021, p. 33). Nonfederal lands are generally managed on a shorter rotation schedule than what is needed to develop nesting habitat (about 125 years) (Sutherland et al. 2016, p. 66), and there is no indication that these patterns of forest removal will not continue for the foreseeable future.

Wildfire

Wildfire can involve tree mortality, changes in canopy cover, and changes in nest platforms, all of which change the structure and availability of nesting habitat and can result in the direct mortality and reduced fitness of adults and nestlings during a fire event. Loss or modification of nesting habitat from fire can subsequently impact connectivity between nesting and foraging habitat.

Historically, the moist forests of western Washington have been characterized by large, stand-replacing fires occurring at intervals of 200 years or more (Long et al. 1998, p. 784; Halofsky et al. 2018, pp. 3-4; Haugo et al. 2019, pp. 2-3), while forests in southern Oregon and California have been characterized by low- and mixed-severity fires occurring every 35 years or less (Perry et al. 2011, p. 707; Haugo et al. 2019, pp. 2-3). In the past several decades, the duration of fire-weather season in the western U.S. has increased significantly, and the total burn area has more than doubled in size (Abatzoglou and Williams 2016, pp. 11,771-11,772), with the Pacific Northwest having the greatest percent increase in the number of wildfires and extent of area burned (Westerling 2016, p. 4; Davis et al. 2017, p. 176). Annual fire extent has increased over time and can be associated with drought conditions (Reilly et al. 2017, pp. 9-10).

Across all land ownerships within the NWFP area, wildfire accounted for approximately 2 percent (1,350.8 ha; 3,338 acres) of gross nesting habitat loss in Conservation Zones 1 through 5 between 1993 and 2017 (Lorenz et al. 2021, pp. 33, 43-44). While the most acres lost due to wildfire occurred in Washington (Conservation Zones 1 and 2), the highest proportion of murrelet habitat lost occurred in California (Conservation Zone 5). The threat of fire in Conservation Zone 5 is especially concerning given the small amount of murrelet habitat that remains.

Outside of the NWFP area, in Conservation Zone 6, the 2020 CZU Lightning Complex Fire burned approximately 35,008 ha (86,509 acres) (Cal Fire 2021, unpaginated; Singer, S., in litt. 2023). The burn perimeter for the CZU Lightning Complex Fire almost completely overlaps with murrelet favored nesting range in the Santa Cruz mountains and burned roughly 61 percent of acreage where murrelet occupancy had been detected in Conservation Zone 6 (Singer, S., in litt. 2023).

Predation

Predation affects murrelets via direct mortality, whether through nest predation in coastal forests or through adult and juvenile predation inland or at sea (Nelson and Hamer 1995, p. 93). Studies across the species' listed range indicate that nest predation is a limiting factor on murrelet populations (Nelson and Hamer 1995, p. 93; McShane et al. 2004, p. 2-16; Piatt et al. 2007, p. 22), and several studies have identified nest predation as the leading cause of nest failure for murrelets (Luginbuhl et al. 2001, p. 556; Peery et al. 2004, pp. 1093-1094; Golightly and Schneider 2011, p. 4). Some studies suggest that as much as 67, 78, or 81 percent of nest failures are due to predation (Luginbuhl et al. 2001, p. 556; McShane et al. 2004, p. 4-87; Peery et al. 2004, pp. 1093-1094). However, others have not found such evidence of predation in their study of nest failures (Lorenz et al. 2019, p. 160), revealing a degree of uncertainty associated with depredation studies. While the rates of nest failure due to predation are variable from study to

study, reported rates are generally higher in California than in Oregon and Washington (McShane et al. 2004, p. 4-87).

The rate of predation of artificial nests has been significantly correlated to corvid (i.e., crows, ravens, and jays) abundance, particularly near human settlements and campgrounds (Marzluff and Neatherlin 2006, p. 310; Hébert and Golightly 2007, p. 221; Malt and Lank 2009, p. 1274). Food subsidies at campgrounds have contributed to the abundance of Steller's jays (*Cyanocitta stelleri*) in campgrounds (Singer et al. 1991, p. 330; West et al. 2019, p. 6), and reducing these anthropogenic subsidies has been shown to reduce Steller's jay population densities in protected areas (Brunk et al. 2021, p. 6). Bird feeders and roadkill also subsidize corvid populations. Increased nest predation is also associated with proximity of nests to forest edges, which may be because corvids are generalist predators that can utilize these forest edge habitats and are present more frequently and at higher densities than in other portions of the landscape (Malt and Lank 2007, 165, 169; Hagar et al. 2024, pp. 4-5). Corvid management actions, such as visitor education, at some California State Parks have demonstrated that reducing anthropogenic subsidies can successfully reduce generalist predator populations at campgrounds (Brunk et al. 2021, p. 7), which may be ameliorating nest predation of murrelets near campgrounds, and could potentially continue to do so in the future.

Predation of juveniles and adults is also attributable to raptors. Of the tagged adult murrelet fatalities documented in one radio-tagging study, approximately half of the tagged murrelet fatalities were attributed to raptor predation, specifically bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*) (Garcia-Heras et al. 2020, unpaginated). Given the recovery of avian predator populations, predation by raptors may represent a growing threat, relative to the time of listing.

Coastal and Nearshore Development

Coastal and nearshore development involves a suite of activities, including underwater detonation; pile-driving; heavy equipment use; vehicle, vessel, and air traffic; culvert and bridge repair; stormwater facilities; shoreline modifications; repair, maintenance, and installation of in-water or overwater structures; and dredging. These activities can produce elevated underwater and in-air sound levels, visual disturbance, and altered forage conditions for murrelets. Specific effects of exposure to these conditions include avoidance behaviors, flushing, diving, increased vigilance, aborted feeding attempts, physiological stress, auditory injury, and barotrauma (Yelverton et al. 1973, pp. 45-51; Yelverton et al. 1975, p. 17; Yelverton and Richmond 1981, p. S84; Korschgen et al. 1985, p. 290; Turnpenny and Nedwell 1994, pp. 29-30; 67 FR 48145, July 23, 2002; Schummer and Eddleman 2003, p. 789; Hastings and Popper 2005, pp. 25-40; Agness et al. 2008, p. 346; Halvorsen et al. 2012, pp. 604-607; Arlettaz et al. 2015, p. 1208; Kleist et al. 2018, pp. E650-E653).

Coastal and nearshore development can also result in degradation of foraging habitat through shading from overwater structures, disruption of natural shoreline processes, increased risk of exposure to contaminants, and, ultimately, reduced prey availability. Foraging activity of murrelets has been shown to have a linear relationship with prey availability (Ronconi and Burger 2008, p. 256), and decreased prey availability leads to increased energy expenditure by murrelets. When forage conditions are moderate to poor, murrelets may forgo breeding (Cairns

1987, p. 264; Furness 2007, p. 249; Cury et al. 2011, p. 1704; Garcia-Heras et al. 2024, pp. 9-12), and it has been demonstrated that murrelets have decreased reproductive success in years with low prey availability (Peery et al. 2004, p. 1094-1095; Becker et al. 2007, p. 276; Ronconi and Burger 2008, p. 252).

Development occurs throughout the listed range of the murrelet in all six Conservation Zones but poses the biggest threat to murrelets in Conservation Zones 1 through 4 and in areas with a dense human population such as Puget Sound or Monterey Bay. An evaluation of the relative influence of marine and terrestrial factors on the distribution and abundance of murrelets within the NWFP area found that marine-human footprint was the second-best predictor in Conservation Zone 1, likely reflecting the relative higher impact of development activities in this conservation zone (Raphael et al. 2016, p. 106; McIver et al. 2021, p. 29) and indicating that coastal and nearshore development occurs at a scope and magnitude sufficient to have a population-level effect. As the human population continues to grow and shipping traffic increases in the coastal areas, the foraging areas used by murrelets may become further restricted by coastal and nearshore development. Elevated sound levels associated with development vary in their intensity and duration, but human population growth can be used as a general surrogate for anthropogenic noise. In the past two decades, populations in Washington, Oregon, and California have all shown an increasing trend that we can expect to continue into the future (World Population Review 2023a, b, c, unpaginated), indicating that the threat of coastal and nearshore development will continue to impact murrelet populations into the future.

Climate Change

Climate change is a multi-dimensional threat that impacts both the terrestrial and marine environments occupied by murrelets. In the terrestrial habitat, atmospheric changes associated with climate change, primarily air temperature and changing precipitation patterns, impact the frequency and intensity of forest disturbances like drought, fires, and insects. Historically, forests within the listed range of the murrelet have not typically been water limited, especially in Washington and northern Oregon (McKenzie et al. 2001, p. 531; Nemani et al. 2003, p. 1560; Littell et al. 2010, p. 139). However, in recent decades, every part of the listed range has been affected by multi-year drought at some point from 1918 to 2014 (Crockett and Westerling 2018, p. 345). In 21st century, water deficits affecting forests are not expected to be uniform, with the California and southern Oregon Coast Ranges, Klamath region, eastern Olympic Peninsula, and parts of the Cascades and northern Oregon Coast Range projected to experience greater hydrological drought, and some portions of the Washington Cascades and Olympic Mountains projected to experience reductions in water deficit (McKenzie and Littell 2017, p. 31).

The effects of climate change are already being observed within the murrelet's listed range. In western Washington, Oregon, and southwestern British Columbia, tree mortality more than doubled from 1975 to 2005, likely due to increasing water stress (van Mantgem et al. 2009, pp. 522-523). Such mortality can be caused directly by warm dry conditions, or when dry conditions compound the effects of fire, insects, and tree disease. Increased drought conditions are associated with increased annual fire extent, and changes in the intensity and frequency of wildfire are related to climatic changes (Reilly et al. 2017, pp. 9-10). Similarly, higher average temperatures and warmer winters likely increase the severity and distribution of insects and

diseases like bark beetles and Swiss needle cast, which can result in tree mortality and changes in canopy cover (Littell et al. 2010, p. 146; Shaw et al. 2021, p. 417).

The primary changes to ocean conditions resulting from climate change include increasing sea surface temperatures; increasing frequency, severity, and duration of marine heatwaves; increasing ocean acidification; rising sea levels; and changes in primary productivity. These changes lead to altered forage conditions (i.e., prey availability, abundance, and quality) for murrelets. In the northeastern Pacific Ocean, capelin, Pacific sand lance, and rockfish (*Sebastes* spp.) abundance are all negatively correlated with seasonal sea surface temperatures (Thayer et al. 2008, p. 1616). The abundance and nutritional quality of forage fishes on the continental shelf, including capelin (*Mallotus catervarius*), sand lance, and Pacific herring, decreased during and after heatwaves that occurred between 2014 and 2016 (Arimitsu et al. 2021, p. 1859; Cushing et al. 2023, p. 23).

Changes in forage conditions can negatively impact reproductive success, fitness, and survival. Murrelets forego breeding when forage conditions are moderate to poor (Cairns 1987, p. 264; Furness 2007, p. 249; Cury et al. 2011, p. 1704; Garcia-Heras et al. 2024, pp. 9-12), and have decreased reproductive success in years with low prey availability (Peery et al. 2004, p. 1094-1095; Becker et al. 2007, p. 276; Ronconi and Burger 2008, p. 252). In other alcids, reproductive success and chick survival is higher when nestling diets consist of energy-dense, high-lipid content prey (Litzow et al. 2002. p. 292; Romano et al. 2006, p. 411), and food limitation during nesting can result in poor growth, delayed fledging, increased mortality of chicks, and nest abandonment by adults (Øyan and Anker-Nilssen 1996, p. 836). These changes in reproductive success and survival may be further exacerbated by the increased exposure and vulnerability of murrelets to harmful algal blooms and other diseases that are increasing due to climate change.

Climate-related changes in the terrestrial and marine environments are occurring throughout the listed range of the murrelet, and changes are expected to increase in intensity into the future. The effects of these changes impact individuals and populations through loss and modification of nesting habitat, changes to forage conditions, reduced fitness, and reduced nesting success. While the magnitude of these impacts into the future is relatively uncertain and the geographic scope is highly variable, climate change currently affects murrelets at a population level and is expected to continue to do so in the future.

Conservation Measures

Conservation measures exist for murrelets throughout their range. We focus on protections and conservation benefits provided by federal and state statute and regulation (Factor D) while recognizing that conservation benefits to the species may also arise from efforts taken outside of these statutory and regulatory frameworks.

There are several Federal provisions that provide protection for marbled murrelets. Among the most consequential is the NWFP. Protections include a system of congressionally reserved lands and late-successional reserves. These reserves were designed to protect most remaining old-growth forests and encompass a high proportion of murrelet nesting habitat on federal lands. The NWFP requires that, on federal lands within the murrelet range, occupancy surveys be conducted before forest management projects that would remove murrelet nesting habitat begin. If

occupancy surveys are positive, all contiguous existing and recruitment habitat within a 0.81-km (0.5-mile) radius becomes protected (USDA and USDI 1994a, pp. C–8-C–10). As of 2017, there were approximately 8.1 million ha (20 million acres) of lands capable of supporting forest within the NWFP area. However, only about 7 percent of those lands are currently considered nesting habitat (Lorenz et al. 2021, pp. 2-3, 25). The pattern of nesting habitat loss and accrual between 1993 and 2017 varies among conservation zones, with Zones 1, 2, and 5 experiencing an overall loss in nesting habitat, and Zones 3 and 4 experiencing an overall gain in nesting habitat (Table 3) (Lorenz et al. 2021, pp. 29-30). The majority of nesting habitat occurs on federal lands that have been designated reserves in the NWFP, as detailed in Table 4 (Lorenz et al. 2021, pp. 25, 39). Overall, the NWFP is an important mechanism for protecting and assessing the availability of nesting habitat.

Table 3. Net change in modeled nesting habitat from 1993 to 2017 by Conservation Zone (Lorenz et al. 2021, pp. 39-41)

Conservation Zone	Nesting habitat in 1993 (acres)	Nesting habitat in 2017 (acres)	Net change in habitat (acres [percent])
Zone 1	512,645	476,793	-35,851 [-6.99%]
Zone 2	487,372	459,186	-28,186 [-5.78%]
Zone 3	439,852	474,561	34,710 [7.89%]
Zone 4	71,100	79,611	8,511 [11.97%]
Zone 5	2,107	2,077	-31 [-1.49%]
Total	**1,513,076**	**1,492,228**	**-20,847 [-1.38%]**

Table 4. Acres of modeled nesting habitat within the NWFP area by conservation zone and landowner, in 2017 (Lorenz et al. 2021, pp. 25, 39)

Conservation Zone	Federal Reserved (acres)	Federal Non-reserved (acres)	State (acres)	Other Landowners (acres)	Total (acres)
Zone 1	332,707	31,958	50,544	61,584	476,793
Zone 2	369,685	7,683	44,256	37,562	459,186
Zone 3	254,302	35,814	80,235	104,210	474,561
Zone 4	30,167	2,920	20,588	25,936	79,611
Zone 5	484	11	511	1,071	2,077
Total	**987,347**	**78,386**	**196,144**	**230,353**	**1,492,228**

Murrelets also receive protections through the Bureau of Land Management (BLM) Resource Management Plans (RMPs). As a result of adoption of new RMPs in 2016, BLM lands in Oregon that were previously managed under the NWFP are now managed under the revised RMPs (BLM 2016a, entire; 2016b, entire). This change resulted in the addition of 12,946 ha (31,991 acres) of habitat designated as reserves, including an additional 7,298 ha (18,034 acres) of highly suitable habitat. In addition, for new murrelet sites recognized under the RMPs, occupied stand protection

and associated Late Successional Reserve mapping changed from only protecting contiguous habitat within 0.8 km (0.5 miles) of an occupied murrelet site to protecting all forest structure within 0.4 km (0.25 mi), with an additional 90 m (300 foot) buffer. The revised RMPs also include protection from disruption in stands known to be occupied by murrelets, which the NWFP did not.

After lands managed by USFS or BLM, most remaining federal lands within the listed range of murrelets are administered by the National Park Service (NPS). Unlike USFS and BLM administered lands, which were included in the NWFP management provisions, NPS administered lands were designated Congressionally Withdrawn Areas under the NWFP (FEMAT 1993, p. II-19). As such, they are not managed according to the NWFP, but are instead managed according to existing management plans and applicable federal law (USDA and USDI 1994b, pp. S-7). In contrast to USFS and BLM, whose mandates include resource extraction, the NPS is mandated to "to conserve the scenery and the natural and historic objects and the wild life [sic] therein" (NPS 2022, unpaginated). Consequently, murrelet habitat that occurs on NPS administered land is considered to be in conservation status. Nesting habitat that occurs on NPS lands are included in the total presented in Table 4.

Several state laws and regulations also offer protections for murrelets. The species is listed as endangered under state endangered species laws in Washington, Oregon, and California (WDFW 2022, p. 1; ODFW 2023, unpaginated; CNDDB 2023, p. 21). These laws provide similar, but typically more limited, protections than the Federal Endangered Species Act. In addition, murrelet habitat that is not conserved via the NWFP or other federal protections receives at least some protection under state forest practice rules. These rules cover state- and privately-owned lands and apply to known, occupied habitats. Protections vary by state, but generally include buffering occupied sites and restricting harvest within these buffers and retaining vegetation in riparian corridors. Despite these protections, loss of nesting habitat due to timber harvest on state and private land continues. Between 1993 and 2017, approximately 150,000 acres of modeled nesting habitat on non-federal land was lost due to timber harvest, compared to approximately 6,000 acres on federal land (Lorenz et al. 2021, p. 33).

In addition to the murrelet-specific conservation measures discussed above, there are other federal and state laws that provide protections to species and their habitats (e.g., the Migratory Bird Treaty Act, the National Environmental Policy Act, the Clean Water Act). Although murrelets may not be named specifically in these laws, the protections they provide contribute to the overall conservation of murrelets. Many of these laws are described in more detail in Appendix B of the 2009 Marbled Murrelet 5-year review (Service 2009, entire).

There are a number of other conservation measures specific to marbled murrelets within the listed range. These include numerous Habitat Conservation Plans and Safe Harbor Agreements, primarily within Conservation Zones 1 and 2. These agreements, authorized under section 10 of the Act, are intended to provide long term certainty for both murrelet conservation and landowners. In addition, funding for conservation planning, land acquisition, and other conservation activities is available through the Cooperative Endangered Species Conservation Fund, authorized in section 6 of the Act, and the Natural Resource Damage Assessment and Restoration Program, which seeks to restore natural resources that are injured as a result of oil

spills or hazardous substances releases. Finally, within Conservation Zones 1 and 2, there are several Tribal conservation measures that have a federal nexus and for which we have records. Compared to other Federal and state protections described above, these programs have a more modest, but not insignificant impact on murrelet conservation. A more complete summary of these conservation measures is available in the SBR (Service 2024, pp. 38-48).

Summary
The CA, OR, WA DPS of marbled murrelet continues to face a number of threats. Loss and modification of habitat (Factor A) continues to act negatively on murrelets, primarily as a result of timber harvest and wildfire. Regulatory protections (Factor D) have improved since the time of listing, but continued loss of nesting habitat as a result of legally permitted timber harvest indicates that regulatory mechanisms are not sufficient to fully protect remaining habitat. Additional threats include predation (Factor C) and manmade factors (Factor E), including nearshore and coastal development and climate change that act through changes in nesting habitat and foraging conditions. Overutilization for commercial, recreational, scientific, or educational purposes (Factor B) is not a present threat to the species.

Recovery Criteria

Recovery Plan: U.S. Fish and Wildlife Service. 1997. Recovery Plan for the Threatened Marbled Murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California. U.S. Fish and Wildlife Service, Region 1. Portland, Oregon. 203 pp.

The recovery plan includes two interim delisting criteria: (1) trends in estimated population size, densities and productivity have been stable or increasing in four of the six Conservation Zones over a 10-year period, which should encompass at least one to two El Niño events, and (2) management commitments, including protection and monitoring in marine and terrestrial habitats, have been implemented to provide adequate protection of marbled murrelets in the six Conservation Zones for at least the near future (50 years). These criteria have not been fully satisfied. Based on the available statistical analysis of trends, population size appears to be decreasing within two conservation zones, increasing within two conservation zones, and showing neither a positive nor negative trend in the remaining two conservation zones. However, because estimates of productivity remain very low throughout the listed range and do not appear adequate to sustain a demographically stable population, Criterion 1 has not been fully met. Research and monitoring of marbled murrelet populations has been ongoing, and implementation of landscape management plans has substantially reduced the loss of nesting habitat. Yet, while trends in nesting habitat vary across conservation zones, rangewide acreage has continued to decline slightly. It is unclear whether these actions are sufficient to ensure long-term protection of the species, given the current and anticipated future threats including climate-related changes in the marine and terrestrial environments; thus Criterion 2 has been only partially met.

Synthesis
Based on available abundance data, the murrelet population appears to be relatively stable at a range-wide scale. However, at the state and conservation zone scale, trends in abundance are variable, with some areas apparently increasing in abundance, and some areas apparently decreasing. The downward trend in abundance in the northern part of the range is of particular

concern, where declines of 58 percent in Conservation Zone 1 and 33 percent in Conservation Zone 2 have been observed since 2001.

The overall lack of recovery of murrelet populations within their listed range is attributable largely to the effects of low productivity. Murrelets have limited reproductive capacity since they lay a single egg per nesting attempt, nest only once per year, and do not reach sexual maturity until 2 to 4 years of age. Even if murrelets realized their full reproductive potential, the pace of recovery would be slow, about 3 percent per year (Service 1997, pp. 9-10). All indications are that murrelets are not achieving their reproductive potential within the listed range. Across the range, measures of nesting attempts, nesting success, and overall fecundity are well below what is required to maintain the stable population size, indicating that low productivity continues to limit recovery. Mortality of fledged juveniles, subadults, and adults also likely contributes to the overall failure of murrelet recovery following listing.

The ultimate drivers of murrelet status are complex and interactive. The current state of nesting habitat, as a function of both historical and contemporary losses due primarily to timber harvest and wildfire, continues to influence murrelet populations through reduction of reproduction and recruitment. In addition, marine factors that affect prey quality and quantity, including coastal and nearshore development and climate change, also likely influence populations, again linked to reproductive success. Long commutes between quality nesting and quality foraging areas may further contribute to low productivity, as they exacerbate energetic bottlenecks associated with nesting and rearing chicks. Finally, direct mortality, especially predation, also appears to be consequential driver of murrelet status within the listed range.

Our evaluation of viability indicates that population resiliency ranges from moderate to very low, but that murrelets within the listed range continue to have the ability to withstand catastrophic events (redundancy) and have some ability to adapt to changes in their physical and biological environments (representation).

Although available conservation measures do appear to be mitigating some threats in some parts of the listed range, the apparent lack of recovery indicates that they do not outweigh the cumulative effects of ongoing threats to murrelets throughout the entire listed range. Loss of nesting habitat, the primary threat identified at the time of listing, has not been fully abated, and additional threats have been identified. In addition, we anticipate that some existing threats will continue to grow in scope and magnitude. In particular, we expect that the effects of climate change and coastal and nearshore development will have increasingly negative effects of reproductive success, fitness, and survival, acting primarily through altered foraging and nesting habitat conditions. Given the existing low productivity rates and lack of population growth, we conclude that the species remains likely to become endangered in the foreseeable future and therefore continues to meet the definition of a threatened species.

Based on our evaluation of the current state of murrelet populations, habitats, and threats, we have determined that the murrelet should remain listed as threatened. As described above, the interim delisting criteria have not been met. While a number of recovery actions have been implemented and research and monitoring are ongoing, at the listed-range scale, demographic indicators are similar to the time of listing, indicating overall lack of recovery.

RESULTS

Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (*Indicate reasons for delisting per 50 CFR 424.11):*
____ Extinction
____ Recovery
____ Original data for classification in error
_X__ No change is needed

New Recovery Priority Number: NA

Listing and Reclassification Priority Number: NA

RECOMMENDATIONS FOR FUTURE ACTIONS

- Revise the recovery plan (issued in 1997) to incorporate more recent information regarding threats and population status.
- Continue to monitor at-sea abundance and trends, range-wide.
- Continue to monitor terrestrial habitat abundance and trends, range-wide.
- Conduct habitat assessment and evaluate the demographic effects of habitat loss due to fire in Conservation Zone 6.
- Improve our understanding of marine threats, including climate change, and their effects on foraging habitat and associated impacts on diet quality and composition.
- Work with private nonindustrial timberland owners on strategies to retain and enhance murrelet terrestrial habitat, including developing Conservation Benefit Agreements (formerly Safe Harbor Agreements), as appropriate.
- Find opportunities for collaboration on projects that address the above questions and leverage funding sources and existing resources and expertise.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF MARBLED MURRELET (CA, OR, WA DPS)

Current Classification: Threatened

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (*Indicate reasons for delisting per 50 CFR 424.11):*
____ *Extinction*
____ *Recovery*
____ *Original data for classification in error*
__X__ No change is needed

Appropriate Listing/Reclassification Priority Number, if applicable: NA

FIELD OFFICE APPROVAL:

BRADLEY THOMPSON

Digitally signed by BRADLEY THOMPSON
Date: 2024.08.05 11:47:37 -07'00'

Field Supervisor, Washington Fish and Wildlife Office

REGIONAL OFFICE APPROVAL:

Digitally signed by KATHERINE NORMAN
Date: 2024.08.05 12:16:41 -07'00'

Assistant Regional Director, Ecological Services
Pacific Regional Office