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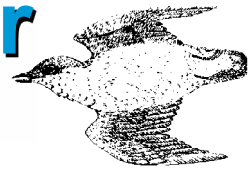
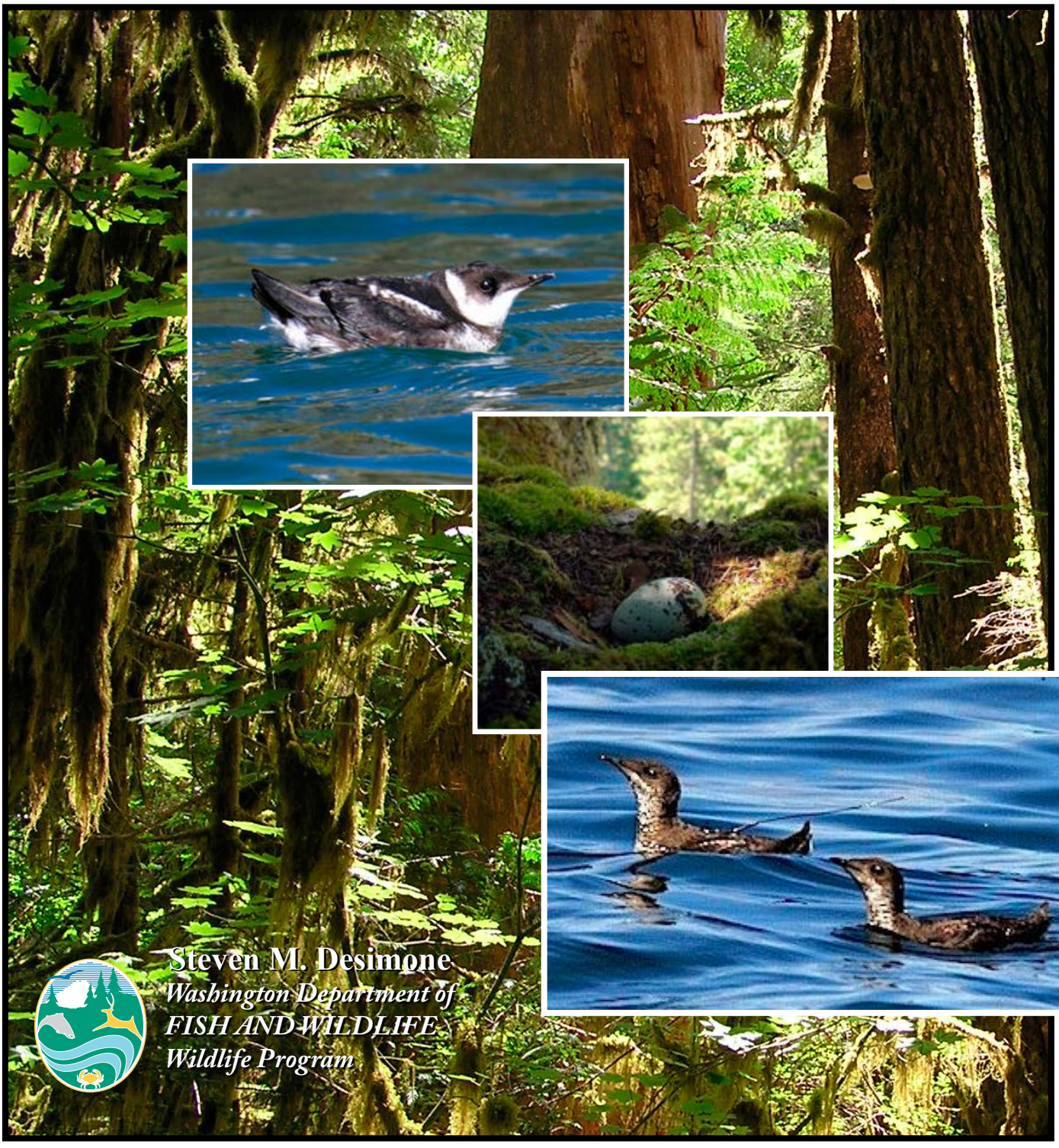
STATE OF WASHINGTON July 2016

Periodic Status Review for the Marbled Murrelet





Steven M. Desimone
Washington Department of
FISH AND WILDLIFE
Wildlife Program

The Washington Department of Fish and Wildlife maintains a list of endangered, threatened, and sensitive species (Washington Administrative Codes 232-12-014 and 232-12-011). In 1990, the Washington Wildlife Commission adopted listing procedures developed by a group of citizens, interest groups, and state and federal agencies (Washington Administrative Code 232-12-297). The procedures include how species listings will be initiated, criteria for listing and delisting, a requirement for public review, the development of recovery or management plans, and the periodic review of listed species.

The Washington Department of Fish and Wildlife is directed to conduct reviews of each endangered, threatened, or sensitive wildlife species at least every five years after the date of its listing by the Washington Fish and Wildlife Commission. The periodic status reviews are designed to include an update of the species status report to determine whether the status of the species warrants its current listing status or deserves reclassification. The agency notifies the general public and specific parties who have expressed their interest to the Department of the periodic status review at least one year prior to the five-year period so that they may submit new scientific data to be included in the review. The agency notifies the public of its recommendation at least 30 days prior to presenting the findings to the Fish and Wildlife Commission. In addition, if the agency determines that new information suggests that the classification of a species should be changed from its present state, the agency prepares documents to determine the environmental consequences of adopting the recommendations pursuant to requirements of the State Environmental Policy Act.

This document is a Draft Periodic Status Review for the Marbled Murrelet. It contains an update of information pertaining to the status of the Marbled Murrelet in Washington. The Department intends to present the results of this periodic status review to the Fish and Wildlife Commission at a meeting in November 2016.

Submit written comments by e-mail on this report by 10 October 2016 to:
T&Epubliccom@dfw.wa.gov

Or by mail to:

Listing and Recovery Section Manager, Wildlife Program
Washington Department of Fish and Wildlife
600 Capitol Way North, Olympia, Washington 98501-1091

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On the cover: photo of two murrelets by Aaron Barna; bird in winter by U. S. Fish and Wildlife Service; murrelet egg by Nick Hatch; background by Derek Stinson.
Black and white illustration by Siobhan Sullivan

This work was supported in part by personalized and endangered species license plates

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The periodic status review for Marbled Murrelet provides a relevant summary of the best available science to date that informs the current status of the species and makes a recommendation as to what the conservation status should be based on the information. It is not intended to be a comprehensive species account describing the entirety of the state of knowledge of the species.

This document was reviewed by species experts and state and federal agencies. This was followed by a 90-day public comment period from July 12 to October 10, 2016. All comments received were considered during the preparation of the final periodic status review. The Department intends to present the results of this periodic status review to the Fish and Wildlife Commission for action at the November 2016 meeting.

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ACKNOWLEDGMENTS

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EXECUTIVE SUMMARY

The Marbled Murrelet (*Brachyramphus marmoratus*) is a small seabird that inhabits nearshore marine environment in western North America. The distribution of murrelets in Washington includes the southern Salish Sea and the outer coast. The species was listed as threatened under the U.S. Endangered Species Act in 1992 in Washington, Oregon and California, primarily due to loss of old forest nesting habitat from commercial timber harvesting and mortality associated with net fisheries and oil spills, and was subsequently listed by the Washington Fish and Wildlife Commission as threatened in 1993. In 1997, Washington enacted State Forest Practices Rules to address impacts to murrelets of timber management on non-federal lands. Marbled Murrelets forage in the marine environment and fly up to 55 miles inland where they nest and rear a single young on large tree limbs in mature and old conifer forests. Murrelets prey primarily on a variety of forage fishes, and sometimes on larger zooplankton. They exhibit strong site fidelity to nesting areas, appear to nest in alternate years, on average, and have a naturally low reproductive rate.

In Washington, nesting habitat losses due to timber harvest since 1993 have been substantial, with an estimated loss on nonfederal lands of 30%. For all Washington land ownerships combined, the net loss was 13.3%, an average annual rate of -0.7% per year. At-sea population monitoring from 2001 to 2015 indicated a 4.4% decline annually, which represents a 44% reduction of the population since 2001. The 2015 population estimate for Washington is about 7,500 birds.

Sustained low juvenile recruitment of has been identified as a main cause of the decline, but mechanisms and cumulative interactive affects from threats on individuals and populations is not fully known; vital demographic data are lacking, such as adult and post-fledging survival and reproductive and emigration rates. Nest success is influenced by both terrestrial and marine factors: the availability of nesting sites, and the amount and juxtaposition of nesting habitat, which influences nest predation risk by avian predators such as jays, crows, and ravens. A nest success rate in Washington of 20% for the period 2004-2008 was attributed to nestling starvation or adults abandoning eggs before completing incubation, suggesting low prey availability. Human marine activities appear to influence murrelet abundance and distribution in the Salish Sea. Declines in populations of forage fish species such as herring and anchovy subsequently resulted in an increased use of lower trophic level, less calorie-rich food sources (invertebrates). Ultimately, these changes to the marine food web may have influenced reproductive output. Federal and state landscape plans, and Forest Practices Rules implemented to help stem the loss of higher quality nesting habitat have been beneficial, but sometimes with mixed success.

The magnitude of the population decline indicates that the status of the Marbled Murrelet in Washington has become more imperiled since state listing in 1993. Without solutions that can effectively address these concerns in the short-term, it is likely the Marbled Murrelet could become functionally extirpated in Washington within the next several decades. Therefore, our recommendation is to list the Marbled Murrelet as a state endangered species in Washington.

DESCRIPTION AND LEGAL STATUS

The Marbled Murrelet (*Brachyramphus marmoratus*) is a small seabird of the Alcidae family (Figure 1), inhabiting marine coastal waters in western North America. It has the unusual behavior among seabirds of flying considerable distances inland during the breeding season to establish nest locations. The Marbled Murrelet is considered threatened south of its Alaskan breeding range by federal and state agencies and Canada (Burger 2002, Piatt et al. 2007). The species was listed as threatened in 1992 under the U.S. Endangered Species Act in Washington, Oregon and California, primarily due to loss of old forest nesting habitat from commercial timber harvesting and mortality associated with net fisheries and oil spills (USFWS 1992). It was subsequently listed as threatened by Washington State Fish and Wildlife Commission in 1993 (WAC 232-12-001).

Figure 1. Marbled Murrelet (left to right): adult breeding (Glenn Bartley/Vireo); chick on moss nest (Tom Hamer); adult non-breeding (Rick and Nora Bowers/Vireo).

DISTRIBUTION

Marbled Murrelets are found in coastal marine areas (generally within 5 to 8 km of shore) from the Aleutian Islands of Alaska south along the Pacific coast to central California (Ridgley et al. 2007, Nelson 1997; Figure 2). In Washington, the current and historical marine distribution of the Marbled Murrelet includes the southern Salish Sea (Puget Sound, Strait of Juan de Fuca) and the outer coast (Pacific Ocean; Figure 2). Its terrestrial nesting habitat distribution includes western Washington within 55 miles of marine waters (Falxa and Raphael 2016). Nest locations in Washington have been documented from near sea level to 4200 feet elevation and inland to 36.5 miles from nearest marine water. An audio detection 70 miles from marine waters has been recorded (D. Lynch and W. Ritchie, USFWS, pers. comm.). Analyses of genetic samples from Washington (Bloxton and Raphael 2009), Oregon and California helped confirm an earlier finding that murrelets from mainland Alaska to northern California (the main genetic unit) are genetically distinct from peripheral populations in the central and western Aleutian Islands and from central California (USFWS 2009).

NATURAL HISTORY

Nesting habitat requirements. The species is unusual among Alcids in that it does not nest in colonies at the marine-terrestrial interface. In the central and southern parts of its range, including Washington, the murrelet nests in coastal forests (Barbaree et al. 2014, Bradley and Cooke 2001, USFWS 2009). During April to mid-September, breeding murrelets make daily flights from marine foraging areas to tend inland nest sites.

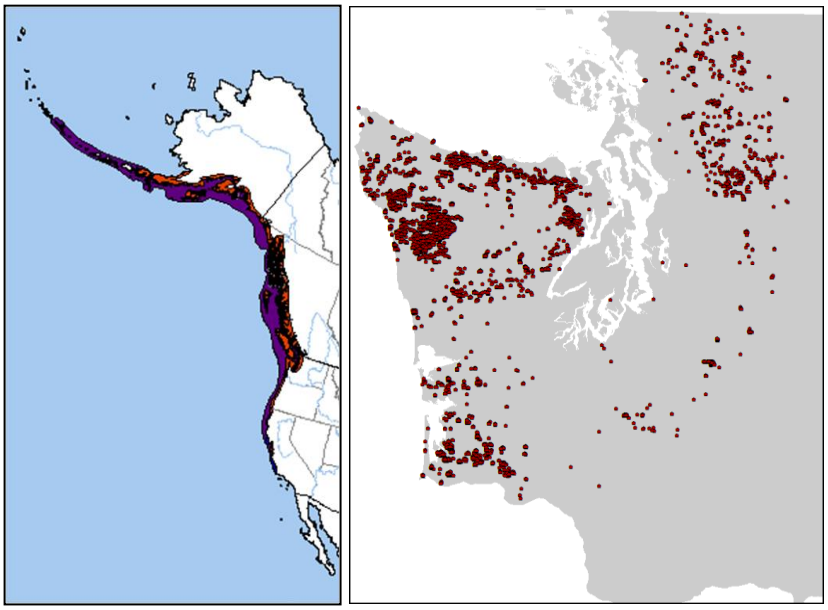

Figure 2. Global range of the Marbled Murrelet (left, Ridgely et al. 2007), and breeding season occurrences in Washington (right, Washington Surveys and Data Management 2016).

In Washington, Marbled Murrelets usually nest in older forests dominated by western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), Douglas-fir (*Pseudotsuga menziesii*) and western redcedar (*Thuja plicata*) trees that have large branches that support substantial moss, epiphytes and debris to form platforms on which a single egg is laid (Hamer and Nelson 1995, Ralph et al.1995, Nelson 1997, Nelson et al. 2006, Wilk et al. 2016; Figure 1). While most nests are on large limbs (e.g., 30-75 cm width) of trees that are >150 years old (Hamer and Nelson 1995, Burger 2002, Wilk et al. 2016), relatively younger patches of predominantly western hemlock (70-100+ years) with mistletoe infection, moss and epicormic branching have been used for nesting in southwestern Washington (Hamer and Nelson 1995, Nelson and Hamer 1995). Nesting habitat includes forest structure of sufficient height and depth to provide vertical and horizontal cover to the nest and nest tree. This structure appears to enhance microclimate conditions and minimizes predation risk by providing hiding cover (Raphael et al. 2002b, Meyer et al. 2004, Huff et al. 2006).

Foraging (Marine) Habitat and Diet. Marbled Murrelets forage in marine waters, usually within 2- 8 km of shore (Nelson 1997, Hebert and Golightly 2008, USFWS 2009). Marbled Murrelets prey primarily on forage fish such as Pacific herring (*Clupea pallasii*), northern anchovy (*Engraulis mordax*), eulachon (*Thaleichthys pacificus*), Pacific sand lance (*Ammodytes hexapterus*), surf smelt (*Hypomesus pretiosis*), juvenile rockfish (*Sebastes* spp.) and juvenile salmon (*Oncorhynchus* spp.). Fish regularly comprise 60-100% of the diet and larger zooplankton, such as krill (Euphausiacea) and Mysiids are also taken (Ralph et al.1995, Nelson 1997, Carter and Sealy 1986, Hobson 1990, Piatt et al. 2007). Murrelets have occasionally been observed using larger freshwater lakes in close proximity to marine areas for limited resting and foraging (Carter and Sealy 1986, WDFW Wildlife Surveys Data Management 2016).

Home Range and Site fidelity. The highest densities of Marbled Murrelets in Washington waters during the breeding season are found on the northern outer coast, northern Puget Sound,

and the Strait of Juan de Fuca (Miller et al. 2006, Lance et al. 2013, Lance and Pearson 2016, Falxa and Raphael 2016, Figure 4). Large areas of mature and old forests adjacent to those areas provide high quality potential nesting sites for murrelets. In Washington, straight-line distance from a nest to the nearest marine shoreline ranged from 4–58 km (2.5-36.5 miles; WDFW Wildlife Surveys Data Management 2016). There is considerable variation in home range size and movement behavior across the species' range (Hull et al. 2001, Bloxton and Raphael 2009, Barbaree et al. 2015). In Washington, movements of radio-marked birds between the outer coast, Puget Sound, and Strait of Juan de Fuca were all observed within a season, indicating that some individuals incorporate substantial movements to secure food resources and may use portions of multiple marine regions in a single year. Several murrelets radio-tagged in Washington waters were later located along Vancouver Island to Desolation Sound (Bloxton and Raphael 2009). A bird nesting in the Hoh River drainage of the Olympic Mountains regularly foraged in the San Juan Islands, making daily flights of about 112 km (70 miles) from the nest, and sometimes visiting the Washington outer coast. A murrelet nesting in the Cascade Range foraged in the San Juan Islands >120 km (75 miles) from the nest (Bloxton and Raphael 2009). The mean home range of adults over 5 breeding seasons varied from 944-1802 km^2 (range 13 to 7,816 km^2) including marine water, land area and travel corridors (Bloxton and Raphael 2009). Northern California breeding season marine foraging areas (land excluded) were 505 ±75 km^2 (Hebert and Golightly 2008).

Marbled Murrelets exhibit strong site fidelity to nesting areas, with some birds documented nesting in the same trees in successive years and re-use of the same nest (e.g., Bloxton and Raphael 2009, Burger et al. 2009, Hebert and Golightly 2006). Multiple pairs nesting within a forest stand is well documented (see Plissner et al. 2015). Marbled Murrelets make social inland flights (usually multiple birds) to re-visit breeding areas in mid-winter (Naslund 1993, O'Donnell et al. 1995, Piatt et al. 2007).

Marbled Murrelet adults are generally assumed not to disperse widely between populations (Peery et al. 2004, Becker and Beissinger 2006, Norris et al. 2007); however, some seasonal migration does occur in Washington, as birds from British Columbia move to the sheltered waters of Puget Sound in fall and winter (Beauchamp et al. 1999).

REPRODUCTION AND SURVIVAL

The Marbled Murrelet is believed to be a relatively long-lived seabird, but reliable longevity estimates are lacking. Average lifespan is estimated at 15 years (U.S. Fish and Wildlife Service http://www.fws.gov/wafwo), and generation time has been estimated between 7 and 13 years (Burger 2002). Golightly and Schneider (2009) reported a breeding bird at least 9-11 years old. The Marbled Murrelet has a low reproductive rate; when in breeding condition, females produce a relatively large single egg (nearly 25% of body mass) and 1 brood per season (Nelson 1997). Given the high energetic cost of breeding, females are not likely to be in breeding condition every year and may nest in alternate years (Hull et al. 2001, Peery et al. 2004, Bradley et al. 2004). Both parents provision the chick daily with fish (1-8 feedings per day; Singer et al. 1991, Nelson and Hamer 1995, Jones 2001, Hebert and Golightly 2006). Marbled Murrelets have a relatively low wing area relative to body mass and consequently it is necessary for them to

constantly flap their wings to remain airborne. Fledging chicks must attempt a direct flight to water without rest to avoid the fatal consequences of grounding. Nest success is influenced by both terrestrial and marine factors: the amount and juxtaposition of nesting habitat and the distribution and quality of adequate food resources (Raphael et al. 2002b; Marzluff et al. 2004; Malt and Lank 2007, 2009).

Adult murrelets were radio-tagged in Washington during 2004-2008 and 20 nests were found and monitored. Four of these nests were surmised to have been successful for a nest success rate of 0.20. Nest initiation rate was an average of 12.6% per year (Bloxton and Raphael 2009). The majority of nest failures appeared to be related to nestling starvation or adults abandoning eggs before completing incubation. This, coupled with a low nest initiation suggests low prey availability during the study (Bloxton and Raphael 2009).

Yearly adult survival was estimated to be 0.83-0.93 in Desolation Sound, British Columbia. Fecundity there was estimated at 0.19 to 0.23 female offspring produced per adult female per year (Cam et al. 2003). Another study using data from California and British Columbia, reported a fecundity estimate of 0.12 (Beissinger 1995). The threshold for fecundity, above which is thought to characterize a stable population, is 0.20 (Beissinger 1995:390). In British Columbia, the likelihood of females breeding in a given year was estimated to be 0.65 (range 0.55 to 0.79) and nest success ranged from 0.38 to 0.48 over 4 years (Bradley et al. 2004).

In a small central California population, the estimated average proportion of breeders was 0.31, and murrelets spent more time foraging in poor reproductive years, suggesting availability of food was low, and so reproduction was limited by food availability and/or nest predation (Peery et al. 2004). At those rates, adult birds in central California are not able to replace themselves, as the fecundity estimate was so low (0.03-0.04; Peery et al. 2004). Annual survival, productivity, fecundity and reproductive viability estimates of Marbled Murrelets remain challenging data to obtain because of the difficulty of finding and capturing murrelets, and the low probability of recapturing birds from year to year. Relatively few studies have been able to achieve sample sizes needed to obtain reasonable estimates of adult survival and nesting success (Cam et al. 2003; Bradley et al. 2004; Peery et al. 2004, 2006a,b).

Survival rates in central California were negatively affected by wearing radio transmitters in the year after tagging (Peery et al. (2006b). Six-year average survival estimates were 0.87 to 0.90 for control (both sexes) and 0.53 to 0.57 for radio-tagged murrelets; it was concluded that radio-tagging caused physical stressors that likely affected murrelet breeding performance and ability to pursue prey (Peery et al. 2006b).

Diet shifts from historical marine trophic levels and murrelet productivity. The effects of decreased or changed prey availability during the last century, thought largely to be from depletion of forage fish, may have driven Marbled Murrelets to increasingly rely on other food sources (e.g., krill, zooplankton) and subsequently led to declines in reproductive output (Becker and Beissinger 2006, Norris et al. 2007, Gutowsky et al. 2009). Becker and Beissinger (2006) calculated about 80 krill equal the caloric value of 1 sardine. Norris et al (2007) reported a 62% drop in trophic feeding level in the northern Salish Sea (Georgia Strait) based on nitrogen isotope data over a period of about 100 years, and suggested that the murrelet population was often

limited by diet quality after the 1950s. Gutowsky et al. (2009) reported a similar change in the diet of nestlings between 1854 and 2008 and suggested this decline in diet quality may have influenced the population decline in the Salish Sea. Becker and Beissinger (2006; central California) similarly found a 36% trophic level decline in murrelet diet coinciding with the collapse of the Pacific sardine fishery in the late 1940s. The present-day estimates of the juvenile to adult reproductive ratio in central California were almost an order of magnitude lower (0.03 to 0.05) than the historical estimate of 0.30, which represents an 83-90% reproductive decline (Peery et al. 2006a,b) due to decreased forage supply (Becker and Beissinger 2006), while adult survival rates have likely remained unchanged (Beissinger and Peery 2007).

In response to higher ocean forage productivity, Murrelet productivity in California was positively related to the proportion of mid-trophic level prey in post-breeding diets following a decadal shift to cooler conditions and lower local sea surface temperatures. This supported increased availability of higher quality prey to murrelets and improved murrelet reproductive success (Becker et al. 2007).

HABITAT AND POPULATION STATUS

Forest (nesting) Habitat

Nesting habitat loss and subsequent fragmentation of remaining stands was identified as a primary factor leading to population declines and listing (USFWS 1997). The federal interagency Northwest Forest Plan (NWFP) was developed to meet requirements to primarily track status and trend of late-successional and old-growth forests, and population and habitat trends for Marbled Murrelets and Northern Spotted Owls. For murrelets, the ultimate goal is to relate population trends to nesting habitat conditions over time (Madsen et al. 1999).

Washington nesting habitat. In Washington, the NWFP 1993 baseline estimate of higher quality ("Suitability" Classes 3 and 4) habitat was 1.549 million acres for all ownerships combined (58% federal, 42% nonfederal). The NWFP 2012 estimate for all ownerships in Washington was 1.343 million acres of higher quality potential nesting habitat (66% federal, 34% nonfederal lands) (Raphael et al. 2016). Most (89%) of the habitat on federal lands occurred within designation reserved areas, such as National Park, wilderness, late-successional reserves, or other congressionally or administratively withdrawn lands (Falxa and Raphael 2016). Figure 3 gives a comparison of habitat amounts on the NWFP area to Washington.

Since 1993, loss of potential nesting habitat has occurred from timber harvest, windthrow events, fire, and forest disease. From 1993 to 2012, higher quality nesting habitat for all lands was reduced by an estimated 418,400 acres from the 1993 estimate (-27% change) (Table 1; Raphael et al. 2016). Most of this loss (95%) was attributed to timber harvest (Raphael et al. 2016) which also included loss due to wind throw on all ownerships, especially in southwestern Washington within the last decade (WDNR 2008). Newer habitat gained through forest growth in the 20-year period was estimated at 212,700 acres. However, the recruitment of relatively lower quality habitat may not offset the loss of an equal amount of high quality habitat (Falxa and Raphael 2016). The change for all lands in Washington (gains and losses) was a net loss of about

205,700 acres of habitat, representing a –13.3% change from 1993-2012 (Figure 3, Raphael et al. 2016).

On Washington nonfederal (state and private) lands, there were 649,300 acres of Class 3 and 4 in 1993. In 2012, there were 456,000 acres, representing a 30% decline (Raphael et al. 2016). It was estimated that 98% of the loss on nonfederal lands in Washington was attributed to timber harvest (Table 1; Raphael et al. 2016). The loss occurring on nonfederal lands was not further classified according to state-owned and private forest lands.

The estimated total of habitat for federal lands in Washington in 2012 was about 886,400 acres (66% of 1.343 million) (Table 2). For 1993-2012 period there was a net change (losses plus habitat gains) of about -12,450 ac in Washington, about -1.4% change (Figure 3) (Raphael et al. 2016).

Table 1. Acres of loss, gain and net change in Marbled Murrelet higher-quality (model classes 3 and 4) nesting habitat, and net change for the highest-quality(model Class 4) nesting habitat, from 1993 to 2012, for nonfederal and all ownerships in Washington (from Raphael et al. 2016: Table 2-10).

Washington Nonfederal					**Washington All ownerships**			
Higher-quality (Classes 3+4)					**Higher-quality (Classes 3+4)**			
Province	**Losses**	**Gains**	**Net Change**		**Losses**	**Gains**	**Net Change**	
			Acres	**%**			**Acres**	**%**
Olympic Peninsula	137,349	50,398	-86,951	-29.1	190,238	88,436	-101,802	-11.9
Western Lowlands	130,778	48,785	-81,993	-32.0	134,437	53,379	-81,058	-30.1
Western Cascades	41,547	17,151	-24,396	-26.2	90,551	65,843	-24,708	-6.1
Eastern Cascades	657	693	36	2.7	3,220	5,033	1,813	10.0
Total	**310,331**	**117,027**	**-193,304**	**-29.8**	**418,446**	**212,691**	**-205,755**	**-13.3**

Table 2. Acres of loss, gain and net change in Marbled Murrelet higher-quality (Classes 3 and 4) nesting habitat, and from 1993 to 2012, for federal ownership in Washington (data from Raphael et al. 2016).

Federal Washington Marbled Murrelet habitat (acres)				
	losses	gains	Net change class 3+4	Net change class 4
All owners	418,446	212,691	-205,755	-45,917
Nonfederal	(310,331)	(117,027)	(-193,304)	(-43,314)
Federal total	**108,115**	**95,664**	**-12,451**	**-2,603**

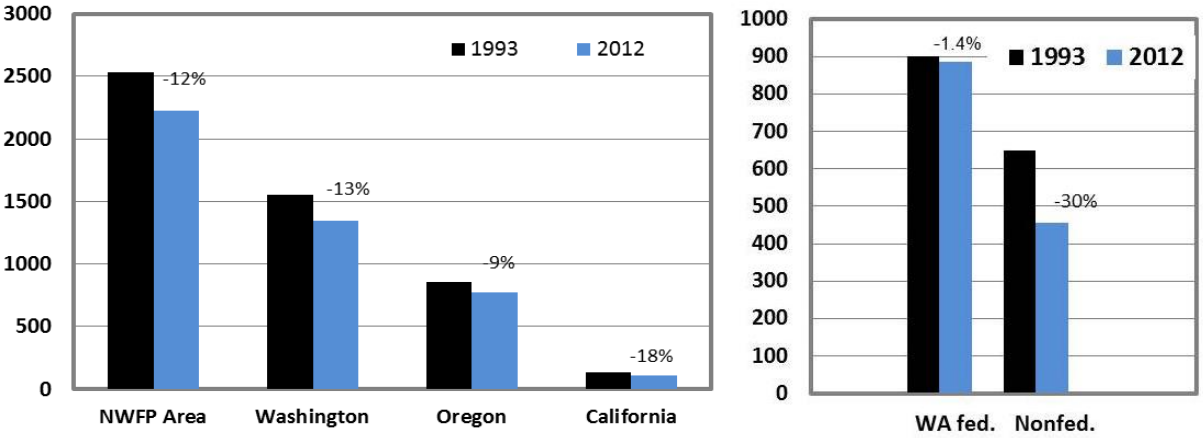

Figure 3. Net change of potential nesting habitat of higher quality (model classes 3 and 4 combined), Northwest Forest Plan Area, all ownerships (left); and Washington only (right), federal and nonfederal ownerships, 1993 vs. 2012 (1000's of acres; data from Raphael et al. 2016).

Marine Habitat Status

Oceanic forage fish production is particularly influenced by both sea surface temperature and summer upwelling events. These events are influenced by both short- and long-term climatic events (e.g., El Niño and Pacific Decadal Oscillation) and local offshore winds. Lower sea surface temperatures and strong upwelling events have strong positive influences on fish populations.

In contrast, the southern Salish Sea is a non-upwelling system whereby foraging conditions are influenced more by freshwater inputs and tidal activity. The complex interaction between these two marine ecosystems – coastal ocean and inland Salish Sea – and their influence on predators and their prey are not well understood. To date, research indicates that the on-water distribution of murrelets during the breeding season is influenced primarily by the amount and pattern of higher-suitability nesting habitat and less by marine factors (Raphael et al. 2015). In addition, human activities appear to have a stronger influence on murrelet abundance and distribution in the Salish Sea than in other parts of the range (Raphael et al. 2015).

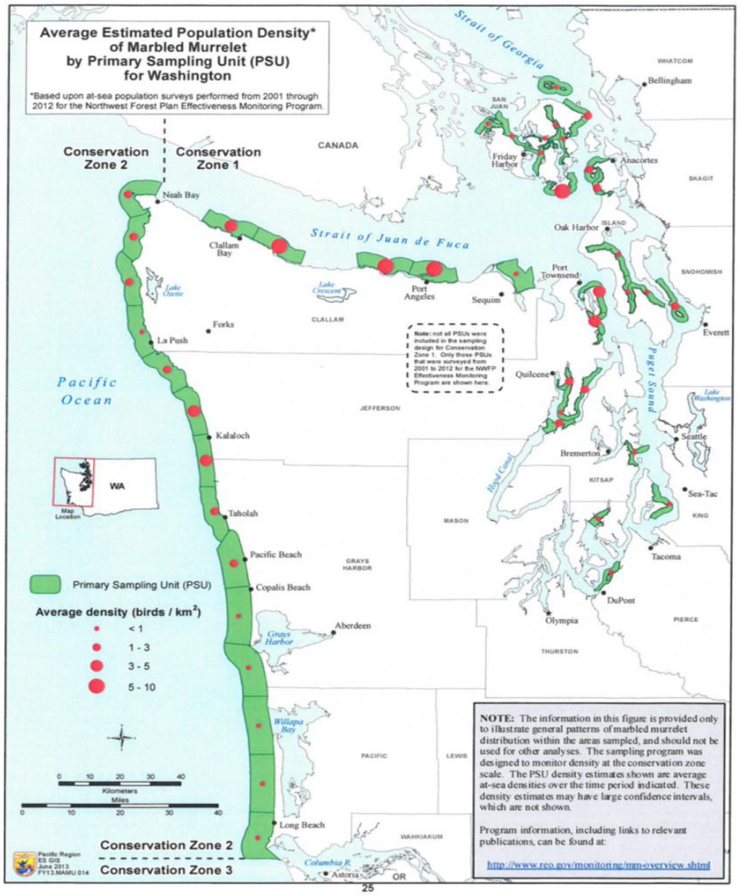

Figure 4. Average estimated at-sea population density, Zones 1 and 2, Marbled Murrelets by primary sampling unit (map from Falxa et al. 2013, used with permission).

Global sea surface temperatures have increased 1.1°F since 1950, but no significant ocean warming offshore of North America was observed between 1900 to 2008, except in localized areas west of Vancouver Island (Tillmann and Siemann 2011). The coastal waters of Washington have exhibited seasonally hypoxic conditions since at least 1950, and the lowest recorded dissolved oxygen levels of the California Current System. Since 1800, outer coastal water acidity in Washington has increased by about 10 to 40 percent, translating to a pH decline of -0.05 to -0.15. This increased acidification in some areas of Puget Sound has shown disruption in calcification processes that affect development of some invertebrates, which may affect some forage fish (Tillmann and Siemann 2011).

Forage fish studies. Pacific herring stocks in Puget Sound (in aggregate) were generally listed as "moderately healthy" as of 2012, with the exception of the Cherry Point stock, which has declined 62% since 1986 and is now regarded as "critical" (Stick et al. 2014). Other Puget Sound herring stocks in aggregate have seen a 26% decline from 1986-2010 (Stick et al. 2014). Data are lacking for herring and other forage fish stocks for the Washington outer coast. Northern anchovy stocks, smelt species and sand lance populations and demographics have been little documented in Puget Sound (Penttila 2007). Eulachon was recently listed as endangered under the U.S. Endangered Species Act. Marine habitat for Marbled Murrelets in Washington in terms of forage quality and location has not been studied in detail.

Population Status

The "at-sea" survey methods for monitoring population size and trends were devised for the NWFP because of the difficulty of finding murrelet nests over large tracts of potential nesting habitat. Standardized transect surveys for murrelets were conducted within 1.5 km ("inshore") and 1.5 to 5-8 km ("offshore") to detect birds on the water during the breeding season (Miller et al. 2006, Falxa et al. 2016a, Figure 4). From 2000 to 2010, there was a 29% decline of the listed portion of the population (Washington to central California; Miller et al. 2012). Current annual estimates of the total population for the listed range between Washington and central California overall have shown no clear trend (Falxa et al. 2016a).

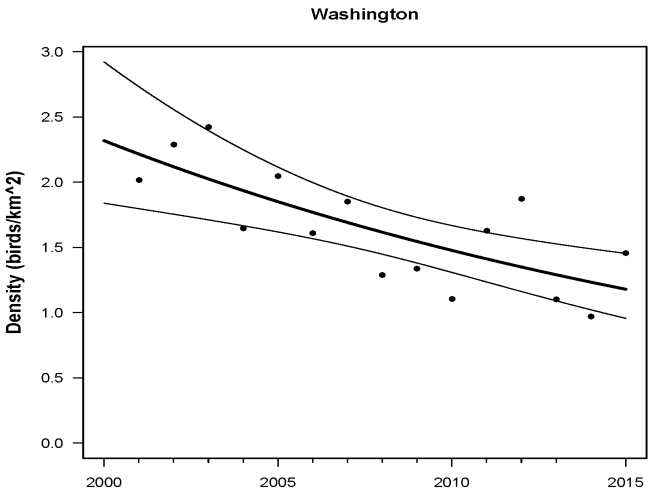

Figure 5. At-sea densities of Marbled Murrelets for 2001-2015 based on surveys conducted in Washington recovery zones 1 and 2 combined. The trend is a significant annual rate of decline in murrelet density of 4.4% (from Lance and Pearson 2016).

Washington population. Washington data, however, have shown a significant downward trend during the same monitoring period described above. The overall annual rate of change in murrelet density in Washington for 2001-2015 was -4.4% (95% CI= -6.8 to -1.9) (Lance and Pearson 2016, Falxa et al. 2016b; Figures 5, 6). For 2015, the population estimate for the Salish Sea was 4,290 birds, with a -5.3% average annual rate of decline for the 2001-2015 period (Lance and Pearson 2016). The population estimate for the Washington outer coast for 2015 birds

indicated -2.8% for the same interval, but was not a significant change. The 2015 total population estimate for Washington (Salish Sea and outer coast combined) was 7,494 birds (95% CI = 3,667 to 11,320). This represents a significant decline in Washington Marbled Murrelet abundance of 44% over the last 15 years.

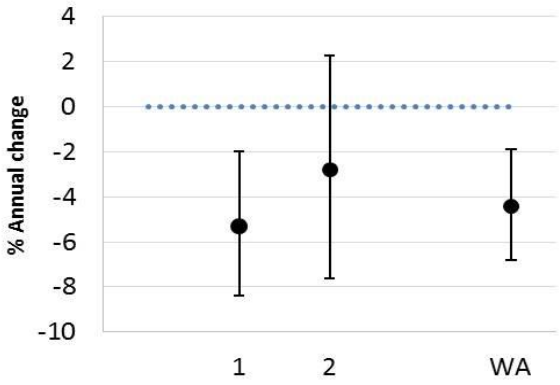

Figure 6. Marbled Murrelet population average rate of annual change from 2001-2015, with 95% confidence intervals for the Salish Sea (Zone 1), outer coast (Zone 2) and combined (WA). Dashed line (0) indicates stable population; intervals not overlapping 0 are significant (figure from Falxa et al. 2016b, used by permission).

Forest Habitat and Marine Abundance Correlations

The annual variation in murrelet numbers was more strongly correlated with the amount and configuration of adjacent nesting habitat than with trends in marine factors such as productivity and sea surface temperature (Raphael et al. 2015). Specifically, murrelet density and distribution at sea was strongly correlated with the amount of larger blocks of unfragmented areas of older forest (i.e., greater "habitat cohesion"). Moreover, the highest densities of birds were offshore of reserved federal lands from Washington to California (Meyer et al. 2002; Cooper et al. 2006; Raphael et al. 2002a, 2015). "Hotspots" were concentrated areas of murrelets at sea and in Washington were identified as: Strait of Juan de Fuca and San Juan Islands and the northern outer coast. These hotspots were areas where abundance of nesting habitat had less fragmented forest and was strongly correlated with higher densities of murrelets in the adjacent waters (Raphael et al. 2015, Falxa and Raphael 2016).

FACTORS AFFECTING CONTINUED EXISTENCE

Adequacy of Regulatory Mechanisms

The U.S. Fish and Wildlife Service assembled an expert panel of scientists to form a Recovery Implementation Team (USFWS 2012) to develop a prioritized list of actions to help stem the Marbled Murrelet population decline in the short-term. They concluded that sustained low recruitment of young into the population is the main cause of decline, and identified 5 main mechanisms contributing to the decline: 1) ongoing and historical loss of forest nesting habitat; 2) low nest success from predation on eggs and chicks in nest; 3) changes in marine forage conditions affecting abundance, distribution and quality of prey; 4) post-fledging mortality; and 5) cumulative and interactive affects from factors on individuals and populations. These and other threats are summarized in the sections below.

Federal critical habitat. The recovery plan for the Marbled Murrelet specifies actions necessary to halt the species' decline, including designating critical habitat (nesting) considered essential to the conservation of the species in Washington, Oregon and California (USFWS 1997). This designation was recently reaffirmed (80 Federal Register 164:51506, August 2015). The primary

objectives of the recovery plan were to stabilize murrelet populations at or near their listing date levels by maintaining or increasing productivity and removing or minimizing threats to survivorship, largely through conservation and recovery of nesting habitat (USFWS 1997). In terms of nesting habitat persistence on federal land, the NWFP (which includes all federal critical habitat) has been largely effective for Washington (Falxa and Raphael 2016), as >99% of designated critical habitat in Washington occurs on federal lands. However, the goals of maintaining populations for Washington have not yet been met. Over the next 50 to 100 years, the amount of nesting habitat on federally protected lands should increase as forests mature. Implementation of the Northwest Forest Plan at a level lower than anticipated, in conjunction with designation of critical habitat, has limited the rate of habitat loss on federal land, such that the net loss on federal lands from all causes is only 5% of total net loss among all ownerships for Washington (Raphael et al. 2016; Tables 1, 2). Critical habitat for Marbled Murrelet in marine areas has not been designated to date (80 Federal Register 164, August 2015). The northern outer Washington coast from Cape Flattery to Copalis has been designated as Olympic National Marine Sanctuary and National Wildlife Refuge.

Federal Habitat Conservation Plans and acquisitions. Seven Habitat Conservation Plans (HCPs) that include Marbled Murrelet as a covered species have been implemented in Washington since the 1992 listing (USFWS 2009). These plans vary considerably in scale and scope of murrelet habitat protection and this variation is based on ownership objectives, forestry operations, capabilities, and geographic location. Of note, Washington Department of Natural Resources (WDNR) is currently developing the final long-term conservation strategy amendment for their HCP (WDNR 1997a). It is estimated that about 15.5% (approx. 213,000 ac) of the potential nesting Marbled Murrelet habitat in Washington currently exists on WDNR-managed lands; of this, about 40,000 acres are designated as Marbled Murrelet occupied habitat and currently deferred from harvest (Raphael et al. 2008; S. Horton, WDNR, pers. comm.). Since 1997, habitat loss on WDNR lands has been largely consistent with the Department's Habitat Conservation Plan (WDNR 1997b), plus the salvage of unforeseen windthrow or diseased habitat (S. Horton, WDNR, pers. comm.). Also of note, Seattle Public Utilities (2000) HCP committed to maintain existing mature and old forest, using active and passive restoration to aid recovery of old forest conditions for wildlife including murrelets over about 86,000 acres, with about 17% (14,623 acres) of the covered lands currently in forest ≥190 years old.

The USFWS Cooperative Endangered Species Conservation Fund has made purchase possible of about 15,000 acres of private forest lands in Washington for murrelet conservation through Section 6 of the ESA. About 1,500 acres of these lands are currently recognized as potential nesting habitat, with the majority being of higher quality (USFWS 2009; M. Acker, USFWS pers. comm.).

State Forest Practices Rules. The Washington Forest Practices Rules (FPR) regulate timber harvest on state, county, private, and municipal lands that do not have a federal HCP, Safe Harbor Agreement or other federal agreement (WDNR 1997b). The rules for Marbled Murrelet require forest landowners to identify potential nesting habitat, and to conduct surveys (i.e., Evans Mack et al. 2003) to detect murrelets before modification or alteration of habitat can be permitted. If surveys determine there is a high likelihood that nesting birds are present within a given forest patch, the contiguous habitat is designated "occupied" and possible further assess

any activities that would pose a likely adverse impact to the environment (WDNR 1997b). Forest practices may be allowed on nonfederal lands if the habitat surveyed was not "occupied," or, if the landowner has an accepted alternative plan or agreement such as a HCP. The rules allow management without surveys in lower quality habitat that does not meet the definition of habitat included in the rules. Some unintended loss of habitat has occurred (mostly minor) when rule-defined habitat was unreported or was not correctly identified through the Forest Practices Applications process (S. Desimone, pers. comm.). For the period 2013-2015, survey quality and compliance reviews conducted by WDFW showed that about 300 acres per year of rule-defined habitat on private lands had completed the FPR survey requirement and were no longer constrained by state regulation for murrelets and thus available for forest management (S. Desimone, unpublished data).

Outside of federal HCPs, Safe Harbor Agreements, or state Forest Practices alternative plans, no real incentive exists for private landowners to grow habitat to help with recovery goals. One unfortunate circumstance of FPR and land ownership patterns is that some smaller occupied stands may become isolated and insular in landscapes dominated by younger forests and recently cut lands. These patches are vulnerable to edge effects and wind disturbance events over time so that the habitat provides increasingly less function, or eventually blow down completely. In aggregate, the degradation of these areas over the landscape during last two decades has likely had some impact on the breeding population in areas regulated by FPR.

Continued Risks and Threats

Ongoing loss of forest nesting habitat. From 1993 to 2012 across the entire Northwest Forest Plan area, there was a 27% net loss of potential nesting habitat on nonfederal lands and about 2% on federal lands. Habitat loss to timber harvest since 1993 has been greatest in Washington, with a 30% net loss on non-federal lands. Aside from harvest loss and degradation is occurring from chronic wind disturbances and smaller storms (WDNR 2008). Wind damage occurs more frequently along hard forest edges where there is significant contrast between older, interior forest conditions and adjacent recently harvested or younger regeneration stands. High contrast edges also affect interior forest microclimate well inside the forest edge, modifying sunlight, temperature and humidity, and may reduce moss and epiphyte abundance for development and maintenance of potential nesting platforms (Chen et al. 1995, van Rooyen et al. 2011).

Low nest success. At present population trend rates, adult birds in Washington do not appear to be replacing themselves (Lance and Pearson 2015, 2016; USFWS 2012). This could be the result of low recruitment (nest success), but without good demographic information, it is unclear how low adult survival, post-fledging mortality, or birds emigrating out of state waters might contribute.

Habitat fragmentation, Forest edge, and predation. Degradation of existing nesting habitat by human influence is an ongoing problem in Washington. Forest edge effects from timber harvest patterns are largely a direct result of habitat fragmentation. Increasing fragmentation can lead to higher predation levels by corvids (jays, crows and ravens) by reducing the size of the habitat patch and increasing the high contrast edge around habitat patches. Predation rates by corvids on murrelet eggs and chicks were higher when nests were within 50 meters of hard-edged forest, but

the relationship varies with proximity to human activity and the structure of the adjacent forest (Raphael et al. 2002b). Predation in nesting stands was higher with increasing proximity to forest edge when the matrix landscape contained human settlement and recreation sites, but not as great when the adjacent forest was dominated by young and regenerated forests without humans (Raphael et al. 2002b, Marzluff et al. 2004, Marzluff and Neatherlin 2006). Predation risk was lower in nest patches with increasing average tree height in the adjacent developing stands without human presence (Malt and Lank 2007, 2009). Predator density can also increase at high-use recreational sites within or near murrelet habitat areas, where corvids seek human-related foods and refuse (Peery et al. 2004, Marzluff and Neatherlin 2006). Reducing the suitability and accessibility of campgrounds to corvids can help manage to decrease predation risk (Neatherlin and Marzluff 2004).

Raphael et al. (2016) indicate high levels of habitat fragmentation throughout the NWFP area, with about half of all higher quality habitat in Washington in smaller patches classified as "edge" (>90 meters from interior of habitat patch) for all ownerships. On nonfederal lands in Washington and Oregon, 80-90% of total higher quality habitat was in edge category (Falxa and Raphael 2016).

Genetic flow. Genetic research comparing historical (museum) and modern Marbled Murrelet specimens from central California suggests that largescale timber harvest and fragmentation of nesting habitat over the past century has led to genetic divergence of murrelets (Peery et al. 2006a, Piatt et al. 2007, Peery et al. 2010). The extent to which numbers of murrelet individuals may disperse from harvested nesting habitat to search for new habitat is generally unknown, but they do not appear to pack into the remaining local nesting habitat after logging (Burger 2001, Raphael et al. 2002a, Hall et al. 2009, Peery et al. 2010). It is suspected that Washington populations should have relatively less inhibited genetic flow, as they are positioned geographically in the middle of the range; however, consistently depressed population numbers off the southern Washington and northern Oregon coasts coupled with little nesting habitat in that region could lead to some inhibited genetic flow between Oregon and Washington (USFWS 2009).

Changes in marine forage conditions and distribution, abundance and quality of prey. Reductions of prey abundance and timing of prey availability are major concerns for seabird populations worldwide. A recent study found widespread reproductive failure in 14 seabird species worldwide (colony nesters) when forage fish and krill populations were below 1/3 of their long-term maximum prey biomass (Cury et al. 2011). There have been centennial declines in forage fish populations in the range of the Marbled Murrelet (Becker and Beissinger 2006, Norris et al. 2007, Gutowsky et al. 2009). In Puget Sound, the preservation of forage fish spawning, rearing, seasonal and migratory habitats is critical for forage stock maintenance, and habitat conservation of these stocks to some extent will depend on the application of shoreline regulations on state and private marine tidelands (Penttila 2007).

In the U.S. portion of the Salish sea (Zone 1), Raphael et al. (2015) found a slightly greater influence of human-related threats (commercial vessel traffic, pollution, fishing, shoreline alteration, climate influences) on the distribution and abundance of murrelets over time, than

other marine factors such as primary productivity (surrogate for forage fish), sea temperature factors and forest habitat cohesion.

Climate effects on marine habitat. Timing and abundance of prey are often dependent on ocean temperature and upwelling events (e.g., Becker et al. 2007), and these factors are closely linked with trends in climate change (Cury et al. 2011). Northwest ocean temperatures are projected to increase 2.2°F by the 2040s due to climate change (Tillmann and Siemann 2011). The Marbled Murrelet is considered "moderately to high vulnerability" to climate change, mainly due to the effects of warmer sea surface temperature in changing marine systems and associated changes in forage fish populations that can affect murrelet behavior, growth, health, reproductive success and survival (Tillmann and Siemann 2011).

Oil and chemical pollution. Large-scale oil spills have the potential to devastate local Marbled Murrelet populations and are a major anthropological threat. Significant Marbled Murrelet mortality in Washington has occurred during known during oil spill events in 1956, 1964, 1985, 1988 and 1991 (Neel et al. 2007). The 1991 *Tenyo Maru* oil spill near the entrance to the Strait of Juan de Fuca was thought to have killed about 9-12% of Washington outer coast murrelet population (*Tenyo Maru* Trustees 2000). No new major spills have occurred in Washington since 1991. Improvements in safety, spill response and tanker design have reduced major spills in recent years, but increasing volume of tanker and freighter traffic in the Salish Sea system presents substantial risk threat (Van Dorp et al. 2014, WDOE 2014).

Chronic smaller scale oil and chemical pollution is much harder to detect and track, and the number of murrelets actually affected is not clearly known. USFWS (2009:58) estimated current mortality of 2-3 Marbled Murrelets annually for Washington due to oiling. In the straits of Juan de Fuca and Georgia, 271 intentional or accidental smaller scale spills were reported from surveillance aircraft from 1997-2006, which represents a minimum estimate of 2,464 detectable spills per year, most of which are likely in the coastal areas where murrelets are typically found (O'Hara et al. 2013). These levels of chronic oil spill incidents represent a likely decline from before 1997.

Good et al. (2014) compared the persistent organic pollutants in the forage fish fed to Rhinoceros Auklet (*Cerorhinca monocerata*) chicks in the Salish Sea to those on the Washington outer coast and found that the Salish Sea forage fish were 2-4 times more contaminated than those on the Washington coast. These Salish Sea auklets are foraging on the same forage fish species and in the same waters occupied by murrelets.

Commercial fishing net mortality. Fishing net mortality, or "bycatch," of Marbled Murrelets is currently considered rare in Washington, but is a continuing concern. A purse seine monitoring study from 1996 to 2000 had no Marbled Murrelets recorded during 1,442 purse seine sets (WDFW 2004). Direct effects from gillnet entanglement likely have actually decreased in many areas over the last twelve years (NMFS and BIA 2015). From 2001 to 2014, Marbled Murrelet interactions and mortalities in Puget Sound net fisheries had not been documented in annual reporting, and interaction rates vary considerably between locations and depend on local conditions, characteristics of the fishery, and murrelet density. NOAA Fisheries' National Marine Fisheries Service modeled the probability of encountering murrelets during Treaty and

non-Treaty commercial, ceremonial and recreational fisheries based on actual encounter rates and murrelet densities from at-sea surveys, which indicated that interactions between Marbled Murrelets and gillnet fisheries are relatively rare (NMFS and BIA 2015).

Alternative energy projects. Wind energy projects within the range of Marbled Murrelets in Washington have been proposed in recent years. To date, one project with 4 wind turbines has been completed and is in operation within 2 km of the ocean, and no monitoring reports on impacts to Washington wildlife have been produced. Of 8 other wind turbine projects proposed within the range of the murrelet on state or private land in Washington between 2010 to present, none have been built. Radar monitoring studies of murrelet flights have been conducted for most of these proposed wind turbine sites (e.g., Hamer 2009), and have found that murrelet-like targets can be detected. A U.S. Fish and Wildlife Service expert panel developed a protocol for using radar technology to survey for murrelets near proposed wind energy projects to help assess potential project impacts and needed survey intensity (Nelson et al. 2013). The protocol directs project developers to collect data on murrelet passage rates, flight paths, flight altitudes and suggests the survey effort needed on proposed project sites. They recommend careful siting of wind projects to avoid areas of known use by murrelets. Recently proposed use of tidal generators in the Salish Sea present new risks to the species and will need to be addressed.

Effects of climate on forest habitat. Some future climate forecast models predict a generally warmer, drier trend for western Washington in the coastal spruce/hemlock zone (e.g., Halofsky et al. 2011). There is considerable uncertainty associated with the degree of climate change, but any warming could lead to increased fire risk and intensity, and possibly contributing to habitat loss. For nesting habitat, a reduced moisture climate could also affect moss and epiphyte development and its role in providing and sustaining potential nesting platforms in tree branches, and possibly increase prevalence of tree insect and disease outbreaks.

MANAGEMENT ACTIVITIES

Recovery Implementation Team. The Recovery Implementation Team (USFWS 2012) identified actions that state and federal resource agencies could implement in the near-term to help counter low recruitment. In the last two decades a number of management recommendations have been addressed to some extent, as summarized here. Conservation plans (HCP, SHA) have been developed to help benefit murrelets, but it is too early to know the effectiveness of such plans for the long-term benefit to murrelets. Various projects involving forage fish species and how they may affect murrelet reproduction potential are underway with cooperating agencies (Forest Service, WDFW, NMFS, NOAA) although budgets and time constraints limit the number of projects that can be implemented. The infrastructure for improved trash regulation and containment on state and federal public lands near murrelet nesting habitat to help control corvid numbers is in implementation phase and progress is variable among states and agencies.

The federal recovery plan (1997) and Federal Critical Habitat rules have led to management decisions in recent years for federal lands that realize conservation of remaining higher quality (Class 3 and 4) habitat should be an effective short-term measure (next 3-5 decades) (Falxa and

Raphael 2016), and that management practices which have helped to conserve and restore higher quality nesting habitat in near productive marine habitat is most beneficial to the species (Meyer et al. 2002, Raphael 2002a, Raphael 2006). Given the species' strong site fidelity to previously used nest areas, the dispersal and colonization of new or previously unused habitat is more likely when it is adjacent or near to areas presently used by murrelets (McShane et al. 2004, Raphael 2006, USFWS 2009). Existing smaller and isolated murrelet nesting stands in fragmented forest landscapes could be more productive if surrounded by dense or similar structured conifer forests on longer rotations (Malt and Lank 2007, 2009).

Continuation of at-sea monitoring. Population monitoring will continue to be essential for measuring effectiveness of conservation and recovery efforts. Beginning in 2016, the Northwest Forest Plan at-sea monitoring will be changed from annual to biannual surveys. Washington Department of Fish and Wildlife will be solely responsible for implementing the surveys for state waters during the breeding season, alternating between Zones 1 and 2 in successive years (Falxa and Raphael 2016).

Pacific Seabird Group Inland Survey Protocol revision. The Pacific Seabird Group Marbled Murrelet technical committee is currently reviewing and revising aspects of the terrestrial survey protocol (Evans Mack et al. 2003). This revision can have important management implications regarding Washington State Forest Practices Rules. A revised protocol is expected to be produced for the 2017 survey season (P. Harrison, pers. comm.).

CONCLUSION AND RECOMMENDATION

Marbled Murrelets have undergone population declines nearly range-wide within the last few decades (Piatt et al. 2007, Environment Canada 2014, Falxa and Raphael 2016). Murrelets in Washington have declined 4.4% per year between 2001 and 2015. When the Marbled Murrelet was federally listed in 1992, the primary factor contributing to its threatened status under the Endangered Species Act was the loss of forest nesting habitat. Moreover, there has been an apparent centennial decline in availability of forage fish prey resources, which in combination with habitat loss, appears to have compromised nest success and survival of young. Despite progress in implementing federal forest management plans, habitat conservation plans and state Forest Practices Rules, habitat loss has continued and the Washington Marbled Murrelet population has experienced a decline of approximately 44% over 15 years. The murrelet's low reproductive rate requires high survivorship for the population to grow. The magnitude of the population decline indicates that the status of the Marbled Murrelet in Washington has become more imperiled since state listing in 1993. Without solutions that can effectively address the major threats in the short-term, it is likely the situation for Marbled Murrelets will only worsen and the species could be lost from some landscapes in the decades ahead. Therefore, our recommendation is to uplist the Marbled Murrelet to the status of a state endangered species in Washington.

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Organization of References Cited

References are organized alphabetically, by first author. The "CODE" column indicates the appropriate source category for the reference, as identified and required by RCW 34.05.271.
These codes are as follows:

i. Independent peer review; review is overseen by an independent third party.
ii. Internal peer review; review by staff internal to WDFW.
iii. External peer review; review by persons that are external to and selected by WDFW.
iv. Open review; documented open public review process that is not limited to invited organizations or individuals.
v. Legal and policy document; documents related to the legal framework for WDFW, including but not limited to: (A) federal and state statutes, (B) court and hearings board decisions, (C) federal and state administrative rules and regulations; and (D) policy and regulatory documents adopted by local governments.
vi. Data from primary research, monitoring activities or other sources.
vii. Records of best professional judgement of WDFW employees or other individuals.
viii. Other: sources of information that do not fit into one of the categories identified above.

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APPENDICES

[public comments]

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