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Recovery Strategy Series

Recovery Strategy for the Marbled Murrelet (*Brachyramphus marmoratus*) in Canada

Marbled Murrelet

2014

Canada

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PREFACE

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of recovery strategies for listed Extirpated, Endangered, and Threatened species and are required to report on progress five years after the publication of the final document on the SAR Public Registry.

The Minister of the Environment, as the Minister responsible for the Department of the Environment as well as the Parks Canada Agency, is the competent minister under SARA responsible for the Marbled Murrelet and has prepared this strategy, as per section 37 of SARA. To the extent possible, it has been prepared in cooperation with the Parks Canada Agency, the Department of Fisheries and Ocean, the Province of British Columbia, Aboriginal Organizations, and affected stakeholders as per section 39(1) of SARA.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Environment Canada and the Parks Canada Agency, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Marbled Murrelet and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Environment Canada and the Parks Canada Agency and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

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Current members of the Marbled Murrelet Recovery Team who contributed to this recovery strategy are:

Ian Parnell (Chair - Environment Canada, Canadian Wildlife Service),
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EXECUTIVE SUMMARY

The Marbled Murrelet is a small seabird that spends most of its time at sea within 0.5 km of shore. Marbled Murrelets are secretive and nest as solitary pairs at low densities, typically in old-growth forests within 30 km of the sea. In Canada, Marbled Murrelets are found only on Canada's Pacific coast. The current Canadian population (estimated at 99,100 birds) is about 28% of the estimated global total of 357,900 birds The Marbled Murrelet was assessed as Threatened in 2012 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

The main terrestrial threats to Marbled Murrelets include historic, current and future loss of old-growth nesting habitat; fragmentation of old-growth nesting habitat resulting in increased predation rates and adverse changes to microclimate near the 'hard' forest edges; predation at nest sites; and potential threats related to the development of energy infrastructure, including collision risks and increases in predator concentrations. Marine threats include: chronic and catastrophic oil spills; entanglement in fishing gear (mainly gill-nets); and current and future boat traffic and shipping which disrupts foraging and marine distributions.

Recovery of the Marbled Murrelet is considered biologically and technically feasible.

The short term population and distribution objective for the recovery of Marbled Murrelets is that over the period 2002-2032 (three generations) is to halt the decline of the British Columbia (B.C.) population and the area of its nesting habitat so that the total population and area (amount) of nesting habitat coast-wide will have stabilized above 70% of 2002 levels, with sufficient areas of nesting habitat remaining in the six primary conservation regions. Short term recovery objectives for six primary conservation regions are recommended to achieve the overall coast-wide objective of 70% or greater retention of 2002 population and habitat levels.

The long term population and distribution objective (25+ years) for the recovery of Marbled Murrelets is to ensure that the species will have a high probability of persistence after 2032 across its range. This will be achieved by maintaining or restoring sufficient suitable nesting and marine habitat, and by reducing other threats, within each conservation region to stabilize the Canadian population within the accepted range of natural variation.

The broad strategies to address the threats to the survival and recovery of the species are presented in the section on Strategic Direction for Recovery.

A partial identification of nesting critical habitat is included; there is insufficient information for an identification of marine critical habitat. A schedule of studies outlines the studies required before the critical habitat identification can be completed. Areas within which critical habitat occurs are delineated for the six primary conservation regions (Appendix B). Minimum habitat retention levels (hectares) are included based on the short term recovery objectives (Appendix C).

One or more action plans will be posted on the Species at Risk Public Registry within five years of the final posting of the recovery strategy.

RECOVERY FEASIBILITY SUMMARY

Recovery of Marbled Murrelet in Canada is considered technically and biologically feasible, as it meets all four criteria for determining recovery feasibility recommended in the draft *Species at Risk Act* Overarching Policy Framework (Government of Canada 2009).

1) Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.

> Yes, the current Canadian population estimate is approximately 99,100 birds, so reproductively capable individuals are available, and are broadly distributed.

2. Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.

> Yes, sufficient nesting habitat is available or could be made available through long term recruitment of younger trees into nesting habitat.

3. The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated.

> Yes, the primary threats to the species or its habitat can be avoided or mitigated through a combination of; habitat management, stewardship, communications and outreach, and additional research.

4. Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe.

> Yes, recovery techniques exist to achieve the population and distribution objectives. In the short term, habitat management will involve detailed characterization of suitable nesting habitat, nesting habitat protection, and the development of best management practices (for both habitat management and threat reduction) for affected land managers. In the longer term, research and monitoring will help better inform techniques for threat reduction and marine habitat characterization and management.

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1. COSEWIC SPECIES ASSESSMENT INFORMATION

Date of Assessment: May 2012

Common Name (population): Marbled Murrelet

Scientific Name: *Brachyramphus marmoratus*

COSEWIC Status: Threatened

Reason for designation: This small seabird is largely dependent on old growth coastal forests in British Columbia for nesting. Habitat loss has been estimated at over 20% for the past three generations. Future threats including ongoing habitat loss, coupled with increased threats from proposed shipping routes in the core of the species' range, increased fragmentation from a variety of proposed and recently initiated developments, fisheries bycatch and changing at sea conditions have resulted in projected population losses exceeding 30% over the next three generations.

Canadian Occurrence: British Columbia

COSEWIC Status History: Designated Threatened in April 1990. Status re-examined and confirmed in November 2000 and May 2012.

2. SPECIES STATUS INFORMATION

The Marbled Murrelet is assigned a global status rank of G3 (assessed 23 January 2013) - vulnerable (NatureServe Explorer 2013). The species has been ranked nationally in Canada by NatureServe as N3 – vulnerable (9 September 2011; NatureServe Explorer 2013). Within B.C. the Marbled Murrelet is on the provincial Blue List and ranked as S3B (special concern, vulnerable to extirpation or extinction – breeding population), S3N (special concern, vulnerable to extirpation or extinction - non-breeding population) (B.C. Conservation Data Centre 2013). The global population of Marbled Murrelet is estimated to be about 357,900 birds, with an estimated 99,100 birds currently in Canada (28%). Marbled Murrelets were assessed as Threatened in Canada by COSEWIC in 1990 and this status was confirmed in 2000 and 2012 (COSEWIC 2012). The Marbled Murrelet is listed as Threatened on Schedule 1 of the *Species at Risk Act* (Species at Risk Public Registry, 2013).

3. SPECIES INFORMATION

3.1 Species Description

The Marbled Murrelet is a small seabird (length 24–25 cm; mass 190–270 g) (Nelson 1997, Gaston and Jones 1998). There are no sexual size or colour differences. Adult

breeding (alternate) plumage is a marbled grey-brown plumage that provides good camouflage at nest sites. The non-breeding (basic) and juvenile plumages are black and white, typical of most diving seabirds. The Marbled Murrelet, like most seabirds, spends most of its life on the ocean and comes on land only to breed. Marbled Murrelets nest in solitary pairs at very low densities, typically within 30 km of the sea, but nests have been located up to 50 km or more inland. Marbled Murrelets do not begin breeding until they are 2-3 years of age and they have low reproductive output. No nest is constructed but a single egg is laid on a moss-covered branch. Nests are typically found in old-growth coniferous trees, but a few nests are on mossy cliff ledges. Both males and females incubate the egg, and both adults feed the nestling with fish. Marbled Murrelets forage by diving, using their wings for underwater propulsion. The species flies at a very fast speed (usually >60 km/h) using rapid wing beats. Most time is spent on the water within 0.5 km of shore.

3.2 Population and Distribution

Marbled Murrelets are found in coastal waters and adjacent inland areas from the Aleutian Islands (low numbers) through southern and southeastern Alaska, B.C., Washington, Oregon, and central California (Figure 1). Genetic studies suggest three distinct populations; one at the northern end of the range (outer Aleutians), one at the southern end of the range (central California), and the third consisting of individuals in the central part of the range from the eastern Aleutians through northern California (Piatt et al. 2007).

For the purposes of this document, the term “population” refers to geographic regions, either the entire B.C. range or conservation regions, depending on context. For management purposes the B.C. range has been divided into seven conservation regions (Figure 2; CMMRT 2003). The Alaska Border region was added in 2008 when two nests were found there (COSEWIC 2012). The number of Marbled Murrelets nesting in this region is unknown, but thought to be small, with birds flying in from Alaskan waters, and to date this region has not been included in any tallies of habitat. Consequently only populations and habitat within the remaining six primary conservation regions are considered here.

No estimates exist of the number of Marbled Murrelets that historically inhabited coastal B.C., although they likely occupied most inshore marine waters in various seasons. There are insufficient data to determine the extent or significance of population changes in B.C. over the past century. Anecdotal evidence since the early 1900s and some quantitative data from the last 30 years indicate that some local populations are declining, whereas others appear stable (Burger 2002, Piatt et al. 2007, COSEWIC 2012). Declines in Marbled Murrelet populations in B.C. have been inferred primarily from the reductions in potential nesting habitat throughout much of the B.C. range (Section 4.2 and COSEWIC 2012). Limited at-sea surveys covering >10 years (starting 1974-1995), show declining populations overall, but also show evidence of stable populations since about 1999 (COSEWIC 2012). Repeated radar surveys in six

conservation regions across coastal B.C. between 1996 and 2011 showed no overall trend in the sampled Marbled Murrelet populations over this period, but radar counts in the Eastern Vancouver Island conservation region showed evidence of decline from 2003 to 2011. Further investigation is required to understand the cause of this observation (Bertram et al. in prep.(a)). It is not clear if the cause of the estimated decline in Eastern Vancouver Island is habitat loss or a change in ocean conditions.

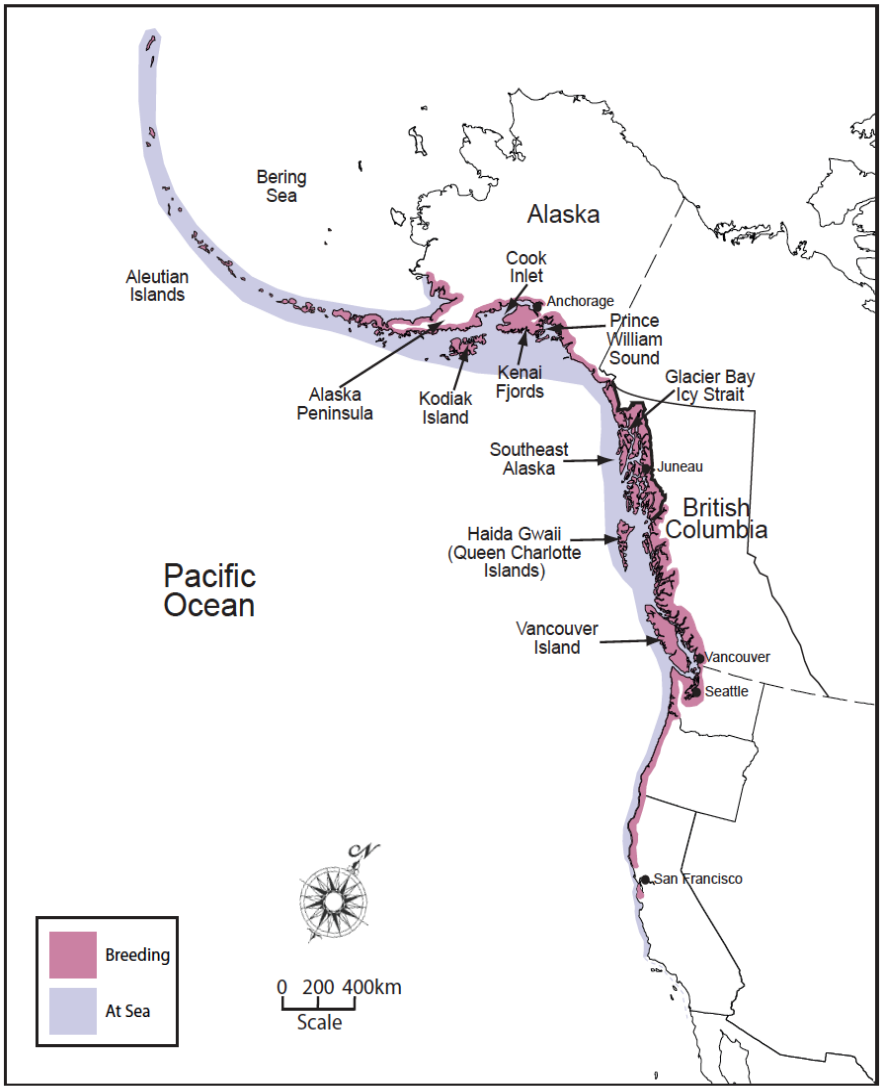

Figure 1. Global distribution of Marbled Murrelets (from Piatt et al. 2007, with permission).

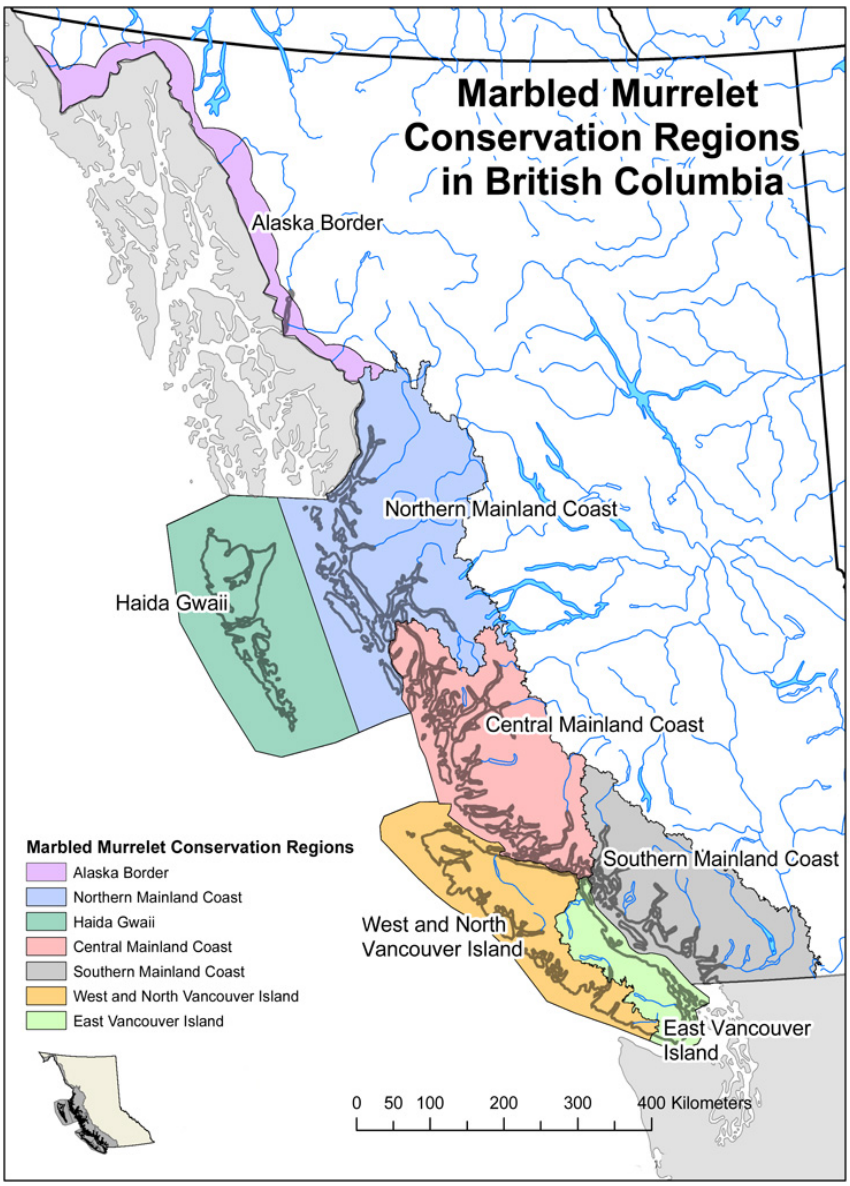

Figure 2. Map of the seven conservation regions recognized by the Marbled Murrelet Recovery Team in B.C. Map provided by M. Mather and L. Sinclair (BC Ministry of Forests, Lands and Natural Resource Operations, Nanaimo, BC).

The most recent estimate of the Canadian population gives a range of 72,600-125,600 birds, with a median point of 99,100 birds (Table 1; Bertram et al. 2007). The estimated population within each of the six primary conservation regions is shown in Table 2. These B.C. population estimates should be viewed with caution since they are, in all regions, based on incomplete data (at-sea and radar counts), numerous assumptions and extrapolations and expert opinion (explained in Burger 2002 and Appendix D of Piatt et al. 2007).

Table 1. Estimates of Marbled Murrelet populations (rounded numbers).

Region	Est. no. of birds	Likely range of estimate[1]	Source
Alaska	237,500[2]	Not available	Piatt et al. 2007; M. Kissling pers. comm.
B.C.	99,100	72,600-125,600	Bertram et al. 2007
Washington, Oregon and California	21,300	16,700-25,900	Falxa et al. 2013
Total	**357,900**		

[1]The range for B.C. is an estimate from Bertram et al. (2007; see Table 2 below); the range for the U.S. states (except for Alaska) is the 95% confidence interval based on modelling using at-sea densities (Falxa et al. 2013).

[2] The Alaska Marbled Murrelet population given here is based on the Piatt et al. (2007) estimate of 271,182 birds for both *Brachyramphus* species (Marbled and Kittlitz's Murrelets) minus the estimated population for Kittlitz's Murrelet (minimum 33,736 birds; SE 5745; M. Kissling, US Fish & Wildlife Service, unpubl. data) to estimate 237,446 birds.

Table 2. Estimates of Marbled Murrelet populations in each conservation region (rounded numbers). The numbers given are for birds of all ages; about 75% of these birds could be considered mature adults (COSEWIC 2012). Data from Bertram et al. (2007) and D. Bertram (unpubl. data)

Conservation region	Estimated range (birds)	Mid-point
Northern Mainland Coast	18,400-26,000	22,200
Haida Gwaii	8,500-25,000	16,750
Central Mainland Coast	20,000-42,000	31,000
Southern Mainland Coast	6,000-7,000	6,500
West & North Vancouver Island	18,700-23,600	21,150
East Vancouver Island	1000-2000	1,500
Total for B.C.		
All birds	72,600-125,600	99,100
Mature adults (rounded)	54,500-94,200	74,300

3.3 Needs of the Marbled Murrelet

Marbled Murrelet require both terrestrial habitat to support nesting and marine habitat for foraging and moulting. Both habitat types need to be considered in recovering this species. Marbled Murrelets are distributed widely over near-shore marine habitats in

B.C. in both the breeding and non-breeding seasons and mitigating risks to the species in these habitats is important for long term population maintenance. Migratory patterns are poorly known, but evidence of juvenile dispersal from breeding areas, migration of adults birds to and from breeding areas and consistent year-to-year use of regional breeding areas have been reported (Burger 2002; COSEWIC 2012). Nest sites are widespread across the landscape and are both cryptic, and high up in trees, making them very difficult to locate. The level of certainty in characterizing Marbled Murrelet nesting habitat decreases as one moves from the scale of nests, trees and stands to the broader landscape.

Biologically limiting factors that will influence recovery include the long time it takes for forests to develop the biophysical attributes necessary to support nesting. In addition, Marbled Murrelets are slow to recover from impacts, because they do not begin breeding until they are 2-3 years of age, and they have low reproductive output.

Terrestrial habitat – nest sites and nest trees

Typically, Marbled Murrelets nest on large, mossy limbs in the canopy of large (30 m and taller) conifers in old-growth forest within 50 km of the ocean (Nelson 1997; Burger 2002; McShane et al. 2004). Occasionally, they will nest on the ground or in older deciduous trees (Bradley and Cooke 2001; Burger 2002; Ryder et al. 2012). A single nest discovered in 1955 was found approximately 62 km from the coast (Ryder et al. 2012). Important characteristics of nest sites and surrounding canopy include sufficient height for 'stall' landings and jump-off departures; canopy openings for unobstructed flight access; sufficient platform diameter to provide a nest site and landing pad; soft substrate for the nest cup; and overhead cover to provide protection from predators. Detailed microhabitat and habitat stand attributes are presented in COSEWIC (2012). Specific biophysical attributes related to nesting critical habitat are presented in Tables 6 and 7 in section 7.1.2 of this document.

Marine habitat

Marine habitat features important to Marbled Murrelets were reviewed by Burger (2002) and Piatt et al. (2007). Murrelets tend to remain close to shore: on exposed shores usually within 0.5 km of the shore, but in more sheltered waters up to 2 km from shore. They generally forage in waters less than 30 m deep. The characterization of preferred marine habitats where foraging aggregations regularly occur has proven difficult, with few common features recognized among different studies. Tides, sea temperatures and salinity do not consistently explain habitat preferences. Sub-tidal substrates appear to be important, primarily because Pacific Sand Lance (*Ammodytes hexapterus*), which periodically bury themselves in sand or gravel, are an important prey item. Large-scale modelling of marine habitat (Yen et al. 2004) has not produced reliable predictions of Marbled Murrelet aggregations in all coastal areas of B.C. (Burger et al. 2008; Ronconi 2008). Marine distributions during the breeding season are affected by both marine habitat features that influence prey availability and by proximity to inland nesting habitat (Meyer et al. 2002; Ronconi 2008).

4. THREATS

4.1 Threat Assessment

Table 3. Threat assessment to Marbled Murrelet populations in B.C.

Threat	Level of Concern[1]	Extent	Occurrence	Frequency	Severity[2]	Causal Certainty[3]
Habitat Loss or Degradation						
Loss of Nesting Habitat	High	Widespread	Historic and Current	Continuous	High	High
Forest Fragmentation	High	Widespread	Historic and Current	Continuous	Medium - High	High
Aquaculture and Foreshore Development	Low	Localized	Current	Continuous	Low	Low
Tidal Power Generation	Low	Localized	Anticipated	Unknown	Low	Low
Natural Processes or Activities						
Increased Predation Risk	High	Widespread	Historic and Current	Continuous	Medium - High	High
Disease, Parasites and Bio-toxins	Low	Unknown	Unknown	Unknown	Unknown	Low
Accidental Mortality						
Collision with Wind Turbines and Power Lines (on land or in near-shore waters)	Medium	Localized	Current and Increasing	Continuous	Unknown	Low
Entanglement in Fishing Gear	Medium	Localized	Historic and Current	Recurrent	Medium	High
Pollution						
Oil Mortality **–** Chronic (ongoing small oil spills)	Medium	Widespread	Current	Recurrent	Medium	High
Oil Mortality – Acute (major oil spills)	Medium	Localized	Anticipated	Recurrent	Medium	High
Chemical Contaminants	Low	Localized	Unknown	Continuous	Unknown	Low
Climate and Natural Disasters						
Ocean Climate Variability	Medium	Widespread	Historic and Current	Recurrent	Unknown	Low
Disturbance or Harm						
Boat Traffic	Low	Localized	Current and increasing	Continuous	Low	Medium
Changes in Ecological Dynamics or Natural Processes						
Fisheries Induced Prey Depletion	Low	Localized	Historic	Unknown	Medium	Medium

[1] Level of Concern: signifies that managing the threat is of (high, medium or low) concern for the recovery of the species, consistent with the population and distribution objectives. This criterion considers the assessment of all the information in the table.

[2] *Severity: reflects the population-level effect (High: very large population-level effect, Moderate, Low, Unknown).*

[3] *Causal certainty: reflects the degree of evidence that is known for the threat (High: available evidence strongly links the threat to stresses on population viability; Medium: there is a correlation between the threat and population viability e.g., expert opinion; Low: the threat is assumed or plausible).*

4.2 Description of Threats

Despite the fact that the Marbled Murrelet spends most of its life on the ocean, the primary focus of research and recovery efforts to date has been on threats to terrestrial nesting habitat. To achieve full recovery of Marbled Murrelet, it will be necessary to direct additional attention towards addressing marine threats, recognizing that quantifying and comparing the population level impacts of terrestrial and marine stresses is a significant challenge.

Habitat Loss or Degradation - Loss of Nesting Habitat

Although it remains a relatively common and widespread seabird in B.C., the Marbled Murrelet is assessed as Threatened primarily because of inferred population declines due to historical and continued loss of old-growth forest nesting habitat (COSEWIC 2012). Loss of nesting habitat in old-growth forests is also identified as the principal threat to the species in Washington, Oregon and California (Ralph et al. 1995, McShane et al. 2004; Miller et al. 2012) and as a contributing factor to declines in Alaska (Piattet al. 2007). In general, loss of nesting habitat is likely to result in population decline. Several independent studies show close associations between Marbled Murrelet numbers and the area of forest habitat considered to be suitable for nesting (Burger and Waterhouse 2009; Raphael et al. 2011). Consequently, populations are expected to decline in proportion to the loss of suitable nesting habitat.

Risk modelling also indicates that Marbled Murrelet population persistence is sensitive to the amount and quality of nesting habitat (Steventon et al. 2003, 2006). Few studies have empirically tested the population effects of loss of habitat in this species. Radar counts show that within watersheds that have lost large areas of nesting habitat, Marbled Murrelets do not appear to pack into the remaining habitat patches in higher densities; instead, densities remain relatively constant and populations are reduced (Burger 2001, Raphael et al. 2002). Miller et al. (2012) reported that annual declines in Marbled Murrelet counts at sea in nine zones from Washington to California were correlated with loss of inland nesting habitat, but more recent survey data (2011 and 2012) show that these declines were overestimated and not statistically significant (Falxa et al. 2013).

Nesting habitat is lost primarily as a result of forestry operations. Land clearing for urbanisation and agricultural development and other resource uses have historically contributed to habitat loss, and may be a current factor in some regions. Estimates of the total loss of coastal old-growth forest in B.C. (much of it likely Marbled Murrelet nesting habitat) since European settlement, due to logging, agriculture or urbanisation,

range from 35% to 53% by the late 1990's (COSEWIC 2012). Proposed energy developments (e.g., run-of-river hydro and wind farms and their associated power lines) also have the potential to contribute to loss of nesting habitat and habitat fragmentation, and associated increases in predation risk. The area of suitable forest nesting habitat in coastal B.C. was estimated to have declined by 22% between 1978 and 2008 (i.e., over three Marbled Murrelet generations; Long et al. 2011; COSEWIC 2012). Current estimates of suitable nesting habitat that were developed as part of this recovery strategy show an approximate 5.4% decline province-wide between 2002 and 2011 (Appendix C).

Future net loss of suitable habitat is likely to continue but at a reduced rate compared to past decades due to reduced Allowable Annual Cuts in old forests and a shift to harvesting of second-growth forests (COSEWIC 2012).

Habitat Loss or Degradation - Forest Fragmentation

In addition to the loss of nesting habitat areas, fragmentation of remaining old forest habitat by forestry operations, land clearing and road-building is known to have negative effects on breeding Marbled Murrelets (COSEWIC 2012). The main impact appears to be increased risk of predation at Marbled Murrelet nests near 'hard' forest edges created by recently-cleared cutblocks or roads (<20 years of re-growth). Forest fragmentation also affects canopy micro-climates (exposure to wind and sun) and the development of mossy limbs that are often used for nesting; these changes are thought to negatively affect nesting Marbled Murrelets (Van Rooyen et al. 2011) but their impacts have not been directly confirmed (Burger 2002, COSEWIC 2012).

Habitat Loss or Degradation - Aquaculture and Foreshore Development

Sheltered marine areas where Marbled Murrelets often forage are also used for finfish and shellfish aquaculture. In some important foraging areas for Marbled Murrelets, aquaculture tenures affect up to 8% of the water surface area (COSEWIC 2012). Both types of aquaculture have greatly increased since the 1980s but their impacts on Marbled Murrelets are poorly known and difficult to assess. Other foreshore developments, such as marinas, floating lodges and new port facilities, could similarly have localized impacts on Marbled Murrelets if they affect foraging areas and increase boat traffic and the risk of oil contamination.

Habitat Loss or Degradation - Tidal Power Generation

Tidal power generators have been proposed for coastal B.C. but there are no imminent plans for their construction. If these occur in areas used by foraging aggregations these projects might have localized impacts on Marbled Murrelets.

Natural Processes or Activities - Increased Predation Risk

Predation is the most frequently documented cause of Marbled Murrelet nesting failures (McShane et al. 2004). Known or suspected predators of adults, chicks or eggs in forest habitat include falcons, accipiter hawks, owls, jays, ravens, crows and arboreal rodents (COSEWIC 2012). At sea, Bald Eagles (*Haliaeetus leucocephalus*) and Peregrine Falcons (*Falco peregrinus*) are the greatest threats, with gulls, sea lions and large fish as possible occasional predators. Populations of many predators of Marbled Murrelets, especially members of the crow family (corvids), Bald Eagles and Peregrine Falcons, have increased appreciably in the Pacific Northwest during the past 30 years (Marzluff et al. 1994; Raphael et al. 2002; Piatt et al. 2007; Peery and Henry 2010). Increases in eagle and falcon populations are considered to be due to population recoveries from past DDT impacts and persecution. However increases in populations of crows, jays and ravens are largely due to human activities which provide food and habitat for these predators. Several studies have shown increased densities of avian predators, especially members of the crow family to be associated with human activities (towns, logging camps, garbage dumps etc.) and forest fragmentation (Burger 2002; Malt and Lank 2007, 2009). In central California, management efforts to recover the small resident population of Marbled Murrelets include measures to reduce corvid numbers near their nesting habitat (Miller et al. 2012).

Natural Processes or Activities - Disease, Parasites and Bio-toxins

Populations of Marbled Murrelets are not known to be significantly affected by disease or parasites. Near-shore seabirds in the Pacific Northwest have recently suffered widespread mortality as a result of blooms of dinoflagellates and other algae which produce toxic by-products or surfactants affecting birds' waterproofing (U.S. Fish and Wildlife Service 2009; COSEWIC 2012). The impacts to Marbled Murrelet populations of these marine blooms are not known but are likely to be relatively minor to date. Blooms of some marine phytoplankton species are more likely to occur in warmer water and risks to Marbled Murrelets might increase should seawater warm as predicted under climate change scenarios.

Accidental Mortality - Collision with Wind Turbines and Power Lines

In addition to habitat loss, habitat fragmentation, and increased predation risk, small-scale hydroelectric (run-of-the-river) projects, wind farms and their associated power transmission lines pose a potential threat to nesting Marbled Murrelet by introducing the risk of collisions with turbines and power lines, both on land and in near-shore shallows. Although the current risks to Marbled Murrelets from such projects in coastal B.C. are low, both wind and small-scale hydroelectric power projects are likely to affect increasing areas in the next decade or two (COSEWIC 2012). Some hydroelectric and wind turbine proponents are studying the effects of their developments on Marbled Murrelets but no results have been publically released.

Accidental Mortality - Entanglement in Fishing Gear

Entanglement in fishing gear (mostly salmon gill-nets) is known to impact local populations of Marbled Murrelets in B.C. and elsewhere (COSEWIC 2012). Because adult birds are often killed, the population impacts may be disproportionately high (Carter and Sealy 1984). Gill-net entanglement seems to have declined since the 1980s due to reduced fishing effort. However in 2005, based on the fishery at that time, it was predicted that up to 550 Marbled Murrelets could become entangled each year in British Columbia (Smith and Morgan 2005). Research is currently underway to update this estimate (D. Bertram, pers. comm.).

Pollution – Oil Mortality, Chronic and Acute

Oil spills are often divided into chronic (generally small, often unreported spills that occur regularly wherever there is shipping or recreational boating) and acute or catastrophic (rare occurrences involving large volumes of oil from tankers, other large vessels or oil wells). Marbled Murrelets and other related seabirds (alcids) are among those species most vulnerable to oil spills at sea, and this threat has always been a consideration in designating its status (COSEWIC 2012). There has been no documented mortality of Marbled Murrelets from oiling in B.C. in the past 20 years, probably because mortalities from oil spills go undetected (O'Hara and Morgan 2006), especially as most of the Marbled Murrelet population lives in areas visited by few people.

Nonetheless, threats from chronic and acute spills remain. Levels of chronic oil spills declined from 1997 to 2006 in the straits of Georgia and Juan de Fuca (where marine aerial reconnaissance occurred frequently to deter oil spills), but oil spill rates likely remained the same for the rest of the B.C. coast (O'Hara et al. 2013). Between 1997 and 2006, 271 intentional or accidental spills were reported in detail from surveillance aircraft (a further 141 possible spills lacked adequate data), and given the most optimistic rates of detection by this surveillance (1.1% of all spills) this represents a minimum of 2,464 detectable spills per year, most of which are likely in the coastal areas where Marbled Murrelets are typically found (Serra-Sogas et al. 2008, O'Hara et al. 2013).

Proposed increases in oil exports via B.C. ports (National Energy Board 2013; National Energy Board and Canadian Environmental Assessment Agency 2013) and increased shipping in general (e.g., Prince Rupert expansion; proposed shipments of liquefied natural gas) have the potential to greatly increase ship traffic and therefore the risk of both chronic and acute oil spills in near-shore waters used by Marbled Murrelets. The proposed increase in shipping in the core of the Marbled Murrelet's range was specifically identified as a reason in maintaining the species' Threatened status (COSEWIC 2012). Marbled Murrelets and related seabirds were the birds most affected by the *Exxon Valdez* spill in Alaska and Marbled Murrelets had the highest number of identified carcasses; *Brachyramphus* murrelet mortality, mostly Marbled

Murrelets, was estimated to be 12,800-14,800 birds (Piatt et al. 2007). These birds represented 7-12% of the murrelet population in the spill zone.

Pollution - Chemical Contaminants

The threats to Marbled Murrelets posed by chemical contaminants (other than oil) are poorly known, but because this species feeds on fish that are fairly high up in the food chain, it is likely to be susceptible to contaminants that bio-accumulate. Polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs; used as a flame retardant) are currently viewed as the greatest contaminant risks to Marbled Murrelets in sheltered inland seas (U.S. Fish and Wildlife Service 2009). Concentrations of PCBs and organochlorine pesticides (e.g., DDT, dieldrin) in eggs of fish-eating birds (herons, cormorants, and osprey) have declined significantly in B.C. since the 1970s and remain at stable low levels (Harris et al. 2005). In contrast, levels of PBDEs in the eggs of these birds increased exponentially from 1979 to 2002 (Elliott et al. 2005).

Toxicity of PBDEs is poorly known, but in some areas close to urban and industrial areas (Salish Sea) concentrations might be approaching toxic thresholds for fish-eating birds (Elliott et al. 2005). Based on the spatial distribution of contaminants in fish-eating birds (Elliott et al. 2005, Harris et al. 2005, U.S. Fish and Wildlife Service 2009), contamination in Marbled Murrelet is most likely in the Salish Sea region (East Vancouver Island and Southern Mainland Coast conservation regions, Figure 2), and significantly less likely through the rest of the B.C. range which is more distant from urban, agricultural and industrial sources.

Climate and Natural Disasters – Ocean Climate Variability

It is not known how Marbled Murrelets might fare in B.C. under future climate regimes. There do not appear to be any obvious negative effects linked with the predicted changes of the dominant tree species or distributions of the coastal terrestrial biogeoclimatic zones (COSEWIC 2012). Possible negative effects in the forest nesting habitat might include reduced growth of canopy epiphytes providing nest substrates; mossy mats on canopy limbs tend to be negatively affected by dry, warm summer conditions (e.g., Burger et al. 2010). Changes in the marine environment affecting prey densities and distribution are likely to have a more direct impact. Generally, warmer seas are associated with: lower marine productivity; increased occurrence of harmful algal blooms that can affect seabirds; and negative effects on Pacific sand lance, one of the Marbled Murrelet's primary prey in B.C. The net impacts of current and future climate change on Marbled Murrelets remain speculative although potentially highly important, and most changes likely to occur in near-shore seas could negatively affect the species prey base (reviewed by: Piatt et al. 2007; U.S. Fish and Wildlife Service 2009).

Disturbance or Harm - Boat traffic

Marbled Murrelets are easily disturbed by the passage of boats, especially fast recreational craft. Negative responses to boats include disruption of feeding, flight away from foraging areas, and failure to retain fish being held for nestlings (COSEWIC 2012). Repeated disturbance by boats is likely to cause Marbled Murrelets to avoid otherwise suitable foraging habitat, which might have long term population consequences (Bellefleur et al. 2009). With increasing recreational boat traffic in many parts of coastal B.C., this might be a significant problem, especially in the Salish Sea (southern Georgia Strait and Juan de Fuca Strait), southwest Vancouver Island, Barkley Sound and Clayoquot Sound, and along commercial shipping routes with high levels of traffic. .

Changes in Ecological Dynamics or Natural Processes - Fisheries Induced Prey Depletion

Over-fishing of prey species important to Marbled Murrelets (herring and other schooling fish) may have contributed to population declines in the Strait of Georgia over the past century (Norris et al. 2007), but is not considered a major threat in B.C. today (COSEWIC 2012). This could change if commercial fisheries for Pacific sand lance or other key prey species (herring, smelt, and euphausiids) were to revive and become prevalent in the future. Sand lance is fished in other countries in the world (COSEWIC 2012).

5. POPULATION AND DISTRIBUTION OBJECTIVES

The population and distribution objectives were developed in the context of the COSEWIC (2012) assessment and the guiding principles outlined by the Marbled Murrelet Recovery Team (CMMRT 2003). Recovery of the Marbled Murrelet focuses on halting the rate of decline of nesting habitat and addressing threats to the species and its habitat then maintaining a stable or increasing, relatively abundant population across the species' present range in B.C. A short term focus on halting the rate of decline explicitly addresses a key COSEWIC criterion that led to the Marbled Murrelet's threatened designation and subsequent listing under the *Species at Risk Act* in 2003.

Short term population and distribution objective

The short term population and distribution objective (next 10-20 years) for the recovery of Marbled Murrelets is to halt the decline of this species in Canada. Specifically, over the 30 year period 2002-2032 (three generations) any decline of the B.C. population and the area of its nesting habitat will have slowed to a halt and the total population and nesting habitat area will have stabilized above 70% of 2002 levels, with areas of nesting habitat in the six primary conservation regions being sufficient to support the objectives for the species.

Short term recovery objectives within each conservation region are (CMMRT 2003):

- East Vancouver Island region – the retention of at least 90% of 2002 populations by retention of proportionate amounts of 2002 nesting habitat;
- Southern Mainland Coast – the retention of at least 85% of 2002 populations by retention of proportionate amounts of 2002 nesting habitat; and,
- Haida Gwaii, Northern Mainland Coast, Central Mainland Coast and West and North Vancouver Island regions - the retention of at least 68% of 2002 populations by retention of proportionate amounts of 2002 nesting habitat.

Long term population and distribution objective

The long term population and distribution objective (25+ years) for the recovery of Marbled Murrelets is to ensure that the species will have a high probability of persistence after 2032 across its range. This will be achieved by maintaining or restoring sufficient suitable nesting and marine habitat, and by reducing other threats, within each conservation region to stabilize the Canadian population within the accepted range of natural variation.

Rationale:

The Marbled Murrelet Recovery Team (CMMRT 2003), in recognizing the link between population size and area of suitable nesting habitat, set a goal to "limit the decline of the British Columbia population and its nesting habitat to less than 30% over three generations (30 years) during the period 2002 to 2032" (a less than 1% decline per year) and to allow no further reductions in the population and its nesting habitat beyond 2032 (reviewed by Burger and Waterhouse 2009). The rationale for not tolerating more than a 30% decline over 30 years is that the retention of greater than 70% of the population and its nesting habitat for the same period of time is a biologically reasonable time frame to halt the decline and it is consistent with a high probability of population persistence.

Risk modelling indicates high resilience of the Canadian population of Marbled Murrelet when there are at least 10,000-12,000 nesting pairs distributed across multiple regions, as based on a range of conservative assumptions about nesting habitat amount, quality and marine conditions (Steventon et al. 2003, 2006). The short-term population and distribution objective in this recovery strategy provides for a population distributed across multiple conservation regions that will comfortably exceed 12,000 nesting pairs, based on the best available population and nest density estimates.

Two approaches can be used to demonstrate the high resilience of the population and distribution objective in the context of the Steventon et al risk modelling results:

1) A population-based approach using the best available population estimates in Table 2 indicates that 70% of 74,300 adults birds is 52,010, or 26,005 pairs, which is above the 12,000 pairs required for high population resilience.

However, the population-based approach brings in uncertainty from both the underlying population estimates (see Section 3.2, Population and Distribution), and the assumption required to convert numbers of adults to breeding pairs. For example, a common rule of thumb is that only 2/3 of adults detected in radar surveys are breeding. Adjusting Table 2 estimates for this assumption still provides results that are above 12,000 pairs, though closer (range of 12,780 – 22,089 nests).

2) A second approach, consistent with the assumption of the 1:1 population:habitat proxy, is to work up from habitat amount to numbers of breeding pairs using ha/nest.

Under this approach the number of breeding pairs is estimated from amount of habitat at 70% of 2002 levels (total across regions in Table 5, see also Table C.1 in Appendix C) using the estimated number of hectares per nest (ha/nest). The empirical range of values discussed by the Recovery Team ranges from ~33 to 67 ha/nest, weighted towards 33. A pooled (coastwide) value of 50 ha/nest is used based on Burger et al 2004. Recent radar work suggests that ha/nest may be lower than 50 ha/nest in some regions; therefore, 50 ha/nest is considered a precautionary value.

Using this value, and the total amount of habitat over all regions at the recommended 2002 retention level (1,039,648 ha, Table C.1), suggests that the amount of habitat in 2002 would support 20,793 nests, or breeding pairs, coastwide. This is above the high reslience value of 10,000 - 12,000 pairs estimated by Steventon et al.

The habitat-based approach supports the population-based approach, but requires fewer assumptions, and is directly related to the underlying assumption of the linear 1:1 population:habitat proxy approach assumed for the Population and Distribution Objectives and subsequent habitat calculations. The nest density information is considered more reliable than population estimates and also results in more precautionary values than the population-based calculation.

This short term population and distribution objective represents an achievable and precautious minimum population size threshold for Marbled Murrelet from which longer term population management goals can be achieved. To be clear, this objective should not be interpreted as an intent to manage populations or nesting habitat down to 70% of 2002 levels; rather, the quantification of suitable nesting habitat and losses over the period between the baseline year of 2002 and the present is an agreed upon starting point against which to measure progress to recovery.

Since the 2002 population (and the current population) can only be estimated with wide confidence limits (COSEWIC 2012; see Table 2 above) population retention levels are expressed as nesting habitat retention levels, set using the assumption of a 1:1 relationship between population abundance and amount (area) of suitable nesting habitat (reviewed in Burger and Waterhouse 2009). The technical identification, mapping and monitoring of Marbled Murrelet nesting habitat is a task more readily accomplished than is estimating total population abundance and distribution. It also has

the advantage of directly addressing the primary threat of nesting habitat loss. Short term retention objectives are specified for each conservation region in accordance with their degree of habitat loss; with higher objectives being set for regions that have experienced higher levels of nesting habitat loss (CMMRT 2003).

6. BROAD STRATEGIES AND GENERAL APPROACHES TO MEET OBJECTIVES

The broad strategies and general approaches to deal with the major threats to Marbled Murrelets follow from the COSEWIC Assessment and Status Report (COSEWIC 2012), the 2001-2003 Marbled Murrelet Conservation Assessment and other actions completed or underway (Section 6.1).

6.1 Actions Already Completed or Currently Underway

There continues to be a significant effort invested in Marbled ;Murrelet recovery. A brief summary of key research and management efforts, carried out by multiple partners, includes:

- A three-part Marbled Murrelet Conservation Assessment undertaken in 2001-2003:
  - A review of the general biology, populations, habitat associations, and conservation of the Marbled Murrelet, relevant to B.C. (Part A; Burger 2002);
  - A statement of conservation and management objectives focused on the needs of the Marbled Murrelet (Part B, by the Canadian Marbled Murrelet Recovery Team; CMMRT 2003);
  - A risk-analysis of management options (Part C; Steventon et al. 2003, 2006).
- Delineation of six primary conservation regions for population monitoring and management of Marbled Murrelet in B.C. (Figure 2, Table 2).
- Range-wide status reviews and data summaries which include the B.C. population (Ralph et al. 1995; McShane et al. 2004; Piatt et al. 2007).
- Development and refinement of radar as a census method and for comparing Marbled Murrelet counts with watershed-level habitat parameters (e.g., Burger 2001, Burger et al. 2004).
- Workshops and power analyses to design long term population monitoring using radar (Arcese et al. 2005).
- Radar surveys conducted repeatedly at 59 sites within the six primary conservation regions (1996-2010; range 3-15 years per region) to detect population trends in each region and across the B.C. coast (Bertram et al. 2007; COSEWIC 2012; Bertram et al. in prep.(a)).
- Nesting habitat research, including habitat analysis of nests located with radio telemetry (e.g., Zharikov et al. 2006, 2007; Silvergieter and Lank 2011a, 2011b, Waterhouse et al. 2008, 2009).

- Improved understanding of the effects of forest habitat fragmentation in relation to predation risk at Marbled Murrelet nests (Raphael et al. 2002; Malt and Lank 2007, 2009).
- Ecological and demographic research (e.g., Cam et al. 2003; Peery et al. 2004; Becker and Beissinger 2006; Becker et al. 2007; Norris et al. 2007).
- Development of GIS-based algorithms using forest cover data to map likely nesting habitat (Mather et al. 2010) and application of this habitat mapping for strategic-level planning (e.g., Horn et al. 2009).
- Development of methods using air photo interpretation and low-level aerial surveys to identify and map likely suitable nesting habitat in forests (Burger 2004; Burger et al. 2009a).
- Application of the air photo and aerial survey protocols to cover large tracts of forested habitat in all six conservation regions, and their widespread use in land-use planning (e.g., in the development of the Haida Gwaii and the North and Central Mainland Coast Land Use Plans) and forestry management.
- Measures for managing Marbled Murrelet nesting habitat as part of the Identified Wildlife Management Strategy in the B.C. Forest and Range Practices Act (B.C. Ministry of Environment 2004) and application of these measures in designating Wildlife Habitat Areas (WHAs) for protecting Marbled Murrelet nesting habitat in forests under provincial jurisdiction.
- Inclusion of extensive areas of suitable nesting habitat within the conservancies and other areas designated for protection or ecosystem-based management as a result of the large-scale land and resources use management planning in Haida Gwaii (Haida Gwaii Strategic Land Use Agreement) and the North and Central Mainland Coast regions (e.g., Central Coast Land and Resource Management Plan) (COSEWIC 2012; B.C. Government 2007, 2008).
- Research on marine habitat associations and the effects of changing marine conditions in B.C. waters (e.g., Yen et al. 2004; Ronconi 2008).
- Studies to estimate and mitigate Marbled Murrelet bycatch in gill-net fisheries (Smith and Morgan 2005; Bertram et al. in prep.(b)).
- Ongoing marine surveys in Pacific Rim National Park Reserve (Y. Zharikov, pers. comm, 2013)
- Compilation of at-sea observations into GIS database (Environment Canada Seabird Occurrence Databases, D. Bertram, pers. comm., 2013).

6.2 Strategic Direction for Recovery

Table 4. Recovery Planning Table

Threat or Limitation	Priority	Broad Strategy to Recovery	General Description of Research and Management Approaches
Loss of Nesting Habitat; Forest Fragmentation; Increased Predation Risk; Collision with Wind Turbines and Power Lines; Knowledge Gaps	Urgent	Habitat Management	• Refine minimum baseline 2002 habitat amount used for estimating habitat retention levels for conservation regions (see Appendix C). • Continue to identify, map and quantify nesting habitat at a stand or site level. • Quantify habitat supply and habitat recruitment by conservation region (including the Alaska Border conservation region). • Develop spatial criteria for functional critical habitat polygons (e.g., minimum patch size, patch size distribution at the landscape scale, and recommended buffers). • By March 31, 2015: Refine the amount and spatial configuration of nesting habitat required to meet the population and distribution objectives, and short term recovery objectives (relative to habitat retention levels for each region, Appendix C), prioritizing conservation regions with high historic habitat loss (East Coast Vancouver Island, Southern Mainland Coast). • Identify nesting critical habitat at key sites (e.g., remnant old-growth coastal Douglas fir forest) within priority conservation regions. • Improve information and management options for nests which occur outside of modeled or mapped forest nesting habitat. • Identify, prioritize, and address region-specific threats. • Identify various land tenures and implement appropriate habitat conservation measures (e.g., best management practices, wildlife habitat areas, stewardship agreements, protected areas, recruitment strategies, etc.).

Threat or Limitation	Priority	Broad Strategy to Recovery	General Description of Research and Management Approaches
Knowledge Gaps	Urgent	Monitoring (population and habitat trends)	• Establish methods and protocol for monitoring changes to amount of suitable nesting habitat. • Review past and future habitat trends. • By March 31, 2015: Re-establish and continue annual monitoring of population status and trends. • Report on population status and trends in each conservation region every five years. • Attribute the causes of population change. • Establish methods and protocols for monitoring movement between conservation regions. • Continue to improve population and trend estimates.
Oil mortality, both chronic and acute; Entanglement in fishing gear; Knowledge Gaps	Urgent	Research	• Investigate and apply population risk models to estimate the likely impacts to Marbled Murrelets of increased shipping and oil exports from B.C. ports. • Investigate and better quantify Marbled Murrelet mortality due to fisheries bycatch. • Research and implement appropriate conservation tools to mitigate threats in the marine environment..
Loss of Nesting Habitat; Forest Fragmentation; Increased Predation Risk; Boat Traffic; Ocean Climate Variability; Aquaculture and Foreshore Development; Fisheries Induced Prey Depletion; Chemical Contaminants; Diseases Parasites	Necessary	Research	• Identify and quantify nesting habitat required to support regional populations. • Refine definitions of nesting habitat in each conservation region. • Refine estimates of population densities within nesting habitat. • Quantify the population impacts of habitat fragmentation (edge-effects) and increasing populations of predators. • Investigate response of populations to habitat loss within watersheds. • Establish the extent and magnitude of all marine threats and other causes of mortality (e.g., boat traffic; ocean climate variability; aquaculture; fisheries induced prey depletion; contaminants; diseases, parasites and biotoxins).

Threat or Limitation	Priority	Broad Strategy to Recovery	General Description of Research and Management Approaches
and Biotoxins; Collisions with Wind Turbines and Power Lines Knowledge Gaps			• Investigate the general and local (project specific) threats to Marbled Murrelets from wind turbines and transmission lines both at sea and on shore. • Investigate the general and local (project specific) threats to Marbled Murrelets from small-scale hydroelectric projects and transmission lines within Marbled Murrelet nesting ranges.
All Threats	Necessary	Stewardship	• Identify directly affected parties and work with them to manage relevant threats.
All Threats	Necessary	Communications and Outreach	• Incorporate Aboriginal Traditional Knowledge made available, as well as local community knowledge, into the development and implementation of recovery measures. • Develop and communicate best management practices and recommendations to affected parties (e.g., First Nations, forest industry, fishing, aquaculture, and recreation industries), including methods and training for ground-truthing nesting critical habitat. • Increase public awareness of threats to seabirds and measures that can be taken to mitigate them.

6.3 Narrative to Support the Recovery Planning Table

Implementation of the stated broad strategies to recovery for Marbled Murrelet will require the commitment, collaboration and cooperation among federal and provincial jurisdictions, Aboriginal people, industry, local communities, landowners, and other interested parties.

The broad strategies to recovery include:

Habitat Management: In the short term, management of nesting habitat is the central focus of recovery for Marbled Murrelet. Quantifying, refining and describing the habitat within each conservation region will be essential to protecting the habitat required to meet the population and distribution objectives. Habitat management and protection will need to involve a wide range of land owners and managers and consider appropriate habitat protection approaches. In the longer term, management of important marine habitat will be required.

Monitoring: Monitoring of both population and nesting habitat trends is an important component of recovery. A reliable estimate of population status and trend is required to measure recovery; however, long term population trends of Marbled Murrelet in B.C. remain unclear and various methods show inconsistent and sometimes conflicting trends (COSEWIC 2012). Monitoring the location and amount of available and suitable nesting habitat will also be important to measure success of recovery against the population and distribution objectives.

Research: Research is required on a range of topics to help better inform management of Marbled Murrelet. The focus will be on population densities, habitat requirements (terrestrial and marine), and improved threat characterization and corresponding management recommendations.

Stewardship & Communication and Outreach: An important component of species recovery will involve the development of best management practices for threat reduction and habitat management. This information will help inform participation in recovery actions by both directly affected parties and the general public.

7. CRITICAL HABITAT

Section 41(1)(c) of SARA requires that recovery strategies include an identification of the species' critical habitat, to the extent possible, as well as examples of activities that are likely to result in its destruction. This federal recovery strategy identifies critical habitat to the extent possible, based on the best available information for Marbled Murrelet. More precise boundaries may be mapped, and additional critical habitat may be added in the future if additional research supports the inclusion of areas beyond those currently identified.

7.1 Identification of Critical Habitat for Marbled Murrelet

Critical Habitat for the Marbled Murrelet is identified as that portion of the suitable habitat required for the survival and recovery of the species as specified by the short and long term population and distribution objectives (Section 5).

Currently available information is adequate to spatially identify and map areas of potentially suitable Marbled Murrelet nesting habitat. Analysis of information to identify and map suitable marine habitat has not been completed at this time. Critical habitat is therefore identified as a state where greater than 70% of the 2002 suitable nesting habitat coast-wide remains, distributed among the six conservation regions as follows*:*

- East Vancouver Island – at least 90% retention of 2002 suitable nesting habitat;
- Southern Mainland Coast – at least 85% retention of 2002 suitable nesting habitat;
- Haida Gwaii, Northern Mainland Coast, Central Mainland Coast, and West and North Vancouver Island – at least 68% retention of 2002 suitable nesting habitat in each region.

Table 5 presents the minimum regional habitat retention levels, based on the region specific retention percentages above, which are required to meet the short term recovery objectives and support the long term recovery of Marbled Murrelet. Appendix C presents details behind the calculation of these minimum habitat retention levels.

Table 5. Minimum regional habitat retention levels. See Appendix C for details.

Conservation Region	Minimum Regional Habitat Level (ha)
East Vancouver Island	73,830
Southern Mainland Coast	103,358
Haida Gwaii	153, 099
Northern Mainland Coast	292,651
Central Mainland Coast	220,976
West and North Vancouver Island	195,734

The six conservation regions containing critical habitat for Marbled Murrelet are presented in Appendix B, Figures B-1 to B-6. Within each conservation region, the nesting critical habitat for Marbled Murrelet is found within the Geographic Location polygons (section 7.1.1, Appendix B, Figures B-1 to B-6) where the biophysical attributes (Section 7.1.2) are found. The spatial location of critical habitat within each conservation region will be refined through the work outlined in Table 4. Detailed

methods and decision-making processes relating to critical habitat identification are archived in a supporting document.

The critical habitat identified in this document constitutes a partial identification of nesting critical habitat; an identification of marine critical habitat is not included at this time. A Schedule of Studies has been developed to provide the information to complete the identification of critical habitat. The identification of critical habitat will be updated when information becomes available, either in an update to the recovery strategy or in an action plan(s).

7.1.1 Geographic Location

The area within which nesting critical habitat is found for Marbled Murrelet is delineated by a set of Geographic Location polygons. These polygons are created by combining 1) mapped potentially suitable habitat, 2) known nest sites, and 3) known occupied detections. For each conservation region all available information was overlaid with no preference given to any particular dataset. This created a set of polygons that represent the largest extent of areas thought to contain suitable nesting habitat, using the best available information. This approach is different from that applied to the calculation of 2002 baseline habitat amounts and regional retention levels (Table 5, Appendix C). The data used in this delineation are described as follows:

1) Mapped potentially suitable habitat:

A number of different mapping approaches that characterize Marbled Murrelet suitable nesting habitat have been completed for different geographic areas and at different scales in B.C. Four approaches are used here:

A) The B.C. Model:

The B.C. Model is a strategic level planning tool developed to estimate the amount (hectares) and distribution of potentially suitable Marbled Murrelet nesting habitat in 2002 across the six primary conservation regions (Mather et al 2010, COSEWIC 2012). The B.C Model uses a subset of the stand and landscape level biophysical attributes (elevation, distance inland, and the key forest cover attributes – tree height and stand age; see 7.1.2 Biophysical Attributes) that can be assessed against provincial forest cover polygons, other regional habitat models (Clayoquot Sound), air photo interpretation data (Haida Gwaii), and Baseline Thematic Mapping. Each polygon is classed as either suitable or not suitable. All polygons classed as suitable in the BC Model version corrected for forest depletions prior to 2002 were retained for use in this identification of critical habitat.

B) Air Photo Interpretation:

Air photo interpretation (API) is a standardized tool used to map suitable Marbled Murrelet nesting habitat, and has been applied across many landscape units in B.C. (Burger 2004, Donald et al. 2010). Most API data were collected between 2006 and 2008. API uses high resolution air photos and a standardized approach to identify key forest structure features based on a subset of the Stand and Landscape level biophysical attributes for nesting habitat (vertical complexity, canopy complexity, tree height, and stand age) (CMMRT 2003; Burger 2004). API uses a six-class ranking system (1 = Very High, 2 = High, 3 = Moderate, 4 = Low, 5 = Very Low, and 6 = Nil) to classify forest stand polygons for their potential as suitable nesting habitat for Marbled Murrelet (Burger 2004). API coverage is variable across the six primary conservation regions. Habitat classes 1-3 are considered suitable nesting habitat (Burger 2004, Burger and Waterhouse 2009) and were retained for use in this identification of critical habitat.

C) Low-level Aerial Surveys:

Low-level aerial surveys (LLAS) are a standardized tool for mapping suitable Marbled Murrelet nesting habitat, and have been conducted across many landscape units in B.C. (Burger 2004, Waterhouse et al. 2010). Most LLAS data was collected between 2002 and 2013. Low-level aerial surveys are conducted from helicopters flying low over the treetops, allowing direct visual evaluation of site level, or microhabitat, biophysical attributes, including the presence of nest platforms, quality of nest substrate, and canopy structure, details that other large-scale methods overlook (Burger 2004). Low-level aerial surveys are thus considered generally more reliable than API for identifying potential nesting habitat for Marbled Murrelets, and is a supported method for identifying or confirming Marbled Murrelet nesting habitat (Waterhouse et al. 2009). LLAS also uses a six class system to rank potentially suitable nesting habitat for Marbled Murrelet (1 = Very High, 2 = High, 3 = Moderate, 4 = Low, 5 = Very Low, and 6 = Nil; Burger 2004). Low level aerial survey coverage is variable across the six primary conservation regions. As for API, LLAS classes 1-3 are considered suitable nesting habitat (Burger 2004, Burger and Waterhouse 2009) and were retained for use in this identification of critical habitat.

D) Port Alberni Integrated Polygons:

The Port Alberni Integrated Polygons are a geographically restricted regional dataset created by provincial biologists in 2001 (C. Miller-Retzer, pers. comm., 2013). The polygons integrate several data sources to map potentially suitable nesting habitat for Marbled Murrelet, including: provincial forest cover maps, pre-standard air photo interpretation, pre-standard aerial surveys, ground transects of potential nesting habitat, and audio-visual surveys to confirm occupancy. The Port Alberni Integrated Polygons are based on forest cover conditions in 2001

and are ranked as High, Medium and Low suitability. The High and Medium ranked polygons are considered analogous to LLAS Classes 1-3 (C. Miller Retzer, pers. comm. 2013); therefore only the High and Medium ranked polygons were retained for use in the identification of critical habitat.

2) Known Nest Sites:

A proportion of known nest sites falls outside of suitable habitat (as identified by forest cover polygons) and this proportion varies according to the spatial scale of analysis. The available evidence shows that although Marbled Murrelets seldom re-use nest trees from year to year, the frequency of re-use increases with the degree of habitat loss in a region (Burger et al. 2009b). Hence the use of a nest tree is an indicator of suitable habitat. All available geo-referenced nest locations are thus retained for use in this identification of critical habitat.

Known nest records include 217 sites, collected between 1990 and 2002, compiled by the B.C Conservation Data Center (2013), 14 sites for Mussel Inlet identified in 1992 (n=2) and 1999 (n=12) (Waterhouse et al. 2011), five nest sites collected between 2005 and 2007 on Southern Vancouver Island by the United States Forest Service (Bloxton and Raphael 2009), 3 nest sites located in southwest Vancouver Island by University of Victoria researchers between 1990 and 1999 (A. Burger, pers. comm., 2014), and a single site discovered near Chilliwack, B.C, in 1955 (Ryder et al 2012). As many of the nest locations were derived from telemetry or before advanced GPS technology, a 200 m radius is established around each record to account for locational uncertainty. A single nest record derived from a verbal description was given a 400 m radius to account for a larger location uncertainty. Additional nest records currently not available may be included in the future.

3) Known Occupied Detections

Audio-visual surveys are an established methodology for terrestrial surveys of Marbled Murrelets and can be used to establish occupancy of a site by probable breeding birds (RISC 2001). A database of occupied detection records (n= 404) from Vancouver Island, collected between 1991 and 2006 has been compiled by provincial biologists (Vancouver Island Marbled Murrelet Consolidated Database, C. Miller Retzer, pers. comm., 2013). An additional data set of occupied detection records (n=74) prepared by provincial biologists used data collected by CWS in 1991 (original data from Savard and Lemon 1994, C. Miller Retzer, pers. comm., 2013). All available occupied detection records are retained for use in this identification of critical habitat. Radii of 200 m were established around each occupied detection record to account for location uncertainty of the observer relative to the occupied site. Additional occupied detection records may be included in the future.

7.1.2 Biophysical Attributes

The biophysical attributes of suitable nesting habitat required by Marbled Murrelet are described at different scales. Table 6 describes the biophysical attributes at the microhabitat scale, such as one might see standing on the ground within a stand of trees, which characterize the nest trees themselves and the immediately adjacent forest canopy structure (Table 6; Burger 2004). Table 7 describes the biophysical attributes at the stand and landscape level, such as one might determine from maps or spatial datasets, which characterizes the larger habitat polygons and their placement according to known geographic restrictions (modified from CMMRT 2003). The stand and landscape-level attributes are correlated with the microhabitat attributes identified in Table 6, and are used as a 'top down' filter to identify those areas that require confirmation at the site level against the microhabitat attributes. Alternatively, one can use the microhabitat attributes to assess habitat and then use stand and landscape-level attributes to assess the likelihood of the site in question being suitable nesting habitat (e.g., distance from salt water). Standardized guidance is available on how these attributes are applied to identify suitable nesting habitat, moving from the stand and landscape scale to the microhabitat scale (e.g., RISC 2001, CMMRT 2003, Burger 2004, B.C. Ministry of Environment. 2004). The microhabitat, stand and landscape level attributes underlie the methods used to create several of the spatial map data sets (i.e., the BC Model, API and LLAS) used to define the Geographic Location polygons.

Table 6. Key microhabitat biophysical attributes for Marbled Murrelet nest sites in B.C. (for more details see Hamer and Nelson 1995; Nelson 1997; Burger 2002).

Nest site requirements	Key habitat attributes
Sufficient height to allow stall-landings and jump-off departures	Nest trees are typically >30 m tall (range 15–80 m), and nest heights are typically >25 m (range 11–54 m); nest trees are often larger than the stand average.
Openings in the canopy for unobstructed flight access	Small gaps in the canopy are typically found next to nest trees, and vertical complexity of the canopy is higher in stands with nests than in other nearby stands.
Sufficient platform diameter to provide a nest site and landing pad	Nests are typically on large branches or branches with deformities, usually with added moss cover; nest limbs range from 15 to 74 cm in diameter; nests are typically located within 1 m of the vertical tree trunk.
Soft substrate to provide a nest cup	Moss and other epiphytes provide thick pads at most nest sites, but duff and leaf litter are used in drier areas.
Overhead cover to provide shelter and reduce detection by predators	Most nests are overhung by branches.

Table 7. Stand and landscape level biophysical attributes of Marbled Murrelet nesting habitat in B.C. (modified from CMMRT 2003). The attributes are ranked by the likelihood that habitat polygons with these features will contain a large proportion of the microhabitat biophysical attributes in Table 6. "Most Likely" and "Moderately Likely" combined represent the spatial suitable nesting habitat as modelled by the BC Model, Air Photo Interpretation and Low-level Aerial Survey; however, "Least Likely" polygons may contain patches of suitable habitat and warrant further investigation.

Stand or Landscape Attribute	Most Likely	Moderately Likely	Least Likely
Distance from saltwater (km)			
All Regions	0.5–30	0–0.5 and 30–50	>50
Elevation (m)			
Central and Northern Mainland Coast	0–600	600–900	>900
Haida Gwaii	0–500	500–800	>800
All other regions	0–900	900–1500	>1500
Stand Age Class			
All regions	9 (>250 yr)	8 (140–250 yr)	<8 (<140 yr)
Tree Height Class [1]			
All regions	4–7 (>28.5 m)	3 (19.5–28.4 m)	<3 (<19.5 m)
Canopy Closure Class[2]			
All regions	Classes 4 – 7	Class 3	Classes 2 and 8
Vertical Canopy Complexity[3]			
All regions	MU	NU, U	VU, VNU
Presence of Potential Nest Platforms[4]			
All regions	Classes 1-2 (>25% of trees with suitable platforms)	Class 3 (6-25% of trees with suitable platforms)	Classes 4-6 (<6% of trees with suitable platforms)

[1]*Nests have been found in polygons ranked height class 1 or 2 but the nests were in larger trees than the polygon average.*

[2]*Canopy Closure and Vertical Canopy Complexity are variables that should be interpreted from air photos specifically for Marbled Murrelets, so use this to gauge trust in the spatial products (e.g., air photo). Canopy Closure is the percentage of ground area covered by the vertically projected crowns of the tree cover for the tree layer (Burger 2004): Classes 4-7 equal 36-75% coverage, Class 3 is 26%-35% coverage, Class 2 is 16-25% coverage, and Class 8 is 76-85% coverage,*

[3]*Vertical complexity ranked from least to greatest (see Waterhouse* et al. *2002, 2008). VU = very uniform (<11% height difference between leading trees and average canopy, no evidence of canopy gaps or recent disturbance). U = uniform (11–20% height difference, few canopy gaps visible, little or no evidence of disturbance. MU = moderately uniform (21–30% height difference, some canopy gaps visible, evidence of past disturbance, stocking may be patchy or irregular. NU = non-uniform (31–40% height difference, canopy gaps often visible due to past disturbance, stocking typically patchy or irregular). VNU = very non-uniform (>40% difference, very irregular canopy, stocking very patchy or irregular).*

[4]*These classifications are based on Low-level aerial survey assessments (Classes 1-6), or ground surveys (%'s).*

7.2 Schedule of Studies to Identify Critical Habitat

Table 8. Schedule of Studies to Identify Critical Habitat

Description of Activity	Rationale	Timeline
Terrestrial Critical Habitat		
Assemble additional data to identify suitable nesting habitat outside of the current geographic location (e.g., nest sites for Haida Gwaii; nest site records and habitat suitability data for the Alaska Border region; and fine-scale suitable habitat outside currently mapped areas).	The current geographic location likely does not include all suitable nesting habitat. This information would be used to identify additional nesting critical habitat in the context of the population and distribution objectives.	2014-2015
Marine Critical Habitat		
Identify and map foraging areas, moulting areas, and large breeding and wintering concentrations at important marine locations in B.C.	Ensure critical habitat is identified to support all life stages and to fully meet population and distribution objectives. Currently only habitat used by breeding adults has been studied intensively in B.C. A partial identification of marine critical habitat will be completed by March 31, 2015	2014-2018
Identify habitat needs for newly-fledged juvenile Marbled Murrelets.	Critical habitat is needed to support all life stages. Habitat used by juveniles is known to differ slightly from that used by after-hatch-year birds (Wong et al. 2008).	2014-2018
Study and model marine biophysical parameters that will reliably predict and map preferred marine foraging areas in B.C.	Past studies appear to be too coarse-scale (Yen et al. 2004) or untested at large scales (Ronconi 2008) to be reliable across the coast.	2014-2018
Delineate the spatial distribution of marine habitat required to meet long term population and distribution objectives (may be proposed as critical habitat if applicable).	Marbled Murrelets spend most of their lives at sea. Identification of marine critical habitat is needed to support nesting critical to ensure long term population stability.	2014-2020

7.3 Activities Likely to Result in the Destruction of Critical Habitat

Understanding what constitutes destruction of critical habitat is necessary for the protection and management of critical habitat. Destruction is determined on a case by case basis. Destruction would result if part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from a single or multiple activities at one point in time or from the cumulative effects of one or more activities over time (Government of Canada 2009). Activities described in Table 9 include those likely to cause destruction of critical habitat for the species; however, destructive activities are not limited to those listed. For additional information on critical habitat protection, the proponent should contact Environment Canada – Canadian Wildlife Service, Pacific and Yukon Region.

Table 9. Activities Likely to Result in the Destruction of Critical Habitat.

Description of Activity	Description of Effect (biophysical attribute or other) in relation to function loss	Details of Effect
Harvesting of suitable nesting habitat	Timber harvesting directly removes suitable nesting habitat, and may create 'hard' forest stand edges adjacent to remaining suitable habitat. Hard edges may have detrimental microhabitat effects (i.e., degradation of required crown closure, canopy complexity, reduction in epiphyte growth, and tree height class) on the adjacent habitat or provide increased opportunity for predator access into suitable nesting sites.	Related threats: Loss of nesting habitat, forest fragmentation, and increased predation risk. A single event (direct effect) at any time of the year is sufficient to result in the loss or degradation of critical habitat. While the effect of direct habitat loss would need to occur within the boundaries of critical habitat, the effects from the creation of hard edges could also occur immediately adjacent to critical habitat boundaries. Not enough information exists about the effects of selective harvesting on suitable nesting habitat to set tolerance thresholds within the boundaries of critical habitat. Most of the microclimate effects occur within the first 50-100m of the forest adjacent to the hard edge, suggesting distance thresholds may be important outside of critical habitat boundaries. It should also be noted that the effects of hard edges are diminished over time with forest regeneration.

Road-building.	The clearing of land for roads may directly remove suitable nesting habitat, and may create 'hard' forest stand edges adjacent to remaining suitable habitat. The effects of this activity are comparable to those of timber harvesting (see above).	Related threats: Loss of nesting habitat, forest fragmentation, and increased predation risk. A single event (direct effect) at any time of the year is sufficient to result in the loss or degradation of critical habitat. While the effect of direct habitat loss would need to occur within the boundaries of critical habitat, the effects from the creation of 'hard' edges could also occur immediately adjacent to critical habitat boundaries. Information available at this time is insufficient to develop a tolerance threshold within critical habitat boundaries, but most of the microclimate effects occur within the first 50-100m of the forest adjacent to the 'hard' edge, suggesting distance thresholds may be important directly adjacent to critical habitat boundaries. The effects of hard edges are diminished over time with re-vegetation.
Land clearing for urban development, agriculture, or power developments (wind, run of river, and utility lines).	The clearing of land would directly remove suitable nesting habitat, and may create 'hard' forest stand edges adjacent to remaining suitable habitat. The effects of this activity are comparable to those of timber harvesting and road building (see above).	Related threats: Loss of nesting habitat, forest fragmentation, and increased predation risk. A single event (direct effect) at any time of the year is sufficient to result in the loss or degradation of critical habitat. While the effect of direct habitat loss would need to occur within the boundaries of critical habitat, the effects from the creation of 'hard' edges could also occur immediately adjacent to critical habitat boundaries. Information available at this time is insufficient to develop a tolerance threshold within critical habitat boundaries, but most of the microclimate effects occur within the first 50-100m of the forest adjacent to the 'hard' edge, suggesting distance thresholds may be important adjacent to critical habitat boundaries. It should also be noted that the effects of 'hard' edges may diminish over time with re-vegetation.

Activities that result in habitat modifications that favour predator species over Marbled Murrelet (e.g., establishment of human settlements, camps, or dumps).	Activities that result in increased predator concentrations in close proximity to nest sites have the potential to lower nesting success rates within that habitat. Crows, ravens and jays, all known nest predators, are known to be attracted to human settlements and corresponding edible garbage.	Related threat: Increased predation risk. A single event (direct effect) at any time of the year is sufficient to result in the loss or degradation of critical habitat. The effect of increased predation within the nesting habitat stands could result from activities within the critical habitat boundaries or in close proximity. There is not enough information available at this time to develop tolerance thresholds for these activities. The effects of this activity would apply year-round given they occur across at least one breeding season.

8. MEASURING PROGRESS

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives.

a) Any decline of the entire provincial population is not to exceed 30% over the period 2002-2032.
b) Habitat retention across the provincial range is stable at no less than 70% of the estimated 2002 area of suitable nesting habitat and is consistent with the recommended short term recovery objectives for each of the six primary conservation regions.
c) 30-year (three generations) trend estimates for the B.C. population based on radar counts and other reliable census methods are available.
d) 30-year trend estimates for the areas of suitable nesting habitat across British Columbia and six conservation regions are available.

9. STATEMENT ON ACTION PLANS

One or more actions plans for Marbled Murrelet will be completed within five years of the final posting of the recovery strategy and will be informed by the best available science and information.

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APPENDIX A: EFFECTS ON THE ENVIRONMENT AND OTHER SPECIES

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

Many other species dependent on coastal old-growth forests in B.C. will benefit from the maintenance of nesting habitat for Marbled Murrelet. Examples of species sharing this habitat and listed by the *Species at Risk Act* include Spotted Owl *caurina* subspecies (*Strix occidentalis caurina*) in a few locations in the southern mainland; Northern Goshawk *laingii* subspecies (*Accipiter gentilis laingi*); Northern Saw-whet Owl *brooksi* subspecies (*Aegolius acadius brooksi*); Great Blue Heron (*Ardea herodias);* Dromedary Jumping-slug (*Hemphillia dromedarius*); and Coast Tailed Frog (*Ascaphus truei*). There are no species known to be reliant on Marbled Murrelets as prey. Future actions to identify and protect important marine habitat will also benefit a wide range of species. Negative effects on any species are not foreseen to occur as a result of recovery activities.

APPENDIX B: CRITICAL HABITAT FOR MARBLED MURRELET *(Brachyramphus marmoratus)*

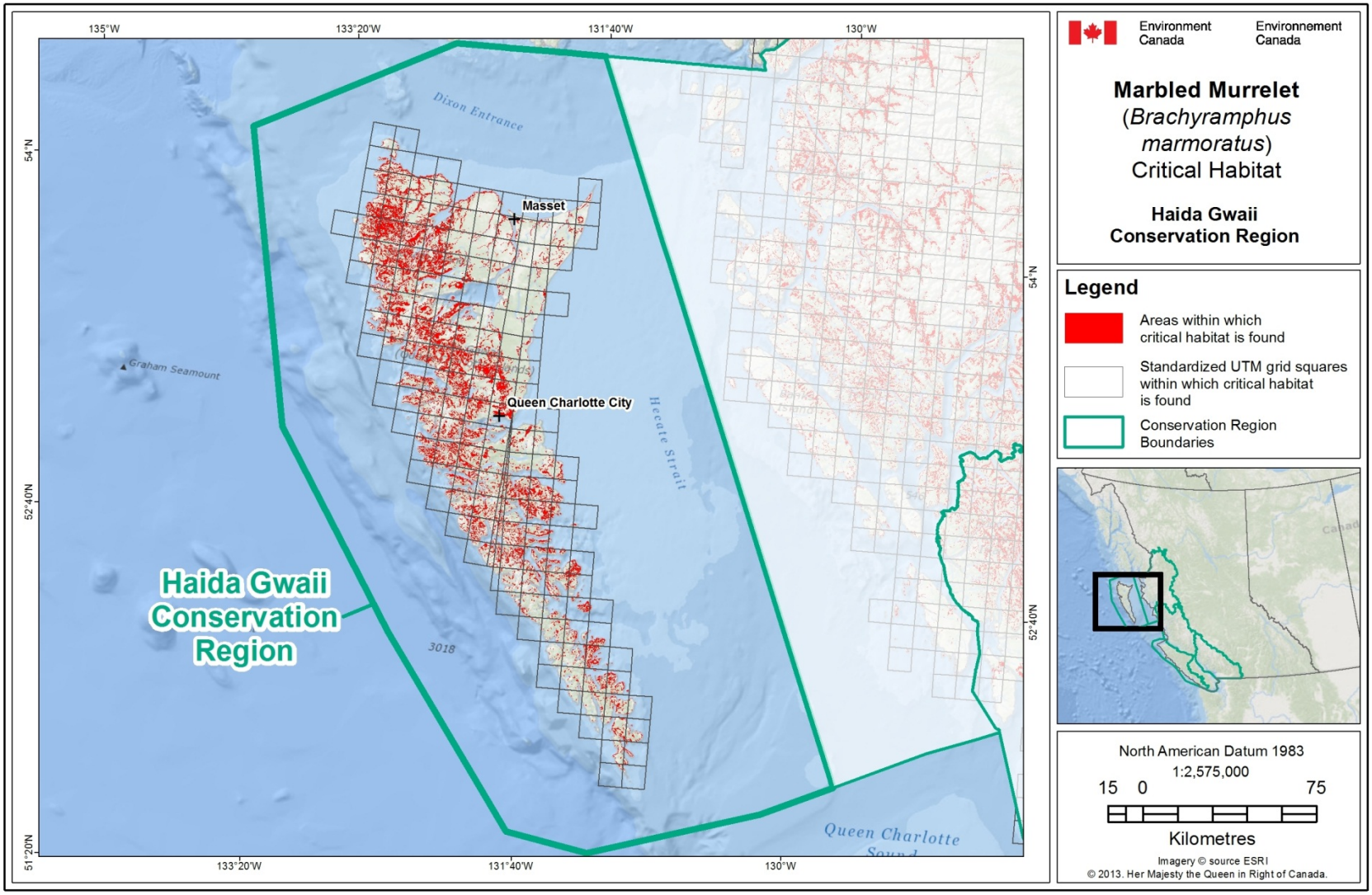

Figure B-1. Critical habitat for Marbled Murrelet in the Haida Gwaii Conservation Region is found within the red polygon areas where the criteria, methodology, and biophysical attributes set out in Section 7 (Critical Habitat) are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat.

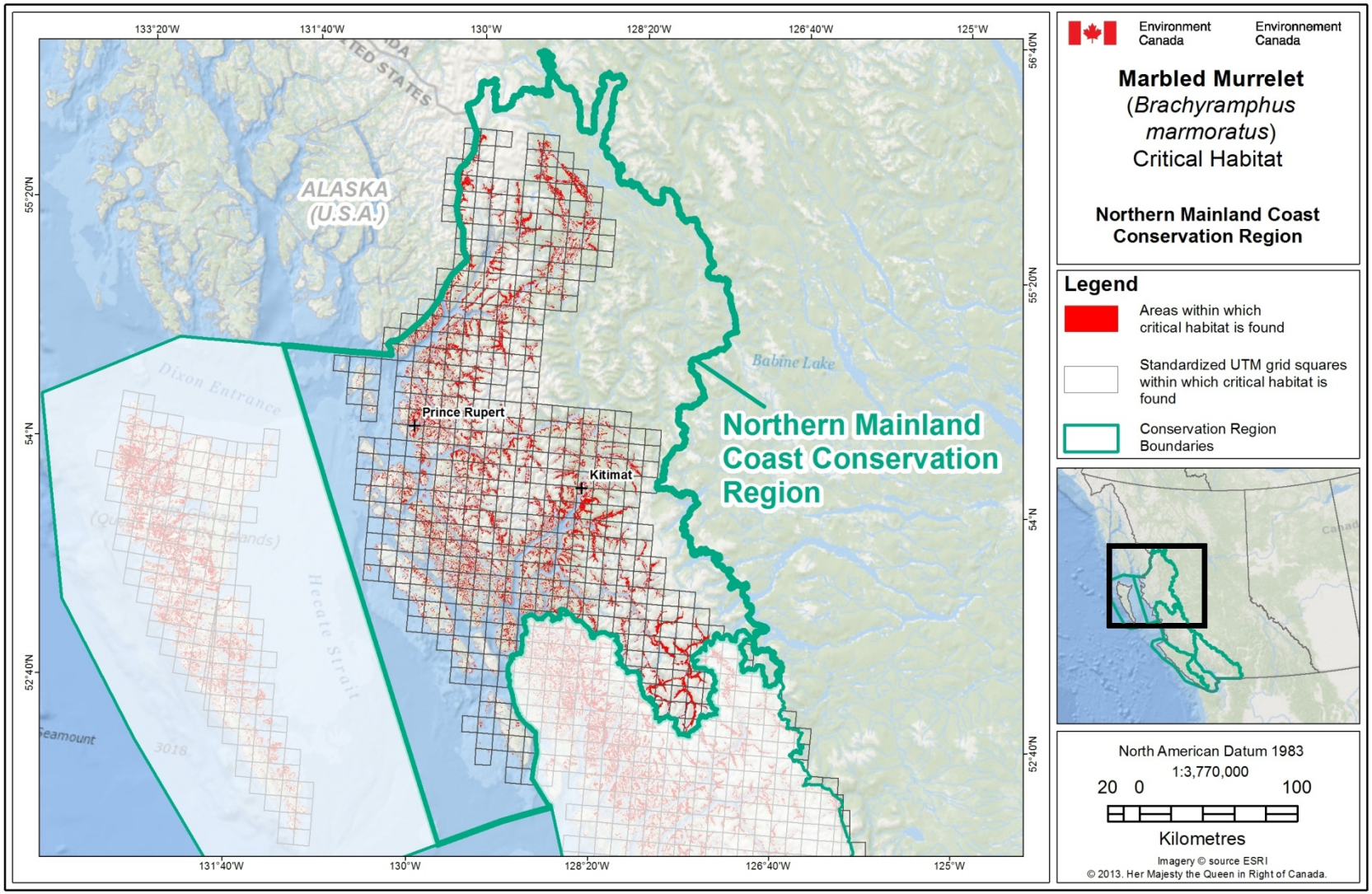

Figure B-2. Critical habitat for Marbled Murrelet in the Northern Mainland Coast Conservation Region is found within the red polygon areas where the criteria, methodology, and biophysical attributes set out in Section 7 (Critical Habitat) are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat.

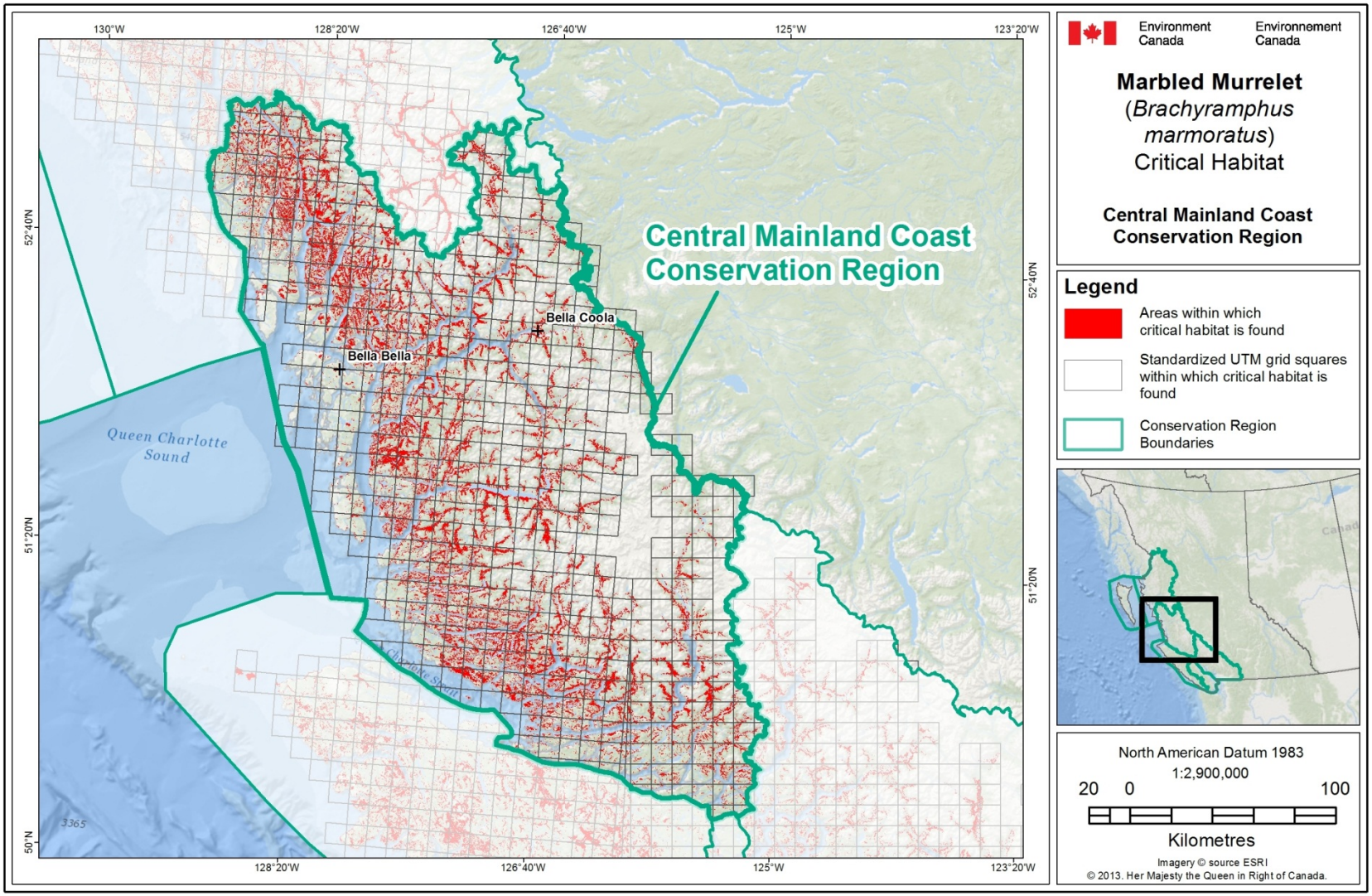

Figure B-3. Critical habitat for Marbled Murrelet in the Central Mainland Coast Conservation Region is found within the red polygon areas where the criteria, methodology, and biophysical attributes set out in Section 7 (Critical Habitat) are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat.

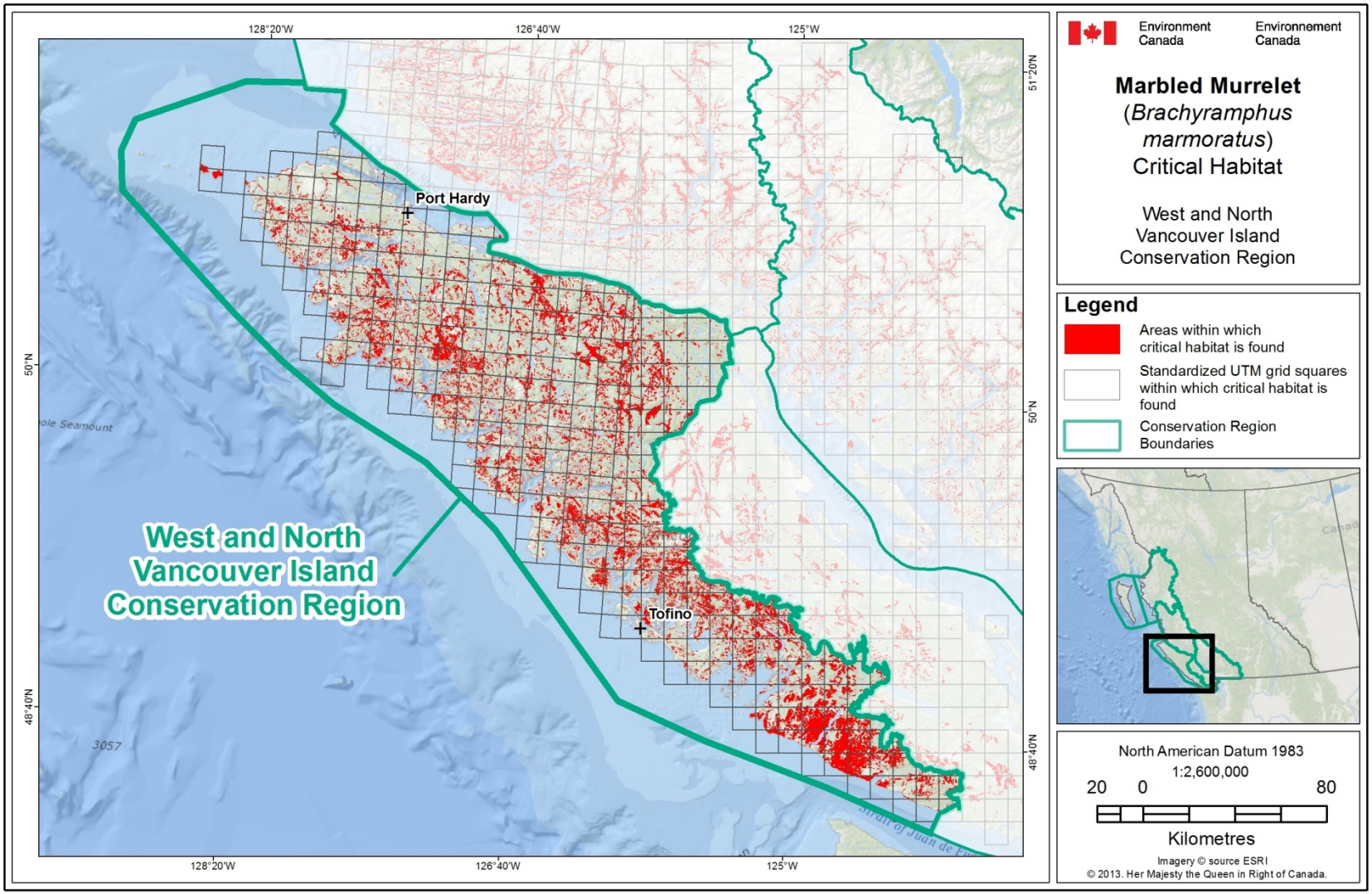

Figure B-4. Critical habitat for Marbled Murrelet in the West and North Vancouver Island Conservation Region is found within the red polygon areas where the criteria, methodology, and biophysical attributes set out in Section 7 (Critical Habitat) are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat.

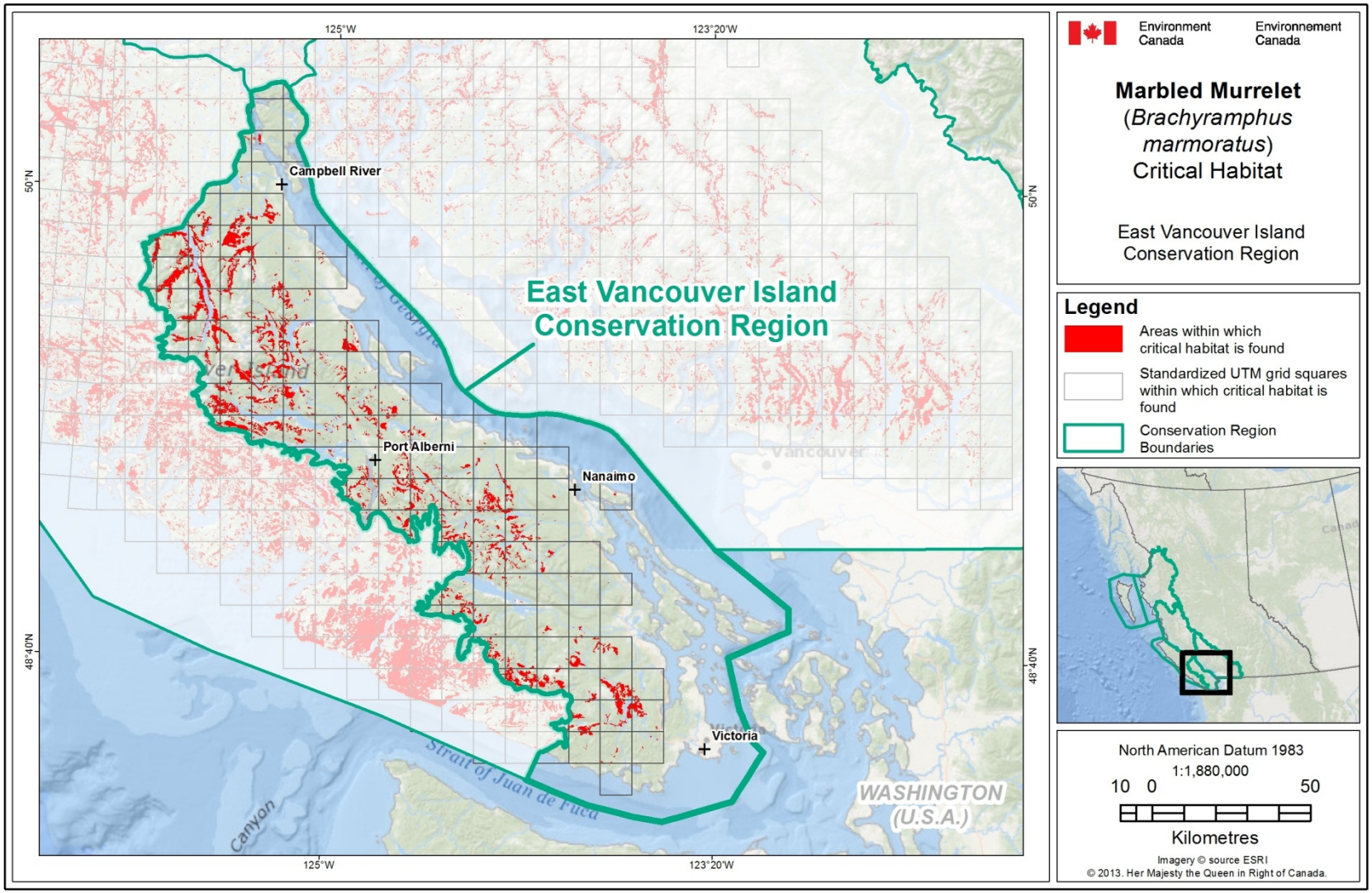

Figure B-5. Critical habitat for Marbled Murrelet in the East Vancouver Island Conservation Region is found within the red polygon areas where the criteria, methodology, and biophysical attributes set out in Section 7 (Critical Habitat) are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat.

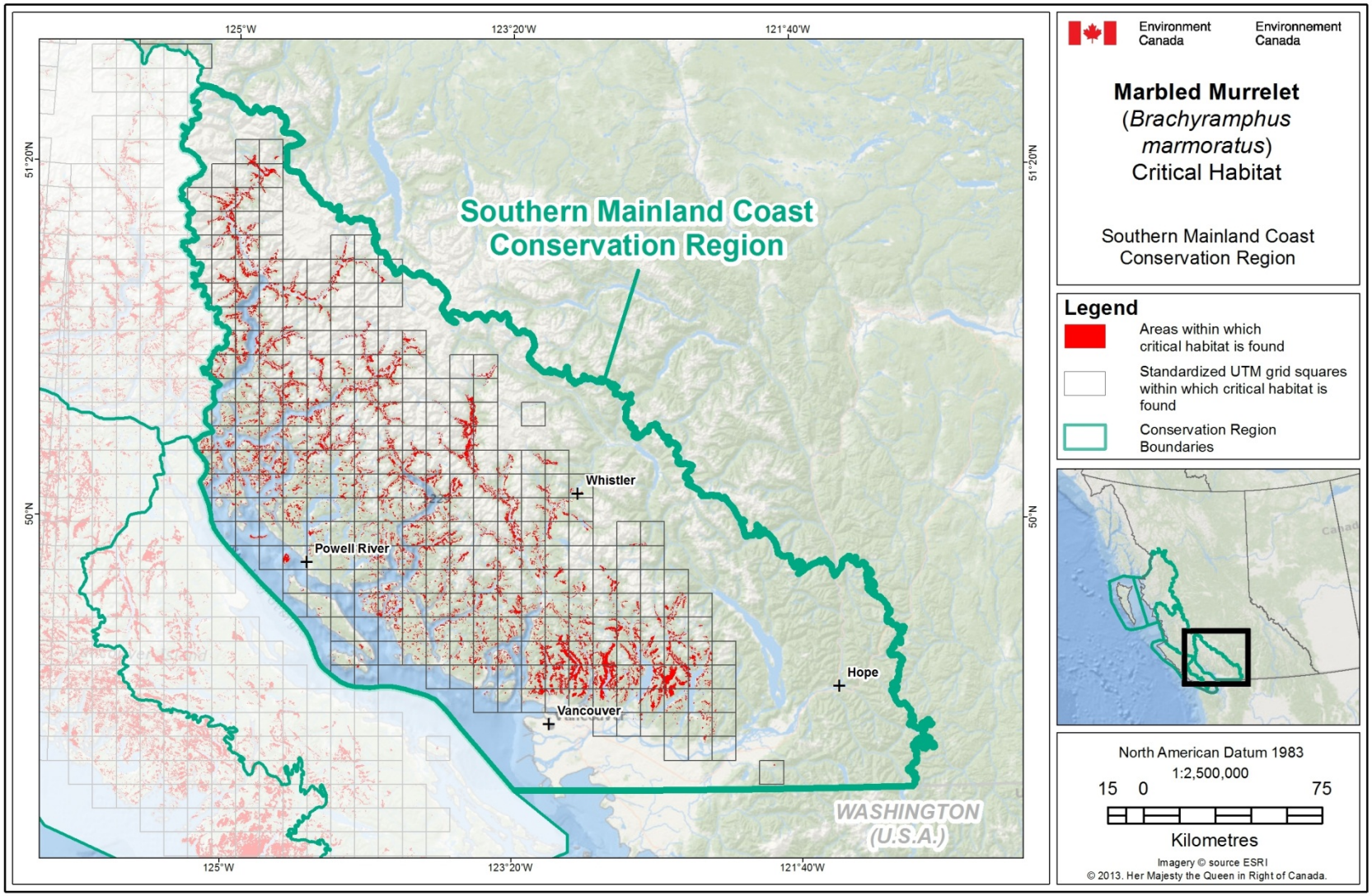

Figure B-6. Critical habitat for Marbled Murrelet in the Southern Mainland Coast Conservation Region is found within the red polygon areas where the criteria, methodology, and biophysical attributes set out in Section 7 (Critical Habitat) are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat.

APPENDIX C: MINIMUM 2002 BASELINE HABITAT AMOUNTS AND REGIONAL HABITAT RETENTION LEVELS.

The baseline 2002 amount of suitable habitat and regional retention levels presented in Table C.1 in this appendix are ***minimum*** amounts, and will be updated as the nesting critical habitat presented in this recovery strategy (Section 7.1) is refined through the actions outlined in Table 4. The area of habitat captured by the Geographic Location approach (7.1.1) and the approach used for baseline level calculation (Hierarchical Approach) are different; these important differences are described below.

Geographic Location for nesting critical habitat:

The Geographic Location (Section 7.1.1; maps in Appendix B) is the broadest area within which critical habitat may be found according to the biophysical attributes (7.1.2). It is created by overlapping all of the data sets referenced in Section 7.1.1 available for each landscape unit in a conservation region. Each spatial data set includes areas of suitable habitat not necessarily classed as suitable by the other data sets. This is a precautionary measure to account for suitable Marbled Murrelet nesting habitat that cannot currently be modeled with the available medium scale spatial habitat information identified in Section 7.1.1. For example, medium scale Low-level Aerial Survey Class 4-6 polygons are considered unsuitable nesting habitat, however, research shows that at the fine-scale (e.g., 100 m diameter patches) suitable habitat occurs within medium scale Class 4 habitat polygons. These fine-scale patches of suitable nesting habitat are important for the recovery of Marbled Murrelet.

Hierarchical Approach for minimum 2002 baseline:

A different approach must be used to estimate the baseline 2002 suitable habitat amount (hectares) and minimum regional retention levels (hectares). These are calculated using a hierarchical approach to assembling the medium scale spatial information from Section 7.1.1. This hierarchical approach is consistent with the accepted management interpretation and use of the available data, and reflects the most defensible approach for estimating amounts of suitable nesting habitat for each landscape unit. Under the hierarchical approach, for each landscape unit, the estimated area (hectares) is less than or equal to the corresponding estimate (area) for Geographic Location. Work to develop defensible correction factors for adjusting regional level amounts is underway (Table 4); therefore, this hierarchical approach represents the most defensible current approach to estimating minimum regional levels.

Calculation of minimum 2002 baseline:

The minimum baseline 2002 suitable nesting habitat amount is estimated as follows:

1) Hierarchical approach: For each landscape unit within a conservation region, the preferred order of use of the medium scale spatial data in Section 7.1.1 is to use Low-Level Aerial Survey (LLAS, Classes 1-3)), or if it is not available to use Air Photo Interpretation (API, Classes 1-3) data, or if neither are available to use the B.C. Model suitable habitat. Additionally, all suitable nest records, occupied detections, and regional habitat polygons are included wherever they are available;

2) Adjust to 2011: Because the data used for each landscape unit cover a range of years, provincial harvest depletion records were used to adjust the habitat area for each landscape unit to 2011 (January 1, 2012). 2011 was used because the provincial depletion database was believed to be most complete for that date, and also to be consistent with previous provincial approaches using the BC Model (see next).

3) Backcast to 2002: The total area (hectares) of 2011 suitable nesting habitat for each conservation region was then backcast to 2002 using loss proportions for the same 2002-2011 period established in provincial analyses (M. Mather, pers. comm., 2014). The estimated loss proportions from the current data set were similar to independent provincial estimates.

As noted above, the minimum levels do not account for suitable nesting habitat that may fall outside the polygons used for the Hierarchical Approach to assembling the spatial information for baseline calculations. Another source of uncertainty is the loss of habitat captured in the provincial depletion database; this may be underestimated in regions containing large proportions of private forest lands, particularly the East Vancouver Island conservation region. While the estimates included in Table C.1 reflect the best available information at the time of this recovery strategy, this uncertainty should be taken into account when interpreting the “Percent of 2011 Habitat Above Habitat Retention Levels” in Table C.1. Refinement of this information is a key activity outlined in Table 4 of the Recovery Strategy.

Table C-1: Minimum 2002 Baseline Suitable Nesting Habitat amounts (hectares) and Minimum Regional Habitat Retention Levels (hectares).

Conservation Region	Area (ha) Habitat in 2002 (Baseline) 1	Short Term Recovery Objectives (2002 – 2032)[2]	Minimum Habitat Retention Levels (ha)[3]	Area (ha) Habitat in 2011[4]	Area (ha) of 2011 Habitat in Excess of Minimum Habitat Retention Levels[5]	Percent of 2011 Habitat Above Minimum Habitat Retention Levels[6]
Northern Mainland Coast	430,369	68%	292,651	420,221	127,570	43.6%
Haida Gwaii	225,145	68%	153,099	212,628	59,530	38.9%
Central Mainland Coast	324,965	68%	220,976	310,427	89,451	40.5%
Southern Mainland Coast	121,598	85%	103,358	115,954	12,597	12.2%
West and North Vancouver Island	287,844	68%	195,734	256,081	60,348	30.8%
East Vancouver Island	82,033	90%	73,830	77,038	3,208	4.3%
Total	**1,471,954**		**1,039,648**	**1,392,351**	**352,703**	

[1]***Area (ha) Habitat in 2002 (Baseline):*** The amount of suitable habitat available in 2002, determined using the backcasting approach.
[2]***Short Term Recovery Objectives (2002 – 2032)***: The minimum regional percentages of suitable habitat required to meet the population and distribution objectives - See sections 5 and 7.1.
[3]***Minimum Habitat Retention Levels (ha):*** The minimum suitable habitat amounts required to meet the regional short term recovery objectives.
[4]***Area (ha) Habitat in 2011:*** The regional amounts of suitable habitat available in 2011, determined using the hierarchical approach and 2011 provincial harvest depletion records.
[5]***Area (ha) of 2011 Habitat in Excess of Minimum Habitat Retention Levels:*** The amount of suitable habitat available in 2011 minus the minimum amount of habitat required to meet the population and distribution objectives.
[6]***Percent of 2011 Habitat Above Minimum Habitat Retention Levels:*** The percentage of suitable habitat available in 2011 in excess of the minimum amount of habitat required to meet the population and distribution objectives.