Species at Risk Act
Recovery Strategy Series

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

Marbled Murrelet

2023

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For copies of the recovery strategy, or for additional information on species at risk, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk (SAR) Public Registry[1].

Cover photos: immature/winter plumage (left) © Kerry Woo
adult breeding plumage (right) © Jenna Cragg

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[1] www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] 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 within five years after the publication of the final document on the Species At Risk Public Registry.

The Minister of Environment and Climate Change Canada and Minister responsible for the Parks Canada Agency is the competent minister under SARA for the Marbled Murrelet and has prepared this recovery strategy, as per section 37 of SARA. To the extent possible, it has been prepared in cooperation with the Minister of Fisheries, Oceans and the Canadian Coast Guard, the Province of British Columbia, Indigenous 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 and Climate Change 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 and Climate Change Canada and/or 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.

The recovery strategy sets the strategic direction to arrest or reverse the decline of the species, including identification of critical habitat to the extent possible. It provides all Canadians with information to help take action on species conservation. When critical habitat is identified, either in a recovery strategy or an action plan, SARA requires that critical habitat then be protected.

In the case of critical habitat identified for terrestrial species including migratory birds SARA requires that critical habitat identified in a federally protected area[3] be described in the *Canada Gazette* within 90 days after the recovery strategy or action plan that

[2] www.canada.ca/en/environment-climate-change/services/species-risk-act-accord-funding.html#2

[3] These federally protected areas are: a national park of Canada named and described in Schedule 1 to the *Canada National Parks Act*, The Rouge National Park established by the *Rouge National Urban Park Act*, a marine protected area under the *Oceans Act*, a migratory bird sanctuary under the *Migratory Birds Convention Act, 1994* or a national wildlife area under the *Canada Wildlife Act* see ss. 58(2) of SARA.

identified the critical habitat is included in the public registry. A prohibition against destruction of critical habitat under ss. 58(1) will apply 90 days after the description of the critical habitat is published in the *Canada Gazette*.

For critical habitat located on other federal lands, the competent minister must either make a statement on existing legal protection or make an order so that the prohibition against destruction of critical habitat applies.

If the critical habitat for a migratory bird is not within a federal protected area and is not on federal land, within the exclusive economic zone or on the continental shelf of Canada, the prohibition against destruction can only apply to those portions of the critical habitat that are habitat to which the *Migratory Birds Convention Act, 1994* applies as per SARA ss. 58(5.1) and ss. 58(5.2).

For any part of critical habitat located on non-federal lands, if the competent minister forms the opinion that any portion of critical habitat is not protected by provisions in or measures under SARA or other Acts of Parliament, or the laws of the province or territory, SARA requires that the Minister recommend that the Governor in Council make an order to prohibit destruction of critical habitat. The discretion to protect critical habitat on non-federal lands that is not otherwise protected rests with the Governor in Council.

Acknowledgments

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

Kerry Woo (Chair - Environment and Climate Change Canada, Canadian Wildlife Service),
Douglas Bertram (Former chair - Environment and Climate Change Canada, Science and Technology)
Alan Burger (University of Victoria - adjunct professor)
John Deal (Western Forest Products)
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Executive Summary

The Recovery Strategy for the Marbled Murrelet (*Brachyramphus marmoratus*) in Canada (Environment Canada 2014) was originally posted on the Species at Risk Public registry in June 2014. This recovery strategy was amended in 2023 to:

- Update marine information in the Needs of the Marbled Murrelet (Section 3.3)
- Update the short term Population and Distribution Objective to better address marine life history (Section 5) and the corresponding Measuring Progress (Section 8)
- Add an identification of marine critical habitat to the extent possible (Section 7; Table 9; Appendix B)
- Update the Strategic Direction for Recovery (Table 5) and Schedule of Studies to Identify Critical Habitat (Table 10), with respect to marine critical habitat
- Add Biophysical Attributes – Marine Critical Habitat (Section 7.1.6) and Activities Likely to Result in the Destruction of Critical Habitat to include marine aspects (Table 10)
- Adjust table numbers and chapter numbering of Section 7 to reflect changes and additions
- Add minor corrections and clarification throughout the document, including the wording in table C-1, Appendix C (note this did not result in any substantive changes to content)

Except for the additions described above, *no other changes were made to the 2014 posted recovery strategy*. Further amendments may be made to update other sections of the document in the future.

The Marbled Murrelet is a small seabird that spends most of its time at sea close to shore. Marbled Murrelets are secretive and nest as solitary pairs at low densities, typically in old-growth forests within 50 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); predation at sea; 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) any decline of the British Columbia (B.C.) population and the area of its nesting habitat will have slowed to a halt and 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, and corresponding sufficient areas of suitable marine habitat to support all life stages of nesting and wintering birds. Short-term recovery objectives for six primary conservation regions are recommended to achieve the overall coast-wide objective of 70% retention of 2002 population and nesting habitat levels.

The long term population and distribution objective for the recovery of Marbled Murrelets is to ensure a high probability of persistence after 2032 across its range, with a stable population level above 70% of 2002 population estimates. This will be achieved by maintaining sufficient suitable nesting and marine habitat, and by reducing other threats.

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.

An identification of terrestrial critical habitat is included to the extent possible. Areas within which terrestrial critical habitat occurs are delineated for the seven conservation regions (Appendix B). Minimum habitat retention targets (hectares) are included based on the short-term recovery objectives (Appendix C).

An identification of marine critical habitat is included to the extent possible, covering an area where information is currently available (in the Salish Sea and adjacent marine waters).

Neither the terrestrial nor marine critical habitat identifications are sufficient to meet the population and distribution objectives. A schedule of studies outlines the work that is required to complete the identification of both terrestrial and marine critical habitat.

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

Based on the following four criteria that Environment and Climate Change Canada uses to establish recovery feasibility, recovery of the Marbled Murrelet has been deemed technically and biologically feasible.

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 and marine habitat is available or could be made available through long term recruitment of younger trees into nesting habitat and appropriate management of marine areas.

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 and marine habitat, nesting habitat protection, management of marine waters, and the development of best management practices (for both habitat management and threat reduction) for affected land managers. In the longer term, continued research and monitoring will help better inform techniques for threat reduction and marine habitat characterization and management.

Table of Contents

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.

* COSEWIC (Committee on the Status of Endangered Wildlife in Canada)

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).

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 Species 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 terms “population” and “sub-population” refer to geographic regions. 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.

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 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 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 the decline (Bertram et al. in prep.(a)).

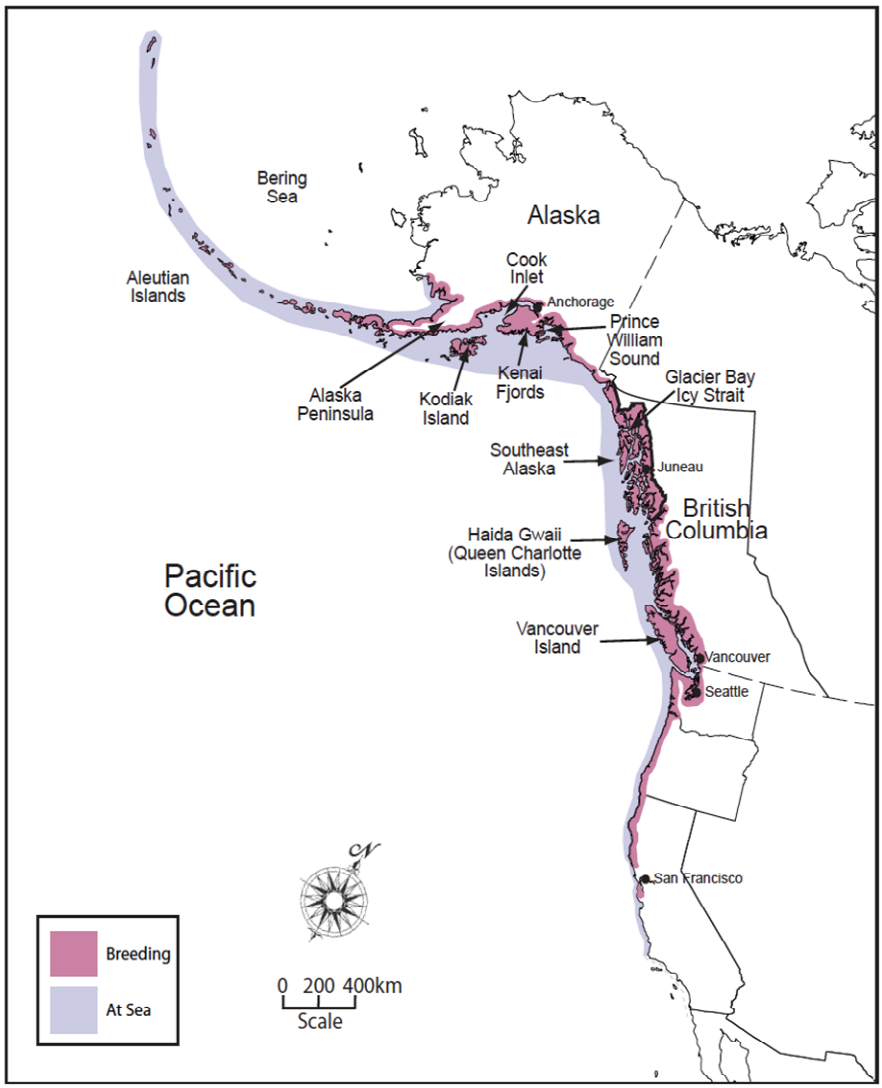

Figure 1. Global distribution of Marbled Murrelets (from Piatt et al. 2007, with permission).

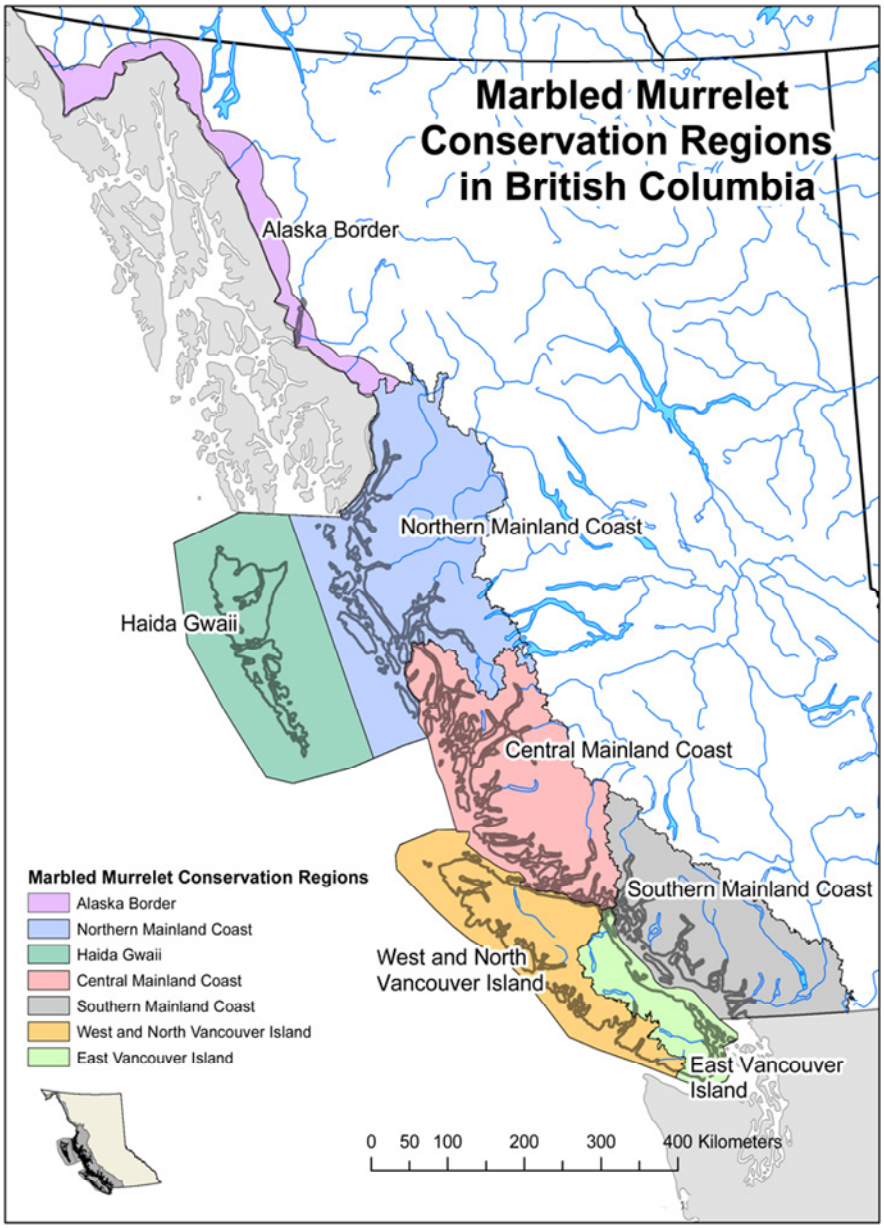

Figure 2. Map of the seven conservation regions recognized by the Marbled Murrelet Recovery Team in B.C., as provided by M. Mather and L. Sinclair (BC Ministry of Forests, Lands and Natural Resource Operations, Nanaimo, BC).

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[a]	Source
Alaska	237,500[b]	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**		

[a] *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).*

[b] *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 7 and 8 in section 7.1.3 of this document.

Marine habitat

Marine habitat and prey that are important to Marbled Murrelets were reviewed by Burger (2002), Piatt et al. (2007) and COSEWIC (2013). In general, marine distributions are affected by marine features that influence prey availability and by proximity to inland nesting habitat (typically <50 km from marine habitat), especially during the breeding season (Meyer et al. 2002; Ronconi 2008; Raphael et al. 2015; Lorenz et al. 2016; O'Hara et al. 2016). Murrelets tend to forage close to shore (typically <0.5 km from shore on exposed coastlines and <2 km from shore in more sheltered areas, such as among islands or in inlets, though sometimes up to 5 km from shore). They generally forage in waters <30 m deep, but have been observed diving to about 60 m. During the breeding season, high energy fish species, including but not limited to Pacific Sand Lance (*Ammodytes hexapterus*), Pacific Herring (*Clupea pallasii*), Capelin (*Mallotus villosus*) and Northern Anchovy (*Engraulis mordax*), are key prey species, both for feeding young on the nest and for adults. Invertebrates, including but not limited to small crustaceans in the families Mysidae and Euphausiidae (e.g., North Pacific Krill, *Euphausia pacifica*) and small squid (e.g., Opalescent Inshore Squid, *Loligo opalescens*) are also important prey, especially in winter. Foraging aggregations tend to occur in predictable areas over multiple years and appear to be related to persistent aggregations of preferred prey species, such as sand lance and herring.

It has proved difficult to quantify the important attributes of marine habitat for Marbled Murrelets, with few features being consistent across different studies (Yen et al. 2004, Burger et al. 2008, Ronconi 2008, COSEWIC 2013). However, recent modelling has identified several important attributes of marine areas in the Salish Sea and surrounding area (Strait of Georgia and adjacent channels, inlets and sounds) for two primary forage fish species (Pacific Sand Lance and Pacific Herring) where significant concentrations of adult Marbled Murrelets are found during the breeding season (Robertson et al. 2013, O'Hara et al. 2016, Robinson et al. 2018; Table 3). Bathymetry (water depth) is a key attribute for forage fish populations (many forage fish typically occur <80 m depth; O'Hara et al. 2016) and also for Marbled Murrelet accessibility (maximum reported diving depth is about 60 m; Piatt et al. 2007). Pacific Sand Lance are a key prey species and when they are not foraging in the water column they typically bury themselves in relatively coarse sediment because they do not have swim bladders (Robertson et al. 2013). These sediments have a specific grain size to allow for efficient burying (0.25 mm to 4.00 mm diameter) and also must not have an overabundance of silt that could suffocate the buried fish (<10% silt). Pacific Herring are another key prey species and their populations have been associated with several types of shorelines in the Salish Sea, most importantly beaches, flats and fans composed of sand or gravel; and rock ramps, rock platforms and rock cliffs (O'Hara et al. 2016). Some oceanographic features have been identified that contribute to the upwelling of nutrients that are important for forage fish populations, and thus Marbled Murrelets, including areas with high tidal currents (especially in inlets) and areas with high undersea slopes (especially in more open waters). And finally, during the breeding season, marine habitats important to both forage fish and Marbled Murrelet populations are found near to suitable inland nesting habitat (up to 50 km from the high tide line; O'Hara et al. 2016).

Table 3. Attributes of key marine habitat features for adult Marbled Murrelets in the Salish Sea and adjacent waters on the coast of B.C. during the breeding season.

Function for Marbled Murrelets	Feature	Attributes
Marine habitat for foraging and resting	Straits, channels, inlets, estuaries; including shorelines and the seafloor	- Water column associated with preferred prey species populations (from 0 m, the high tide line, to a depth of 80 m) - Shorelines associated with Pacific Herring populations (beaches, flats or fans composed of sand and gravel; and rock ramps, rock platforms and rock cliffs) - Adequate burying habitat to support Pacific Sand Lance populations that are a primary prey species for murrelet populations: - Consisting of medium-to-coarse sand (0.25-2.00 mm), with occasional very fine gravel (2-4mm) and low silt (<10%) - Spawning areas for prey species such as herring and sand lance - Areas with high tidal currents, especially in inlets (can contribute to nutrient upwelling for prey species) - Areas with high seabed slope, especially in more open waters (can contribute to upwelling of nutrients for prey species) - Proximate to suitable nesting habitat during the nesting season (typically up to 50 km from the high tide line) - Limited human disturbance on water surface (to ensure effective foraging and sufficient resting for murrelets) - Limited pollution, such as from oil and plastics (to ensure healthy murrelet and prey species populations) - Limited human impacts (e.g., habitat loss, sedimentation, turbidity) to the shoreline, seafloor and water column (to ensure healthy prey species populations)

	Adequate prey species for Marbled Murrelets	- Primary prey species populations must be adequate to support robust murrelet populations, including the full range of preferred prey, including but not limited to:
		  - Pacific Sand Lance, Pacific Herring, Capelin, Northern Anchovy and similar species
		  - Invertebrates (such as krill and squid) and other similar species

4. Threats

4.1 Threat Assessment

Table 4. Threat assessment to Marbled Murrelet populations in B.C.

Threat	Level of Concern[a]	Extent	Occurrence	Frequency	Severity[b]	Causal Certainty[c]
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

Threat	Level of Concern[a]	Extent	Occurrence	Frequency	Severity[b]	Causal Certainty[c]
Changes in Ecological Dynamics or Natural Processes						
Fisheries Induced Prey Depletion	Low	Localized	Historic	Unknown	Medium	Medium

[a] *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.*

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

[c] *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 (Piatt et 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. 2002a). 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 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. 2002a; 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, and this threat has always been considered in the species' status designation (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 Strait of Georgia and Strait of 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 (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 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 marine invertebrates) 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 focuses on halting the decline of nesting habitat and addressing threats to the species and its habitat (nesting and foraging), then maintaining a stable or increasing, relatively abundant population across the species' present range in B.C.

Short term population and distribution objective

The short term population and distribution objective (next 10-20 years) for the recovery of Marbled Murrelet is to halt the decline of this species in Canada: 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 sufficient areas of nesting habitat remaining in the six primary conservation regions, and corresponding sufficient area of suitable marine habitat to support all life stages of nesting and wintering birds.

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

- East Vancouver Island region – the retention of 90% of 2002 populations and proportionate amounts of 2002 nesting habitat, with corresponding sufficient

areas of suitable marine habitat necessary to support all life stages of nesting and wintering birds;
- Southern Mainland Coast – the retention of 85% of 2002 populations and proportionate amounts of 2002 nesting habitat, with corresponding sufficient areas of suitable marine habitat necessary to support all life stages of nesting and wintering birds; and,
- Haida Gwaii, Northern Mainland Coast, Central Mainland Coast and West and North Vancouver Island regions - the retention of 68% of 2002 populations and proportionate amounts of 2002 nesting habitat, with corresponding sufficient areas of suitable marine habitat necessary to support all life stages of nesting and wintering birds.

Long term population and distribution objective

The long term population and distribution objective (25+ years) for the recovery of Marbled Murrelet in Canada is to ensure that the species will have a high probability of persistence after 2032 across its range, with a stable or increasing population level above 70% of 2002 population estimates. This will be achieved by maintaining or restoring sufficient suitable nesting and marine habitat, and by reducing other threats.

Rationale:

The Marbled Murrelet Recovery Team (CMMRT 2003), by 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). Limiting any decline to less than 30% over three generations 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. The purpose of not tolerating a more than 30% decline over 30 years is retention of greater than 70% of the population and its nesting habitat for the same period of time. Because the 2002 population (and the current population) can only be estimated with wide confidence limits (COSEWIC 2012; see Table 2) population retention targets are expressed as nesting habitat retention targets, set using a scientifically supported 1:1 relationship between population abundance and amount (area) of suitable nesting habitat (reviewed in Burger and Waterhouse 2009).

The short-term population and distribution objective represents an achievable and conservative minimum population size threshold for Marbled Murrelet from which longer term population management goals can be achieved. This objective should not be interpreted as an intent to manage populations or nesting habitat down to 70% of 2002 levels. 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 that recognizes past and ongoing multi-jurisdictional management of Marbled Murrelet.

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.

Important marine habitats also require conservation to ensure that all life history requirements of Marbled Murrelets can be provided. Marine habitat use by Marbled Murrelets is not well understood (Yen et al. 2004, Burger et al. 2008, Ronconi 2008), so quantification of the amount and type of marine habitat needed to meet life history requirements is challenging; however, at a minimum marine habitat must be sufficient to support a stable population.

Short-term recovery objectives are recommended 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 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. 2015).
- 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. 2002a; 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; Burger et al. 2018).
- 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).
- The Gwaii Haanas National Marine Conservation Area Reserve and Haida Heritage Site and the Scott Islands marine National Wildlife Area conserve vital marine areas for millions of seabirds on the Pacific coast.
- The Province of British Columbia has protected several marine areas relevant to Marbled Murrelets, including the Desolation Sound Marine Provincial Park, The Hakai Lúxvbálís Conservancy and the Checleset Bay Ecological Reserve.

- Research on marine habitat associations and the effects of changing marine conditions in B.C. waters (e.g., Yen et al. 2004; Ronconi 2008; O'Hara et al. 2016).
- Studies to estimate and mitigate Marbled Murrelet bycatch in gill-net fisheries (Smith and Morgan 2005; Bertram et al. in prep.).
- 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 5. Recovery Planning Table.

Threat or Limitation	Priority[a]	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	Terrestrial Habitat Management	• Refine minimum baseline 2002 habitat amount used for estimating habitat retention targets 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). • 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 targets for each region, Appendix C), prioritizing conservation regions with high historic habitat loss (East Coast Vancouver Island, Southern Mainland Coast).. • Identify and protect nesting critical habitat at key sites (e.g. remnant old-growth coastal Douglas fir forest) within priority conservation regions. • Improve information and management options related to 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[a]	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. • 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 and Biotoxins; Collisions with Wind Turbines and Power Lines Knowledge Gaps	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; plastics; diseases, parasites and biotoxins). • 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.

Threat or Limitation	Priority[a]	Broad Strategy to Recovery	General Description of Research and Management Approaches
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.
Knowledge Gaps	Necessary	Research marine habitat attributes	• Map the abundance and distribution of murrelets at sea at multiple spatial scales and across all seasons across the B.C. coast. • Study and model marine biophysical parameters that will reliably predict and map preferred marine foraging areas in B.C. (including information on forage fish populations and age classes important to Marbled Murrelets). • Address lack of information on physical oceanographic features of nearshore habitat in the 'white strip' (< 30 m depth) of the B.C. coastline by acquiring spatial data and biological information to better characterize these shallow marine habitats. • Field verification of the biophysical attributes of forage fish habitat and Marbled Murrelet occurrences. • Refinement of marine critical habitat by investigating associations between terrestrial and marine critical habitat. • Better understand habitat use by juveniles and after-hatch-year birds (Wong et al. 2008). • Develop a standardized system of sub tidal habitat classification, mapping and modelling (e.g., consider applying Greene et al. 1999 system from San Juan Islands to entire B.C. coast). • Develop a better understanding of the effects of climate change on all prey species and age classes.

[a] *"Priority" reflects the degree to which the broad strategy contributes directly to the recovery of the species or is an essential precursor to an approach that contributes to the recovery of the species.*

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

Critical habitat is defined in the SARA as, "…the habitat that is necessary for the survival or recovery of a listed wildlife species, and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species."
Section 41(1)(c) of the 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.

It is recognized that the terrestrial critical habitat and the marine critical habitat identified here is insufficient to meet the population and distribution objectives for the species. A schedule of studies (Section 7.2) is included to outline the activities required to identify additional critical habitat necessary to meet the population and distribution objectives of the species. 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 Identification of the Species' Critical Habitat

7.1.1 Terrestrial Critical Habitat

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

Currently available information is adequate to spatially identify and map areas of potentially suitable Marbled Murrelet nesting habitat. Critical habitat is therefore identified as a state where greater than 70% of the 2002 suitable nesting habitat coast-wide remains, distributed among conservation regions as follows*:*

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

Table 6 presents the minimum regional habitat retention targets (the short-term recovery objectives) estimated using these regional retention percentages. Appendix C presents details behind the calculation of these minimum targets (in hectares).

Table 6. Minimum regional habitat retention targets. See Appendix C for details.

Conservation Region	Minimum Regional Habitat Target (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

For each conservation region, the minimum area of nesting critical habitat for Marbled Murrelet is the habitat retention target (Table 6) selected from habitat within the Geographic Location polygons (section 7.1.2, Appendix B, Figures B-1 to B-6) that

meets the biophysical attributes (Section 7.1.3). Detailed methods and decision-making processes relating to critical habitat identification are archived in a supporting document.

7.1.2 Geographic Location - Terrestrial

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 targets (Table 6, 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. (Burger et al. 2018). 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 7.1.3 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 standardize 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.

7.1.3 Biophysical Attributes - Terrestrial

The biophysical attributes of suitable nesting habitat required by Marbled Murrelet are described at different scales. Table 7 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 8 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 7, 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 saltwater). 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 7. 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 8. Stand and landscape level biophysical attributes of Marbled Murrelet forested 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 7. A combination of "Most Likely" and "Moderately Likely" 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[a]			
All regions	4–7 (>28.5 m)	3 (19.5–28.4 m)	<3 (<19.5 m)
Canopy Closure Class[b]			
All regions	Classes 4 – 7	Class 3	Classes 2 and 8
Vertical Canopy Complexity[c]			
All regions	MU	NU, U	VU, VNU
Presence of Potential Nest Platforms[d]			
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)

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

[b] *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,*

[c] *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).*

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

7.1.4 Marine Critical Habitat

Information sufficient to identify marine critical habitat is currently limited to the requirements for adult birds during the breeding period and only in the Salish Sea and nearby waters (the Strait of Georgia and adjacent channels, inlets and sounds). With this limited geographic scope, this identification of marine critical habitat covers only a small part of the species' range in B.C. (about 8%). Information about marine habitat requirements for additional life history needs (e.g., for juveniles, during the winter, and across the species' range) is not currently available.

To identify marine habitat areas within which critical habitat is found, modelling was conducted (O'Hara et al. 2016) that looked at environmental parameters, forage fish populations, and Marbled Murrelet densities (using historical Marbled Murrelet at-sea survey data from April-September, 1990-2018). The O'Hara et al. (2016) technical document with detailed methods and decision-making processes relating to the marine critical habitat identification is available on request.

7.1.5 Geographic Location - Marine

The areas within which marine critical habitat is found for Marbled Murrelet within and adjacent to the Salish Sea are delineated by a set of Geographic Location polygons (Table 9; Appendix B, Figures B7 to B18). Within the polygons, all habitat with the appropriate biophysical attributes (see 7.1.6 - Biophysical Attributes – Marine) is identified as critical habitat. The scope of the marine critical habitat identification aligns with currently identified terrestrial critical habitat in the Southern Mainland Coast and East Vancouver Island Conservation Regions.

Areas delineated for the identification of critical habitat (O'Hara et. al 2016; Table 9) incorporated the best available information on oceanographic features and forage fish parameters (including supporting information, such as areas of high by-catch or potential Pacific Sand Lance burying habitat), as well as historical survey information about marine habitat areas with moderate to high densities of Marbled Murrelet, and proximity to potential old growth nesting habitat (Mather et al. 2010).

Description of forage fish parameters in O'Hara et al. (2016) included spatial environmental attributes considered to be important determinants of forage fish use in coastal zones and available information on known forage fish sampling and habitat requirements for fish species important for Marbled Murrelets in the Salish Sea and nearby areas; namely Pacific Sand Lance and Pacific Herring.

Eleven marine critical habitat areas were selected based on areas with high or moderate Marbled Murrelet at-sea density and important known or suspected forage fish habitats or bycatch, as available based on current information (O'Hara et al. 2016; Table 9). Marine critical habitat occurs within these areas where suitable biophysical features occur.

Table 9. List of marine critical habitat areas identified in the Salish Sea area (PSL = Pacific Sand Lance; PH = Pacific Herring).

Marine critical habitat area (Figure no.)	Conservation Region	Surface area (km^2)	Key marine habitat features present	
			Marbled Murrelet density	Forage fish parameters
Desolation Sound (Figure B-8)	Southern Mainland Coast	130.14	High	• High potential forage fish populations and associated shorelines (PH) • Potential PSL burying habitat
Cortes (Figure B-9)	Southern Mainland Coast & East Vancouver Island	168.31	High	• Known forage fish populations (PH, PSL), and associated shorelines (PH) • Potential PSL burying habitat
Bute Inlet (Figure B-10)	Southern Mainland Coast	159.89	High	• Known forage fish populations (PH, PSL), and associated shorelines (PH) • Potential PSL burying habitat
Redonda (Figure B-11)	Southern Mainland Coast	150.73	High to moderate	• High potential forage fish populations and associated shorelines (PH) • Potential PSL burying habitat
Savary (Figure B-12)	Southern Mainland Coast & East Vancouver Island	650.49	High	• Known forage fish populations and associated shorelines (PH, PSL) • Potential PSL burying habitat
Sidney (Figure B-13)	East Vancouver Island	316.75	High to moderate	• Known forage fish populations (PH, PSL), and associated shorelines (PH) • Known PSL burying habitat
Malaspina (Figure B-14)	Southern Mainland Coast	262.05	High	• Known forage fish populations (PH, PSL), and associated shorelines (PH) • Potential PSL burying habitat
Discovery Passage (Figure B-15)	Southern Mainland Coast & East Vancouver Island	93.05	High	• Potential forage fish populations (PH, PSL), and associated shorelines (PH) • Potential PSL burying habitat • Strong tidal mixing

Marine critical habitat area (Figure no.)	Conservation Region	Surface area (km^2)	Key marine habitat features present	
			Marbled Murrelet density	Forage fish parameters
Toba Inlet (Figure B-16)	Southern Mainland Coast	31.80	High	• Potential forage fish populations (PH, PSL), and associated shorelines (PH) • Potential PSL burying habitat
Halfmoon (Figure B-17)	Southern Mainland Coast	191.38	Moderate	• Known forage fish populations (PH, PSL), and associated shorelines (PH) • Potential PSL burying habitat
Queens Reach (Figure B-18)	Southern Mainland Coast	30.56	High	• Forage fish data for PH and PSL and their habitats are deficient for this region.

7.1.6 Biophysical Attributes - Marine

A description of the known biophysical features and attributes of the marine habitat that are required to support Marbled Murrelet life-cycle processes (functions) is provided in Section 3.3, Needs of the Marbled Murrelet (Table 3). These biophysical features and attributes formed the basis of the geospatial delineation of marine critical habitat (as described above; Table 9). As such, within these geospatial polygons, critical habitat includes all waters from the high tide line to a maximum depth of 80 m, including straits, channels, inlets, estuaries and the specific shorelines and seafloor areas associated with forage fish populations (e.g., beaches, flats or fans composed of sand and gravel; and rock ramps, rock platforms and rock cliffs; burying habitats and spawning areas). The areas containing critical habitat for Marbled Murrelet are presented in Appendix B: Figures B7 to B18. Critical habitat for Marbled Murrelet occurs within the shaded polygons shown on each map. Within these polygons, only clearly unsuitable areas are not identified as critical habitat. Examples of clearly unsuitable areas include habitats deeper than 80 m and permanent infrastructure (e.g., docks, boat ramps). The 10 km x 10 km UTM grid overlay shown on these figures is a standardized national grid system that highlights the general geographic area containing critical habitat, for land use planning.

7.2 Schedule of Studies to Identify Critical Habitat

The following schedule of studies (Table 10) outlines the activity required to complete the identification of critical habitat for Marbled Murrelet in Canada[4].

[4] For further research to address knowledge gaps relevant to critical habitat, refer to priority actions outlined in the recovery planning table (Table 5).

Table 10. 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 locations likely do 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.	2023-2025
Marine Critical Habitat		
Identify marine critical habitat to support Marbled Murrelet breeding bird life history in the Haida Gwaii, Northern Mainland Coast, Central Mainland Coast, West and North Vancouver Island Conservation Regions	Additional information is needed to identify the marine critical habitat necessary to support foraging for breeding birds in all conservation regions. Current available information is only adequate to identify marine critical habitat in the East Vancouver Island and Southern Mainland Coast Conservation Regions.	2023-2033
Identify marine critical habitat necessary to support newly fledged juveniles and to include large wintering concentrations of Marbled Murrelets in all Conservation Regions	Understanding of overall marine biophysical attributes is not complete due to a lack of data. Information to identify the marine critical habitat necessary to support all life stages for Marbled Murrelet is not available. Best available information at this time is adequate only for identifying a limited amount of marine foraging habitat used only by breeding adults, and only in the Salish Sea and nearby areas. Marine critical habitat necessary to support newly fledged individuals and large wintering concentrations has not been identified in any of the Conservation Regions.	2023-2033

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 11 include those likely to cause destruction of critical habitat for the species; however, destructive activities are not limited to those listed.

Table 11. 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	Forest 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. Forest harvesting can also result in destruction of marine critical habitat indirectly by increasing the mortality of prey species via increased sedimentation and turbidity.	Related threats: Habitat Loss or Degradation – Loss of Nesting Habitat, Forest Fragmentation, Increased Predation Risk, and Aquaculture and Foreshore Development. In the terrestrial environment, 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. Impacts to the marine environment resulting from activities occurring within terrestrial nesting critical habitat would only occur where the marine environment is adjacent to terrestrial nesting critical habitat (via sedimentation in streams or through intertidal areas). These effects could occur at any time of the year, though would be more likely to result in destruction of marine critical habitat when they occur during the bird or fish breeding seasons (when birds and fish are more frequently closer to shore).

Description of Activity	Description of Effect (biophysical attribute or other) in relation to function loss	Details of effect
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). Road building can also result in destruction of marine critical habitat indirectly by increasing the mortality of prey species via increased sedimentation and turbidity.	Related threats: Habitat Loss or Degradation – Loss of Nesting Habitat, Forest Fragmentation, Increased Predation Risk, and Aquaculture and Foreshore Development. In the terrestrial environment, 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. Impacts to the marine environment resulting from activities occurring within terrestrial nesting critical habitat would only occur where the marine environment is adjacent to terrestrial nesting critical habitat (via sedimentation in streams or through intertidal areas). These effects could occur at any time of the year, though would be more likely to result in destruction of marine critical habitat when they occur during the bird or fish breeding seasons (when birds and fish are more frequently closer to shore).

Description of Activity	Description of Effect (biophysical attribute or other) in relation to function loss	Details of effect
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). Land clearing can also result in the destruction of marine critical habitat indirectly by increasing the mortality of prey species via increased sedimentation and turbidity.	Related threats: Habitat Loss or Degradation – Loss of Nesting Habitat, Forest Fragmentation, Increased Predation Risk, and Aquaculture and Foreshore Development. In the terrestrial environment, 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. Impacts to the marine environment resulting from activities occurring within terrestrial nesting critical habitat would only occur where the marine environment is adjacent to terrestrial nesting critical habitat (via sedimentation in streams or through intertidal areas). These effects could occur at any time of the year, though would be more likely to result in destruction of marine critical habitat when they occur during the bird or fish breeding seasons (when birds and fish are more frequently closer to shore).
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: Habitat Loss or Degradation – 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.

Description of Activity	Description of Effect (biophysical attribute or other) in relation to function loss	Details of effect
Water surface transportation activities (e.g., from large transport ships and recreational boats) that result in chronic or acute pollution from oil or other contaminants (e.g., chemicals, plastics)	Oil spills and contaminants can result in loss of available habitat for murrelet foraging and for prey species (e.g., an uncontaminated water column), and contamination of seabed substrates that support spawning and burying areas for key prey species (e.g., Pacific Herring, Pacific Sand Lance).	Related threats: Pollution – Oil Mortality Chronic (e.g., ongoing small oil spills), Oil Mortality Acute (e.g., major oil spills), Chemical Contaminants (e.g., plastic pollution). Destruction of critical habitat by these activities can be caused at any time of the year, but they are most likely to result in destruction when they occur during the bird or fish breeding seasons (when birds and fish are more frequently closer to shore where these threats are more common). Oil spills and contaminants are most likely to result in destruction when occurring inside the bounds of critical habitat; however, effects on forage prey abundance may result from activities occurring in proximal areas outside the bounds of critical habitat. Destruction of critical habitat by ongoing small oil spills is most likely to occur near to shorelines; destruction of critical habitat by major oil spills is most likely to occur in larger shipping channels; destruction of critical habitat by chemical contaminants is most likely to occur near to shorelines.
Seabed mining, dredging or sediment disposal activities that result in the destruction of sea bottom habitat.	Destruction of sea bottom habitat reduces the availability of habitat for key prey species (e.g., burying habitats for Pacific Sand Lance, spawning areas for Pacific Herring).	Related threat: Changes in Ecological Dynamics or Natural Processes – Fisheries Induced Prey Depletion Destruction of critical habitat by these activities can be caused at any time of the year, but they are most likely to result in destruction when they occur during the bird or fish breeding seasons (when birds and fish are more frequently in shallow waters where these threats are more common). Mining, dredging or sediment disposal are most likely to result in destruction when occurring inside the bounds of critical habitat; however, effects on forage prey abundance may result from activities occurring in proximal areas outside the bounds of critical habitat. Destruction of critical habitat by mining, dredging or sediment disposal is most likely to occur in major shipping lanes and near to shorelines (especially areas with concentrated activity, such as shipping ports, harbours and marinas).

Description of Activity	Description of Effect (biophysical attribute or other) in relation to function loss	Details of effect
Inappropriate level[5] and concentration of marine vessel traffic, i.e., that results in significant adverse effects.[6]	Surface disturbance reduces the ability for Marbled Murrelet to access prey within the subsurface aquatic environment.	Related threat: Disturbance or Harm – Boat Traffic Destruction of critical habitat by these activities can be caused at any time of the year, but they are most likely to result in destruction when they occur during the bird or fish breeding seasons (when birds and fish are more frequently closer to shore where these threats are more common). Disturbance from boat traffic is most likely to result in destruction when occurring inside the bounds of critical habitat. Destruction of critical habitat by disturbance from boat traffic is most likely to occur near to shorelines and to areas of concentrated human activity (e.g., harbours, aquaculture operations).
Fish harvesting activities that result in significant loss of forage fish and reduction of prey populations (primarily Pacific Herring).	Significant loss of key forage prey degrades the suitability of foraging habitat for Marbled Murrelet.	Related threats: Changes in Ecological Dynamics or Natural Processes – Fisheries Induced Depletion Currently, the only known fishery that is expected to affect murrelet foraging is that for Pacific Herring. There is currently no Pacific Sand Lance fishery and other fisheries (e.g., prawn) would not occur in sand lance or herring habitats. Destruction of critical habitat by fisheries can be caused at any time of the year, but they are most likely to result in destruction when they occur during the bird breeding season. Disturbance from fish harvesting activities is most likely to result in destruction when occurring inside the bounds of critical habitat; however, effects on forage prey abundance may result from activities occurring in proximal areas outside the bounds of critical habitat. Destruction of critical habitat by fish harvesting activities is most likely to occur where Pacific Herring fishing occurs.

[5] Additional research is required to determine the level of marine vessel traffic considered destructive to marine critical habitat, i.e., the level at which the features and attributes necessary for habitat functionality are destroyed. However, it is clear that intensive vessel traffic would likely result in destruction of critical habitat.

[6] Significant adverse effects are those that negatively impact the species' survival and recovery. Success of the species' survival and recovery will be assessed against the adopted population and distribution objective and associated performance measures for Marbled Murrelet as they are set out in this document.

Description of Activity	Description of Effect (biophysical attribute or other) in relation to function loss	Details of effect
Activities that result in alteration of shoreline or nearshore habitats, such as aquaculture operations and marine developments (e.g., terminal expansions, marinas).	Destruction of shoreline or nearshore habitats results in degradation of forage habitat by causing habitat loss, sedimentation and increased turbidity in the subsurface aquatic environment.	Related threat: Habitat Loss or Degradation – Aquaculture and Foreshore Development Destruction of critical habitat by these activities can be caused at any time of the year, but they are most likely to result in destruction when they occur during the bird or fish breeding seasons (when birds and fish are more frequently closer to shore where these threats are more common). Disturbance from these activities is most likely to result in destruction when occurring inside the bounds of critical habitat. Destruction of critical habitat by these activities is most likely to occur near to shorelines, especially where human activity is concentrated (e.g., urban areas, marinas, shipping terminals).

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) The area of suitable marine habitat is sufficient to support all all life stages of nesting and wintering birds.
d) 30-year (three generations) trend estimates for the B.C. population based on radar counts and other reliable census methods are available.
e) 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.

10. References

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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*[7]. 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 and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or any of the Federal Sustainable Development Strategy's[8] (FSDS) goals and targets.

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. 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.

[7] www.canada.ca/en/environmental-assessment-agency/programs/strategic-environmental-assessment/cabinet-directive-environmental-assessment-policy-plan-program-proposals.html
[8] www.fsds-sfdd.ca/index.html#/en/goals/

Appendix B: Critical Habitat for Marbled Murrelet *(Brachyramphus marmoratus)*

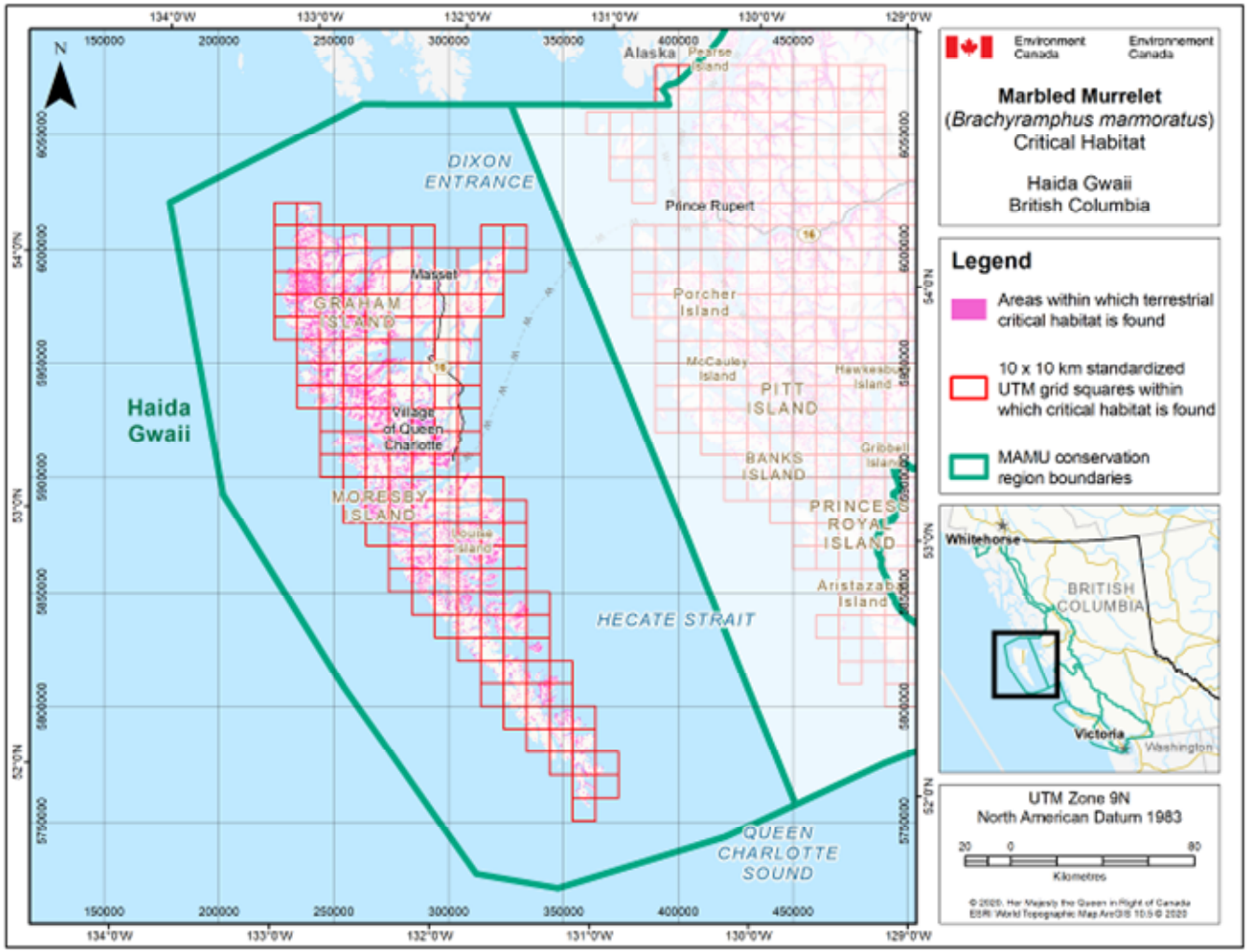

Figure B-1. Terrestrial critical habitat for Marbled Murrelet in the Haida Gwaii Conservation Region is found within the pink polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national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

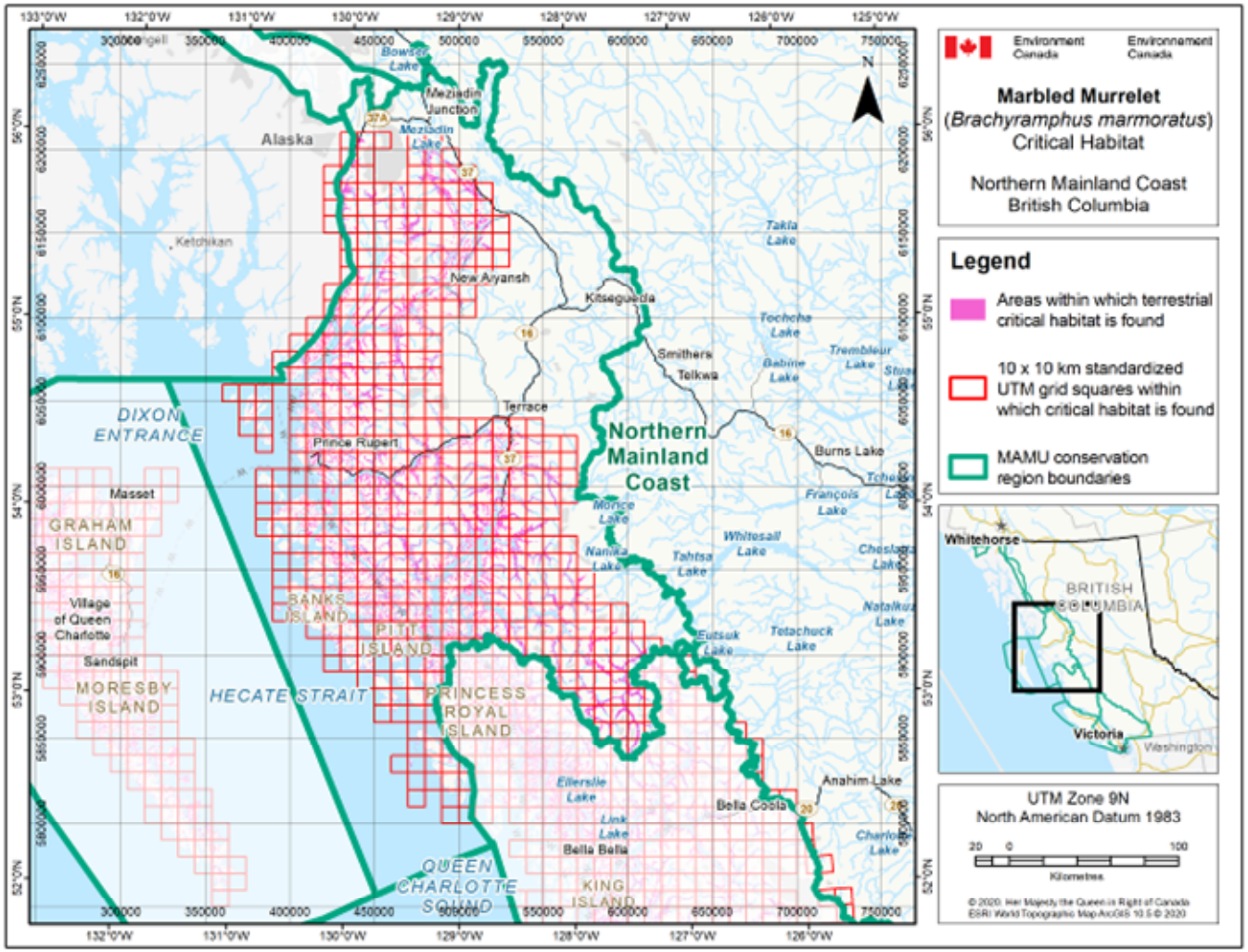

Figure B-2. Terrestrial critical habitat for Marbled Murrelet in the Northern Mainland Coast Conservation Region is found within the pink polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized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

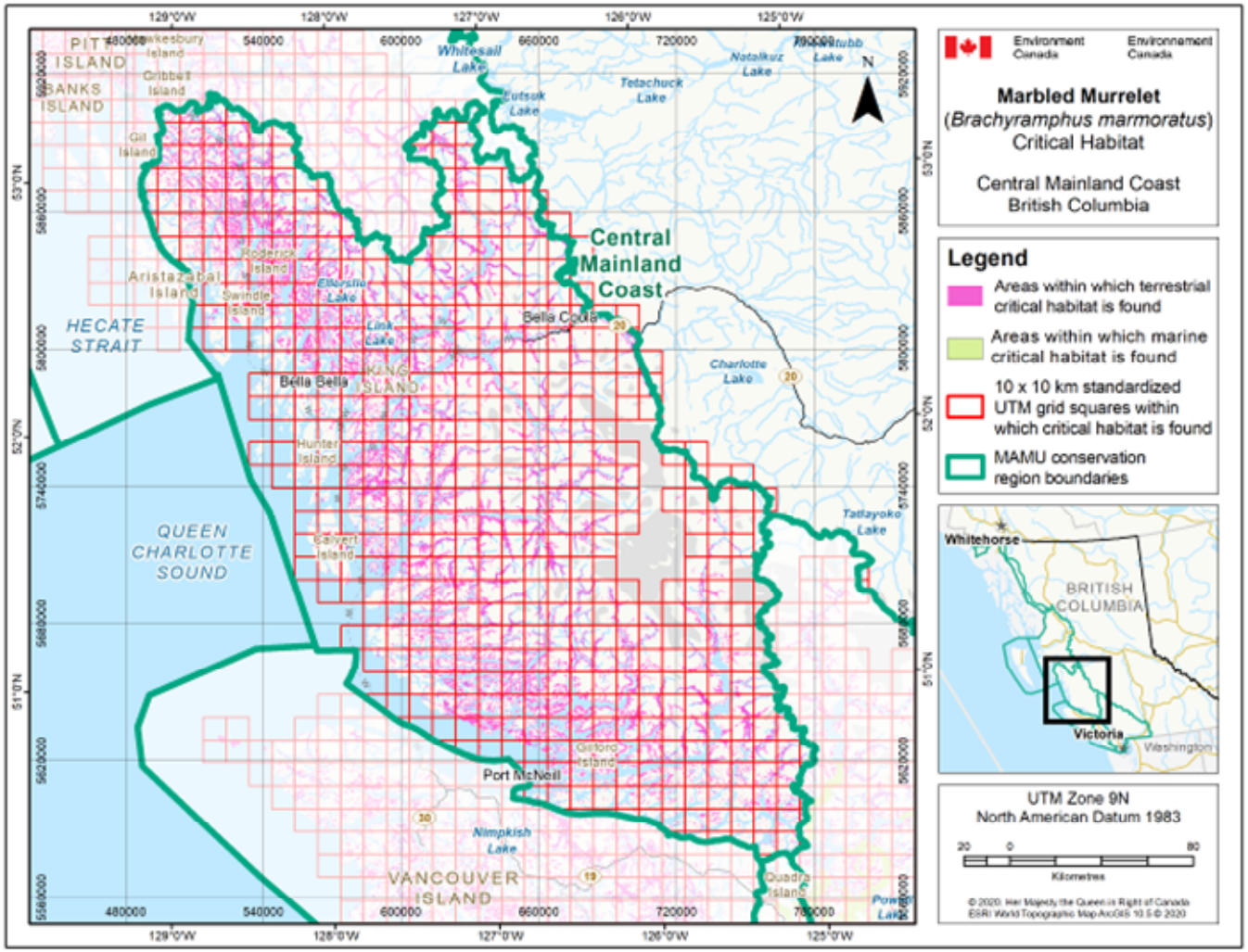

Figure B-3. Terrestrial critical habitat for Marbled Murrelet in the Central Mainland Coast Conservation Region is found within the pink polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Marine critical habitat polygon areas (aligning with content of Figures B-7 to B-18) are included for reference, shown in yellow.

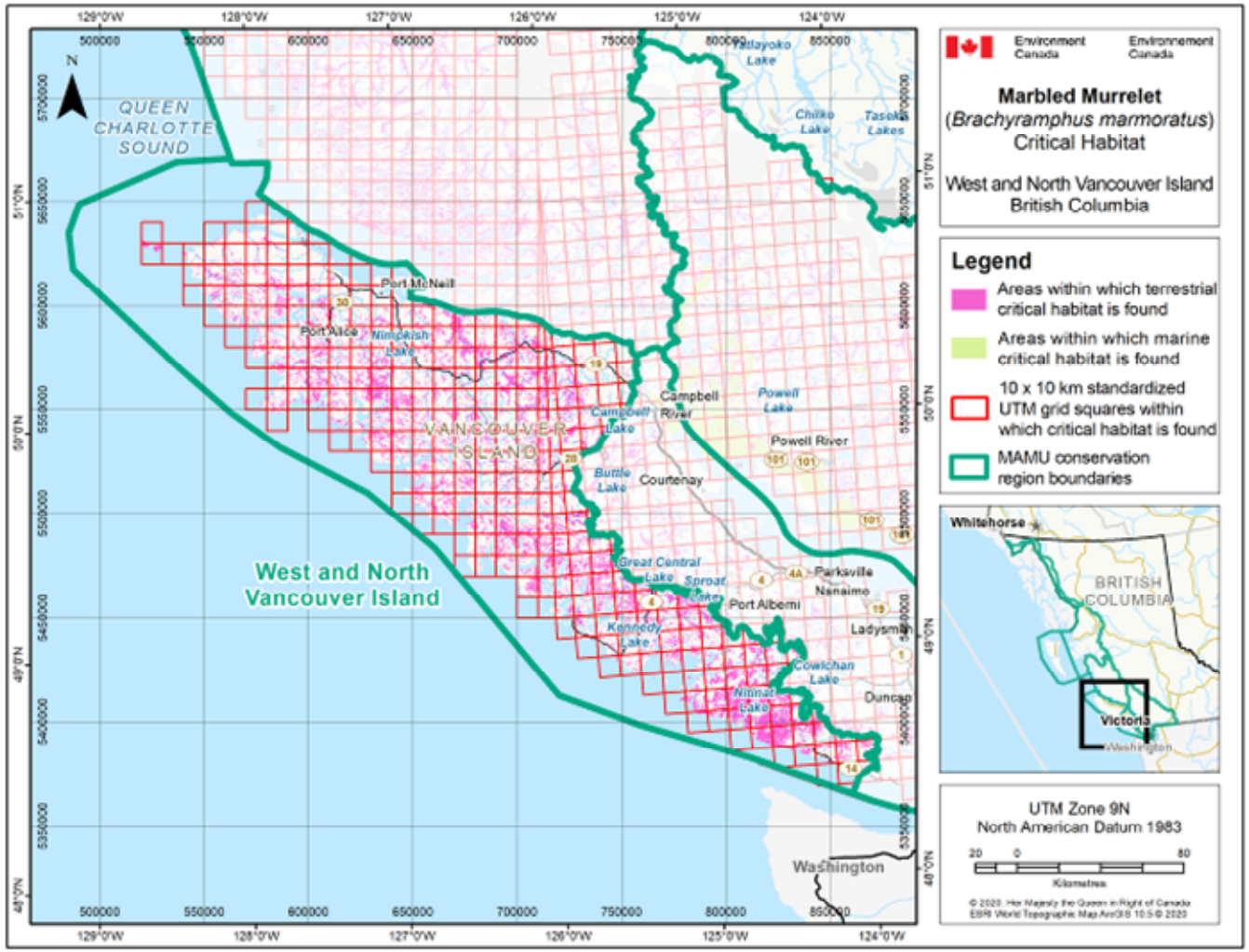

Figure B-4. Terrestrial critical habitat for Marbled Murrelet in the West and North Vancouver Island Conservation Region is found within the pink polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Marine critical habitat polygon areas (aligning with content of Figures B-7 to B-18) are included for reference, shown in yellow.

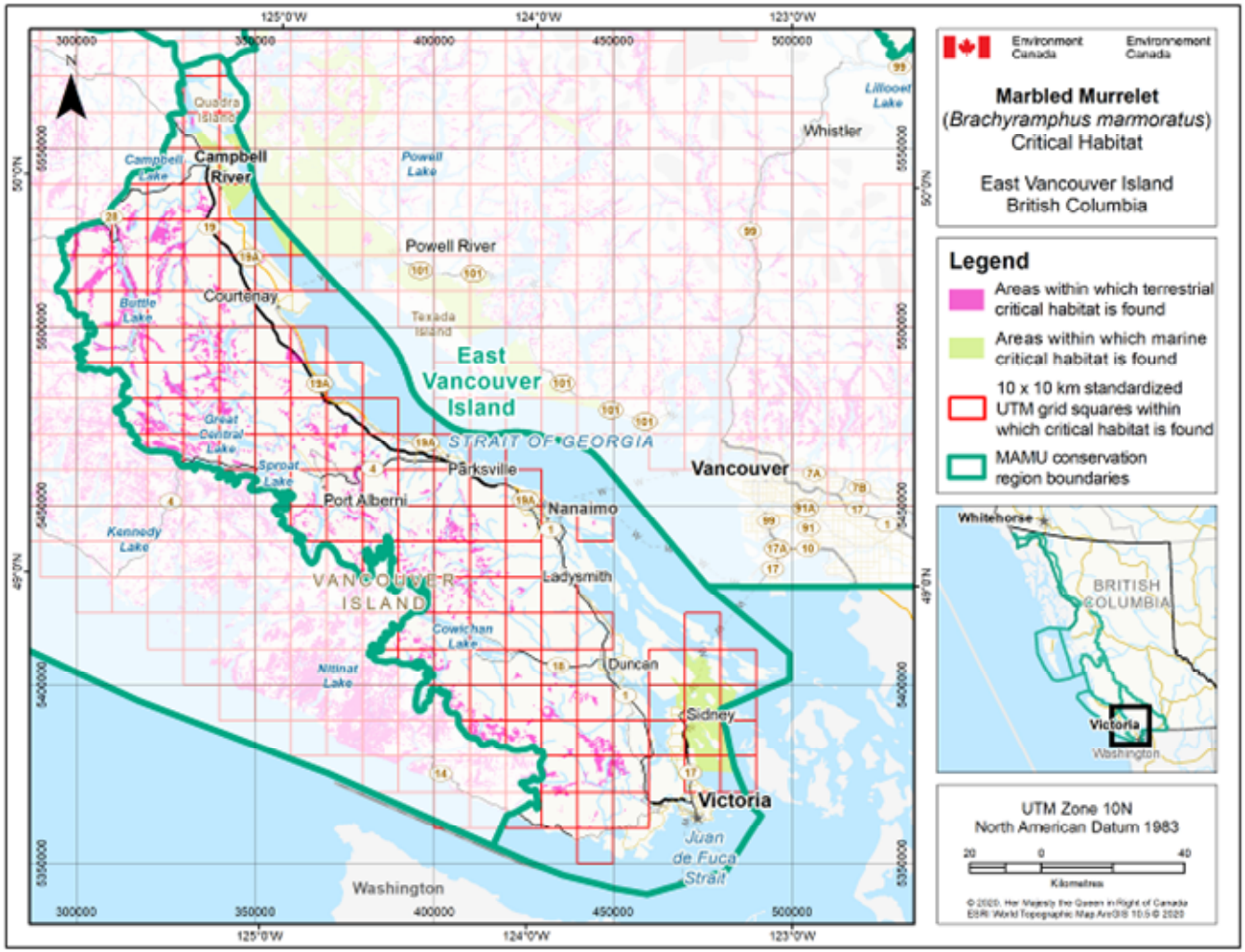

Figure B-5. Terrestrial critical habitat for Marbled Murrelet in the East Vancouver Island Conservation Region is found within the pink polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Marine critical habitat polygon areas (aligning with content of Figures B-7 to B-18) are included for reference, shown in yellow.

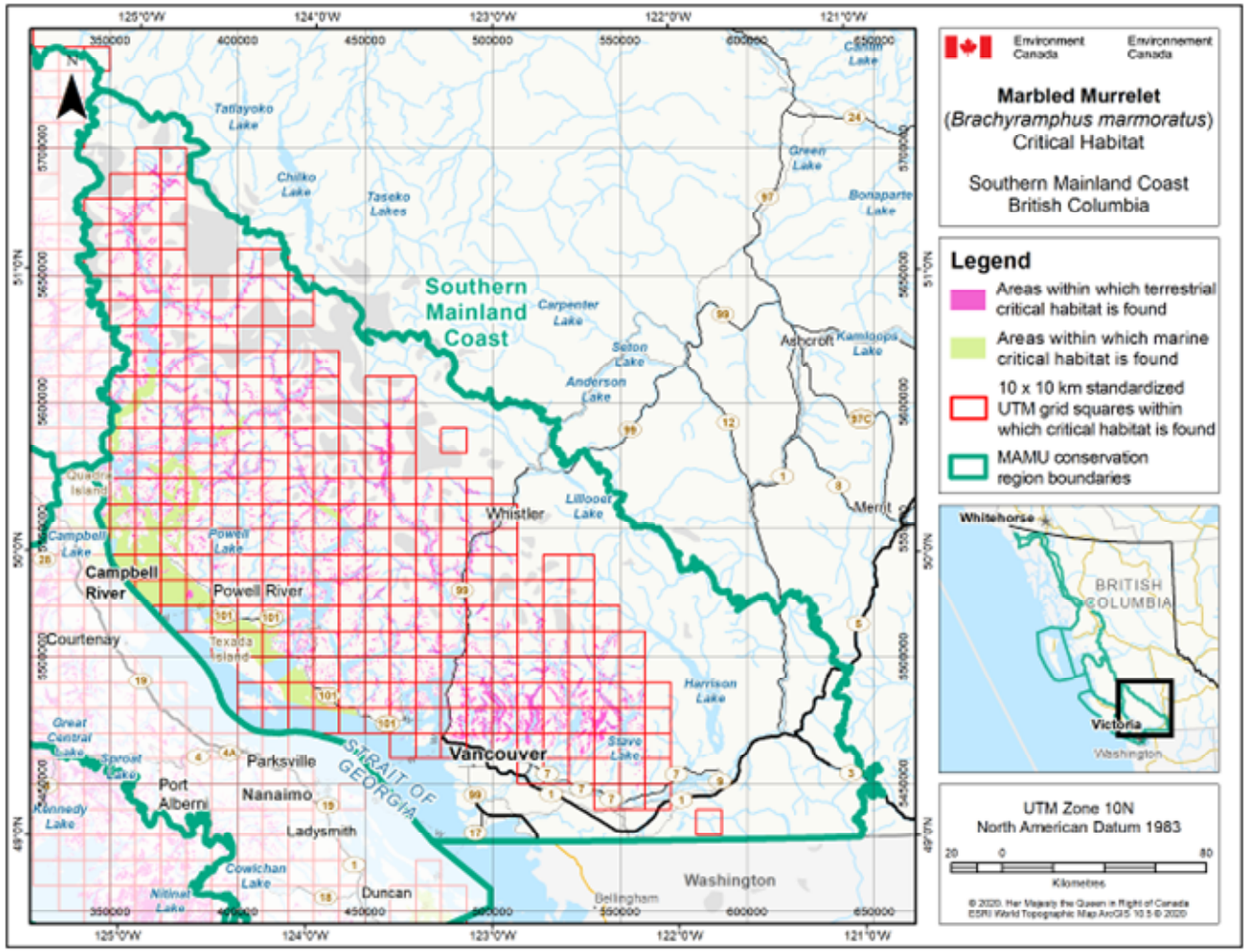

Figure B-6. Terrestrial critical habitat for Marbled Murrelet in the Southern Mainland Coast Conservation Region is found within the pink polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Marine critical habitat polygon areas (aligning with content of Figures B-7 to B-18) are included for reference, shown in yellow.

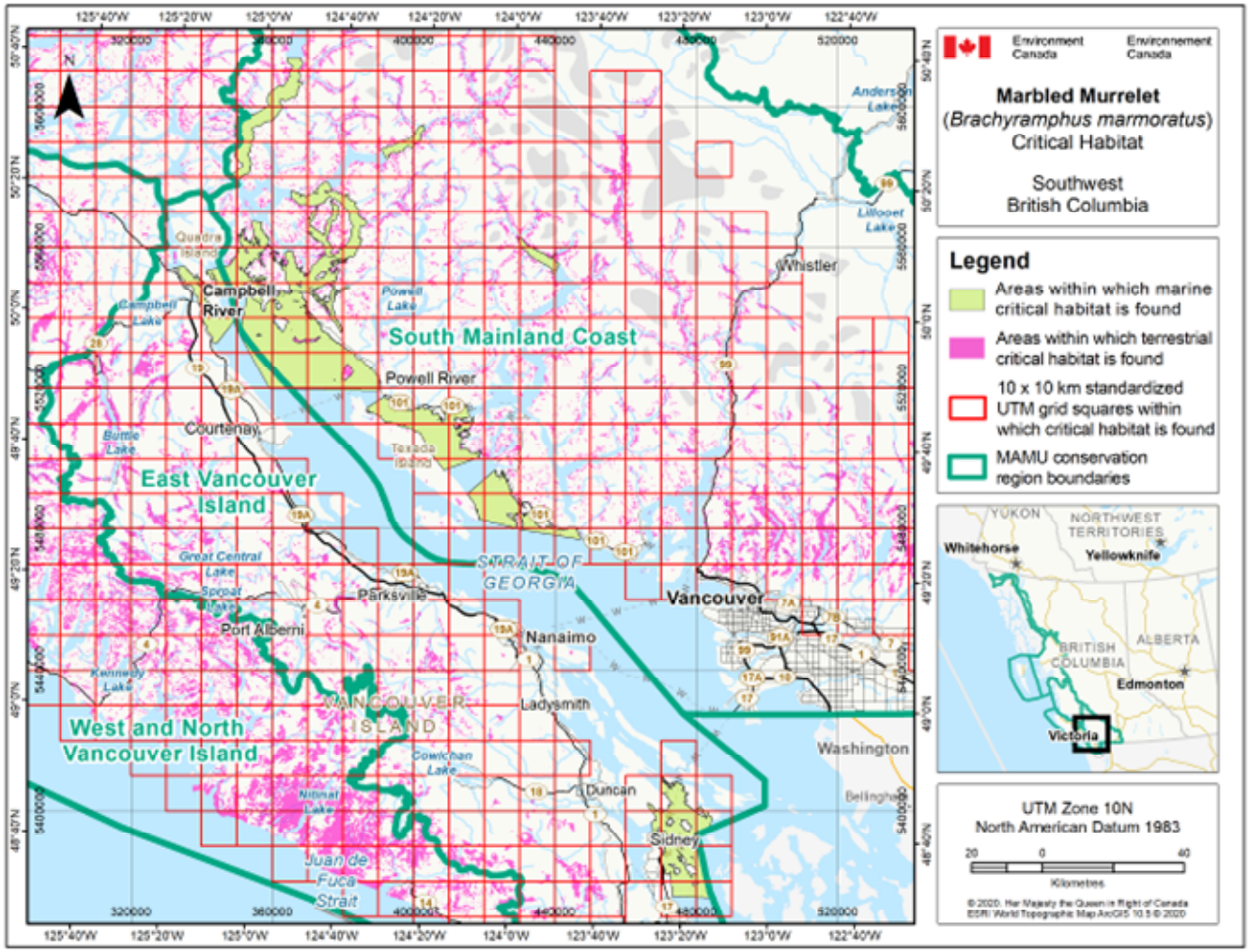

Figure B-7. Overview of the identification of marine critical habitat for Marbled Murrelet. Marine critical habitat is only identified in the Salish Sea, as depicted in the figure, and is found within the yellow polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. Figures B-8 to B-18 outline marine critical habitat in greater detail. Terrestrial critical habitat polygon areas (aligning with content of Figures B-3 to B-6) are included for reference, shown in pink.

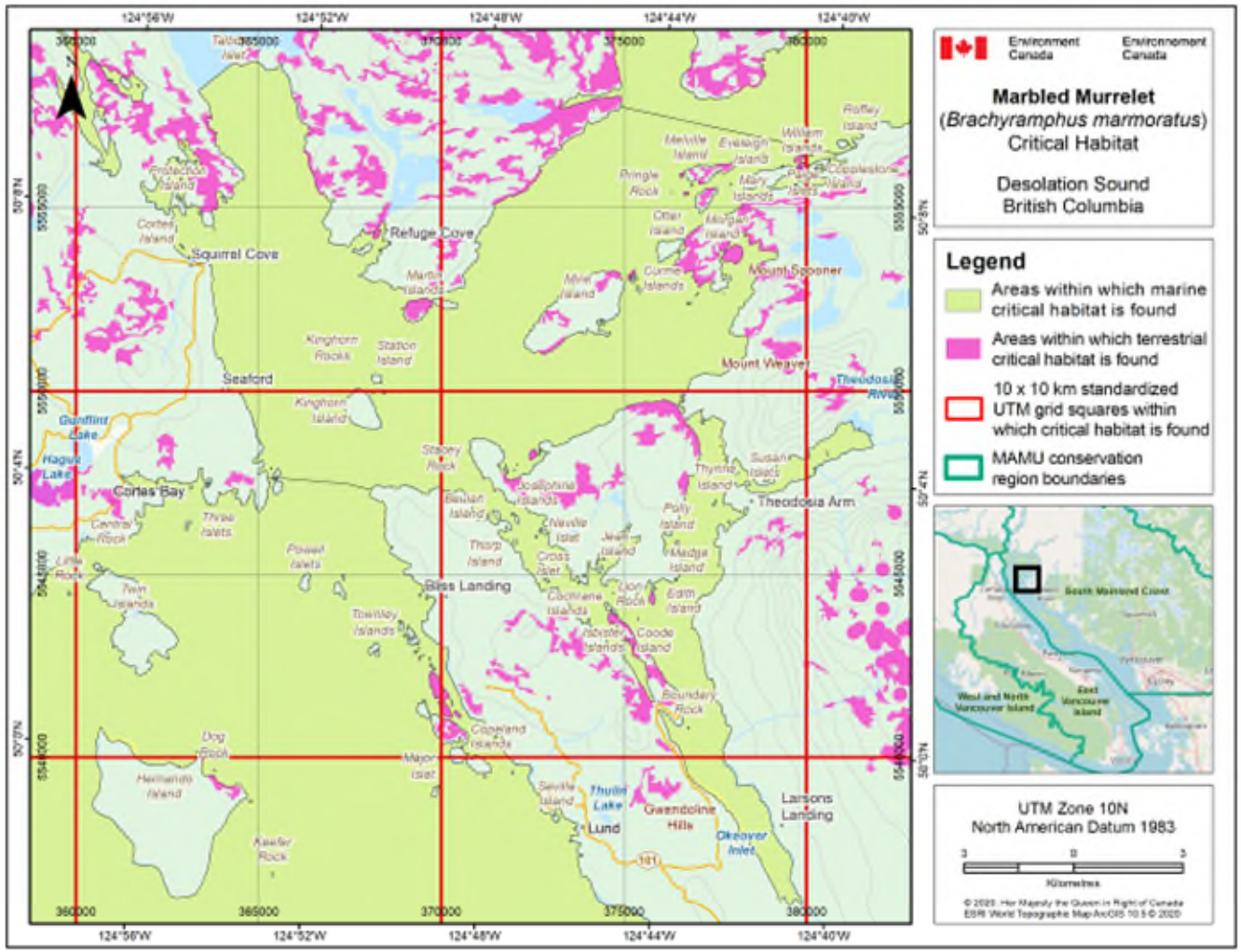

Figure B-8. Marine critical habitat for Marbled Murrelet in the Salish Sea, Desolation Sound area, is found within the yellow polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 1 km x 1 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Terrestrial critical habitat polygon areas (aligning with content of Figures B-1 to B-6) are included for reference, shown in pink.

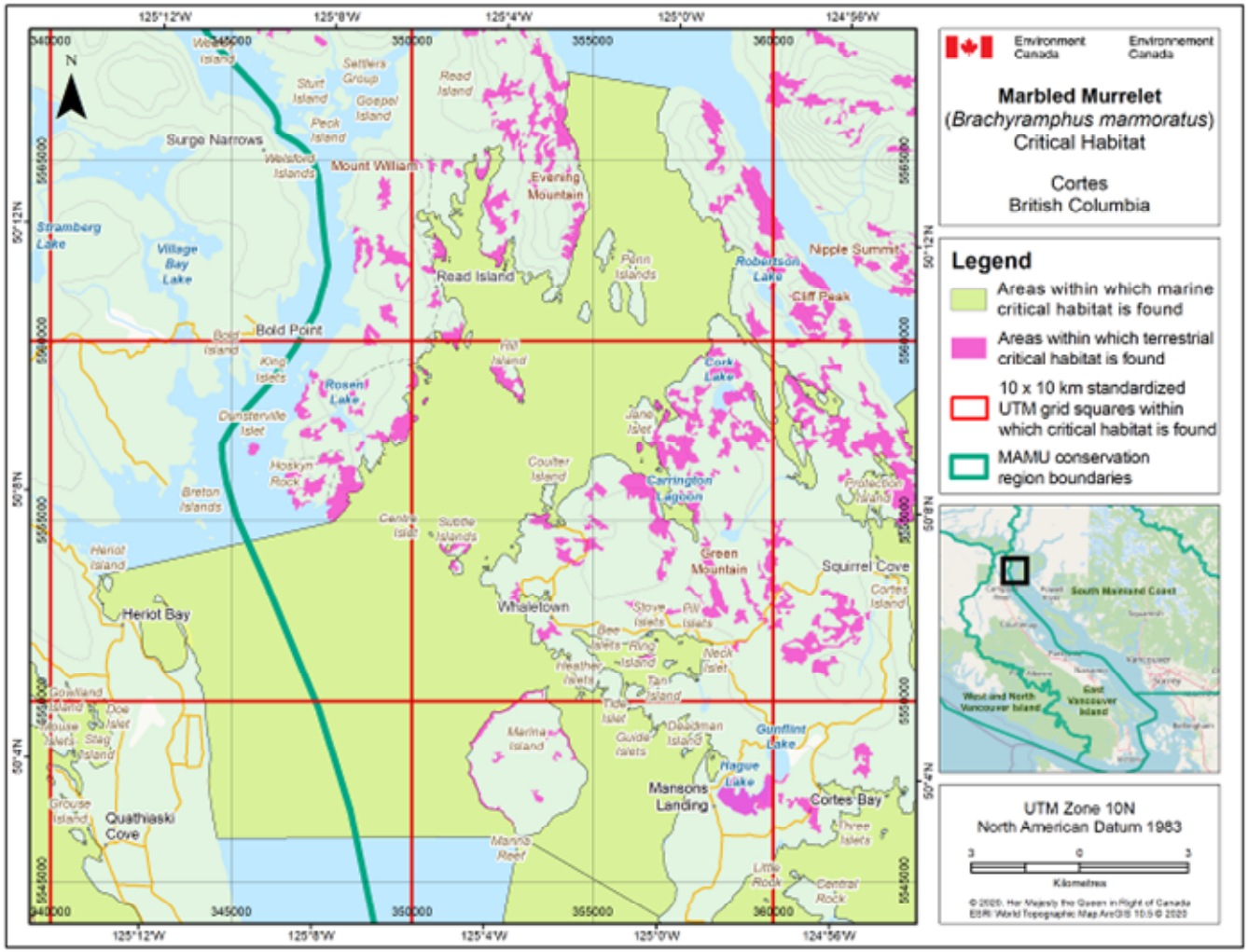

Figure B-9. Marine critical habitat for Marbled Murrelet in the Salish Sea, Cortes area, is found within the yellow polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 1 km x 1 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Terrestrial critical habitat polygon areas (aligning with content of Figures B-1 to B-6) are included for reference, shown in pink.

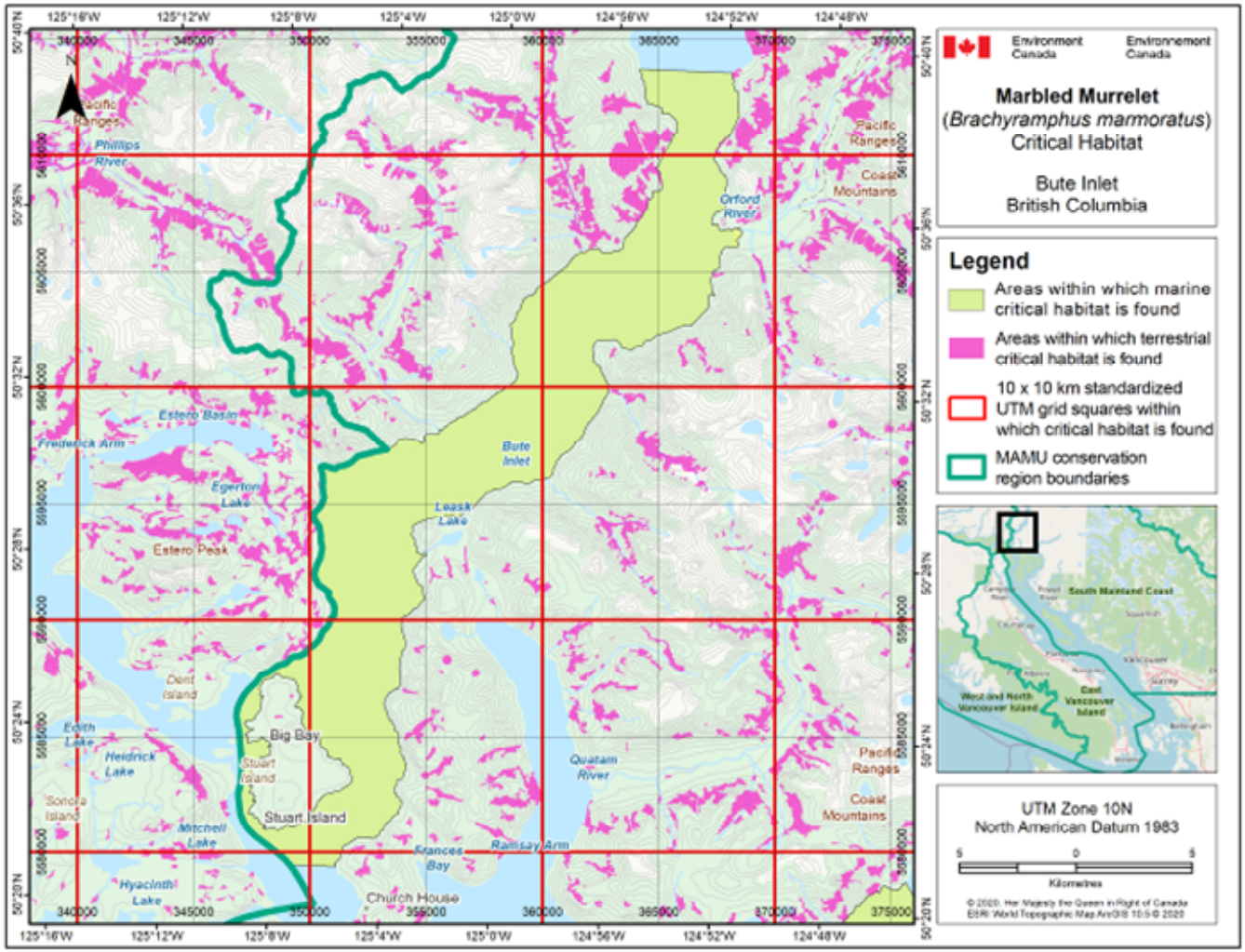

Figure B-10. Marine critical habitat for Marbled Murrelet in the Salish Sea, Bute Inlet area, is found within the yellow polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 1 km x 1 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Terrestrial critical habitat polygon areas (aligning with content of Figures B-1 to B-6) are included for reference, shown in pink.

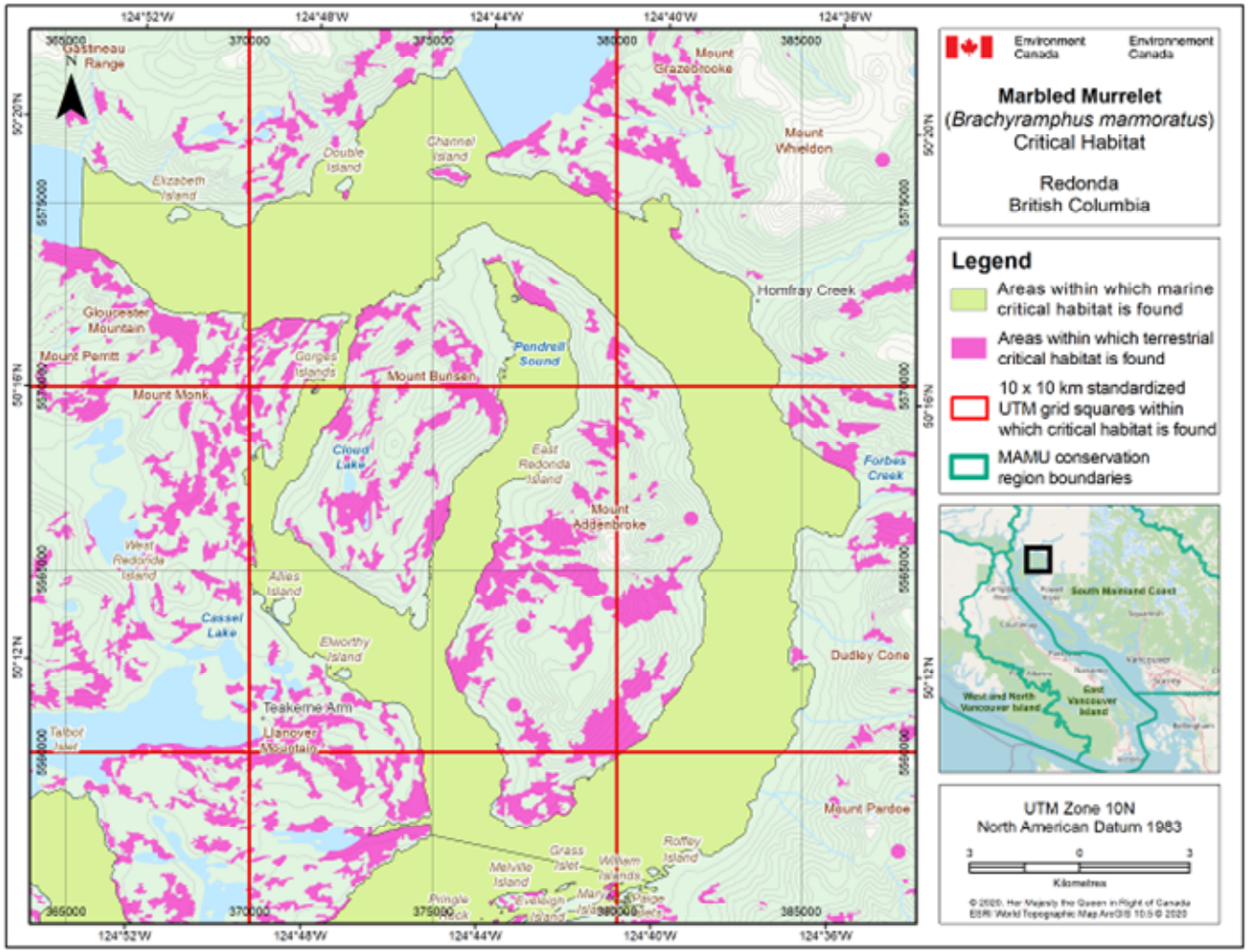

Figure B-11. Marine critical habitat for Marbled Murrelet in the Salish Sea, Redonda area, is found within the yellow polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 1 km x 1 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Terrestrial critical habitat polygon areas (aligning with content of Figures B-1 to B-6) are included for reference, shown in pink.

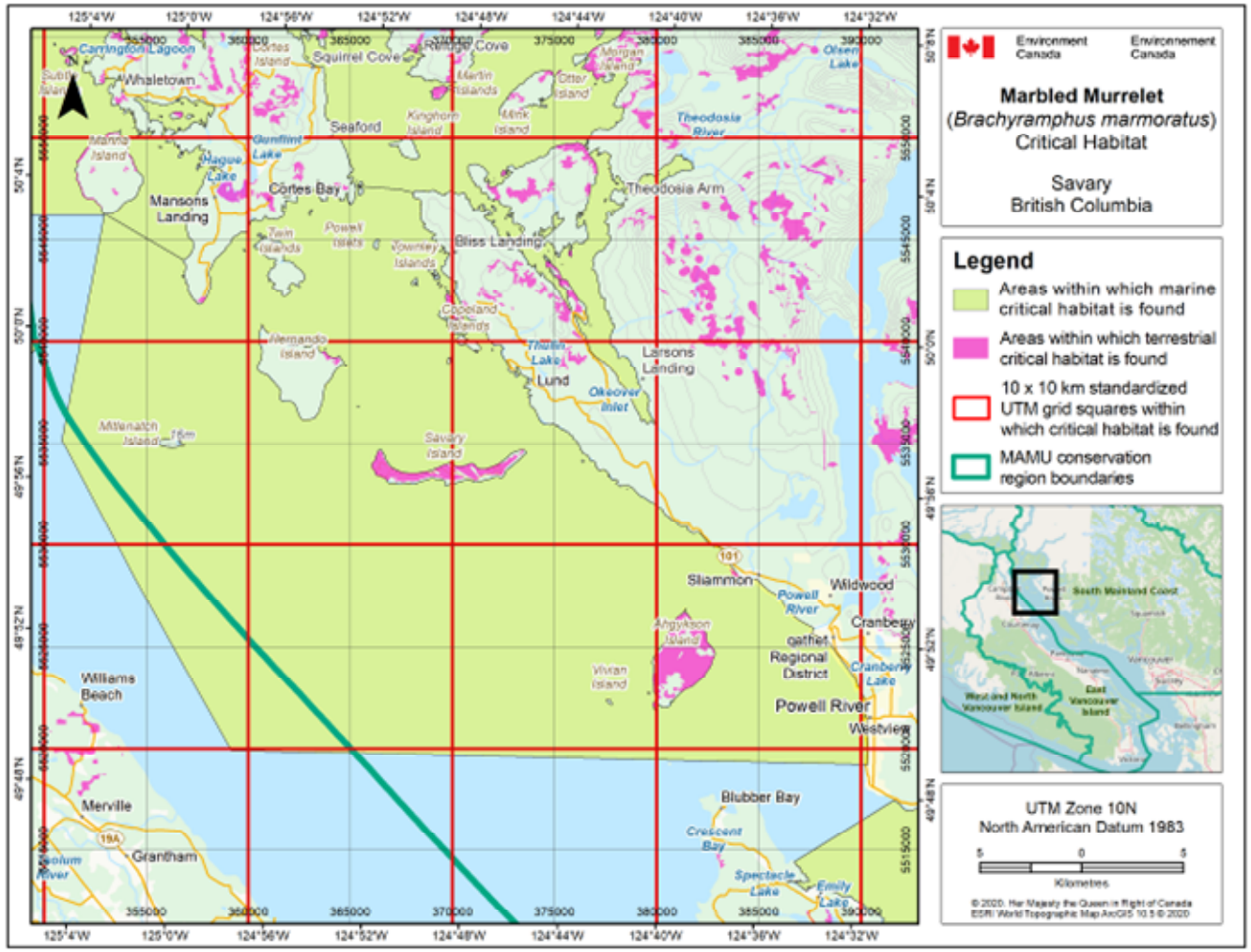

Figure B-12. Marine critical habitat for Marbled Murrelet in the Salish Sea, Savary area, is found within the yellow polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 1 km x 1 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Terrestrial critical habitat polygon areas (aligning with content of Figures B-1 to B-6) are included for reference, shown in pink.

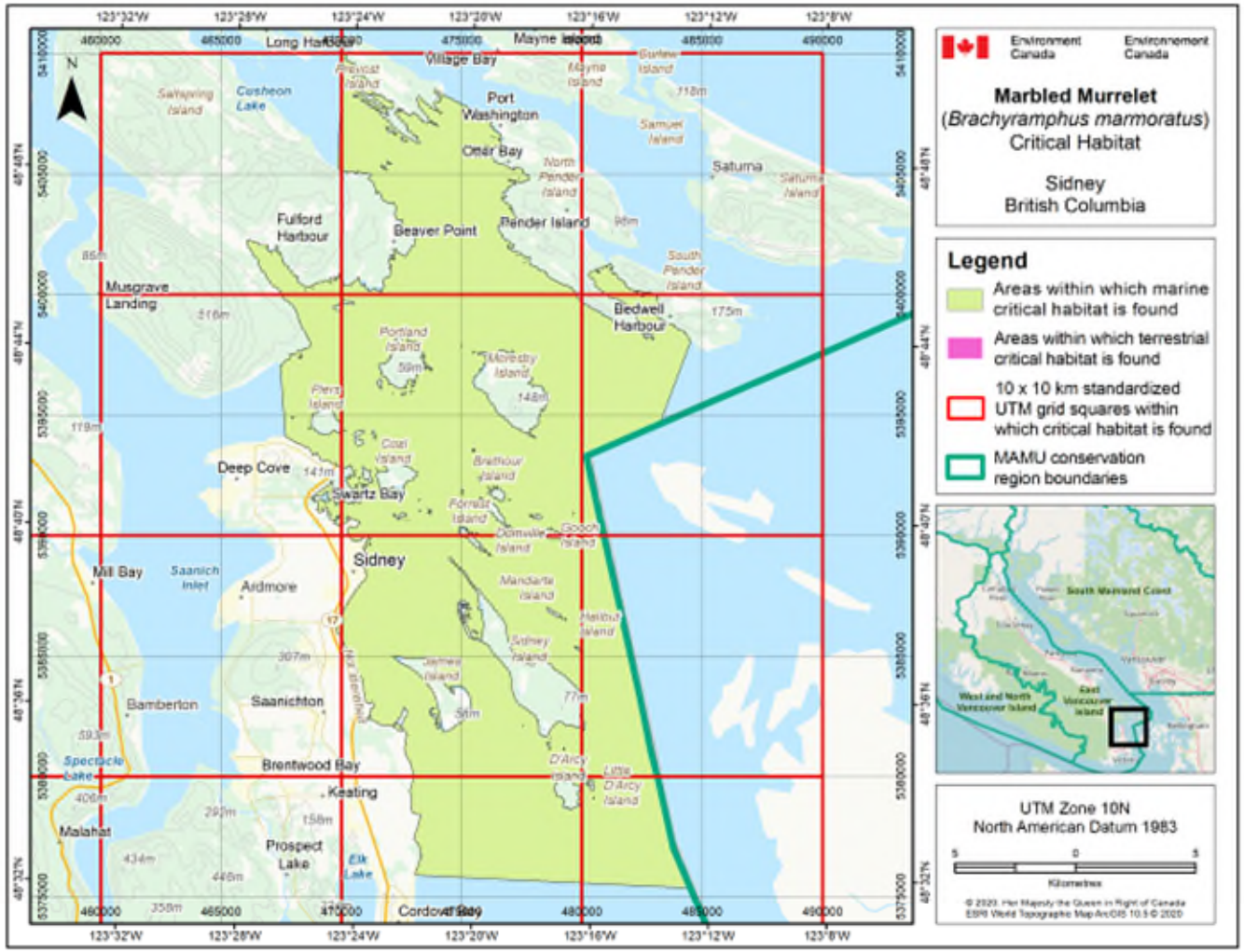

Figure B-13. Marine critical habitat for Marbled Murrelet in the Salish Sea, Sidney area, is found within the yellow polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 1 km x 1 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Terrestrial critical habitat polygon areas (aligning with content of Figures B-1 to B-6) are included for reference, shown in pink.

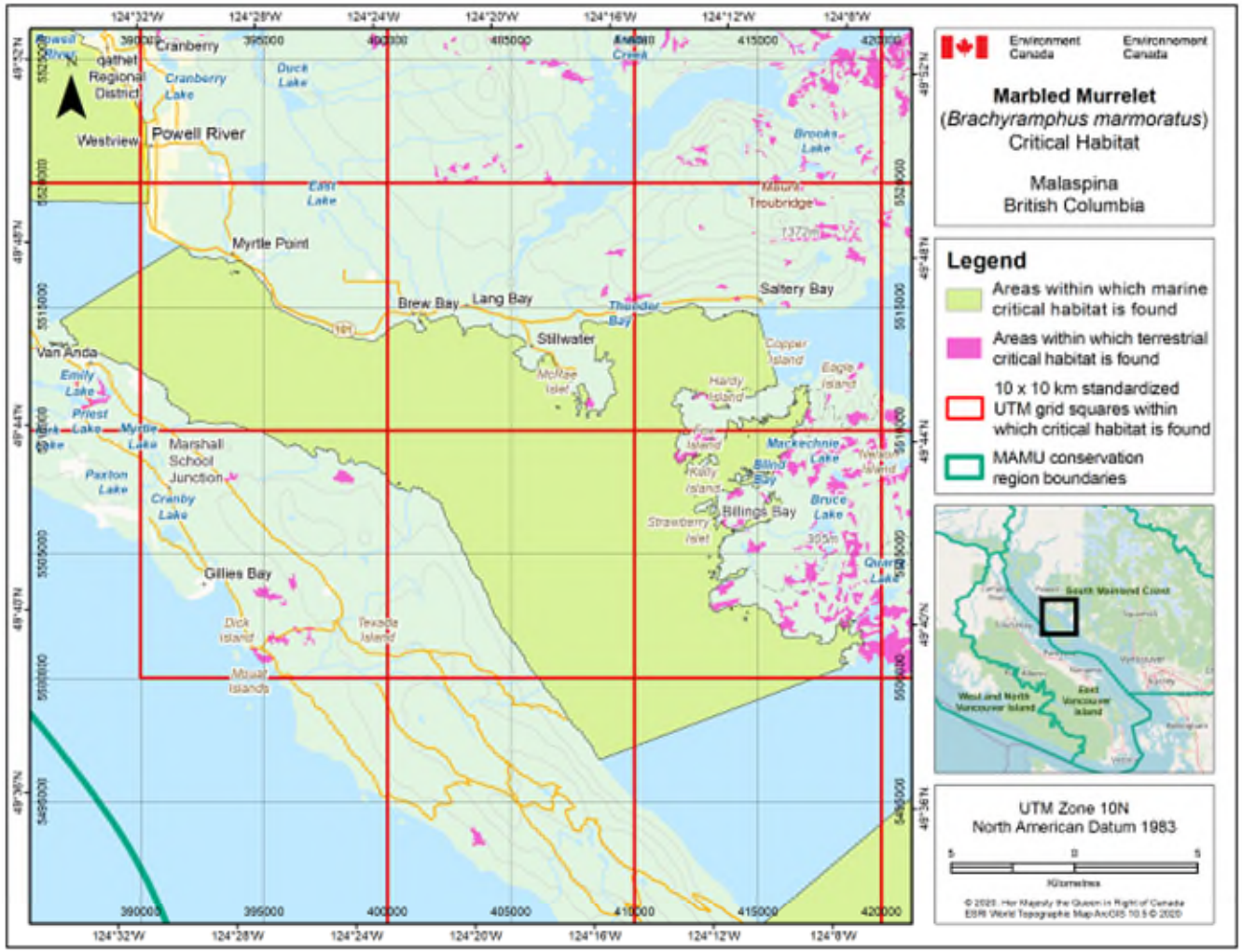

Figure B-14. Marine critical habitat for Marbled Murrelet in the Salish Sea, Malaspina area, is found within the yellow polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 1 km x 1 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Terrestrial critical habitat polygon areas (aligning with content of Figures B-1 to B-6) are included for reference, shown in pink.

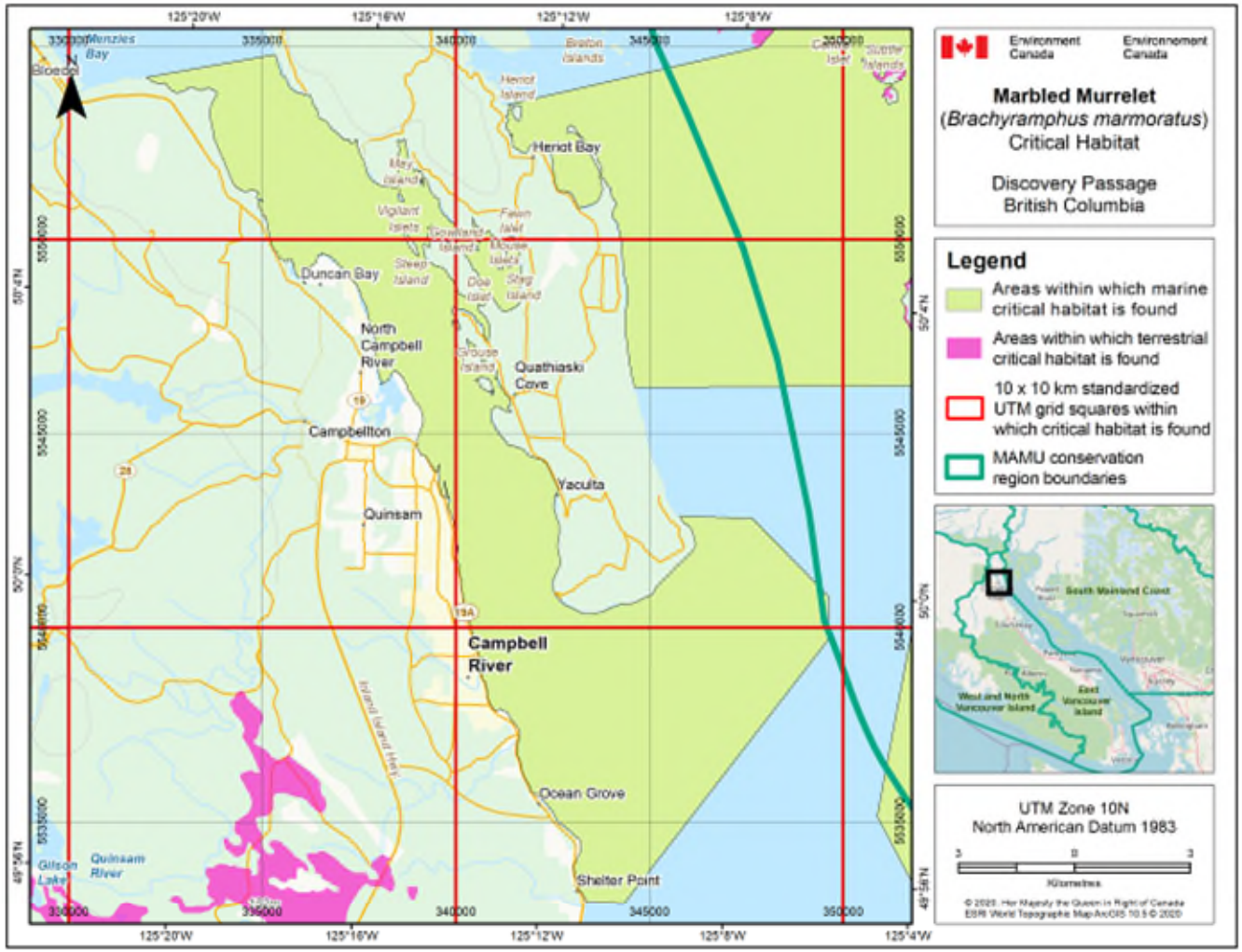

Figure B-15. Marine critical habitat for Marbled Murrelet in the Salish Sea, Discovery Passage area, is found within the yellow polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 1 km x 1 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Terrestrial critical habitat polygon areas (aligning with content of Figures B-1 to B-6) are included for reference, shown in pink.

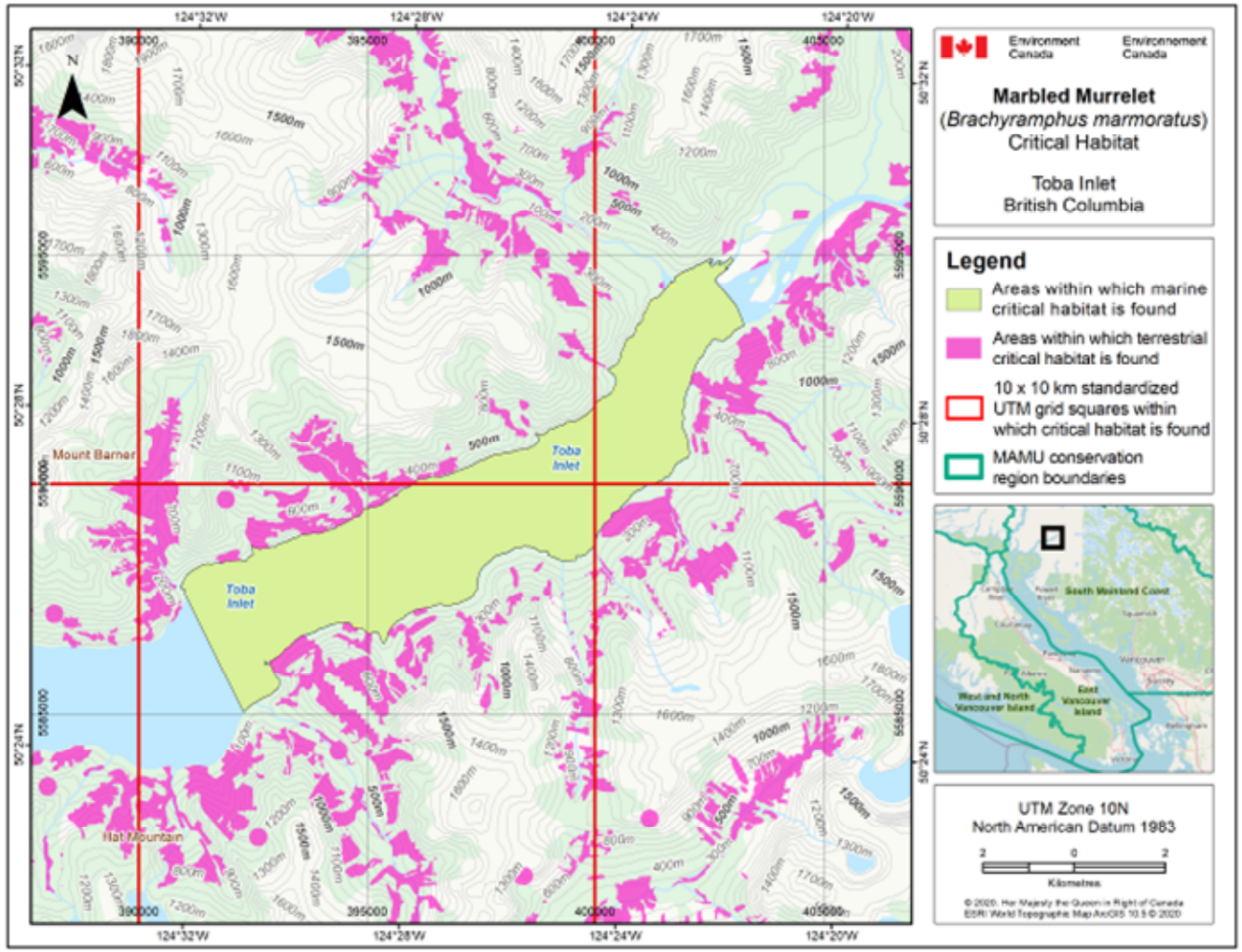

Figure B-16. Marine critical habitat for Marbled Murrelet in the Salish Sea, Toba Inlet area, is found within the yellow polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 1 km x 1 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Terrestrial critical habitat polygon areas (aligning with content of Figures B-1 to B-6) are included for reference, shown in pink.

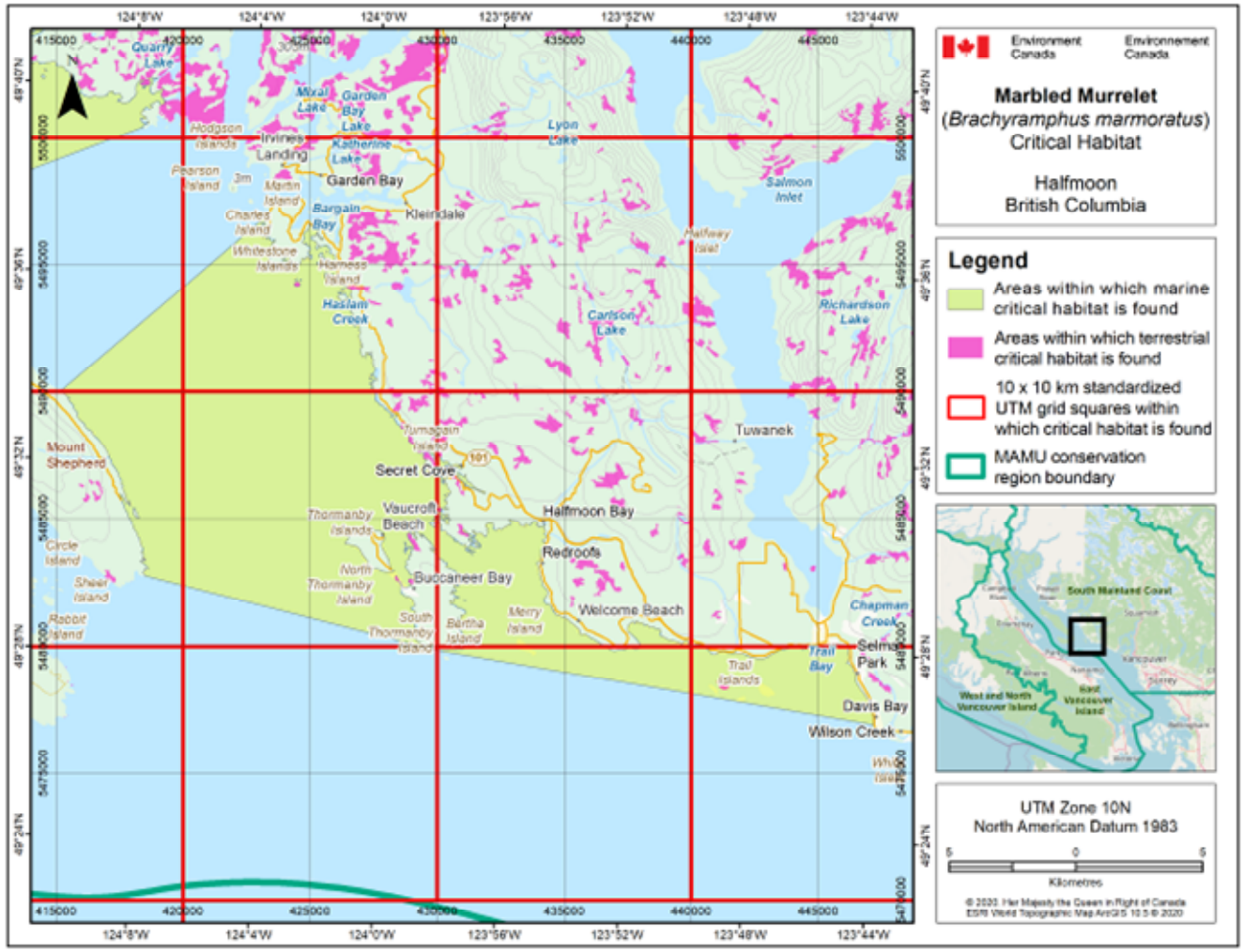

Figure B-17. Marine critical habitat for Marbled Murrelet in the Salish Sea, Halfmoon area, is found within the yellow polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 1 km x 1 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Terrestrial critical habitat polygon areas (aligning with content of Figures B-1 to B-6) are included for reference, shown in pink.

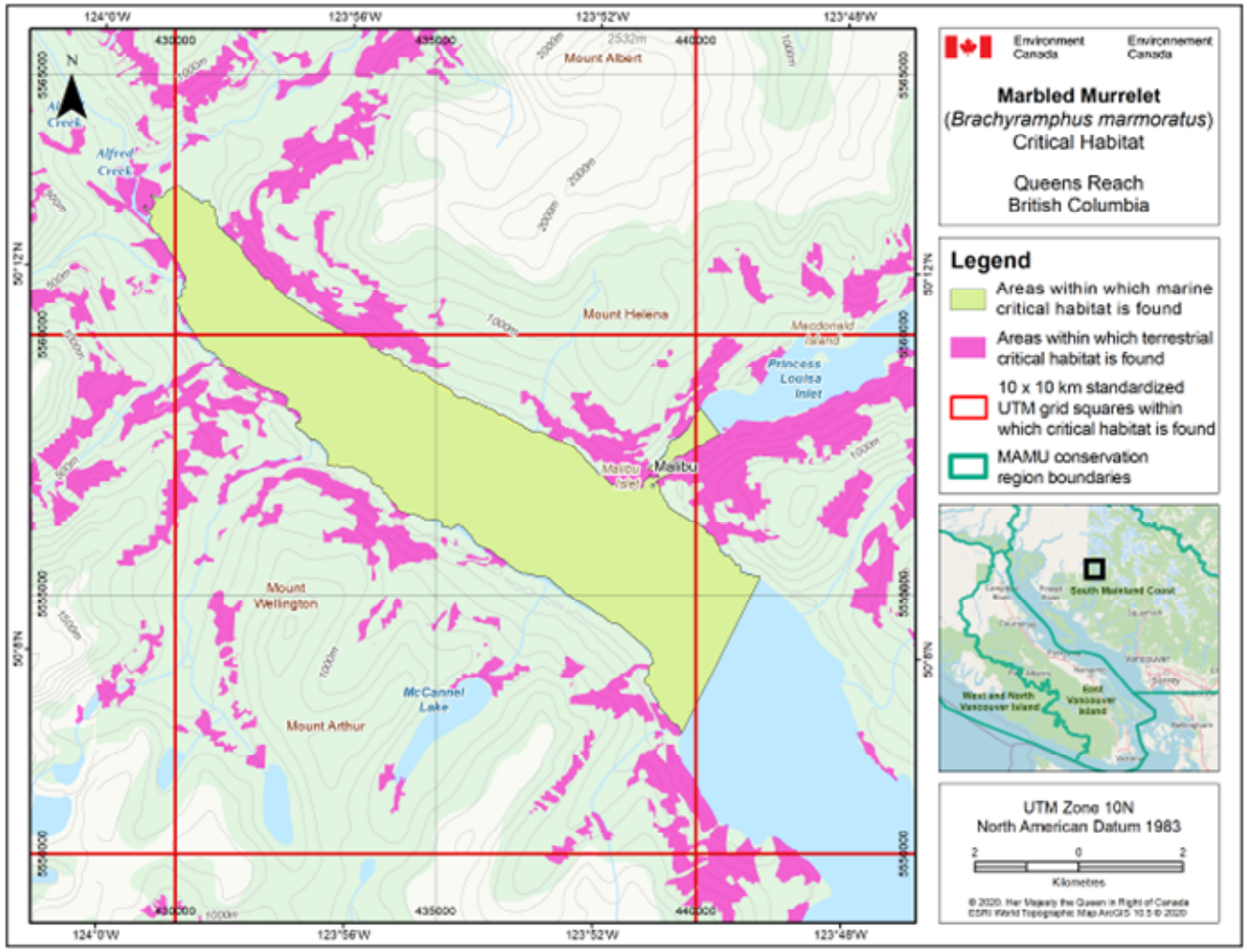

Figure B-18. Marine critical habitat for Marbled Murrelet in the Salish Sea, Queens Reach area, is found within the yellow polygon areas where the criteria and methodology set out in Section 7 (Critical Habitat) are met. The 1 km x 1 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Terrestrial critical habitat polygon areas (aligning with content of Figures B-1 to B-6) are included for reference, shown in pink.

Appendix C: Minimum 2002 Baseline Habitat Amounts and Regional Habitat Retention Targets.

The baseline 2002 amount of suitable habitat and regional retention targets 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 (7.1.2) and the approach used for baseline target calculation (Hierarchical Approach) are different; these important differences are described below.

Geographic Location for nesting critical habitat:

The Geographic Location (Section 7.1.2; maps in Appendix B) is the broadest area within which critical habitat may be found according to the biophysical attributes (7.1.3). It is created by overlapping all of the 7.1.2 data sets 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 in 7.1.2. 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 regional retention targets (hectares). These are calculated using a hierarchical approach to assembling the medium scale spatial information from Section 7.1.2. 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 target amounts is underway (Table 4); therefore, this hierarchical approach represents the most defensible current approach to estimating target amounts.

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 7.1.2 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 aspatial 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 targets 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 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 Targets” in Table C.1. Refinement of this information is a key activity outlined in Table 5 of the Recovery Strategy.

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

Conservation Region	Area (ha) Estimated Habitat in 2002 (Baseline)[a]	Area (ha) Habitat in 2011[b]	Short Term Recovery Objectives (2002 – 2032)[c]	Minimum Habitat Retention Thresholds (ha)[d]	Area (ha) of 2011 Habitat in Excess of Minimum Habitat Retention Thresholds[e]	Percent of 2011 Habitat Above Habitat Retention Thresholds[f]
Northern Mainland Coast	430,369	420,221	≥ 68%	292,651	127,570	43.6%
Haida Gwaii	225,145	212,628	≥ 68%	153,099	59,530	38.9%
Central Mainland Coast	324,965	310,427	≥ 68%	220,976	89,451	40.5%
Southern Mainland Coast	121,598	115,954	≥ 85%	103,358	12,597	12.2%
West and North Vancouver Island	287,844	256,081	≥ 68%	198,420	60,348	30.8%
East Vancouver Island	82,033	77,038	≥ 90%	73,830	3,208	4.3%
Total	**1,471,954**	**1,392,349**		**1,039,648**	**352,703**	

[a] ***Area (ha) Estimated Habitat in 2002 (Baseline):*** The amount of suitable habitat available in 2002, determined using the backcasting approach.

[b] ***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.

[c] ***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.

[d] ***Minimum Habitat Retention Thresholds (ha):*** The minimum suitable habitat amounts required to meet the regional short term recovery objectives.

[e] ***Area (ha) of 2011 Habitat in Excess of Minimum Habitat Retention Thresholds:*** The amount of suitable habitat available in 2011 minus the minimum amount of habitat required to meet the population and distribution objectives.

[f] ***Percent of 2011 Habitat Above Habitat Retention Thresholds:*** The percentage of of suitable habitat available in 2011 in excess of the minimum amount of habitat required to meet the population and distribution objectives.