Biological Assessment for a Determination that Puget Sound Treaty and Non-Treaty (All-Citizens) Fisheries Qualify for Limitation of ESA Take Prohibitions Pursuant to Section 7(a)(2) for Listed Marbled Murrelets

Source: Lummi Nation 2015

Source: WDFW 2015a

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1. Introduction

NOAA's National Marine Fisheries Service (NMFS) proposes to issue a determination that implementation of the annual Treaty and non-Treaty (All-Citizen's) fisheries are consistent with provisions of Limit 9 of the Endangered Species Act of 1973 (ESA) Section 7(a)(2) for listed Puget Sound Chinook salmon, Puget Sound steelhead, Southern Resident killer whale, and three species of Pacific rockfish. This determination would authorize joint Treaty and State co-manager operation of fisheries in the Strait of Juan de Fuca, Southern Strait of Georgia (within Washington State), and Puget Sound.

This biological assessment (BA) supplies the USFWS with the necessary information to determine the effects of the proposed action on listed species under their jurisdiction. The document is prepared pursuant to section 7(c) of the ESA and is intended to ensure that the proposed activities would not jeopardize the continued existence of the listed species, or result in the destruction or adverse modification of its designated critical habitat.

2. Consultation History

From 1993 to 2003, NMFS and the Bureau of Indian Affairs[1] (BIA) have requested separate ESA section 7 consultations for a variety of Treaty and non-Treaty fishery actions in the Strait of Juan de Fuca, southern Strait of Georgia (within Washington State), and the greater Puget Sound (Table 2). In each case, the USFWS concluded that the proposed actions were not likely to jeopardize the continued existence of the listed species affected by the proposed actions.

From 2003 to 2011, NMFS received, evaluated, and approved a series of jointly-developed resource management plans from the Puget Sound Treaty Tribes (PSIT) and the Washington Department of Fish and Wildlife (WDFW) (collectively 'the co-managers'), under Limit 6 of the 4(d) rule. The biological opinions on the NMFS' 4(d) determinations included several federal sub-actions including similar consultations with the BIA and USFWS. The BIA funds the PSIT's management, enforcement, and monitoring projects associated with Treaty fisheries in marine waters of Washington State. The USFWS also provides a small portion of funding and technical assistance for the proposed action as a party to the Hood Canal Salmon management plan. The effects of Puget Sound salmon and steelhead fisheries have been considered for ESA compliance in conjunction with the completion of 17 biological opinions and two time extension authorizations associated with the current biological opinions (USFWS 2001 and USFWS 2004) for marbled murrelets (Table 1). In each case, the USFWS and NMFS (the Services) concluded the proposed actions were not likely to jeopardize the continued existence of the listed species affected by the proposed actions.

[1] The Bureau of Indian Affairs provides funds and ensures implementation of effective tribal self-regulatory and co-management systems for fisheries under the jurisdiction of the Treaty Tribes of Western Washington.

From 2010 to 2015, two requests for time extensions on the biological opinions for non-Treaty Puget Sound commercial and recreational fisheries (All-Citizens Opinion; USFWS 2001) and Treaty commercial salmon net fisheries (Treaty Opinion; USFWS 2004) were initiated in conjunction with the Puget Sound Chinook and steelhead fishery evaluations for the NMFS' 2011 and 2015 biological opinions on salmon and steelhead (NMFS 2011; NMFS 2015).

On May 6, 2010, given the proposed extensions to the non-Treaty and Treaty opinions were not anticipated to exceed the levels of take originally authorized, the USFWS extended the consultation period for both of these biological opinions until April 30, 2015 (Berg 2010).

The effects of Puget Sound salmon and steelhead fisheries have also been considered for ESA compliance under NMFS in conjunction with the completion of three long-term biological opinions for marbled murrelets and one time extension. In each case, the Services concluded the proposed actions were not likely to jeopardize the continued existence of the listed species affected by the proposed actions.

On October 24, 2014, NMFS and the Bureau of Indian Affairs (BIA) submitted a biological assessment on incidental impacts to marbled murrelets in anticipation of NMFS' section 7 consultation with the USFWS regarding Puget Sound salmon and steelhead fisheries that was due to expire on April 30, 2015.

On February 18, 2015, NMFS and the BIA requested consultation for incidental take of marbled murrelets in Puget Sound salmon and steelhead fisheries proposed by the co-managers. A biological assessment was submitted for a determination that the proposed 2015-16 Treaty and non-Treaty fisheries qualified for limitation of ESA take prohibitions pursuant to Section 7(a)(2) for listed marbled murrelets. On April 29, 2015, given that the proposed extension of the non-Treaty and Treaty opinions were not anticipated to exceed the levels of take originally authorized, the USFWS issued a letter extending the consultation period for the current biological opinions (USFWS 2001; USFWS 2004) until April 30, 2016 (Rickerson 2015). This letter authorized a second time extension and documented the USFWS' decision not to initiate formal consultation at that time.

On November 6, 2015, NMFS, in cooperation with the co-managers, sent a draft biological assessment to USFWS for review. This document was submitted in preparation for a joint consultation on Puget Sound salmon and steelhead fisheries proposed by the co-managers.

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Table 1. Biological opinions associated with incidental take of marbled murrelets in Puget Sound salmon and steelhead fisheries.

Consultation Number	Consultation Name	Consulting Agency
1993F0592	Treaty Net Fisheries	BIA
1993F0593	Non-Treaty Net Fisheries	NMFS
1994F0270	Puget Sound Salmon Net Fishery (All-Citizen)	NMFS
1994F0275	Puget Sound Net Fisheries	BIA
1994F0406	Treaty Net Fishery in Hood Canal/Puget Sound	BIA
1994F0407	Treaty Net Fishery in North Puget Sound	BIA
1994F0418	Puget Sound Terminal Fishery	NMFS
1994F0444	Makah Gillnet Fishery	BIA
1995F0296	Non-Treaty Commercial Net Fisheries	NMFS
1995F0295	Treaty Commercial Salmon Net Fishery	BIA
1995F00419	Treaty Commercial Net Fishery/Puget Sound	BIA
1996F0236	Non-Treaty Puget Sound Net Fishery	NMFS
1996F0269	Treaty Salmon Net Fisheries in Strait of Juan de Fuca	BIA
1996F0281	Treaty Salmon Net Fishery in Puget Sound/Hood Canal	BIA
1999F0835	Treaty Gillnet Fishery in Puget Sound 1999-2003	BIA
2001F1636/1-3-04-F-1049	Puget Sound Area Recreational and All-Citizen Commercial Salmon Net Fishery 2001-2011	NMFS
2004F0912/1-3-F-1636	Treaty Gillnet Fishery – Puget Sound 2004-2014	BIA
13410-2010-TA-0284[2]	Time extension on existing Treaty and All-Citizens Gillnet Fisheries 2011-2015	BIA/NMFS
01EWFW00-2015-TA-0334[2]	Time extension on existing Treaty and All-Citizens Gillnet Fisheries 2015-2016	BIA/NMFS

Source: USFWS 2004; NMFS and BIA 2015a.

[2] Biological opinion Xref: 1-3-01-F-1636 and 1-3-04-F-1049.

On November 20, 2015, USFWS provided comments on the draft biological assessment to NMFS, BIA and the co-managers.

On December 17, 2015, NMFS and the BIA provided a final biological assessment to the USFWS requesting joint consultation for incidental take of marbled murrelet in the co-manager proposed Puget Sound salmon and steelhead fisheries.

3. Proposed Action

3.1 Federal Nexus

This document constitutes the NMFS' biological assessment for completion of ESA section 7 consultation for the following federal actions involving the BIA, USFWS, and NMFS:

1) The BIA funding of Puget Sound Treaty Tribes' management, enforcement, and monitoring projects associated with Puget Sound salmon and steelhead fisheries implemented annually;

2) The USFWS authorization of fisheries, as party to the Hood Canal Salmon Management Plan (*U.S. v. Washington*, Civil No. 9213, Ph. I (Proc. 83-8)), implemented annually; and

3) Management of the sockeye and pink fisheries through the action of the Fraser River Panel (FRP) authorized and implemented annually under the Pacific Salmon Treaty (PST),
   (a) Under PST, the U.S. government's annual relinquishment of regulatory control to the bilateral FRP within specified time periods and,
   (b) Issuance of regulatory orders by the Secretary of Commerce that authorize fishing times and areas consistent with management actions of the FRP. This regulatory authority has been delegated to the Regional Administrator of NMFS' West Coast Region (NMFS 2015b)[3].

Because these proposed Federal actions are similar and occurring within the same geographical area, pursuant to 50 CFR402.14(c), NMFS is grouping them in this consultation. The Puget Sound All-Citizen salmon fisheries and related enforcement, research, and monitoring projects associated with fisheries other than those governed by the FRP, are included as interrelated and interdependent actions because the state of Washington and the PST are required under the Puget Sound Salmon Management Plan (*U.S. v. Washington* 1985), and in accordance with the implementation plan for *U.S. v. Washington*, to jointly manage Puget Sound salmon fisheries as

[3] Pacific Salmon Treaty Act, Public Law 99-5, 16 U.S.C. 3634, 16 U.S.C. 3641; Department of Commerce Appropriation Act of 1995.

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co-managers (384 F. Supp. 312 (W.D. Wash. 1974), aff'd, 520 F.2d 676 (9th Cir. 1975)), commonly known as the Boldt decision.

At the same time, NMFS is considering the impacts of the proposed actions on the Puget Sound Chinook salmon Evolutionarily Significant Unit (ESU), the Puget Sound Steelhead Distinct Population Segment (DPS), the Southern Resident Killer Whale DPS, and three listed Puget Sound rockfish DPS' under the ESA. Other listed species under our jurisdiction, occurring in the action area, are either covered under existing long-term ESA opinions or 4(d) determinations, or NMFS anticipates the proposed actions are not likely to adversely affect the species.

3.2 Description of the Proposed Action

The proposed action is the implementation of annual non-Treaty commercial and recreational fisheries and Treaty commercial and ceremonial and subsistence fisheries. Coverage is being sought for a duration of twenty years. Non-Treaty fishing gear types include drift gillnet, skiff gillnet, purse seine, reef net, and beach seine in commercial fisheries and mooching, jigging, trolling, shore angling, and fly-fishing in recreational fisheries (Section 6.1.1 and 6.5.1). Treaty fishing gear types include drift gillnet, set gillnet, purse seine, roundhaul seine, beach seine, troll and hook and line in commercial and ceremonial and subsistence fisheries (Section 6.2.1).

The PSIT of western Washington conduct salmon fisheries for Treaty commercial and ceremonial and subsistence purposes. WDFW implements salmon and steelhead fisheries for the citizens of Washington State (i.e., All-Citizens) for non-Treaty commercial and recreational purposes. These fisheries occur in the marine areas in the Strait of Juan de Fuca, southern Georgia Strait, Puget Sound, and Hood Canal. Marine waters are divided into Marine Catch Reporting Areas (MCAs); freshwater areas include rivers such as, but not limited to, the Elwha, Dungeness, Nooksack, Skagit, Snohomish, Cedar, Duwamish/Green, White, Puyallup, Nisqually, Deschutes, Skokomish, and Quilcene Rivers as well as Lake Washington (Section 4). Within these areas, the PSIT harvest Chinook, chum, sockeye, pink and coho salmon and steelhead in usual and accustomed fishing areas reserved by treaty and reaffirmed under *U.S. v. Washington;* WDFW regulates fisheries for All-Citizen harvest of the same species pursuant to *U.S. v. Washington*.

Treaty and non-Treaty fisheries are established with regulations[4] issued by each participating Tribe or WDFW defined during the Pacific Fisheries Management Council[5] Process and North

[4] WDFW regulations for commercial and recreational fisheries can be found online at: http://wdfw.wa.gov/fishing/regulations/; more information on salmon fisheries management for PSIT can be found online at: http://nwifc.org/about-us/fisheries-management/salmon-fisheries-management/ and http://fisheriesservices.nwifc.org/harvest-management/.

[5] The Pacific Fishery Management Council manages fisheries for about 119 species of salmon, groundfish, coastal pelagic species (sardines, anchovies, and mackerel), and highly migratory species (tunas, sharks, and swordfish) and is one of eight regional fishery management councils established by the Magnuson Fishery Conservation and Management Act of 1976. Management measures developed by the Council are recommended to the Secretary of Commerce through the National Marine Fisheries Service (NMFS). Management measures are implemented by NMFS West Coast Regional offices and enforced by the NOAA Office of Law Enforcement, the 11th and 13th Coast Guard Districts, and local enforcement agencies (http://www.pcouncil.org/).

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of Falcon[6] public meetings. Fishery rules and regulations are a result of discussions involving state, tribal, and Federal fisheries management agencies, commercial and recreational industry representatives, and other interested parties. These regulations set the fishing schedule, stipulate open or closed fishing areas, fishing gear, and size limits. The PSIT and WDFW (co-managers) develop fishing regimes cooperatively pursuant to the legal mandates of *U.S. v. Washington*. NOAA Fisheries provides funding and technical assistance for the proposed action. The co-managers also participate in international fisheries planning forums. For example, harvest of Fraser River sockeye and pink salmon is planned and managed in-season with oversight from the Fraser Panel of the Pacific Salmon Commission (http://www.psc.org/) pursuant to the terms and conditions of the Pacific Salmon Treaty[7] and applicable Federal laws and regulations.

4. Action Area

The action area encompasses marine waters within, and freshwater tributaries flowing to, Puget Sound Salmon Management and Catch Reporting Areas (MCA) 4B – 13I (Figure 1). These areas are described in Washington Administrative Code (WAC) 220-22-030). The MCAs are within the marbled murrelet species range identified in Washington State (Figure 2; Falxa et al. 2014). The proposed action encompasses all of the marbled murrelet Conservation Zone 1 and a small portion of Conservation Zone 2 as described in the marbled murrelet recovery plan (USFWS 1997).

The proposed action occurs in both marine waters and rivers of Puget Sound. However, marbled murrelets are not known to utilize riverine areas and their critical habitat designation does not include marine waters. As mentioned above, this biological assessment includes actions affecting two of the six Marbled Murrelet Conservation Zones in marine catch areas: 1) the Puget Sound Conservation Zone 1, which includes all waters of Puget Sound, the eastern waters of the Strait of Juan de Fuca and associated inland habitat extending 80km (50 miles) from eastern Puget Sound and bisecting of the Olympic Peninsula; and 2) a small portion (e.g., MCA 4B) of the Western Washington Coast Range Conservation Zone 2, which includes the outer coast of Washington, the western waters of the Strait of Juan de Fuca and associated inland habitat

[6] North of Falcon is a parallel public process folded into the Pacific Fishery Management Council process. The North of Falcon process integrates management of ocean fisheries between Cape Falcon (on the north Oregon coast) and the Canadian border, including fisheries in the Columbia River, Puget Sound, and inland Washington coastal waters. Coordination and shaping of the ocean and freshwater fisheries occurs to assure that fish conservation objectives are met and there is reasonable sharing of the conservation burden between the fisheries and various user groups. In this public process, there are allocation agreements reached between Oregon and Washington ocean and freshwater commercial and sport fisheries, as well as mandated allocation agreements between the states and Treaty Indian tribes (http://www.westcoast.fisheries.noaa.gov/fisheries/salmon_steelhead/north_of_falcon.html).

[7] Pacific Salmon Treaty Act - Public Law 99-5, approved March 15, 1985, (16 U.S.C. 3631) implements the Pacific Salmon Treaty between the U.S. and Canada, January 28, 1985; establishes the requirements for Commissioners and the subsidiary Northern, Southern, and Fraser River Panels; and authorizes Federal regulatory preemption by the Secretary of Commerce to meet treaty obligations. The Act authorized creation of an advisory committee to assist the U.S. Section and U.S. Panel Sections, and authorizes appropriations of such sums as may be necessary for carrying out the purposes and provisions of the Treaty and Act (https://www.fws.gov/laws/lawsdigest/PACSALM.HTML).

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extending inland to the midpoint of the Olympic Peninsula, and in southwest Washington as far as 80 km (50 miles) from the Pacific Ocean shoreline.

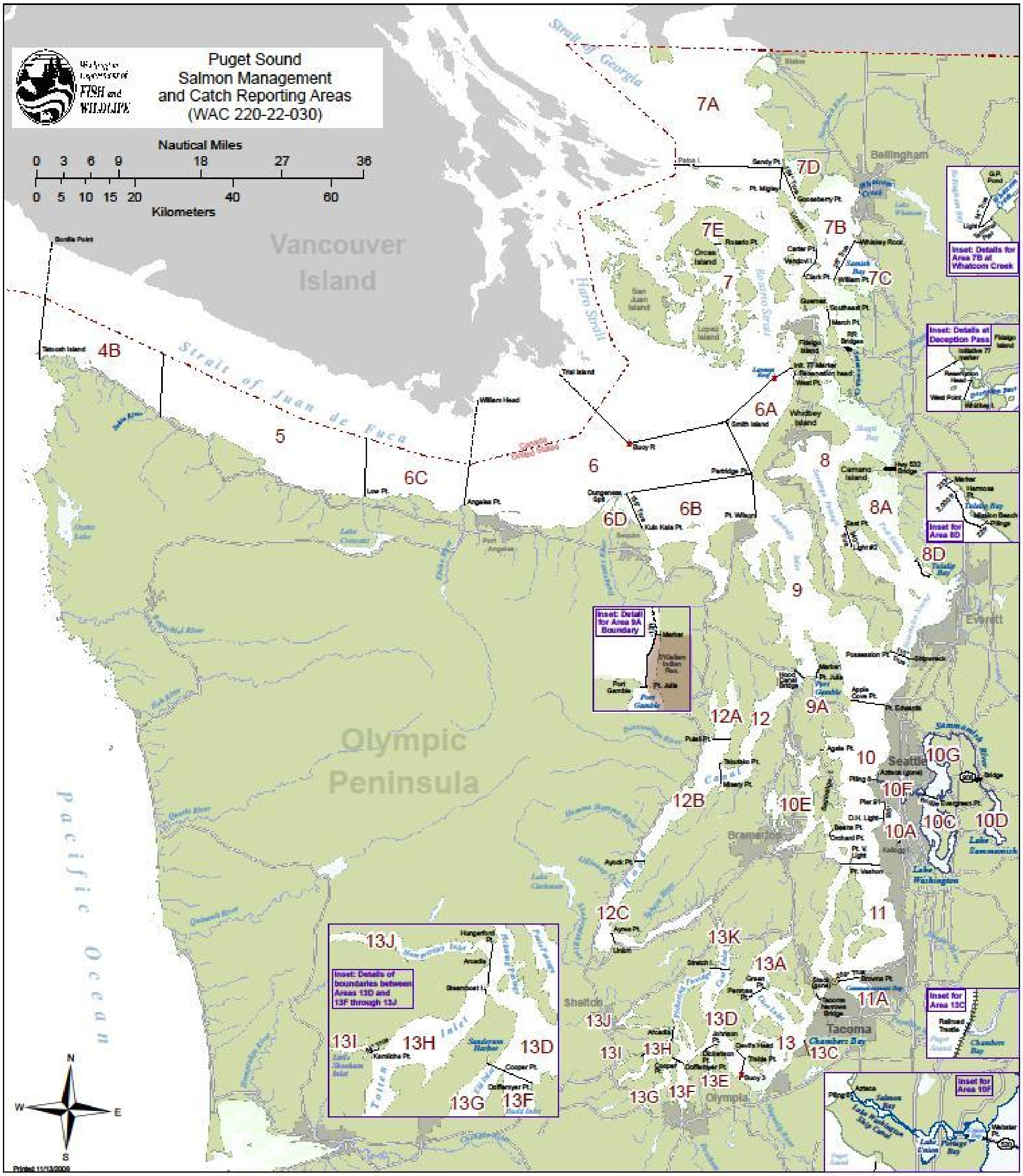

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Figure 1. Puget Sound Commercial Salmon Management and Catch Reporting Areas (see WAC 220-22-030 and Puget Sound Commercial Salmon Regulations (WDFW 2015b)).

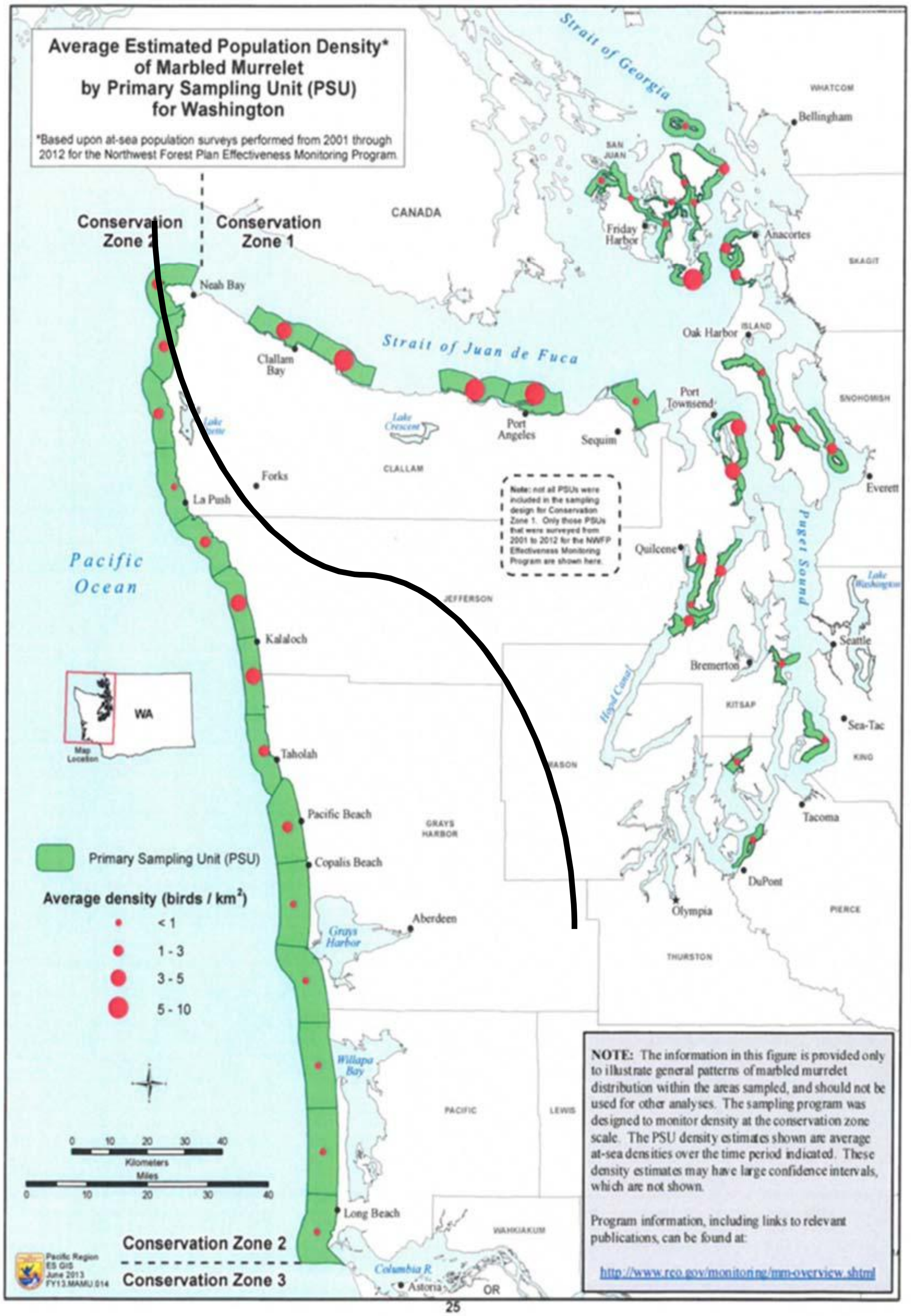

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Figure 2. Ranges of average marbled murrelet densities by Primary Sampling Unit (PSU) monitored in Zones 1 and 2. The action area includes the majority of Zone 1 with a small portion of Zone 2 located in MCA 4B (area depicted between solid and dotted black lines) (Falxa et al. 2014).

5. USFWS ESA-Listed and Candidate Species in the Action Area

Table 2 identifies the ESA-listed species or species that are candidates for listing under USFWS jurisdiction in the action area that, because of their location, may potentially be affected by the fisheries included in the proposed action. The potential for any effect depends on which species may be present, their biological characteristics and behavior, and the location of the proposed fisheries.

Table 2. Federal ESA-listed species, listing status, and critical habitat considered in this Biological Assessment.

Species[1]	Listing Status	Critical Habitat	ESA Determination	
			Species	Critical Habitat
Marbled Murrelet	Threatened September 28, 1992, 57 FR 45328	October 4, 2011, 61 FR 26256	May Affect, Not Likely to Adversely Affect	No effect[2]
Bull Trout	Threatened June 10, 1998, 63 FR 31647	Revised January 14, 2010, 75 FR 2270	N/A; Special 4(d) Rule, 64 FR 58929	No effect[3]

[1] USFWS, Environmental Conservation Online System, Species listed in Washington, accessed October 22, 2015: http://ecos.fws.gov/tess_public/reports/species-listed-by-state-report?state=WA&status=listed.
[2] Critical habitat is designated for terrestrial habitat; the proposed action occurs in marine waters only resulting in no effect.
[3] Although bull trout critical habitat was not designated at the time of the special rule and harvest activities do affect passage in that bull trout may be intercepted, no fishery effects are anticipated because the gear used are integral to the operation of the fisheries and take allowed under the rule.

The proposed action may affect, but is not likely to adversely affect, marbled murrelet (*Brachyramphus marmoratus*). The proposed action will have no effect on marbled murrelet critical habitat because the action area occurs in marine waters only where critical habitat is not designated.

Bull trout (*Salvelinus confluentus*) are also found in the action area but the action agencies are not requesting concurrence on effects to bull trout because the action is consistent with a special rule developed under the authority of section 4(d) of the Act, which follows the taking of bull trout via activities such as the proposed action on bull trout. The special 4(d) rule exempts take of bull trout for fishing activities authorized under State, National Park Service, or Native American Tribal laws and regulations (64 FR 58929, November 1, 1999).

Fisheries under the proposed action are authorized by State and Native American Tribal laws and regulations and do not target bull trout. Although bull trout are not targeted under the proposed action, they may be susceptible to incidental mortality in gillnet and recreational fisheries directed at other Pacific salmonids (Brenkman and Corbett 2005). Bull trout encounters in Puget Sound non-Treaty marine commercial fisheries is considered a rare occurrence (NMFS 2004). In 4,591 observations of Puget Sound non-Treaty commercial purse seine and gill net operations, no bull trout were caught (NMFS 2004). However, one bull trout was brought to WDFW staff for identification from a commercial fisherman (NMFS 2004). When taking into account drop-out[8], the number of observations of sets, and the overall number of potential sets annually, using this one observation, it was estimated that less than 1 bull trout would be taken in the non-Treaty Puget Sound marine purse seine and gillnet fisheries annually (NMFS 2004). To protect weak stocks in commercial fisheries, non-Treaty fisheries are presently managed by time and area closures that restrict the fleet to particular areas or times so that they avoid weak salmonid stocks or listed species (WDFW 2010). From 2001 to 2014, only 3 bull trout have been taken in Treaty commercial gillnet fisheries (C. James, pers. comm. 2015). Based on this data, due to the similarity in nature and timing of co-manager salmon and steelhead fisheries, and because bull trout occurrence in Puget Sound non-Treaty commercial marine fisheries is very rare, Treaty fishery impacts to bull trout are also anticipated to be rare (NMFS 2010).

Bull trout encounters with the Puget Sound non-Treaty marine recreational (hook and line) fisheries are also considered a rare occurrence and all bull trout encountered are required to be released (NMFS 2004). Among 371,300 anglers interviewed from 1999 to 2003, 6 bull trout were encountered in non-Treaty marine recreational fisheries (NMFS 2004). Using this observed ratio, assuming an estimate of 447,024 marine angler trips per year in Puget Sound (Section 6.2.1.7), it is estimated that ~9 bull trout would be encountered (caught and released) by the marine recreational fisheries annually. Taking into account potential drop-out, and assuming a 14 percent catch and release mortality rate[9], it is estimated that 2 bull trout or less would be killed in the Puget Sound marine recreational fisheries annually (NMFS 2004). Bull trout may also be caught by hook and line during Treaty ceremonial and subsistence fisheries for Chinook, coho and chum salmon and steelhead. Since there are no Treaty data to determine bull trout encounters or mortality, NMFS cannot determine the impact to bull trout in ceremonial and subsistence salmon and steelhead fisheries at this time. However, provided the limited scope and catch involved in Treaty ceremonial and subsistence fisheries, the similarity of hook and line gear used for Treaty and non-Treaty fisheries, the number of Treaty participants (10-12 trips annually;

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[8] Drop-outs would be fish gilled but not caught. For Chinook salmon, WDFW uses an estimate of 2 percent for a drop-out mortality rate in gill net marine terminal fisheries. Lacking an estimate of a drop-out mortality rate specifically associated with bull trout, NMFS used the Chinook salmon drop-out mortality rate estimate (NMFS 2004).

[9] For Chinook salmon, WDFW used an estimate of 14 percent for catch and release mortality in marine recreational fisheries. This estimate is supported by available literature. Lacking estimates of a catch and release mortality rate associated specifically to bull trout, this assessment used the Chinook salmon catch and release mortality rate estimate.

Section 6.2.1.7), and resulting impacts provided for non-Treaty recreational fisheries, Treaty impact is also anticipated to be rare (NMFS 2010).

As a result of state-tribal actions taken prior to the Federal listing of bull trout, angling regulations have restricted intentional bull trout harvest to only a handful of locations since the early and mid-1990's (64 FR 58910, November 1, 1999). In the 5-year status review of bull trout, USFWS stated, "the threat of harvest has not significantly increased because most freshwater fishing areas have been closed to bull trout angling since the time of listing" (USFWS 2009). As bull trout abundance declined, more restrictive marine and freshwater regulations were imposed to help protect this species (WDFW 2015c).

The proposed action is not likely to affect bull trout critical habitat. The gear deployed by Treaty and non-Treaty fishers is an essential part of the fisheries for which consequential incidental take of bull trout is approved (64 FR 59910, November 1, 1999). Three fishing gears may pose risk to bull trout critical habitat: 1) hook and line; 2) gill nets (drift and set); and 3) purse seines. If hooks, lines or gill nets do come in contact with substrate or other habitat features their capture efficiency is dramatically reduced. As a result, fishers endeavor to keep hook and line, gillnet, and purse seine gear from being entangled with substrate and habitat features (NMFS 2010). Although bull trout are sometimes caught in gillnets, once released, the nets will not dissuade bull trout from continuing their migration and do not constitute a substantive barrier to fish passage or migration. Bull trout not captured in gill nets will undergo migration as though the temporary gill nets did not exist (NMFS 2010). Use of the fishing gear stated above is integral to operation of the Treaty and non-Treaty fisheries that have been exempted from take. Since encounters with bull trout under the proposed action are considered a rare event, no further analysis regarding effects to bull trout will be provided in this biological assessment.

The following sub-sections provide a description of marbled murrelet current status, population trends, biology, life history, marine distribution, habitat use, and potential gillnet interactions.

5.1 Marbled Murrelet

5.1.1 Status of Species

On October 1, 1992, the marbled murrelet (*Brachyramphus marmoratus*) was listed as threatened by the USFWS in Washington, Oregon, and California (57 FR 45328) because of loss and modification of nesting habitat in old-growth forest stands primarily due to commercial timber harvesting. At that time, marbled murrelets were also considered at risk from mortality associated with gillnet fishing operations off the Washington Coast and the effects of oil spills. In 2009, the USFWS conducted a 5-Year review for the marbled murrelet. Based on the evaluation of threats and trends in population status, USFWS determined that the marbled murrelet should remain listed as threatened (USFWS 2009).

The primary causes of marbled murrelet population decline from historical levels are (1) the loss and modification of nesting habitat through commercial timber harvests, human-induced fires,

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and land conversions, and (2) poor reproductive success in the habitat that does remain (USFWS 1997). Forest fragmentation and increased edge effects from modified forest habitats are thought to decrease murrelet nesting success rates due to increased wind effects and predation opportunities by common nest predators such as common ravens (*Corvus corax*) and Steller's jays (*Cyanocitta stelleri*) (Nelson and Hamer 1995). In 2011, the USFWS developed a Recovery Implementation Team (RITT) to assist in the recovery of the marbled murrelet throughout its range (Washington, Oregon, and California) (USFWS 2012). The RITT concluded that sustained low recruitment is the most likely cause of continued population decline (USFWS 2012). Five mechanisms contributing to the decline of marbled murrelets were identified:

- Historical and ongoing loss of terrestrial (forest) nesting habitat
- Predation on eggs and chicks in their nests
- Changes in marine forage conditions that affect abundance, distribution, and quality of prey
- Post-fledging mortality
- Cumulative and interactive effects of factors on individuals, populations, and the species (USFWS 2012)

Under post-fledging mortality, avian predation, collisions with moving or stationary objects (i.e., vehicles, powerlines, etc.), oil spills, underwater sound (i.e., impact pile driving, detonations, etc.), and nets (i.e., gillnets, purse seines, derelict gear) were identified as sources of mortality but population impacts were unknown (low confidence) (USFWS 2012).

Based on the proposed action, this biological assessment will focus on the potential risk to marbled murrelets posed by interactions with gill nets.

Critical habitat has been designated for the species. However, the proposed action would not affect critical habitat for marbled murrelet.

5.1.2 Population Trends

Current data on the marbled murrelet population for Conservation Zones 1 and 2 is derived from the effectiveness monitoring program of the Northwest Forest Plan (NWFP), which has conducted at-sea population surveys annually during the breeding season since 2000 (Huff 2006, Miller et al. 2006, Raphael et al. 2007). The 2004 5-Year review concluded the population of murrelets in Conservation Zones 1-5 was not declining. However, monitoring results in the 2009 5-year review indicated a population decline since 2000. The 2007 and 2008 population estimates were the smallest estimates on record since monitoring began in 2001. For Conservation Zones 1 through 5 combined, population estimates for 2000-2008 indicated an annual rate of decline in the range of 2.4 to 4.3 percent (USFWS 2009).

From 2001-2013, the marbled murrelet population trend estimate was negative but the confidence interval for the estimate overlapped zero and the evidence for a trend was inconclusive for the entire NWFP monitoring area (Falxa and Raphael 2015). This result differs from the population decline previously reported for the marbled murrelet DPS from 2001-2010; relatively high population estimates for 2011, 2012, and 2013 reduced the slope of the trend and increased estimate variability (Falxa and Raphael 2015). At the scale of individual conservation zones in Washington, there is evidence for population declines in Conservation Zone 1 (5.4% decline per year; 95% CI[10]: -9.1 to -1.6%) and Zone 2 (5.0% decline per year; 95% CI: -9.5 to -0.2%) (Falxa et al. 2015). For the 2001–2014 time period, overall, marbled murrelet population declines are evident in Washington State (Zone 1 and 2 combined) (5.1% decline per year; 95% CI: -7.7 to -2.5%) but evidence for a trend was inconclusive on the DPS scale. Continued monitoring is necessary to document long-term changes in the marbled murrelet population.

Publications that include recent marbled murrelet population and habitat monitoring results are described in detail in Falxa et al. (2011, 2013, 2014, and 2015), Raphael et al. (2011), Miller et al. (2012), and Pearson and Lance (2013 and 2014). More in-depth analyses and discussion of murrelet monitoring data from 1994 through 2013 are included in the Northwest Forest Plan 20-year report (Falxa and Raphael 2015).

5.1.3 Biology, Life History, Marine Distribution and Habitat Use

5.1.3.1 Biology

The marbled murrelet is a small (9.5"-10"), robin-sized, diving seabird that spends the majority (> 90%) of its time resting and feeding in the ocean but flies inland to nest in old-growth forest stands. The marbled murrelet is taxonomically classified in the family Alcidae, a family of Pacific seabirds that possess the ability to dive using wing-propulsion (USFWS 2004). The plumage is identical between males and females but changes during winter and breeding periods, providing some differences in coloration between adults and juveniles (USFWS 2004). Breeding adults have light, mottled brown under-parts below sooty-brown upper-parts contrasted with dark bars (USFWS 2004). Adults in winter plumage have white under-parts extending to below the nape and white scapulars with brown and grey mixed upper-parts (USFWS 2004). The plumage of fledged young is similar to the adult winter plumage (USFWS 1997).

5.1.3.2 Nesting

Marbled murrelets nest in inland old-growth forests that contain large trees with large branches or deformities that can be used as nest platforms (USFWS 2004). Murrelets nest in stands varying in size from several acres to thousands of acres. However, larger, unfragmented stands of old-growth timber appear to be the highest quality habitat (USFWS 2004). Mixed conifers are dominant in nesting stands for marbled murrelet in Washington State.

In Washington State, nests have been found at a variety of elevations from sea level to 5,020' in Conservation Zones 1 and 2 (Burger 2002). However, McShane et al. (2004) reports most nest

[10] CI = confidence interval.

locations are found below 3,500'. More recent research shows marbled murrelets have exhibited "occupied" behaviors up to 4,400' elevation and have been detected in stands up to 4,900' in the north Cascade Mountains (McBride 2006). On the Olympic Peninsula, nesting marbled murrelets have been found occupying stands up to 4,000' in Conservation Zone 1 and up to 3,500' in Conservation Zone 2 based on audio-visual surveys (USFWS 2009). However, on average most nests have been documented at elevations less than 3,800' in Conservation Zone 2 based on radio-telemetry studies (Bloxton and Raphael 2008).

5.1.3.3 Marine Distribution

The proposed action occurs in the marine and freshwater environments (i.e., tributaries that feed into the Strait of Juan de Fuca, Puget Sound and Hood Canal), but interactions with marbled murrelets would not occur in freshwater areas; marbled murrelets are known to use freshwater lakes within their potential nesting habitat (Tesky 1994) and the proposed action occurs in anadromous[11] waters only (targeting anadromous fish). Thus, the potential incidental interaction between marbled murrelets and the proposed action would occur in marine waters only.

In Washington, home range size varies during the breeding season (USFWS 2009). Marbled murrelets are usually found within 5 miles (8 km) of shore and in water less than 60 meters deep (USFWS 2009). In general, murrelets were found closer to shore in exposed coastal areas and farther offshore in protected coastal areas (USFWS 2009).

Courtship, preening, loafing, and foraging occur in near-shore marine waters (USFWS 2004). Most courtship begins in early spring and continues throughout summer; some courtship has been observed during the winter period (Speckman 1996, Nelson 1997). Observations of courtship occurring in the winter suggest that mating pairs remain with each other throughout the year (Speckman 1996, Nelson 1997). Courtship involves bill posturing, swimming together, diving synchronously, vocalizing, and chasing in flights just above the surface of the water (USFWS 2004). Copulation occurs both inland (in the forest) and at sea (Nelson 1997).

Marbled murrelets tend to be more vocal at sea compared to other alcids (Nelson 1997). Mating pairs will vocalize when disturbed or after surfacing apart from each other (Strachan et al. 1995). When pairs are separated by boats, most will vocalize and attempt to reunite (Raphael unpublished data; Strachan et al. 1995). Strachan et al. (1995) noted that vocalizations occurred during loafing periods, predominately during mid-morning and late afternoon.

5.1.3.4 Molting

Molting occurs twice each year. The timing of molts varies throughout their range likely due to prey availability, stress, and reproductive success (Nelson 1997). Adult (after hatch-year) marbled murrelets have two primary plumage types: alternate (breeding) plumage and basic (winter) plumage (USFWS 2004). The pre-alternate molt occurs from late February to mid-May

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[11] The proposed action targets anadromous fish. Anadromous means a fish or fish species that spends portions of its life cycle in both fresh and salt waters, entering fresh water from the sea to spawn.

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(USFWS 2004). This is an incomplete molt during which the birds lose their body feathers but retain their ability to fly (Carter and Stein 1995, Nelson 1997). A complete pre-basic molt occurs from mid-July through December (Carter and Stein 1995, Nelson 1997). During the pre-basic molt, marbled murrelets lose all flight feathers somewhat synchronously and can be flightless for up to two months (Nelson 1997). In Washington, there is some indication that the pre-basic molt occurs from mid-July through August (USFWS 2009).

5.1.3.5 Prey

Throughout their range, marbled murrelets are opportunistic feeders and utilize prey of diverse sizes and species (USFWS 2004). In general, main prey items include small schooling fish (e.g., Pacific herring, sand lance, surf smelt), squid (*Loligo spp.*), large pelagic crustaceans (e.g., euphausiids and mysid shrimp), and large pelagic amphipods. In 2005, marbled murrelets were observed using multiple core feeding areas, most likely in response to poor ocean conditions (Bloxton and Raphael 2008). Overall, differences in home range size and use across their range (Washington, Oregon and California) appear to be related to habitat use and forage availability. Historically, high-trophic level prey items such as sardines, anchovy, and squid tended to dominate murrelet diets. With the collapse of many of these stocks, marbled murrelets now target lower trophic level prey items such as sand lance, mysids, euphausids, and krill (Becker and Beissinger 2006). The energy provided by many of these low to mid-trophic level prey species is substantially less than that of higher trophic prey species (Becker and Beissinger 2006). The decline of a high-energy forage base has likely contributed to the decline of murrelet populations in the Pacific Northwest (Norris et al. 2007). Low food availability in central California affects murrelet demography, behavior, and physiology such that nesting success is limited (Peery et al. 2004).

Marbled murrelets forage at all times of the day, but are most active in the morning and late afternoon (Strachan et al. 1995). Some foraging occurs at night (Strachan et al. 1995). Foraging occurs more frequently in nearshore waters generally less than 98' (30 m) deep (Strachan et al. 1995, Burger 2000). The most common foraging depths are unknown at this time but marbled murrelets typically feed on small schools of fish within 16.4' (5 m) of the surface (Mahon et al. 1992). Marbled murrelets have an estimated maximum diving depth of about 154' (47 m) (Mathews and Burger 1998); the deepest dive recorded for marbled murrelets was 89' (27 m) in a gillnet off of California (Carter and Erickson 1992). Jodice and Collopy (1999) reported that in Oregon foraging typically occurs in water less than 33' (10 m) deep. The duration of dives appears to depend upon age (adults or juveniles), water depth, and prey depth (USFWS 2004). Reported dive durations are highly variable for marbled murrelets, ranging from 7 to 42 seconds, with an average of 14 seconds reported from observations in California (Strachan et al.1995). Carter and Sealy (1990) reported that dive durations in British Columbia averaged 27.8 seconds and Thorensen (1989) reported dive durations in Washington ranged from 15 to 115 seconds.

5.1.4.1 Gillnet Interactions

Marbled murrelet mortality in gillnet fisheries on the West Coast has been documented, although entanglements vary considerably among locations, fishery characteristics, murrelet densities, and local conditions (USFWS 2004). In 1996, the Sustainable Ecosystems Institute sponsored a collaborative study with the U.S. Department of Agriculture (USDA) Forest Service, the U.S. Army (Fort Lewis), the Northwest Indian Fisheries Commission (NWIFC), Puget Sound Treaty Tribes, and WDFW to document the distribution and abundance of seabirds in Puget Sound marine waters. Surveys were conducted in areas with known marbled murrelet presence such as Burrows Bay, Skagit Bay and Saratoga Passage, south to Possession Sound, Port Madison, Admiralty Inlet, and Hood Canal, from Port Townsend to Quatsap Point.

The study found marbled murrelets to be concentrated in well-defined areas with seasonal shifts in the location of these aggregations (USFWS 2004). Courtney et al. (1996) reported there was only limited potential for conflict between gillnet fisheries in Puget Sound and marbled murrelets. Most marbled murrelets occur between 200 and 500 m from shore and placement of gillnets further offshore eliminates most murrelet bycatch (Courtney et al. 1996). Several years of surveys, including surveys done during the winter non-breeding season, will be required to understand the annual variation in distribution and abundance of marbled murrelets relative to fishing areas. Marbled murrelet interactions or mortality has not been documented in Treaty or non-Treaty gillnet fisheries. While there is fishery observer coverage of some non-Treaty gillnet fisheries, it is limited. Therefore, it cannot be assumed that there are no murrelet-net interactions occurring in co-manager commercial gillnet fisheries (USFWS 2009).

The USFWS 2009 5-year status review for marbled murrelets stated that gillnets have the potential for direct mortality in the Puget Sound area and northern Washington Coast (USFWS 2009). McShane et al. (2004) reported gillnet fishing effort through 2003 had declined below effort levels recorded during the 1990s. The decline over this period was in response to management constraints on declining stocks of coho and Chinook salmon (Figure 3). The 2009 marbled murrelet 5-year status review reported increases in the number of landings in some fishing areas after 1999 with some Puget Sound areas seeing increased drift gillnet and/or set gillnet landings for Treaty fisheries and increased gillnet and purse seine landings from 2004 through 2007 for the non-Treaty fishery (USFWS 2009). From 2001-2007, Treaty and non-Treaty fisheries exhibited a stable trend with fishery landings ranging from ~6,000 to 7,500. From 2008 through 2011, there was an increase in fishery landings in some portions of Puget Sound (e.g., South Puget Sound and Hood Canal) with total landings ranging from ~8,500 to 11,500. From 2012 to 2014, decreasing trends in fishery landings have been observed with landings ranging from ~8,700 to 9,500 (Figure 3). Overall, Treaty and non-Treaty commercial, ceremonial and subsistence, and recreational fishery landings combined have declined by over 80% since 1980. Over the last fifteen years, no marbled murrelet interactions or incidental mortality has occurred in Treaty and non-Treaty drift gillnet or set net fisheries.

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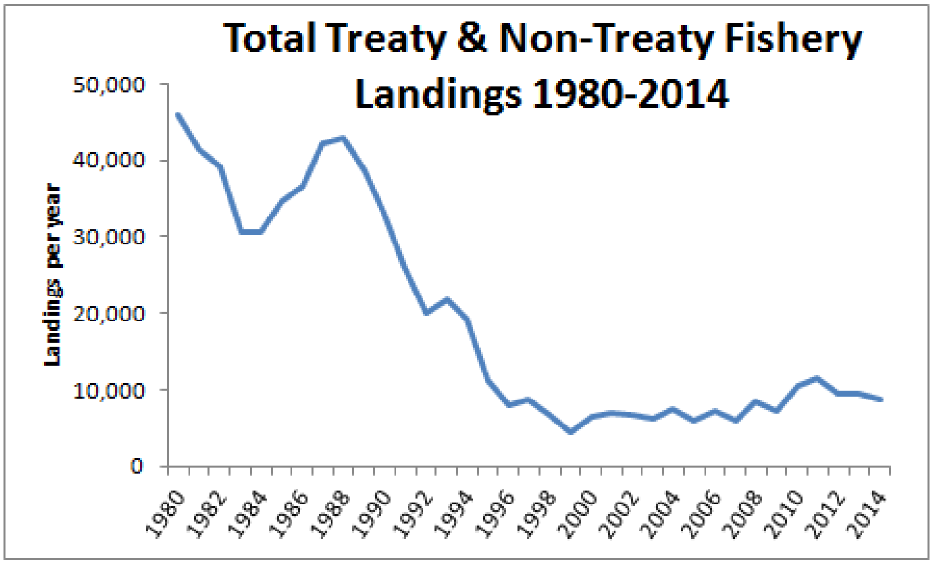

Figure 3. Total annual Treaty (drift gillnet and set gillnet) landings and non-Treaty (drift gillnet) landings combined from 1980 to 2014.

6. Analysis of Effects on Marbled Murrelet

The following assessment of marbled murrelet impacts in Puget Sound salmon fisheries is provided by the co-managers (PSIT and WDFW) and the NWIFC to assist in the NMFS and BIA consultation with the USFWS regarding the annual effects of these fisheries for the next twenty years. This assessment provides an estimate of the probability of gillnet interactions with no marbled murrelets, one, more than one, and more than two marbled murrelets for Treaty and non-Treaty fisheries in the action area.

6.1 Non-Treaty Commercial Salmon Fisheries

Non-Treaty commercial salmon fishers in Puget Sound use gillnets, purse seines, beach seines, and reef nets. A moratorium on issuance of new commercial salmon licenses was enacted by the Legislature in 1974, as reflected in RCW 77.70.090. Because the moratorium was enacted by the Legislature, it would take action by the Legislature to lift it. The number of non-Treaty Puget Sound commercial salmon licenses has declined significantly over the years, and due to the moratorium, will be held to the current 75 purse seine and 195 gillnet licenses. Descriptions of each gear type, of the fisheries in general, and conservation measures in place, are provided in sections 6.1.1 through 6.1.4.

6.1.1 Non-Treaty Commercial Gear Types

Specific regulations and requirements for non-Treaty commercial fishing gear are described in Puget Sound Commercial Salmon Regulations on the Washington Department of Fish and Wildlife website at: http://wdfw.wa.gov/fishing/commercial/salmon/.

6.1.1.1 Drift Gillnet

Gillnets are panels of monofilament or multi-strand nylon mesh designed to entangle fish. They are hung vertically in the water between a "cork-line" consisting of floating line and small buoys or corks distributed along the surface and a submerged weighted line (lead line) along the bottom of the net. Fish swim into the net and become entangled by passing part way through the net and are caught when netting slips behind the gill cover, preventing fish from backing out of the net. Non-Treaty, salmon-directed gillnet fisheries allow only drift and skiff gillnets which are not allowed to be anchored but drift with the current. It is the intention of the fisher to keep the net off the sea floor. Generally, gillnets are set perpendicular to the shoreline to entangle salmon as they swim with or against the currents. It is unlawful to set gillnets in a circle or to set them in other than a substantially straight line. Non-Treaty gillnet fishers may not leave deployed net(s) unattended at any time.

Commercial gillnet gear for non-Treaty fishers is defined in WAC 220-16-040 and WAC 220-16-046 and further restricted in Puget Sound salmon fisheries by WAC 220-47-302. A maximum net length of 1,800' (550 m) may be fished by non-Treaty gillnet vessels. Net mesh size ranges from 5" to 7" depending on the species targeted.

Minimum gillnet mesh sizes, which allow for the selective capture of certain species or age-classes of fish, are specified for non-Treaty fishers in WAC 220-47-411 (Table 3). Management periods are described in Appendix A. The depth of gillnets vary depending upon the fishery and the area fished. Normally they range from 180 to 220 meshes in depth, with shallower nets used in extreme terminal areas and to target certain species or stocks of salmon.

Table 3. Gillnet mesh size requirements for non-Treaty commercial fisheries (WAC 220-47-411).

Management Period	Minimum Mesh Size	Maximum Mesh Size	Maximum Depth
Chinook Season	7"	None	None
Coho Season	5"	None	60 meshes MCA 9A
Pink Season	5"	5.5"	60 meshes MCA 8
Chum Season	6.25"	None	None
Fraser Sockeye	5"	5.5"	None

6.1.1.2 Skiff Gillnet

Skiff gillnet fisheries occur only in MCA 6D, 9A, and occasionally in 12A, in accordance with the Summer Chum Salmon Conservation Initiative (SCSCI). These MCAs are open to skiff gillnets only; regulations prohibit use of drift gillnets in these areas. Skiff gillnets are a type of gillnet limited to a maximum of 600 feet in length and 90 meshes in depth, except in MCA 9A where nets are limited to 60 meshes in depth (Table 3). Skiff gillnets must be pulled by hand, without the use of hydraulics, and are generally fished in extreme terminal marine areas (e.g., estuaries) where larger gillnets cannot operate. Because these nets are actively tended, are very

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small (smaller than beach seines), and are fished by less than 15 license holders annually, encounters with marbled murrelets are extremely unlikely. No effects are anticipated to occur and further analysis of this gear is unnecessary for this assessment. This approach is consistent with the 2010 and 2015 biological assessments (NMFS and BIA 2010; 2015) and incorporated in the current biological opinion (USFWS 2001).

6.1.1.3 Purse Seine

Purse seines capture fish by encircling them, rather than entangling them as by gillnets. A purse seine is designed to act like a drawstring bag, encircling a school of fish and then "pursing" up the rings located at the bottom of the net to trap the fish inside. As with gillnets, the net is hung vertically in the water between a cork-line on top and a lead line at the bottom. The net is set from the purse seine vessel and tethered to a smaller skiff. As the net is set, the two vessels typically move parallel to each other gathering fish before coming together to loosen and purse the net. Purse seine gear for non-Treaty fishers is defined in WAC 220-16-075 and further restricted in Puget Sound salmon fisheries by WAC 220-47-301 and 220-47-319 to a length of no more than 1,800' along the cork-line. Mortality of marbled murrelets in purse seines is believed to be unlikely, based on observations from previous observer programs (Natural Resource Consultants 1994, 1995). Additional data were gathered by WDFW during purse seine monitoring from 1996-2000, and no marbled murrelets entanglements were recorded during the 504 sets observed in MCAs 7 and 7A and the 847 purse seine sets in terminal area chum fisheries (USFWS 2004). Based on the best available information, purse seines are exempted from consideration of risk to marbled murrelets by Puget Sound fisheries because no effects are anticipated. This is further discussed in Section 6.4, and incorporated in the current biological opinion (USFWS 2001) and the USFWS 2010 and 2015 time extensions (Berg 2010; Rickerson 2015).

6.1.1.4 Reef Net

A reef net is an open-bunt, square or rectangular section of netting suspended between two anchored boats in such a manner as to trap salmon. High stands (towers) mounted on barges anchored on either side of the net contain platforms where fishers spot fish entering the net. When fish are seen over the net, the open end of the net is raised, spilling the fish into the entrapment bag. Currently, there are 11 active reef net licenses, associated with specific sites in MCA 7 at Lummi Island, Lopez Island, and Stewart Island. Reef nets are fished only during daylight hours and are closely tended. The potential for murrelet entrapment in reef net fisheries is considered to be zero. Because no effects are anticipated, reef nets are not included in the current USFWS biological opinion (USFWS 2001) and the USFWS 2010 and 2015 time extensions (Berg 2010; Rickerson 2015) nor further discussed in this analysis.

6.1.1.5 Beach Seine

Similar to purse seines, beach seines capture fish by encircling them. One end of the net is secured to shore, and the other end is taken away from shore with a boat, then circled back to shore to trap fish between the net and the beach. Beach seine gear (also referred to as 'drag seine') is defined for non-Treaty fishers in state regulations (WAC 220-16-035) and further restricted in Puget Sound salmon fisheries by WAC 220-47-427, to a length of no more than 990' (302 m) and depth of no more than 200 meshes. For non-Treaty fishers, this gear is currently restricted to a six-week daytime coho fishery in Quilcene / Dabob Bay (MCA 12A) and occasional openings in lower Hood Canal for chum salmon. The number of beach seines is restricted with the WDFW issuing no more than four beach seine permits per year. Because the mesh size (3 to 4 inch/7.6 to 10.2 cm mesh size) and net are small (not to exceed 990 feet/302 m) in length and operators tend the net at all times, there is little to no potential for murrelet entanglement. Marbled murrelet interaction is anticipated to be zero. Because no effects are anticipated, beach seines are not included in the current USFWS biological opinion (USFWS 2001) and the USFWS 2010 and 2015 time extensions (Berg 2010; Rickerson 2015) nor further discussed in this analysis.

6.1.2 Non-Treaty Commercial Gillnet Fisheries

Anticipated fishing schedules for non-Treaty fishers are described in the Puget Sound Commercial Salmon Regulations (http://wdfw.wa.gov/fish/regs/commregs/salregs.htm) with the exception of MCAs 7 and 7A sockeye and pink salmon fisheries. The latter are managed by the Fraser River Panel of the Pacific Salmon Commission, with harvest limits based on abundance of these returning stocks. Openings are established and announced in-season by agreement between U.S. and Canadian Fraser River Panel members.

6.1.2.1 Pre-Terminal (mixed stock) Fisheries (MCAs 7/7A)

These fisheries are limited to Rosario Strait, San Juan Islands, and Strait of Georgia (MCAs 7 and 7A). They include both gillnet and purse seine fisheries, with limited reef net effort in MCA 7. From July to September these fisheries target Fraser River sockeye and in odd years Fraser and Puget Sound pink salmon. In October and November they target Canadian and US-origin chum salmon.

6.1.2.2 Terminal Area Fisheries

Terminal fisheries occur in marine waters where the salmon have substantially separated into their respective stocks prior to their entry into freshwater systems. These fisheries occur in MCAs 6D,7B, 7C, 8, 8A, 8D, 9A, 10, 11, 12, 12A, 12B, and 12C, from mid-July through November. They are managed by agreements made during the annual North of Falcon (NOF) and Pacific Fishery Management Council (PFMC) planning processes.

6.1.3 Overview of Non-Treaty Commercial Gillnet Fisheries

1996 to 2014 gillnet fishing efforts (defined as annual total landings) are summarized in Table 4. In 2007 and 2008, effort in pre-terminal MCA 7/7A was approximately 15% of the previous 11 year average (1996-2006) due to low numbers of harvestable Fraser River sockeye. Effort has since remained variable and depends on the size of Fraser River salmon stocks. In 2012 and 2013, effort was well below the 1996-2000 average of 894 landings, with 156 and 178 landings, respectively. Effort in terminal areas has also been variable over the past 18 years (1996-2013),

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with the minimum in 2002. Effort has generally trended upward since 2002 in all terminal areas other than MCAs 7B and 7C, which have remained stable. Areas in Hood Canal have seen the largest increases in effort with a low of 21 landings in 2002 and over 300 landings annually since 2007.

Table 4. Non-Treaty Puget Sound Commercial Gillnet Landings in 2001-2014 (WDFW 2015).

	Marine Catch Area				
Year	7/7A	7B/7C	8/8A/8D	10/11	12/12B/12C
1996	180	676	173	286	1,75
1997	2,305	828	666	92	1,72
1998	995	837	103	186	86
1999	0	970	80	113	83
2000	615	1,016	67	195	103
2001	129	897	66	132	57
2002	383	614	35	90	19
2003	367	565	22	188	64
2004	444	605	97	336	95
2005	230	472	43	409	249
2006	622	799	233	412	112
2007	80	545	391	346	402
2008	90	565	423	368	471
2009	68	373	43	271	338
2010	564	476	30	431	345
2011	334	795	27	483	369
2012	156	737	4	401	296
2013	178	917	44	171	340
2014	539	482	0	308	341

In 2014, WDFW renewed 195 Puget Sound gillnet licenses (including both drift and skiff gillnets), of which 150 reported successfully landing salmon. The same year WDFW renewed 75 purse seine licenses, of which 74 reported successfully landing salmon. Gillnet effort is broken out by month within each fishing area in Appendix B.

In analyzing fishing trends, WDFW projects annual commercial effort to be similar to the average of the last six years (2009 to 2014; K. Henry, WDFW, pers. comm., 2015). The fisheries targeting Fraser River stocks (MCAs 7/7A) have historically been variable and are difficult to project; however, the six year average was chosen as the best available annual estimation of effort as it includes three years of ‘non-pink’ return years (even-numbered years) and three years of ‘pink’ return years (odd-numbered years). Resulting interactions with marbled murrelet are presented in Section 6.6.

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6.1.4 Non-Treaty Conservation Measures

An evaluation of experimental strategies to reduce seabird bycatch in commercial gillnets was conducted by Melvin et al. (1997 and 1999). These studies recommended several strategies to reduce seabird entanglements while minimizing loss of fishing efficiency. Strategies included using a panel of highly visible net mesh beneath the gillnet cork-line, avoiding fishing during morning change of light, and fishing on high abundances of the target species to reduce effort. In response to these findings, WDFW incorporated these strategies into the non-Treaty commercial fishery regulations described in the WAC.

As noted in previous biological opinions, WDFW has closed fishing in several sub-areas that are known to have concentrations of marbled murrelets (USFWS 2001). Since marbled murrelets are opportunistic foragers, the marbled murrelet distributions from shore can vary on a daily and seasonal basis; however, by implementing closures in high-density marbled murrelet areas, the risk of interactions is expected to be less than that predicted by an estimate in the absence of these closures.

The combined effect of conservation measures (gear restrictions and area closures) is expected to reduce the potential for gillnet interactions with seabirds while not significantly affecting fishing opportunity. The actual benefits cannot be quantified with certainty, but may be significant (USFWS 1996, WDFW and NMFS 1996). WDFW estimates the benefits by making use of the gear studies, by estimating percentages of an area closed within an otherwise open marine catch area, and using long-standing trends in non-Treaty fishery effort locations.

6.1.4.1 San Juan Islands (MCAs 7 and 7A)

The 2010-2014 average for summer marbled murrelet density in MCA 7 (stratum 2[12]) is 1.29 birds/km^2 surveyed, and for MCA 7A (stratum 3) it is 0.55 birds/km^2 (Falxa and Raphael 2015). During sockeye and pink directed fisheries in these areas, regulations require gillnets to be constructed with the first 20 meshes below the cork-line composed of opaque white 5" mesh nylon twine. Gillnet fishing regulations do not allow fishing between the hours of midnight through 1.5 hours after sunrise. Melvin et al. (1997 and 1999) estimated the combined effect of this gear modification and dawn closure would reduce seabird entanglements by 28% from historic levels. Therefore, effort in MCA 7 fisheries is decreased by 28% when estimating murrelet interactions to account for these bycatch reduction measures.

In MCA 7, in addition to the aforementioned restrictions, there are also sub-area closures where concentrations of marbled murrelets have historically been observed. Closed areas are:

- **Orcas Island:** closure extends out 1,500' (457 m) from shore, from Deer Point on the southwestern portion of Orcas Island, north to Lawrence Point, thence following the

[12] Stratum referred to are those defined for the effectiveness monitoring program of the Northwest Forest Plan for Marbled Murrelet Conservation Zone 1.

north shore, extending west then southwest to a point intercepting a line drawn in a direction of 90° originating from the northernmost point of land on Jones Island.

- **San Juan Channel:** waters closed between two lines; the first extending from Limestone Point east to the northernmost point of land on Jones Island hence extending 90° to Orcas Island, the second extending from Reef Point on San Juan Island to the southernmost tip of land on Shaw Island. This area closure extended the boundaries of the existing San Juan Island Salmon Preserve.
- **Decatur Island:** waters closed within 1,500' (457 m) of the eastern shore of Decatur Island from the southernmost point of land on Decatur Island northerly to Fauntleroy Point.
- **Mackaye Harbor/Outer Bay:** waters closed east of a line drawn from Iceberg Point to Iceberg Island and then northwest to the southern tip of Charles Island.
- **Aleck Bay, Hughes Bay, McArdle Bay:** waters closed north of a line drawn from the southernmost prominence of Aleck Bay to the western prominence of Colville Island and thence to Point Colville.
- **Cypress Island:** waters closed within 1,500' (457 m) of shoreline from Cypress Head to Towhead Island.
- **Burrows Bay:** waters closed within 1,500' of the shore on Fidalgo Island from the Initiative 77 (I-77) marker northerly to Biz Point, and closed in those waters east of a line projected from Biz Point on Fidalgo Island to the Williamson Point light, thence to the Dennis Shoal light, thence to the light on the westernmost point of Burrows Island, and thence to south-westernmost point of land at Fidalgo Head. All waters within 1,500' of the western shore of Allan Island, all waters within 1,500' (457 m) of the western shore of Burrows Island, and all waters within 1,500' (457 m) of shore of Fidalgo Island from Fidalgo Head northerly to Shannon Point are closed. The closure of waters within 1,500' (457 m) of the shore of Fidalgo Island from the I-77 marker north to Biz Point was closed as a Chinook conservation measure, and is in effect during sockeye and pink salmon-directed fisheries only.

The benefit of area closures cannot be quantified with certainty, but are thought to be significant (USFWS 1996; WDFW and NMFS 1996) based on annual reporting of take and the authorization of two time extensions (Berg 2010; Rickerson 2015) on the current biological opinions (USFWS 2001 and 2004). This analysis takes a qualitative approach to support a reasonable estimate of the conservation benefits. To that end, current fishing trends were examined in relation to survey locations, primary sampling units (PSUs)[13], and closure areas. Three of the closures (Orcas Island 1,500' closure, the closure around Iceberg Pt and Pt Colville on Lopez Island, and the closure on the western side of Fidalgo Island) contain the primary sample units with the highest summer average densities of marbled murrelets within MCA 7

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[13] Primary sampling units (PSUs) are those defined for the effectiveness monitoring program of the Northwest Forest Plan for Marbled Murrelet Conservation Zone 1.

(refer to Figure 2 for PSUs, and Appendix E for all area closure maps). These PSUs, along with two PSUs in MCA 9, are the major contributors to the density estimate associated with stratum 2. Observed PSU average murrelet density estimates in the areas open to non-Treaty fishers in MCA 7 are estimated to be less than one bird per km^2 (Figure 2), which is comparable to the values found in stratum 3 (Falxa et al. 2015). Catch effort has shifted away from the portions of MCA 7 adjacent to the closed areas; approximately 80% of effort now occurs to the west of San Juan Island (K. Henry, WDFW, pers. comm., 2015), and is assigned stratum 3's murrelet density value (0.546 birds/km^2). Due to the proximity of the remaining 20% effort to the closures, this percentage of effort is not assigned a conservation savings for the sub-area closures (retain full stratum 2 value of 1.293 birds/km^2). As landings (catch) are not assigned to sub-areas, a corresponding combined savings factor for MCA 7 is applied to the projected interaction rate, using stratum 2 density: [(0.8*0.546)+(0.2*1.293)=0.6952; 0.6952/1.293=0.5377, or 54%]. This is a 46% savings[14]. With the 28% reduction for gear restrictions (cited above) used throughout MCA 7, the interaction rate estimate is reduced further, giving approximately a 74% reduction in risk relative to the risk of the interaction in the absence of these measures. Due to uncertainties inherent in qualitative analysis, this reduction is cushioned and a savings of 50% is applied to MCA 7. The 50% savings assignment is consistent with the findings of the previous biological opinions.

6.1.4.2 Skagit Bay, Possession Sound, and Tulalip Bay (MCAs 8, 8A, and 8D)

The following sub-areas are closed where small concentrations of marbled murrelet have been identified:

- **Saratoga Passage, western shoreline of Camano Island in MCA 8:** closed in those waters within 1,500 ft. of the western shore of Camano Island south of a line projected due west from Rocky Point.
- **Port Susan in MCA 8A:** closed in those waters north of a line projected from Camano Head to the fishing boundary marker on the shore at the north side of Tulalip Bay.

For estimating conservation benefits in these marine areas, a different approach was taken than with MCA 7 and 7A, as the closures do not directly overlap with Falxa et al. (2014) surveyed PSUs for qualitative support. Instead fishing effort trends were examined. Approximately 80% of the effort is in MCA 8A (stratum 3) within waters south of a line projected from the Clinton ferry dock to the Mukilteo ferry dock, with the remaining 20% of effort in MCA 8 mainly within Saratoga Passage (K. Henry, WDFW, pers. comm., 2015). The stratum 3 interaction rate was applied to the MCA 8A landings with no conservation savings. There are two closures for non-Treaty fishers in MCA 8: a 1,500' shoreline closure on the west side of Saratoga Passage, and Skagit Bay. It is reasonable to assume that there is a conservation benefit to the marbled murrelets in closing Skagit Bay, given the high degree of protected wilderness areas within the Skagit Basin; however, because there are no marine survey data to reference there are no savings

[14] There are additional closures within MCA 7 that are within lower average density areas or within areas not currently surveyed; these are not included in the savings estimate of 46% but presumably provide an additional conservation benefit.

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assigned. However, Saratoga Passage is known to be used by marbled murrelets (Falxa et al. 2014). The average width of Saratoga Passage is about 13,000', and the closure extends 1,500' from the shoreline on the eastern side of the passage. This closes approximately 11% of the water on average in this section of MCA 8 (where the effort is basically contained), and provides a conservative estimate of the closure's benefit for fishing effort in MCA 8.

6.1.4.3 Central Puget Sound (MCAs 10 and 11)

The following sub-area closure was instituted in 2007 due to the identification of small concentrations of seabirds.

- **Port Madison:** closed in those waters west of a line projected from Point Jefferson to the northernmost portion of Point Monroe.

Previous biological assessments (NMFS and BIA 2010 and 2015) assessed the savings afforded by this closure as 10%, presumably based on the approximate area of the closure compared to the overall size of MCA 10 and 11. Savings applied here are based on the previous co-manager biological assessments.

6.1.4.4 Hood Canal (MCAs 12, 12B, and 12C)

The following sub-areas are closed because small concentrations of marbled murrelets have previously been identified to occur there:

- **Hood Canal, 1,000' eastern shoreline (MCAs 12/12B/12C):** closed in those waters within 1,000' (305 m) of the entire eastern shore. This closure had been in effect through the early 1990s primarily for the protection of Hood Canal coho. This closure has remained in effect as a permanent rule.

A significant proportion of seabirds forage along the eastern shore of Hood Canal, as has been observed during surveys referenced earlier and in previous biological opinions. Therefore, a closure was assumed to provide a benefit in the form of reduced murrelet-gear interaction risk. The average width of Hood Canal is 7,874 feet (2,400 m), and the closure width is 1,000 feet (305 m). Therefore, about 13% of the area is closed, which provides a conservative estimate of the conservation benefit. The dawn closure regulation provides an additional savings, and brings the conservative estimate of benefit to 25%. This estimate is consistent with the current biological opinion (USFWS 2001).

6.2 Treaty Commercial Salmon Fisheries

The Puget Sound Treaty Tribes conduct commercial and ceremonial-and-subsistence (C&S) fisheries for salmon and steelhead throughout the marine waters of the Strait of Juan de Fuca, Rosario Strait and Georgia Strait, Puget Sound proper, and Hood Canal. Each Tribe promulgates and enforces species specific fishing regulations that define schedules, areas, gear requirements, and other measures under which their fisheries must operate. The Tribes develop and implement salmon fishery management regimes in collaboration with WDFW, pursuant to the legal mandates of *U.S. v. Washington*, and the guidelines in the Puget Sound Salmon Management Plan.

6.2.1 Treaty Commercial Gear Types

The Treaty salmon fisheries in marine waters use drift gillnet, set gillnet, purse seine, round-haul seine, beach seine, troll, and hook and line gear.

6.2.1.1 Drift Gillnet

Drift gillnets (driftnets) range from 600' to 1,800' in length and up to 75' deep depending on respective Treaty fishing regulations. Gillnets are constructed of transparent nylon mesh hung from a cork-line and suspended at the bottom by a lead line. The mesh size of gillnets varies with the target salmon species and area fished. Sockeye, pink, and coho fisheries commonly use a mesh size ranging from 5" to 6". Chinook and chum fisheries use 6" to 7" mesh. Drift gillnets are attended continuously when deployed. Treaty use of drift gillnet gear is widely distributed throughout the pre-terminal and terminal marine areas, as described in detail below.

Treaty fishers also utilize small vessels (skiffs) and deploy smaller nets, generally 900' long or less by hand (without the aid of hydraulics) and are also continuously attended to. Even though skiff gillnet fisheries are not anticipated to pose any measurable risk to marbled murrelets, the Tribal Online Catch Accounting System (TOCAS) database does not differentiate between drift and skiff gillnet gear types so Treaty skiff gillnet fisheries are included in the overall Treaty drift gillnet estimates.

6.2.1.2 Set Gillnet

Set gillnets (set nets) are anchored on shore or near shore in shallow water. Design and construction is similar to drift gillnets. The nets are usually 300' to 900' in length, approximately half the size of drift gillnets, in most circumstances. However, in some areas nets may exceed 2,000'. Many regulations limit fishing to defined hours in a day, although some areas do allow fishing 24 hours a day. Regulations generally require that set nets are checked at least once every 24 hours, but the gear is continuously monitored in some fisheries, either voluntarily or through regulations, particularly where marine mammal depredation occurs. Fishing practices and gear requirements differ substantially among fisheries by respective tribe, salmon species, and catch area. Treaty use of set net gear is widely distributed, but is used primarily in terminal areas.[15] Staked gillnets, fished primarily in MCA 7B, because of their similar design and static fishing action are included in this category.

6.2.1.3 Purse Seine

Purse seines are 1,600' to 2,000' in length and constructed of 4" to 5" heavy twine mesh. They are deployed from a relatively large vessel, typically exceeding 50', using a power skiff to aid in maintaining the position of the seine while fishing and assist in the closing of the net. The seine

[15] Fishing areas near freshwater, usually the mouth of rivers or bays or near a hatchery release site, where the targeted fish species is returning to spawn.

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may be deployed for various durations (generally around 30 minutes per set) depending on obstructions in the water, abundance of target species, and other fishing vessels waiting or actively fishing in the same location. Treaty purse seines operate during Fraser sockeye and pink fisheries in MCAs 7 and 7A, Chinook and chum fisheries in MCAs 7B and 7C, and chum fisheries in MCA 10.

6.2.1.4 Roundhaul Seine

Tulalip Treaty members operate roundhaul seines in fisheries targeting pink, coho, and chum salmon in MCA 8A. The net is of similar construction but smaller (maximum 900') than a standard purse seine but with a larger bunt, has no purse rings, and is deployed by a smaller vessel sometimes with the aid of a skiff to maintain net position and assist closing of the net.

6.2.1.5 Beach Seine

Beach seines are constructed of woven webbing hung between a cork line and lead line. The net is deployed by boat in an arc from the shoreline and then closed by hand. Treaty use of beach seine gear is less widely distributed than gillnet gear, and is used for pink, coho, and chum fisheries in some terminal areas.

6.2.1.6 Troll

Troll gear involves multiple lines of baited hooks or lures (up to six per side) attached to a weighted downrigger. The gear is typically fished down to 18 m for coho and down to 45 m for Chinook. There are Treaty troll fisheries in the Strait of Juan de Fuca (MCAs 4B, 5, and 6C) targeting Chinook in the winter (October through March), and Chinook and coho in the summer (June – September). Participation in the Strait of Juan de Fuca troll fishery during the summer is dependent on Ocean Troll opportunity; fishers will focus effort on salmon runs to capitalize on higher priced ocean caught salmon. As such, participation in the summer troll fishery in the Straits is influenced by available troll fishery opportunities in the ocean. During the winter troll fishery, participation is often minimal (2-3 boats per day) due to poor weather and low catch rates. If catch rates increase, participation may increase to about 10 vessels. There have been no reports of marbled murrelet interactions with troll gear.

6.2.1.7 Hook and Line

Treaty fisheries use hook and line gear (i.e., rod and reel) in a few MCAs that primarily target Chinook and coho salmon. Effort in Treaty marine hook and line fishing is extremely minimal and accounts for an average of 15 successful marine angler trips per year (James 2015). Because of this substantially small effort, no marbled murrelet impacts are anticipated in Treaty marine hook and line fisheries.

The USFWS (2004) concluded that purse seine, roundhaul seine, beach seine, troll, and Treaty hook and line gear do not pose measureable risks to marbled murrelets and these gear types are not considered further in this biological assessment.

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6.2.2 Treaty Commercial Gillnet Fisheries

The following Treaty salmon gillnet fisheries are described by marine catch area.

6.2.2.1 Strait of Juan de Fuca (MCAs 4, 4B, 5, 6C, and 6D)

All species of salmon are fished for in these catch areas. Marine set net fishing for Chinook is open in MCAs 4, 4B, 5, and 6C from mid-June through August though effort occurs primarily in MCAs 4B and 5. A marine set net fishery for steelhead occurs primarily in MCA 4B in December through March, but has had very low effort recently (~5 landings a year). Set net fisheries are excluded within a 1,000' radius of stream and river mouths to protect local salmon stocks. Drift gillnet fisheries targeting sockeye are managed by the Fraser River Panel under the Annex IV to the Pacific Salmon Treaty. Sockeye fisheries may be opened in early July if there is harvestable abundance of early-timed stocks. This has not occurred in recent years. Fisheries targeting early summer, summer, and late-timed stocks of Fraser sockeye occur from mid-July through August. In odd-numbered years, the Strait fisheries may be extended into September to target Fraser pink salmon. Coho directed gillnet fisheries operate in the Strait from mid-September through mid-October. The chum salmon fishery occurs from mid-October to early-November, although effort after October is minimal and mostly occurs in MCA 5. Set net fisheries in MCA 6D target coho salmon and steelhead.

6.2.2.2 San Juan Islands and Point Roberts (MCAs 6, 7, and 7A)

MCA 6 is located in eastern Strait of Juan de Fuca but the Treaty net fishery there is managed in concert with MCAs 7 and 7A under Fraser Panel fisheries. Treaty gillnet fisheries are directed at Fraser River sockeye, pink, and chum salmon stocks originating in southern British Columbia. Fisheries for sockeye are managed by the Fraser River Panel, under the Annex IV of the Pacific Salmon Treaty. Sockeye fisheries may be opened in early July if early-stock abundance is sufficient, but in recent years have not opened until August. In odd-numbered years, pink salmon fisheries may occur from late August through mid-September. Chum fisheries operate from early October through mid-November. Fisheries in MCAs 7 and 7A involve primarily drift gillnet and purse seine gear, while in MCA 6 set net gear is more commonly used. Pink salmon harvest is primarily by purse seines.

6.2.2.3 Bellingham and Lummi Bay (MCAs 7B, 7C, and 7D)

Treaty fisheries directed at fall Chinook, coho, and chum salmon involve drift, set, and staked gillnet gear in these terminal areas. A majority (~90%) of the fishing effort occurs in MCA 7B. Staked gillnets are fished along Lummi Shore Road in Bellingham Bay in MCA 7B within waters less than 4.5 m deep in an area approximately 5-10 km^2 in size. Fishing effort is similar during Chinook and coho fisheries, and lower during the chum fishery.

6.2.2.4 Skagit Bay and Saratoga Passage (MCA 8)

Treaty fisheries target spring chinook, sockeye, pink, coho, and chum salmon. Chum fishing effort has been extremely limited over the past decade due to low abundance; a directed chum fishery has not taken place since 2008. Pink fisheries occur in odd-numbered years from late

August to early September, and include beach seining effort in northern Skagit Bay. Nearly all of the gillnet effort involves drift gillnet gear. Treaty purse seiners are not allowed in MA 8. A small scale steelhead fishery has occurred in MA 8 from the end of November through mid-February targeting hatchery steelhead, but effort has been minimal (0-3 landings per year). With the termination of the Skagit hatchery steelhead program in 2013, future steelhead fisheries will continue to be limited pending development of an independent Fisheries Management and Evaluation Plan for Skagit steelhead (in progress) separate from the Comprehensive Chinook Harvest Management Plan.

6.2.2.5 Possession Sound and Tulalip Bay (MCAs 8A and 8D)

The Tulalip Tribes open a summer Chinook C&S fishery in Tulalip Bay (MCA 8D) in May. The Chinook commercial fishery follows in June, July, and August. In odd-numbered years, a pink salmon fishery is usually open in MCA 8A. The coho season extends from early September through the third week of October in MCA 8A, and late September through the first week of November in MCA 8D. The chum fishery occurs from mid-October through the end of November. A small-scale steelhead fishery has occasionally occurred in MCA 8A and 8D, between December 1 and March 30. Treaty fisheries in MCAs 8A and 8D involve drift gillnet and set net gear. There is substantial drift gillnet effort in both areas, but fishers in MCA 8D primarily use set nets. Within Tulalip Bay, a shallow (<1 m deep) 1.5 km^2 harbor, fisheries exclusively use set net gear. Regulations for MCA 8D limit fisheries to specific time periods which are almost entirely daylight hours and require net attendance at all times.

6.2.2.6 Hood Canal (MCAs 9A, 12, 12A, 12B, 12C, and 12D)

Treaty fisheries in northern Hood Canal (MCAs 12 and 12B) target coho and chum salmon from late September through November. There is a 1,000' closure to net fishing around stream mouths in the Hood Canal catch areas. Approximately 75% of the gillnet effort in these areas involves set net gear. Fisheries in Port Gamble (MCA 9A) target coho and chum salmon from mid-August through November. Gillnet fishers in MCA 9A use set net gear almost exclusively. Seventy-five percent of set net effort in MCA 9A is located on the eastern shore of Port Gamble within the boundary of the Port Gamble S'Klallam Reservation, is in waters less than 10' deep and an area less than 0.5 km^2 in size, and occurs primarily during the coho fishery. A coho fishery occurs in MCA 12A (Quilcene Bay and Dabob Bay) from late August through mid-October, but has been limited in recent years due to protection concerns for listed Hood Canal summer chum. Fisheries in southern Hood Canal (MCA 12C) target Chinook, coho, and chum salmon. There are set net sites in Quilcene Bay and Dabob Bay, but fishing is prohibited near stream mouths. Approximately 85% of the gillnet effort in MCA 12 involves set net gear, however, total effort is less than 50 landings a year, on average. Fishermen attend drift and set gillnet gear constantly in these areas because of intensive marine mammal predation.

6.2.2.7 Central Puget Sound (MCAs 10, 10A, 10E, 11, 11A)

Treaty fisheries target sockeye, Chinook, coho, and chum salmon in central Puget Sound. C&S fisheries targeting Lake Washington sockeye may occur in MCA 10F but are of short duration

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and involve limited effort. Larger scale commercial sockeye fisheries have occurred infrequently in recent years because the Lake Washington stock has not achieved harvestable abundance. Most of the C&S fishing for sockeye occurs inside the entrance to the Ship Canal. Chinook directed fisheries in MCA 10A (Elliot Bay) have been closed in recent years due to low abundance. Set net fishing for coho and chum occurs in the mouth of the east and west Duwamish waterways; a heavily industrialized and channelized area of Seattle.

There are Chinook, coho, and chum fisheries in Sinclair Inlet (MCA 10E) targeting local hatchery production. The set net effort during the Chinook and coho fisheries occurs from mid-August through October. There is little if any set net effort during the chum season in November, except in Chico Bay in Dyes Inlet. Most fishing is concentrated toward the back end of Sinclair Inlet during Chinook fisheries (Ross Point westward) and in and around the reservation boundary during coho fisheries (Pt Bolin through Agate Pass to the mouth of Miller Bay mostly on the northern shoreline). Fishing is concentrated in Chico Bay during chum season, with a few nets possible off of the mouth of Blackjack Creek near Port Orchard.

MCA 11 is generally opened for Treaty fishing simultaneously with MCA 10. When they occur, coho fisheries are short in duration dependent on the in-season update of run-size abundance; most of the gillnet fishing (97%) in these areas occurs during the chum fishery in October through mid-November. Approximately 90% of the driftnet effort occurs in MCA 10. Set net effort has been minimal in recent years averaging 11 landings per year.

6.2.2.8 South Puget Sound (MCAs 13 and 13A-K)

Fisheries targeting hatchery Chinook occur south of the Tacoma Narrows Bridge in MCA 13, Chambers Bay (MCA 13B), Carr Inlet (13C), and Budd Inlet (13F). Fisheries targeting coho and chum also occur in these areas, and in Case Inlet and Pickering Passage (MCA 13D and K, respectively), and other sub-areas. Gillnet effort in MCA 13 has been minimal in recent years (averaging less than 2 landings per year). In Carr Inlet (MCA 13A) fisheries occur north of Penrose Point. Set net fishing comprises about 65% of total gillnet effort. The fishery at Chambers Bay (MCA 13C) targets local Chinook hatchery production in August, and Treaty fishers use set net gear almost exclusively. The fishing sites are located inside the lagoon at the mouth of Chambers Creek. Fisheries in Case Inlet and Pickering Passage (MCA 13D) primarily target coho and chum salmon. Approximately 70% of the gillnet effort uses set net gear. Set net sites are widely distributed in these inlets. Most of the fishing effort in Budd Inlet (MCA 13F) targets local Chinook hatchery production in August. Treaty fishers primarily use driftnet gear (65%), and much of the fishing occurs in the southern end of the inlet in West Bay. Fisheries in Eld Inlet (MCA 13G) and Totten Inlet (MCA 13H) target coho and chum salmon. About 70% of the gillnet effort in Eld Inlet is from set net gear, but the majority of effort in Totten Inlet is by driftnet gear. Set net sites in these areas are widely distributed.

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6.2.3 Overview of Treaty Commercial Gillnet Fisheries

The following section provides an overview of Treaty salmon gillnet effort for all MCAs from 2004 through 2014 (Table 5, Table 6).

Drift gillnet effort in the Strait of Juan de Fuca has been variable since 2004, with average annual effort of 31 landings from MCA 4B and 122 landings from MCA 5. Set net effort in these areas is lower, averaging 14 and 22 annual landings, respectively. Fishing effort in the San Juan Islands (MCA 6, 7, and 7A), has been variable and was lower in most recent years due to a low harvestable surplus of Fraser River sockeye. Annual drift gillnet effort averaged 117 landings in MCA 7 and 347 landings in MCA 7A. There was no set net effort in MCA 7 and minimal effort in MCA 7A.

The majority of drift and set gillnet effort in the MCA 7B (Bellingham Bay), MCA 7C (Samish Bay), and MCA 7D (Lummi Bay) region occurs in MCA 7B and 7C. Driftnet effort has increased in recent years, while set net effort has been stable. Drift gillnets are the predominant gear type in these areas. Aggregate, average annual driftnet effort for this region was 1,736 landings and set net effort was 342 landings. Set net effort primarily occurs in MCA 7B. This effort is technically a staked net fishery, occurring in a small area (~5-10 km^2) along the western side of Bellingham Bay in waters less than 4.5 m deep.

Fisheries in Skagit Bay primarily involve driftnet gear with 66 average landings per year. There was no set net effort in MCA 8 in some years and set net effort averaged only 5 landings annually. Fisheries in MCA 8A involve driftnet gear exclusively and average annual effort was 390 landings per year. Gillnet fishing in MCA 8D primarily uses set net gear. The average annual set net effort was 583 landings and average annual driftnet effort was 166 landings. The boundary of MCA 8D includes Tulalip Harbor, but extends north and south approximately 2.5 km each direction in a narrow zone (~500 m from shore) outside of the harbor. Set net fishing effort occurs exclusively inside the harbor in waters <1m deep. The distribution of Treaty fishing effort in MCA 8A and 8D depends on the target species and the abundance of hatchery and wild stocks, (e.g., effort will be relatively higher in MCA 8D which targets local hatchery production when wild stock abundance constrains fisheries in MCA 8A).

Treaty drift gillnet fishing occurs regularly in MCA 10 (central Puget Sound), 10A (Elliott Bay), 10E (Sinclair Inlet), and 11 (south-central Puget Sound). Aggregate average annual effort in MCA 10 and 11 was 126 landings and occurs primarily during the chum season in October and early November. There is minimal set net effort in MCA 10 and 11. In Elliott Bay (MCA 10A), which is an urban and heavily industrialized area at the mouth of the Green River, average annual set net effort was 85 landings, whereas driftnet effort averaged 45 landings. In Sinclair Inlet drift and set gillnet effort was, on average, equal with about 65 landings per year.

In marine areas south of the Tacoma Narrows, gillnet fisheries occur in Carr Inlet (MCA 13A), Chambers Bay (MCA 13C), Case Inlet and Pickering Passage (MCA 13D), Budd Inlet (MCA

13F), Eld Inlet (MCA 13G), and Totten Inlet (MCA 13H). Gillnet effort is minimal in the Nisqually Reach (MCA 13), Skookum Inlet (MCA 13I), Oakland Bay (MCA 13J), and northern Case Inlet (MCA 13K). In Carr Inlet average annual set net effort (48 landings) exceeds driftnet effort (27 landings). The same is true of MCA 13D where average annual set net and driftnet landings were 92 and 36, respectively. In Budd Inlet, average annual driftnet effort (83 landings) exceeded set net effort (43 landings). In Eld Inlet, average annual set net effort (34 landings) was higher than driftnet effort (15 landings). In Totten Inlet, average annual driftnet effort (41 landings) exceeded set net effort (14 landings). In all these deep South Sound areas, set net sites are in relatively shallow water. In Chambers Bay, fishing effort occurs exclusively inside the lagoon.

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Table 5. Annual Treaty commercial gillnet effort (landings) in marine waters in greater Puget Sound by MCA, 2004-2014 (GN = gillnet).

MCAs	4B, 5, 6C, 6D Strait of Juan de Fuca		6, 7, 7A San Juan Island		7B, C, D Bellingham Bay		8, 8A, 8D Saratoga - Possession		10, 10A, 10E, 11, 11A Central Puget Sound		13, 13A-I South Puget Sound		9, 9A, 12A-D, Hood Canal	
Year/Gear	Drift	Set	Drift	Set	Drift	Set	Drift	Set	Drift	Set GN	Drift	Set	Drift	Set
2004	216	106	628	8	1,699	133	513	967	272	46	73	45	121	1,066
2005	93	122	416	5	1,165	210	514	813	210	68	92	76	9	708
2006	196	67	1,168	4	1,411	218	254	90	162	189	56	132	76	1,055
2007	120	115	67	0	1,482	439	115	227	175	120	40	190	129	918
2008	256	111	133	2	2,088	428	407	368	205	179	343	657	186	1,199
2009	33	160	43	13	1,678	531	733	652	266	108	285	457	235	937
2010	297	167	1,600	1	1,703	478	512	1,002	420	214	319	236	266	1,326
2011	144	189	345	10	2,167	366	911	1,001	294	235	359	309	318	1,837
2012	78	151	244	8	2,129	249	606	843	184	200	273	258	387	1,652
2013	59	110	63	0	1,864	371	844	819	260	316	303	219	241	1,749
2014	66	123	1,410	16	1,048	195	392	828	155	285	216	230	384	1,384

Table 6. Total Treaty commercial drift and set gillnet effort (landings) in marine waters in greater Puget Sound from 2004- 2014.

	Total Puget Sound	
Year	**Drift Gillnet**	**Set Gillnet**
2004	3,522	2,371
2005	2,499	2,002
2006	3,323	1,755
2007	2,128	2,009
2008	3,618	2,944
2009	3,273	2,858
2010	5,117	3,424
2011	4,538	3,947
2012	3,901	3,361
2013	3,634	3,584
2014	3,671	3,061

In Hood Canal, gillnet fishing is concentrated (~61%) in MCA 12C (southern Hood Canal). Average annual set net effort (786 landings) far exceeds driftnet effort (120 landings). Fisheries in MCA 12C target Chinook, coho, and chum salmon, with chum fishing in October and early November having the greatest effort. Driftnet and set net effort have increased since 2004. There are also substantial set net fisheries in Port Gamble (MCA 9A) and Quilcene/Dabob Bays (MCA 12A) targeting coho in September.

6.3 Methods for Estimating Gillnet Interaction Risk

Neither interaction, nor mortality, of marbled murrelets has been documented in Treaty or non-Treaty gillnet commercial fisheries within the action area. However, since there is limited seabird observer coverage in these fisheries, it cannot be assumed that there are no murrelet interactions (USFWS 2009). In response, we used a fundamentally similar approach to that in previous biological opinions to estimate potential murrelet interaction, by scaling an interaction risk according to recent murrelet density, and applying average gillnet fishing effort (expressed as number of landings) in the various fishing areas. This current analysis differs from previous analysis in that (1) it corrects the base interaction rate (BIR) from a previous analysis to a value of 0.0021 (vs 0.00763), per the 2001 biological opinion (USFWS 2001), (2) it scales the BIR from the 1994 study to projected 1994 murrelet density, (3) summer verses winter bird density estimates are considered, (4) recent five year average (2010-2014) of estimated murrelet density are used, (5) a more detailed description of Treaty set net fisheries is provided, (6) we use stratum level bird population trend values, instead of Primary Sampling Unit (PSU) values based on the USFWS recommendations, and (7) the interaction risk is presented in this analysis as a probability risk, rather than a point value, to represent the potential effect of the fisheries with a more appropriate and accurate statistical approach in consideration of the constraints of the available data. These changes to the approach must be considered when comparing projected interactions to those of previous assessments. This assessment discusses each of these factors within Section 6.3, with the exception of the use of stratum level density estimates instead of PSU values, which is discussed in Section 6.6.

The Pierce et al. (1996) estimate of a BIR for gillnet fisheries during the 1994 sockeye fisheries in MCA 7 (within stratum 2) and 7A (within stratum 3) was based on a single observation of a marbled murrelet interaction with a gillnet in MCA 7. The 2001 Puget Sound Area Recreational and All-Citizen Commercial Salmon Net Fishery Biological Opinion (Opinion) referenced this study: "For MCA 7, the rate was 0.00158 birds/set (90 percent CI: 0.00017- 0.00615), and for MCA 7A, the rate was 0 marbled murrelets/set (90 percent CI: 0-0.00265)." These values were combined and converted to a "per landing" unit (as opposed to per set), and a BIR of 0.0021 per landing was applied to the action area (Table 7), per the 2001 Opinion. A subsequent Opinion (2004 Treaty commercial fisheries) also referred to this study, but based the BIR solely on observed fishing effort in MCA 7, thus disregarding up to 70% of the sampling effort in MCA 7A. The consequent value of 0.00763 birds/landing was maintained in time allowance extensions for 2010 and 2014 for Treaty and non-Treaty fisheries. In the current analysis, the BIR is corrected to the appropriate 0.0021 birds/landing value and applied to strata 2 and 3. However, a BIR of 0.00763 birds/landing (the value when considering stratum 2 alone) is applied as a surrogate value for stratum 1. Use of this surrogate value is supported by the fact that most of the Pierce et al. study observations in MCA 7 were in close proximity to the boundary of strata 1 and 2 (southern portions of management units near Salmon Bank, Hein Bank, and Iceberg Point), and because PSU densities in stratum 1 are consistent with PSU densities (Falxa et al. 2013) in the vicinity of Salmon Bank, Hein Bank, and Iceberg Point (Figure 4).

Table 7. Reprint of Tables 5 and 8 from Pierce et al. (1996).

Parameter	MCA 7 (Stratum 2)	MCA 7A (Stratum 3)	MCAs Combined
mamu-gn interactions observed	1	0	1
Gillnet (GN) sets observed	631	1,574	2,205
Total estimated GN sets in fishery	9,345	23,741	33,086
Estimated mamu-gn interactions	15	0	15
Total Estimated GN Landings[a]	1,964	5,184	7,148
Estimated mamu-gn interactions per landing	0.00763	0.00000	0.00210

[a] In Pierce et al. (1996) boat-trips are reported, which are equivalent to landings.

6.3.1 1994 Marbled Murrelet Density Scalar

The marbled murrelet population has declined 5.4% per year since 2001 (Falxa et al. 2015). As murrelet-gear interactions are assumed to be a function of density, a decline in population will affect the interaction rate. In response, a scalar is applied to the 1994 BIR to estimate the appropriate BIR for a lower population density. Efforts to monitor murrelet densities in Conservation Zone 1 were initiated in 2000 and do not include the period of the 1994 observer study. Although it is uncertain that the current observed 2001-2014 declining trend for Zone 1 was apparent during the years after the 1994 study, regional data from Canada supports that this decline was likely occurring. Burger et al. (2002 in Piatt et al. 2007) noted a negative trend in at-sea marbled murrelet densities around Vancouver Island in a number of data sets collected during the mid- 1990s to early 2000s. Of the eight datasets analyzed, five had significant annual declines from (-5.8% to -21.3%). The remaining three datasets also had declining rates but were not statistically significant, likely due to small sample sizes. Additionally, Bertram et al. (2015) noted declining trends of radar detected marbled murrelets from 1996-2013 along the British Columbia Coast, particularly East Vancouver Island and the South Mainland Coast (declines of -8.6% and -3.1% per year, respectively). These data suggest consistent declines over a longer period and at rates consist with that reported by Falxa et al. (2015).

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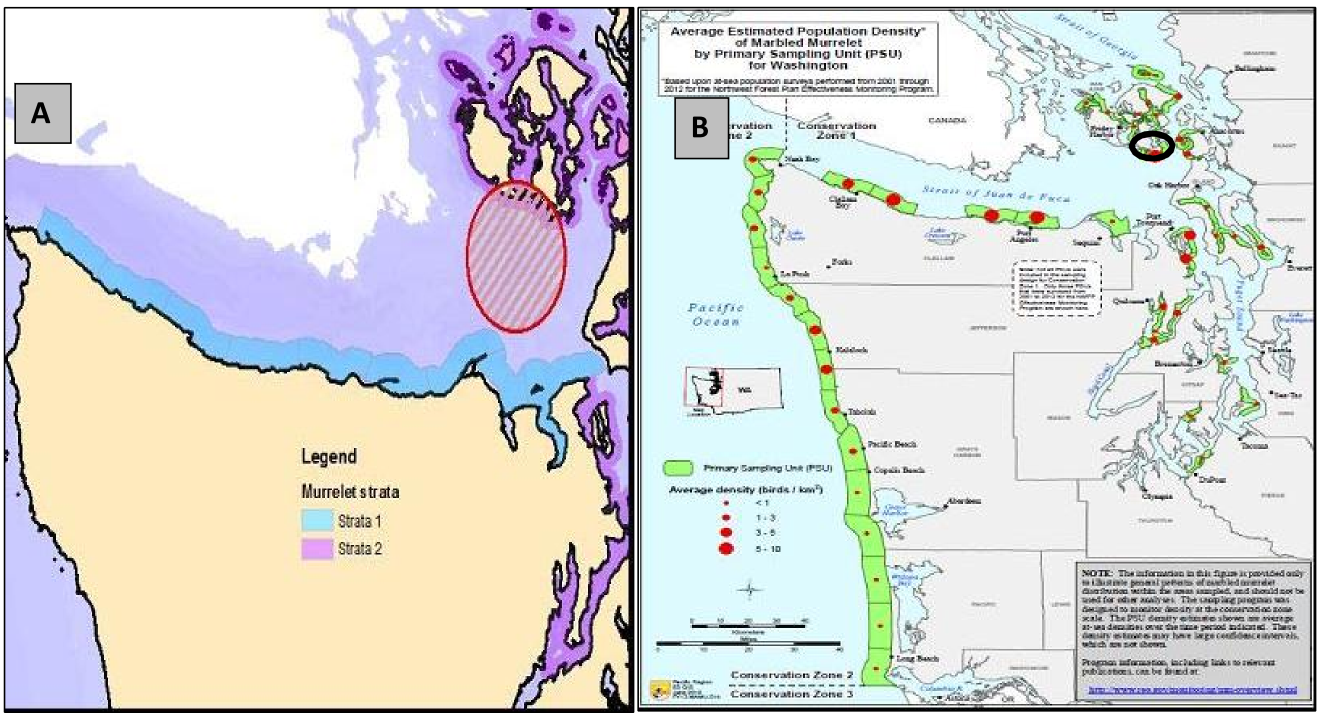

Figure 4. (A) General vicinity of Salmon Banks, Hein Banks, and Iceberg Point (red hatched circle) in relation to marbled murrelet strata 1 and 2 in Puget Sound and (B) reprint of Appendix A map (Falxa et al. 2013) of 2001-2012 average density for Primary Sampling Units (PSU) with PSU 1-2-06 noted by black oval.

Three methods were explored to estimate marbled murrelet density in 1994:

1. a stratum level regression, applying a simple linear regression to each stratum, using the Falxa et al. (2015) 2001-2014 density data to extrapolate a 1994 value,
2. zone level regression, using the aforementioned -5.4% annual decline extended back to 1994 and then parsed out for each stratum, and
3. 2001-2005 (or nearest available five years of data) density average.

Based on assessments of the statistical model fits and the overall objective of the analysis, the zone level regression method was concluded to provide the best estimates of marbled murrelet density in 1994. The zone level regression model was highly significant ($P = 0.009$) compared to the strata level regression models which had P values > 0.05. After applying average relative deviations of each stratum from the Zone 1 annual estimate to estimated 1994 density estimates, the estimated stratum estimates were comparable in scale to the estimated strata maximums from the 2001-2014 data sets (Table 8). The additional uncertainty in generating estimates outside of the observed data from a regression model is acknowledged. While the 2001-2005 average relies on observed data, the approach is inappropriate as it provides an average annual density estimate for those years but does not account for the decline in density that is assumed to have occurred between 1994 and that period. The adopted zone regression approach is described below, and a description of the other methods considered is provided in Appendix H.

Falxa et al. (2015) estimated a statistically significant declining trend of -5.4% annually for Zone 1 marbled murrelet densities (P value= 0.009) from 2001 to 2014. Based on this trend, a hindcasted density for Zone 1 in 1994 was estimated as 3.450 birds/km^2. Recognizing that the NWFMP stratified Zone 1 to account for spatial differences in density, stratum level densities in 1994 were estimated by calculating the mean relative deviation of each annual stratum density estimate from the annual Zone 1 total density estimate for each year from 2001 to 2014 (Table 8). The relative deviations (R) were calculated as:

$$R_{i,y} = (S_{i,y} - Z_y)/Z_y$$

where S is density for stratum i in year y, and Z_y is the Zone 1 density in year y.

For each stratum, the 1994 stratum level densities ($S_{i,94}$; stratum 1=7.334 birds/km^2, stratum 2=2.738 birds/km^2, stratum 3=1.745 birds/km^2) were estimated with the following equation:

$$S_{i,94} = (1 + \bar{R}_i) * 3.450$$

where $S_{i,94}$ is the estimated 1994 density for stratum i and $\bar{R}_i$ is the average of the relative deviations for stratum i.

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Table 8. Estimated Zone 1 and stratum densities (marbled murrelets/km^2) from 2001 to 2014 (Falxa et al. 2015) and the calculated annual relative deviations for each stratum from the Zone 1 density estimate.

Year	Zone 1 Density	Stratum 1 Density	Relative Deviation	Stratum 2 Density	Relative Deviation	Stratum 3 Density	Relative Deviation
2001	2.553	4.506	0.765	1.764	-0.309	2.067	-0.190
2002	2.788	7.207	1.585	1.879	-0.326	0.972	-0.651
2003	2.428	6.644	1.736	1.441	-0.407	0.793	-0.673
2004	1.562	3.833	1.454	1.513	-0.031	0.286	-0.817
2005	2.275	2.501	0.099	2.426	0.066	2.021	-0.112
2006	1.687	2.760	0.636	1.418	-0.159	1.284	-0.239
2007	1.997	3.445	0.725	1.218	-0.390	1.796	-0.101
2008	1.344	3.572	1.658	0.899	-0.331	0.416	-0.690
2009	1.608	3.811	1.370	0.689	-0.572	1.083	-0.326
2010	1.256	2.004	0.596	1.783	0.420	0.391	-0.689
2011	2.055	5.580	1.715	1.243	-0.395	0.676	-0.671
2012	2.414	7.166	1.969	1.507	-0.376	0.402	-0.833
2013	1.257	2.379	0.893	0.657	-0.477	1.097	-0.127
2014	0.807	1.258	0.559	1.274	0.579	0.163	-0.798
		Average	1.126		-0.193		-0.494

The interaction rate (IR) for each stratum is calculated by multiplying its associated BIR by the proportion of the recent five-year (2010-2014) murrelet density average estimate relative to the 1994 density estimated by zone level regression (Table 9).

Table 9. Estimated stratum base interaction rates (BIR) scaled to 1994 marbled murrelet density estimates.

Stratum and (BIR)	**2010-2014 average density**	**1994 density estimate**	**IR scaled to 1994 density**
Stratum 1 (0.00763)	3.6774	7.334	0.0038
Stratum 2 (0.00210)	1.2928	2.738	0.0010
Stratum 3 (0.00210)	0.5458	1.745	0.0007

6.3.2 Marbled Murrelet Winter Density

Observers have noted a seasonal influx of marbled murrelets into Puget Sound from British Columbia and the Washington Coast which could result in higher densities of marbled murrelets in fishing areas during winter months in Puget Sound. Limited radio telemetry data suggests that a proportion of the marbled murrelets foraging in the San Juan Islands, the Strait of Juan de Fuca, and other Puget Sound areas, originate in British Columbia. Additionally, Courtney et al. (1996) and Merizon et al. (1997) suggest an increase in marbled murrelets in northern Puget Sound occurring primarily in and after November. Commercial gillnet fisheries are primarily in the summer (May-October) with minimal effort in the fall (November-December), and even less effort in the winter (January-March) as target species have moved up-river into freshwater by fall and winter. Treaty fishery effort during each of these monthly periods is shown in Figure 5, and non-Treaty effort is provided in Appendix B. Fall and winter fishing effort is generally in areas where summer and winter marbled murrelet density is estimated to be quite low.

For this BA, estimates of murrelet density during the winter time period are available for the first time. Estimates are available for winters 2012/13 and 2013/14 (Pearson and Lance 2013 and 2014), and there are preliminary estimates for winter 2014/15 (Pearson, unpublished). While these data visually suggest an increase in density in November, particularly for 2014/2015 data, the overlap of the 95% confidence intervals of the estimates indicates that these differences in estimated density are not statistically significant (Figure 6).

Further, Pearson and Lance (2013 and 2014) stratified their winter surveys differently[16] than the summer surveys by the effectiveness monitoring program of the NWFP. Although all winter surveys are within NWFP strata 2 and 3, the winter data are presented within five strata for 2012/2013 (for analysis purposes Pearson and Lance combined two strata into one [Stratum A] which is consistent with subsequent years' strata) and four strata in 2013/2104 and 2014/2015. As such, a winter stratum may contain sections of multiple summer strata (e.g., winter stratum A covers parts of both summer strata 2 and 3, see Figure 7). For this reason, a direct comparison between the available summer estimates and the winter estimates is problematic. To facilitate comparisons, analyses were conducted at a finer scale using available PSU density data available in Falxa et al. (2013) with the winter stratum data where overlap of surveys occurred. At a coarser scale, mean density estimates for strata 2 and 3 from the summer (USFWS) surveys were compared to the mean winter estimates for the combined strata (for all relevant strata).

Marbled murrelet density estimates for winter, and averages, were compared to corresponding summer PSU density ranges presented in Falxa et al. (2013). Results of that comparison indicate that winter strata density estimates for stratum A were marginally greater only in the winter of 2012/2013 in comparison with summer density ranges (PSUs 1-2-31 and 1-2-32). However, when the three years of winter data were averaged for winter stratum A, the value was within the summer range data. All other winter strata density estimates, and their three year averages, were consistent with the available corresponding summer PSU range data (Table 10).

[16] Pearson and Lance used numeric definitions for their winter strata. To minimize confusion, we redefined them alphabetically such that winter stratum 1 is stratum A (in 2012/2013 this is strata 1 and 2), stratum 2 = stratum B, stratum 3 = stratum C, and stratum 4 = stratum D.

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Table 10. Comparison of summer PSU unit marbled murrelet density (birds/km^2) estimates with the corresponding winter strata estimates.

Summer PSU(s)	Winter Strata	Summer Density Category	Winter Strata Density			Average Winter Density
			2012/2013	2013/2014	2014/2015	
1-2-31, 1-2-32	A	3-5	5.50	2.43	3.86	3.92
1-2-34, 1-2-35, 1-2-36, 1-2-38	B	<1-3	1.78	1.15	0.78	1.23
1-2-26, 1-2-27, 1-3-3	C	<1-3	1.07	1.22	0.76	1.01
1-3-25	D	<1	0.05	0.03	0.06	0.05

Note: PSUs in each row are contained within the respective winter strata.

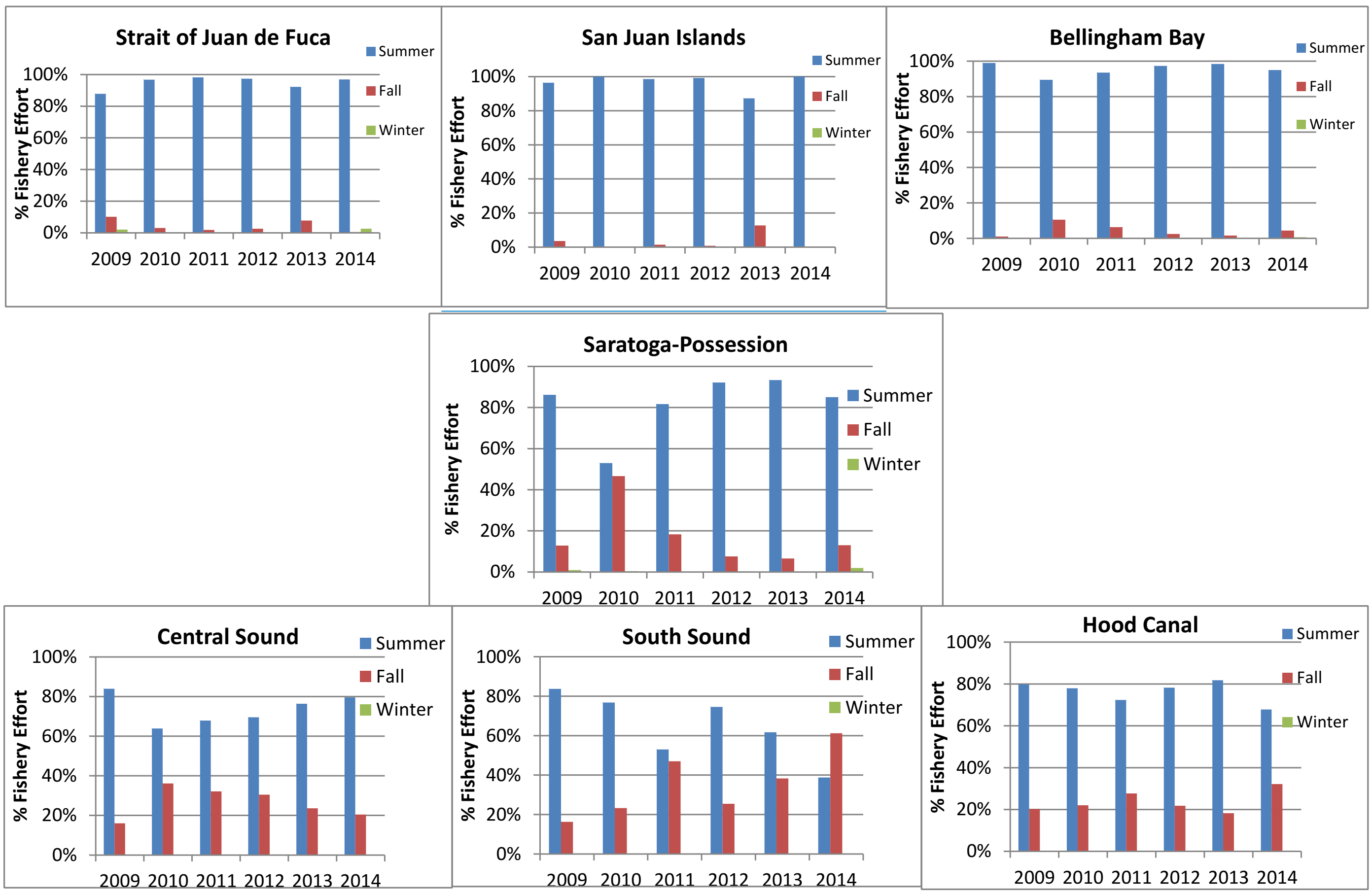

Figure 5. Seasonal distribution of Treaty commercial gillnet and set net fisheries from 2009-2014.

Note: Summer = May-October; Fall = November-December; Winter = January-March.

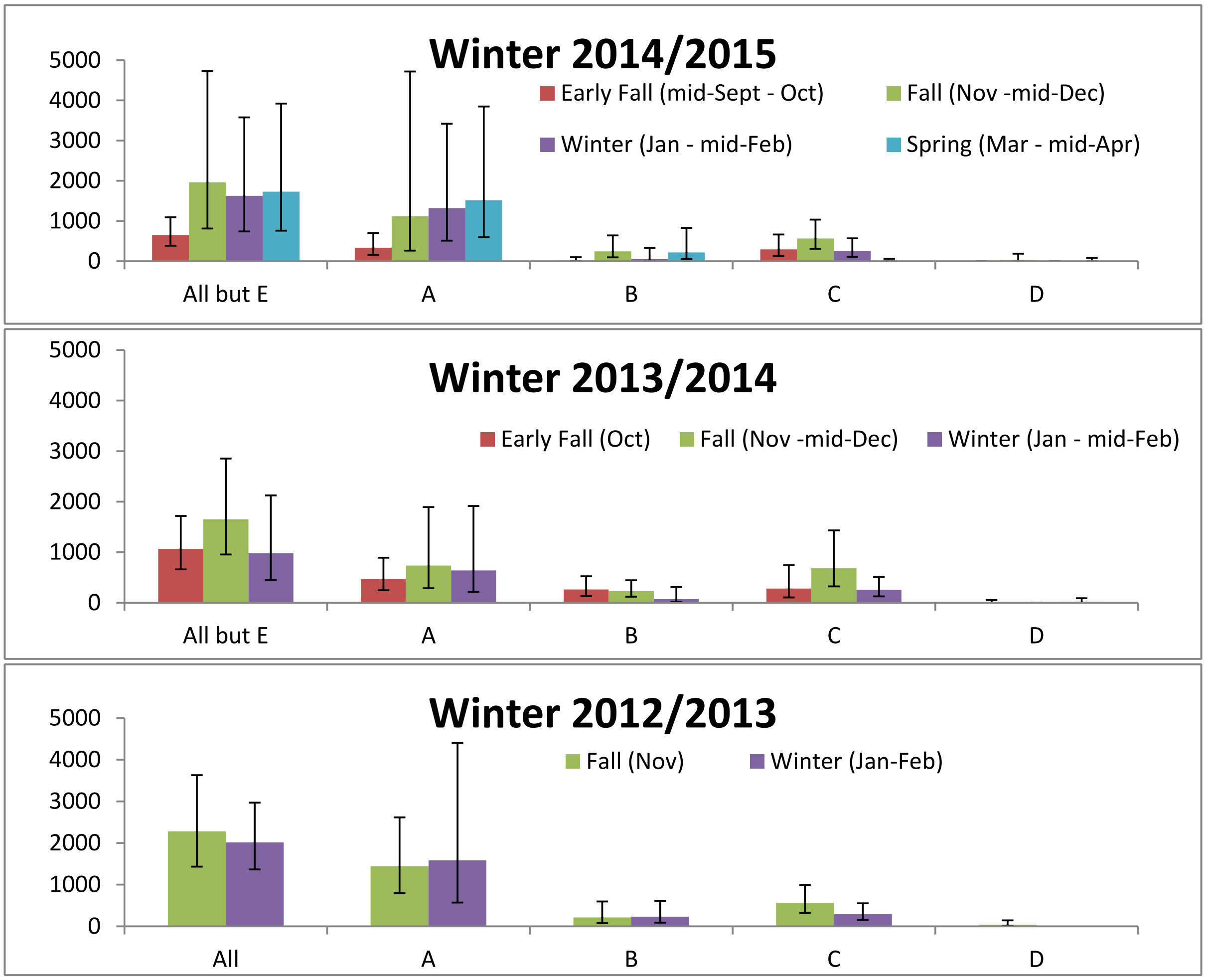

Figure 6. Seasonal marbled murrelet abundance estimates (with 95% confidence bars) for WDFW winter survey strata A, B, C, D, and the combined estimate of all strata (All) from winter 2012/2013 to winter 2014/2015.

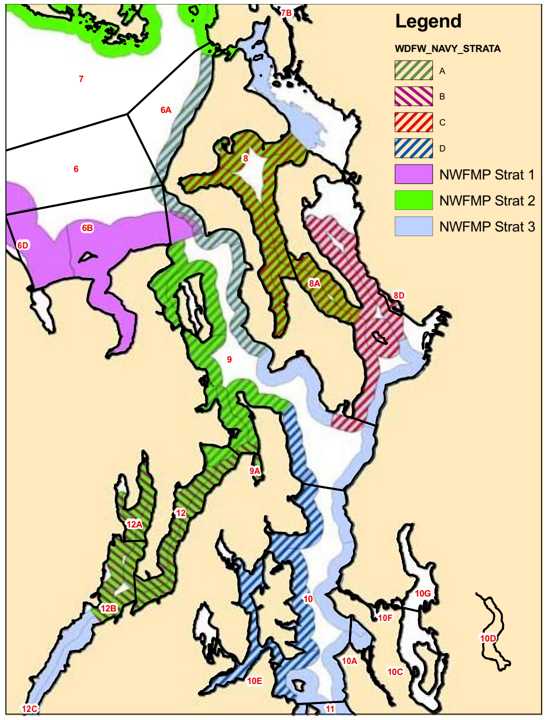

Figure 7. Map showing the distribution of WDFW winter surveys in relation to the NWFMP strata.

At a coarser scale (using strata level data only), a pair-wise Z test was used to compare density estimates for the NWFP summer strata 2 and 3 to an estimate for the combined winter strata. Six comparisons were made: a given winter (2012 and 2013) is compared to both the summer before and to the summer after, i.e. contiguous time periods (Table 11). There were significant differences ($P < 0.05$) for the following comparisons:

- 2012 summer stratum 3 mean density was lower than the 2012 winter mean density,
- 2013 summer stratum 2 mean density was lower than the 2012 winter mean density, and
- 2013 summer stratum 2 mean density was lower than the 2013 winter mean density.

Table 11. Summary of marbled murrelet density (birds/km^2) estimates by season, year, and stratum and results of the Z tests comparing mean summer densities to the winter density in a pair-wise manner.

Year, Season, and (Stratum)	Mean Density	SE	CV	Z test Statistic	Significance
2012 Summer (2)	1.507	0.458	30.4%	-1.146	0.126
2012 Summer (3)	0.403	0.194	48.1%	-4.008	0.000
2012 Winter	2.209	0.407	18.4%		
2012 Winter	2.209	0.407	18.4%		
2013 Summer (2)	0.657	0.132	20.1%	3.629	0.000
2013 Summer (3)	1.097	0.707	64.4%	1.363	0.086
2013 Summer (2)	0.657	0.132	20.1%	-2.551	0.005
2013 Summer (3)	1.097	0.707	64.4%	-0.291	0.385
2013 Winter	1.313	0.221	16.8%		

Note: Bonferroni adjustments were made to the P level to account for multiple tests.

In the winter of 2015 (late-January through March), WDFW attempted to resurvey the exact same PSUs sampled during the summer monitoring to facilitate a more direct comparison of seasonal densities. About 60% of stratum 1, 65% of stratum 2, and 100% of stratum 3 PSUs monitored in the summer were included in these winter surveys. The results indicate a substantial increase of marbled murrelets in stratum 2, particularly in the San Juan Archipelago (S. Pearson, WDFW, unpublished data), while the estimates for strata 1 and 3 were very similar for summer and winter surveys. The density increase in stratum 2 was primarily detected offshore of the San Juan Islands corresponding to MCA 7. However, winter surveys were well outside the timeframe of commercial fisheries in that area (which end the first week of November).

In summary, although available data indicate that winter densities of marbled murrelets may be higher than summer densities within the action area, this does not warrant adjusting net interaction rates for late season fisheries for the following reasons:

1. There are several concerns with the available winter survey data and our ability to make comparisons between the seasons; the winter and summer PSUs were stratified differently, so no direct comparisons could be made.
2. Winter strata level density estimates are consistent with available PSU summer density range estimates (strata between seasons were not directly comparable, so PSU data were used as a proxy).
3. In analysis at the strata level (where all winter strata were combined and averaged to facilitate the comparison), significant density estimates differences were not consistent (only 50% of the time).
4. The 2015 winter surveys facilitated a more direct comparison of density estimates between seasons. A significant increase in winter density was found in stratum 2 only. Approximately 90% of the marbled murrelets observed during the winter surveys were detected in the San Juan Islands area of stratum 2. However, the timing (late-January through March) is well outside the

timeframe of any gillnet fisheries in this area. Use of this density data would misrepresent the interaction rate for the fall and winter gillnet fisheries.

6.3.3 Set Gillnet versus Drift Gillnet Fisheries

In recent Biological Opinions covering Treaty set net fisheries, the USFWS assumed the interaction rate for set nets was twice that of driftnets, which were the focus of the 1994 Observer Program. This assumption was based exclusively on considering time as a factor influencing net-murrelet interactions: driftnets may be fished up to 8-10 hours per day while set nets are sometimes fished 24 hours a day during open fisheries (USFWS 2004). Although some set net fisheries may be open 24 hours a day, not all set net fisheries are ubiquitously open 24 hours per day; many Treaty regulations limit set net fishing to defined daylight hours. Further, for set net fisheries open 24 hours per day, actual participation may not occur 24 hours per day due to the constant fouling of nets, which reduces salmon catch efficiency.

In addition, the previous assumption does not consider the influence of how the gear is fished and subsequently the geographical area covered, nor the size of the nets. Driftnets, as the name implies, are fished drifting with the current resulting in a greater area fished the longer the net is deployed. This distinction is analogous to conducting a survey from a fixed point (i.e., a set net) versus surveying across a transect (i.e., driftnet); encounter probabilities will be greater on a transect survey that is constantly moving from its original point of deployment. Conversely, set nets are anchored to or near shore and effectively fish a constant area (do not move of original point of deployment) irrespective of the amount of time the net is deployed. Additionally, set nets are generally about one-half to one-third the surface area of driftnets so the overall effective interaction area of set nets is reduced. Figure 8 is a schematic representation illustrating the general difference in net size and effective area of interaction for both set nets and driftnets. Therefore, a consistent base interaction rate for the different gear types is assumed to be more appropriate than setting the interaction rate for set nets to a rate twice that of driftnets. Without additional gear specific data on bird interactions, it is premature to conclude a higher interaction risk for set net fisheries.

6.3.4 Reduced Interaction Fisheries

A few set net fisheries operate in small, confined areas and specific regulations for those fisheries are promulgated, such that, they are expected to be of lower risk for interaction to marbled murrelets as a result (10% of the stratum IR). While the expectation is that no marbled murrelets would be at risk (0%) in the fisheries described in this section, applying a quantitative 10% rate of the Stratum IR provides a level of caution for when a random or rare interaction may occur. The catch areas and regulations for those specific fisheries where a lower risk is applied are described below.

6.3.4.1 Dungeness Bay (MCA 6D)

MCA 6D (Dungeness Bay) is located on the eastern end of the Strait of Juan de Fuca at the mouth of the Dungeness River. This 22 km^2 catch area is a fairly shallow bay (<3m) with deepest areas (~40m) in the north section of the area off New Dungeness Lighthouse (Figure 9). Regulations limit maximum net length to 600' although the majority of nets are closer to 300'. Fishers retrieve nets from the beach and as such some are above water during low-tide events. MCA 6D net fishery regulations during the first half of the season limit fishing to a 12 hour period (0700-1900 hours) with fishers required to constantly tend their nets. This results in concentrated human presence and boat traffic in a very small area, and likely deters murrelet presence in and around fishing gear. During the second half of the fishery, the regulations allow for fishing 24 hours per day and requires net tending during daylight hours (dawn-dusk). Given the large quantity of vegetation present (which clogs nets), marine mammal predation of catch, and low catch numbers, at least 90% of the fishing during the 24 hour open period is conducted during daylight hours. Further, during the month and a half long fishery, fishery managers monitor the fishery extensively (80% sample rate) and are present on most days observing fishers. During the winter months, a set net fishery targeting steelhead is scheduled. However, due to the typically poor weather conditions and the relatively small number of steelhead returning the Dungeness, effort is extremely low; the last known participation in this fishery was in 2011 when one landing was recorded. While very little marbled murrelet survey effort is focused on monitoring in MCA 6D, previous results of WDFW PSAMP surveys indicate that marbled murrelets do occur outside of MCA 6D, however, none have been observed inside of the area boundaries (Nysewander et al. 2005).

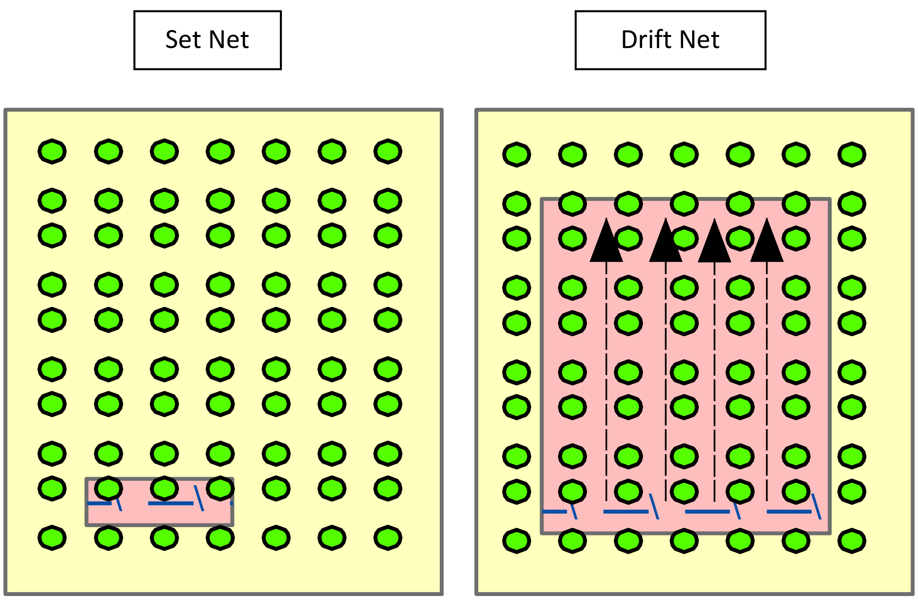

Figure 8. Schematic representation of set net fishing and driftnet fishing potential interaction area (red rectangle) based on general net size and deployed net action.

Note: Green dots depict a hypothetical population distribution for the nets to encounter.

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6.3.4.2. Tulalip Bay (MCA 8D)

MCA 8D encompasses ~4.4 km^2 on the Tulalip Reservation. Set net fisheries in MCA 8D are regulated to occur only inside Tulalip Bay (Figure 10) which covers approximately 1.5 km^2. Set net fishing is further restricted to 58 sites located around the perimeter of the bay (Appendix C). Specific regulations adopted for set net fisheries in MCA 8D require fishers to attend their nets when actively fishing. This regulation is mandatory and results in heavy boat traffic in and around the fishing gear during fishing activity, likely deterring marbled murrelets from utilizing this area. Regulations further restrict fishing to an average of 12.5 hours per day (range: 7-19.5 hours per day) when open with 95% of total fishery effort occurring during daylight hours. While little murrelet survey effort is focused on monitoring in MCA 8D, previous results of WDFW PSAMP survey monitoring indicate that marbled murrelets do occur outside of MCA 8D, but none have been observed inside of the area boundaries (Nysewander et al. 2005). Additional surveys conducted in 1995 and 1996, found no marbled murrelets inside of Tulalip Harbor (Courtney et al. 1996 and Merizon et al. 1997).

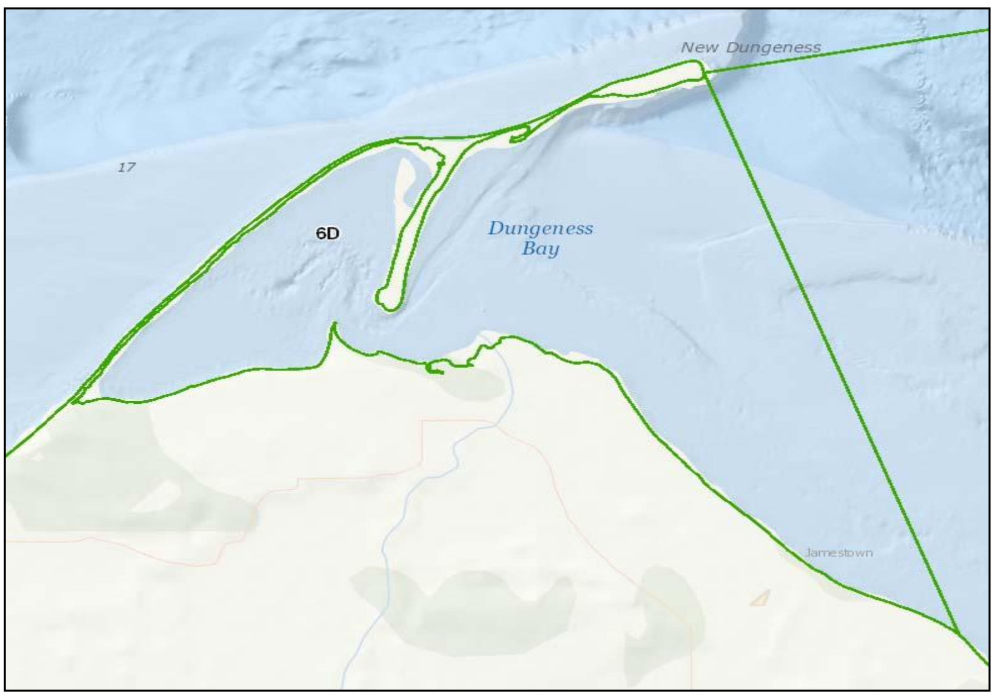

Figure 9. Three dimensional bathymetry map of MCA 6D.

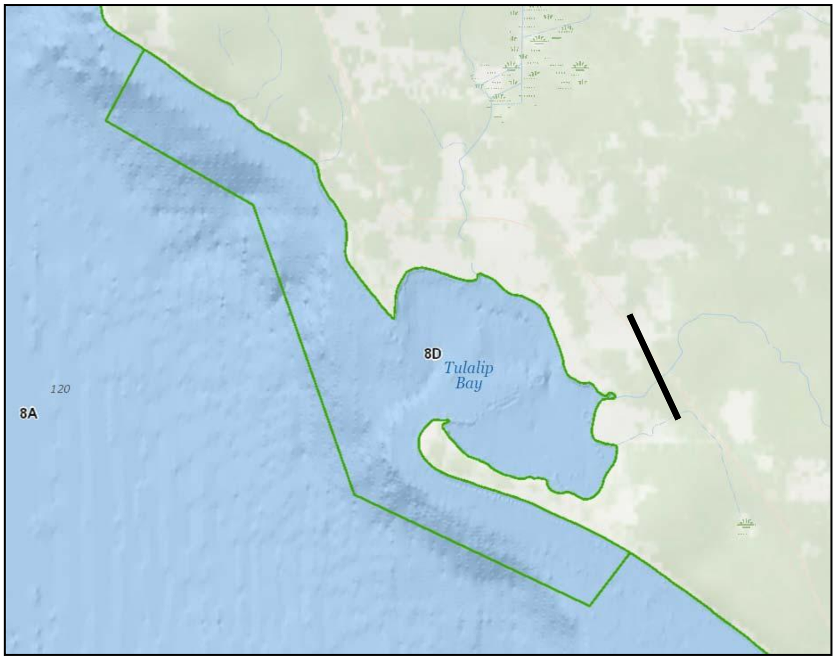

Figure 10. Three dimensional bathymetric map of MCA 8D (Tulalip Bay).

Set net fisheries occur only within the Bay (inshore of the black line).

6.3.5 Application of 2010-2014 Average Marbled Murrelet Density Estimates

Marbled murrelet density estimates are from standardized marine surveys conducted in Puget Sound and analyzed at the stratum level (Falxa et al. 2015). Falxa et al. (2015) provide annual density estimates by stratum and for Zone 1 in total; recent year averages of the stratum estimates are summarized in Table 12. Strata are defined geographically in Figure 11.

Table 12. Marbled murrelet average density estimates (birds/km^2) by stratum with corresponding marine catch areas (MCAs).

Stratum	MCAs	Average Density (2010-2014)
1	4A, 4B, 5, 6, 6C, 6D	3.6774
2	7, 9*, 9A, 12, 12A	1.2928
3	7A, 7B, 7C, 7D, 8*, 8A, 8D, 10, 10A, 10E, 11, 11A, 12B, 12C, 12D, 12H, 13, 13A-I	0.5458

Note: MCAs 8 and 9 occupy both strata 2 and 3, and were assigned to respective strata based on their location and the locations of their associated sub-areas.

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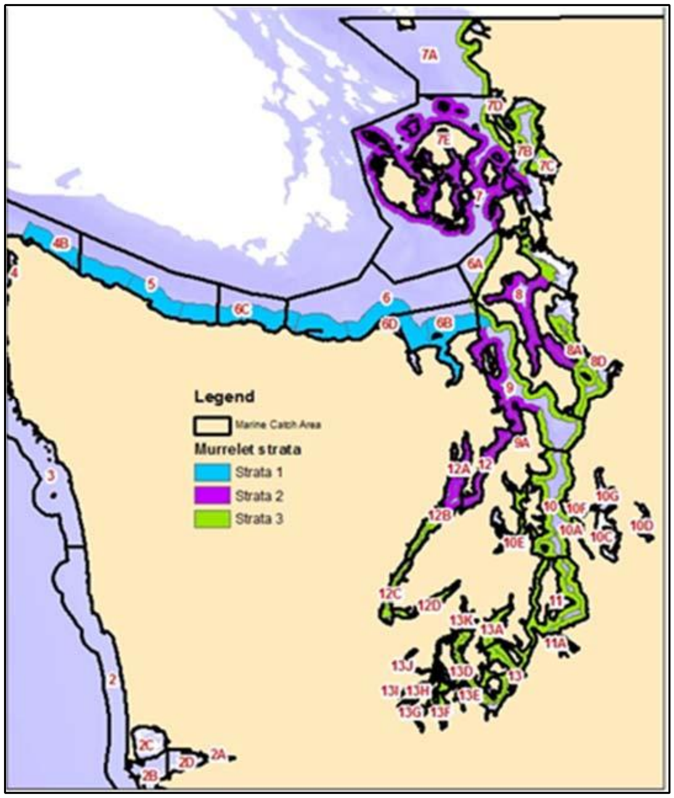

Figure 11. Overlap of marbled murrelet survey stratum 1, 2, and 3 in conservation Zone 1 with MCAs in Puget Sound.

Stratum level BIR estimates were scaled to account for the decrease in murrelet density since 1994 (when the BIR data were collected). Each stratum level BIR estimate was multiplied by the ratio of the 2010-2014 average murrelet density to the back-cast estimate of 1994 murrelet density to estimate interaction risk in commercial gillnet fisheries (Table 13).

Table 13. Reprint of Table 9 (BIR estimates scaled to 1994 murrelet density estimates).

Stratum and BIR	2010-2014 average density	1994 density estimate	IR scaled to 1994 density
Stratum 1 (0.00763)	3.6774	7.334	0.0038
Stratum 2 (0.00210)	1.2928	2.738	0.0010
Stratum 3 (0.00210)	0.5458	1.745	0.0007

Note: BIR units are expected number of marbled murrelet interactions per gillnet landing.

Recognized limitations of the 1994 observer study:

- it was conducted over 20 years ago,
- it was conducted only in MCAs 7 and 7A, and
- the single interaction recorded occurred in an area where commercial gillnet fishers are not allowed to fish (A. Chapman, pers. comm., 2015).

This single encounter is used to estimate entanglement risk in all other fishing areas and may not be representative of current interaction risk for each MCA. However, it is the best available data to currently extrapolate risk to marbled murrelets in gillnet fisheries.

6.3.6 Application of 2009-2014 Commercial Gillnet Catch Effort

Fishing effort (represented by a recent 6-year average of the number of landings) in each stratum is multiplied by the appropriate stratum-level IR (described above) to estimate future annual risk of interactions between marbled murrelets and the Treaty and non-Treaty gillnet fisheries. A 6-year average was chosen so that there were three years with pink salmon fisheries and three years without pink salmon fisheries. For both Treaty and non-Treaty gillnet fisheries, risk (number of possible marbled murrelet-gillnet interactions per year) is estimated for each MCA as the product of the adjusted average annual effort and the appropriate scaled IR.

Annual Treaty gillnet effort was summarized from the TOCAS[17] fish ticket database for the years 2009-2014 (Table 14). The effort metric in the database is the count of the number of landings for each unique fisher identification number by date across MCAs and gear types (driftnet and set net).

[17] TOCAS is the Treaty Online Catch Accounting System.

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Table 14. Treaty commercial set net and driftnet fishery effort by MCA for 2009-2014.

MCA	Strata	2009	2010	2011	2012	2013	2014	Average
4	1	0	0	0	0	2	0	0.3
4B	1	14	116	50	67	41	6	49.0
5	1	71	256	141	61	53	96	113.0
6	1	13	0	0	3	1	10	4.5
6C	1	3	0	2	1	5	7	3.0
6D	1	105	92	140	100	68	80	97.5
7	2	12	338	164	83	9	193	133.2
7A	3	31	1,263	191	166	53	1223	487.8
7B	3	1,914	1,897	2,183	1,945	1,778	970	1,781.2
7C	3	229	236	252	399	372	234	287.0
7D	3	66	48	98	34	85	39	61.7
8	3	38	42	88	107	211	72	93.0
8A	3	607	197	562	318	447	209	390.0
8D	3	740	1,275	1,262	1,024	1,005	939	1,040.8
9	2	11	1	4	1	7	4	4.7
9A	2	177	184	329	363	307	166	254.3
10	3	190	283	191	155	216	160	199.2
10A	3	101	111	160	94	160	149	129.2
10E	3	48	203	126	124	196	114	135.2
11	3	31	28	50	11	4	16	23.3
11A	3	4	9	2	0	0	1	2.7
12	2	33	132	307	297	167	205	190.2
12A	2	48	20	18	40	34	14	29.0
12B	3	194	289	313	154	103	131	197.3
12C	3	705	959	1,162	1,163	1,371	1,248	1,101.3
12D	3	4	7	22	21	1	0	9.2
13	3	2	1	4	1	0	0	1.3
13A	3	142	78	104	49	26	26	70.8
13B	3	1	0	2	2	0	0	0.8
13C	3	32	2	10	30	25	3	17.0
13D	3	254	142	131	202	137	108	162.3
13E	3	0	0	1	2	0	0	0.5
13F	3	221	213	127	139	173	61	155.7
13G	3	27	41	121	50	72	165	79.3
13H	3	63	78	158	56	88	83	87.7
13I	3	0	0	10	0	1	0	1.8

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Non-Treaty drift gillnet effort was summarized from the WDFW fish ticket database for the years 2001-2014 (July 2015 query). Average gillnet effort by MCA for the 6-year period 2009-2014 is presented in Table 15.

Table 15. Summary of non-Treaty commercial gillnet effort from 2009-2014.

Marine Catch Area	Recent year NT catch effort						
	2009	2010	2011	2012	2013	2014	2009-2014 AVG
6D	75	39	70	99	79	63	**71**
7	50	236	259	86	49	153	**139**
7A	18	328	301	102	148	490	**231**
7B	241	378	987	555	831	389	**564**
7C	132	100	365	374	400	142	**252**
8	19	0	21	0	45	0	**14**
8A	8	19	6	0	30	0	**11**
8D	16	11	17	4	4	0	**9**
9A	52	23	68	123	63	23	**59**
10	222	388	472	454	181	302	**337**
11	49	43	39	28	6	15	**30**
12	318	318	428	380	354	381	**363**
12A	19	0	0	1	0	0	**3**
12B	21	28	33	23	28	2	**23**
12C	0	0	6	4	0	0	**2**

6.4 Purse Seine Entanglement Rates

An observer program was conducted in 1994 to estimate the rate of marbled murrelet entanglements with purse seine nets. During the sockeye fishery in MCA 7 and 7A, 1,187 purse seine sets were observed (representing 4.3% of the total fishery effort) and no marbled murrelets entanglements were recorded (NRC 1993, cited in NOAA 1995). During the chum fishery in MCA 7 and 7A, 56 purse seine sets were observed (representing 9.8% of the total fishery effort), and no marbled murrelets entanglements were recorded (NRC 1993, cited in NOAA 1995). In the chum fishery in MCA 12 (Hood Canal) and 13 (south Puget Sound), 199 purse seine sets were observed (representing 7.3% of the total fishery effort) and no marbled murrelets entanglements were recorded (NRC 1993, cited in NOAA 1995).

From 2001 through 2013, anecdotal observations of five seabird interactions described as ‘murrelet’ associated with non-Treaty purse seine fisheries were reported by WDFW salmon fishery observers (Appendix F). All five interactions occurred in 2003 under new observers, with one observation in MCA 7 during sockeye fisheries, and four observations in MCA 11 during chum fisheries (NOAA and BIA 2015). Unfortunately, salmon observers are not trained in seabird identification, nor focused on identifying seabird bycatch. Their bird identification skills are not monitored, and this is confounded by the minimal time allotted for bird identification (the interaction and flushing of a bird happens within seconds while the observer is focused on salmon catch). None of these birds were available for retrieval or positive identification to species (four released alive, one reported flushed but injured). The co-managers regard the 1994 study cited above as the best available data regarding purse seine interactions with marbled murrelets. The purse seine WDFW fishery observer data is viewed as not reliable based on the following factors: (1) the data contradicts the 1994 focused study using trained seabird observers, during a timeframe where the marbled murrelet population was considerably more abundant than in 2003 (when observations to genus were recorded); (2) over the thirteen year timeframe, encounters were only recorded in 2003, and four of the five identifications were made by a single observer, on two dates, in MCA 11 where the marbled murrelets are not likely found; (3) the action of this gear type (described above) minimizes the potential for seabird encounters; and (4) there is no corresponding reporting by the non-Treaty fishers, who are very knowledgeable in the identification of marbled murrelets and aware of the duty to report marbled murrelet interactions. Thus, based on the best available information, purse seines are exempted from consideration of risk to marbled murrelets by Puget Sound fisheries. This is consistent with the USFWS biological opinions and the 2010 and 2015 time extensions on the current opinions (USFWS 2001 and 2004).

6.5 Non-Treaty Recreational Fisheries

Recreational anglers catch salmon throughout marine waters of Puget Sound (MCAs 5 through 13). Anglers use a variety of terminal gear arrangements and presentation styles which are described below.

6.5.1 Non-Treaty Recreational Fishing Gear

Recreational anglers catch salmon throughout marine waters of Puget Sound (MCA 5 through 13) using standard 6 to 10 foot (1.8-3.0 meter) fishing rods equipped with spinning, casting, or fly-type reels. Lines vary in strength, but commonly 8 to 20 pound test (3.5-9.0 kg) lines are used. Single-point barbless hooks are required for fishing in all Washington marine areas, with up to two such hooks allowed per line. Regulations require that all fishing gear be under the direct control of the angler while fishing. The vast majority of recreationally caught salmon are by anglers using small boats in the 12 to 30 foot (3.7 - 9.0 meter) range. Shore fishing from public fishing piers and suitable beaches is also popular in some areas. Anglers use a variety of terminal (freshwater) gear arrangements and presentation styles, and these are described below. Recreational fishing anglers conduct hundreds of thousands of trips per year (i.e., 447,024; WDFW 2012[18]).

6.5.1.1 Mooching and Motor Mooching

Terminal mooching gear consists of a 1 to 6 oz. banana-shaped lead weight (generally with swivels at both ends), connected to an approximately 7' long leader, with one or two hooks baited with whole or cut herring. Hook size used generally ranges from 4/0 to 1/0, approximately measuring 3 to 7 cm in length, respectively, depending on the size of the bait (i.e., herring ranges from 10 to 20 cm long). Baits are often rigged with two different sized hooks. Herring are attached in a manner that causes them to rotate as they are slowly moved through the water by the motion of the boat drifting under the influence of wind, waves, and current. In general, anglers seeking coho fish surface waters down to 60' (18.3 m)

[18] Washington Department of Fish and Wildlife Sport Catch Reports are available online at: http://wdfw.wa.gov/fishing/harvest/.

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deep, while Chinook anglers work deeper waters near the bottom in waters up to 150' (45.7 m) deep. "Motor mooching" refers to using the boat's motor to vary the terminal gear's presentation in the water column by changing the engine speed, by putting the motor in and out of gear, or in some cases reversing the propulsive force.

6.5.1.2 Jigging

Jigging is similar to mooching (using a drifting or slowly maneuvering boat), but it involves the use of lures instead of bait.

6.5.1.3 Trolling

Trolling is the most popular method of salmon angling and involves towing terminal gear slowly through the water behind a boat. The terminal gear is made up of a flasher board (or dodger) attached to the end of the line that is connected to the rod and reel with several feet of additional leader (line) connected to the other end of the flasher board. At the end of the leader, two hooks are baited with either whole or partial herring in a way as to spin when pulled through the water. The leader may alternatively be equipped with various lures including plugs, spoons, spinners and plastic simulated squid (hootchies). The terminal gear is lowered to a desired depth by attaching the line in front of the flasher board by three main methods: (1) a lead sinker weight, (2) a diving plane board that pushes the gear deeper by the angle of the diving plane board, (3) or a cable with a large suspended weight attached to the bottom that is mounted to the boat and controlled by a large reel like device called a down-rigger. The terminal gear is fished in surface waters down to 60' (18 m) deep when targeting coho and pink, while Chinook anglers generally work deeper waters near the bottom at depths up to 150' (45 m).

6.5.1.4 Shore angling

Salmon angling from shore or public fishing piers is generally conducted by repeatedly casting out and retrieving the terminal gear. Action may be given to the terminal gear by pumping the rod up and down as the gear is retrieved. Various types of lures such as spoons, spinners and weighted jigs are used. Baited terminal gear is less popular when using this method because the bait tends to dislodge from the hook during repeated rounds of casting and retrieval. However, baited hooks with whole or partial herring are used by two methods: (1) attaching a bobber above the bait approximately 6-8 feet and casting offshore and allowed to soak, or (2) attaching a small weight 2-3 feet above the bait, casting out and retrieving it in a manner that the bait spins. Wind and current impart action to dead bait while the motions of live bait serve as the attractant.

6.5.1.5 Fly-fishing

Fly-fishing has a relatively small group of anglers compared to other fishing methods, but is increasing in Puget Sound. Many new fly-fishing anglers are thought to come from a combination of converting from other angling methods, as well as experienced fly-fishing anglers who are new to fishing for salmon in Puget Sound. Fly-fishers generally fish from shore or in wading-depth water, casting with light action, specifically designed fly rods and reels. Fly-fishing is also done from drifting boats. Casting distance of fly-fishing is very limited and controlled. This is a very specialized fishing method that minimizes bycatch of any kind. The terminal gear does not include bait (incidentally lessening the

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attraction of foraging marine seabirds), but rather consists of wet (sinking) or dry (floating) artificial flies which are hooks specially prepared with threads, feathers, fur and other materials that give the hook the appearance of a fish's prey species.

6.5.2 Description of Non-Treaty Recreational Fisheries

Recreational salmon fisheries occur throughout the Strait of Juan de Fuca and Puget Sound (MCAs 4-13) throughout the year. Seasons vary by area, with seasons generally lengthening with distance from the ocean. For example, over the past few years MCA 4 has only been open from late June to mid-September, while MCA 13 is generally open year-round. The daily limit is typically one or two salmon per angler, except for Hood Canal (which has a four salmon limit from July 1 through December 31), Sinclair Inlet (which has a three salmon limit from July 1 through September 30), and during odd years most MCAs (5-13) allow two additional pink salmon from July through September.

Detailed descriptions of the non-Treaty recreational fisheries, with specific opening dates, gear and species limitations, and other restrictions, are available in the Sport Fishing Rules Pamphlet, which can be found at http://wdfw.wa.gov/fishing/regs_seasons.html.

6.5.3 Non-Treaty Encounter Rates

The 2010 Biological Assessment (NMFS 2010) used data collected by dockside samplers on recreational fishers' encounters (defined here as interaction or entanglement) with birds from 2001 to 2008 to calculate encounter rates with marbled murrelets. Encounter rates are recalculated here using basic extrapolation and incorporating data from 2001 through 2014. No differentiation is made between the recreational gear types, but rather the fisheries are considered as a whole, as we do not have data to support analysis of risk per each gear type.

There have been only three identified seabird encounters in 14 years of monitoring recreational fisheries, adding considerable uncertainty to the extrapolated estimate. Further adding to the uncertainty, there are several species of murrelet along the Pacific Northwest coast and inland seas, including Xantus's, Kittlitz's and Marbled murrelets (B.C. Conservation Data Center 2010). Most species are similar in body shape, size, foraging and nesting characteristics. Xantus's murrelet is more restricted to California and Mexico while Kittlitz's murrelet occur almost exclusively in Alaska. Ancient murrelets have been recorded in the action area during seabird surveys. Ancient murrelet could be confused with marbled murrelet, especially juveniles as well as juveniles of other seabirds such as auklets and murres (B.C. Conservation Data Center 2010). Seabird identification skills of recreational anglers are unknown but this is the only available data for seabird encounters so the assumption was made that bird identifications by recreational anglers are accurate. As a conservation approach, WDFW assumes that identified seabirds are marbled murrelets, although Ancient Murrelets, Rhinoceros Auklets, and the Common Murre have all been recorded in this area during seabird surveys. Furthermore, seabird identification skills of anglers are unknown. Unlike commercial fishers who spend a predominant amount of time on the water and are well educated in marine species they may encounter, recreational fishers may not be as well educated when it comes to marine bird identification. But, again, a conservative assumption is made that identifications by recreational fishers are accurate.

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During the 14 years monitored, 663 total seabird encounters were recorded in the Puget Sound/Strait of Juan de Fuca area. Of those 663, anglers identified 506 seabirds to family; the 506 seabirds includes the 3 "murrelets" mentioned previously, as well as classifications of either diving or non-diving birds, "duck", and "shorebird".

The total number of marbled murrelets encountered over this time period is estimated by the sum of identified murrelets encountered (3), and the number of murrelets that could be assigned to the categories where birds weren't fully identified. To do this, the proportion of identified murrelets within the identified bird category (3/506) is applied to the remaining birds (157). The resulting numbers are summed (3+0.931), and divided by 14 year sampling period, resulting in an estimate of 0.281 encounters per year.

This rate represents the portion of the salmon fishery sampled. The fishery is not sampled 100%, but rather sub-sampled (goal of 20%). To account for this, the annual encounter rate of 0.281 was divided by the sampling rate for each year. Sampling rates are estimated by comparing the total number of salmon (all species) recorded by dockside samplers with the total number of salmon (all species) reported caught within sampling areas through the WDFW Catch Record Card database. From 2001 to 2014, salmon sampling rates have ranged from 16.9% to 29.2%.

Using these methods, the estimated annual number of marbled murrelet encounters in the Puget Sound recreational fishery from 2001 to 2014 ranged from 0.961 to 1.663, with an annual average of 1.202 birds (Table 16). When considering just the last six years, and using this same method (one bird out of 145 birds identified as a murrelet species, plus 0.166 out of 24 unidentified birds), the estimate drops to 0.765 murrelet species per year (minimum 0.663 to maximum 0.926 birds per year).

Table 16. Non-Treaty recreational interaction risk estimates.

	% of fishery sampled	Average encounter rate	Estimated IR
2001	16.9	0.281	1.663
2002	18.9	0.281	1.484
2003	21.3	0.281	1.322
2004	23.0	0.281	1.219
2005	27.6	0.281	1.017
2006	21.5	0.281	1.305
2007	25.0	0.281	1.125
2008	26.9	0.281	1.043
2009	27.9	0.281	1.007
2010	29.2	0.281	0.961
2011	28.4	0.281	0.988
2012	21.0	0.281	1.341
2013	24.0	0.281	1.172
2014	23.8	0.281	1.181

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6.6 Potential Interactions with Marbled Murrelets

Applying the methods described in Section 6.3 to recent Treaty and non-Treaty gillnet effort (presented in Tables 14 and 15), the risk of potential marbled murrelet interactions in the gillnet fisheries can be estimated. This risk was estimated by assuming the number of encounters has a Poisson distribution (Poisson(λ)) where lambda (λ) is the product of the stratum-specific bird interaction rate (Table 13 last column) and the MCA commercial landings averaged for the period 2009-2014 (Tables 14 and 15). For non-Treaty commercial fisheries, an associated savings is applied in calculating encounter risks (Table 17) for conservation measures (fishing exclusion zones and gillnet gear requirements) that are anticipated to continue to be implemented.

Table 17. Summary of conservation factors used to estimate the number of possible marbled murrelet-gillnet interactions and average gillnet landings by MCA (2009-2014) for non-Treaty gillnet fisheries.

MCA	Stratum	Conservation Factor	Average Landings (2009 - 2014)
6D	1	1.00	70.8
7	2	0.72	138.8
7A	3	0.5	231.2
7B	3	1.00	563.5
7C	3	1.00	252.2
8	3	0.89	21.3
8A	3	1.00	15.8
8D	3	1.00	10.4
9A	2	1.00	58.7
10	3	0.90	336.5
11	3	0.90	30.0
12	2	0.75	363.2
12A	2	1.00	6.7
12B	3	0.75	22.5
12C	3	0.75	2.5

Note: The marbled murrelet survey stratum associated with each area is indicated.

For Treaty set net fisheries in MCAs 6D and 8D, an associated savings is applied in calculating interaction risks due to examination of the characteristics of the set net fisheries (Section 6.3.4) reducing their risk to marbled murrelets by 90%. Refer to Table 14 for a summary of average landings by MCA for the Treaty gillnet fisheries. Table 18 describes MCA interaction rates for all Treaty fisheries.

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Table 18. The marine catch areas for Puget Sound with associated survey stratum, the associated reductions used in calculating encounter risks, and the landings per MCA averaged for the Treaty fisheries, period 2009-2014.

MCA	Stratum	Interaction Reduction Rates	Average Landings (2009 - 2014)
4	1	1	0.3
4B	1	1	50
5	1	1	115.3
6	1	1	4.6
6C	1	1	3.1
6D	1	0.1	99.5
7	2	1	135.8
7A	3	1	497.6
7B	3	1	1816.8
7C	3	1	292.7
7D	3	1	62.9
8	3	1	94.9
8A	3	1	397.8
8D (Drift)	3	1	249.1
8D (Set)	3	0.1	812.6
9	2	1	102
9A	2	1	259.4
10	3	1	203.2
10A	3	1	131.8
10E	3	1	137.9
11	3	1	23.8
11A	3	1	2.7
12	2	1	194
12A	2	1	29.6
12B	3	1	201.3
12C	3	1	1123.4
12D	3	1	9.4
13	3	1	1.4
13A	3	1	72.3
13B	3	1	0.9
13C	3	1	17.3
13D	3	1	165.6
13E	3	1	0.5
13F	3	1	158.8
13G	3	1	80.9

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MCA	Stratum	Interaction Reduction Rates	Average Landings (2009 - 2014)
13H	3	1	89.4
13I	3	1	1.9

Fishery risks are presented as the probability of encountering no birds [P(Encounter = 0)], one bird [P(Encounter = 1)] , more than one bird [P(Encounter > 1)], and more than two birds [P(Encounters > 2] Table 19 summarizes these probabilities for non-Treaty fisheries and Table 20 for Treaty fisheries.

Table 19. Probabilities of encountering no murrelets, one, more than one, and more than two murrelets for each marine catch area (MCA) based on the average non-Treaty fishery landings, interaction reduction rates, and stratum-specific interaction rates.

MCA	P(Enc. = 0)	P(Enc. = 1)	P(Enc. > 1)	P(Enc. > 2)
6D	0.764	0.236	0.030	0.003
7	0.905	0.095	0.005	< 0.001
7A	0.922	0.078	0.003	< 0.001
7B	0.674	0.326	0.060	0.008
7C	0.838	0.162	0.014	< 0.001
8	0.987	0.013	< 0.001	< 0.001
8A	0.989	0.011	< 0.001	< 0.001
8D	0.993	0.007	< 0.001	< 0.001
9A	0.943	0.057	0.002	< 0.001
10	0.809	0.191	0.020	0.001
11	0.981	0.019	< 0.001	< 0.001
12	0.762	0.238	0.031	0.003
12A	0.993	0.007	< 0.001	< 0.001
12B	0.988	0.012	< 0.001	< 0.001
12C	0.999	0.001	< 0.001	< 0.001

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Table 20. The probabilities of encountering no murrelets, one, more than one, and more than two murrelets for each marine catch area (MCA) based on the average Treaty fishery effort, interaction reduction rates, and stratum specific interaction rates.

MCA	P(Enc. = 0)	P(Enc. = 1)	P(Enc. > 1)	P(Enc. > 2)
4	0.999	0.001	< 0.001	< 0.001
4B	0.827	0.157	< 0.001	< 0.001
5	0.645	0.283	0.010	0.001
6	0.983	0.017	< 0.001	< 0.001
6C	0.988	0.012	< 0.001	< 0.001
6D	0.685	0.259	0.007	< 0.001
7	0.873	0.119	< 0.001	< 0.001
7A	0.706	0.246	0.005	< 0.001
7B	0.280	0.357	0.136	0.040
7C	0.815	0.167	0.001	< 0.001
7D	0.957	0.042	< 0.001	< 0.001
8	0.936	0.062	< 0.001	< 0.001
8A	0.757	0.211	0.003	< 0.001
8D (Drift)	0.840	0.146	< 0.001	< 0.001
8D (Set)	0.566	0.322	0.020	0.003
9	0.903	0.092	< 0.001	< 0.001
9A	0.772	0.200	0.002	< 0.001
10	0.867	0.123	< 0.001	< 0.001
10A	0.912	0.084	0.004	< 0.001
10E	0.908	0.088	< 0.001	< 0.001
11	0.983	0.016	< 0.001	< 0.001
11A	0.998	0.002	< 0.001	< 0.001
12	0.824	0.160	0.001	< 0.001
12A	0.971	0.029	< 0.001	< 0.001
12B	0.869	0.122	< 0.001	< 0.001
12C	0.455	0.358	0.045	0.009
12D	0.993	0.007	< 0.001	< 0.001
13	0.999	0.001	< 0.001	< 0.001
13A	0.951	0.048	< 0.001	< 0.001
13B	0.999	0.001	< 0.001	< 0.001
13C	0.988	0.012	< 0.001	< 0.001
13D	0.891	0.103	< 0.001	< 0.001
13E	1.000	0.000	< 0.001	< 0.001
13F	0.895	0.099	< 0.001	< 0.001
13G	0.945	0.054	< 0.001	< 0.001
13H	0.939	0.059	< 0.001	< 0.001
13I	0.999	0.001	< 0.001	< 0.001

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These estimates are mitigated by several factors:

a) Marbled murrelet data is currently only available at a stratum level, while fisheries are managed at a finer scale (i.e. multiple MCAs per stratum). Recognizing that murrelets often congregate in particular geographic areas (Courtney et al. 1996), presenting data at such a coarse scale limits the resolution to adequately understand where marbled murrelet-gill net interactions are likely to occur in a meaningful manner that allows co-managers to accurately capture interaction risk.

b) Because of the marbled murrelet survey design, birds have potential to be counted on separate (multiple) occasions. While the NWFP analytical attempts to address for spatial and temporal autocorrelation based on sampling which occurs close to each other by assigning PSUs to a cluster, it does not account for potential resampling of individuals on multiple occasions. We are concerned that not accounting for this possibility in the analysis could violate population modeling assumptions when rolling up population trend estimates, and therefore densities, to coarser scale levels (i.e. stratum and Zone scale). This could result in higher levels of uncertainty associated with the estimates and an overestimation of risk.

c) While it is not appropriate to directly compare interaction risks of this biological assessment to previous assessments of biological opinions, due to the concerns previously noted, a comparison of the effort metric could be warranted for current and future impacts of proposed actions. A joint Geographic Information Systems (GIS) mapping study was initiated in 2011 to examine fishing trends and marbled murrelet densities in the action area (Section 7.1).

d) The 1994 observer study (Pierce et al 1996) estimated wide confidence intervals about the interaction rate observed in MA 7; the entanglement rate per gillnet set was estimated at 0.00158 (90% CI 0.00017 – 0.00615). This estimate was based on a single observed murrelet encounter, which was subsequently released alive. There is substantial uncertainty in using a value based on a single observation, and particularly when extrapolating this entanglement rate to other fishing areas.

e) Previous biological opinions (USFWS 2001 and USFWS 2004) have assumed that all of the murrelets subject to net entanglement are killed. Pierce et al (1996) reports that some marbled murrelets are released alive following net entanglement. Observations of marine birds hooked by recreational fishers also report that recreational encounters may not necessarily result in bird mortality (Noviello 1999).

7. Species Effects

Because the proposed action overlaps with the Marbled Murrelet Conservation Zone 1 (and very small component of Conservation Zone 2) in Washington, there is the rare potential for direct and indirect effects to marbled murrelets. The following sections described these effects.

7.1 Direct Effects

Historically, the mortality of marbled murrelets from entanglement in gillnet fisheries on the West Coast was documented to occur (McShane et al. 2004). However, no marbled murrelet interactions or mortalities have been documented from 2001 to 2014 in Puget Sound co-managed gillnet fisheries, likely due to the implementation of the reasonable and prudent measures under the current biological opinions (USFWS 2001 and 2004).

Boat disturbance can have a direct effect on marbled murrelets in the action area. Marbled murrelets are known to exhibit behavioral responses to boat disturbance (Kuletz 1996, Spekman 1996, Nelson 1997, McShane et al. 2004). The disturbance of a boat encounter may result in vocalization among pairs; if a marbled murrelet pair is separated, most will vocalize and attempt to reunite (Ralph unpublished data; Strachan et al. 1995). Most marbled murrelets will move away from an approaching motor vessel (USFWS 2007). Effects from boat disturbance would be short in duration, and is likely to result in a small, temporary disturbance but not likely to result in injury or mortality.

The probability of a direct effect by a gear interaction varies considerably between locations, depending on local conditions, characteristics of the fishery, and marbled murrelet densities. The primary concern is the potential reduction of population size from direct mortality of adults and juveniles. The indirect effect of chick mortality (should a nesting pair die) is also considered during the timeframe of the nesting season (Section 7.2). The interaction of murrelets and fishing gear may or may not result in adult or sub-adult mortality.[19] Gear interaction could include negative effects ranging from harm, such as being hooked (recreational gear), swimming into a net, or becoming entangled, to mortality from drowning, if held under water for a sufficient length of time (USFWS 2004). If fisheries occur during the molting period (i.e., mid-July through end of August) when birds are flightless, marbled murrelets will dive rather than flush, which may increase risk of entanglement (USFWS 2004).

Non-Treaty recreational fisheries are calculated separately and are considered in this analysis, although the quality of the data is unknown as it depends on fisher identification skills which are variable by nature and not monitored by WDFW. Current data compilation does not allow for a probability approach to interaction risk for these fisheries, as is done for the commercial fisheries. Since we do not have data to support analysis of risk per recreational gear type identified, no differentiation is made between gear types and the fisheries are considered as a whole (all gear types combined). The projected annual murrelet interaction, using the most recent six years of available data, is 0.765 murrelet species (minimum 0.663 to maximum 0.926 birds per year) (Section 6.5.3).

Other fishery operations normally operated during daylight hours and are closely tended, thus, non-Treaty skiff, purse seine, reef, and beach seine as well as Treaty purse seine, roundhaul seine, beach seine, troll, and hook and line are expected to pose no measurable risk (Section 6.1 and Section 6.2).

The analysis of direct effects will focus exclusively on the remaining fisheries. The marbled murrelets primarily affected by the Proposed Action are those using the marine waters of Puget Sound and the Strait of Juan de Fuca (i.e., Conservation Zone 1 and a small portion of Conservation Zone 2) during the breeding season and are present at specific locations during timeframes corresponding to an active

[19] Not all bird encounters result in mortality; some bird encounters may result in release (Pierce ta l. 1996; Noviello 1999); this range estimate includes birds that may be incidentally harassed, encountered and released, or killed.

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gillnet fishery. The probability analysis in Section 6.6 makes the assumption that the birds are at the average stratum density at the specific time and location of the fishery. Probabilities are described as that of encountering zero, one, more than one, and more than two murrelets for each MCA. The probabilities are based on projections of Treaty and non-Treaty fishery effort (based on recent year averages of landings by MCA), with consideration of conservation measures, and using estimated stratum-specific interaction rates. The results demonstrate that interactions between marbled murrelets and gillnet fisheries continue to be a rare event (Section 6.6, Tables 19 and 20).

Using the method described above for Puget Sound non-Treaty commercial fisheries in MCAs 6D – 12C, the probability of interactions in fisheries for:

- 0 marbled murrelets (P(Enc. = 0)) = 0.674 to 0.998;
- 1 marbled murrelet (P(Enc. = 1)) = 0.0002 to 0.326;
- > 1 but no more than 2 marbled murrelets (P(Enc. = > 1)) = < 0.001 to 0.060; and
- > 2 marbled murrelets (P(Enc. = > 2)) = < 0.001 to 0.008.

Using the same method described above for Puget Sound Treaty commercial and ceremonial and subsistence fisheries in MCAs 4 – 13I, the probability of interactions in fisheries for:

- 0 marbled murrelets (P(Enc. = 0) = 0.2874 to 0.9997;
- 1 marbled murrelet (P(Enc. = 1)) = 0.0001 to 0.357;
- > 1 but no more than 2 marbled murrelets (P(Enc. = > 1)) = < 0.0001 to 0.37711; and
- > 2 marbled murrelets (P(Enc. = > 2)) = < 0.001 to 0.0379.

In interpreting these estimates, it is important to note the high level of uncertainty in our assumption that the strata densities are accurate at the location (a geographic point within the stratum) and for the timing of the fishery. When comparing the stratum and PSU data qualitatively, it becomes evident that many fisheries occur within locations where the PSU density value is considerably lower than the stratum average. Without information to assess the spatial variation of marbled murrelet abundance/density within each strata, we assumed a uniform density within each strata while still accounting for spatial variability in fishery effort at a finer, more resolute scale (e.g. marine catch area). This analytical approach can result in relatively higher estimations of expected interaction risk within an area of low marbled murrelet density, and so a relatively higher risk would then be assigned to each landing within that fishery based on strata data. Thus, the above estimates for determining the probability of interactions of marbled murrelet in Puget Sound Treaty and non-Treaty fisheries are considered overestimates of encounters (i.e., conservative estimates).

A recent collaborative GIS mapping study found no clear correlation between the decline in marbled murrelet density estimates from 2001 to 2014 and fishing effort for the same time period within the action area (NMFS unpublished data 2015) (Appendix I). Preliminary analysis demonstrates that overall, fishing effort (i.e., boat landings) has been decreasing within areas with historically high marbled murrelet density (Strait of Juan de Fuca, north Puget Sound), and increasing in areas with historically low murrelet density (central and south Puget Sound, Hood Canal) (NMFS unpublished data 2013 and 2015). There was an increase in fishing effort in some areas currently not surveyed for murrelets, but these fisheries are primarily in central and south Puget Sound where murrelet density is historically low. Based on this information, we see no correlation between these fisheries and marbled murrelet population decline; overall direct effects from gillnet fisheries appear to have remained the same or even decreased in specific areas over the last fourteen years due to a spatial change in distribution of fishery catch effort.

In addition, a recent joint citizen science effort[20] estimated the probability of locating a marbled murrelet was near zero (i.e., less than 0.25, where 1% would be considered significant) for 62 sites included in their survey analysis (shoreline to 300 meters; October - April) throughout Puget Sound (Ward et al. 2014). The probability of "hotspots" (concentrations of marbled murrelets) at survey locations was > 75% in north Puget Sound, and < 75% probability in central and south Puget Sound (Ward et al. 2014). Since increasing fishing effort was shown to have shifted to central and south Puget Sound (NMFS unpublished data 2015) with the rarest probability of occurrence being a listed marbled murrelet (Ward et al. 2014), and most murrelets occur between 200 and 500 meters from shore where placement of gill nets further offshore eliminates most by-catch (Courtney et al. 1996), the direct effects from gillnet entanglement appear to have actually decreased in some areas over the last twelve years based the results of the GIS and joint citizen science effort studies.

7.2 Indirect Effects

Potential indirect effects include the loss of marbled murrelet chicks in nests if the parents are killed in a gillnet fishery. Unfledged chicks depend solely on their parents for food; if both parents are killed in a gill net during the nesting season, the young will starve (USFWS 2004). If a single parent is killed in a gill net, the chick or young juvenile has a reduced chance of survival (Nelson and Hamer 1995). Not all marbled murrelets are capable of breeding every year (USFWS 2004); while the percentage of non-breeders is still unknown, McShane et al. (2004) suggested less than 10% did not breed in most years.

Chick mortalities as a result of fisheries effects is considered an infrequent event since 87% of the chicks will have fledged in Washington by early August prior to the occurrence of the majority of fisheries (Hamer et al. 2003). Less than 6% of fishery effort occurs prior to August, primarily in June and July. USFWS anticipated that approximately 13% of chicks may potentially be exposed to indirect effects of adult interactions with fishing gear, although fishing does not occur during the breeding season in all areas (USFWS 2004) and should be considered in determining overall effects. Given the

[20] Participants include: NOAA's Northwest Fisheries Science Center, Seattle Audubon Society; Burke Museum of National History and Culture, University of Washington, Washington Department of Fish and Wildlife, Puget Sound Partnership, and University of Puget Sound. This study was done using trained seabird observers.

indication that the pre-basic molt occurs between mid-July and August in Washington (USFWS 2009), nesting would be completed by this time period, as its impossible for marbled murrelets to tend nests if flightless (Carter and Stein 1995). Any anticipated indirect effects to marbled murrelet chicks would have to occur prior to the pre-basic molt period and are expected to be zero after August.

In summary, while the overall impact to chicks is unknown since adult interactions with fishing gear would not necessarily result in mortality, indirect effects to chicks are anticipated to be extremely low for the following reasons: (1) little fishing (less than 6% prior to August) occurs during the nesting season; (2) fishing does not occur during the breeding season in all areas (USFWS 2004); (3) 87% of the chicks would have fledged by early August prior to the start of major fisheries; (4) 10% of the marbled murrelet adults may not breed in a given year (McShane et al. 2004); and (5) no indirect effects on chicks are anticipated during and after the pre-basic molt stage (mid-July through August) since adults are expected to be flightless and unable to attend to the nest (Carter and Stein 1995).

Potential indirect effects may also occur to adult marbled murrelets from derelict fishing gear. Potential negative effects include injury or mortality. Nets can become entangled on obstructions such as rocky reefs, wood debris, other human placed objects within the water, or during unfavorable weather conditions. Entangled nets can be retrieved dependent on severity of the entanglement. Modern nets are usually made of artificial polyamides such as nylon and can take decades to decompose, although nets of organic polyamides, such as wool or silk, are still used but not as common. If not removed, entangled gear can continue to cause negative effects to marbled murrelets through injury or death.

Recent programs have been developed, such as the Northwest Straits Foundation (NWSF) Derelict Fishing Gear Removal, Prevention, and Research Project[21], to provide resources to remove derelict gear. In the mid-1990s, the non-Treaty fishers developed a 'best fishing practices' document that included the creation of a hotline to report and assist in the retrieval of newly lost gear and prevent it from becoming derelict. In 2002, the state of Washington passed legislation establishing a derelict gear removal program that would be administered by the federally created Northwest Straits Marine Conservation Initiative. Removal of derelict fishing gear began in 2002 after the Northwest Straits Marine Conservation Commission[22] identified this action as a high priority. In July 2009, the Northwest Straits Foundation received $4.6 million of federal funding through the American Recovery and Reinvestment Act (ARRA) and the National Oceanic and Atmospheric Administration (NOAA) toward meeting that goal. This program has reported removing 5,635 derelict fishing nets, of which a large majority were portions of

[21] The Northwest Straits Foundation is a non-profit partner of the Northwest Straits Initiative, established to support scientific, restoration, and education projects and programs in partnership with the Northwest Straits Commission and Marine Resources Committees. More information on the derelict gear removal, prevention, and research can be found at the Northwest Straits Foundation online website at: http://www.nwstraitsfoundation.org/Foundation/Current-Projects.aspx#Derelict Gear. Joint work between the Foundation and WDFW is posted regularly at: www.derelictgear.org.

[22] The Northwest Straits Commission is a regional coordinating body comprised of people who care about the marine areas where they live, and who work together to protect and restore marine resources. The Northwest Straits Commission carries out regional conservation projects and supports the work of seven Marine Resources Committees through funding, technical support, training and regional coordination. More information on the Northwest Straits Commission can be found online at: http://www.nwstraits.org/.

"legacy" gillnets (defined as nets estimated to have been in the water four years or more), from Puget Sound, the San Juan Islands, and the Strait of Juan de Fuca between 2002 and May of 2015. The retrievals reported also include "newly lost" nets (defined as nets estimated to have been in the water three years or less).

In 2012, the state passed a law (RCW 77.12.870) requiring non-Treaty commercial fishermen to report to WDFW any lost or abandoned gear within 24 hours so that efforts can be made to locate and remove it as soon as possible (WDFW 2015b). The co-managers provide annual reports to the NMFS regarding reporting and accounting for derelict net gear in accordance with the Terms and Conditions of the Puget Sound Chinook Harvest Plan (NMFS 2011) and work in close coordination with the NWSF in addressing derelict gear concerns. In July 2013, the Washington State Legislature approved $3.5 million[23] for WDFW to work in partnership with NWSF to remove derelict fishing nets in shallow (< 105') waters of Puget Sound.

The NWSF also encourages reporting of all lost nets within 24 hours of loss. The NWSF regularly coordinates with co-managers and enforcement staff whenever the report of a lost (or found) net is received in order to ensure retrieval of all lost nets before they become derelict (J. Drinkwin, pers. comm., 2015). In the last two years, the NWSF has received 38 reports of confirmed newly lost nets (or portions of nets) and have been able to successfully remove 24 of those nets (J. Drinkwin, pers. comm., 2015). No marbled murrelets have been identified in derelict gear to date; however, marbled murrelets exhibit similar underwater feeding strategies to the bird species found on a regular basis (J. Drinkwin, pers. comm., 2015). Nets have been found in areas showing high summer density for the marbled murrelet (i.e., south Lopez Island) (J. Drinkwin, pers. comm., 2015).

The NWSF identifies species of seabirds encountered in derelict gear through bone specimen analysis. Over 900 of the 1,102 seabird species were identified using bone specimens, retrieved from 5,681 nets removed from Puget Sound from 2002 to December of 2015, as presented in Appendix J (J. Drinkwin, pers. comm., 2015). The specimens are outsourced to confirm identification to at least family groups. Two birds were identified as *Alcidae sp.* of the 1,102 seabirds encountered. It is not possible to determine exact impacts to marbled murrelets based on this data, but if the two *Alcidae sp.* are assumed to be marbled murrelet, this represents 0.18% of the total seabirds retrieved. We anticipate that marbled murrelets will continue to be negatively affected by derelict gear, but the impact would be small and

[23] WDFW news release available online at: http://www.nwstraitsfoundation.org/uploads/pdf/Derelict%20Gear/DG-News%20Release%20Funding%20Aug%202013.pdf.

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continue to lessen over time as the NWSF derelict fishing gear project continues and fishers report lost gear as promptly as possible.

8. Cumulative Effects

Cumulative effects of future State, Tribal, local, or private actions are that certain to occur in the action area include the release of petroleum products and contaminants, discarded material from boats, and disturbance from recreational or commercial boats and research monitoring vessels in the marine environment.

Marbled murrelets within Conservation Zone 1 have a high probability of experiencing large oil spills and other marine pollution (USFWS 2007). Puget Sound contains onshore oil facilities, tanker ports with high amounts of boat traffic annually, large industrial development, high numbers of tanker and other shipping routes, and bypass traffic from southern British Columbia (USFWS 2007). The action area has experienced several oil spills and other pollution events that have affected local seabirds (USFWS 2007).

In northern Washington and southern British Columbia, crude oil spills greater than 1,000 barrels are anticipated every 2.5 years and spills of all other petroleum products every 1.3 years (USFWS 2001). Significant numbers of murrelets could be negatively affected (e.g., harm and mortality) by spills from crude oil and other petroleum products (Burger 1995). McShane et al. (2004) stated that one large oil spill in Alaska (e.g., such as the former Exxon Valdez event) has the potential to wipe out most of the marbled murrelets within a Conservation Zone. Minor oils spills that occur more frequently may also have negative effects on individual murrelets foraging, socializing, or loafing in marine areas. Even without a large spill, other oil spills on a lesser scale are likely to occur and impact the marbled murrelet population although their expected frequency of occurrence is difficult to predict (USFWS 1997). Medium to small oil spills from tankers and other commercial traffic that pass by coastal areas far out to sea are likely to have less impact on marbled murrelets (USFWS 1997). Oil pollution has had a considerable impact on the marbled murrelets in western Washington in the past. However, these effects have likely been felt only sporadically by the local population (USFWS 2007). Stricter regulations on commercial marine vessels in the 1990s have decreased the threat of oil spills in the marine environment. However, due to economic growth in the last twenty years, boat shipping traffic has increased, which indicates that pollution from oil spills will likely continue.

Marine pollutants and contaminants, which have the potential to degrade the marine environment, are anticipated to continue. Marine pollutants such as those from industrial sources (e.g., pulp mills, agriculture, highways) may negatively affect marbled murrelets through harm, including prey impacts or mortality. Other main sources of marine pollution in Washington are chlorinated hydrocarbon contaminants and chemical dumping, which can include effluent from onshore sources and direct dumping of chemicals at sea (Fry 1995). Eight marbled murrelets recovered from gillnet fisheries in the late 1990s in Puget Sound were analyzed for pollutants and contaminants. All specimens were within normal ranges for seabirds from clean environments (J. Grettenberger, pers. comm., in USFWS 1997).

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The extent of marine pollutants and contaminants from industrial sources is unknown (McShane et al. 2004) and effects of other marine pollution sources on marbled murrelets have not been fully investigated.

Discarded material from boats such as cigarette lighters, light sticks, and other plastic debris that float in the water column may be consumed by seabirds while they are foraging (USFWS 2007). Ingestion of plastic may cause negative effects such as dehydration and starvation, intestinal blockage, internal injury, or exposure to dangerous toxins (Cousins 1998 and Seivert and Sileo 1993 in USFWS 2007). Impacts from discarded material have not been documented in marbled murrelets but it is reasonable to assume that ingestion of small plastics may occur (USFWS 2007). The extent of effects from discarded material from boats on marbled murrelet is unknown.

Disturbance from recreational and commercial boaters as well as research vessels have the potential to negatively affect marbled murrelets. Disturbance from fishing vessels is included in Section 7.1. Boat disturbance is known to provoke behavioral responses in marbled murrelets (Kuletz 1996; Speckman 1996; Nelson 1997; McShane et al. 2004) and the majority will move away from approaching motor vessels but the long-term effects to marbled murrelets are unclear (USFWS 2007).

In summary, cumulative effects to marbled murrelets from the marine environment (e.g., petroleum products and contaminants, discarded material, and disturbance from vessels) are likely to have negative effects. The extent of these impacts to marbled murrelets have not been quantified (USFSW 2007). Due to economic growth in Puget Sound, an increase in oil and chemical spills and discharges as well as boat traffic is likely to increase in the future (Puget Sound Research Council 2004). Although these future non-Federal actions represent continuing threats, the significance or extent of these negative effects to marbled murrelets in the action areas is unknown.

9. Conclusion

As described above, the proposed fisheries have the rare potential for marbled murrelet interactions resulting in release (unharmed) and harm from net injury or indirect mortality. Risk of non-Treaty fisheries on marbled murrelet varies from the probability of no interactions ranging from 0.674 to .998 to the probability of over 2 marbled murrelet interactions (P(Enc. = > 2) ranging from < 0.001 to 0.008. Risk of Treaty fisheries on marbled murrelet varies from the probability of no interactions ranging from 0.2872 to .9997 to the probability of over 2 marbled murrelet interactions (P(Enc. = > 2) ranging from < 0.001 to 0.0379. The proposed fisheries may also result in a small amount of disturbance to marbled murrelets or their avoidance of fishing areas. Marbled murrelet interactions with fishing gear during the nesting season may have a small effect on nesting birds and their chicks (0.007%) exposed to indirect effects of adults entangled in fishing gear. The overall impact to chicks is unknown since adult interactions with fishing gear would not necessarily result in mortality but mortality of both parents is assumed in the estimate of risk to unfledged chicks. In addition, potential indirect effects may also include the loss of marbled murrelets in derelict fishing gear. Because, (1) no marbled murrelets have been identified in derelict gear from 2001 to 2014 (Section 7.2), (2) it is impossible to determine

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marbled murrelet mortality based on available data, and (3) even if risk assumptions are made with the existing derelict gear data, derelict fishing gear from the proposed action ranges from no risk up to a small (i.e., 0.18%) potential risk to marbled murrelets (Section 7.2).

10. Reporting Requirements

The co-managers recommend marbled murrelet encounters be reported to Federal agencies (e.g., US Fish and Wildlife Service and NOAA Fisheries) by May 15 annually. The previous 2001 (non-Treaty) and 2004 (Treaty) biological opinions (USFWS 2011 and USFWS 2004) and 2010 joint take extension (USFWS 2010) have two reporting dates: January 1 for estimated marbled murrelet take from previous year's fisheries, and April 1 for upcoming fisheries information. Co-managers are not able to meet either time frame for reporting since: (1) not all fishery data are available by January 1; and (2) timing of the North of Falcon process prevents availability of the North of Falcon agreed-to fisheries for the upcoming year by April 1. Combining the reports and moving the annual reporting date to May 15 will allow co-managers to complete reporting requirements for marbled murrelet encounters in Puget Sound Treaty and non-Treaty fisheries in a timely manner.

The co-managers would summarize annual gillnet fishing effort and provide those data to the USFWS annually in May. These reports will allow evaluation of potential murrelet interactions with the anticipated take using the same methodology applied in this biological assessment. The methodologies may be re-evaluated when new information on interaction risk, murrelet distribution, or murrelet density becomes available. Fisher-reported encounters with marbled murrelets would be reported immediately to the USFWS and any mortalities will be made available to the Fish and Wildlife Service for examination.

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APPENDICES

Appendix A: Marine Area Fishery Management Periods. (K. Henry, pers. comm. 2014).

Catch Area	Spring Chinook		S/F Chinook		Pink		Coho		Summer Chum		Fall Chum		Winter Chum		Winter Steelhead	Early Sockeye	Mid-Late Sockeye	
4B	4/16	6/16	6/17	8/13	8/14	9/6	8/14	10/10		\e	10/11	11/10	11/11	12/30		6/23 7/14 \c	7/15	8/11
5	4/16	6/20	6/25	8/14	8/14	9/6	8/15	10/10		\e	10/11	11/10	11/11	12/30		6/23 7/16 \c	7/17	8/14
6	4/16	6/30	7/1	8/28	8/16	9/8	8/27	10/13		\e	10/14	11/14	11/15	1/3		6/24 7/22 \c	7/23	8/16
6A	4/16	6/12	6/12	9/3	8/4	9/13	9/4	10/16		\e	10/17	11/15	11/15	1/3		6/24 7/19 \c	7/23	8/17
6C	4/16	6/26	6/27	8/17	8/15	9/7	8/17	10/10		\e	10/11	11/11	11/12	1/1		6/23 7/21 \c	7/22	8/15
6D			7/25	9/18	8/8	9/25	9/18	10/26			10/26	11/30			12/2 3/31			
7	4/16	7/4	7/5	9/8	8/17	9/7	9/8	10/16		\e	10/17	11/14 \d	11/15	1/1		6/26 7/23 \c	7/24	8/17
7A	4/16	7/7	7/8	9/10	8/17	9/9	9/11	10/16		\e	10/16	11/13 \d	11/14	12/30		6/26 7/23 \c	7/24	8/17
7B	4/15		\b	9/7	6/30	8/17	9/8	10/26			10/27	12/14						
7C	4/15			10/10			10/15	10/26			10/27	12/7						
7D			7/23	9/7			9/8	10/26			10/27	12/14						
7E			7/30	9/9														
8	4/15	6/16	6/17	8/31	8/22	9/15	9/1	10/26			10/27	11/28			12/2 4/15	6/24 7/13		
8A			7/21	9/9	8/9	9/9	9/10	10/21			10/22	11/30			12/1 3/30	\e		
8D			8/4	9/21			9/22	11/7			11/8	12/17						
10	4/15	6/29	7/1	9/7	8/18	9/10	9/8	10/12	9/8	10/11	10/12	11/30	12/1	1/1		6/21 7/18 \c		
10A			7/1	9/14			9/15	11/2			11/3	11/30				6/21 7/18 \c		
10E			7/1	9/13			9/27	10/18	9/28	10/11	10/19	12/31						
11	4/15	6/29	7/1	9/5	8/11	9/10	9/6	10/10	9/10	10/11	10/12	11/30	12/1	1/8				
11A	4/15	6/29	7/1	8/29	8/18	9/5	8/30	10/17			10/19	12/10						
13	4/15	6/29	7/1	9/19	8/10	9/25	9/20	10/17	9/17	10/11	10/12	11/30	12/1	1/15				
13A	4/15	8/10	8/8	9/17	8/16	9/17	9/17	10/24			10/23	12/5						
13C			7/15	10/13			10/14	11/30			10/12	11/30	12/1	1/16				
13D			7/1	9/21			9/22	10/12	9/17	10/11	10/12	12/31						
13E			7/1	9/21			9/22	10/12			10/12	12/31						
13F			7/1	9/21			9/22	11/6			11/7	12/12						
13G			7/1	9/21			9/22	11/6			11/7	12/12						
13H			7/1	9/21			9/22	10/12			10/12	12/31						
13I			7/1	9/21			9/22	10/12			10/12	12/31						
13J			7/1	9/21			9/22	10/12	9/22	10/26	10/12	12/31						
13K			7/1	9/21			9/22	11/6	9/22	10/26	11/7	12/31						
9A		\e					9/16	11/2			11/3	12/1			12/5 3/31			
12	4/15	7/13	7/14	9/5	7/30	9/27	9/10	10/17	8/1	10/10	10/18	11/20						
12A							8/30	10/15	8/1	10/10	10/15			12/26				
12B	4/15	7/15	7/16	9/13	7/30	9/27	9/14	10/23	8/1	10/10	10/24	11/20						
12C	4/15	7/16	7/17	9/18	7/30	9/11	9/17	10/28	8/1	10/10	10/29	11/23						
12D	4/15	7/16	7/17	9/18			9/17	10/28	8/1	10/15	10/29	11/23						

\a Management periods are adjusted annually for administration of fisheries
\b Management period currently under technical dispute; subject to change according to long range management planning
\c FW & PNPTC stock abundance date, April 1993 and June 1994
\d Management period under technical review
\e Stock present, but no management period yet established

AR010724

Appendix B: Non-Treaty commercial salmon drift gillnet landings 2001-2014, presented by marine area and by month.

2001:											2001 Monthly
Marine Area	7	7A	7B	7C	8	8A	8D	10	11	12	Totals
JULY											
AUG	70	59	141	50	2	6					328
SEPT			302	17			2				321
OCT			284			11	3	78	12	35	423
NOV			103		7	33	1	37	5	22	208
DEC							1				1
Area Totals	70	59	830	67	9	50	7	115	17	57	1281

2002:												2002 Monthly
Marine Area	7	7A	7B	7C	8	8A	10	11	12	12B	12C	Totals
JULY												0
AUG	114	247	150	57								568
SEPT			230	10								240
OCT	1	19	93		2	12	44	16	11			198
NOV	1	1	69		13	8	19	11	4	2	2	130
DEC			5									5
Area Totals	116	267	547	67	15	20	63	27	15	2	2	1141

2003:											2003 Monthly
Marine Area	7	7A	7B	7C	8	8A	8D	10	11	12	Totals
JULY	11	11									22
AUG	155	139	84	89							467
SEPT			186	54							240
OCT	10	13	64			2	2	69	33	43	236
NOV	25	3	86		2	16		59	27	21	239
DEC			2								2
Area Totals	201	166	422	143	2	18	2	128	60	64	1206

2004:												2004 Monthly
Marine Area	7	7A	7B	7C	8	8A	8D	10	11	12	12B	Totals
JULY	69	39										108
AUG	222	67	48	125								462
SEPT			204	40			16					260
OCT	17	24	130		2	29	11	230	33	28	1	505
NOV	5	1	58		14	22	3	61	12	66		242
DEC												
Area Totals	313	131	440	165	16	51	30	291	45	94	1	1577

2005:												2005 Monthly
Marine Area	7	7A	7B	7C	8	8A	8D	10	11	12	12B	Totals
JULY												
AUG	50	68	17	120								255
SEPT	36	51	157	52			4					300
OCT	7	12	51			7	2	222	39	127	1	468
NOV	6		75		3	27		99	49	89	32	380
DEC												
Area Totals	99	131	300	172	3	34	6	321	88	216	33	1403

2006:											2006 Monthly
Marine Area	7	7A	7B	7C	8	8A	8D	10	11	12	Totals
JULY											
AUG	234	235	59	172							700
SEPT	5	46	244	79			2				376
OCT	35	47	106		3	86	2	223	56	62	620
NOV	20		139		40	100		99	34	50	482
DEC											
Area Totals	294	328	548	251	43	186	4	322	90	112	2178

2007:												2007 Monthly
Marine Area	7	7A	7B	7C	8	8A	8D	10	11	12	12B	Totals
JULY												
AUG		2	37	157								196
SEPT	1		142	88			4					235
OCT	31	19	50			63	5	248	40	140	5	601
NOV	18	9	71		13	304	1	50	8	248	9	731
DEC						1						1
Area Totals	50	30	300	245	13	368	10	298	48	388	14	1764

2008:												2008 Monthly
Marine Area	7	7A	7B	7C	8	8A	8D	10	11	12	12B	Totals
JULY	5	1										6
AUG	2	1	53	201								257
SEPT			251	18			12					281
OCT	29	46	11			102	4	197	33	284	29	735
NOV	4	2	31		2	302	1	111	27	142	16	638
DEC												
Area Totals	40	50	346	219	2	404	17	308	60	426	45	1917

2009:												2009 Monthly
Marine Area	7	7A	7B	7C	8	8A	8D	10	11	12	12B	Totals
JULY												
AUG	7	2	24	104	19	8		1				165
SEPT	7	4	189	28			15					243
OCT	35	10	12				1	130	28	205	2	423
NOV	1	2	16					91	21	112	19	262
DEC												
Area Totals	50	18	241	132	19	8	16	222	49	317	21	1093

2010:											2010 Monthly
Marine Area	7	7A	7B	7C	8A	8D	10	11	12	12B	Totals
JULY											
AUG	197	269	30	79							575
SEPT	31	52	194	20		2					299
OCT	8	7	94		19		212	17	191	14	562
NOV			59			9	176	26	126	14	410
DEC											
Area Totals	236	328	377	99	19	11	388	43	317	28	1846

2011:													2011 Monthly
Marine Area	7	7A	7B	7C	8	8A	8D	10	11	12	12B	12C	Totals
JULY													
AUG	108	73	37	240	10	3							471
SEPT	4	6	414	14	3	1	9						451
OCT	25	102	11				1	159	22	240	21		581
NOV	12	4	79					291	11	97	5	6	505
DEC													
Area Totals	149	185	541	254	13	4	10	450	33	337	26	6	2008

2012:											2012 Monthly
Marine Area	7	7A	7B	7C	8D	10	11	12	12B	12C	Totals
JULY											
AUG	43	37	14	278							372
SEPT			299	71	3						373
OCT	25	44	36	1	1	269	22	209	6		613
NOV	4	3	38			105	5	65	12	4	236
DEC											
Area Totals	72	84	387	350	4	374	27	274	18	4	1594

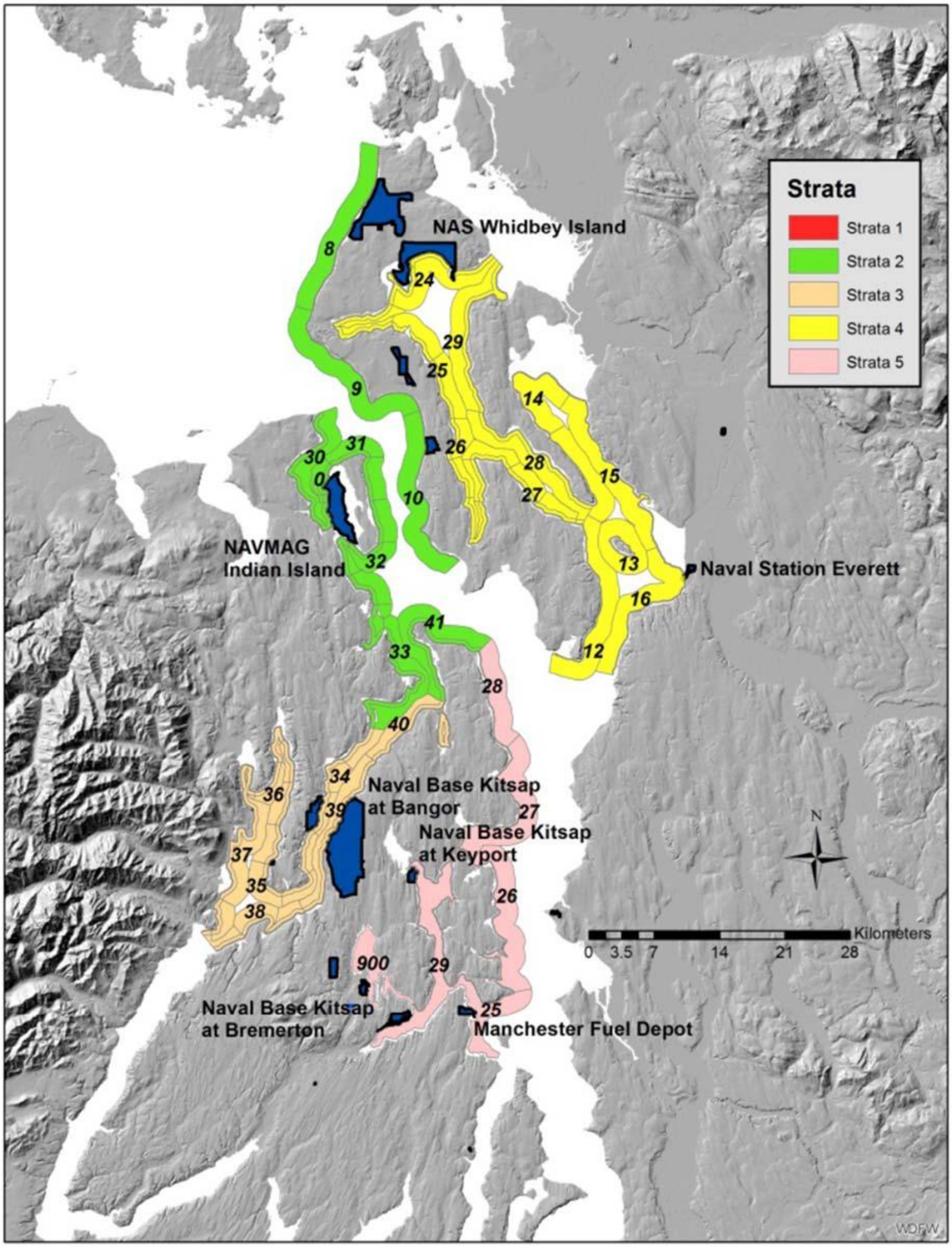
2013:												2013 Monthly
Marine Area	7	7A	7B	7C	8	8A	8D	10	11	12	12B	Totals
JULY												
AUG	7	11	40	301	16	16		3				394
SEPT	8	13	401	41	8		2					473
OCT	30	99	53				2	53	3	212		452
NOV		10	81					109	3	101	27	331
DEC												
Area Totals	45	133	575	342	24	16	4	165	6	313	27	1650

2014:												2014 Monthly
Marine Area	7	7A	7B	7C	8	8A	8D	10	11	12	12B	Totals
JULY												
AUG	118					229	5	78	13			443
SEPT	7				12	85	118	61	10			293
OCT	17	135	8	299	48	100	23			1		631
NOV		160	7	42			197					406
DEC												
Area Totals	142	295	15	341	60	414	343	139	23	1		1773

Appendix C. Map showing set net fishing locations inside Tulalip Bay (Area 8D).

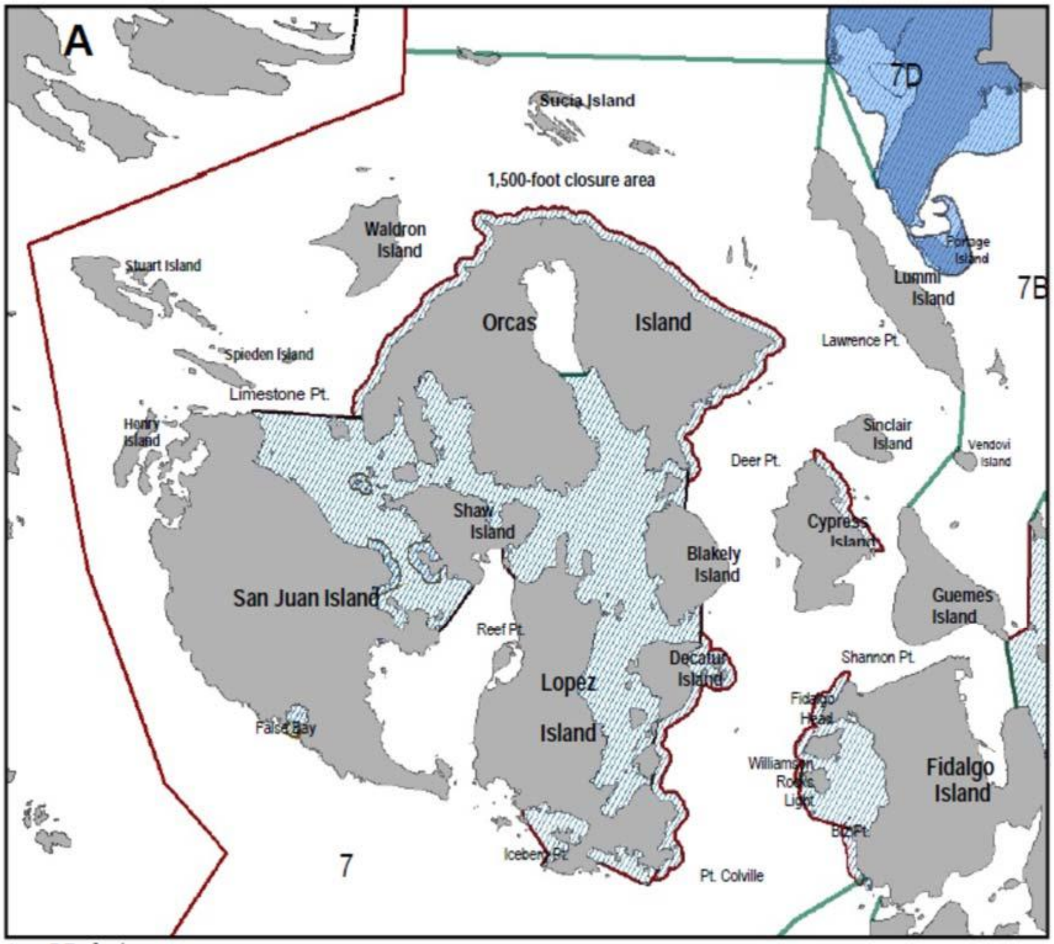
AR010726

Appendix D: Winter stratum and primary sampling unit locations. Strata are defined in the figure Key and PSUs are labeled on the map. (Pearson and Lance 2014).



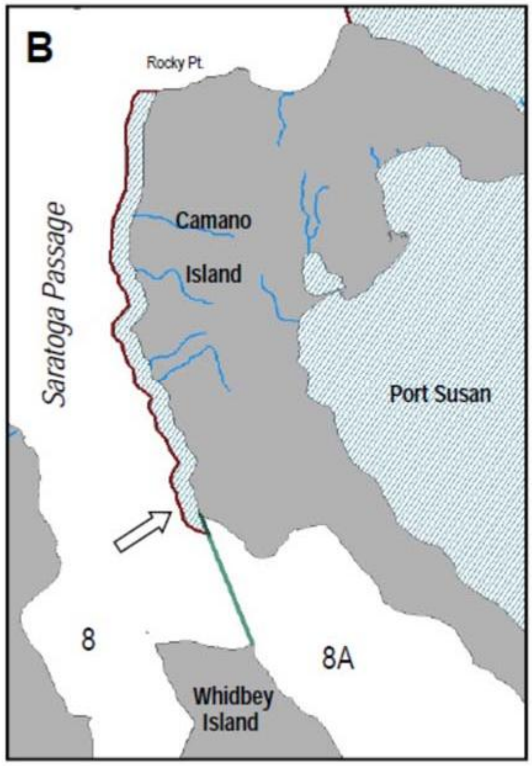
AR010727

Appendix E: Non-Treaty commercial gillnet fishery area closures.

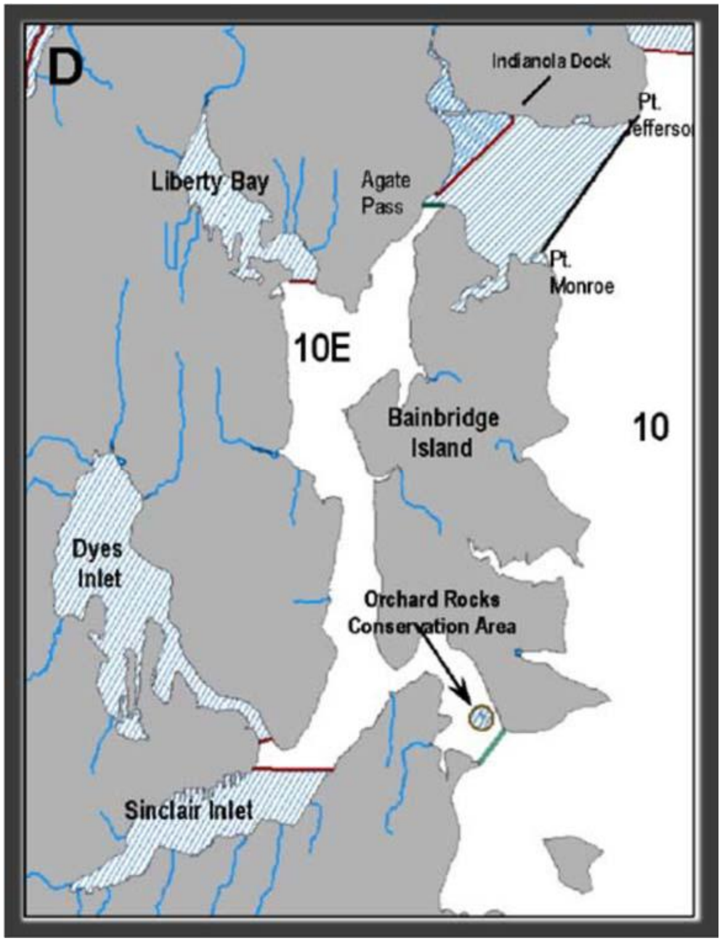


MCA 7/7A closures.

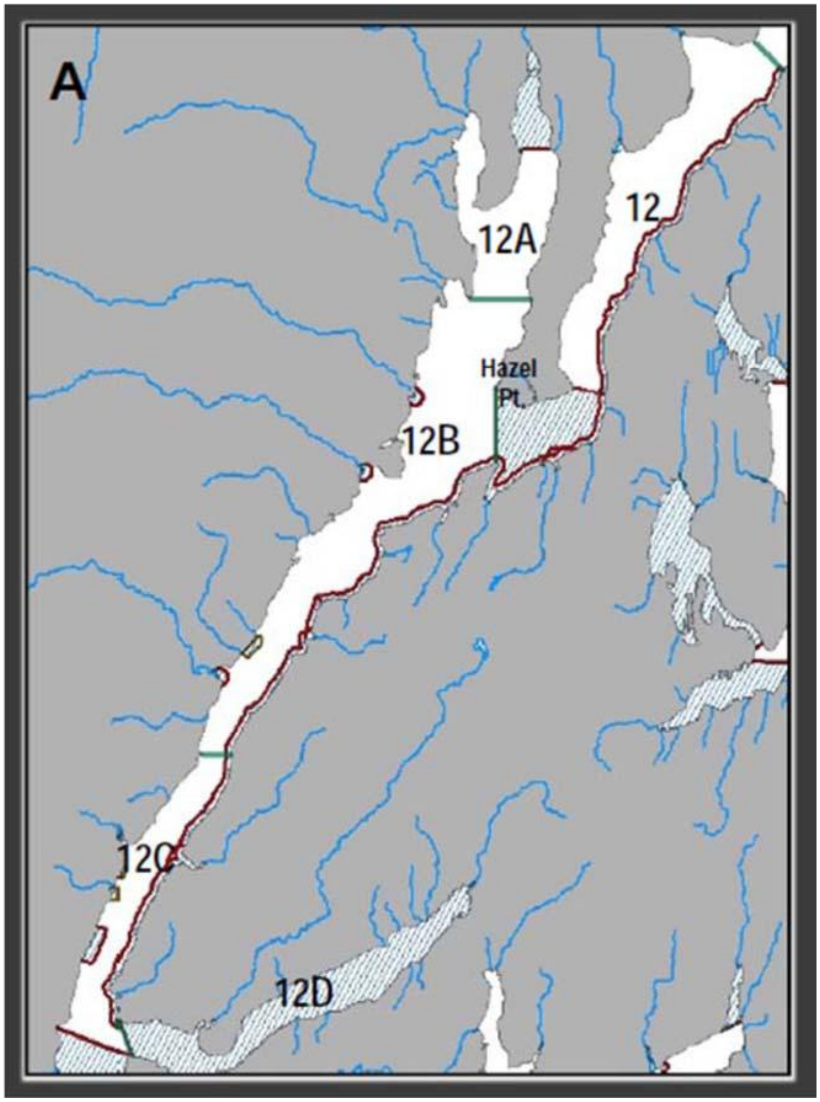
AR010728



MCA 8/8A closures.



MCA 10&11 closures.



Hood Canal area closures.

AR010731

Appendix F. Anecdotal seabird observations 2001-2013 during Non-Treaty purse seine fisheries (WDFW, unpublished data).

YEAR	MONTH	AREA	CONDITION: alive	dead	injured	unknown
2001	AUGUST	7	3 UN-ID'd			
	OCTOBER	11	1 UN-ID'd			
2003	AUGUST	7	39 AUKLET		7 AUKLET	12 AUKLET
		7				4 UN-ID'd
		7A	2 UN-ID'd			
	SEPTEMBER	7	1 AUKLET		1 MURRELET	
	OCTOBER	10	1 PIGEON GUILLEMOT			
		10	2 MURRE			
		11	1 MURRE			
		11	4 MURRELET			
		11	4 UN-ID'd			
		8A	1 GREBE			
	NOVEMBER	12	1 GREBE			
2004	OCTOBER	7	4 GREBE			
		7A	4 MURRE			
	NOVEMBER	11	1 MURRE			
		8A	1 UN-ID'd			
2005	AUGUST	7	42 MURRE		9 MURRE	
	SEPTEMBER	7	1 MURRE			
2006	OCTOBER	8A	1 GREBE			
	NOVEMBER	8A	1 UN-ID'd			
2007	AUGUST	7	1 MURRE			
			1 GREBE			
	SEPTEMBER	7A			1 MURRE	
	OCTOBER	7A	1 MURRE			
	NOVEMBER	11			2 MURRE	1 MURRE
2008	OCTOBER	10	1 LOON			
		11	3 UN-ID'd			
	NOVEMBER	10	1 UN-ID'd			
		11	1 UN-ID'd			
2009	OCTOBER	7	1 UN-ID'd			
2010	AUGUST	7	5 UN-ID'd			
	NOVEMBER	11	1 UN-ID'd			
2011	AUGUST	10	1 UN-ID'd			
		7A		1 SCOTER		
	OCTOBER	10	1 UN-ID'd			
	NOVEMBER	10	1 UN-ID'd			
		11	1 MURRE			
		11	4 UN-ID'd			
2012	AUGUST	7	3 UN-ID'd	2 UN-ID'd		
	NOVEMBER	10	3 UN-ID'd			
		11	1 MURRE			
2013	OCTOBER	10	1 MURRE			
		11	1 AUKLET			
		11	3 MURRE			

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Appendix G. Anecdotal seabird observations 2001-2013 during Non-Treaty gillnet fisheries (WDFW, unpublished data).

YEAR	MONTH	AREA	CONDITION: alive	dead	injured	unknown
2001	OCTOBER	11	1 UN-ID'd			
	NOVEMBER	10	7 UN-ID'd			
		11	1 UN-ID'd			
2003	OCTOBER	11	1 MURRE			
	NOVEMBER	11	3 MURRE			
		8A	2 MURRE			
2006	OCTOBER	7	6 MURRE	10 MURRE		
2007	OCTOBER	10			1 MURRE	
2011	AUGUST	7		6 AUKLET 5 MURRE 1 UN-ID'd		
		7A		2 MURRE 1 UN-ID'd		
	OCTOBER	10		1 MURRE		
		12		1 UN-ID'd		
	NOVEMBER	10		3 AUKLET 12 MURRE 1 UN-ID'd		2 AUKLET
		11		3 MURRE		
2012	AUGUST	7		4 AUKLET 3 MURRE		
	NOVEMBER	10		6 MURRE		
		7		1 MURRE		
2013	OCTOBER	10		1 MURRE		
		7		1 UN-ID'd		
	NOVEMBER	10		7 MURRE		2 LOON

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Appendix H. Hindcasting Marbled Murrelet Densities by Strata in Zone 1 for 1994

The marbled murrelet - gillnet interaction rate ($\widehat{IR}$) is assumed to be proportional to marbled murrelet density in a fishing area (i.e., if the density of marbled murrelets in a fishing area increases then the number of gillnet interactions for a given level of fishing effort is expected to increase). There are no estimates of marbled murrelet density in the study areas for the year of the Pierce et al. (1996) $\widehat{IR}$ study (1994) to pair with the interaction rates estimated by the study. We therefore used standard regressions methods to hindcast marbled murrelet densities (birds/km^2) for strata 1, 2, and 3 in Zone 1 for 1994.

We examined regressions using untransformed and LN transformed estimates of density ($\hat{\Delta}$) from the years 2001-2014. The LN transformed estimates were examined because this is currently the preferred method of estimating long-term rates of change in marbled murrelet density using the USFWS survey data. Figure 1 shows annual estimates of marbled murrelet densities for strata 1, 2, and 3 in Zone 1 for the years 2001 to 2014.

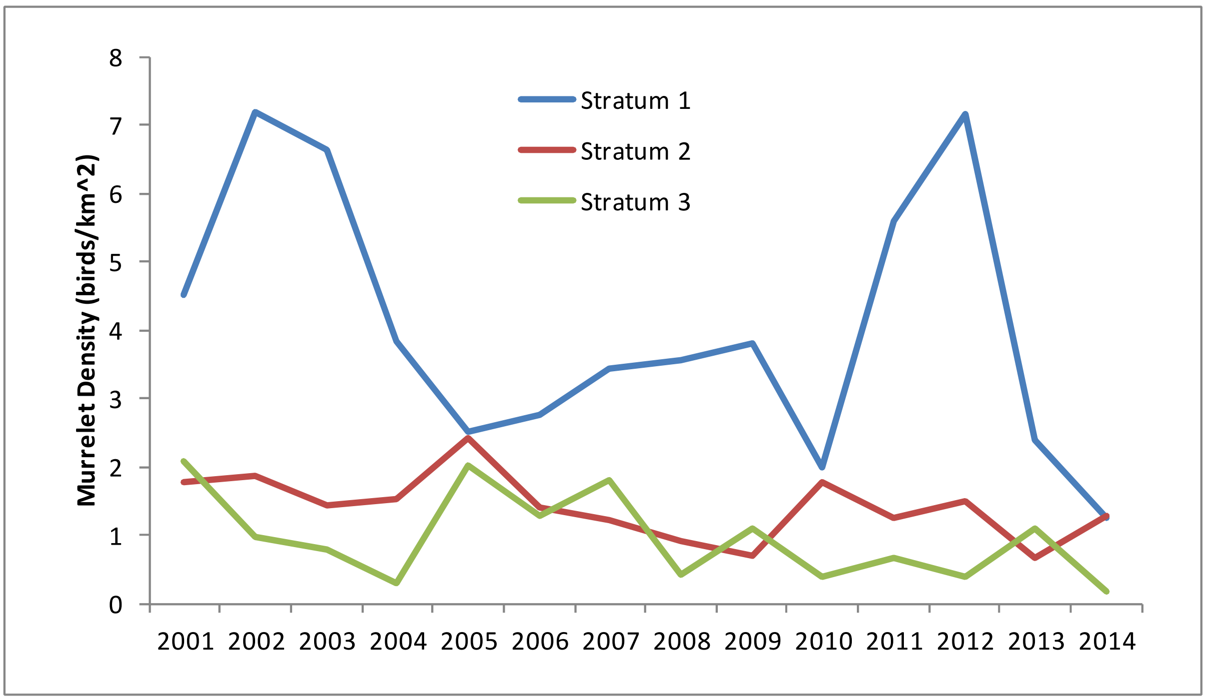

Figure 1. Annual estimates of marbled murrelet mean density (birds/km^2) for the three strata in Zone 1.

Stratum 1 Regression Models:

Summary regression output for the stratum 1 models using untransformed and LN transformed annual density estimates are shown in Table 1. Neither model is significant or explains much of the variation in annual density estimates. Figure 1 shows the fit of each model to the estimated density data.

Table 1. Summary regression output for the stratum 1 models using untransformed and LN transformed annual density estimates.

Debsity

Regression Stats.	
R Square	0.136
Adj. R Square	0.0645
SE	1.868
Observations	14

ANOVA

	Df	SS	MS	F	Signifigance
Regression	1	6.619	6.6190	1.897	0.194
Residuals	12	41.871	3.4892		
Total	13				

Coefficients		St. Error	t Stat	P-value
Intercept	346.47	248.61	1.394	0.189
X-Variable	-0.1706	0.124	-1.377	0.194

LN(Density)

Regression Stats.	
R Square	0.211
Adj. R Square	0.1452
SE	0.4732
Observations	14

ANOVA

	df	SS	MS	F	Signifigance
Regression	1	0.719	0.719	3.209	0.0985
Residuals	12	2.688	0.224		
Total	13				

Coefficients		St. Error	t Stat	P-value
Intercept	114.113	62.987	1.812	0.0951
X-Variable	-0.0562	0.0314	-1.791	0.0985

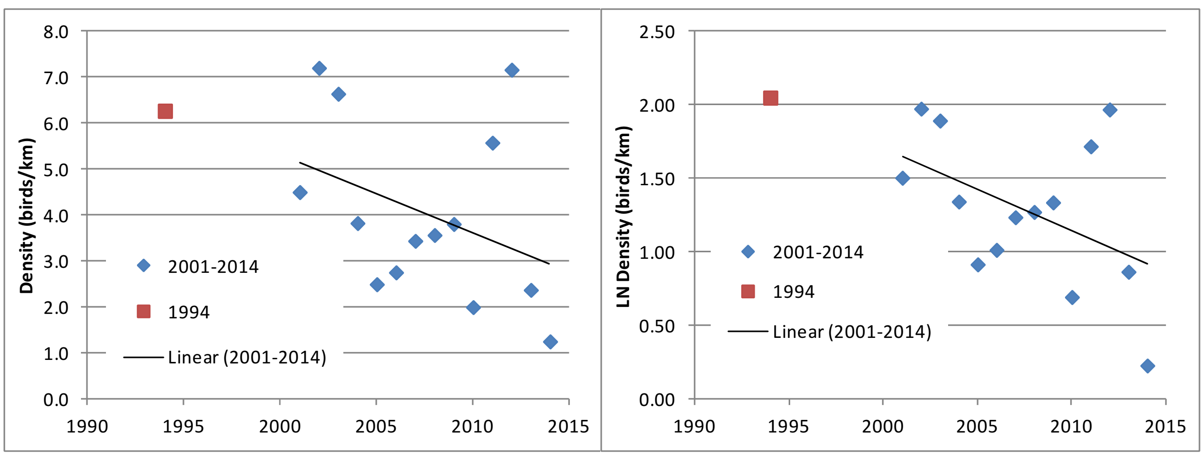

Figure 1. Estimated regression models for stratum 1 compared to untransformed and LN transformed mean density estimates from 2001-2013. Hindcast density for stratum 1 in 1994 is shown, also.

Stratum 2 Regression Models:

Summary regression output for the stratum 2 models using untransformed and LN transformed annual density estimates are shown in Table 2. The regression model using LN transformed mean density estimates for stratum 2 had significant slope and intercept estimates ($P < 0.05$). The regression model using untransformed data was slightly above the significance level. Both models model explain about 30% of the variation in annual density estimates. Figure 2 shows the fit of each model to the estimated density data.

Table 2. Summary regression output for the stratum 2 models using untransformed and LN transformed annual density estimates.

Debsity

Regression Stats.	
R Square	0.2664
Adj. R Square	0.2053
SE	0.426
Observations	14

ANOVA	df	SS	MS	F	Signifigance
Regression	1	0.791	0.791	4.358	0.059
Residuals	12	2.178	0.181		
Total	13				

Coefficients		St. Error	t Stat	P-value
Intercept	119.78	56.701	2.112	0.056
X-Variable	-0.059	0.0282	-2.088	0.059

LN(Density)

Regression Stats.	
R Square	0.265
Adj. R Square	0.2042
SE	0.3307
Observations	14

ANOVA	df	SS	MS	F	Signifigance
Regression	1	0.474	0.474	4.335	0.0594
Residuals	12	1.312	0.109		
Total	13				

Coefficients		St. Error	t Stat	P-value
Intercept	91.9264	44.016	2.088	0.0587
X-Variable	-0.04565	0.0219	-2.082	0.0594

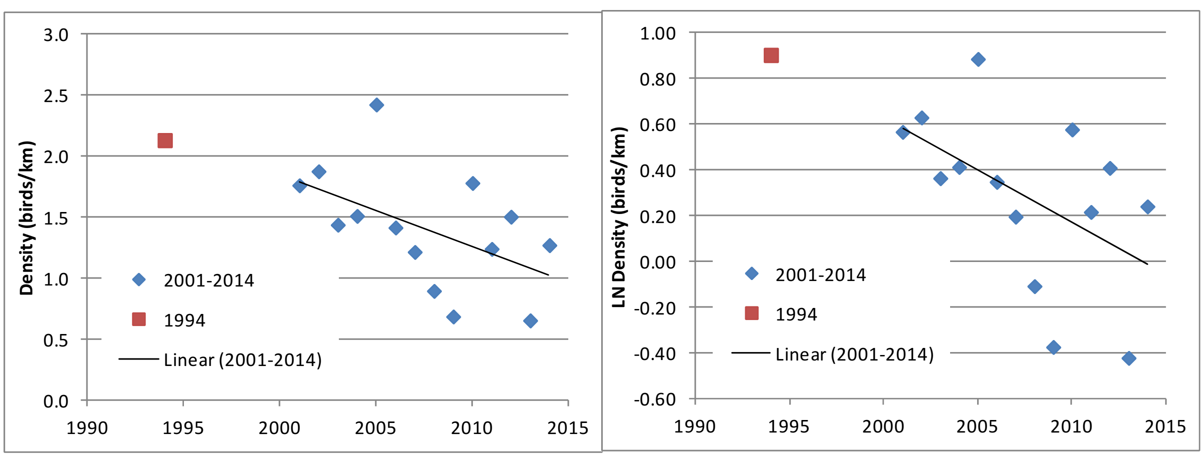

Figure 2. Estimated regression models for stratum 2 compared to untransformed and LN transformed mean density estimates from 2001-2013. Hindcast density for stratum 2 in 1994 is shown, also.

Stratum 3 Regression Models:

Summary regression output for the stratum 3 models using untransformed and LN transformed annual density estimates are shown in Table 3. Neither model is significant or explains much of the variation in annual density estimates. Figure 3 shows the fit of each model to the estimated density data.

Table 3. Summary regression output for the stratum 3 models using untransformed and LN transformed annual density estimates.

Debsity

Regression Stats.	
R Square	0.243
Adj. R Square	0.180
SE	0.579
Observations	14

ANOVA	df	SS	MS	F	Signifigance
Regression	1	1.292	1.292	3.854	0.0732
Residuals	12	4.0254	0.335		
Total	13				

Coefficients		St. Error	t Stat	P-value
Intercept	152.29	77.09	1.976	0.0717
X-Variable	-0.07538	0.038	-1.963	0.0732

LN(Density)

Regression Stats.	
R Square	0.2498
Adj. R Square	0.1841
SE	0.7016
Observations	14

ANOVA	df	SS	MS	F	Signifigance
Regression	1	1.936	1.936	3.933	0.0707
Residuals	12	5.907	0.492		
Total	13				

Coefficients		St. Error	t Stat	P-value
Intercept	184.889	93.378	1.980	0.0711
X-Variable	-0.09224	0.0465	-1.983	0.0707

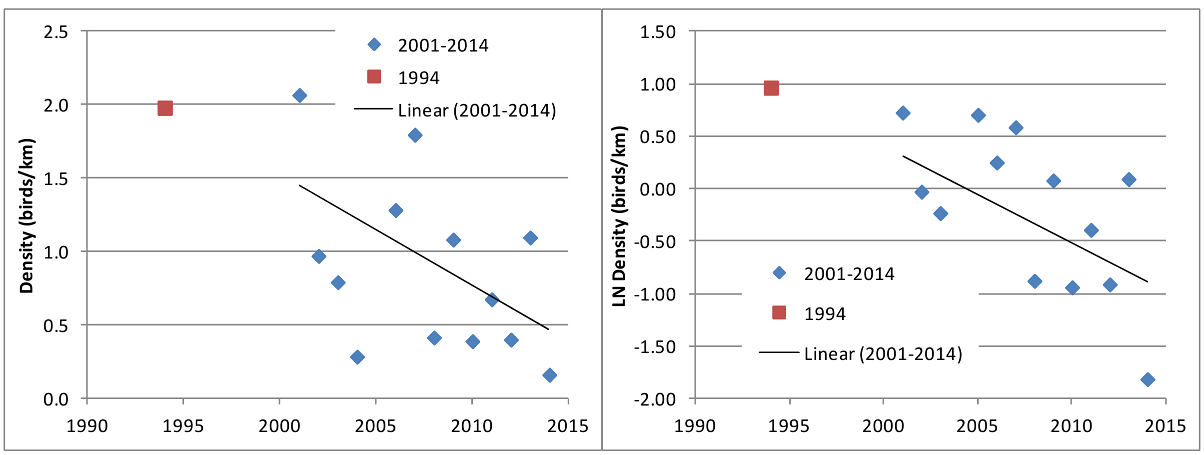

Figure 3. Estimated regression models for stratum 3 compared to untransformed and LN transformed mean density estimates from 2001-2013. Hindcast density for stratum 3 in 1994 is shown, also.

Estimates of Density for 1994 from Model Hindcasts:

Table 4 compares the estimated densities of marbled murrelets in 1994 for each of the regression models for each of the strata. Estimates from the models using untransformed and LN transformed density estimates are generally similar, the largest relative percent difference was for stratum 2 (18%). Compared to the models using untransformed data, the models using LN transformed data estimated higher densities in 1994 for strata 1 and 2 but a lower density for stratum 3. The hindcast densities for 1994 were not higher than estimated densities in the relevant stratum (i.e., the observed data) during the years surveyed (2001 to 2013) except for the LN transformed model for stratum 2. We used hindcast estimates of marbled murrelet density in 1994 from the regression models using the untransformed density data to scale the base year interaction rates ($\widehat{IR}$) to recent period densities. Regression models using untransformed density data were used for the hindcasts because:

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- we wanted to use a consistent approach for all strata,
- the differences between estimates from the two models were relatively small, and
- we did not want to use a model hindcast that estimated a higher marbled murrelet density in 1994 than had been estimated previously during the 2001 to 2013 survey period.

Although only one of the regression models examined had significant ($P < 0.05$) regression parameters, the hindcasts from these models provide the best available estimates of marbled murrelet density in each stratum during 1994. They should be viewed as conservative estimates as there is little likelihood that they overestimate densities in 1994 since they are all smaller than mean densities estimated for at least one of the survey years in each respective stratum and a downward trend in density during the 2001-to-2013 period is suggested by the data.

Table 4. Comparison of marbled murrelet density estimates in 1994 based on regression models using both untransformed and LN transformed annual density estimates.

Stratum	Model	Est. Slope	Est. Intercept	1994 Projection	% Difference
1	density	-0.1706	346.4697	6.274	23.8%
1	LN(den.)	-0.05620	114.1130	7.769	
2	density	-0.05896	119.7798	2.134	15.7%
2	LN(den.)	-0.04565	91.92641	2.469	
3	density	-0.07538	152.2907	1.982	32.2%
3	LN(den.)	-0.09224	184.8894	2.621	

[a] Percent difference relative to the model using untransformed data.

2001-2005 Average Density

Because there is an inherent degree of uncertainty in estimating (hind-casting) a point estimate outside the extent of available data, we calculated the 2001-2005 mean density by stratum (Table 5), as suggested by USFWS staff. However, this model does not attempt to estimate the likely expected density in 1994. Rather it simply is modeling the mean estimated density of 2001-2005.

Table 5. Stratum level marbled murrelet densities from 2010-2014.

Year	Stratum 1	Stratum 2	Stratum 3
2010	2.004	1.783	0.391
2011	5.580	1.243	0.676
2012	7.166	1.507	0.402
2013	2.379	0.657	1.097
2014	1.258	1.274	0.163
2010-2014 Mean	3.677	1.293	0.546

Appendix I. GIS Mapping Project

Results of GIS mapping study comparing marbled murrelet population trend estimates from 2001 to 2010 with Treaty and Non-Treaty gillnet fisheries landings from 2001 to 2014.

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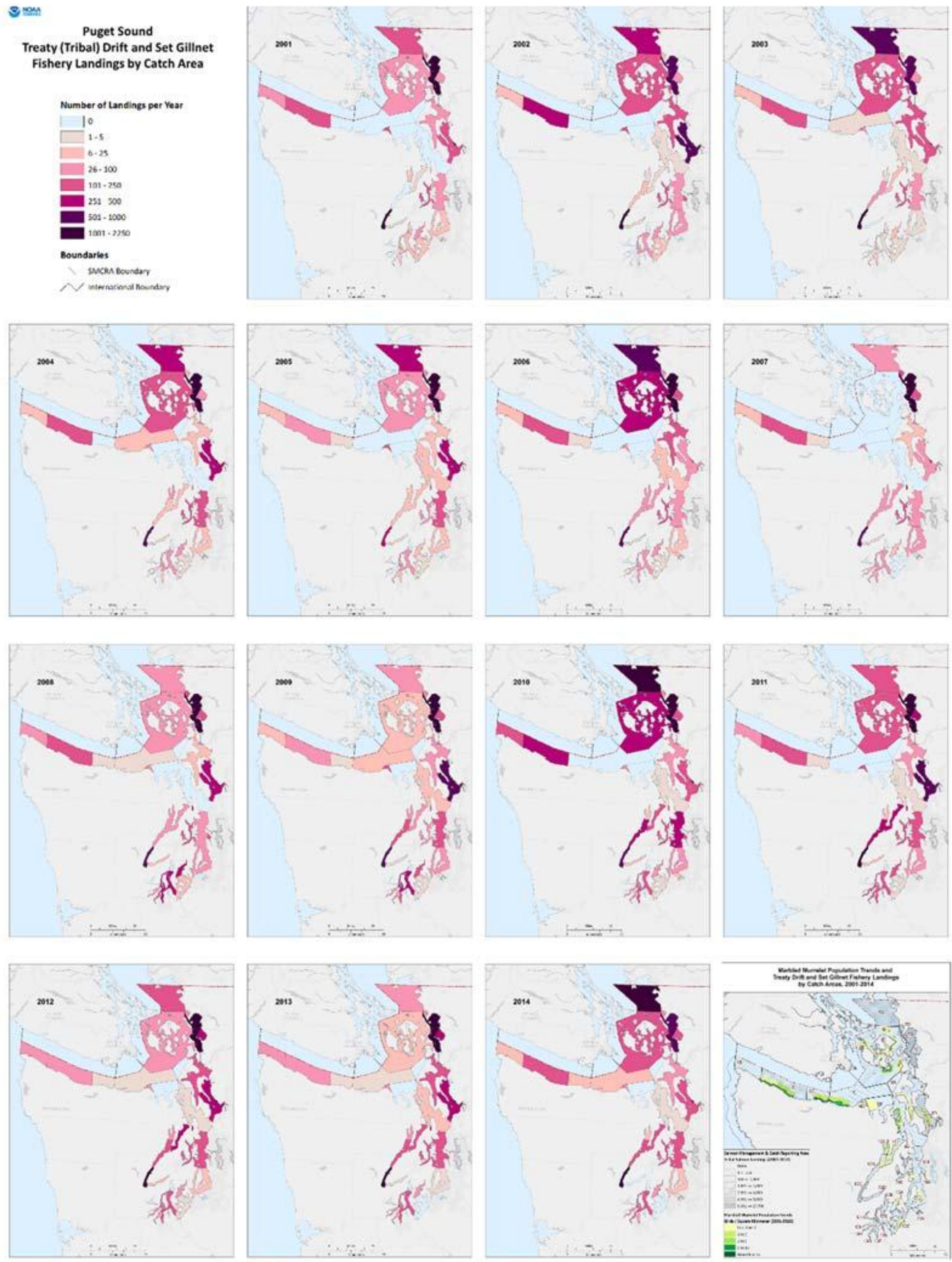

Figure 12. Puget Sound Treaty (Tribal) Drift and Set Gillnet Fishery Landings by MCA.

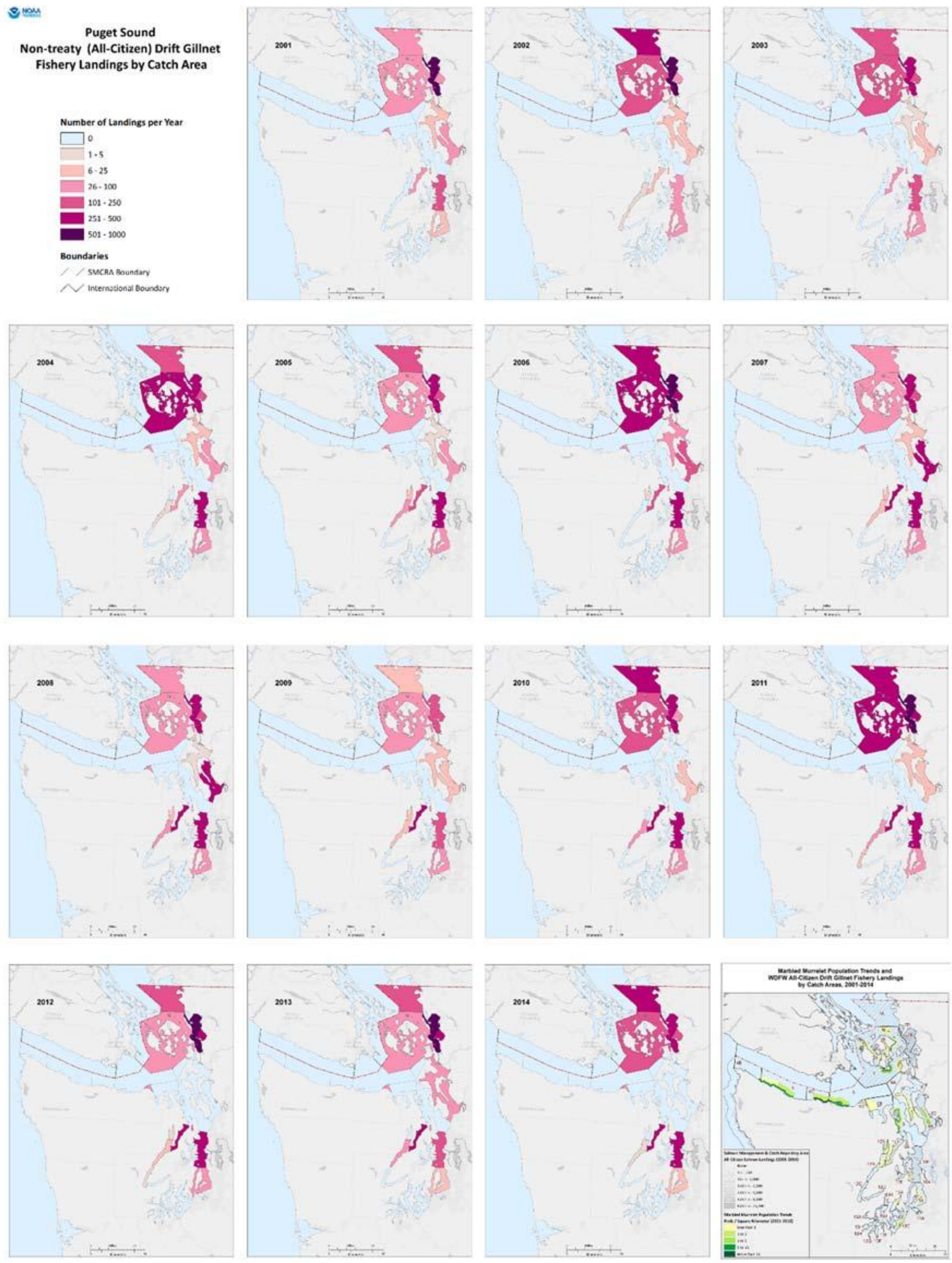

Figure 13. Puget Sound Non-Treaty (All Citizens) Drift Gillnet Fishery Landings by MCA.

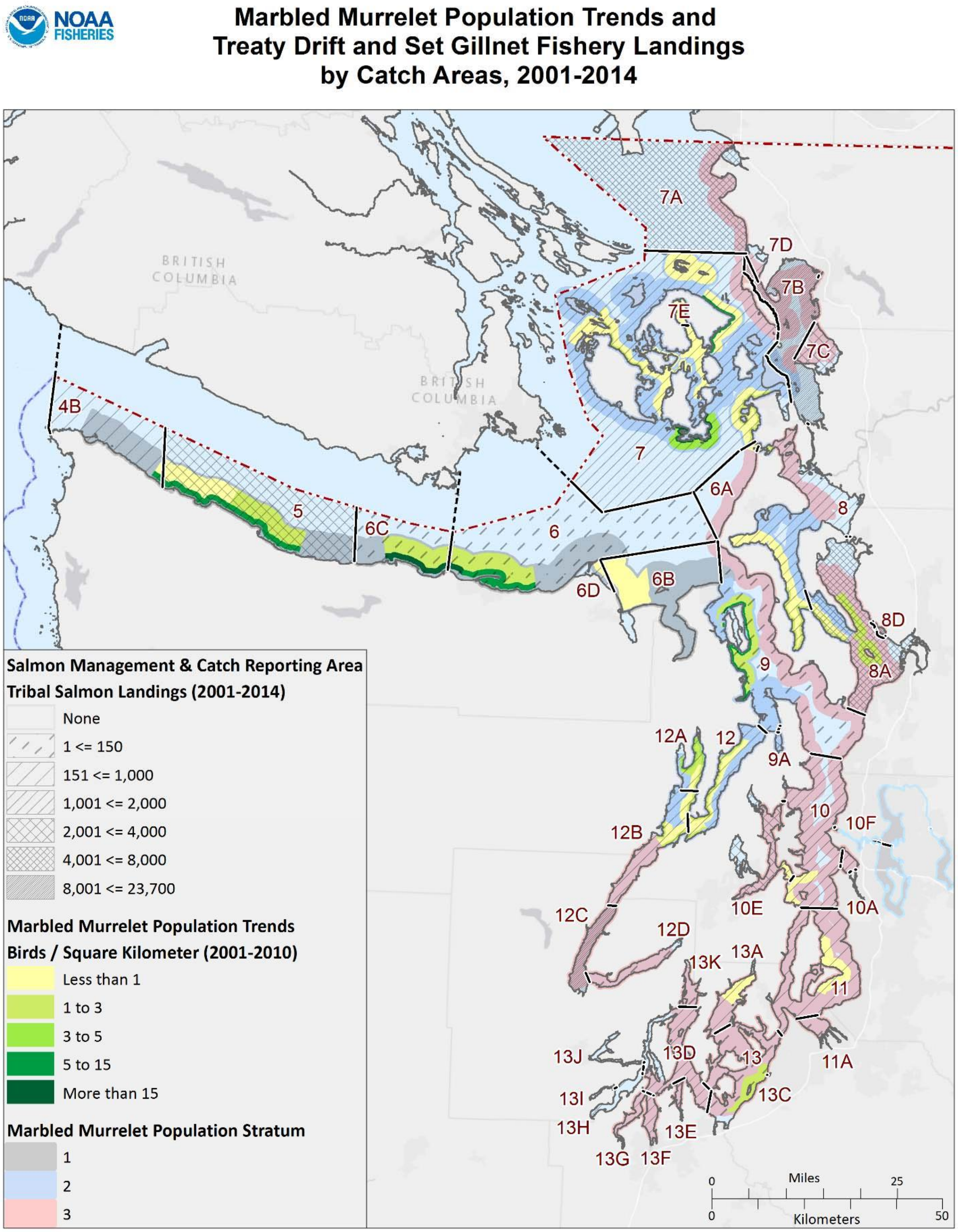

Figure 14. Marbled Murrelet Population Trends and Treaty Drift and Set Gillnet Fishery Landings by MCA, 2001-2014.

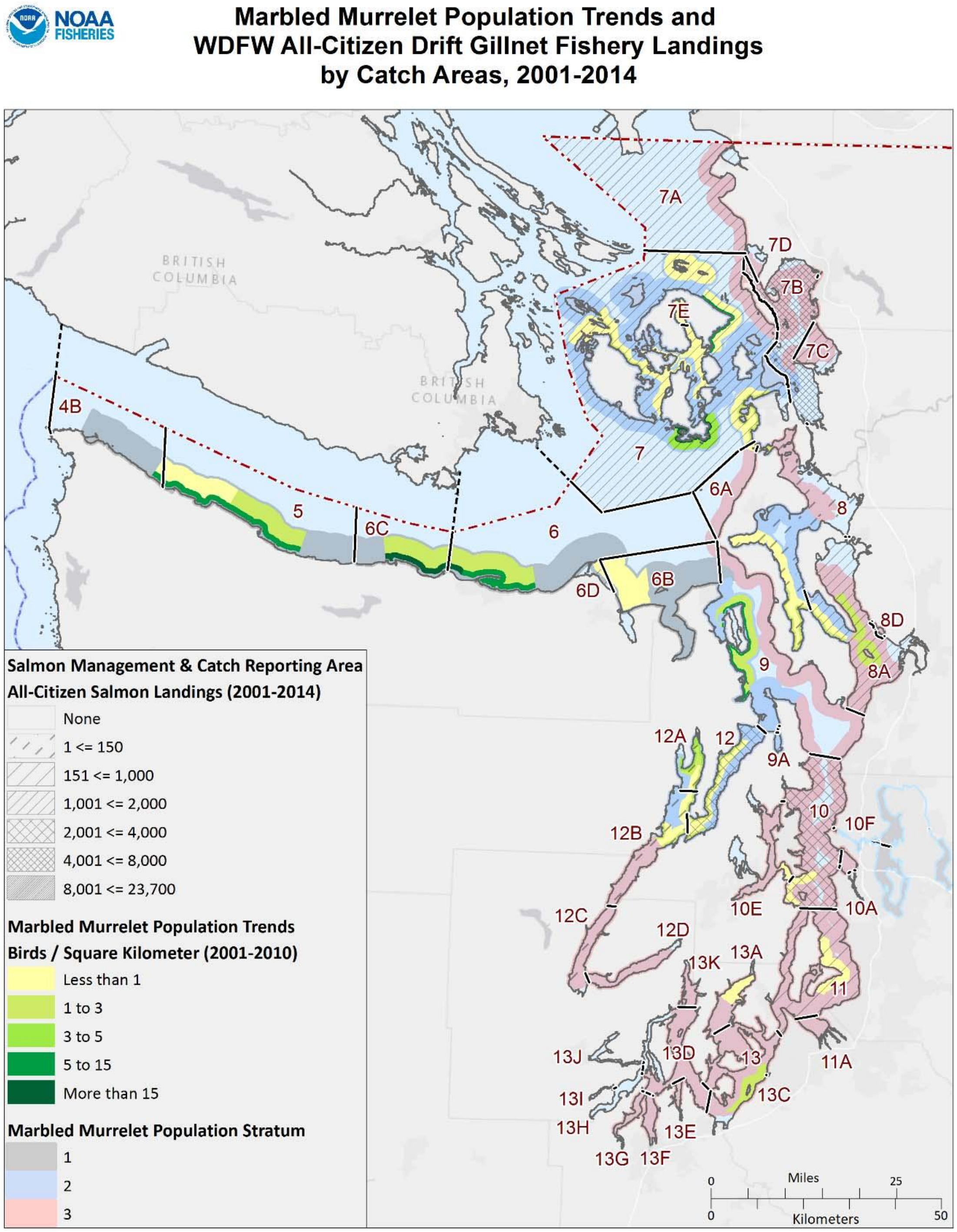

Figure 15. Marbled Murrelet Population Trends and WDFW All-Citizen Drift Gillnet Fishery Landings by MCA, 2001-2014.

Appendix J. Species encountered by type in 5,681 derelict nets removed by the Northwest Straits Foundation from 2002 to December 8, 2015 (NWSF; Drinkwin 2015).

Local Common Name	**Scientific Name**	**Total**
Alcidae	*Alcidae sp.*	2
Barrow's Goldeneye	*Bucephala islandica*	1
Brandt's Cormorant	*Phalacrocorax penicillatus*	213
Bufflehead	*Bucephala albeola*	2
Common Loon	*Gavia immer*	13
Cormorant unidentified	*Phalacrocorax sp.*	168
Cormorant unidentified	*Phalacrocoracidae sp.*	33
Double-crested Cormorant	*Phalacrocorax auritus*	10
Great Blue Heron	*Ardea herodias*	1
Grebe unidentified	*Aechmophorus sp.*	20
Grebes	*Podicipedidae*	3
Gull unidentified	*Larus sp.*	2
Loon unidentified	*Gavia sp.*	28
Merganser	*Mergus sp.*	1
Murre unidentified	*Uria sp.*	36
Pacific Loon	*Gavia pacifica*	36
Pelagic Cormorant	*Phalacrocorax pelagicus*	248
Pigeon Guillemot	*Cepphus columba*	9
Puffin unidentified	*Fratercula sp.*	1
Red-necked Grebe	*Podiceps grisegena*	37
Red-throated Loon	*Gavia stellata*	31
Scoter unidentified	*Melanitta sp.*	26
Seabird unidentified		119
Surf Scoter	*Melanitta perspicillata*	31
Swan	*Cygnus*	1
Waterbird unidentified	*Anatidae sp.*	14
White-winged Scoter	*Melanitta fusca*	15
	Bird Total	1,102