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Olympic Coast National Marine Sanctuary 2021 Condition Report: Status and Trends 2008–2019

Authors

Olympic Coast National Marine Sanctuary
George Galasso
Jenny Waddell
Katie Wrubel

NOAA Office of National Marine Sanctuaries
Kathy Broughton
Stephen R. Gittings, Ph.D.
Danielle Schwarzmann, Ph.D.

National Centers for Coastal Ocean Science
Ayman Mabrouk, Ph.D.
Bryan Costa
Charles Menza
Sarah Hile

Commented [1]: The report will also include an Acknowledgements section that will thank everyone who contributed to the report - provided data sets, participated in workshop or other consultations, reviewed the report, etc.

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Office of National Marine Sanctuaries
The Office of National Marine Sanctuaries (ONMS), part of the National Oceanic and Atmospheric Administration (NOAA), serves as the trustee for a system of underwater parks encompassing more than 620,000 square miles of ocean and Great Lakes waters. The 14 national marine sanctuaries and two marine national monuments within the National Marine Sanctuary System represent areas of America's ocean and Great Lakes environment that are of special national significance. Within these ~~their~~ waters, giant humpback whales breed and calve their young, coral colonies flourish, and shipwrecks tell stories of our maritime history. Habitats include beautiful coral reefs, lush kelp forests, whale migration corridors, spectacular deep-sea canyons, and underwater archaeological sites. These special places also provide homes to thousands of unique or endangered species and are important to America's cultural heritage. Sanctuaries range in size from less than one square mile to more than 582,000 square miles and serve as natural classrooms, cherished recreational locales~~spots~~, and ~~are~~ home bases for~~to~~ valuable commercial industries.

Olympic Coast National Marine Sanctuary

Olympic Coast National Marine Sanctuary includes 3,188 square miles of marine waters off the rugged Olympic Peninsula in northwest Washington state. The sanctuary covers much of the continental shelf and several major submarine canyons. It protects a productive upwelling zone that is home to marine mammals and seabirds. Along its shores are thriving kelp and intertidal communities, teeming with fishes and other sea life. In the darkness of the seafloor, scattered communities of deep-sea coral and sponges form habitats for fish and other important marine wildlife.

In addition to important ecological resources, the sanctuary has a rich cultural and historical legacy. The vibrant contemporary communities of the Makah Tribe, Quileute Tribe, Hoh Tribe, and Quinault Indian Nation have forged inseparable ties to the ocean environment, maintaining traditions of the past while navigating the challenges of the present and future. Also, over two hundred shipwrecks are documented here.

Framework for Condition Report

Sanctuary condition reports are used by NOAA to assess the condition and trends of national marine sanctuary resources and ecosystem services. Condition reports provide a standardized summary of resources in NOAA's sanctuaries, driving forces~~ers~~ and pressures on those resources, and current conditions and trends for resources and ecosystem services. These reports also describe existing management responses to pressures that threaten the integrity of the marine environment. Condition reports include information on the status and trends of water quality, habitat, living resources, and maritime heritage resources, and the human activities that affect them. They present responses to a set of questions posed to all sanctuaries (Appendix A). The reports also rate ecosystem service status and trends (Appendix B). Resource and ecosystem service status are assigned ratings ranging from good to poor, and the timelines used for comparison vary from topic to topic. Trends in the status of resources and ecosystem services are also reported, and are generally based on observed changes in status since the prior condition report, unless otherwise specified.

Sanctuary condition reports are structured around two frameworks: 1) a series of questions posed to all national marine sanctuaries; and 2) a management-logic model called the Driving forces (Drivers)-Pressure-State-Ecosystem Services-Response (DPSER) framework (detailed below). The questions are derived from a conceptual, generic model of a marine ecosystem. The DPSER framework defines the structure of the condition reports themselves.

Although the National Marine Sanctuary System's 14 national marine sanctuaries and two marine national monuments are diverse in many ways, including size, location, and resources, condition reports allow ONMS to consistently analyze the status and trends of abiotic and biotic factors in each site's ecosystem to inform place-based management. To that end, each unit in the sanctuary system is asked to answer the same set of questions, located in Appendix A, during ~~in~~ the preparation of each condition report. Additional details about how the condition report process has evolved over time are below.

Driving forces (Drivers)-Pressure-State-Ecosystem Services-Response (DPSER) Framework

In 2019, ONMS ~~we~~ began re-structuring sanctuary condition reports on a model that describes the interactions between driving societal forces (Driving forces~~ers~~), resulting threats (Pressures), their influence on resource conditions (State), the impact to derived societal benefits (Ecosystem

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Commented [4]: Without an understanding of how sanctuaries work the naïve reader may wonder how this is accomplished. You could say something like "By virtue of its enacting legislation, and ongoing refinement of case-specific conservation measures, the sanctuary protects . . . "

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services), and management responses (Response) to control or improve them. The DPSER framework recognizes that human activities, the primary target of management actions, are linked to demographic, economic, social, and/or institutional values and conditions (collectively called drivers). Changes in these drivers affect the nature and level of pressures placed on both natural and heritage resources, which determines their condition (e.g., the quality of natural resources or aesthetic value). This, in turn, affects the availability of benefits that humans receive from the resources (ecosystem services[1]), which prompts targeted management responses intended to prevent, reduce, or mitigate ~~the~~ undesirable changes (see Figure FCR.1).

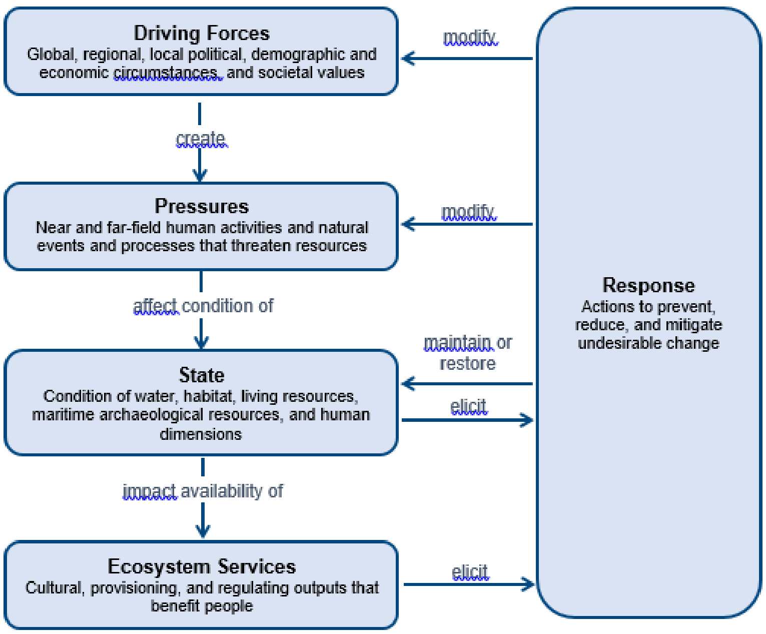

Figure FCR.1. This diagram of the DPSER framework illustrates the functional connections between compartments and the targets of management responses designed to modify driving forces, pressures, and resource conditions. Image: NOAA

About This Report

The purpose of a condition report is to use the best available science and most recent data to assess the status of various parts of the sanctuary's ecosystem. The first condition report for

[1] For the purposes of this report, ecosystem services are defined as "benefits that humans desire from the environment" (e.g., recreation or food). They are what link humans to ecosystems, can be goods or services (e.g., food is a good, and coastal protection is a service), are valued by various types of users, and can be regulated directly by the environment or managed by controlling human activities or ecosystem components (e.g., restoring habitats). Whether or not specific services are rendered can be evaluated directly or indirectly based on attributes of the natural ecosystem that people care about. For example, recreational scuba divers care about water clarity and visibility in coral reef ecosystems. These are attributes that can be measured and factored into status and trend ratings, which then allows one to track one or more specific ecosystem services to which they pertain.

OCNMS was released in 2008 (NOAA Office of National Marine Sanctuaries, 2008); ratings from that report are provided in Appendix C. This updated condition report marks a second comprehensive description of the status and trends of sanctuary resources. The findings in this condition report document status and trends in water quality, habitat, living resources, and maritime heritage resources from 2009–2019, unless otherwise noted. The report helps identify gaps in current monitoring efforts, as well as causal factors that may require monitoring, and potential remediation, through management actions in the coming years. The data discussed will not only enable sanctuary resource managers and stakeholders to acknowledge and have a shared perspective on prior changes in resource status, but will also inform management efforts to address challenges stemming from pressures, such as increasing coastal populations and climate change.

The findings in this condition report will provide critical support for identifying high-priority sanctuary management actions, and will specifically help to shape updates to the OCNMS management plan. The management plan helps guide future work and resource allocation decisions at OCNMS by describing strategies and activities designed to address priority issues and advance core sanctuary programs. The next update to the sanctuary management plan will begin in 2022, building on the 2011 management plan, which contains a number of actions to address issues and concerns (NOAA Office of National Marine Sanctuaries, 2011). The process will involve significant public input, agency consultations, and environmental compliance work, and, depending on the complexity of actions proposed, may take one to three years to complete.

The State section of this document reports the status and trends of water quality, habitat, living resources, and maritime heritage resources from 2009–2019, unless otherwise noted. The Ecosystem Services section includes an assessment of human benefits derived from consumptive recreation, non-consumptive recreation, science, education, heritage, sense of place, commercial harvest, subsistence harvest, and collection of ornamentals within the sanctuary.

In order to rate the status and trends of resources, human activities, and ecosystem services, sanctuary staff consulted with a group of non-ONMS experts familiar with resources, activities, and services in the sanctuary. These experts also had knowledge of previous and current scientific efforts in the sanctuary (Appendix D). Evaluations of status and trends were based on the interpretation of quantitative and, when necessary, qualitative assessments, as well as observations of scientists, managers, and users.

Two other important changes to the condition report process since 2008 should be noted. First, in response to feedback provided to ONMS, the process used to generate the current condition report is more quantitatively robust and repeatable. This was achieved by using the NOAA Integrated Ecosystem Assessment (IEA) framework (NOAA, 2019), which takes a literature-based approach to developing indicators for key components of the ecosystem. Status and trend assessments can then be made for the selected indicators over time. This approach ensures that, whenever possible, the expert community has quantitative data representative of core ecosystem components available to them as they contribute to assessment ratings. These indicators continue to be tracked over time, and updated time series data can be used in subsequent assessments.

The second ~~Another~~ improvement pertains to communication of confidence, which was not done in a consistent way in earlier reports. Determination of confidence is now based on an evaluation of the quality and quantity of data used to determine the rating (e.g., peer-reviewed literature vs. expert opinion) and the level of agreement among ~~the~~ experts (Appendix D). The new approach allows for a consistent and standardized characterization of confidence. The symbols used for status and trend ratings have been modified to depict levels of confidence as judged by the ~~our~~ expert~~s~~ panel.

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This condition report meets the aforementioned standardized format and framework prescribed for all ~~NOAA~~ ONMS condition reports. To the extent possible, authors have attempted to make each section's narrative consistent and comparable in terms of content, detail, and length; however, it is important to understand that each section contains different types and amounts of information given the realities and confines of datasets and expert opinions that were available during this process. In addition, this report is the result of a multi-year, collaborative effort across multiple authors, contributors, and reviewers and thus contains stylistic writing differences across some sections. These differences do not detract from the validity or quality of this report but, rather, reflect the diversity of voices and cultures involved in report generation. Finally, ratings reflect the collective interpretation of sanctuary staff and outside experts based on their knowledge and perception of local conditions. When the group could not agree on a rating, ~~the~~ sanctuary staff determined the final rating with an acknowledgement of the differences in opinion noted in the report. The interpretation, ratings, and text in this condition report are final and the responsibility of ~~a~~ ONMS. To emphasize this important point, authorship of the report is attributed to ONMS; subject matter experts are not authors, though their efforts and affiliations are acknowledged in the report. This report has been peer reviewed and complies with the White House Office of Management and Budget's peer review standards, as outlined in the Final Information Quality Bulletin for Peer Review (White House Office of Management and Budget, 2004).

Executive Summary

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Olympic Coast National Marine Sanctuary Summary of Resource Conditions

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Olympic Coast National Marine Sanctuary Summary of Ecosystem Services

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Literature Cited

NOAA (National Oceanic and Atmospheric Administration), 2019a. “Integrated Ecosystem Assessment (IEA) framework.” https://www.integratedecosystemassessment.noaa.gov/ (accessed 7 January 2020).

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Site History and Resources

Overview

Olympic Coast National Marine Sanctuary (OCNMS or sanctuary) is one of 14 national marine sanctuaries and two marine national monuments comprising a national system of ocean and Great Lakes areas selected for their ecological, recreational, historical, cultural, and aesthetic values. Designated in 1994, the sanctuary's mission is to protect the Olympic Coast's natural and cultural resources through responsible stewardship, to conduct and apply research to preserve the area's ecological integrity and maritime heritage, and to promote understanding through public outreach and education.

Located adjacent to relatively pristine temperate rainforests in northwest Washington State, the lands and waters of the western Olympic Peninsula have sustained and hosted some of the earliest human populations in North America, whose descendants remain on the coast today. OCNMS spans 3,188 square miles of marine waters off the ~~Washington state's~~ rugged Olympic Peninsula (Figure SH.1). Extending seaward 25 to 45 miles, the sanctuary covers much of the continental shelf and the heads of three major submarine canyons, in places reaching depths of over 4,500 feet. The sanctuary borders an undeveloped coastline, enhancing protection provided by the 56-mile-long wilderness of Olympic National Park's coastal strip, as well as more than 600 offshore islands and emergent rocks that extend 100 miles along the coast within the Washington Maritime National Wildlife Refuge (NWR) Complex. Furthermore, the sanctuary is adjacent to the reservations of four coastal treaty tribes (Quinault Indian Nation, Hoh Indian Tribe, Quileute Indian Tribe, and Makah Indian Tribe) and is located within their usual and accustomed fishing grounds. Superimposed on a nutrient-rich upwelling zone with high primary productivity and composed of a multitude of marine habitats, the sanctuary is home to numerous marine mammals and seabirds, diverse populations of kelp and other macroalgae, and speciose ~~diverse~~ fish and invertebrate communities. OCNMS is one of North America's most productive marine regions, supports some of the highest biodiversity on the west coast, and has sustained native peoples for thousands of years.

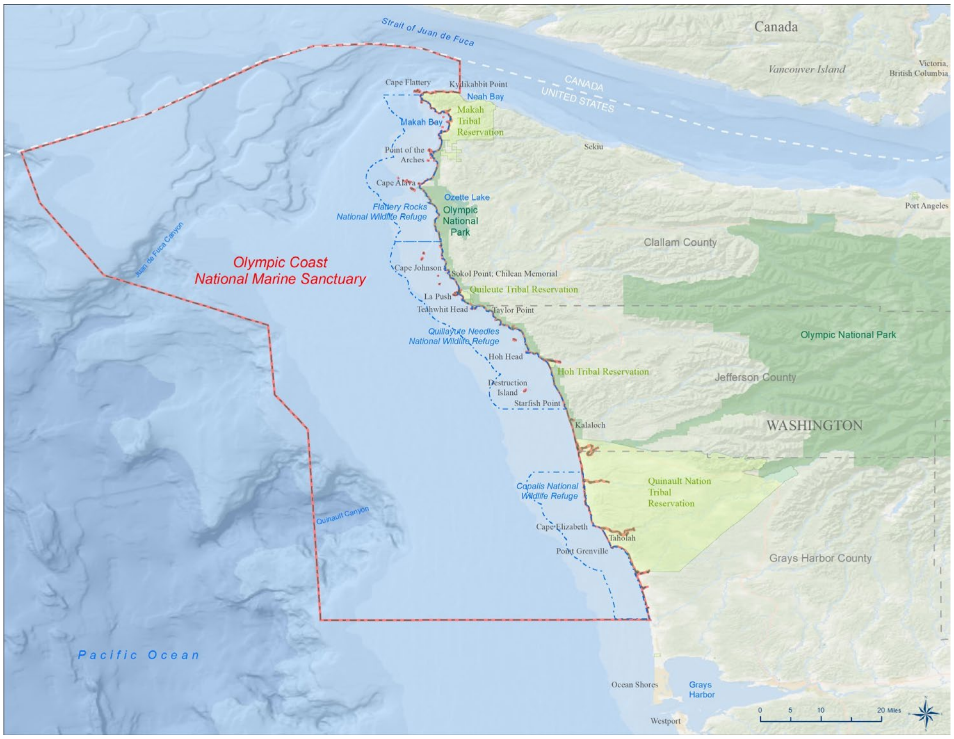

Figure SH.1. Map of Olympic Coast National Marine Sanctuary in relation to adjacent coastal counties and communities, tribal reservations for the four Coastal Treaty Tribes, and boundaries of Olympic National Park and three National Wildlife Refuges; coastal ports along this wilderness coastline are limited to Neah Bay and La Push, which are both on tribal reservations, and Westport. Locations on the map are mentioned throughout this report. Source: Reyer/NOAA ONMS.

Jurisdictional Authorities

Under the authority of the National Marine Sanctuaries Act of 1972 (NMSA), as amended, 16 U.S.C. §§ 1431 et seq., and its implementing regulations, the Office of National Marine Sanctuaries (ONMS) works:

(1) "to identify and designate as national marine sanctuaries areas of the marine environment which are of special national significance and to manage these areas as the National Marine Sanctuary System;

(2) to provide authority for comprehensive and coordinated conservation and management of these marine areas, and activities affecting them, in a manner which complements existing regulatory authorities;

(3) to maintain the natural biological communities in the national marine sanctuaries, and to protect, and, where appropriate, restore and enhance natural habitats, populations, and ecological processes;

> (4) to enhance public awareness, understanding, appreciation, and wise and sustainable use of the marine environment, and the natural, historical, cultural, and archeological resources of the National Marine Sanctuary System;
>
> (5) to support, promote, and coordinate scientific research on, and long-term monitoring of, the resources of these marine areas;
>
> (6) to facilitate to the extent compatible with the primary objective of resource protection, all public and private uses of the resources of these marine areas not prohibited pursuant to other authorities;
>
> (7) to develop and implement coordinated plans for the protection and management of these areas with appropriate Federal agencies, State and local governments, Native American tribes and organizations, international organizations, and other public and private interests concerned with the continuing health and resilience of these marine areas;
>
> (8) to create models of, and incentives for, ways to conserve and manage these areas, including the application of innovative management techniques; and
>
> (9) to cooperate with global programs encouraging conservation of marine resources." (16 U.S.C. §1431(b)).

There are multiple overlapping jurisdictions on the Olympic Coast (Figure SH. 2). OCNMS works in coordination with multiple authorities and aims to facilitate compatible uses to the extent practicable. Under the regulations (15 CFR §922.152), the following activities, with some exceptions, are prohibited within OCNMS:

- Exploring for, developing, or producing oil, gas, or minerals within the Sanctuary.
- Discharging or depositing, from within the boundary of the Sanctuary, any material or other matter.
- Moving, removing, or injuring, or attempting to move, remove, or injure, a Sanctuary historical resource.
- Drilling into, dredging, or otherwise altering the seabed of the Sanctuary.
- Taking any marine mammal, sea turtle, or seabird in or above the Sanctuary.
- Disturbing marine mammals or seabirds by flying motorized aircraft at less than 2,000 feet over the waters within one nautical mile (NM) of the Flattery Rocks, Quillayute Needles, or Copalis National Wildlife Refuges or within one NM seaward from the coastal boundary of the Sanctuary, except for activities related to tribal timber operations conducted on reservation lands, or to transport persons or supplies to or from reservation lands as authorized by a governing body of an Indian tribe. Failure to maintain a minimum altitude of 2,000 feet above ground level over any such waters is presumed to disturb marine mammals or seabirds.
- Possessing within the Sanctuary (regardless of where taken, moved or removed from) any historical resource, or any marine mammal, sea turtle, or seabird taken in violation of the MMPA, ESA, or MBTA.
- Interfering with, obstructing, delaying, or preventing an investigation, search, seizure, or disposition of seized property in connection with enforcement of the Act or any regulation or permit issued under the Act.

- The Department of Defense is prohibited from conducting bombing activities within the Sanctuary.

OCNMS spans 3,188 square miles (8,257 square kilometers) of marine waters off Washington state's rugged Olympic Peninsula. Extending seaward 25 to 45 miles (40 to 72 kilometers), the sanctuary covers much of the continental shelf and the heads of three major submarine canyons, in places reaching depths of over 4,500 feet (1,400 meters). The shoreward boundary of the Sanctuary is the mean lower low water line when adjacent to tribal reservations and State and county lands. When adjacent to Federally managed lands, the coastal boundary extends to the mean higher high water line. The coastal boundary cuts across the mouths of all rivers and streams.

The sanctuary borders an undeveloped coastline, enhancing protection provided by the 56-mile-long (90-kilometer) wilderness of Olympic National Park's coastal strip, as well as more than 600 offshore islands and emergent rocks that extend 100 miles (161 kilometers) along the coast within the Washington Maritime National Wildlife Refuge (NWR) Complex established in 1907, which includes Flattery Rocks NWR, Quillayute Needles NWR, and Copalis NWR and is managed by the U.S. Fish and WIldlife Service (USFWS).

The majority of the sanctuary is located within the boundaries of the adjudicated usual and accustomed fishing grounds (U&As) of the Hoh, Makah, and Quileute Tribes and Quinault Indian Nation (hereinafter referred to as the coastal treaty tribes). While the sanctuary boundary was established in 1994, the U&As were acknowledged by the United States via treaties with the coastal treaty tribes in 1855 and 1856. Tribal U&As extend 30–40 miles offshore and tribal commercial, ceremonial, and subsistence fisheries occur throughout. OCNMS does not manage fisheries; fisheries resources are managed in coordination by federal, state, and tribal co-managers. Tribal governments also manage the land, resources, and people on their respective reservations. Several tribes, including the Makah Tribe and Quinault Indian Nation, have treatment as a state under the Environmental Protection Agency (EPA) and manage water quality on reservation, issue permits, and perform other activities under the Clean Water Act.

The National Environmental Protection Act requires federal agencies to prepare an Environmental Impact Statement for major federal actions that would significantly affect the environment. NOAA's National Marine Fisheries Service (NOAA Fisheries) manages fisheries from ~~between~~ 3–200 ~~nm~~NM through Fishery Management Plans prepared by the Pacific Fisheries Management Council under the Magnuson-Stevens Fishery Conservation and Management Act of 1976. NOAA Fisheries and the USFWS manage marine mammals under the Marine Mammal Protection Act, and threatened and endangered species under the Endangered Species Act. The USFWS also implements the Migratory Bird Treaty Act. The U.S. Coast Guard is the lead federal agency in managing vessel traffic, oil and other hazardous spills, navigation, maritime safety, search and rescue, and federal enforcement (Clean Water Act, fisheries, sanctuary regulations, etc.). Military activities in the area of the sanctuary consist of subsurface, offshore surface, and aerial operations by the U. S. Navy. The U.S. Army Corps of Engineers manages dredging activities as well as jetty maintenance. The EPA manages ocean dumping, vessel scuttling, air and water quality, and pollution activities, including permitting point~~permitting for point~~ source pollution into navigable waters of the U.S. or ocean waters, such as the National Pollution Discharge Elimination System (NPDES) program. Agencies must also comply with the National Historic Preservation Act to protect cultural and archeological resources; Section 106 requires agencies to consider ~~the~~

potential impacts of their actions, which includes the review of permit applications for projects that may allow ~~the~~ disturbance of the seabed where archaeological remains may lie. Section 110 requires agencies to actively search for archaeological resources and to assess them for their significance and eligibility for inclusion in the National Register of Historic Places.

State and local authorities apply within state waters (0-3 NM~~nm~~). However, under the Coastal Zone Management Act (CZMA), the federal consistency clause allows state agencies to review federal actions that will affect the state's coastal resources and to ensure consistency with the Coastal Zone Management Program's (CZMP) approved enforceable policies. State agencies and local governments implement the State Environmental Protection Act (SEPA), in which they review propos~~als~~ed actions to identify environmental impacts. The Ocean Resources Management Act (ORMA) outlines state policies and regulations on the planning and permitting of ocean uses on the outer Washington coast.

Washington State Department of Ecology is charged with implementing portions of the Clean Water Act as delegated by the EPA, including Section 401 certification to ensure a project will comply with state water quality standards as well as NPDES Construction Stormwater Permit. Ecology is also the state lead in implementing the approved CZMP, which is approved by NOAA under the CZMA. The Washington Department of Natural Resources administers leases, easements, and rights-of-entry to authorize use of the seabed of Washington's marine waters under Aquatic Use Authorizations. The Washington Department of Fish and Wildlife manages state commercial and recreational fisheries, finfish aquaculture, and hydraulic projects in state waters.

OCNMS is adjacent to Clallam, Jefferson, and Grays Harbor counties. Local governments (county or city) implement several authorizations and permits relevant to the ocean. Under the Shoreline Management Act, counties and cities develop Shoreline Master Programs to protect shoreline resources and public access while allowing for water ~~-~~dependent uses out to 3 NM~~nm~~. The Shoreline Master Plans are approved by the State as part of their CZMP~~Coastal Zone Management Program~~. Local governments also implement the Growth Management Act and Floodplain Management.

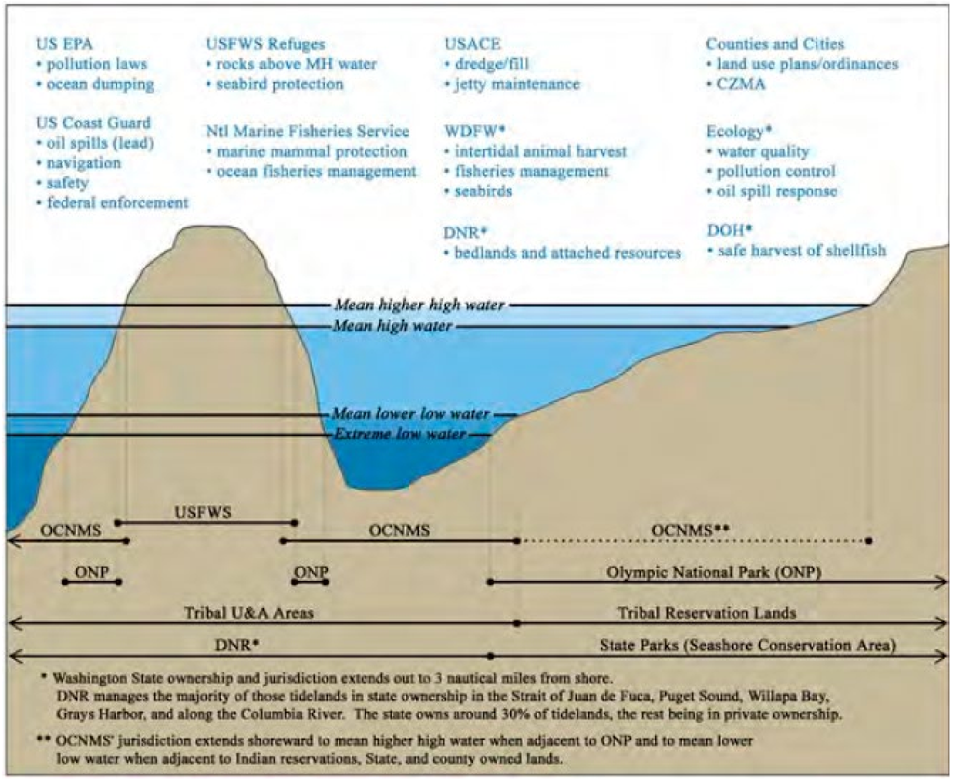

Figure SH.2: Jurisdictional authorities of the Olympic Coast. Source: Antrim/NOAA OCNMS.

Geology

OCNMS ~~Olympic Coast National Marine Sanctuary~~ is located within a region known for dynamic plate tectonics that have shaped marine and terrestrial habitats and continue to affect the sanctuary in a geologic context. Earthquakes, tsunamis, and massive glaciers have shaped the landscape over time, isolating the Olympic Mountains to produce endemic species, carving submarine canyons and coastlines, and depositing boulders and other glacial moraines on the adjacent continental shelf. Efforts to better understand the region's geologic past continue to inform contemporary research efforts, including seismic testing of active submarine faults associated with a 700-mile subduction zone offshore; understanding differential vertical shifting of land on the Olympic Peninsula relative to sea level; mapping for hazard planning and modeling; and development of tsunami inundation maps and alert systems for residents and visitors to the region's coastal areas.

The Olympic Coast is subject to tectonic forces caused by the combined movements of the large Pacific and North American Plates and the smaller Juan de Fuca Plate. The Juan de Fuca Plate and the Pacific Plate are spreading away from each other at a divergent plate boundary offshore, with the Juan de Fuca plate being pressed toward and beneath the North American Plate. The area encompassing this activity is known as the Cascadia Subduction Zone (Figure SH.3). These forces have produced a chain of volcanoes within the uplifted Cascade Range. The geologic activity in the area off the Olympic Coast gives rise to potential hazards such as earthquakes and associated submarine landslides, tsunamis, and volcanic eruptions.

Figure SH.3. Location of the Cascadia Subduction Zone. Image: Mustafa Lazkani/Federal Emergency Management Agency

Due to geological forces, the northern portion of the Olympic Peninsula is experiencing vertical land movement (uplift), which results in low relative sea level rise compared to the southern portion of the sanctuary, where relative sea level rise is more pronounced. Plate tectonics, and to a lesser extent isostatic rebound of land following glacial melt, are the driving forces in this vertical land movement.

The Cascadia Subduction Zone is capable of generating a magnitude nine~~9~~ or higher earthquake and resulting tsunami. Such a large magnitude earthquake could significantly impact remote communities on the Washington coast within a few minutes, and affect major cities throughout ~~Puget Sound and~~ the Salish Sea soon after. Places like Neah Bay, that are currently experiencing vertical uplift, are at risk of significant subsidence following an earthquake, and may experience slumps and drops of up to 6 feet (2 meters). Drops of 2 feet following 2001's 6.8 magnitude Nisqually earthquake near Olympia, Washington, made roads hazardous. A similar event would be especially impactful on the Olympic Coast where most coastal communities have one road in or out and several bridges that would likely fail (Figure SH.4).

Figure SH.4. Image taken near Allyn, Washington, showing damage to the road following the 2001 Nisqually earthquake (6.8M). Impacts to remote coastal communities could be more significant, especially following a 9.0M earthquake, including critical failure of roads and bridges connecting these isolated communities. Photo: U.S. Geological Survey

The sanctuary seafloor is a rich and varied component of the marine ecosystem (Figure SH.5). The glacial landscape that has been submerged for the last 10,000 years contains deeply eroded canyons, rocky shorelines, and scattered boulders, along with glacial ridges and vast, uninterrupted sand and mud plains. A continental shelf reaches out 13–64 kilometers (8–40 miles) from Washington's coast and provides a relatively shallow (200 meters or 660 feet in depth or less) coastal environment within the sanctuary. Unconsolidated, soft-bottom sediments comprise the majority of habitat in the sanctuary. Several submarine canyons cut into the continental shelf along the western boundary of the sanctuary, and the Strait of Juan de Fuca flows into the trough of the Juan de Fuca Canyon in the northern portion of the sanctuary. Submarine canyons act as channels for coastal sediment to reach the deep seafloor~~,~~; enhance upwelling by providing deep, cold, nutrient-rich water to the surface~~,~~; and are habitats with high biodiversity. In the northern portion of the sanctuary, ~~the~~ sediments on the shelf are largely glacial deposits from the Ice Age, and the shelf slope is steep and jagged. Modern sediments are carried west through the Strait of Juan de Fuca, north from the Columbia and Chehalis rivers, and oceanward from the prominent coastal rivers of Quinault, Queets, Hoh, and Quillayute. These materials are generally transported northward by year-round bottom currents and winter storms, and eventually accumulate on the shelf. Some of the sanctuary seafloor has been mapped, however, various methods have been used, resulting in disparate ~~varied~~ resolution and detail. Thus, a full understanding of habitat distribution, as defined by sediment type and bathymetry (depth of seafloor), remains elusive (Battista et al., 2017). Fortunately, in recent years, the sanctuary and partners have prioritized, and are working to fill gaps in, mapping of the sanctuary.

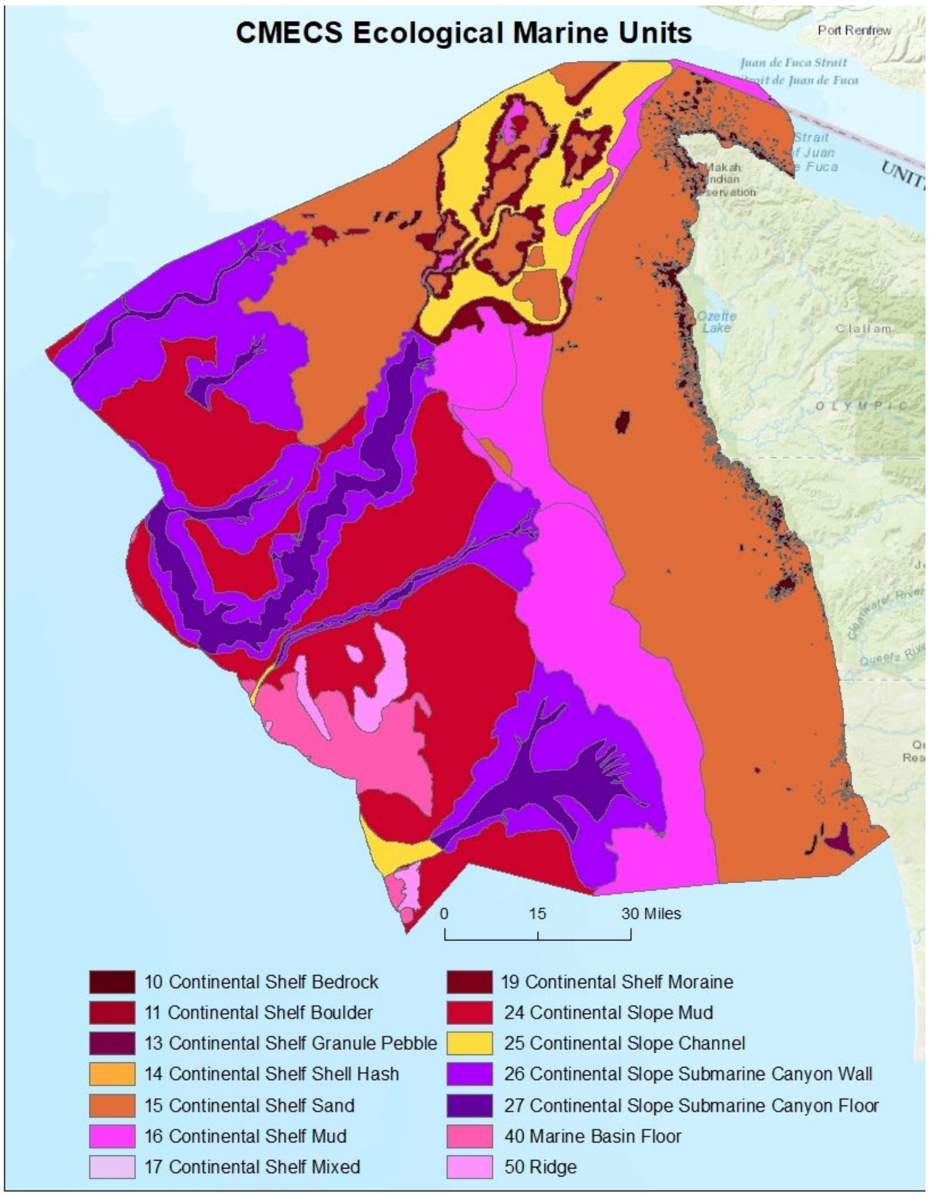

Figure SH.5. Map of ecological marine units as defined in the habitat framework developed by the Intergovernmental Policy Council. Source: Northwest Indian Fisheries Commission, personal communication, 2021.

Broad beaches with various grain sizes (e.g., sand, gravel, cobble), dunes, and ridges dominate the Washington coastline from Cape Disappointment, on the north side of the Columbia River mouth, to the Hoh River. Wave action has eroded the shoreline through time and has formed steep cliffs at various places along the coast, and forested hills and sloping terraces are found near river mouths. Between Point Grenville and Cape Flattery, rocky cliffs can rise abruptly 15 to 90 meters (50 to 300 feet) above a wave-cut platform that is underwater except during extreme low tides. This wave-cut platform can be almost three kilometers (2 miles) wide in some places. Small islands, sea stacks, and rocks dot the platform's surface.

Original Peoples

The Olympic Coast has sustained human communities for at least 4,000–8,000 years, and possibly much longer. Native American villages were located along the coast, at protected harbors, and at river mouths, where people practiced ocean- and river-dependent hunting, gathering, fishing, sealing, and whaling activities. The four treaty tribes adjacent to the sanctuary—Hoh, Makah, and Quileute tribes and Quinault Indian Nation —have treaty-reserved rights off reservation, including usual and accustomed fishing grounds that extend 30–40 nautical miles offshore. There are three distinct language groups on the Olympic Coast, Quinault (Coast Salish), Quileute and Hoh (Chimakum), and Makah (Wakashan). The coastal treaty tribes are each sovereign governments, with their own cultures, histories, languages, place names, ceremonies, and practices (Figure SH.6).

Figure SH.6. Makah ~~cedar- carved~~ welcoming figures carved of cedar greet visitors to Neah Bay, WA. Photo: Makah Tribe

Artifacts from one prehistoric site, the Ozette Indian Village Archeological Site[1] near Cape Alava, provide a window into the daily life of the Makah culture immediately before European contact. Tools made from natural materials developed from their intimate relationship with natural resources, and complex artwork and rich oral traditions demonstrate the sophistication of these Native American societies.

Coastal Treaty Tribes of the Outer Coast of Washington

Quinault Indian Nation - The Quinault Indian Nation consists of the Quinault and Queets Tribes and descendants of five other coastal tribes. Quinault are Coast Salish. The Quinault Indian Reservation, located in the southwest corner of the Olympic Peninsula, includes 23 miles of Pacific coastline and covers 208,150 acres of forested land. Quinault are a party to the Treaty of Olympia.

Hoh Indian Tribe - The Hoh call themselves Chalá·at: People of the Hoh River. The Hoh Reservation was ~443 acres, but through property acquisition the Hoh Tribe now has 908 acres in trust and ~162 acres in fee lands. The Hoh reservation is located 28 miles south of Forks at the mouth of the Hoh River. The Hoh is a river-based fishing community, dependent on resources from the Hoh River. The reservation has about 1 mile of beachfront between the mouth of the Hoh River and nearby Ruby Beach, and is surrounded by Olympic National Park. Hoh speak~~spoke~~ a dialect of Chimakum distinct to the tribe. Hoh are a party to the Treaty of Olympia.

Quileute Indian Tribe - Surrounded on three sides by the Olympic National Park, the Quileute Reservation is located on 2,100 acres along the Pacific Ocean on the south banks of the Quillayute River and includes the Village of La Push. Traditionally, most of the Quileute lived inland and visited La Push seasonally to fish. The Quileute are the only Chimakum language speakers on the Olympic Coast. Quileute are a party to the Treaty of Olympia.

Makah Indian Tribe - Qʷidiččaʔa·tx̌ is the Tribe's name for themselves in their language, meaning "the people who live by the rocks and seagulls." Located in the northwestern most corner of the contiguous U.S., the Makah Reservation consists of 30,000 acres, ~~and~~ is bounded by the Pacific Ocean and the Strait of Juan de Fuca, and includes the town of Neah Bay. Over 1,000 acres of the land bordering the Pacific Ocean have been reserved as a wilderness area. The Makah are part of the Nootkan branch of the Wakashan culture, which includes two other First Nations in British Columbia, Canada. Makah are a party to the Treaty of Neah Bay.

~~**Each of the coastal treaty tribes** derive their sustenance from natural resources of the ocean, rivers, and land which may include whaling, sealing, fishing, and intertidal harvesting as well as upland hunting and gathering. Their personal, cultural, and spiritual survival depend on the ability to fish, hunt, and gather the bountiful natural resources in this region.~~

[1] Ozette Indian Village Archeological Site was added to the National Register of Historic Places in 1974 following an 11-year excavation. The Makah Cultural and Research Center houses the 55,000 artifacts recovered.

Recent research on earlier Makah sites confirms maritime-adapted cultural practices of offshore fishing and whaling dating at least 1,500 years before present and occurring 40–100 miles offshore (Renker, 2018). Native peoples lived as part of, and modified, their environment to ensure ready access to resources for current and future generations, as well as for commerce and trade. Burning prairies for camas, berries, and ferns to grow; tending clam gardens to ensure bountiful shellfish; and designing fish traps to readily access fish resources were commonplace. Native peoples also utilized new information and technology to enhance their success. For example, when Federal Indian agents attempted to turn Makah into farmers, the Makah instead used tines from the pitchforks to make fish hooks.

Traditional Knowledge (TK)[2], as defined in Van Pelt et al. (2017) is "a cumulative body of scientific knowledge, passed through cultural transmission, that evolves adaptively through time as a result of Indigenous peoples living in and observing the local environment for many generations; it is a form of adaptive management." TK is a robust and dynamic knowledge system that is based on observations and experiences over thousands of years and should be considered peer-reviewed in western science standards (Chang et al., 2019). "Respecting and embracing indigenous knowledge as important science benefits all of us" (Greene, 2018). Sharing TK should be based on free, prior, and informed consent with ownership and intellectual property rights belonging with the tribal communities or knowledge holders. The coastal treaty tribes have lived on the Olympic Coast for thousands of years, and each has cultivated a body of knowledge on ecosystem processes, timing, location of important habitats and species, and a variety of other topics over generations (Chang et al., 2019; Shannon et al., 2016).

The four coastal treaty tribes are independent sovereign nations, with the inherent right to self-governance and decision making on issues that affect their own people, lands, and resources. In the mid-1800s, Isaac Stevens, governor and superintendent of Indian affairs of ~~the~~ Washington Territory, was authorized to conduct treaty negotiations with tribes on behalf of the United States government. Through the treaties, many tribes ceded title to hundreds of thousands of acres of land to allow for the settlement of the Washington Territory by non-Indian settlers and to provide for a peaceful co-existence by recognizing tribal resource rights. In return, treaty tribes were to receive reservation homelands for their exclusive use and were promised assistance from the United States. The 1855 Treaty of Neah Bay with the Makah Indian Tribe and the 1856 Treaty of Olympia with the Hoh Indian Tribe, Quileute Indian Tribe, and the Quinault Indian Nation reserved the rights of those coastal tribes to continue to fish, hunt and gather resources off reservation at their usual and accustomed places to maintain their lifestyles and economies. It is important to emphasize that these rights were reserved by the tribes, not rights given to the tribes. The treaties continue to govern the relationships between the federal government and individual tribal governments today.

The Treaty of Olympia, also referred to as the Quinault River Treaty, continued Governor Isaac Stevens policy of consolidating tribes, often requiring tribes to move far from their homeland to a reservation to

[2] Traditional Knowledge, Traditional Ecological Knowledge, Indigenous Knowledge, and numerous variations of these terms will be referred to as Traditional Knowledge ~~or~~ (TK) here.

be occupied by several unrelated tribes. The Treaty of Olympia resulted in the establishment of the Quinault Reservation in the Quinault homeland but required several tribes, including the Quileute and Hoh to move there, although few did. Reservations for the Quileute and Hoh Tribe were established by Executive Orders in 1889 and 1893, respectively.

The coastal treaty tribes ceded lands for the formal reservation of certain inherent rights as well as some monies and a "tract or tracts of land sufficient for their wants" and other services, including education and healthcare. The treaties were a grant of rights from the tribes and a reservation of rights not granted. Of these rights reserved, the "right of taking fish[3] at all usual and accustomed (U&A) grounds and stations[4,5]" into perpetuity was vital to each of the coast treaty tribes. The marine ecosystem and its associated natural resources form an essential foundation for the economies and cultures of the coastal treaty tribes. They view the continued ability to harvest and utilize water, plants, mammals, fish, and other resources of this region as being critical to the protection of their treaty rights and the continuity of their distinct societies and cultures.

In the 1970s, treaty tribes in the state of Washington sought to access their treaty resources and uphold their treaty rights through legal action in federal court. The outcome of this arduous legal path re-established these treaties as the supreme law of the land and culminated in the seminal case of *United States v. Washington*, written by Judge George Boldt and often referred to as the "Boldt decision."[6] In arriving at the decision upholding the treaty rights, Judge Boldt traced the history of the fishing tribes of the state of Washington to treaty-time signing periods. ~~Judge Boldt's decision recounts:~~

> ~~*"From the earliest known times, up to and beyond the time of the Stevens' treaties, the Indians comprising each of the treating tribes and bands were primarily a fishing, hunting, and gathering people dependent almost entirely upon the natural animal and vegetative resources of the region for their subsistence and culture. . . .*~~
>
> ~~*The treaty-secured rights to resort to the usual and accustomed places to fish were a part of larger rights possessed by the treating Indians, upon the exercise of which there was not a shadow of impediment, and which were not much less necessary to their existence than the atmosphere they breathed. The treaty was not a grant of rights to the treating Indians, but a grant of rights from them, and a reservation of those not granted."*~~[7]

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The Boldt decision upheld tribal treaty rights to 50% of the harvestable fish that are available in tribal ~~usual and accustomed (~~U&A~~)~~ areas. This decision also recognized~~established~~ Washington treaty tribes as co-managers of fishery resources with the state of Washington, empowering tribes to develop infrastructure and capacity to manage treaty resources. Each tribal government regulates the fishing activities of its members within its respective U&A in accordance with tribal law and approved fisheries management plans. Each tribe also maintains its own fisheries management and enforcement staff,

[3] The Treaty of Neah Bay has unique language reserving Makah's right to "whaling and sealing" in addition to fish.
[4] 1855 Treaty of Neah Bay. 12 Stat. 939; January 31, 1855. Makah Tribe is the only tribe party to this treaty.
[5] 1856 Treaty of Olympia. 12 Stat. 971; July 1, 1855, and January 25, 1856. Quinault Indian Nation, Hoh Tribe, and Quileute Tribe are parities to this treaty.
[6] *United States v. Washington*, 384 F. Supp. 312 (W.D. Wash. 1974), *aff'd* 520 F.2d 676 (9th Cir. 1975).
[7] ~~*United States v. Washington*, 384 F. Supp. 406-407.~~

enters into management agreements, and engages in a wide variety of research for resource protection and stewardship. Federal regulations further recognize the sovereign status and co-manager role of treaty tribes over shared fishery resources.

Today, the coastal treaty tribes carry their heritage forward, balancing the very modern needs of their communities with long tradition. As provided in their treaties with the United States, treaty tribes share fishery resources with non-tribal residents and are active as co-managers of the fisheries with the state of Washington and the federal government. To this day, tribes exercise their treaty rights, hold potlatches and ceremonies (e.g., first salmon ceremony), and celebrate their cultures through songs, dances, names, language, and more. Tribal governments employ researchers and resource managers in their natural resource departments that gather data and conduct research to protect their treaty rights and co-manage fisheries resources.

In 2007, in recognition that the Hoh, Makah, Quileute Tribes, the Quinault Indian Nation and the state of Washington are managers of the fisheries resources and their habitats within OCNMS, the Intergovernmental Policy Council (IPC) was formed. The first of its kind within the national marine sanctuary system, the IPC provides a regional forum for resource managers to exchange information, coordinate policies, and develop recommendations for resource management within the sanctuary. However, this forum does not supplant the federal trust responsibility or direct government-to-government relationships between the sanctuary and individual tribal governments.

European Exploration

~~In 1592, Juan de Fuca, a pilot on a Spanish ship, told mariners' tales of visiting a Northwest Passage that emptied into the Pacific Ocean. For the next 200 years, Spain, England, France, and Russia all sent explorers to confirm his report and lay claim to the region and its riches. De Fuca's visit is unlikely, however his name was preserved on later English maps and the passage is now known as the Strait of Juan de Fuca.~~

The first recorded European contact with the coastal Indians involved the Spanish explorers Bruno Heceta and Don Juan Francisco de la Bodega y Quadra in 1775. They were quickly followed by other Europeans, and later Americans, all hoping to capitalize on the sea otter and fur seal trade. In 1778, the English explorer Captain James Cook sailed the coast and ~~. I~~in 1788~~, another English sea captain,~~ he was followed by fellow Englishmen John Meares~~, was so impressed by Mount Olympus that he named it after the mythical home of the Greek gods. "If that be not the home where dwell the Gods, it is beautiful enough to be, and I therefore call it Mount Olympus," he wrote. The name was made official 14 years later when Captain George Vancouver entered the name on his maps and referred to the whole range as the Olympic Mountains.~~ Although the Spanish built the first European settlement near Neah Bay in 1792, it was abandoned after only five months when Spain came under the threat of war from Great Britain.

At the start of the 19th century, there were conflicting claims in the Pacific Northwest. First and foremost, it is important to remember that these lands were not unclaimed. While European powers maneuvered to exert claims and influence, Indigenous people went about their own lives, interacting with traders on their own terms. The primary players were initially the Russian Empire, the United Kingdom, and the Kingdom of Spain. Ultimately, the United Kingdom and United States compromised in the 1846 Treaty of Oregon, adopting the 49th parallel, which already marked the U.S.-Canada border east of the Rockies, as the international boundary in the mainland Pacific Northwest.

The "Great Migration" along the Oregon Trail funneled many settlers to the northwest. Settlements grew around Puget Sound as lumber became a money making industry. The California Gold Rush of 1849 attracted thousands of miners to California and sparked demand for Puget Sound timber. As commerce intensified in and out of the Puget Sound, the government erected lighthouses at critical nearshore shoals to improve navigation. After Washington became a territory in 1853, the pressure from American settlers moving into the area led to the placement of the tribes onto reservations.

Commerce

Native peoples exchanged resources and employed a local currency system prior to European settlement. Extensive trade routes via waterways were established by Native peoples, who followed the coast to the Columbia River, into Puget Sound, and up to Alaska. Trade of whale oil, furs, halibut, salmon, and other resources were prevalent amongst the coastal treaty tribes.

Much of the early contact between the European and Indigenous cultures was associated with the early maritime fur trade. Furs were the key to opening the northwest coast to European trade in the late 1700s, especially the profitable fur seal and sea otter pelts that were obtained from the tribes~~ by English, Russian, Spanish, and American fur traders~~. In the 1700s, Russian fur sealing operations spread throughout the Aleutian Islands and down the coast of Southeast Alaska~~, and by 1799, a fur sealing center had been established in Sitka, Alaska.~~ European fur sealers established a fur sealing station in Victoria, British Columbia in 1837, hunting animals along the coast of Vancouver Island and purchasing pelts from local Indian tribes. Stimulated by the high price paid by non-tribal sealers for skins, tribes spent considerable time hunting seals using canoes and spears during the mid and late 1800s. Using sailing craft, white fur sealers operated out of Vancouver Island and Seattle and hunted fur seals as far south as Mexico. ~~between 10 and 300 nm offshore. Since fur seals feed at night and sleep during the day, they were an easy target for hunters. Furthermore, they tended to break free of the water during swimming, making them easier to spot.~~ Fur seals were hunted into the 20th century, but hunting ceased as the populations were driven to very low levels and the governments of Canada and the U.S. interceded.

The sea otter trade was central to the Pacific Northwest economic and political development. The international fur trade business ventures transitioned the lower-~~ ~~impact local exchange into ~~the higher~~ worldwide consumer exploitation. Several Indian tribes engaged in the commercial sea otter trade as the dense fur made its pelt extremely valuable to fur traders~~, and were referred to as "soft gold"~~ (Hughes, 2008). However, this commercial trade ultimately led to ~~the~~ overexploitation, and by the early 1900s~~,~~ hunters had completely extirpated sea otters from Washington waters. ~~In 1969 and 1970, 59 sea otters were translocated from Amchitka Island, Alaska to the Olympic Coast, where they gradually reestablished a breeding population; the 2019 census identified a minimum of 2,785 sea otters on the Washington outer coast (Jeffries et al., 2019).~~

Over time, the focus shifted from ~~on~~ the fur trade ~~shifted~~ to settlement, with increasing vessels plying the outer coast and inland waters of Washington Territory. Fishing became an important economic activity of European and other immigrants to the Pacific Northwest soon after they settled along the U.S. Pacific Coast, within Puget Sound, and in British Columbia, Canada. There can be little doubt that the development of commercial fisheries by settlers began with the harvest of salmon, most likely in central California and along the Columbia River. It is known that the Hudson's Bay Company began to export salted salmon to Hawaii in the 1820s. B~~By the mid 1800s, the first salmon cannery along the Pacific Coast had been constructed in Sacramento, and b~~y 1877 a salmon cannery was operating in Puget Sound. However, it is not clear when the first settlers moved their salmon fishing operations ~~out~~ into the Strait of Juan de Fuca and, eventually, into ~~the~~ Pacific Ocean waters off and to the south of Cape Flattery. It is likely that a major early source of salmon to Puget Sound canneries involved~~resulted from the~~ purchase of fish caught by local Indians who had been involved in trading salmon for centuries.

Three commercial fisheries appear to have started in the waters offshore from Cape Flattery prior to the end of the 1800s. These included the salmon troll fishery as well as the halibut and sablefish (blackcod) handline and longline fisheries. Canneries were established along the Columbia River and outer coast, with three salmon canneries in Aberdeen by 1890. ~~The arrival of settlers from Europe and other continents would, o~~Over time, t~~significantly alter the character of fisheries of the Olympic Coast. T~~he introduction of modern fishing methods and the types of boats employed in the Pacific Northwest was~~has been~~ strongly influenced by immigrants from Norway and other Scandinavian countries, in addition to fishermen from Yugoslavia, Portugal, and Italy.

Through the latter part of the 1800s, pioneers moved into the Olympic Peninsula to farm, fish, and cut timber. Like many tribes, most early settlers chose to settle along the coast. In 1851, Port Townsend became the first permanent American settlement on the peninsula, providing a gateway for further settlements to the west. Port Angeles, with its harbor, lighthouse, military reservation, customs house, and strategic location on the Strait of Juan de Fuca, was designated ~~by President Abraham Lincoln~~ as a town site in 1862 and the Nation's second national city. ~~Today, it is the county seat of Clallam County and the peninsula's largest town, with a population of 20,076 (in 2018).~~ Farther west, the town of Forks had European settlers as early as the 1860s. People were originally drawn to Forks by gold prospects, and for a short period by oil prospects, but timber became the mainstay of the economy ~~of Forks and other west end towns~~.

Although the area attracted logging, farming, and fishing interests, ~~the rugged western coast and interior of the peninsula retain significant roadless wilderness. However,~~ in the southern portion of the peninsula, the timber industry ~~was~~ clearcut~~ting~~ large swaths of land. In Grays Harbor, the deep ports allowed this region to become a center of timber production, driving timber barons to Hoquiam and Aberdeen. The first mills were established in 1882 and by 1890 Aberdeen had four mills. This changed the landscape of the peninsula forever.

Frederick Weyerhaeuser purchased 900,000 acres of western Washington timber in 1900 ~~from the Northern Pacific Railroad,~~ and by 1903 he held 26% of all private timberlands in Washington. In 1910, Weyerhaeuser began milling and manufacturing, building mills in Everett, Longview, Aberdeen, Raymond, and elsewhere. Railroad expansions and the arrival of large corporations transformed the timber industry in Washington, becoming the largest employer in the state and establishing Washington as the leading U.S. producer of timber until the late 1930s.

Olympic National Park was established in 1938 and the coastal strip of the park was added in 1953, together encompassing nearly a million acres of mountain, forest, and coastline designated as wilderness. The adjacent Olympic National Forest was designated in 1897 as the Olympic Forest Reserve, and now contains 88,265 acres (15 percent of the total national forest acreage) of designated wilderness.

Throughout the period of European settlement on the western Olympic Peninsula, the link between the land and the ocean has shaped history. All coastal trade vessels working between California and Puget Sound, as well as vessels visiting the region for trans-Pacific trade, traversed the area that is now the sanctuary. The lumber trade on the Pacific Coast was a long-lived and very significant aspect of maritime trade along the coast. Beginning in the 1850s with the establishment of sawmills on Puget Sound, larger vessels, many of them veterans of the California Gold Rush, commenced the trade. Early canneries, logging operations, and hotels reflected not just the economic opportunities offered by coastal resources, but the hardships imposed by the Olympic Coast's remoteness, such as lack of or limited road infrastructuretransport. Coast-wide trade linked the productive Olympic Peninsula with Seattle and markets in California, Hawaii, Australia, and beyond. The deep ports and rail access in Grays Harbor was instrumental to the development of the timber and fishing industries on the coast. In addition, the completion of railroad links across the Continental Divide in both Canada and the United States made the ports of Vancouver, Seattle, Everett, Tacoma, Grays Harbor, and Victoria important sources of grain, timber, gold, and other resources for the world's economy. The Northern Pacific Railroad was the first rail line to serve the Grays Harbor region, constructed in 1892. Due to its isolated geography, it took decades for rail lines to be built to boost the economic development of the northern Olympic Peninsula, with lines between Port Angeles and Port Townsend not constructed until 1915. Railroads were essential in the timber industry, in shipping goods to market, and connecting the region to tourists.

Today, commerce on the Olympic coast depends largely on commercial and recreational fishing, logging, and tourism. In the 1990s, the local timber industry was impacted by reduced harvests driven by environmental protections under the Endangered Species Act (ESA) in addition to automation of the lumber industry and diminishing old-growth forests, and the local economy has struggled since. Fishing continues to be an important commercial, ceremonial, subsistence, and recreational venture for coastal communities like Neah Bay and La Push. Fisheries have improved in recent years with several rockfish stocks rebuilt and no longer considered overfished or depleted. The recovery of these fish stocks were a result of extensive efforts by fisheries management entities (federal, state, and tribal co-managers) through the Pacific Fisheries Management Council (more information on these efforts are in the Response section). However, for some fisheries, harvest is still a fraction of what it was in the 1970s and 1980s. The recovery of these fish stocks were a result of extensive efforts by fisheries management entities (federal, state, and tribal co-managers) through the Pacific Fisheries Management Council (more information on these efforts are in the Response section)

Coastal communities continue to respond to a changing economy by developing innovative enterprises such as value-added wood product manufacturing (local manufacturing rather than export of raw timber) and accommodating the growth of tourism to diversify the economic base, while remaining still reliant on natural resources.

Military History

In 1841, the U.S. Exploring Expedition, led by John Wilkes, entered the Strait of Juan de Fuca and Puget Sound on their way to Fort Nisqually, which may have been the first appearance of the U.S. Navy in Washington waters. Wilkes sent out several surveying parties, one group explored and charted the waters of Puget Sound.

The United States military has had a presence on the Olympic Coast since the 1850s. ~~President Jefferson signed a bill for the "Survey of the Coast" establishing the U.S. Coast Survey in 1807.~~ In 1851, George Davidson of the U.S. Coast Survey undertook detailed charting of Washington's coast, first focusing at the mouth of the Columbia River for critical navigation and commerce and then the northern coast. ~~The Makah were suspicious of the efforts of the Coast Survey and a council was arranged. Davidson emphasized that the surveyors were not going to steal the Makah's lands or rights, but to only aid U.S. shipping. While tensions remained high, Makah Chief Clisseet granted Davidson permission to conduct the survey.~~

Following the coast survey, Davidson recommended Tatoosh Island for construction of a lighthouse. This recommendation was prior to the 1855 Treaty of Neah Bay negotiation. A lighthouse was built on Tatoosh Island in 1857 and operated by the USCG and Navy for over one hundred years. During World War II a radio intercept station was operated on Tatoosh until the end of the war when long range navigation (LORAN) equipment was installed. The lighthouse and LORAN equipment were automated in 1976 and in 2008 a separate LED pole was erected, eliminating the need for USCG personnel on Tatoosh.

The Makah never gave up on their claims on Tatoosh Island, and as a result of settling a claim under the Indian Claims Act, negotiated for its return in 1984. S~~The return of Tatoosh Island had a condition that the USCG would retain the lighthouse and surrounding facilities. No longer requiring the lighthouse for navigation, the Coast Guard proposed turning it over to the Makah in 2012. Since that time the Makah have worked with the Coast Guard to stabilize and rehabilitate the Cape Flattery Lighthouse[8] and nearby structures before accepting the property. Furthermore, s~~ince 1999 the Makah Tribe has been working with USCG and the Department of Defense under the Native American Lands Environmental Mitigation Program to conduct remediation at numerous sites on reservation, including Wa'adah and Tatoosh Islands, by conducting soil cleanup, removal of dilapidated buildings and underground storage tanks, and other activities.

~~In 1878, a lifeboat station was commissioned at Wa'adah Island station in Neah Bay and decommissioned in 1890. In 1906, a life saving station was established in Neah Bay by Congress to be operated by the U.S. Life-Saving Service (20 Stat. 163). The life saving station was established on Wa'adah Island in 1908, originally staffed by Makah, making the first Native American service in the USCG. However, large waves forced the station to move to Ba'adah Point on the mainland across from Wa'adah. The Life-Saving Service and the Revenue Cutter Service, a seagoing military service established in 1790 under the Department of the Treasury, eventually merged to form the USCG in 1915 (38 Stat. 800). The USCG Quillayute River Station was established in 1929. The USCG still has stations at these locations.~~

Following the attack on Pearl Harbor in 1941, the U.S. military mobilized defenses to the west coast. During this time, the Olympic Peninsula was considered one of the most threatened and vulnerable locations of the contiguous U.S. (Evans 1983). During World War II the military referred to the Olympic Coast as the Northwest Sea Frontier and mobilized the U.S. Army, Navy, and Coast Guard to the region. This included forts at the entrance to Puget Sound and fixed gun installations planned for Cape Flattery. ~~In 1943, the commander of the Northwest Sea Frontier stated: "The general function of the Navy in~~

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[8] ~~On March 16, 1972 Tatoosh Island was placed on the National Register of Historic Places. On August 25, 2017 Cape Flattery Lighthouse was named a National Treasure by the National Trust for Historic Preservation.~~

Coastal Defense is to conduct Naval operations to gain and maintain command of vital sea areas and to protect the sea lanes vital to the United States, thereby contributing to the defense of the Coastal Frontiers" (NARS:RG 26 1943, 10 April).

The USCG was transferred to the command of the Navy in 1941 and established the Coast Lookout System in 1941. The purpose of the Coast Lookout System was to "prevent communication between persons on shore and the enemy; to observe the actions of any enemy vessels in coastal waters and to transmit such information to naval or army commands; and finally, to report attempts of enemy landing to army and naval commands and to assist in preventing such action" (Evans 1983). During this time, the strip of coastline that is now Olympic National Park was occupied by the USCG. The USCG took over the army camp at Lake Ozette, creating the Ozette Lake Coast Guard Station. USCG activity included ten beach patrol outposts and three lookout towers positions at Cape Alava, Eagle Point, and the mouth of Starbuck Creek. Beach patrol stations included La Push and Kalaloch. The beach patrolling activities ended in 1944.

In 1941, the Navy began construction of a new airfield southwest of Quillayute. In 1944 the Quillayute Naval Auxiliary Air Station opened southwest of Quillayute. This same yearIn 1944 the Navy was granted the use of a number of rocks within the Washington Islands Refuges for bombing and strafing activities. The main island used was Sea Lion Rock. The USFWS later determined that this practice was not compatible with the purposes of the refuge and in 1993 the Navy use of the area was rescinded by the Secretary of the Interior.

The U.S. Army leased land from the Makah Tribe to construct a coastal battery in 1942. However, guns were never installed and the lease was terminated in 1945 with all lands returned to Makah, except 10 acres on Bahokus Peak. The Air Force also had a presence on the outer coast, with the Makah Air Force Station built in 1951, prompted by the Korean War. This was a surveillance radar station and was established as the 758th Aircraft Control and Warning Squadron[9] activated on Bohokus Peak in 1950. The land for the station was leased from the Makah Tribe. The base closed in 1988 and the Air Force station and housing were turned over to the Makah Tribe, and is now serve as the Makah Tribal Council Center. However, there is still radar at the site operated by the Federal Aviation Administration (FAA) as part of the Joint Surveillance System.

The Navy has utilized the airspace of the Olympic Peninsula for over 70 years. The Navy continues to exercise military readiness in the air and water of the Olympic Coast as part of their Northwest Testing and Training Study Area and Naval Undersea Warfare Center Division Keyport Range Complex. The Navy's mission is to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas (10 U.S.C. §8062). The Naval Undersea Warfare Center Division Keyport Range Complex includes the Quinault Range Site (QRS), which is located off the coast in Jefferson and Grays Harbor Counties, includes one mile1 miles of shoreline at Pacific Beach. The QRS provides key oceanographic features, depth, and logistics proximity for select at-sea testing events, including access to shore, that cannot be conducted elsewhere within the NWTT Offshore Area.

[9] Later the 758th Radar Squadron.

Oceanography

The Washington outer coast is known for its rough seas and large waves. Extreme wave heights up to 15 meters (49 feet) have been recorded on and beyond the continental shelf (Ruggiero et al., 2013). Winter storms travel across the fetch of the Pacific Ocean and the energy is magnified as they encounter the shallower continental shelf, where their force pounds the coast with gathered intensity. Storm intensity and wave height have increased over the past 50 years (Ruggiero et al., 2013).

Surface winds generated by atmospheric pressure systems are the main force driving ocean surface circulation off the Pacific Northwest, and produce two distinct ‘seasons’ that are tightly associated with regional productivity and energy flow. Spring and summer winds blow generally from the north~~toward the south~~ and push surface waters southward and offshore, resulting in nearshore upwelling of cold, nutrient-rich water to the surface. This influx of nutrients enhances plankton communities that support the region’s productive fisheries. Downwelling tends to occur in the fall and winter months, when the winds blow generally from the south ~~toward the north~~, forcing surface water into the subsurface. Other physical features also play a role in these dynamics, including shelf platform width, river plumes, submarine canyons, banks, coastal promontories, and offshore eddies. These geographic features influence the retention, magnitude, and timing of nutrient delivery to plankton, and may explain why primary productivity is higher along the Washington coast than the Oregon coast (Hickey and Banas, 2003, 2008).

On a regional scale, the California Current transports cold subarctic water southward from British Columbia along the Washington coast to Baja California, directly influencing the local distribution of marine organisms. The California Current generally occurs from the continental shelf break to a distance of about 1,000 kilometers from shore and rides above the narrower California Undercurrent, which flows northward and is implicated in the transport of larvae and other plankton. The California Current and Undercurrent are strongest in the summer, while the seasonal, nearshore Davidson Current flows northward during winter months, transporting the Columbia River plume along the Washington coast. Another local feature, the Juan de Fuca Eddy, which is approximately 50 kilometers in diameter and located offshore of the mouth of the Strait of Juan de Fuca, persists in summertime, and entrains nutrient-rich, cold water in a counterclockwise circulation pattern.

Oceanic and atmospheric events across the Pacific basin ~~also~~ influence the waters off the Olympic Coast. For example, the El Niño Southern Oscillation (ENSO) is primarily driven by sea surface temperatures in the Equatorial Pacific Ocean, but is a major source of interannual climate variability in the Pacific Northwest, with events lasting 6 to 18 months. El Niño periods generally produce lower chlorophyll and higher sea surface temperatures (SST), while La Niña years produce high chlorophyll and low SST. ~~Kelp forests tend to do well in cold, nutrient-rich water during upwelling (La Niña) and do poorly in warm, nutrient-poor waters (El Niño).~~ During an El Niño phase, storms have also created erosion hotspots (Ruggiero et al., 2013). Similarly, the Pacific Decadal Oscillation (PDO) is a dominant driver of climate variability in the Pacific Northwest, where warm or cool phases can each last 20 to 30 years. Warm PDO phases correlate with diminished upwelling along the California Current. Positive PDO phases result in warm temperatures and higher sea level (Miller et al., 2013). The phase of ENSO and PDO may also reinforce or weaken the climatic effect of each phenomenon. Climatic cycles such as these are natural events and often are associated with strong fluctuations in weather patterns and biological resources.

Habitat

OCNMS contains a broad diversity of habitats including rocky shores, sand and gravel beaches, kelp forests, sea stacks and islands, open ocean or pelagic habitats, a broad continental shelf, deep-sea habitats, and submarine canyons.

Along the shoreline, tide pools are nestled amid boulders and rocky outcrops that provide both temporary and permanent homes for an abundance of marine plants (e.g., macroalgae and seagrasses), invertebrate species such as sea stars, hermit crabs, and sea anemones, and intertidal fish. Rocky shores of the Olympic Coast have among the highest biodiversity of marine invertebrates and macroalgae of all eastern Pacific coastal sites from Central America to Alaska (Schoch et al., 2006). Nestled between these rocky headlands are numerous pocket beaches that host their unique array of intertidal algae, invertebrates, and fishes. While beach sediments in the north may be composed of pebbles and cobbles as well as sand, near the southern portion of the sanctuary, sandy beaches are more prevalent.

The pelagic zone includes all water column habitat from near the seafloor to the surface. Currents, upwelling, and other physical oceanographic drivers influence this dynamic zone, at times generating high primary productivity.

Kelp forests include floating kelp canopies as well as submerged kelp beds. Floating kelp forests form dense stands in nearshore waters, with individual plants anchored to the seafloor and reaching more than 20 meters in height. The structure of this living habitat alters the physical forces (waves and currents) in the nearshore area and creates a protective environment for fish and invertebrates, from their holdfast bases on the seafloor to their canopies at the surface. Kelp forests occur primarily along the northern coast of the sanctuary. There are 21 species of kelp found in the sanctuary, with another two species likely (Mumford, SAC presentation 2014). Sea otters often form rafts of animals that rest in and near kelp canopies, while many species of fish, including the more vulnerable younger age classes, utilize this protective habitat.

Pinnacles (sea stacks) and islands along the coast provide havens and resting sites for California and Steller sea lions, harbor and elephant seals, and thousands of nesting seabirds. High-relief submerged topographic features such as rock piles often serve as fish aggregation areas and settlement habitats for sessile invertebrates, concentrating biodiversity in relatively small areas.

A majority of the sanctuary lies over the continental shelf, extending from the shoreline to the shelf break near the 200-meter depth contour. The shelf is composed primarily of soft sediment and glacial deposits of cobble, gravel, and boulders, punctuated by rock outcrops, and it is inhabited by creatures such as flatfish, rockfish, octopuses, crabs, brittle stars, and sea pens that have evolved~~adapted~~ to flourish in the darkness, cold, and pressure of the seafloor. Sanctuary boundaries extend beyond the edge of the continental shelf and include portions of Nitinat, Juan de Fuca, Quileute, and Quinault submarine canyons. Quinault canyon is the deepest, descending to 1,420 meters (4,660 feet) at its deepest point within the sanctuary. Many creatures, such as corals, sponges, crinoids, rockfish, and shrimp, inhabit these areas of physical extremes.

Hundreds of new methane seeps were also recently discovered within OCNMS (Figure SH.6). These fascinating habitats are only beginning to be understood in terms of their contributions to ocean chemistry and biodiversity and their role as essential fish habitat, not to mention possible biopharmaceutical applications. Many of the seeps recently identified are adjacent to submarine canyons, which are dynamic areas of the seafloor where massive submarine landslides can shape the steep side walls, undetected, and canyon bottoms collect sediment deposited from above. Canyons also serve as conduits for dense, cold, nutrient-rich seawater that is upwelled and pulled toward shore, fueling productivity at the base of the food web.

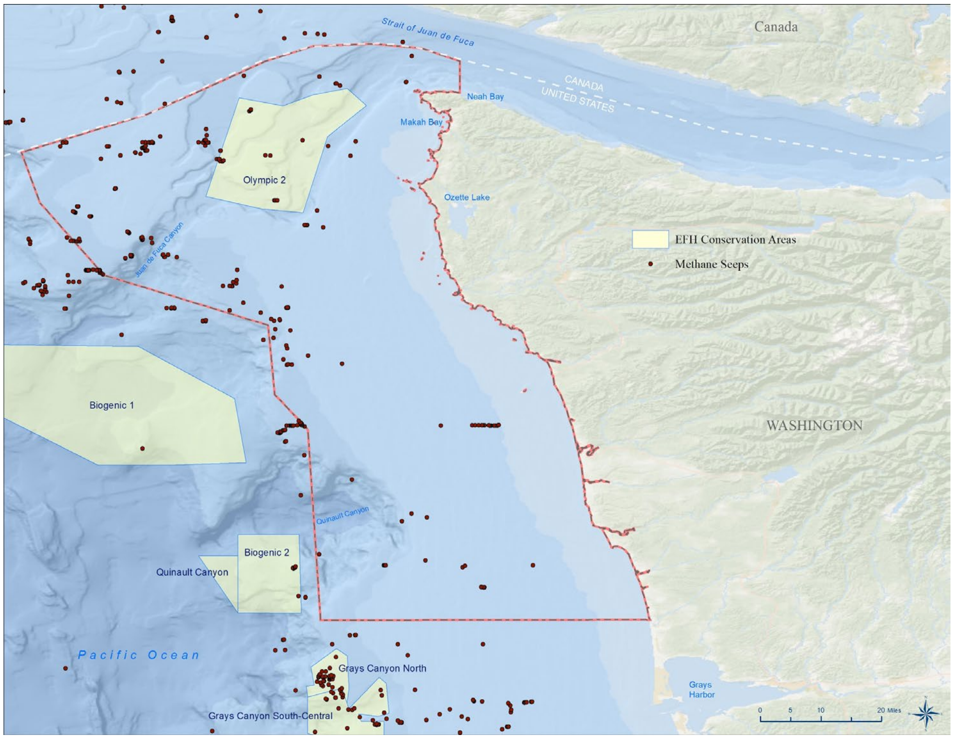

Figure SH.6. Locations of known methane seeps in and adjacent to OCNMS. Source: Dr. Andrew Thurber/OSU; NOAA PMEL. Map: NOAA ONMS.

Scientists have also documented deep-sea corals and sponge reefs in the sanctuary. Unlike the better-known shallow-water tropical corals, deep-sea corals live on continental shelves, slopes, canyons, and seamounts in waters ranging from 50 m to over 2,000 m in depth. Deep-sea corals lack the symbiotic algae (zooxanthellae) found in most shallow reef building tropical corals, so unlike their shallow water relatives that rely heavily on photosynthesis to produce food, deep-sea corals take in plankton and organic matter for their energy needs. Many deep-sea corals are also extremely long-lived and slow growing animals, which makes their populations particularly vulnerable to physical disturbance. The branching and upright growth structure of these organisms serves as biogenic habitat for other invertebrates and fish (Whitmire & Clarke, 2007). Habitat-forming corals and sponges can provide shelter, attachment sites, and food sources for animals living in deep sea environments.

Living Resources

The high primary productivity, strong coastal upwelling, and diverse seafloor (including submarine canyons) of OCNMS supports a variety of marine life, including more than 300 species of fish, more than 56 species of seabirds and 24 species of shorebirds, 29 species of marine mammals, and a growing list of invertebrates and marine algae.

Of the 29~~twenty-nine~~ species of marine mammals sighted in OCNMS, eight species are listed under the ESA. Two species are frequent foragers in OCNMS: the humpback whale and the southern resident killer whale. Gray whales, which were removed from the endangered species list in 1994 and as of 2016 number ~27,000, travel through OCNMS on their annual migrations between breeding and calving grounds off the Baja Peninsula and summer feeding grounds in the northern Pacific. Harbor and elephant seals, and Steller and California sea lions aggregate along the shore and haul out on land at many locations along the coast throughout the year. Sea otters, which were reintroduced to this coast from Alaska in the 1970s, have continued to reproduce and proliferate over the past four decades.

Three sea turtle species (leatherback, loggerhead, and green) also occur infrequently within OCNMS, with the leatherback sea turtle being the most likely to occur. All three species are listed under the ESA. Sea turtles use this area for foraging but breed in tropical habitats.

Seabirds are the most conspicuous members of the offshore fauna of the Olympic Coast. Sea stacks and islands provide critical nesting habitat for 19 species of marine birds and marine-associated raptors and shorebirds, including seven alcid species (e.g., murres, puffins, murrelets), three cormorant species, four gull and tern species, two storm petrel species, two raptors, and one shorebird, the black oystercatcher. Marbled murrelets are listed as threatened under the ESA. Productive offshore waters attract large feeding aggregations of marine birds that breed in other regions of the world but travel great distances to forage in productive sanctuary waters during the summer upwelling season. The sooty shearwater, for example, breeds along the coasts of New Zealand and Chile in the austral summer and congregates along the Pacific coast in its non-breeding season. Blackfooted and Laysan albatross travel far from their breeding grounds in Hawaii and Japan to forage in the eastern Pacific. Nearer to shore, sand and gravel beaches furnish foraging areas for shorebirds, crows, gulls, and a host of other birds and mammals, including black bears. The coastline forms an important migratory pathway for millions of birds that pass through each year, guiding waterfowl, cranes, shorebirds, and raptors toward northern breeding areas during the spring, and southward as winter approaches.

Sanctuary waters are inhabited by diverse and abundant fish and invertebrate populations. Commercially important fish and shellfish include at least 30 species of rockfish and 16~~5~~ species of flatfish (including~~,~~ Pacific halibut), Pacific herring and other forage fishes, Pacific cod, Pacific whiting, lingcod, sablefish, Dungeness crab, razor clams, and several species of shrimp. Five species of Pacific salmon (Chinook, sockeye, pink, chum, and coho) occur along the outer coast of Washington and breed in the Olympic Peninsula's rivers and streams. Three additional ~~similar~~ salmonid species found in freshwater systems (sea-run cutthroat trout, bull trout, and steelhead) spend portions of their lives in nearshore marine waters. Olympic Coast populations of Lake Ozette sockeye and bull trout were added to the federal list of threatened species in 1999. Nearshore habitats of the sanctuary are important for salmon that spawn in adjacent streams. OCNMS also encompasses the migration corridor of both juvenile and adult salmonids from California, Oregon, and British Columbia, Puget Sound, and from other rivers in Washington, including the mighty Columbia River and its tributaries, numerous populations of which are ESA listed. Forage fish such as Pacific herring, surf smelt, and eulachon feed in nearshore and pelagic waters of OCNMS and are important components in the food web. Sharks, albacore tuna, sardines, mackerel, anchovies, and other migratory species are also found in OCNMS seasonally.

Intertidal habitats challenge inhabitants with exposure, desiccation, extreme temperatures, and salinity and oxygen fluctuations, along with powerful physical forces such as sand scouring and wave action. Invertebrate communities in rocky intertidal zones are some of the richest on the West Coast and include a wide diversity of sea stars, sea urchins, mussels, barnacles, nudibranchs, chitons, and polychaetes. Macroalgae or seaweeds are also extremely diverse in the region, with an estimated 120 species occurring within the sanctuary rocky intertidal zone (Dethier, 1988), and with more than 180 species likely (Tom Mumford, personal communication, August 31, 2020). Shi Shi beach, for example, exhibits high diversity of intertidal seaweeds (Tom Mumford, personal communication, 2020). Sandy intertidal areas host sand-dwelling invertebrates and several notable fish species including starry flounder, staghorn sculpin, Pacific sand lance, sand sole, surfperches, and sanddabs. Surf smelt spawn at high tide on sand-gravel beaches where surf action bathes and aerates the eggs. Rocky intertidal habitats hold another roster of residents: tidepool sculpins, gunnels, eelpouts, pricklebacks, cockcombs, and warbonnets, to name a few. Intertidal areas transition to sandy habitat that support large populations of Pacific razor clams in the southern reaches of OCNMS.

In the deeper waters ~~areas~~ of OCNMS investigations have found stunning colonies of brightly colored, cold-water corals and sponges (Figure SH.7). These unique assemblages include soft coral species from multiple families (e.g., gorgonians, *Primnoa pacifica*), stony corals (e.g., *Lophelia* spp.and *Desmophyllum* spp.), and at least 40 species of sponges, including some that are believed to be new species (Brancato et al., 2007; Waddell et al., 2019; Thurber et al, 2021). The sanctuary is working to better explore and characterize deep sea communities and their distribution through research cruises and remotely operated vehicle (ROV) surveys, modeling efforts, environmental DNA sampling, specimen collection, and taxonomic validation of new species.

Figure SH.7. A beautiful, mature colony of the deep sea coral, *Primnoa pacifica*, encountered in central Juan de Fuca Canyon during a remotely operated vehicle dive in OCNMS in September 2019. Photo: MARE/ROV *Beagle* and OCNMS

Maritime Heritage Resources

The Olympic Coast is characterized by its broad continental shelf, which would have appeared as a topographically homogeneous coastal plain during the last glacial maximum, approximately 19,000 years before present (BP). Due to shifts in sea level, many prehistoric archeological sites may be submerged or found further upland. In 2013, the Bureau of Ocean Energy Management (BOEM) published an inventory of coastal and submerged archaeological sites (ICF International et al., 2013), and also assessed the relative sensitivity of cultural resources identified along the Pacific Coast. These resources include archaeological resources, built environment resources, and culturally significant properties. The modern shoreline of the Olympic Peninsula contains dozens of late prehistoric archaeological sites that are rich in materials documenting the character of the maritime environment and the use of this environment by the region’s native peoples. Nearshore coastal forests adjacent to OCNMS contain mid-Holocene shorelines and older prehistoric archaeological sites. These older sites are rich in materials documenting the character of maritime paleo-environments, the history of environmental change, and the record of use of these environments by the region’s native peoples.

The earliest dated archaeological site on the Washington Coast occurs adjacent to OCNMS on the Makah Indian Reservation, establishing human presence for at least the last 6,000 years. Although complex geological and climatic factors have changed the shoreline due to tectonic uplift and global sea level rise, it is evident that humans have occupied the coastal zone and adapted to changing habitats over time. The recent investigation of paleo-shoreline sites on the Makah Reservation reveals high sea-stand village sites inland near Ozette and the Tsoo-Yess (Sooes) and Wa'atch river valleys ranging from 7–14 meters above current sea level and kilometers from the current ocean shore (Wessen, 2003; Wessen & Huelsbeck, 2015). These sites indicate complex interactions with marine resources of the period and yield important clues to large-scale ocean and climate regimes, marine wildlife and fish populations, habitat distribution, and cultural patterns of marine resource use. Late prehistoric cultural patterns are particularly well documented. The Makah Cultural and Research Center in Neah Bay houses an extraordinary collection of artifacts from the Ozette Indian Village Archaeological Site, which was partially buried by a mudslide nearly 500 years ago and excavated in the 1970s. Ozette Indian Village Archeological Site is listed on the National Register for Historic Places. Excavated items are used for research as well as displayed in the Makah Museum, highlighting the tools and activities of prehistoric Makah people including whaling, seal hunting, and a variety of fishing gear.

Other tangible records of prehistoric human occupation include petroglyphs—both above the intertidal zone and within it—and canoe runs, or channels cleared of boulders to facilitate landing of dugout watercraft. Research and preservation of coastal native languages, traditional cultural properties, and traditional practices of song, dance, and activities like whaling also enhances awareness in native and non-native peoples of the region's rich ocean-dependent heritage. The canoe culture, as celebrated in the annual "Tribal Journeys," is a transfer of knowledge and understanding of coastal culture to new generations.

Maritime resources for native peoples are not exclusive to tangible resources. Locations, language, and activities are linked to the marine environment and are the foundation for the Olympic Coast's maritime heritage. For example, traditional places and activities (fishing, whaling, sealing), plant knowledge, prehistoric navigational aids, and others contribute to the unique character of this region.

OCNMS is within one of the more significant and unique maritime cultural landscapes in the United States. It lies at the international border with Canada, at the entrance to a major inland maritime highway and the Inside Passage to Alaska, as well as serving as the gateway to several historically significant and active ports. The combination of fierce weather, isolated and rocky shores, and thriving ship commerce have, on many occasions, made the Olympic Coast a graveyard for tribal and non-tribal ships and their crews. While there are few recorded shipwrecks prior to the mid-19th century and no verified wrecks during the 18th century, the number of vessel losses increased significantly as Puget Sound developed into an economic center and as Victoria, the provincial capital of British Columbia, developed on the north side of the Strait of Juan de Fuca in the 19th century. The 19th-century lumber trade, in particular, greatly expanded vessel traffic—for example, more than 600 vessels entered and cleared Puget Sound past Cape Flattery in 1886. Ship losses were predominantly weather-related and included founderings, collisions, and groundings. Many ships simply disappeared, their last known location recorded by the lighthouse keeper at Tatoosh Island before they disappeared into watery oblivion. As of July 2015, more than 197 shipwrecks have been documented in the vicinity of the Olympic Coast ~~through a literature review~~, yet only a few have been investigated using modern survey techniques (OCNMS, 2018). Currently, 69 shipwrecks have been identified with confirmed, specific~~,~~ or general locations within and adjacent to OCNMS, with nine of the wrecks being located and confirmed (Figure SH.8).

OCNMS Maritime Heritage Resources
July 16, 2014

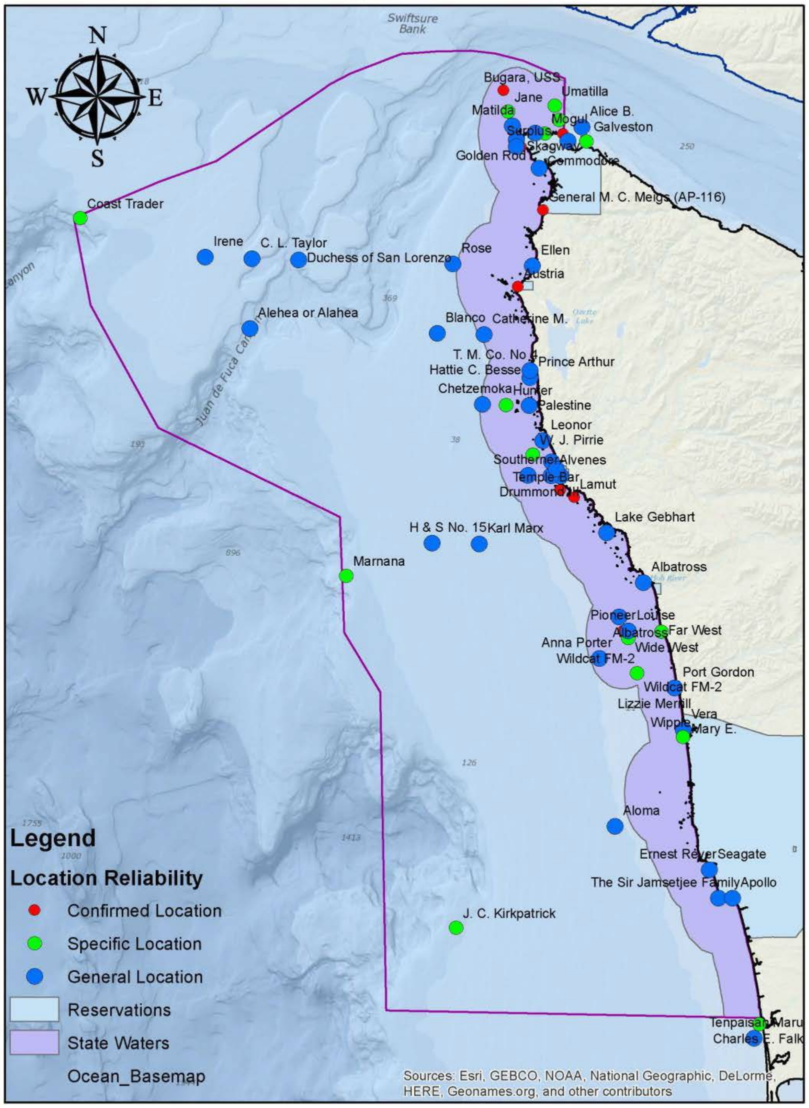

Figure SH.8. OCNMS maritime heritage spatial data provided by DAHP in July 2016. Includes vessels with confirmed, specific, and general locations. Source: Esri, GEBCO, NOAA, National Geographic, DeLarme, HERE, Geonames.org, and other contributors

The SS *Coast Trader* was surveyed by the E/V *Nautilus* in 2016. The SS *Coast Trader* was built in 1920 and operated as a merchant ship during World War II before sinking in 1942 from a torpedo fired by ~~from~~ a Japanese Imperial Navy submarine. The SS *Coast Trader* was observed acting as an artificial reef, with lingcod, yelloweye, and other fish using the shipwreck (Figure SH.9). Additionally, several trawl nets were caught on the shipwreck over time.

Figure SH.9. The SS *Coast Trader* serves as an artificial reef to many species, including lingcod as observed here. Source: Ocean Exploration Trust, 2016.

The USS *Bugara* (SS-331) was a U.S. Navy submarine that served in WWII, the Korean War, and Vietnam War before being decommissioned in 1970 (Olympic Coast National Marine Sanctuary, 2017). The USS *Bugara* sank in 1971 near Cape Flattery, Washington while under tow to serve as a target vessel. The E/V *Nautilus* surveyed the USS *Bugara* in 2017 (Delgado et al., 2018).

Historic structures on land, while technically outside of OCNMS boundaries, are important tangible fragments of the past and provide insight into past human interactions with the ocean. These include middens, village sites, historic lighthouses at Tatoosh and Destruction islands, lifesaving station remnants at Wa'adah Island and La Push, wartime defense sites at Cape Flattery and Anderson Point, and sites of coastal patrol cabins scattered along the Olympic Coast. Homesteads, resorts, graves, and memorials also reflect a human dimension to the coast now largely reclaimed by time, the forest, or the sea.

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This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

Driving Forces

For purposes of condition reports, driving forces or drivers are defined as societal values, policies, and socioeconomic factors that influence different human uses of the ecosystem. Drivers can influence the condition, or state, of the environment, creating both negative results, considered pressures, as well as positive results that benefit the environment. Drivers can result in pressures that affect the condition, or state, of the environment. They help us understand the forces behind pressures and are the ultimate cause of anthropogenic~~-based~~ changes in ecosystems. Further, drivers may be local, regional, national, or international in scale. Because the majority of influential drivers originate and operate at such large geographic scales, this section necessarily begins with a broad focus on drivers, followed by a much more locally focused discussion of ~~on~~ pressures that directly affect sanctuary water, habitat, living resources, and maritime archaeological resources. Trends in drivers and pressures support the assessment of these resources and can aid in forecasting the direction and influence of future pressures.

Commented [1]: Interesting, this is very different usage from what I am used to, where environmental driving forces, like climate change, are also considered 'drivers'. I wonder if you should specify "human driving forces" or "societal...".

Pressures may be affected by one or more driving force~~s~~, which often affects multiple pressures. The most influential drivers of pressures at OCNMS are shown in Table DP.DF.1 and are also integrated in discussions of each pressure. Table DP.DF.1 shows the relationships between drivers and pressures.

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Table DP.DF.1. Driving forces and their relationship to pressures that affect OCNMS resources. For each row, the bullets indicate the range of influence of drivers across pressures. For each column the bullets indicate drivers affecting individual pressures. The geographic scales at which different drivers originate to affect pressures is also shown (I - international, N - national, R - regional, L - local). See text below for explanations of specific drivers and pressures.

		PRESSURES													
Drivers	**Scale**	Changing Ocean Conditions	Noise	Large Vessel Traffic	Petroleum & other Che	Vessel Discharges	Exhaust Gas Cleaning	Cables & Pipelines	Fishing	Military Activity & Use	Marine Debris	Non-indigenous/Invasiv	Research Activities	Aquaculture	Visitation

					mical Spills		Discharges					e Species			
Tribal Treaty Rights and Gov't Relationships	I, N, R, L	●	●	●	●	●		●	●	●	●	●	●	●	●
Traditional Management	L								●					●	●
Human Population	I, N, R, L	●	●	●	●	●	●	●	●		●	●	●	●	●
Per-capita Income	I, N, R, L	●	●	●	●	●	●	●	●		●	●		●	●
Gross Domestic Product	I, N, R, L	●	●	●	●	●	●	●	●		●	●		●	●
Fuel Prices	I, N, R, L	●	●			●			●		●				●
Demand for Seafood	I, N, R, L	●	●	●		●			●		●	●		●	●
Regulatory Exemptions	N, L		●	●	●	●				●					
Demand for Energy	I, N, R, L		●	●	●			●							
Societal Values /Conservation Ethic	N, R, L	●							●		●	●	●	●	●
Environmental Activism	R, L	●	●	●	●	●	●		●	●	●	●	●	●	●
Ocean Policy	N, R, L	●	●	●	●	●	●	●	●		●	●		●	●

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U.S. National Security	N		●	●		●				●			●		●
Technological Advancement	I, N, R, L		●	●	●		●	●	●		●	●		●	

Drivers operate at different, and sometimes multiple, scales~~,~~ ranging from local to international. Most affect demand for resources (e.g., food, infrastructure, and access for recreation), and thus, levels of activities (e.g., development, ship traffic, boating, pollution, noise~~, etc.~~) that alter resource conditions. Some, like the gross domestic product (GDP) of foreign countries, have global influence. Among other things, GDP affects global demand for seafood and the pressure of commercial fishing. Local drivers, on the other hand, are those that originate from and influence the OCNMS "local economy" (sometimes called the "study area" or "sanctuary economy") (Figure DP.DF.1). This area is identified by looking at commuter work flows in the counties adjacent to the sanctuary to determine the spatial footprint of localized socioeconomic contributions stemming from the use of sanctuary resources. These contributions include income, jobs, and economic output, all of which respond to changes in resource conditions that are influenced by changing pressures. Although the population centers within these counties are not on the outer coast, these counties contain the highest concentration of people who depend on the sanctuary and its resources for their livelihoods.

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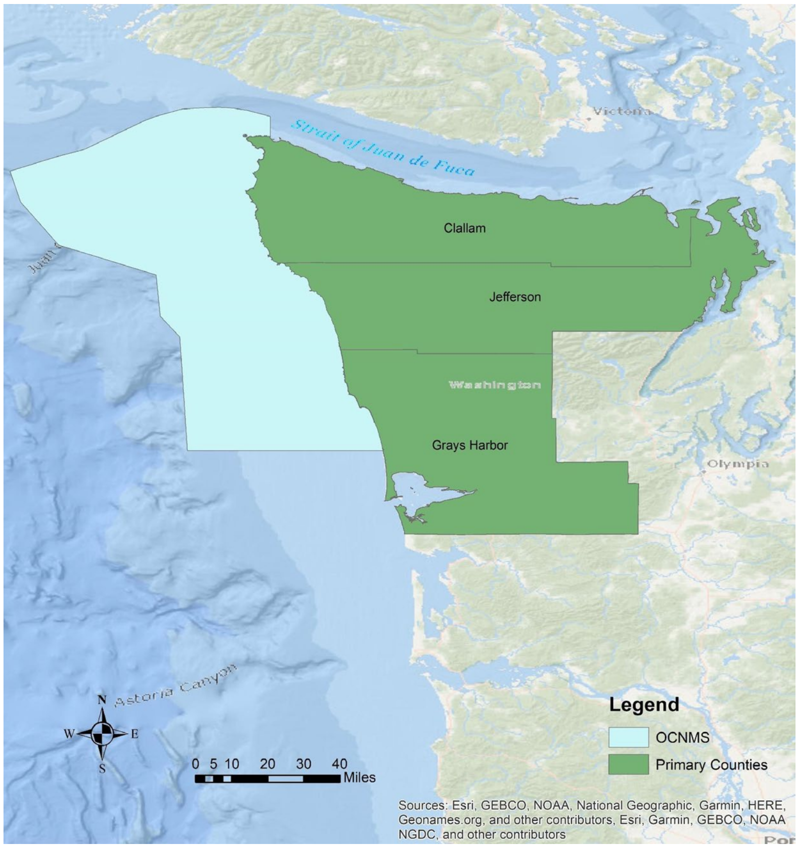

Figure DP.DF.1. Map of Olympic Coast National Marine Sanctuary and the study area, which includes counties with populations that are likely to have the greatest economic dependence on sanctuary resources. Map: NOAA ONMS.

Some drivers influence the supply or access to resources. These stem mostly from management and policy actions, whether local, state, tribal, national, or international, and may increase or decrease the pressures on resources. Some, such as relationships established and dictated through treaties, create cooperative management approaches that can preempt pressures (e.g., cooperative fisheries management, preparation of oil spill response plans). Importantly, these drivers also exemplify a concept frequently expressed by Indigenous peoples, namely the reciprocal relationship between people and the environment. This originates from Indigenous peoples' sense of oneness with nature and emphasizes the mutual roles of both in supporting the other. Advocates of the modern conservation movement will recognize this as a foundational aspect of their efforts as well. In this way, both can be considered "positive" drivers.

Before discussing other drivers, it is important to consider NOAA and OCNMS mandates as institutional drivers. Starting with federal agencies' basic obligation of public service, each employee has an oath-bound responsibility to the United States government and its citizens to display ~~place~~ loyalty to the Constitution, laws, and ethical principles (5 CFR § 2635.101). This includes fulfilling the responsibilities outlined in the the National Marine Sanctuary Act (NMSA) (16 U.S.C. § 1431), which:

> "establishes areas of the marine environment which have special conservation, recreational, ecological, historical, cultural, archeological, scientific, educational, or esthetic qualities as national marine sanctuaries managed as the National Marine Sanctuary System will—(A) improve the conservation, understanding, management, and wise and sustainable use of marine resources; (B) enhance public awareness, understanding, and appreciation of the marine environment; and (C) maintain for future generations the habitat, and ecological services, of the natural assemblage of living resources that inhabit these areas."

This guiding language ensures that the sanctuary acts in a manner to improve conservation and management for generations to come. The fulfillment of the OCNMS designation, authorized by the NMSA and carried out as a public process, is a public trust. The designation (59 FR 24586) states:

> "The Act authorizes the issuance of such final regulations as are necessary and reasonable to implement the designation, including managing and protecting the conservation, recreational, ecological, historical, research, educational, and aesthetic resources and qualities of the Olympic Coast National Marine Sanctuary."

Tribal Treaty Rights and Government Relationships

The Treaties of Neah Bay and Olympia are the "supreme law of the land[1]" under the U.S. Constitution and, accordingly, the federal government has a Federal Trust Responsibility to protect the treaty rights of signatory tribes. This legally enforceable fiduciary obligation protects tribal treaty rights, lands, assets, and resources. Several Supreme Court cases have used language affirming legal responsibilities, moral obligations, and the fulfillment of understandings and expectations that have arisen over the history of the relationship between the United States and treaty tribes.

Federal agencies are required to consult with federally recognized tribes on policies with tribal implications under Executive Order 13175 (2000) and those requirements have been reaffirmed by subsequent Presidential Memoranda~~ums~~ supporting the ~~e~~Executive

[1] Constitution of the United States, Art. VI, Clause 2

~~o~~Order. To the extent consistent with federal law, NOAA implements its trust responsibility toward the coastal treaty tribes and discharges its statutory mission under the National Marine Sanctuaries Act to:

- Protect and conserve treaty trust resources;
- Protect the exercise of treaty rights by the coastal treaty tribes;
- Support the development of and deference to tribal treaty resource management plans meeting the objectives of the NMSA; and
- Consult with the coastal treaty tribes on a government-to-government basis when proposing an action that may affect treaty resources or tribal treaty rights or resources of cultural or historical significance.

The coastal treaty tribes have place-based rights in the ocean, with reserved rights to half of the harvestable marine species that transit through. The Usual and Accustomed Areas (U&As) of the coastal treaty tribes overlap with OCNMS and the majority of the sanctuary is within a tribal U&A. The presence of treaty rights, and the federal government's responsibility to uphold those rights, are positive drivers that help maintain the condition of OCNMS. Those positive drivers include ensuring sustainable fish populations upon which to exercise treaty rights in perpetuity and protecting the coast from oil spills that would threaten those rights.

Collaborative research with the coastal treaty tribes also benefits the OCNMS by forming partnerships that help to secure competitive funds, extend the ability to monitor and conduct research in remote areas of the sanctuary, and ~~by~~ incorporate~~ing~~ the long history of traditional knowledge of coastal ecosystems carried by members of the treaty tribes.

Traditional Management

Tribal and traditional knowledge enhances contemporary management through the robust knowledge each of the coastal treaty tribes have developed in this region over thousands of years. Tribes also have a reciprocal relationship with nature, meaning that people benefit or receive services from nature and nature benefits or receives services from people. This is demonstrated in a variety of ways, through restoration and conservation efforts, in oral history and traditional knowledge, and in policy and management decisions.

Population and Per Capita Income

International and domestic demand for goods and services, at all scales ranging from local to global, is directly tied to changes in population and real per capita income. It is and will remain a ubiquitous, primary driver of pressures on sanctuary resources. The data provided in this section are ~~is~~ from the U.S. Census.

Commented [6]: What year? Place a citation here.

The U.S. population increased by 5.8% between 2010 and 2018. In Washington, the increase was greater, at 11.8%. Of the 7.5 million residents of Washington State, just over 182,000 (2.4%) live in the three-county OCNMS study area (Clallam, Jefferson, and Grays Harbor counties) (Table DP.DF.2). The population in the study area grew by only 4.7% from 2010 to 2018~~, which is less than that for the U.S. and Washington~~.

Per capita income in the study area has also increased at a slower rate than in both the U.S. and Washington. It increased by 34.3% in the United States, 45.3% in the state of Washington, and 33.2% in the study area from 2010 to 2018.

Table DP.DF.2. Population and real per capita income for study area, 2010–2018. Source: US Census, 2020.

Year	Per Capita Income	Population	Per Capita Income (% Change)	Population (% Change)
2010	$33,743	174,243	N/A	N/A
2011	$35,054	173,958	3.9%	-0.2%
2012	$36,586	173,330	4.4%	-0.4%
2013	$36,597	173,098	0.0%	-0.1%
2014	$38,905	173,399	6.3%	0.2%
2015	$40,075	174,580	3.0%	0.7%
2016	$41,276	176,748	3.0%	1.2%
2017	$43,032	179,456	4.3%	1.5%
2018	$44,938	182,367	4.4%	1.6%

The expected result of increases in both per capita income and population over the past decade would be an increase in pressures on resources in OCNMS, created by higher demand for products and services. Activities required to meet the demand could include fishing, transportation, energy development and exploration, submarine cable installation, construction, land development, and visitation. These have direct impacts on resources, such as pollution, removal of fish, seafloor disturbance, ship strikes of marine mammals, and underwater sound impacts on marine mammals and other species. Many of these activities also produce greenhouse gases, increase rates of run-off and pollution, and change the way land is used. An increase (or decrease) in pressures based upon population increases may vary by county. Therefore, they can have direct and indirect influences on threats ranging in scale from beach closures to climate change.

In 2018, there were about 11,100 people living within ZIP~~zip~~ codes adjacent to the Olympic Coast, mostly in small, rural, remote communities. Tribal reservations are the only communities situated on the coast, many of which are adjacent to the mouths of rivers. These communities have primarily natural ~~-~~resource~~-~~dependent economies, relying on commercial fishing, timber harvest, and tourism. The figure below shows how the population has changed from 2011 to 2018 by ZIP~~zip~~ code on the Outer Coast.

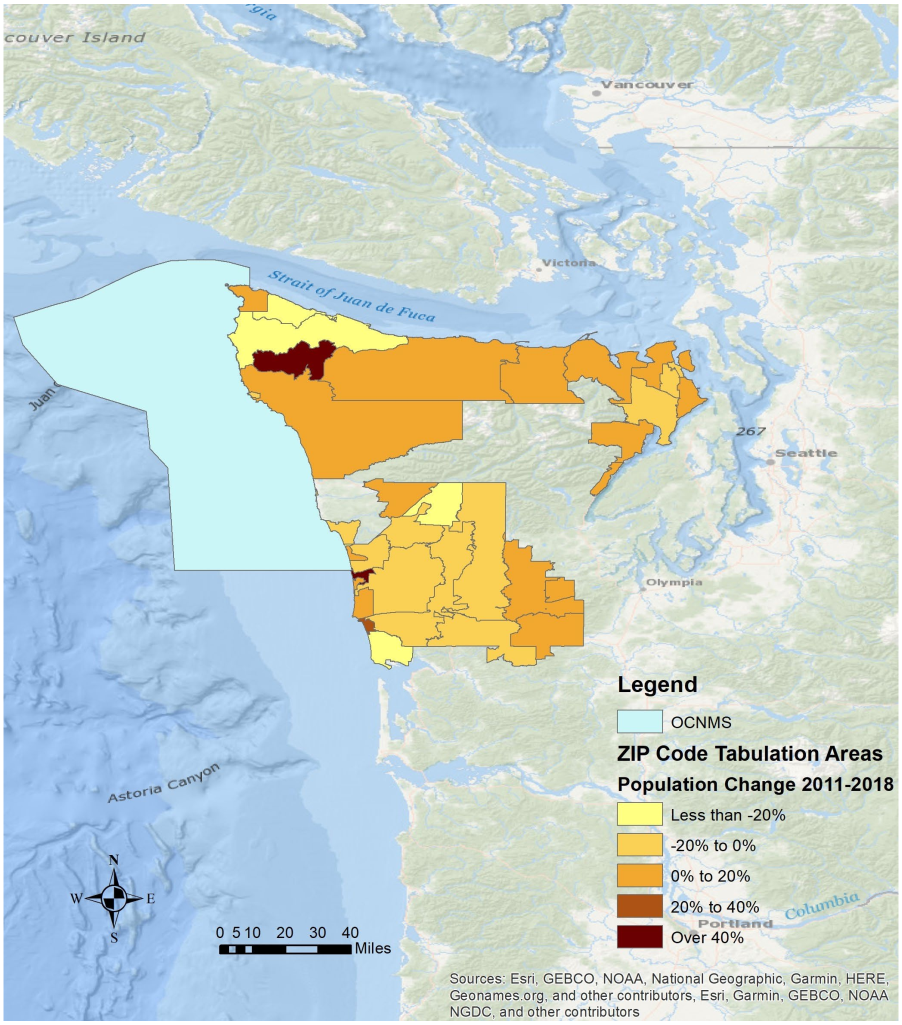

Figure DP.DF.2. Population change from 2011 to 2018 by ZIP ~~zip~~ code. Source: US Census, 2020

Gross Domestic Product

Another high-level driver of pressures on natural ~~U.S.~~ resources, including those in OCNMS, is the GDP of trade partners that were the top importers of U.S./tribal seafood and other fishery products in 2018, namely Canada, the European Union, China, Japan, Switzerland, and South Korea (NOAA Fisheries, 2019). Changes in GDP in these countries directly affect demand for all goods. Furthermore, seafood is bought and sold in

Commented [7]: The document makes a point that these are shared resources, why specify here that they "belong" to the U.S.?

a global market such that changes to demand directly affect prices of species caught in OCNMS and, thus, affect fishing behavior in and around the sanctuary itself. GDP growth for each of these trading partners is shown in Figure DP.DF.2. With the exception of China, most countries' GDP growth remained stable from 2008 to 2018. Despite remaining stable (or decreasing in China), GDP growth for all countries has been positive since 2013, so it is likely that demand for OCNMS products continued to increase (OECD, 2020 and Figure DP.DF.3).

Figure DP.DF.3. GDP growth in top countries of U.S. seafood exports. Source: OECD, 2020

Fuel Prices

Fuel prices are an important, and often an immediate, driver of many ocean activities. Ocean users consider fuel prices in their decisions about whether to conduct activities like commercial fishing, to buy and register boats for ocean recreation, or to explore for offshore oil and gas (and in the longer term, install offshore renewable energy facilities). Gasoline prices varied from 2008 to 2018, but had no clear trend (Figure DP.DF.4). By the end of the study period, fuel prices were 5.3% below those of 2008, but Washington boat registrations during the period decreased by 7.5% (EIA, 2020; NMMA, 2020). This may be partly explained by higher fuel prices between 2011 and 2014, but there were likely other drivers that influenced the use of boats in the area. While fewer boat registrations would suggest that pressures from on-water use of motorized vessels may have decreased, state-wide registration data do not indicate spatial patterns of use. Regardless, considering data from registrations, it is likely that the pressures from on-water use of motorized vessels may be decreasing.

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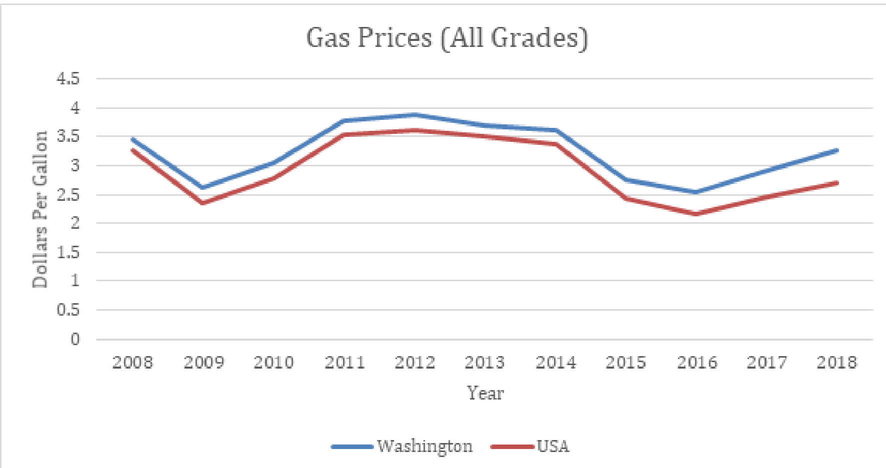

Figure DP.DF.4: Retail gas prices for Washington and the US, 2008-2018. Source: EIA, 2020

Demand for Seafood

As global and domestic demand for seafood grows, it will require effective management of wild-caught fish as well as continued increases in the growth of aquaculture (NOAA Fisheries, 2020b). Yet, while these approaches are needed to meet demand, they may also lead to increased pressures on resources and ecosystems. While this section considers global and national demand, local and regional markets are likely to be affected and face increased pressures to meet the global and national demands. Further, as prices fluctuate locally, this may change the willingness of commercial fishermen to expend time and resources targeting specific species. For example, if the price of salmon increases, while the price of black cod stays the same, more effort may be spent harvesting ~~the~~ salmon. For more information on harvest revenue and landings of species within the Olympic Coast region, see the Commercial Harvest Ecosystem Service section of this report~~write-up~~.

Global seafood production has quadrupled over the past fifty years, while the world population has more than doubled, and the average person now eats almost twice as much seafood as half a century ago (Ritchie & Roser, 2019; FAO, 2019). Although the global supply of wild-caught fish has been relatively steady for more than 20 years, the human population continues to grow, and the U.S. imports over 80% of seafood, about half of which is farmed seafood (NOAA Fisheries, 2020). Aquaculture has been increasing in Washington State and there are roughly 2,100 acres of Washington State-owned land under lease for aquaculture (primarily in tidelands; WSG, 2014; WADNR, 2020). Aquaculture in Washington State is dominated by shellfish and occurs in Puget Sound, Grays Harbor, and Willapa Bay. Washington State is the largest producer of farmed shellfish in the U.S., generating ~~comprising~~ 25% of domestic production. Washington

State has banned non-native fish net pen aquaculture within state waters following a failure of an Atlantic salmon net pen near Cypress Island in Puget Sound, in which approximately 250,000 Atlantic salmon were released, with remaining facilities phasing out by 2025 (RCW 77.125). However, interest in aquaculture of native finfishes aquaculture may has increased in Puget Sound in response to this moratorium.

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Regulatory Exemptions

Federal agencies implement regulatory requirements under their respective statutes and mandates. However, in some cases individuals, entities, or certain activities are exempt from statutory or regulatory requirements. For example, the Clean Water Act provides a permit exemption for some point source pollution sources. These regulatory exemptions could affect the sanctuary through water quality degradation, injury to sanctuary resources or habitats, or other impacts.

There are several sanctuary regulations for which federal agencies or other entities have exemptions. The Department of Defense, specifically the Navy, has trained and tested in this region for decades prior to the designation of OCNMS. As such, some military operations are exempt from sanctuary regulations, including:

- Hull integrity tests and other deepwater tests;
- Live firing of guns, missiles, torpedoes and chaff;
- Activities associated with the Quinault Range Site, including the in-water testing of non-explosive torpedoes; and
- Anti-submarine warfare operations.

The proposal for a Department of Defense exemption for the Quinault Range Site on the Olympic Coast could also affect the designation of critical habitat for humpback whales and southern resident killer whales.

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Other examples of regulatory exemptions for OCNMS include:

- Coastal treaty tribes exercising treaty-secured rights;
- Overflight requirements for tribal timber operations conducted on reservation lands, or to transport persons or supplies to or from reservation lands as authorized by a governing body of an Indian tribe;
- Certain activities that may incidentally affect the submerged lands of the sanctuary, including:
    - Installation of navigation aids;
    - Lawful fishing operations[2];
    - Anchoring vessels;
    - Harbor maintenance in the areas necessarily associated with the Quillayute River Navigation Project, including dredging of entrance channels and repair, replacement or rehabilitation of breakwaters and jetties, and related beach nourishment;

[2] Fisheries are regulated under the Magnuson-Stevens Act and not by OCNMS or NMSA.

- Construction, repair, replacement or rehabilitation of boat launches, docks or piers, and associated breakwaters and jetties; and
- Beach nourishment projects related to harbor maintenance activities.

Demand for Energy

The demand for energy, whether from non-renewable or renewable resources, is also a driver. Pressure to increase supplies of energy or energy products (e.g., raw or refined) may place pressures on sanctuary resources through increased development and/or shipping near or through the sanctuary. For example, the Trans Mountain Pipeline expansion was oversubscribed by over one-third in early 2018 (Trans Mountain, 2018), meaning the pipeline capacity is insufficient to meet demand. The project is in response to requests from shippers to increase supply so that they may meet demand in new and growing markets. This is North America's only pipeline with West Coast access, and its expansion would increase shipping traffic along the coast and within the sanctuary. Specifically, oil-laden tanker traffic would increase seven-fold from one tanker a week to one a day, which would increase pressures on resources and the risk of an oil spill in the region.

Societal Values/Conservation Ethic

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Information on societal values related to conservation can be obtained from various national or local opinion polls. Nationally, several are relevant to the OCNMS pressures. First, a national poll focusing on how much people worry about climate change found that the percentage of people who "worried a great deal" increased from 37% to 44% from 2008 to 2019 (Figure DP.DF.5). Further, the percentages "worrying a great deal" in the last three years (2017–2019) have been the highest since the poll started in 1995 (Gallup, 2019).

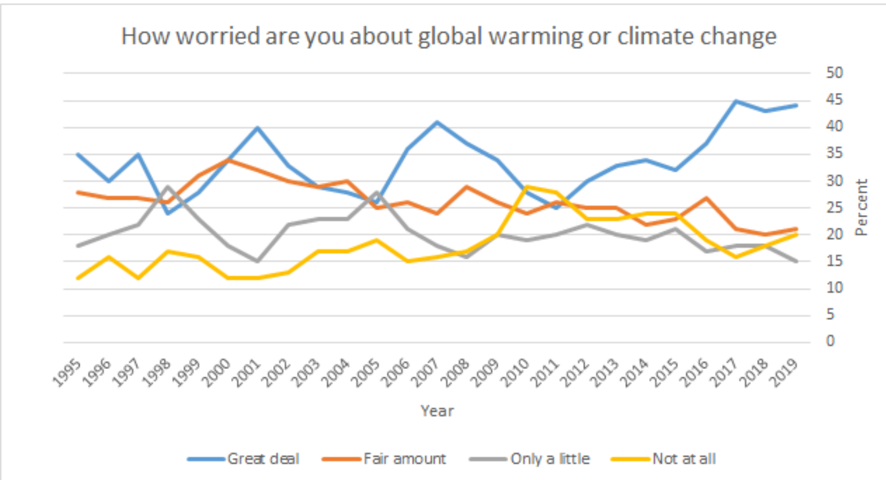

Figure DF.DP.5. National Opinion Poll: “How worried are you about global warming or climate change?” Data from 1995–2019. Source: Gallup, 2020

Additionally, a national poll conducted by Pew since 2014 found that more Americans now oppose (51%) than favor (42%) allowing offshore oil and gas drilling in U.S. waters, most likely reflecting increasing awareness over links between fossil fuel consumption and climate change. This represents a ten percentage point decline in those who favor expanded offshore drilling since 2014 (Jones, 2018).

According to a poll conducted annually in the State of Washington, between 2009 and 2018 no more than 7% of people considered the environment a top priority. In January of 2019, however, 15% of respondents considered the environment a priority, the highest since 2001. Likely reasons for the increase include growing impacts from wildfire smoke in Washington, a marine heatwave from 2013–2016, and the death soon after birth of a killer whale calf (Secaira, 2019) that was the first in years to be born to a pod of southern resident killer whales. International attention on ~~to~~ the threats to orca populations resulted from images of the mother whale carrying around the calf’s body and pushing it to the surface for seventeen days over hundreds of miles (Buch, 2018).

Another study of Washington households provides a point estimate about attitudes and perceptions related to the sanctuary (Leeworthy et al., 2017). Specifically, survey respondents were willing to pay, on average, $152 annually to ensure that there is low impact of development, no offshore structures, and easy access to beaches and shores. This is a driver that helps to inform local attitudes towards pressures related to coastal and offshore development, such as energy development, and indicates there is support to maintain natural viewscapes void of development.

Environmental Activism

As conservation ethics change, levels of environmental activism are likely to as well. This can affect the implementation of many types of activities and management actions, which can dramatically alter and re-distribute pressures.

Activism directly related to the changing conservation ethic discussed above resulted in several new programs forming on the outer Washington coast. In 2015, the Washington State Legislature created the Washington Coast Restoration and Resiliency Fund (WCRRI), targeting $10–15 million per biennium on coastal restoration projects and local economic development. The Surfrider Leadership Academy also launched in 2015, focused on effective leadership development for coastal conservation on the Washington coast. Past participation included individuals from the Makah and Quileute Tribes, Quinault Indian Nation, Pacific Coast Shellfish Growers Association, Mayor of Ocean Shores, The Nature Conservancy, and more.

In the Heritage Ecosystem Service, other examples from the sanctuary's history are discussed in further detail, including a hike by Supreme Court Justice William O. Douglas of the Olympic Coast in 1958 to protest a proposed highway through the undisturbed old growth forest of the coast, and Washington's Attorney General replicating his hike in protest of proposed offshore oil and gas exploration along the Olympic Coast 60 years later.

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Ocean Policy

The United States is ~~a~~ party to numerous ~~international~~ agreements that~~. These agreements~~ establish international entities composed of member governments that focus on various topics, ranging from managing shipping (International Maritime Organization, IMO), global whale stocks (International Whaling Commission), fisheries (International Pacific Halibut Commission, Pacific Hake/Whiting Joint Management Committee, Pacific Salmon Commission, etc.), and oil spill response (CANUSPAC). These international agreements affect local processes, such as the Area to be Avoided designated by the IMO.

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Since 2010, the United States has had an ocean policy, first with Executive Order 13547 (2010), which was later replaced with Executive Order 13840 (2018). While the primary focus differs between these policies, both emphasize improving cross-agency coordination on management of the ocean and its resources, and access to data. Mapping the seafloor of our nation's waters is a priority under the current ocean policy to enhance navigation and development of the Blue Economy. Furthermore, in 2019, a Presidential Memorandum on "Ocean Mapping of the United States Exclusive Economic Zone (EEZ) and the Shoreline and Nearshore of Alaska" set forth a strategy for mapping, exploring, and characterizing the EEZ through enhanced collaboration.

The west coast states have collaborated on ocean policy initiatives since the Tri-State Agreement on Ocean Health was signed in 2006. Since that time, this regional ocean partnership has evolved to better include tribal governments, broader federal agency representation, and a variety of regional priorities. Today, the West Coast Ocean Alliance is focused on: (1) compatible and sustainable ocean uses; (2) effective and transparent decision making; (3) comprehensive ocean and coastal data; and (4) increased understanding of and respect for tribal rights, traditional knowledge, resources, and practices.

Washington State completed a marine spatial plan (MSP) for the outer coast in 2018. The MSP covers the entire outer coast of Washington State to 700 fathoms (4,200 ft) depth and is focused on planning for potential new uses (marine renewable energy, offshore aquaculture, dredge disposal, mining, and marine product harvesting) and maintaining existing sustainable uses (fishing, shellfish aquaculture, recreation, maritime shipping). The sanctuary was supportive of the MSP process, including having the entire sanctuary included in the study area.

U.S. National Security

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The ocean plays a critical role in the mobility and readiness of our Armed Forces and the preservation of our national security. Uncertainty regarding ~~on~~ the dynamics of future conflicts require our military to train and prepare for a variety of scenarios, especially given emergent technologies. The State Department, Department of Defense, Department of Homeland Security, National Security Administration, Department of Transportation, and others all play key roles in national security. Climate change is also viewed as a national security issue, not only its direct effects on military bases via sea level rise, but also because melting of the polar caps can open new avenues for shipping and security concerns.~~, and~~ ~~i~~Increasing intensity and frequency of natural disasters increase demand for disaster relief, ~~all of which~~further threatening ~~our~~ national security.

The Department of Defense has had a presence on the Olympic Coast for over one-hundred years. The Navy tests and trains to ensure it meets its statutory mission to “maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas" (10 U.S.C. §8062). U.S. military activities may affect pressures on sanctuary resources in OCNMS, including disturbance from noise and vessel traffic. This is discussed further in the Pressures section in the context of the Navy’s Northwest Testing and Training study area.

Technological Advancement

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Technological advancement may be viewed as either a positive and negative driver depending on the technology and what it promotes. For example, requirements for seafloor mapping may act as a positive driver by increasing knowledge and awareness of sensitive habitats and refining our understanding of species distributions. Significant efforts to increase seafloor mapping in OCNMS by vessels such as the *R/V Nautilus* and R/V *Ocean Titan* have taken place in the past decade. On the other hand, seafloor mapping may also identify previously unknown deposits of oil and minerals, which could increase pressures to extract those resources. Advancements in fishing technology in the past have resulted in increased harvests while decreasing the effort needed to catch the fish. Improvements in fishing gear technologies can also reduce bycatch of sensitive species. Advancements in autonomous vehicles have helped to estimate fish abundance to promote sustainable fishing, while reducing the risks to human health and fish (NOAA Fisheries, 2020a).

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This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

Pressures

Human activities and natural processes both affect the condition of natural, cultural, and maritime heritage resources in marine sanctuaries. The following section discusses the nature and extent of the most prominent human influences upon OCNMS, including changing ocean conditions, maritime transportation, submarine cables, fishing, whale entanglement, military activities, non-indigenous and invasive species, contaminants, offshore aquaculture, offshore energy, and increased visitation.

Changing Ocean Conditions

Over the next century, climate change is projected to profoundly impact coastal and marine ecosystems on a global scale, with anticipated effects on sea level, temperature, ocean chemistry, storm intensity, and ocean current patterns. At a regional scale, we can anticipate significant shifts in the species composition of ecological communities, seasonal flows in freshwater systems, rates of primary productivity, occurence/persistence of hypoxia, sea level rise, coastal flooding and erosion, and wind-driven circulation patterns (Miller et al., 2013). Climate change will affect all aspects of the sanctuary, including but not limited to, water quality, species abundance and distribution, human activities, and ecosystem services.

Anthropogenic climate change is primarily caused by greenhouse gas emissions. Greenhouse gases (i.e., carbon dioxide, methane, ~~etc.~~) trap heat in the atmosphere; as greenhouse gases increase so does the amount of heat trapped, which leads to higher air and water temperatures. Since pre-industrial times, global air temperature has increased, on average, by 1.8°F (1°C), and inof ~~which~~ the last 50 years this increase has been driven nearly entirely by anthropogenic greenhouse gas emissions (IPCC, 2019).

As global temperatures rise, the ocean has absorbed much (>90%) of the excess heat, causing the average ocean temperature to increase world-wide (IPCC, 2019). In OCNMS, water temperatures are expected to increase 2°F (1.1°C) by 2050 (Mote & Salathe, 2010). Warmer sea surface temperatures may weaken circulation patterns that drive upwelling, resulting in lower productivity. Furthermore, copepod communities are impacted by increasing ocean temperatures, with lipid-poor, warm-water species becoming more prevalent than cold-water, lipid-rich ~~copepod~~ species (McClatchie et al., 2016). Warmer ocean temperatures hold less oxygen and increase stratification (Miller et al., 2013; IPCC, 2019), weaken upwelling and productivity, and affect species composition and ranges. This is especially problematic given the placed-based rights that each of the coastal treaty tribes have to marine resources in their usual and accustomed fishing areas.

Marine heatwaves (MHWs) are declared when sea surface temperatures exceed the 90th percentile for at least five consecutive days (Hobday et al., 2016). First detected in 2013, peaking in 2015, and finally dissipating in mid-2016, a marine heat wave in the Pacific Ocean known as "the Blob" led to water temperatures 1.8–7.2°F (1.0-4.0°C) above normal (Bond et al., 2015; Kintisch, 2015). These warm waters also fueled the largest harmful algal bloom (HAB) ever recorded in the Northeast Pacific, which produced toxins that killed whales, sea lions, and birds and led to the closure or delay of the Dungeness crab fishery (McCabe et al., 2016; Washington State Department of Ecology, 2018). As temperatures warm, such HABs may become more common, last longer, and be more toxic (McKibben et al., 2017).

Commented [1]: This list doesn't match the content presented below. Ocean Sound, Marine Debris, and Research are missing. Also, i would move the fishing and aquaculture sections to be adjacent to one another, as they are inherently linked.

Commented [2]: Although climate projections typically cover the 100-year time frame, it would be helpful to note that these changes are already occurring and will continue to do so.

Commented [3]: Don't use etc. with e.g.

Commented [4]: I would also argue that the place-based boundaries of the sanctuary, and the fact that changing these requires political will and broad support garnered through an extensive campaign of outreach, represents a huge issue too. Shifting boundaries is time consuming and costly, and if the pace can't keep up with changes in habitat and biodiversity both may be lost before they can be protected.

Commented [5]: Is there a standard time period used for comparing the temperature anomaly?

Commented [6]: Relative to what period? All of monitored history? A minimum of 10 years of data? Please place a time bound of some sort on this if possible.

Given current projections for climate change, all of these things may occur, in addition to HABs covering ever larger geographic swaths ~~Furthermore, marine heatwaves may become more common in the future, lasting longer and becoming larger~~ (IPCC, 2019). For instance, in 2019, another marine heatwave appeared in the Northeast Pacific lasting until mid-January 2020, becoming the second largest and longest event recorded in the northern Pacific Ocean (Figure P.1).

Commented [7]: I've reworked this sentence because, as written, it said "furthermore," but then repeated two of the three items in the list.

Commented [8]: I disagree with the re-write. The first sentence was about HABs and the second about MHWs. So, it was not repeating...I would restore to the original.

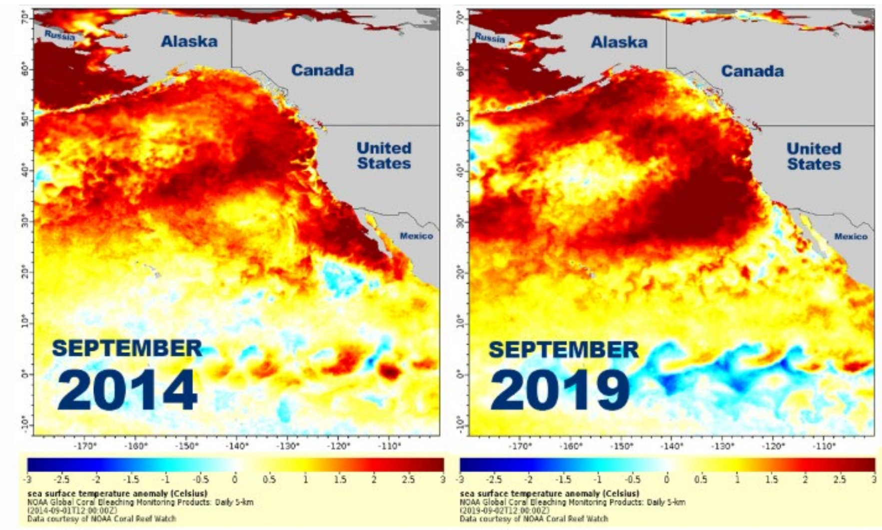

Figure P.1. Several intense marine heatwaves have affected the ~~n~~Northeast Pacific in recent years. Source: NOAA Fisheries, 2019.

~~Harmful algal blooms (HABs) are blooms of algae that can produce toxins that have harmful effects on people, fish, shellfish, marine mammals, and birds.~~ There are many kinds of HABs, caused by a variety of algal groups with different biotoxins. HABs of greatest importance in the Pacific Northwest are those that produce neurotoxins, such as paralytic shellfish poisoning (PSP) caused by dinoflagellates in the genus *Alexandrium,* and domoic acid, a neurotoxin produced by diatoms in the genus *Pseudo-nitzchia*. Climate change is expected to increase the frequency of harmful algal blooms because~~due to~~ warmer sea surface temperatures increase~~ing~~ metabolism rates of algae and other primary producers, fueling blooms (Miller et al., 2013; Trainer et al., 2020), which then impact~~will affect~~ commercial, recreational, and subsistence harvest as well as outdoor recreation and visitation. HABs are also influenced by upwelling, which increases nutrient transport to surface waters. HABs were identified early as a concern on the Olympic Coast, resulting in significant investments by NOAA (i.e., Northwest Fisheries Science Center, National Centers for Coastal Ocean Science), the State of Washington (i.e., the Washington Department of Fish and Wildlife, Department of Health), the Integrated Ocean Observing System (IOOS) and NANOOS, coastal treaty tribes, and other partners ~~in order~~ to effectively protect human health and coordinate through the Olympic Region Harmful Algal Bloom (ORHAB) partnership.

Commented [9]: This is established in the paragraph above when HAB is first defined.

Commented [10]: When?

About one-third of the carbon dioxide (CO_2) released into the atmosphere is absorbed by the ocean, causing a chemical reaction that leads to ocean waters becoming acidified, that is, resulting in a lower pH ~~more~~ ~~acidic~~ (Chan et al., 2016; Eyre et al., 2018). Globally, the ocean pH has become 30% lower ~~more acidic~~ since the beginning of the industrial revolution in the 1880s (Doney et al., 2009). Another change from the chemical reactions is a reduction in the availability of the carbonate ion. This makes the waters ~~I~~increasingly corrosive ~~. acidic waters This change makes it difficult~~ for animals like oysters, crabs, pteropods, and deep sea corals, that utilize calcium carbonate to make and maintain shells and skeletons ~~utilizing calcium carbonate~~ (USGCRP, 2018; Davies & Guinotte, 2011; Miller et al., 2013; Barton et al., 2015; Jones et al., 2018; Bednaršek et al., 2017, 2020). The increased CO_2 in the seawater~~,~~ ~~and~~ may affect the development and behavior of finfish (Williams et al., 2019) and zooplankton (McClaskey et al., 20xx). Furthermore, ocean acidification will affect marine food webs by impacting prey species (i.e., pteropods, zooplankton) that many important fishery species depend on, such as salmon, herring, and mackerel (Chan et al., 2016). Recent studies of fossil foraminifera off the west coast of the U.S. indicate that rates of decline in pH in this region may exceed global rates of decline by more than a factor of two (Osborne et al., 2019). The waters over the continental shelf within OCNMS are especially susceptible to acidification because ~~due to~~ coastal upwelling brings waters high in CO_2 to the surface, where they mix with the atmospheric load also (Miller et al., 2013; Jones et al., 2018); the projection for ocean acidification is to cause a decrease in pH by ~~and may increase in acidity~~ up to 50% by 2100 (Feely et al., 2012).

Commented [11]: NO!!! Ocean waters are not acidic so cannot be more acidic. This is a major thing OA scientists try to correct.

Commented [12]: The functional link that underlies this statement isn't firmly made here. How does upwelling of deep, cold, nutrient-rich water result in lower pH? Is it because low-pH waters are pushed inshore and trapped there? Expand to explain.

During the summer upwelling season, low concentrations of dissolved oxygen (DO) are a common feature in the subsurface waters of OCNMS, owing to high levels of primary production that create an organic load which sinks and becomes respired, and strong and persistent stratification that impedes mixing with more oxygenated surface waters. O~~, keeping o~~ccasionally hypoxic waters shoal~~ing~~ to occupy ~~affect~~ most of the water column. Hypoxia, defined as DO concentrations low enough to cause stress to aquatic animals (<2 mg/L), has been observed throughout the historical record of the past sixty years (cite Hickey book). However, unusually severe hypoxia has been associated with mortality of fish, crabs, and other marine life off the coasts of Washington and Oregon in recent years. The California Current is expected to continue to experience substantial oxygen loss with future conditions. Under global climate change, hypoxic regions are expected to expand due to warming of the ocean surface and changing circulation patterns (IPCC, 2019; Howard et al., 2020). Furthermore, species will experience habitat compression with hypoxia constraining suitable habitat from below and warmer sea surface temperatures constraining it from above (Howard et al., 2020). As water temperatures increase, ocean waters hold less oxygen , yet organisms require more oxygen to survive in warmer water.

Commented [13]: It might be worth noting that this particularly affects species with less mobility that cannot escape adverse conditions.

Climate change is predicted to impact the coast of OCNMS through changes in sea level and storm intensity. Average sea level is rising worldwide (USGCRP, 2018). However, factors such as currents and changing land height from tectonic activity cause changes in relative sea level to vary by location. As a result, relative sea level is falling in the northern part of OCNMS and rising on the southern coast (Miller et al., 2018). Furthermore, increasing storm intensity is contributing to coastal erosion along Olympic Coast beaches through increased wave height and larger storm surges (Miller et al., 2013).

A better understanding of regional ocean responses to global scale climatic changes is needed in order to improve interpretation of observable ecosystem fluctuations, such as changes in temperature, dissolved oxygen, and ocean chemistry. Forecast models that have been down-scaled to the Washington-Oregon coast, such as by Siedlecki et al., 2021, are providing some insights.

Ocean Sound

Noise pollution in the ocean has significantly increased in the past 50 years (Hildebrand, 2009). The primary source of low-frequency ocean sound is commercial shipping~~,~~; however, military training activities, fishing activities, oil and gas exploration, sonar, airguns, and other active acoustic technologies used in research contribute to anthropogenic sound underwater. The acoustic environment or 'soundscape' within the sanctuary has been studied through passive acoustic monitoring (Figure P.2), and results indicate that there is a predictable presence of sensitive species that actively use low-, mid-, and high-frequency sound throughout this region (Debich et al., 2014, 2016; Hatch & Broughton, 2015). Understanding of the soundscape is critical for the conservation of marine species, including marine mammals, fish, and invertebrates. Impulsive noise sources, such as pile driving, seismic surveys and underwater explosives, can result in physical injury and mortality;~~,~~ however, chronic and continuous sound sources are also a concern due to the potential for impacts to species' fitness and decreases in ~~species~~ survival and recovery of protected species (Gedamke et al., 2015, 2016). Anthropogenic sound is not uniformly distributed throughout the sanctuary; areas with higher sound include vessel traffic lanes.

Since the early 2000s, several ocean sound monitoring efforts have been sponsored in and around OCNMS by the U.S. Navy's Marine Species Monitoring program, which has maintained an active research portfolio to better understand underwater sound impacts on marine mammals. Past projects have yielded critical insights about sound impact to animals, and have included a decade (starting in 2004) of passive acoustic monitoring by Scripps Institute of Oceanography at deep and shallow sites in Quinault Canyon (Oleson et al., 2009; Wiggins et al., 2017); long-term (2014 to present) deployment by NOAA's Northwest Fisheries Science Center of Ecological Acoustic Recorders for detecting southern resident killer whale (SRKW) movements on the Washington Coast (Emmons et al., 2019; Hanson et al., 2018; Hanson et al, 2017); and NWFSC's placement of an array of Vemco acoustic receivers in OCNMS and along the Washington Coast as part of the Salmon Ocean Behavior and Distribution (SOBaD) project to elucidate movement patterns of ~~the~~ tagged Chinook and other salmonids that make up the primary prey species favored by SRKW (Smith and Huff, 2020; Smith and Huff, 2019). The SanctSound program continues the collaboration between National Marine Sanctuaries and the Navy through a 4-year sound monitoring program involving eight sites within the sanctuary system. Recordings from four sites in OCNMS that are being monitored from 2018 to 2022 have already yielded~~are yielding~~ important insights about the underwater sound environment in this region and enabling comparisons within and among sites across the sanctuary system, while building capacity and infrastructure to continue to monitor this dynamic and important variable.

Commented [14]: Sound and noise are used interchangeably in this section. You might define/differentiate the two with a sentence. Generally, noise is any unwanted or disruptive sound (thus one person's sound can be another's noise).

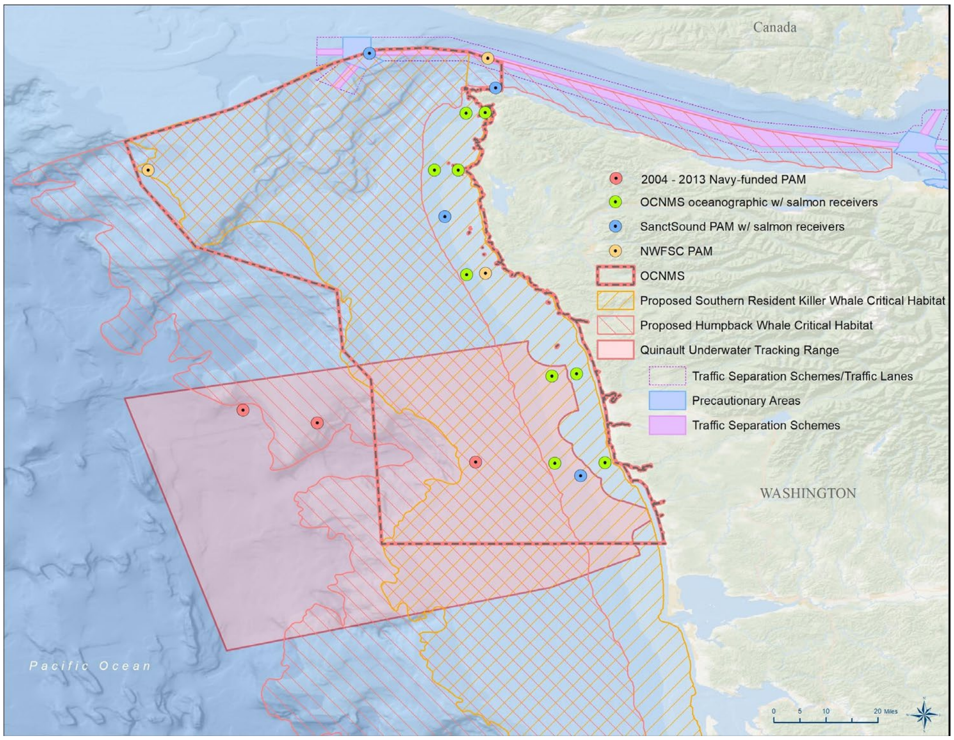

Figure P.2. Overlap between OCNMS, NOAA Fisheries' Proposed Critical Habitats for Southern Resident killer whales and Pacific humpback whales (2019) and the Quinault Range Site (QRS) within the U.S. Navy's Northwest Testing and Training Range (NWTT). Further identified are the locations of other important sound monitoring projects conducted in and around OCNMS and mentioned in this document. Source: ONMS

Underwater sound is known to impact marine mammals. Marine mammals may respond to sound in a variety of ways, including, but not limited to, altering their breathing rates, spending more time underwater, changing the depths or speeds of their dives, shielding their young, changing their vocalization content and durations, and swimming away from the source of the sound (Richardson et al., 1995; Gedamke et al., 2016). Noise pollution can be acute (intense sound events) or chronic (rising ambient sound) (Hatch & Broughton, 2015). Acute sound impacts may result in temporary or permanent hearing loss and disorientation, which could account for some ship strikes with marine mammals that are unaware of the approaching vessel. Sound impacts could also affect predation efficiency for marine mammals that use sound to forage. ~~Southern Resident Killer Whales (~~SRKW~~)~~ may be especially vulnerable to sound impacts limiting their ability to effectively forage for Chinook salmon and other prey ~~species~~. SRKW are critically endangered. Factors limiting~~Limiting factors to~~ their recovery are lack of prey, sound disturbance, and contaminant levels (i.e., polychlorinated biphenyls (PCBs)). Lacy et al. (2017) projected~~found~~ that reducing acoustic disturbance by 50 percent, combined with increasing Chinook by 15 percent, would meet SRKW recovery goals and have the same effect as increasing Chinook by 30 percent, equivalent to their highest levels since the 1970s.

Commented [15]: RJ. "Quinault Underwater Tracking Range" has since been renamed to Quinault Range Site.

Commented [16]: Please update the text within the figure for consistency

Commented [17]: @tony.reyer@noaa.gov Hi tony. This one is just a quick correction to the legend please! The name of the range actually changed... please note for future reference. ;)

Commented [18]: I updated that map previously and removed those areas. See the updated maps in the Google Drive folder <https://drive.google.com/drive/folders/1HrPeXRlEQY8FTU4YcYnJxVFpce9MlcN2?usp=sharing>.

Tony

On 4/16/2021 10:49 AM, Jenny Waddell - NOAA F... (Google Docs) wrote:
>
>
> Jenny Waddell - NOAA Federal mentioned you in a comment in the
> following document
>
> 4. Pressures
>
<https://docs.google.com/document/d/1oAgdc0wZKFLkbo4h9o9Hm5s6fy9QwwSJGhI8r4j5inc/edit?disco=AAAALd7dhdo&ts=6079a3de&usp=comment_email_document&usp_dm=false>
>
> Figure P.2
> User profile picture Stephanie Sleeman
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> RJ. "Quinault Underwater Tracking Range" has sinc...

Commented [19]: Tony sorry but I do not see the new map anywhere in the folder. Could it be somewhere else? The only things that need to change from the original were the legend items (see next comment below). Please do not remove the proposed critical habitat areas for SRKW and humpbacks. Also the ...

Commented [20]: Apologies. Updated map is now on Google Drive. Thought there was a comment previously regarding removing the proposed critical habitat areas. Those have been retained and needed changes to the legend items have been made.

Commented [21]: @jenny.waddell@noaa.gov could you please replace map and then clear out comments _Assigned to Jenny Waddell - NOAA Federal_

Commented [22]: This CH has now been finalized for humpbacks. Please update the legend on the map and here.

Commented [23]: Already introduced above.

Fish also have the potential to be affected by ~~from~~ sound in the water. Fish have two sensory systems that can detect sound in the water: the inner ear, which functions similarly to the inner ear in other vertebrates, ~~-~~and the lateral line, which consists of a series of receptors along the body of the fish (Popper & Schlt, 2008). The inner ears of fish are directly sensitive to acoustic particle motion, and direct inertial stimulation of fish otoliths from acoustic particle motion is the most common mode of hearing in fishes (Popper & Fay, 2010; Gedamke et al., 2016). Impulsive sound sources, such as air guns for seismic exploration were shown to cause extensive damage to sensory epithelia of fish ears (McCauley et al., 2003). Swim bladders also affect acoustic pressure sensitivity (both hearing and physical), making fishes with swim bladders more susceptible to physical injury from sound than those without (Gedamke et al., 2016).

Commented [24]: There is no further mention of impacts to lateral line receptors from sound. This is a poorly studied topic, and that should be noted here rather than simply ignoring it.

While sound impacts on invertebrates ha~~ves~~ve not been extensively studied, we do know that some invertebrates (e.g., larval coral, squid, octopuses, and oysters)~~,~~ may use sound to inform their physical orientation in the~~ir~~ environment, ~~and~~while others rely on sound for courtship, foraging, and protection from predators (Gedamke et al., 2016). However, it is not clear if invertebrates are sensitive to acoustic pressure changes, nor how any impacts from this sensitivity might affect specific behaviors, population dynamics, or ecological interactions.

Maritime Transportation

As one of North America's major gateways to Pacific Rim trade, the Strait of Juan de Fuca is one of the busiest waterways in the world, with vessel traffic going to several busy ports in Washington State and Vancouver, British Columbia. Every year, approximately 8,300 deep-~~-~~draft vessels transit the northern part of the sanctuary to enter and depart the Strait of Juan de Fuca (Washington Department of Ecology, 2019). Since the sanctuary was designated in 1994, there has been an ongoing effort to track vessel incidents in or in the vicinity of the sanctuary. Since 1998, the sanctuary has been using a vessel traffic-monitoring program using Automatic Identification System (AIS) vessel data to monitor compliance with the Area to be Avoided (ATBA) provision, which was established to reduce the risk of oil spills on the remote Olympic Coast. There have been no major oil spills in this region since 1991.~~,~~ ~~t~~The ATBA may also play a role in reducing sound in the nearshore environment of the sanctuary. (More information on ATBA compliance is in the Response Section).

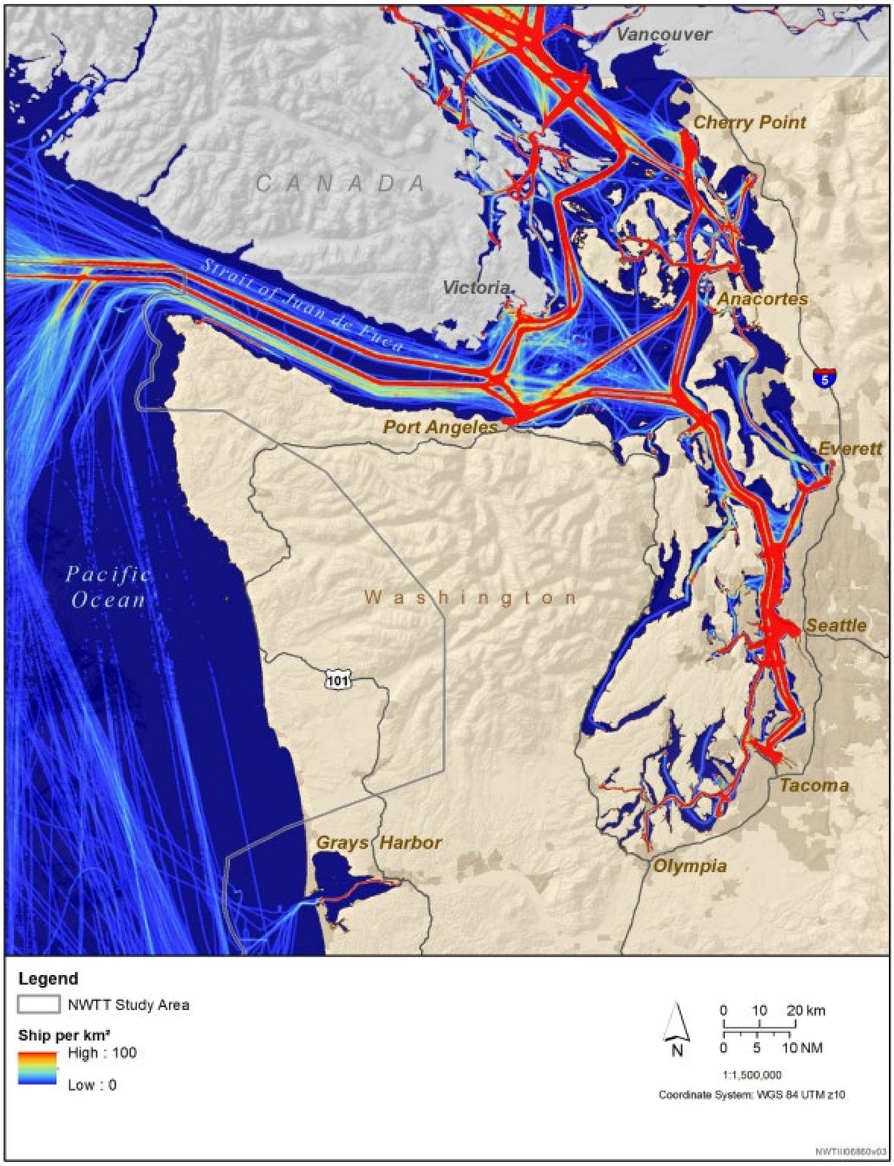


Figure P.3: Relative Density of Vessel Traffic. Image: Navy NWTT 2020 p. 3.12-7

Commented [25]: We may replace this image with a map of vessel traffic density zoomed into OCNMS

Commented [26]: I think both maps are actually useful: one showing just how busy the Strait is, and thus how large the risk of an oil spill that could affect the sanctuary is, and one showing more direct effects of traffic via chronic pollution and noise.

Ship Strikes

Whales rely on the highly productive waters of the California Current as part of their migratory routes. Whales are vulnerable to ship strikes as they swim or rest (Sato and Wiles, 2021). Ship strikes are one of the main human causes of mortality for large whales (Rockwood et al., 2018). Ship strikes have increased in recent decades due to increasing shipping traffic, vessel speeds, and whale abundance (Sato and Wiles, 2021). Most strikes occur in coastal waters on the continental shelf, where large marine mammals aggregate to feed and vessel traffic is concentrated. OCNMS is host to numerous whale species, several of which are listed as endangered or threatened, such as blue, humpback, orca, and fin whales, among others. Ship strikes are the leading cause of death for blue, humpback, and fin whales along the west coast~~,~~; however, of these species only humpback has a modeled mortality risk off of Washington (Rockwood et al., 2018). From ~~Between~~ 2013-2017 along the west coast, a total of 65 marine mammals, including 14 humpback and 7 gray whales, were reported as being struck ~~resulting in death or~~ and injured~~y~~ or killed (Carretta et al., 2019). However, only the Navy and USCG are required to report ship strikes with whales to NOAA's NMFS. Underreporting is assumed, actual deaths of humpback whales along the west coast are ~~is~~ estimated to be 28 animals annually (Rockwood et al., 2018). In Washington state, from ~~between~~ 1980-2017, only two humpback whales were reported killed by ship strikes, with the mouth of the Strait of Juan de Fuca being one identified high risk area for collision (Carretta et al., 2019). High levels of vessel traffic, increases in abundance and distribution of whales, and changes in feeding areas within the sanctuary increase the risk of ship strikes to whales resulting in injury or death.

Commented [27]: The dash between the dates is read as "to" so the sentence reads "From 2013 to 2017 . . ."

Oil Spills

Washington is one of the nation's primary petroleum refining centers, with~~in which~~ 20 billion gallons of oil moving~~e~~ through the state annually. Crude oil moves into the state via tank vessels inbound to Puget Sound to the refineries. Large quantities of crude oil also move through the Trans Mountain Pipeline from Canada. Refined products are exported from Washington to other western states primarily via ~~through~~ pipelines, barges, and tankers. These transportation corridors are the greatest risk for major spills (Figure P.4; Washington State Department of Ecology, 2017). Total oil moved within Washington State has remained stable at 20 billion gallons since 2008, with a slight change in mode of transportation, namely a reduction in vessels and increase in rail (Figure P.5).

Commented [28]: You mention increased use of rail below. Are the tankers noted here tanker vessels, tanker trucks, or tank cars on trains? Either way, incorporate rail here so that the note about its increased use below follows logically.

Biodiesel refineries exist in Grays Harbor and along the Columbia River. The Grays Harbor Biodiesel Plant is the largest biodiesel production facility in the U.S., with an annual capacity of 100 million gallons. Biodiesel is a renewable fuel manufactured from vegetable oils, animal fats, or recycled restaurant grease. Biodiesel, and other biofuels, can spill and pose similar risks as oil spills; biofuels are toxic to aquatic and marine ecosystems and are highly flammable.

Cargo, fishing, and passenger vessels involved with Pacific Rim commerce can also hold substantial quantities of petroleum products in their fuel tanks and are at risk for spills through groundings, collisions, sinkings, and other vessel incidents.

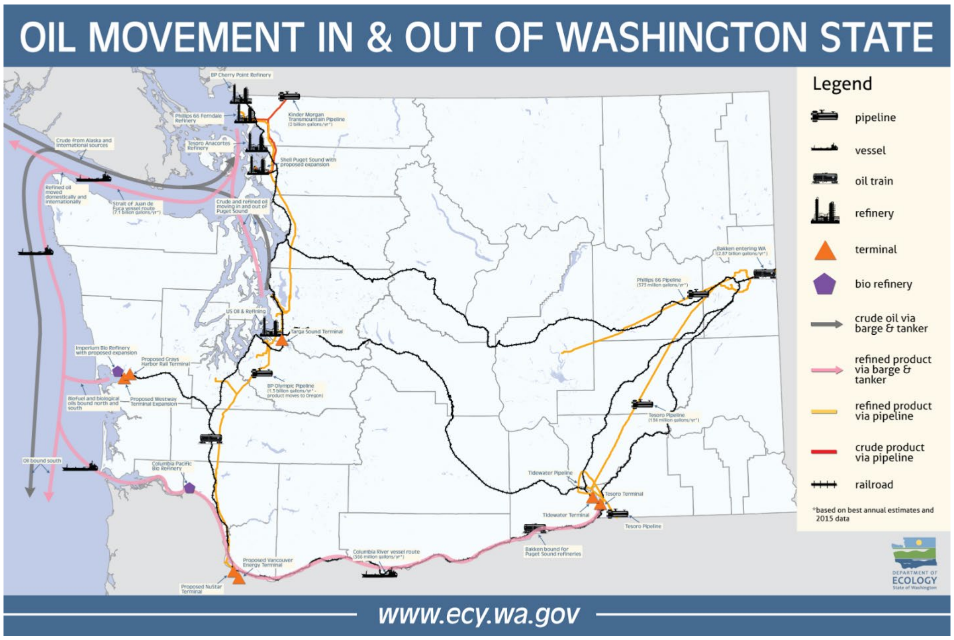
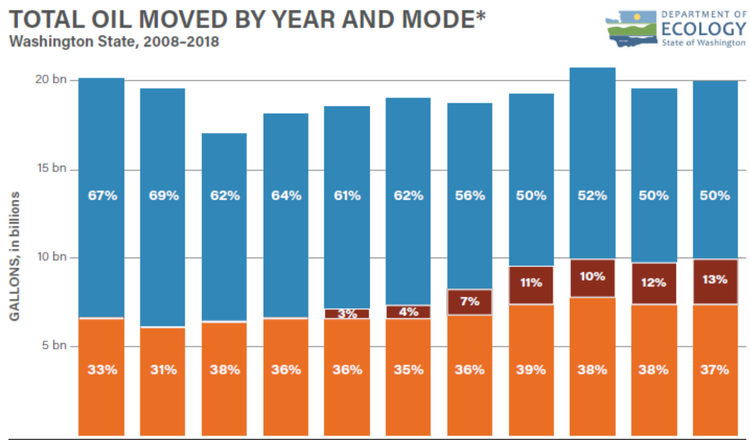


Figure P.4. Oil movement within Washington state via railroads, pipelines, vessels, and refineries. Image: Washington State Department of Ecology, 2017.



MODE	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Vessel	13,489,096,404	13,406,380,470	10,556,937,762	11,489,223,816	11,359,982,970	11,716,994,562	10,516,130,310	9,691,929,114	10,786,931,736	9,845,272,248	10,048,573,500
Rail	0	0	0	0	509,176,752	691,808,250	1,378,094,256	2,105,479,236	2,100,000,000	2,285,077,536	2,496,842,670
Pipeline	6,551,744,766	6,139,363,356	6,393,628,374	6,603,628,374	6,606,600,000	6,639,091,452	6,772,845,156	7,445,220,258	7,821,949,800	7,429,803,906	7,402,487,652
TOTALS	20,040,841,170	19,545,743,826	16,950,566,136	18,092,852,190	18,475,759,722	19,047,894,264	18,667,069,722	19,242,628,608	20,708,881,536	19,560,153,690	19,947,903,822

**All oil of any kind including crude oil, petroleum, gasoline, fuel oil, diesel oil, oil sludge, oil refuse, biological oils and blends. Cargo only. Does not include fueling transfers.*

Spill Prevention, Preparedness and Response Program | www.ecology.wa.gov/SpillsProgram | Publication 17-08-014 | July 2019 (revised)

Figure P.5. Twenty billion barrels, on average, are moved through Washington state annually and in recent years there has been a slight decrease in oil movement by vessel and an increase in the use of rail. Image: Washington State Department of Ecology, 2017.

Oil spills directly adversely impact water quality, plants, animals, and habitats (Washington State Department of Ecology, 2018). Oil contamination of marine mammals and seabirds can cause eye irritation, impairment of thermal regulation, loss of buoyancy, toxicity, reproductive abnormalities, and ultimately death. Oil spills can deplete food sources and destroy habitat characteristics essential for survival of vertebrate species. A spill could wipe out at least one generation of a population, and in a worst-case scenario, extinguish multiple species on a local or regional scale. Sea otters and many species of seabirds that inhabit or use the ocean's surface are particularly susceptible to damage from oil in nearshore environments.

Oil spills can have lethal as well as long-term, sub-lethal effects on fish (e.g., behavioral changes, reproductive abnormalities) and can also contaminate fish targeted for human consumption. Some sectors of the fishing and shellfishing industries could be shut down for years by an oil spill, causing long-term negative effects on the economy of local tribes and other coastal harvesters~~fishers~~. Oil spills and associated response methods could also impact fish at various life history stages, affecting juvenile survival and future fish stocks. Nearshore habitats, critical for survival of juvenile fish, can also be severely impacted by oil spills that smother or poison kelp, sea grasses, and other marine plants. Oiling and subsequent cleanup of intertidal areas can cause significant damage to invertebrates, habitats, and cultural sites, with negative impacts that can linger for decades. In Prince William Sound, there are still pockets of residual, unweathered oil found along the shoreline more than a quarter of a century following the Exxon Valdez spill (Shigenaka, 2014).

In 2010 the Deepwater Horizon oil rig, located in the Gulf of Mexico, experienced a blast that killed 11 workers and sank the oil platform. Oil escaped from the damaged well for five months off of the coast of Louisiana, resulting in the worst oil spill in United States history. In addition to the direct impacts of the oil, chemical dispersants were used at the spill release site, introducing oil to deep water ecosystems where it normally would not have remained. Deep sea corals in the area were injured or killed, and subsequent lab studies suggested that oil/dispersant mixes may cause more damage than oil alone (DeLeo et al., 2015). Both the Exxon Valdez and Deepwater Horizon oil spills have demonstrated the consequences of uncontrolled, large-volume, single source spills, and that spill response choices (e.g., booming, skimming, dispersing, and burning) need to be carefully considered in light of their potential impacts beyond those of the spill itself.

The Washington coast has endured damage from several large oil spills, including the 1972 *USS General M.C. Meigs* wreck that spilled 115,500 gallons of heavy fuel oil off Shi Shi Beach on the Makah Indian Reservation. The 1988 *Nestucca* barge spill released 231,000 gallons of fuel oil into waters off Grays Harbor, impacting many kilometers of coastline as far north as Canada. In 1991, a fishing vessel, *Tenyo Maru*, spilled 361,000 gallons of diesel fuel that spread as far south as Oregon but most heavily impacted the Makah Indian Reservation and Olympic National Park wilderness coast. The *Tenyo Maru* spill killed thousands of common murres and 7-10% of the total outer coast population of marbled murrelets (Skewgar & Pearson, 2011). No large oil spills have occurred off the Olympic Coast since 1991.

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While generating significant damage, large oil spills are rare; smaller spills occur far more frequently, representing an ongoing, chronic stressor (Washington State Department of Ecology, 2018). Although state and federal oil spill prevention and response policies are continually improving, the potential for severe environmental damage remains a strong concern in the region. Furthermore, the remoteness of the Olympic Coast, which complicates beach access and hinders ~~including accessing beaches,~~ staging of response equipment, increases~~and~~ potential for impacts to cultural sites and resources ~~pose significant challenges in responding to an~~ from any incident in this region.

Vessel Discharge and Ballast Water

Vessel discharges can impact water quality through introduction of pathogens, nutrients, or toxins (Washington State Department of Ecology, 2018). All types of vessels generate wastewater that ~~and~~ necessitates discharge or disposal, the type and volume of the discharge depends on the type of vessel and passenger load (Washington State Department of Ecology, 2018). Wastewater includes sewage (raw or treated), graywater (water from showers or dishwashing), bilgewater (a mixture of leakage from machinery, water leaking through the hull, cleaning agents, and other products), and ballast water (used to stabilize a vessel). Sanctuary regulations prohibit the discharge of vessel sewage within the sanctuary (except from approved marine sanitation devices), requiring vessels to use onshore pumpout facilities. However, currently there are no functioning pumpout facilities adjacent to the sanctuary. The closest functioning sewage pumpout facilities are Westport and Port Angeles. Furthermore, the closest oily bilge pumpout facility is in Seattle. The current lack of appropriate facilities makes compliance with ~~to~~ the regulations problematic.

Millions of liters of seawater are routinely carried around the world as ballast aboard oil tankers and other commercial vessels to increase stability at sea. If ships empty their ballast tanks of water transported from other regions there is a risk of introducing non-native fish, invertebrates, and plants, many of which can alter ecosystems, sometimes in catastrophic ways. Washington State implemented

Commented [29]: This seems like an odd unit of measure for this parameter given that a single oil tanker can carry 200,000,000 l of ballast water (200,000 m^3). I think this value could be more like billions of liters, but it's probably better expressed in cubic meters or some larger increment.

regulations to minimize this risk by requiring ballast water treatment or exchange in offshore waters beyond the sanctuary. State ballast water management regulations require “ships to perform an open sea ballast water exchange…to minimize discharge of high-risk coastal species” if the vessel does not have an approved ballast water treatment system (Washington Department of Fish and Wildlife, 2015, p. 5). Even with these regulations in place~~Still~~, invasive species can also be introduced through a variety of other mechanisms, including hull fouling, smaller commercial and recreational vessels, aquaculture practices, release of captive animals and plants (e.g., aquarium specimens), floating marine debris, or range expansion.

Cruise Ship Discharges

The cruise ship industry in Seattle ~~has~~ experienced a ~~10~~ten-fold increase in the number of passengers carried by cruise ships between 2000 and 2019, with an 26% increase between 2008 and 2019 (Figure P.6; Port of Seattle, 2019). In 2019, 445 cruise ships transited near the sanctuary, with 179 passing directly through ~~the~~ sanctuary waters. While cruise ship numbers are increasing, it is possible wastewater discharges have decreased due to several management changes. Since 2011, the sanctuary management plan and EA have prohibited treated and untreated wastewater (sewage and graywater) discharges from cruise ships within the sanctuary. Furthermore, since 2004 Washington state has had a memorandum of understanding (MOU) with the cruise industry to prevent wastewater discharges in state waters, including where these waters overlap OCNMS. The agreement bans wastewater discharges (except discharges treated with advanced wastewater treatment systems), allows Ecology to inspect the wastewater treatment system on each vessel, and requires cruise lines to sample and monitor wastewater discharges from their ships, including submitting an annual report on their practices. Ecology is able to inspect each vessel’s wastewater records and equipment to verify compliance. The agreement covers only cruise lines that are members of the Cruise Lines International Association North West & Canada (CLIA-NWC) and does not cover non-~~-~~CLIA-NWC member smaller passenger ships (<249 passengers), Washington state ferries, Alaska Marine Highway ferries, or large cargo ships. Almost all member cruise lines have decided not to discharge in waters covered by the MOU. Furthermore, cruise ships have self-reported discharge violations within the sanctuary.

Commented [30]: As written, it sounds like the MOU is for state waters and all of OCNMS. I believe it's only the three-mile overlap area, correct? I've suggested a revision to capture that.

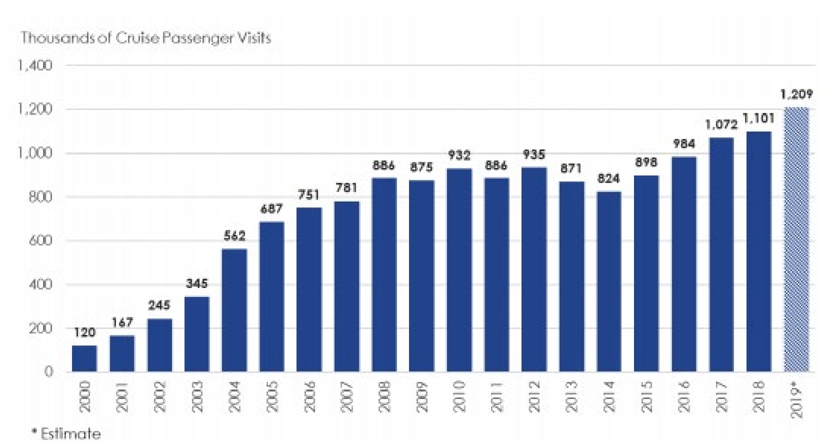

Figure P.6. Passenger embarkments, disembarkments, and in-transit stops at the Port of Seattle, 2000–2019. Image: Port of Seattle, 2019.

Exhaust Gas Cleaning System

The adverse effects of exhaust emissions from internal combustion engines and boiler exhaust gases on human beings and sensitive ecosystems have been well documented by the scientific community (Kalender, 2019). In 2000, sulfur dioxide~~SO_2~~ emissions from shipping were estimated to be ~~3~~ three times greater than that from all road traffic and aviation (Eyring et al., 2005). The Marine Environment Protection Committee (MEPC) of the IMO adopted the 1997 Protocol to the International Convention for the Prevention of Pollution from Ships (MARPOL), which added Annex VI, Regulations for the Prevention of Air Pollution from Ships. This Annex went into force on May 19, 2005. To reduce the harmful effects of sulfurous~~SOx~~ emissions on human health and the environment, Regulation 14 to Annex VI introduced a worldwide limit on the sulfur content of marine fuels of 4.5% and a limit within designated ~~SOx~~ sulfur emission control areas (SECA) of 1.5%. Further reductions have led to 0.1% (1000 ppm) being the current limit for OCNMS waters. For comparison, automotive diesel fuel sulfur limits are currently at 15 ppm.

In 2010, the IMO designated waters off North American coasts as an Emission Control Area for stringent international emission standards that will apply to ships. In 2012, the first-phase fuel standard began, the second phase in 2015 (fuel sulfur standard of 0.1% fuel sulfur), and stringent nitrogen oxide~~NO_x~~ engine standards began in 2016. This stringent fuel standard is expected to be met through fuel switching~~,~~; however, some vessels may equip exhaust gas cleaning systems. Exhaust Gas Cleaning Systems (EGCS), also known as scrubbers, remove sulfur from diesel exhaust and are currently being used to enable vessels to meet IMO air emission standards. These scrubbers achieve the required emission reduction, but generate effluent that ~~which~~ is discharged into the marine environment. There is a risk for acidification, eutrophication, and accumulation of polycyclic hydrocarbons (PAHs), particulate matter (PM), and heavy metals from these discharges (Endres et al., 2018). For several metals (arsenic, copper, lead, nickel and selenium), concentrations in wash water discharge have been shown to exceed EPA's National Recommended Water Quality Criteria for the protection of aquatic life for saltwater organisms (EPA, 2011). In addition, the Predicted No Effect Concentration for PAHs is regularly exceeded even in properly operating systems. If scrubbers become a central tool for atmospheric pollution reduction from shipping, then modeling and experimental studies will be needed to determine the ecological and biogeochemical effects of discharge from scrubber wash water on the marine environment (Endres et al., 2018).

Submarine Cables

In 1999–2000, a pair of submarine fiber optic telecommunication cables, called the Pacific Crossing-1 (PC-1) system, were laid across the northern portion of the sanctuary. Totalling 11,201 nautical miles (20,800 km), one cable (PC-1 North) runs from Mukilteo, Washington, to Japan (Figure P.7), the other (PC-1 East) from Washington to Grover Beach, California. The cables cross the northern portion of OCNMS, both running for approximately 29 nautical miles (52 km), roughly parallel to one another and separated by several hundred meters at water depths of 100-330 m. The minimum anticipated service life for these cables was 25 years (David Evans and Associates, 1998).

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The installation of submarine cables can damage benthic habitat in the immediate vicinity of the cable, but the impacts are localized to within a few meters of the cable route. Submarine cable installation involves substantial seafloor disturbance along a narrow swath as a plow cuts about a meter into the substrate to bury and protect the cable and to avoid future entanglement with anchors, fishing gear, or organisms. Although successful cable burial was reported, surveys of the PC-1 cables in the sanctuary conducted in 2000 revealed that substantial portions of each cable were not buried at a sufficient depth to avoid risks, and in many places the cables were unburied and suspended above the seafloor. In this condition, cable movement could increase the area of seafloor damage, and they are susceptible to damage by fishing trawl gear, requiring repairs that could repeatedly disturb seafloor communities. Additionally, where unburied and suspended, the cables pose a serious safety concern for fishers employed in bottom contact fisheries who could snag gear on an exposed cable, a risk that limits access of treaty tribal fishers to portions of their treaty-reserved U&A fishing grounds. In light of these risks, the cable owners agreed to recover and re-lay the cables in the sanctuary, an effort that was completed in late summer 2006. There have been no reports of fisheries interaction with the submarine cable. A survey has not been conducted since 2004, but planning for a survey is underway.

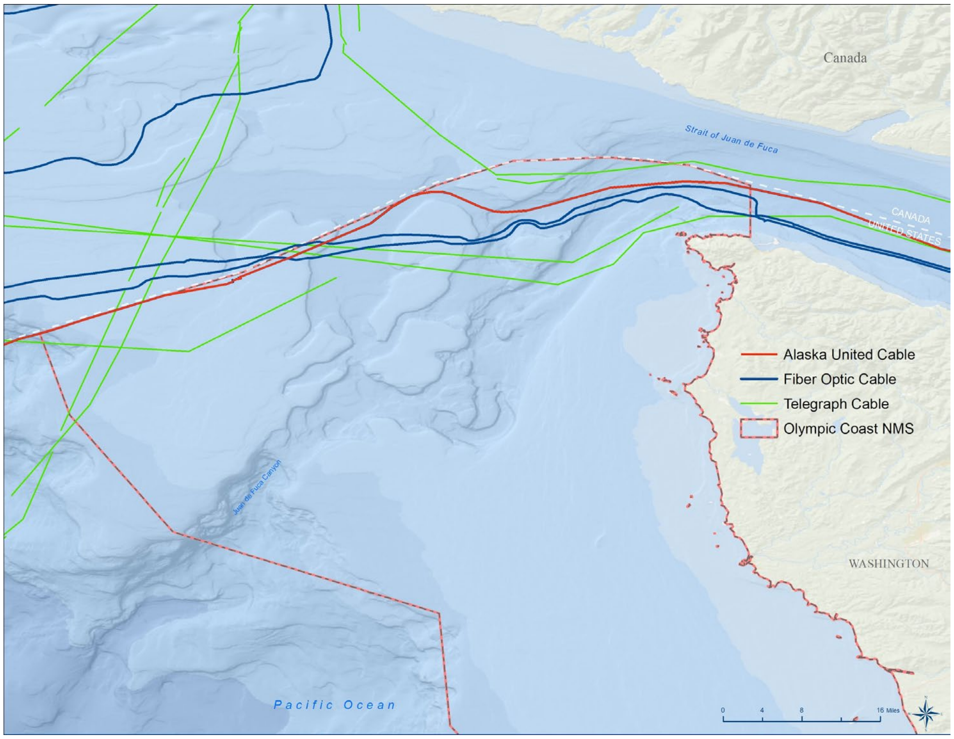

Figure P.7. Location of submarine cables of different types installed in the northern portion of OCNMS. Map: NOAA ONMS.

Fishing

Commercial and recreational fishing are important to the coastal economy and provide valuable food resources to the Pacific Northwest and beyond. The management of fisheries resources on the Olympic Coast is part of a comprehensive, complex mixture of federal, state, and tribal management. For the coastal treaty tribes, fishing is a treaty-reserved right and provides significant cultural, spiritual, economic, and subsistence benefits to tribal communities. Furthermore, the coastal treaty tribes are co-managers of the fishery resources. While fishing occurs within the sanctuary, OCNMS does not manage fisheries. Some aspects of fishing practices and regulations have been under scrutiny from co-managers or environmental non-governmental organizations (NGOs) for their potential negative impacts to habitat, maritime archeological resources, water quality, and/or to ecosystem functions. For instance, bottom contact fishing gear can alter hard bottom habitats and damage biogenic habitat (i.e., deep sea corals and sponges), which are long-lived and slow growing. However, fishery managers have made gear adjustments and spatial restrictions to freeze the footprint of, and reduce the impacts ofrom, bottom contact fishing on sensitive habitats. Furthermore, bottom trawling with small-footrope gear has been shown to have minimal impacts to both the seafloor and invertebrate communities in soft sediment habitats (Lindholm et al., 2013).

At-Sea Processors

Pacific hake (or Pacific whiting, *Merluccius productus*) is one of the most abundant groundfish in the California Current ecosystem. Whiting are harvested using mid-water trawls and are processed either at shore-based processors or at sea via motherships or catcher-processor vessels. At-sea processors process the whiting and discharge water and unutilized remaining whiting biomass. The seafood processing waste is thought to exacerbate ocean acidification and low oxygen conditions due to an influx of decomposition of organic matter (EPA, 2017),; however, there are no direct or baseline data available to inform this assumption. In 2015–2016, OCNMS and EPA conducted a Section 304(d) consultation under the NMSA on the proposed issuance of the NPDES General Permit for Offshore Seafood Processors in Federal Waters off the Washington and Oregon Coast, banning discharge in waters shallower than 100 meters. This permit went into effect on May 1, 2019; as such, we do not yet have trend data.

Derelict Fishing Gear

Rough waters and complex seabed features of the sanctuary increase the potential for fishing gear entanglement and loss. Crab pots are especially susceptible to being lost and/or becoming derelict. Roughly 10% of commercial crab pots are lost off the Olympic Coast every year. Lost or abandoned fishing gear can remain for decades, potentially entangling and killing species that encounter the gear (NRC Inc. 2008). This phenomenon has been called “ghost fishing,” where derelict gear continues to fish by attracting, trapping, and killing a wide variety of targeted and non-targeted species. Dead organisms attract other animals, resulting in serial unintended mortality until the gear degrades. However, derelict crab pots have a rot cord that should prevent them from fishing if lost, once the cord rots and egress from the pot is possible through the lid or escape panel.

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A direct economic impact of ghost fishing is the reduction of fishery stocks otherwise available for commercial and recreational harvestfishers. Accumulations of gear on critical spawning and rearing habitat can significantly impact fishery stocks. Derelict fishing gear also can threaten human safety, restrict other legitimate sanctuary uses, such as fishing, anchoring, and operation of vessels, and diminish the aesthetic qualities for recreational activities. Derelict fishing gear also increases the risk of whale entanglements.

Whale Entanglement

NOAA has responded to a 400% increase in large whale entanglements reported on the West Coast (Figure P.8). The ~~w~~West ~~c~~Coast annual average between 1982 and 2013 was nine confirmed entangled large whales, but this jumped to an average of 41 confirmed entanglements between 2014 and 2017 (Saez et al., 2020), with 46 in 2018. Gray and humpback whales are the most frequently reported entangled species. Gillnet and commercial Dungeness crab pots are the most common fishing gear types associated with large whale entanglements. This increase in reported entanglements may be due to multiple factors, including, but not limited to, an increase in public awareness and reporting, and changes in the spatial distribution and abundance of whales, fishing effort, and ocean conditions. For example, shoreward shifts in prey caused by changes in upwelling force whales closer to shore. Combined with increasing whale populations, the result is more entanglement (Santora et al., 2020).

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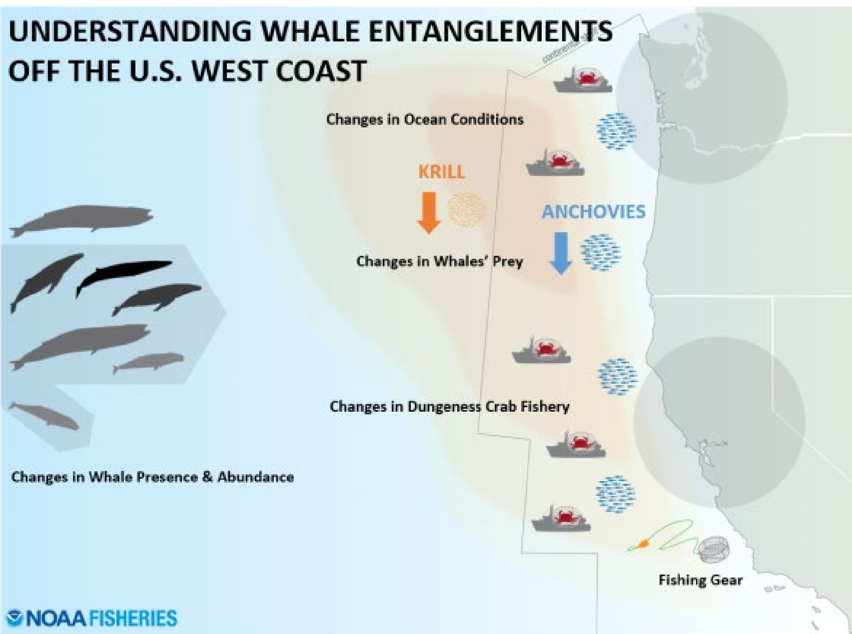

Figure P.8. Whale entanglements increased on the west coast in 2018 due to a variety of changes. Source: Santora et al., 2020.

Military Activities

The Navy's Northwest Testing and Training (NWTT) Offshore Area overlaps the entire sanctuary. NWTT activities ensure that the Navy meets its statutory mission, which is to "maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas" (U.S. Navy, 2020, p. 1-4). Activities occurring within the sanctuary include anti-submarine warfare testing, sonar testing and training, non-explosive mine countermeasures and neutralization testing, unmanned underwater testing and training, and acoustic and oceanographic research. The Navy also conducts aerial training using EA-18G Growler jets. An average of 2,300 flights are conducted over the Olympic Military Operations Area (MOA) annually, approximately 6.3 flights per day~~ with~~. ~~t~~The majority occur~~ring~~ during daylight hours on the weekdays and 95% are above 10,000 feet (U.S. Navy 2020). According to the FAA, approximately 25% of all flights that occur over the Olympic National Park are military. These testing and training areas include warning area W-237A and MOA Olympic A that are designated training and operating areas for the Pacific Fleet air and surface forces (Figure P.9). Military activities in these areas consist of subsurface, offshore surface, aerial training activities, and other military operations as discussed in the sanctuary’s original environmental impact statement (NOAA, 1993). Most Navy activities take place outside of OCNMS. Furthermore, the use of explosives is prohibited within the sanctuary.

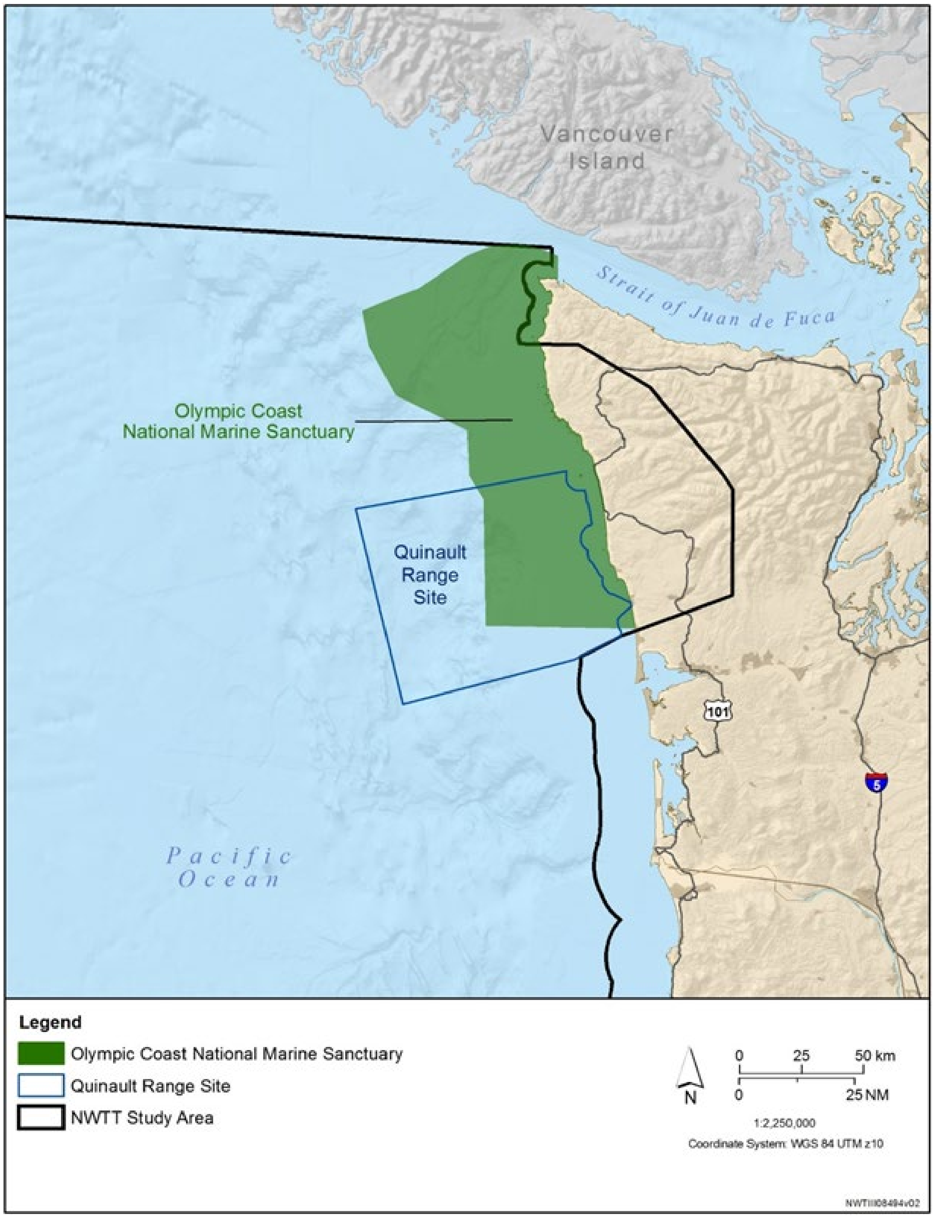

Figure P.9. Offshore Area of the Northwest Training and Testing Study Area. Source: U.S. Navy, 2020.

The Naval Undersea ~~Navy's Underwater~~ Warfare Center (NUWC) Division Keyport operates and maintains the Quinault Range Site (QRS). This range is instrumented to track surface vessels, submarines and various undersea vehicles. It is the policy of NUWC Division Keyport not to test in the presence of cetaceans. Both the QRS and the larger NWTT Study area extend beyond the boundaries of the OCNMS. The Navy has expanded the Quinault Range Site's area more than 40-fold to support existing and future needs in manned and unmanned vehicle program development, and it now includes a surf-zone landing site. The Navy's QRS, where testing activities subject to consultation occur, was originally 48 square nm (2% of OCNMS) when the sanctuary was designated, but was expanded in 2011 and now overlaps 34% of OCNMS (809 square nm).

The Navy has established three geographic mitigation areas for testing and training activities from 2020–2027, including an Olympic Coast National Marine Sanctuary Mitigation Area, Marine Species Coastal Mitigation Area, and Seafloor Resource Mitigation Area. The OCNMS Mitigation Area does not allow the use of explosives.

Potential effects associated with Navy testing and training activities were recently evaluated in separate environmental impact statements (EIS) via the National Environmental Policy Act (NEPA) process and 304(d) consultation with OCNMS. During 304(d) consultation, the sanctuary considered a wide variety of issues, including: disturbance to birds, fish, and mammals from increased activity and noise; accidental discharges of pollutants; interference with tribal fishing and subsistence harvest activities; restrictions on the ability of sanctuary and affiliated scientists to conduct research; and recommendations regarding research priorities.

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Marine Debris

According to NOAA's Marine Debris Program, marine debris is any persistent, manufactured, or processed solid material that is directly or indirectly, intentionally or unintentionally, disposed of or abandoned in the marine environment. Marine debris can include a wide variety of objects (e.g., lost fishing gear, lost vessel cargo, plastics, balloons~~, etc.~~) from multiple sources (e.g., stormwater runoff, landfills, recreational and commercial activities, military activities).

The amount of marine debris in open-ocean and coastal systems is on the rise throughout the world. Impacts from marine debris include entanglement and drowning of animals, inadvertent ingestion of plastics by marine species (mammals, turtle, birds, fish, and invertebrates), transfer of diseases from land-based sources to marine wildlife, fouling of active fishing gear, serving as a vector for introducing non-native species, and ~~benthic habitat~~ degradation of benthic habitat. The prevalence of debris within the sanctuary is affected by both natural and human factors.

Many types of marine debris exist in the sanctuary and collect at various accumulation locales~~places in the sanctuary~~. Plastic is the most prevalent type of marine debris found in the ocean and accounts for 92% of the debris found on beaches on the outer coast of Washington (Washington State Department of Ecology, 2018). Rather than disappear, plastics in the marine environment tend to fragment into smaller pieces, eventually breaking down into microplastics (plastic less than five millimeters in length). Recent research suggests these microplastics can accumulate in marine species, particularly shellfish (Smith et al. 2018; Baechler et al. 2019).

In March 2011, a magnitude 9.0 undersea megathrust earthquake occurred off the coast of Japan, claiming nearly 16,000 lives. The Government of Japan estimated that the tsunami generated five million tons of marine debris and that 70 percent of that debris sank nearshore. However, some of that debris came ashore in OCNMS, including boats, docks, and numerous other items (Figure P.10). The majority of this debris arrived between 2012 and 2014, ranging in size from fishing boats to plastic bottles. Ninety percent of larger debris items (e.g., boats and docks) were removed from beaches. There was a ten-fold increase in debris influx to sites in northern Washington State compared to the nine year period prior to the tsunami event (Clarke Murray et al., 2019). Biofouled marine debris transported by ocean currents arrived on the west coast and within OCNMS, bringing non-native species, resulting in 289 non-indigenous species being introduced to the U.S. , with the majority landing in Washington and Oregon.

Figure P.10. Dock washed ashore following the Japanese tsunami. Photo: National Park Service

Crushed cars litter the northern portion of OCNMS. Open-deck barges from Canada, stacked with crushed cars routinely travel through the sanctuary, headed to scrap yards in Portland, Oregon. Since 2011, at least four crushed cars have been pulled up in fishing gear of Makah tribal members (Figure P.11). In 2015, a survey off Cape Flattery revealed an additional thirteen cars in the sanctuary, and there are no requirements or plans to remove them. While some measures have been enacted to reduce the potential for lost cargo, like improving loading techniques by leaving extra room around the edge of the barges, it is likely cargo will continue to be lost.

Figure P.11. Crushed car pulled up in fishing gear by a Makah tribal member. Photo: Larry Buzzell

Non-indigenous and Invasive Species

Non-indigenous species are any plants, invertebrates, vertebrates, parasites, and even diseases that are introduced into a non-native environment. Those that harm resources in that environment are called invasive species. Several established and expected non-indigenous species, such as the invasive brown alga (*Sargassum muticum)*, invasive red alga (*Caulacanthus okamurae)*, and the European green crab (*Carcinus maenas*) threaten both critical habitat and important commercial species in the Pacific Northwest. In 2017, European green crabs were found in two estuaries on the Makah reservation, adjacent to OCNMS (Figure P.12). A dedicated trapping effort by Makah Fisheries Management has caught over 2,500 green crabs since 2017, the most anywhere in Washington State. European green crabs may compete with native species, like Dungeness crab, and have devastated~~decimated~~ eelgrass habitats on the east coast (Malyshev & Quijón, 2011). There is widespread recognition that invasive species can affect fisheries, waterways and adjacent facilities, as well as the functioning of natural ecosystems. The introduction of aquatic invasive species into the coastal waters of the Pacific Northwest poses serious economic and environmental threats recognized by resource managers, the aquaculture industry, non-governmental organizations, and concerned citizens. Coastal estuaries in Washington, which provide critical habitat for many commercially important species such as Dungeness crab, shellfish, and many marine fish species, are particularly susceptible to rapid development of aquatic invasive species populations.

Figure P.12. European green crab trapped on Makah reservation. Photo: Washington Sea Grant

Contaminants

Chemical contaminants (i.e., metals, persistent organic pollutants, hydrocarbons, dioxins) can adversely affect marine waters and resources therein. Contaminants enter the marine systems through stormwater, wastewater, air deposition, biological transport, and direct pathways. Furthermore, watershed alterations from increased land use, such as timber harvest and agriculture, may affect water quality by increasing sediment loads and nutrient runoff. Excessive sediment introduced to the nearshore environment can suffocate benthic marine life and reduce water clarity. On the Olympic Coast, there are no point sources for pollution and limited facilities resulting in the potential for human waste issues. However, along the Straits, portions of Vancouver Island, including Victoria, British Columbia, have been discharging raw sewage into the Straits due to lack of wastewater treatment plants.

Some persistent industrial chemicals, even those no longer in use in this country, such as Dichloro-diphenyl-trichloroethane (DDT), ~~polychlorinated biphenyls (~~PCBs~~)~~, and polybrominated diphenyl ether (PBDE), have found their way into marine food webs and can be detected in tissue samples of higher-order predators (Southern Resident Orca Task Force 2018). These persistent organic pollutants (POPs) bioaccumulate in upper trophic level species and can result in “immunotoxicity, neurotoxicity, and reproductive impairment” (Mongillo et al., 2012, p. 263). This is especially true for PCBs and PBDEs, which are found in high levels in marine mammals. This is particularly concerning for the highly endangered Southern Resident killer whale, whose population is 74 individuals at the time of this report, and their prey, several stocks of which are also ESA listed (Southern Resident Orca Task Force, 2018).

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There are several contaminants of emerging concern, including pharmaceuticals, detergents, personal care products, microplastics~~ (plastic particles smaller than 5.0 mm)~~, and others that enter marine waters through wastewater treatment plants, stormwater outfalls and runoff, industrial outfalls, aquaculture operations, landfills, and agricultural runoff (Southern Resident Orca Task Force, 2018;

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Masura et al., 2015). Microplastics enter waterways as either primary (manufactured raw plastic material including plastic pellets, scrubbers, and microbeads) or secondary (fragments of larger plastic items) microplastics (Masura et al., 2015). Microplastics are small enough to pass through wastewater treatment systems and may concentrate hydrophobic contaminants, which in turn are ingested by marine species (Masura et al., 2015).

Research Activities

There are numerous research activities that occur at any given time within OCNMS. This research helps in monitoring ocean conditions, understanding fish stocks for fisheries management, tracking marine mammals and seabird distribution and abundance patterns, measuring ocean sound dynamics, and a variety of other topics that are reflected throughout this Condition Report. Many of these research activities involve setting or releasing monitoring equipment that affects sanctuary habitats and resources. For example, many deep moorings are not able to recover their anchors, resulting in areas of anchor abandonment that can impact seafloor habitats. Furthermore, research activities occur within the U&As of the coastal treaty tribes and can interfere or disrupt treaty fishing activities, such as when fishing gear becomes entangled on moorings or abandoned anchors.

Offshore Aquaculture

Aquaculture is the growing of fish, shellfish, or other aquatic plants and animals. Shellfish aquaculture is a major industry in Washington state, which is ranked first among all U.S. states in sales of aquaculture products (Washington State Department of Ecology, 2018). Washington State has banned non-native fish net pen aquaculture within state waters following a 2017 failure of an Atlantic salmon net pen near Cypress Island in Puget Sound, in which approximately 250,000 Atlantic salmon were released (Chapter 79.105, Chapter 77.125, and Chapter 90.48 RCW). There are currently no aquaculture activities occurring or proposed within the sanctuary.

NOAA's Aquaculture Program is currently exploring possibilities for open-ocean or offshore aquaculture production in federal waters, which include all sanctuary waters more than three nautical miles (5.5 kilometers) off the Washington coast. Open-ocean aquaculture is a controversial issue for some segments of the public and raises regulatory concerns with regard to pathogens, nutrient loading, fishing area restrictions, and habitat and ecosystem impacts. Although sea conditions are dynamic and challenging in the sanctuary, technological developments in anchoring and structural design may make such development feasible in the sanctuary in the future. If projects are proposed for the sanctuary, it will be necessary for sanctuary staff to investigate potential environmental impacts and weigh these against sanctuary goals and mandates while making permitting decisions.

Offshore Energy

While there are no offshore oil or gas leases off of the Washington coast, and there has been a moratorium on new offshore oil and gas leasing across the ~~w~~West ~~c~~Coast since 1988, Executive Order 13795 (2017) directed the Department of the Interior to develop an updated Outer Continental Shelf (OCS) Oil and Gas Leasing Program, which included reviewing the entire OCS for offshore oil and gas leasing (with the exception of national marine sanctuaries, where regulations prohibit the activity). The 2019–2024 proposed program is still under development and a final program may or may not include the ~~w~~West ~~c~~Coast for leasing consideration. However, if this activity is permitted on the ~~w~~West ~~c~~Coast, even outside of OCNMS, construction operations or an oil spill in adjacent waters could still impact sanctuary resources.

Renewable energy can be produced in offshore areas from wind, waves, tides, or currents. Typically, cables run from offshore energy-generating devices to an onshore energy grid. There are barriers for marine renewable energy projects off of the Washington coast, including transmission grid infrastructure, existing uses, energy costs, and local community concerns (Washington State Department of Ecology, 2018). There are several marine renewable energy areas proposed in California (Diablo Canyon, Morro Bay, and Humboldt) and Newport, Oregon. We are not aware of any current marine renewable energy proposals off the Washington Coast.

In 2007, there was a significant effort to develop the Makah Bay Offshore Wave Energy Pilot Project. The in-water portion of the project was within sanctuary boundaries, and the shore-based facilities would be located on Makah tribal land. In December 2007, the project was issued a conditional license by the Federal Energy Regulatory Commission; this was the first federal license for an ocean energy project in the U.S. The one-megawatt (enough to power 150 homes) demonstration project would have tested a novel technology and delivered power to the Clallam County Public Utility District's grid from a renewable energy source—ocean waves. As proposed, the project included four interconnected, floating buoys tethered to the ocean floor with a complex anchoring system and a submarine electrical transmission cable laid across the seabed to the shore and routed underground past sensitive nearshore habitat. Authorization from the sanctuary was required, but the original project proponent (Finevera Renewables) changed ownership and moved their wave energy efforts to Scotland.

~~Emergent technology pairings using marine renewable energy may be of interest in the future. For example, pairing wave energy with oceanographic monitoring equipment to enable at-sea charging or to power a small-scale or emergency desalination device may be more feasible given the energy output from kinetic energy devices paired with existing energy costs in Washington State.~~

Increased Visitation

The Olympic Coast is remote and largely rugged wilderness with limited public access locations. Long-time residents as well as tourists from around the world are drawn to the many recreational opportunities of the Olympic Coast, including hiking, sport fishing, kayaking, surfing, wildlife viewing, clamming, and beachcombing (Figure P.13). While there are limited at-sea whale watching opportunities, the Whale Trail promotes shore-based whale watching, with several sites along the Washington coast. In 2013, Washington residents alone took an estimated 5.2 million person-trips to the coast, with 6% of Washington households recreating within the sanctuary (Leeworthy et al., 2016). While much of this recreation occurs outside of the sanctuary's boundaries on the shore, recreational use can put unintended pressures on the coastal ecosystem. There is limited infrastructure within the Olympic National Park, during the summer season large aggregations of recreators visit these remote beaches leaving behind human waste due to lack of sanitation facilities. Beach going and tidepooling can involve trampling, and often includes beachcombing and other collecting by visitors. Motorized and non-motorized recreational boaters and sight-seeing pilots can inadvertently disturb wildlife. Although human access to most seabird colonies is restricted by the U.S. Fish and Wildlife Service's Washington Maritime Refuge Complex regulations (USFWS, 2007), Makah Tribal restrictions for Tatoosh Island, and Quileute Tribe's restrictions for James Island, wildlife on the refuge islands is vulnerable to disturbance from low-flying aircraft that do not comply with the 2,000-foot elevation requirement established by the sanctuary or by the increasing use of Unmanned Aerial Vehicles (UAV or drones). Cliff-nesting seabirds often abandon their nests when frightened, leaving eggs and nestlings exposed to avian predators.

Resting pinnipeds can abandon their haulout sites for the water when disturbed, often at a large energetic cost, especially to young animals. While use of commercial and recreational UAVs have increased over the past decade, the documentation ofed impacts to birds or marine mammals is still limited (Rhodes & Speigel, 2018). UAVs (especially electric devices) are quieter than manned aircrafts and can be flown lower without increasing the level of harassment (MMC, 2016). Other beach users such as bird watchers, dog walkers, and surfers can displace foraging migratory birds at important resting and staging areas. Damage to cultural sites (middens, petroglyphs, etc.) or scavenging of artifacts are increasing risks with increasing visitation.

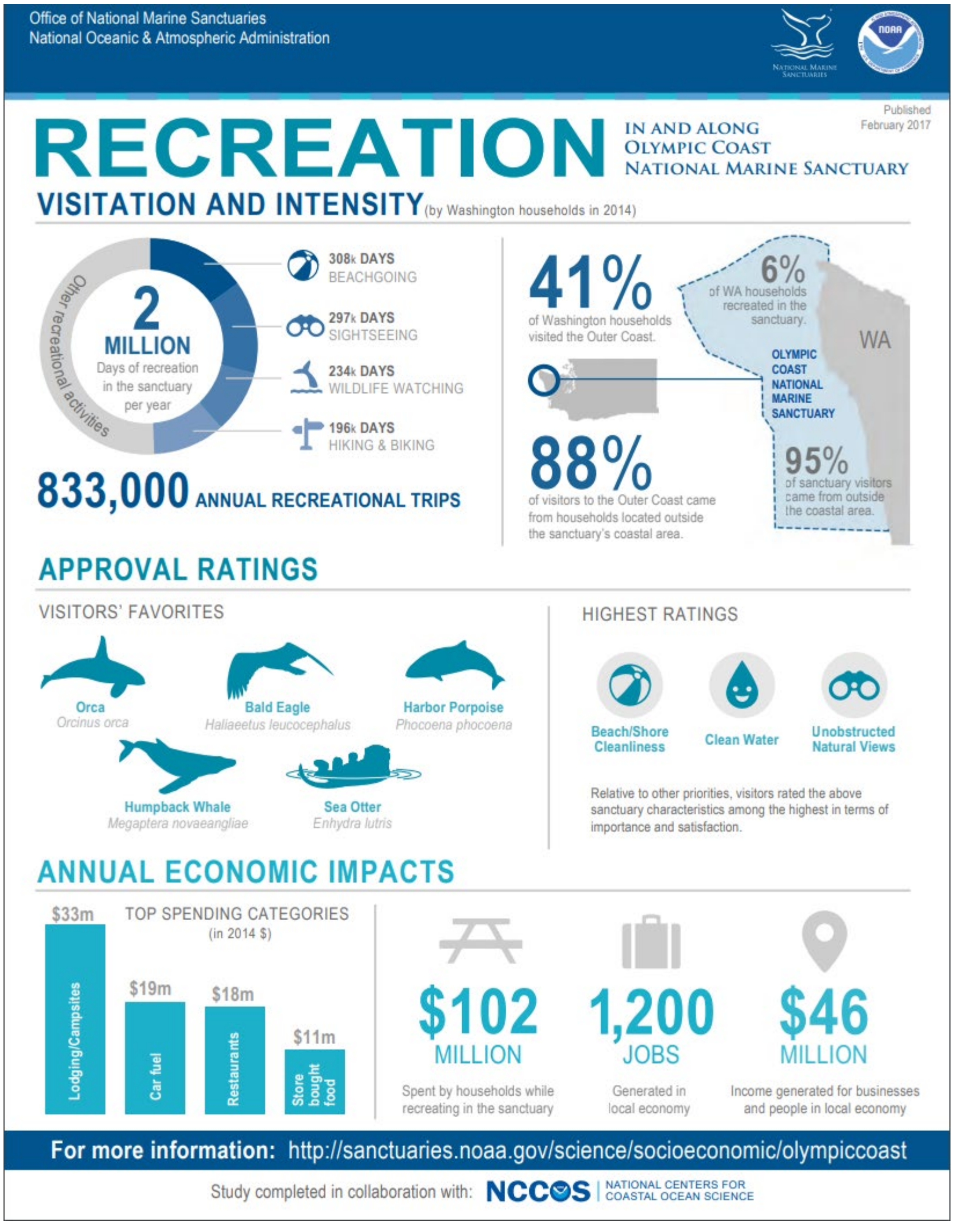

Figure P.13. Socio-economic summary for Olympic Coast National Marine Sanctuary. Image: NOAA ONMS

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This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

Table of Contents

Question 1. What are the states of influential human drivers and how are they changing?

Question 2: What are the levels of human activities that may adversely influence water quality and how are they changing?

Question 3: What are the levels of human activities that may adversely influence habitats and how are they changing?

Question 4: What are the levels of human activities that may adversely influence living resources and how are they changing?

Question 5: What are the levels of human activities that may adversely affect maritime heritage resources and how are they changing?

State of Drivers and Pressures

Below are answers to questions related specifically to the drivers and pressures discussed above. The status and trends of sanctuary resources are addressed in the next section. An expert workshop was convened on January 14–16, 2020 to discuss and determine status and trend ratings in response to a series of standard condition report questions.[1] Answers are supported by data and the rationale is provided at the end of each section for each resource area. Where published or additional information exists, the reader is provided appropriate references and web links. Workshop discussions and ratings were based on data available at the time (i.e., through January 2020). However, in select instances, sanctuary staff later incorporated newly available data in order to more accurately describe the current status and trends of resources. Situations where data were used by sanctuary staff to support a rating, but were not presented or discussed during the workshop, are noted in the text.

Question 1: What are the states of influential human drivers and how are they changing?

The primary drivers influencing pressures on OCNMS resources were previously described in the Driving Forces section of this report. Driving forces help to explain the origins of pressures on resources and potentially estimate ~~the~~ future trends for ~~of~~ those pressures. Drivers reflect the relationship between the demand and supply of goods and services that humans consume.

Commented [1]: Here it specifies "human drivers", which is helpful. See my comment/suggestion in the Drivers section.
But, here I would say human driving forces...to avoid confusion with people driving cars....

[1] A follow-up virtual workshop was held on May 4, 2020 with an expanded group of subject matter experts who were unable to attend the January 2020 workshop. Experts discussed indicators and datasets with the goal of determining a status and trend rating for Question 5: What are the levels of human activities that may adversely affect maritime heritage resources and how are they changing?

More specifically, drivers help to illustrate the direction and magnitude of demand for different ecosystem goods and services. Drivers include economic factors, such as income and spending; demographics, like population levels and urbanization; and societal values, such as levels of conservation awareness, political leanings, or changing opinions about the acceptability of specific behaviors (e.g., littering). All influence pressures on resources by changing human preferences and, consequently, the levels of demand for different resources and services.

After thoughtful consideration, ONMS and OCNMS staff decided not to rate the status and trend of influential human drivers at OCNMS. The primary purpose for rating the status and trends of resources through this process is to use condition reports to assess program effectiveness, and to influence management of human activities and certain natural resource actions, such as restoration (see About This Report). For the most part, drivers are not manageable, at least not under the authority of the NMSA, nor do most of them originate at scales relevant to management by marine sanctuaries. While understanding them is important, rating them is not necessary to achieve the goals of the condition report.

ConverselyOn the other hand, the pressures that result from drivers can be managed, either directly by ONMS or through engagement with those who have appropriate authority. Thus, status and trend ratings for pressures (i.e., human activities) and their potential effects on sanctuary resources have been determined and described in Questions 2–5.

Pressure Ratings (Questions 2–5)

Human activities that adversely impact water quality are the focus of Question 2. These include commercial and recreational vessel-based activities, and fishing activities.

Question 3 covers human activities that may adversely influence habitats. Some human activities may have structural and non-structural impacts to habitats. For example, fishing activities that physically disrupt the seafloor (e.g., trawls and lost gear), and ocean dumping may result in structural impacts to seafloor habitats. Non-structural impacts could include oil spills, sounds, and climate change. For this question we focus on structural impacts to habitats.

Human activities that have the potential to negatively impact living resources are the focus of Question 4. These include activities that remove plants or animals, as well as activities that have the potential to injure or degrade the condition of living resources.

Activities that influence maritime heritage resource quality are the subject of Question 5. These include activities that diminish resource quality through intentional or inadvertent destruction of maritime heritage resources. Importantly, and unlike most natural resources, maritime archaeological resources are non-renewable. Once degraded or destroyed, their archaeological value is lost forever.

Commented [2]: I'm not sure this section adds much. Could the 'and this is why we ask it" part of the summary for each question be put under each appropriate question heading? It seems a bit redundant to tell us what the questions are all about before you ask them.

Commented [3]: How is it that none of these questions address climate change? Human activity increases CO2!! This affects water quality, SLR so habitat, and species via OA so living resources. I do not understand what this section doesn't ascribe climate change to human activity.

Question 2: What are the levels of human activities that may adversely influence water quality and how are they changing?

Status: Good/Fair, Confidence - Medium; **Trend**: Not Changing, Confidence - Medium ~~(Table S.P.2.1)~~

Status Description: Some potentially harmful activities exist, but they have not been shown to degrade water quality to a degree that raises substantial concern.

Rationale: Several human activities have the potential to adversely influence water quality, but generally do not seem to be doing so within OCNMS waters, except on very localized, short-term scales. Activities of concern include oil spills from vessels, vessel discharges from sewage and exhaust gas cleaning systems, and at-sea seafood processing.

Commented [4]: This will be replaced with a symbol, I don't think referencing the table will be useful.

Commented [5]: Dumping literal tons of fish guts from a processing boat degrades water quality in the immediate vicinity for a few minutes or an hour, for example.

Comparison to 2008 Condition Report

In the 2008 condition report, this question was rated "good/fair" and "not changing." The basis for judgement was the threat of oil spills from vessels (Table S.P.2.1). Since 2008, levels of human activities affecting water quality within and around the sanctuary have generally remained steady. However, we are beginning to learn more about some activities that have been ongoing for some time, e.g., offshore seafood processing. ~~-~~Other activities are new, such as large commercial vessels generating a new type of effluent from ~~-~~exhaust gas cleaning systems. The amount of published data on these human activities is limited. The cumulative effects of these anthropogenic activities have the potential to alter water quality in the sanctuary. However, these activities do not seem to be currently having an adverse effect except on a very localized, short-term basis. ~~-~~Therefore, the status ~~response~~ for this question is still rated "good/fair" (medium confidence). The trend rating remains "not changing" (medium confidence).

Commented [6]: if this is why you are scoring confidence as medium, state so here. If not, explain reasoning for the medium rating elsewhere in the paragraph

Summary of New Information from 2008–2019

Commented [7]: I'm finding that I want better linkage between 3b (Pressures) and this text. Meaning as I was reading, I went back to 3b see what of this material had already been presented. The material isn't redundant, which is good. A couple of options come to mind. 1 - add a sentence in 3b to say "read more about new info 2008-2019 for [pressure X, e.g., vessel traffic, oil spills, fishing] in section 3.x". 2 - move the material here up into section 3b and then in the section here, just refer back succinctly to that section. I like option 2 better, so that I can get the full story for each pressure in one spot. It's also possible that you plan to make these section linkages a bit more clearly in the next iteration, in which case, read this comment as my support for doing so!

The Strait of Juan de Fuca (Figure S.P.2.1) serves as the entrance to the nearby ports of Seattle and Tacoma, Washington and Vancouver, British Columbia, Canada. Because the sanctuary encompasses the entrance to the Strait of Juan de Fuca, it sees approximately 8,300 transits from deep~~-~~-draft vessels annually~~per year~~ (ECY 2019) (Figure S.P.2.2). An analysis of maritime traffic can be used as an indicator of the risk of oil spills, as well as other potential impacts. An oil spill in the Strait of Juan de Fuca traffic lanes could impact large areas of the sanctuary, as occurred during the F/V *Tenyo Maru* oil spill in July of 1991 (Figure S.P.2.3).

Washington State Department of Ecology (ECY or Ecology) produces an annual report on transit numbers, the Vessel Entries And Transits (VEAT) report (ECY 2019). The Ecology data include cargo and passenger vessels 300 gross tons and larger, tank ships, and oil tank barges. In the time period from 2008 through 2019, shipping in these categories varied by vessel type and destination. In this time period there was a 13% increase in cargo and passenger vessel transits and a 24% decrease in tank ships, with an overall increase of 7% (Table S.P.2.2).

No major oil spills occurred in the sanctuary from 2008 through 2019. Oil spills reported during this time period originated from smaller vessels (19 to 78 ft), with reported spill volumes of diesel fuel up to 3,800 gallons (Galasso, 2017). NOAA Office of Response and Restoration considers diesel fuel spills of 500–5000 gallons to be small, and, while acutely toxic, when spilled in open water and unconfined, they evaporate or naturally disperse within a few days (ORR, 2020). Therefore, for the purposes of assessing human activities that may adversely influence water quality, we do not consider the number of incidents and volume of oil spilled to indicate a significant change in risk from oil spills. The OCNMS incident database shows that the most incidents were reported in 2012 and 2016, with five incidents each. The year with the most spilled oil reported was 2011, with 3,825 gallons (Galasso, 2017). The number of lost vessels (22) and volume of spilled oil (approximately 10,000 gallons) over an 11--year period is believed to not have caused a significant impact on sanctuary water quality.

In the 2011 OCNMS management plan and environmental assessment (EA; NOAA, 2011), we estimated both the amount of sewage and graywater produced by commercial vessels, including fishing vessels, as well as recreational and charter fishing vessels. 2009 was the year used for the analysis, and data are is summarized for 14 different vessel categories for sewage and graywater in the 2011 EA. Passenger vessels (>1,600 gross tons) were the largest contributors, with 63.3% of the estimated sewage discharge and 74.9% of the estimated graywater discharge. Based on this analysis, OCNMS changed its discharge regulations to prohibit most discharges from passenger vessels. We therefore assume that the overall discharge of sewage and graywater in the sanctuary has decreased,; however, six instances of cruise ships self-reporting accidental illegal discharges since 2011 have occurred (NOAA enforcement records 2014-1, 2016-2, 2017-1, 2018-2).

Another discharge into sanctuary waters is the offshore processing of Pacific whiting. This activity is not new, but we have recently learned more about the process. Pacific whiting, or hake, is a semi-pelagic schooling species of groundfish. There are three stocks of Pacific whiting: a migratory coastal stock; a Puget Sound stock; and a Strait of Georgia stock. While the latter two have declined significantly, the coastal stock remains large and healthy and is the most abundant commercial fish stock on the WestPacific Coast.

Commented [8]: This is the term you've used above, and pollock in AK are a bigger stock that is also on the "Pacific Coast," albeit the Bering Sea.

Pacific Whiting are processed in several ways, with at least two methods of at-sea processing: at-sea mothership processors and catcher-processor vessels[2]. After the usable portions of the fish are processed and boxed for marketing, the scraps are ground and discharged from the vessel[3]. Increasingly, offshore processors are incorporating meal plants into their at-sea operations to generate byproducts such as fish meal, fish oil, and bone meal, and reduce discharges of the fish byproduct and waste that are produced during processing. In 2019,

[2] The coastal stock of Pacific whiting is managed through the bilateral Pacific Whiting Agreement between the United States and Canada, and by the Pacific Fishery Management Council's Pacific Coast Groundfish Management Plan.
[3] Offshore Seafood Processors in Federal Waters Off the Coast of Washington and Oregon are regulated under EPA general permit (WAG520000).

Environmental Protection Agency (EPA) Region 10 issued a NPDES General Permit to seafood processing vessels that discharge in federal Waters off the coast of Washington and Oregon[4]. Vessels operating under the permit are required to submit an annual report, including a summary of discharges (EPA, 2020). We anticipate that these annual reports may be an important source of information for future condition reports, and the amount of discharge a potential indicator. The sanctuary received copies of these reports for 2019, but because we only have one year of information we could not determine a trend, and the information ~~it~~ was not considered in the rating of this question (Figure R.2).

Local data on air pollution, collected by the Olympic Region Clean Air Agency at the Cheeka Peak Atmospheric Observatory located on the Makah Reservation, may show a local benefit of these regulations. A study from January 2011 and December 2014 investigated source factors contributing to ambient concentrations of particle pollution, specifically PM2.5[4]. The first factor, identified as marine-traffic residual fuel oil (RFO), was the highest contributor to PM2.5 during late summer. Over the four-year analysis, the RFO percent contribution to total PM2.5 declined. This is consistent with previous studies elsewhere, and may be attributed to regulations restricting the sulfur content of ship fuel (Hadley, 2017).

Reductions of emissions from sulfur oxides can be accomplished by either burning fuel with lower sulfur content or by using exhaust gas cleaning technology. EGCS, also known as scrubbers, remove sulfur from diesel exhaust and are currently being used to enable vessels to meet IMO air emission standards. Little is currently known about the impacts of this type of discharge in OCNMS, and how it is offset by benefits from improved air quality, thus it was not used in rating this question.

Conclusion

Several human activities have the potential to adversely influence water quality, but generally do not seem to be doing so to a concerning degree. Human activities considered include vessel traffic, sewage discharges, at-sea seafood processing, and exhaust gas cleaning systems. The primary consideration for this rating continues to be the level of shipping in the sanctuary as an indicator for oil spill risk, as that remains the largest human risk to water quality in the sanctuary. Data gaps identified in addressing human activities that adversely influence water quality include, but are not limited to: volume and impacts of vessel discharges, including black water and gray water discharges from offshore seafood processing, and EGCS effluent.

Question 2 References

EPA Office of Waste Management. (2011, November). Exhaust Gas Scrubber Washwater Effluent (EPA-800-R-11-006). https://www3.epa.gov/npdes/pubs/vgp_exhaust_gas_scrubber.pdf

[4] Areas excluded from the general permit include state water, and waters shallower than 100 meters in depth and shoreward during April 15th – October 31st, unless the Permittee can demonstrate that its discharge will not contribute to hypoxic conditions.

Commented [9]: For all of these, I would start the section with the Conclusion, actually, relabeled as "Summary" or "Finding". As the report itself is so long, it's helpful to have the findings stated at the start for each section, following by rationale for the findings. If you do reposition the Conclusion section, merge it with the existing Rationale section as they are somewhat redundant.

Commented [10]: I would move all references to the end of the document, labeled by question and section. Again, I'm trying to get the reader through the text of the report more efficiently, and the refs interrupt the flow. Possible this is what you already had in mind and just have the refs here now for ease of review!

EPA. (2020, March 26). NPDES General Permit for Offshore Seafood Processors in Federal Waters Off the Washington and Oregon Coast. Retrieved May 21, 2020, from https://www.epa.gov/npdes-permits/npdes-general-permit-offshore-seafood-processors-federal-waters-washington-and-oregon

Galasso, G. (2017). Review of Olympic Coast vessel incidents from 1995 – 2016. ONMS-17-07. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 85pp.

Hadley, O. L. (2017). Background PM2.5 source apportionment in the remote Northwestern United States. Atmospheric Environment, 167, 298-308. doi:10.1016/j.atmosenv.2017.08.030

Kalender S.S., Alkan G.B. (2019) Air Pollution. In: Hussain C. (eds) Handbook of Environmental Materials Management. Springer, Cham. https://doi.org/10.1007/978-3-319-73645-7_77

Washington State Department of Ecology (ECY). (2019). Report of Vessel Traffic and Vessel Traffic Safety: Strait of Juan de Fuca and Puget Sound Area (Rep. No. 19-08-002). https://fortress.wa.gov/ecy/publications/summarypages/1908002.html

Washington Department of Ecology (ECY). (2020). Vessel Entries And Transits (VEAT) Reports for Washington Waters (27 publications 1994-2020). Retrieved May 21, 2020, from https://fortress.wa.gov/ecy/publications/UIPages/PublicationList.aspx?IndexTypeName=Topic

Office of Response and Restoration (ORR). (2020). Small Diesel Spills (500-5,000 gallons). Retrieved August 4, 2020, from https://response.restoration.noaa.gov/sites/default/files/Small-Diesel-Spills.pdf

Olympic Coast National Marine Sanctuary (OCNMS): Final management plan and environmental assessment. (2011). Port Angeles, WA: Office of National Marine Sanctuaries, National Oceanic and Atmospheric Administration, Olympic Coast National Marine Sanctuary.

Question 2 Tables

Table S.P.2.1. 2008 (left) and 2020~~19~~ (right) status, trend and confidence ratings for the human activities ~~pressures~~ questions~~, including question 2~~.

2008 Questions		2008 Rating	2020 Questions		2020 Rating			
					Status	Confidence (Status)	Trend	Confidence (Trend)
N/A	N/A	N/A	1	Influential Drivers				

Commented [11]: Guessing you'll add more text here to explain the delta, dash/flatline, and question mark so that table can be interpreted on its own.

Commented [12]: I'm on the fence about the order of these tables. I want the 2020 Rating to jump out at me, and it's a bit cluttered now. I know you'll have the ONMS production team take a look at this, so that will likely help. I would consider having the 2020 information on the left side of the graph, and the 2008 on the right. I also think that you could use shading or a small symbol to indicate confidence levels, so as to reduce the number of columns.

Commented [13]: Graphic designer - please replace with the symbols you create. Thank you.

4	Human Activities & WQ	—	2	Human Activities & WQ	Good/Fair	Medium	—	Medium
8	Human Activities & Habitat	▲	3	Human Activities & Habitat	Fair	Medium	?	Medium
14	Human Activities & LR	▲	4	Human Activities & LR	Good/Fair	High	▲	Medium
17	Human Activities & MAR	?	5	Human Activities & MAR	Fair	Medium	?	High

Questions		2008 Rating	Questions		2019 Rating			
					Status	Confidence	Trend	Confidence
	N/A	N/A	1	**Influential Drivers**				
4	**Human Activities & WQ**	–	2	**Human Activities & WQ**	G/F	Medium	–	Medium
8	**Human Activities & Habitat**	▲	3	**Human Activities & Habitat**	Fair	Medium	?	Medium
14	**Human Activities & LR**	▲	4	**Human Activities & LR**	G/F	?	▲	?
17	**Human Activities & MAR**	?	5	**Human Activities & MHR**	Fair	Medium	?	High

Commented [14]: In the bottom row of the table the 2008 question is Human Activities & MAR, while for 2019 it's Human Activities & MHR. Need to state difference between MAR and MHR so the reader knows this is apples to apples.

~~**Table S.P.2.2** Vessel Entries and Transits data collected from 2008 - 2019 demonstrates an overall 7% increase in cargo, passenger and tank shipping, with variation by vessel type and destination. Source: Washington Dept. of Ecology, 2020.~~

Commented [15]: I would cut this table - you have the info in text and the table doesn't add a whole lot more.

~~**Vessel Type**~~	~~**Destination**~~	~~**Change**~~
~~Cargo & Passenger~~	~~WA~~	~~-20%~~
~~Cargo & Passenger~~	~~Canada~~	~~+44%~~
	~~Combined~~	~~+13%~~
~~Tank~~	~~WA~~	~~-30%~~
~~Tank~~	~~Canada~~	~~-8%~~
	~~Combined~~	~~-24%~~
	~~**Net Change**~~	~~**+7%**~~

Question 2 Figures

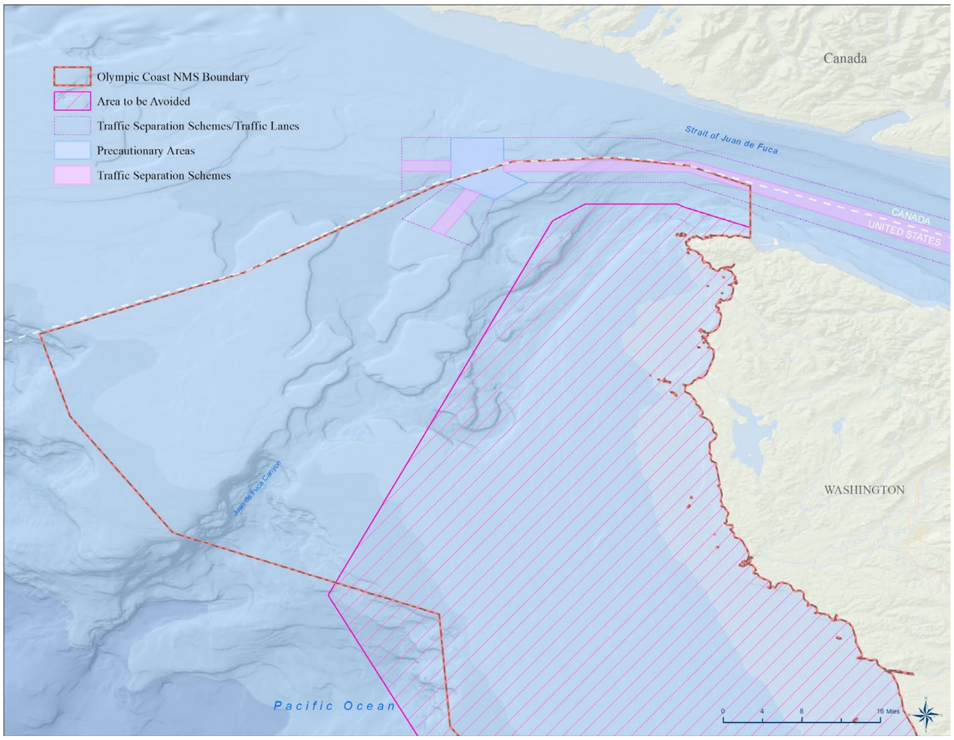

Figure S.P.2.1. Map showing the northern portion of the sanctuary relative to the entrance to the Strait of Juan de Fuca, international shipping lanes and traffic separation schemes, and the Area to be Avoided designated by the International Maritime Organization to reduce risks to the Olympic Coast from vessels over 400 gross tons. Map credit: NOAA ONMS

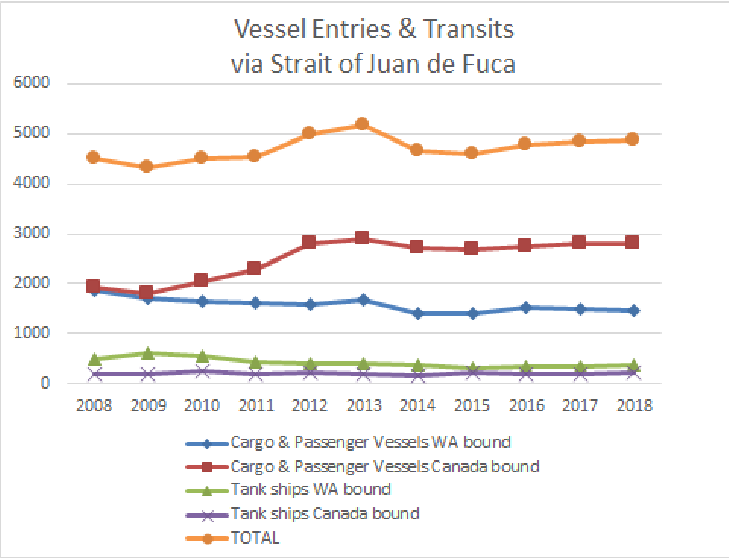

Figure S.P.2.2. Number of inbound vessel transits to the Strait of Juan de Fuca, including cargo and passenger vessels 300 gross tons and larger; and tank ships and tank barges, transporting oil, of any tonnage (ECY 2020).

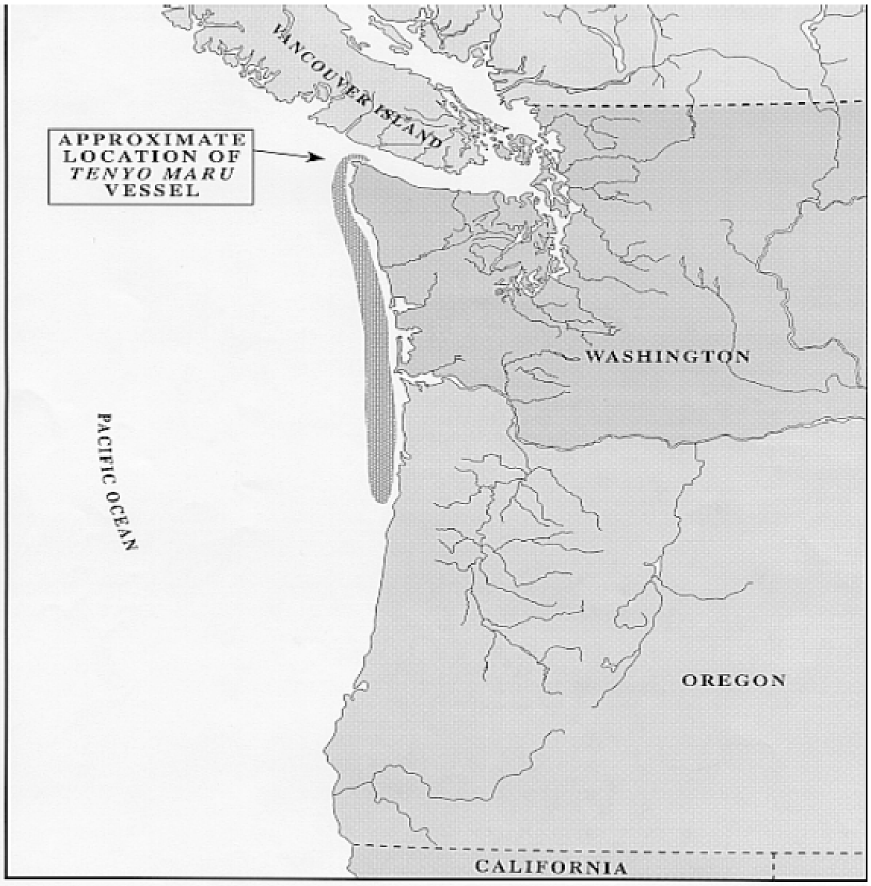

Figure 1-1. Approximate area impacted by *Tenyo Maru* Oil Spill

Figure S.P.2.3. Approximate area impacted by 1991 Tenyo Maru Oil Spill
https://www.cerc.usgs.gov/orda_docs/DocHandler.ashx?task=get&ID=551

Question 3: What are the levels of human activities that may adversely influence habitats and how are they changing?

Commented [16]: This figure seems to come from another document. Should it be attributed to that source?

Commented [17]: move to 3b for sure as that's where you refer to the spill

Status: Fair, Confidence - Medium; **Trend**: Undetermined, Confidence - Medium ~~(Table S.P.3.1)~~

Status Description: Selected activities have caused measurable resource impacts, but effects are localized and episodic, ~~and not~~rather than widespread or persistent.

Rationale: There have been shifts in the location of trawl impacts, and improved management of bottom contact gear. Activities of potential concern to benthic habitats include bottom-contact fishing gear~~,~~; abandoned, lost, or derelict crab pots~~,~~; lost vessels~~,~~; and ocean dumping.

Comparison to 2008 Condition Report

In the 2008 condition report, this question was rated "fair" and "improving~~.~~" (see Table S.P.2.1). The basis for judgement was a decrease in bottom trawling and, presumably, impacts to hard bottom habitats. Since 2008, the level of non-tribal trawling in the sanctuary has remained relatively stable, with a shift in activity from the north to the south. In addition, state and tribal fishery managers have taken management actions to reduce the level of abandoned, lost, or derelict crab pots. OCNMS has also tracked the number of lost vessels and learned of incidents of lost cargo from ships. ~~But t~~The lack of data for some of the known or suspected pressures considered in the current report, however, led the experts to rate the trend as “undetermined.”

New Information in 2019 Condition Report

NOAA Fisheries' California Current Integrated Ecosystem Assessment (CCIEA) Ecosystem Status Report for 2020 (NOAA CCIEA, 2020) provides the Pacific Fishery Management Council with an annual update on the status of the California Current Ecosystem. The CCIEA evaluates and tracks ecosystem indicators for the entire California Current to assess ecosystem attributes of interest, such as ecosystem health and resilience and socio~~-~~economics. One such indicator is bottom trawl contact with the seafloor, which ~~to~~ estimates ~~fishery~~ effort in ~~of~~ the groundfish fishery and potential ~~fishery~~ impacts to ~~different~~ seafloor habitats~~.~~. OCNMS requested that CCIEA staff evaluate bottom trawl contact with the seafloor on the scale of OCNMS, and for areas immediately adjacent to the sanctuary, from 2008-2019 to identify shifts in trawling locations and trends in distances trawled. Figure S.P.3.1 portrays bottom contact indicators for the federal non-tribal groundfish fisheries operating within the boundaries of, and adjacent to, OCNMS~~,~~ from 2002–2019.

Figure S.P.3.2 provides the~~a~~ spatial distribution of non-tribal bottom trawl effort, calculated from annual distances trawled within 2x2 km grid cells (2002–2019). The left panel shows mean distance trawled annually from 2002 to 2007. The middle panel shows mean distance trawled annually from 2008 to 2019. These maps indicate a large decrease in the footprint of non-tribal bottom trawling effort in the northern regions of the sanctuary between the two time periods, explaining much of the overall decrease observed over time (Figure S.P.3.1). The right panel shows the trend in bottom trawling effort from 2008 to 2019, highlighting the increasing trend in effort in the southwest region of the sanctuary. Figure S.P.3.3, representing the same time period, shows changes in non-tribal bottom trawling effort among six habitat types in the sanctuary. Distances trawled among habitat types can be observed primarily in soft habitats,

Commented [18]: Font is inconsistent here, likely due to a cut and paste issue.

with slight increases in soft, shelf habitats and slight decreases in soft, upper slope habitats since 2008.

Another significant user of bottom-contact gear in the sanctuary is the Dungeness Crab fishery, managed by both Washington State and the Coastal Treaty Tribes. Washington State implemented a two-tier pot limit structure for the coastal Dungeness crab fishery in 2000. Each existing license was permanently assigned either a 300-pot or 500-pot limit based on historical landings. This has not changed in the reporting period from 2008-2019. It is estimated that approximately 37,000 crab pots are set in the sanctuary each year, with an estimated 10% annual loss ~~(Ayres, 2020)~~ of ~~pot~~ gear (Ayres, 2020). While the number of pots set annually has remained constant, there have been successful management efforts, by both Washington and Tribal resource managers, to reduce the number of abandoned, lost, or discarded pots in Washington State waters.

Commented [19]: What efforts? Could use a sentence or two here describing outreach, best practices, etc. being employed.

Experts also considered other ~~-~~human activity pressures, such as anthropogenic ~~human~~ debris on the seafloor. In 2017, OCNMS completed a report (Galasso, 2017) on incidents that resulted in vessels being lost in or near the sanctuary. The report includes vessels that have sunk, grounded, or capsized, regardless of whether the vessel was salvaged. Since 2008, 30 vessels have been lost in the sanctuary, the majority of which were small recreational or commercial fishing vessels. ~~-~~In that period, there was no consistent trend, though contributing factors certainly include operator experience, sea state, and weather. 2016 had a high of six lost vessels, with only two in the following three years.

Makah fishermen reported recovering ~~recovered~~ crushed cars in their nets on four occasions in recent years, in 2011, 2013, 2016 and 2017 (Figure S.P.3.4). When we tracked a recovered license plate, ~~-~~the registered owner reported delivering the car to the metal recycling yard of Amix Recycling/Schnitzer Steel Industries, Inc. in New Westminster, British Columbia, Canada in October 2007. OCNMS identified additional documented cases of scrap metal being lost from open deck barges. This included a 2010 case where an entire barge capsized off the Columbia River, losing its entire 4,500 ton load (Ryan, 2019).

Commented [20]: Somewhere in this discussion a brief statement needs to be make about the impacts of lost cars, i.e., why they are bad. Do they crush/cover habitat? do they serve as habitat? Are they just a risk to trawl fishermen? Do they still contain oils and other toxic chemicals? None of this is addressed here.

Commented [21]: Unless you're certain that the reports are comprehensive.

Using sanctuary vessel monitoring data, OCNMS attempted to identify the transit that could have been involved in the loss of the vehicle delivered to the recycling yard in October 2007. Several potential transits were identified, with the most likely occurring on December 13, 2007. OCNMS also identified additional transits with the same profile. This analysis covered the period between October 2007 and February 2013. OCNMS's search identified 44 southbound transits between the New Westminster and Portland Recycling Yards.

OCNMS continued to look for additional transits following this period, but until recently was unable to identify a continuation of this practice. On February 9, 2018, OCNMS staff observed a scrap metal deck barge westbound from Port Angeles (Figure S.P.3.5). This transit followed the same route as those previously identified between 2007~~–~~ and 2013.

Conclusion

The rating of Fair was based primarily on the effects of bottom contact fishing gear and various forms of debris on the seafloor from other human activities. The effects of human activities are measurable, but localized. Following a large decrease in trawling activity, prior to the reporting period, activity levels have been more consistent, with shifts in the location of trawling. Activities of primary concern include bottom-contact fishing gear~~,~~; abandoned, lost, or derelict crab pots~~,~~; lost vessels~~,~~; and ocean dumping. Data gaps identified in addressing human activities that may adversely influence habitats include, but are not limited to, details on lost cargo and marine debris.

Question 3 References

Auster, P. J. (1998). A conceptual model of the impacts of fishing gear on the integrity of fish habitats. Conservation Biology 12: 1198-1203.

Ayres, D. (2020, May 14). WA Coastal Crab Pot limits [E-mail interview].

Galasso, G. (2017). Review of Olympic Coast vessel incidents from 1995 – 2016. ONMS-17-07. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 85pp.

NOAA CCIEA. (2020). California Current Integrated Ecosystem Assessment (CCIEA) California Current Ecosystem Status Report, 2020 (Rep. No. Agenda Item G.1.a IEA Team Report 1). Retrieved May 21, 2020, from https://www.pcouncil.org/documents/2020/02/g-1-a-iea-team-report-1.pdf/

Ryan, J. (2019, June 19). Sedan overboard! How the sea floor got littered with cars off the Northwest coast. Retrieved May 21, 2020, from https://www.kuow.org/stories/sedan-overboard-how-the-bottom-of-the-Pacific-got-littered-with-junk-cars

Turner, S. J., S. F. Thrush, J. E. Hewitt, V. J. Cummings and G. Funnell. (1999). Fishing impacts and the degradation or loss of habitat structure. Fisheries Management and Ecology 6: 401-420.

~~**Question 3 Tables**~~

~~**Table S.P.3.1**. 2008 (left) and 2019 (right) status, trend and confidence ratings for the pressures questions, including question 3.~~

Questions		2008 Rating	Questions		2019 Rating			
					Status	Confidence	Trend	Confidence
	N/A	N/A	1	**Influential Drivers**				
4	**Human Activities & WQ**	–	2	**Human Activities & WQ**	G/F	Medium	–	Medium
8	**Human Activities & Habitat**	▲	3	**Human Activities & Habitat**	Fair	Medium	?	Medium
14	**Human Activities & LR**	▲	4	**Human Activities & LR**	G/F	?	▲	?
17	**Human Activities & MAR**	?	5	**Human Activities & MHR**	Fair	Medium	?	High

Question 3 Figures

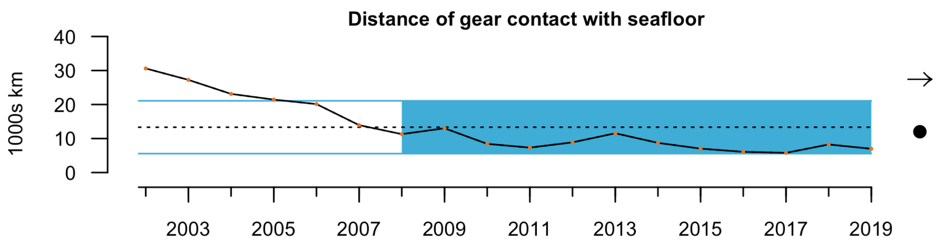

Figure S.P.3.1. Seafloor contact (in thousands km) by bottom trawl gear from federal groundfish fisheries operating within the boundaries of OCNMS from 2002-2019. The dashed line is the mean of the entire time series and the solid horizontal lines are ±1 standard deviation (SD) of the mean. Arrow at upper right indicates there was no trend in seafloor contact from 2008 to 2019 (shaded region). Symbol at lower right (•) indicates the mean from 2008 to 2019 was within 1 SD of the long-term mean. Source: NOAA Northwest Fisheries Science Center, Fisheries Observation Science Program.

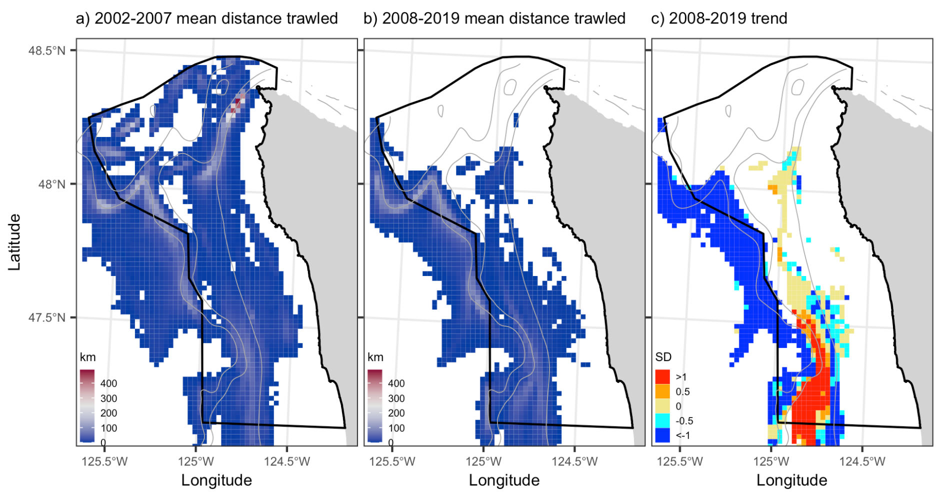

Figure S.P.3.2. Spatial representation of seafloor contact by bottom trawl gear from federal groundfish fisheries operating within and near OCNMS. Grid cells with < 3 vessels operating within the time period represented have been removed due to confidentiality. Cell colors in (c) indicate levels relative to the long-term mean (2002–19) (e.g., red indicates >1 SD above the mean and blue indicates >1 SD below the mean)). Source: NOAA Northwest Fisheries Science Center, Fisheries Observation Science Program.

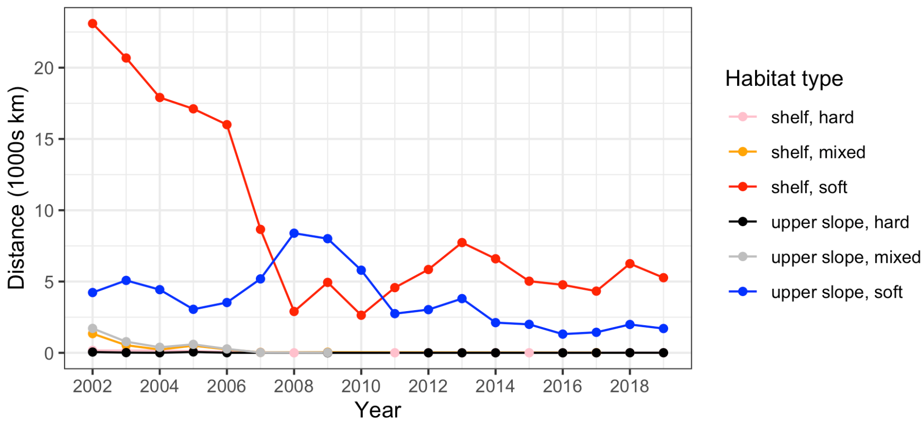

Figure S.P.3.3. Extent of seafloor contact among habitat types by bottom trawl gear from federal groundfish fisheries operating within the boundaries of OCNMS (2002–19). Source: NOAA Northwest Fisheries Science Center, Fisheries Observation Science Program.

Figure S.P.3.4. Crushed cars entangled in trawl nets. Photos: Makah Fisherman.

Figure S.P.3.5. Ocean Mariner towing an open deck barge, with of scrap metal, off Port Angeles on February 9, 2018. Transit originated in New Westminster, British Columbia enroute to Portland Oregon, through OCNMS. Photo: G. Galasso/NOAA.

Question 4: What are the levels of human activities that may adversely influence living resources and how are they changing?

Commented [22]: This section deals well with direct, first-order impacts of human activities that are readily observable, but what about microplastics, climate change, and ocean acidification? If these global factors are not included here I think it's worth noting why, and directing the reader to other sections. When you say 'human activities that may adversely influence living resources" this section is pretty myopic.

Status: Good/Fair, Confidence: High; **Trend**: Improving, Confidence: Medium (Table S.P.4.1).
Status Description: Some potentially harmful activities exist, but they have not been shown to degrade living resource quality to a degree that raises significant concern.
Rationale: Despite recent spikes in the number of whale entanglements, impacts from human activities overall either declined during the assessment period (e.g., a reduction in the number of overfished species) or remained at lower levels than earlier periods (trawling, and, presumably, gear impacts).

Comparison to 2008 Condition Report

In the 2008 condition report, this question was rated "fair" and "improving." (see Table S.P.2.1). The basis for judgement was decreased pressure from commercial and recreational fishing. Since 2008, levels of human activity within and around the sanctuary have varied, with both increases and decreases in harmful activities or impacts related to human activities. The level of non-tribal trawling in the sanctuary has remained relatively stable, with a southward shift in activity (Figure S.P.3.1 and Figure S.P.3.2). There have been management actions undertaken to reduce the level of abandoned, lost, or discarded crab pots. In 2011, the Department of the Navy (Navy) significantly expanded the Quinault Range Site (QRS), with considerable overlap of ~~in~~ the sanctuary. There has been an increase in the number of whale entanglement cases coastwide, including in OCNMS. In 2018, the number of reports from Washington and Oregon was exceptionally high. Marine debris loading increased in 2012 with the arrival of debris from the 2011 Japanese tsunami and again in 2015 with the onset of a strong El Niño event.

New Information in 2019 Condition Report

Impacts from groundfish trawling are of concern to OCNMS because bottom-contacting gear affect both non-target~~ed~~ species and other benthic organisms. Many organisms, like corals and sponges, are slow to recover (Miller et al., 2012). While such damage is caused primarily by bottom tending gear, unintended bottom contact by mid-water trawls, as well as impacts from lost gear, can have similar effects.

As discussed in question 3, NWFSC used data from their Fisheries Observation Science Program to look specifically at OCNMS, and immediately adjacent areas, from 2008–2019. Figure S.P.3.1 shows a substantial decrease in seafloor contact from bottom trawl gear used by ~~from~~ federal groundfish fisheries operating within the boundaries of the Olympic Coast National Marine Sanctuary, from 2002–2019. This decrease slowed after 2008, but annual levels were below the long~~-~~term mean for the entire period (shaded region).

Through careful science-based management and collaboration among fishermen, the Pacific Fishery Management Council, tribes, West Coast states, and NOAA Fisheries (NMFS), many stocks, including canary rockfish, bocaccio, darkblotched rockfish, and Pacific Ocean perch, rebounded faster than expected and are now fully rebuilt. Research and stock assessments by NOAA Fisheries' Northwest and Southwest Fisheries Science Centers documented the resurgence, opening the way for more harvest opportunities (Figure S.P.4.1). Others, such as yelloweye rockfish, have also been found to be rebuilding much faster than anticipated (NOAA NMFS, 2018). Related to these stocks, OCNMS contains large areas of untrawlable, and therefore unassessed, habitat that~~. That rocky habitat~~ is used extensively by some of these species. Tribes and others have noted for years that the NMFS trawl surveys don't account for the fish in these areas. Rocky habitat in the OCNMS has acted as refuge for many species, especially some rockfish (J. Schumacker, personal communication, July 22, 2020).

The U.S. Navy has a long history of testing and training activities in the Pacific Northwest, which predated the sanctuary's 1994 designation. The types and frequency of Naval activities has continued to evolve. Since the last OCNMS Condition Report was completed, the Navy has produced ~~conducted~~ four4 NEPA documents that cover activities in the sanctuary (NUWC, 2010; USN, 2010; USN, 2015; USN, 2020). The Navy has also invested considerable resources ~~in~~to research ~~on~~ impacts to natural marine resources and consults regularly with NOAA on the ecological implications of these impacts. These consultations result in science based, agreed to

Commented [23]: This is very vague. Need to mention ghost fishing, coverage of the seafloor by nets such that prey base is blocked, etc.

Commented [24]: Not sure what this term means. Is 'tending' the right word? Above, you've used bottom contact, or bottom-contacting, gear.

mitigation and avoidance measures intended to reduce the scope and scale of impacts to sensitive fish, wildlife, and habitats.

In 2010, the Navy expanded the Quinault Underwater Testing Range (now known as the Quinault Range Site) from the original 48.3 square nm (2% overlap with OCNMS) when the sanctuary was designated, to 809 square nm, with 759 square nm in the sanctuary (34% overlap with OCNMS). The Navy also proposed the testing of vehicle propulsion systems, submarines, inert mine detection, unmanned undersea vehicles, unmanned aerial systems and shore deployment systems, an increase in the average annual number of tests and days of testing, and addition of a surf zone at Pacific Beach.

In 2015 and in 2020, in accordance with section 304(d)[5] of the NMSA, the Navy and NMFS consulted with the sanctuary on the ~~U.S.~~ Navy's Northwest Training and Testing (NWTT) activities in OCNMS (2015 and 2020) and for associated National Marine Fisheries Service authorization of incidental take under the Marine Mammal Protection Act (2020). As part of the consultations the Navy (2015 and 2020) and NMFS (2020) prepared sanctuary resource statements (SRS). The purpose of the SRS~~sanctuary resource statement~~ is to provide the ONMS with enough information to understand the nature of the proposed activity and its potential impacts on sanctuary resources. Activities that had the potential to injure sanctuary resources were included in the 2015 and 2020 SRSs. The following activities are those that: 1) could occur within OCNMS (e.g., testing activities); 2) have the potential for propagation into OCNMS (e.g., training activities); or 3) may injure a marine mammal as defined under Section 304(d).

Training
- Anti-Submarine Warfare Tracking Exercise – Submarine (2015)
- Anti-Submarine Warfare Tracking Exercise – Surface (2015)
- Anti-Submarine Warfare Tracking Exercise – Maritime Patrol Aircraft (2015)
- Surface Ship Sonar Maintenance (2015)
- Submarine Sonar Maintenance (2015)
- Unmanned Underwater Vehicle Training (2020)

Testing
- Torpedo Testing (Non-Explosive) (2015)
- Autonomous and Non-Autonomous Vehicles: Unmanned Underwater Vehicle (2015)
- Fleet Training/Support: Anti-submarine Warfare Testing (2015)
- Acoustic Component Test: Countermeasures Testing (2015)
- Anti-Surface Warfare/Anti-Submarine Warfare Testing Countermeasure Testing (2015)
- New Ship Construction: Anti-Submarine Warfare Mission Package Testing (2015)
- At-Sea Sonar Testing (2020)
- Mine Countermeasures and Neutralization Testing (2020)

[5] Pursuant to Section 304(d) of the National Marine Sanctuaries Act (NMSA), consultation is required when federal agency actions are "likely to destroy, cause the loss of, or injure a sanctuary resource."

- Mine Detection and Classification Testing (2020)
- Unmanned Underwater Vehicle Testing (2020)
- Undersea Warfare Testing (2020)
- Acoustic and Oceanographic Research (2020)

In annual meetings between the Navy and OCNMS actual testing and training that occured within the sanctuary in the previous year is discussed, as security allows. Actual training and testing activities are often at lower levels than projected~~planned for~~ in the Navy NEPA documents. This makes trends in Navy activities difficult to assess. However, ~~Navy receives authorizations under MMPA and ESA from~~ NMFS and USFWS ~~that find~~have found that ~~the~~ higher levels of Navy activity on scales larger~~in a broader studied area~~ than ~~just~~ the sanctuary ~~shows to be~~have negligible impact on ~~to~~ marine mammals and do not jeopardize listed species, especially in light of added minimization measures over time. The Navy's permit authorizations include monitoring commitments and reporting to NMFS that indicate~~s~~ authorization levels have not been exceeded.

Over the last few years, NOAA Fisheries has responded to a higher than usual number of large whale entanglements reported to the West Coast Marine Mammal Stranding Network and Large Whale Entanglement Response Network. In 2018, a total of 46 whales were confirmed entangled off the coasts of California, Oregon, and Washington. NMFS also had 32 confirmed cases in 2017, 55 in 2016, and 53 in 2015. These were the highest annual totals for this region since NMFS started keeping records in 1982 (NOAA NMFS, 2020).

Data from the adjacent counties of Clallam, Jefferson, and Grays Harbor (Figure S.P.4.2) showed that the highest number of entanglements occurred in 2018, by a substantial margin. Of the 10 reported entanglements in 2018, two~~2~~ were gray whales and eight~~8~~ were humpback whales. The gear causing the entanglement was reported as commercial Dungeness crab gear (3), gillnets (4), and unknown (3).

Though most human activities discussed here have remained fairly constant between 2008 and 2019, conditions in the ocean changed dramatically, including an anomalous and persistent marine heat~~-~~wave from 2014 to 2016. A recent study found that this unprecedented marine heat wave caused “habitat compression” by restricting coastal upwelling, changing the availability of forage species (krill and anchovy), and forcing foraging whales shoreward, increasing interactions with the Dungeness crab fishery (Santora et al., 2020). This may account for the higher number of whale entanglements.

Marine debris impacts include wildlife entanglement and ingestion. Data from the OCNMS Marine Debris program (Figure S.P.4.2) shows that large debris items (black line on graph) increased in 2012 with the arrival of debris from the 2011 Japanese tsunami and gradually decreased following its peak in 2014. Considerably higher levels of debris were also encountered following the strong El Niño event of 2015/2016.

Conclusion

The rating of Good/Fair was largely based on changes in fisheries practices that have led to a reduction in the number of overfished species, a significant management achievement. As for negative indicators such as an increase in whale entanglements and pulses in marine debris, we believe these to be short term events attributable to specific anomalies. We consider the levels of human activities that may adversely influence living resources to represent an overall improving trend. Data gaps identified in addressing human activities that may adversely influence living resources include, but are not limited to: under-reporting of whale entanglements and ship strikes, and acoustic impacts.

Question 4 References

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Question 4 Tables

Table S.P.4.1. 2008 (left) and 2019 (right) status, trend and confidence ratings for the pressures questions, including question 4.

Questions		2008 Rating	Questions		2019 Rating			
					Status	Confidence	Trend	Confidence
	N/A	N/A	1	**Influential Drivers**				
4	**Human Activities & WQ**	–	2	**Human Activities & WQ**	G/F	Medium	–	Medium
8	**Human Activities & Habitat**	▲	3	**Human Activities & Habitat**	Fair	Medium	?	Medium
14	**Human Activities & LR**	▲	4	**Human Activities & LR**	G/F	?	▲	?
17	**Human Activities & MAR**	?	5	**Human Activities & MHR**	Fair	Medium	?	High

Question 4 Figures

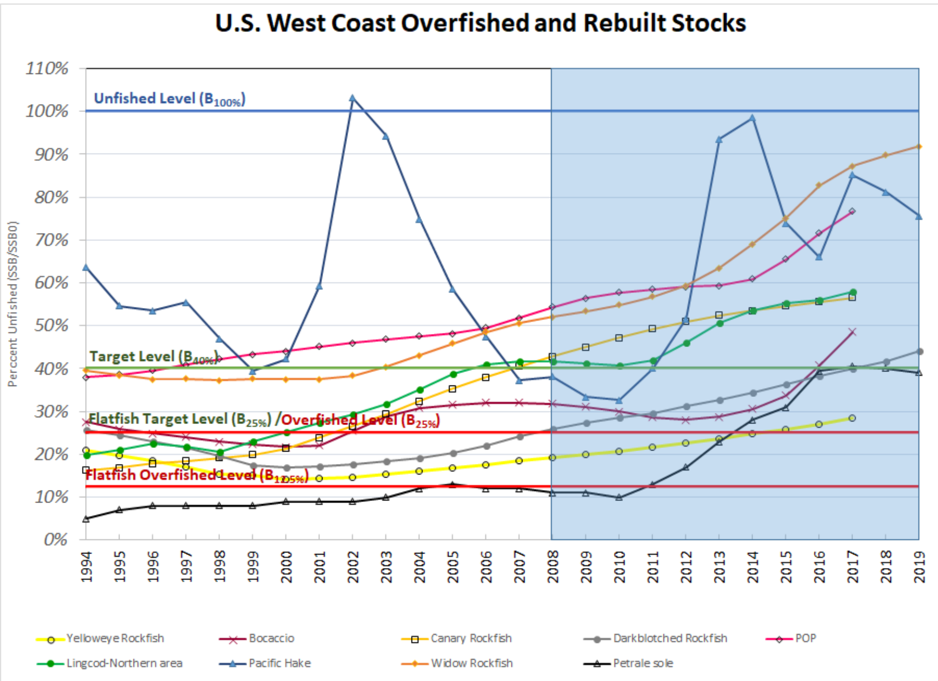


Figure S.P.4.1 West Coast Overfished and Rebuilt Stocks. NOAA Fisheries. 2021. Stock SMART data records. Retrieved from www.st.nmfs.noaa.gov/stocksmart. 09/16/2020.

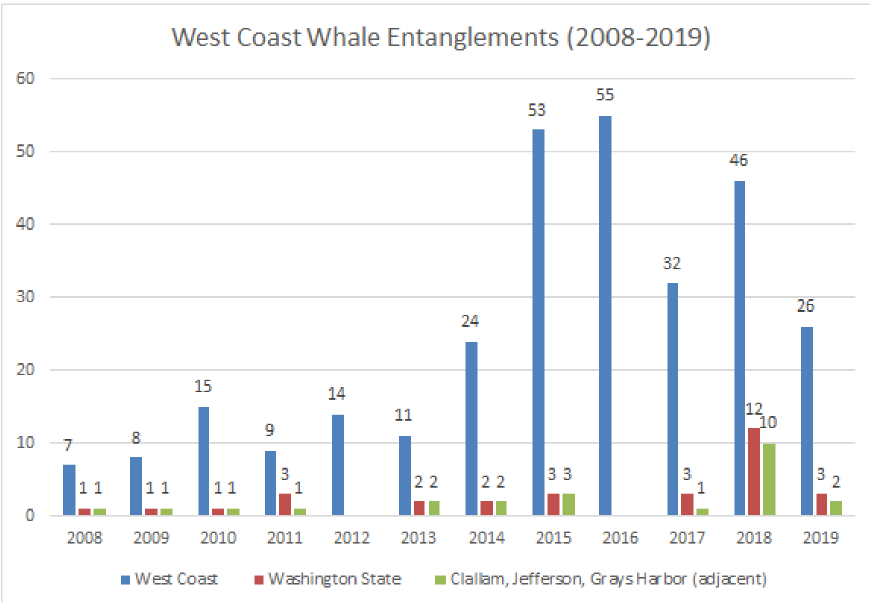
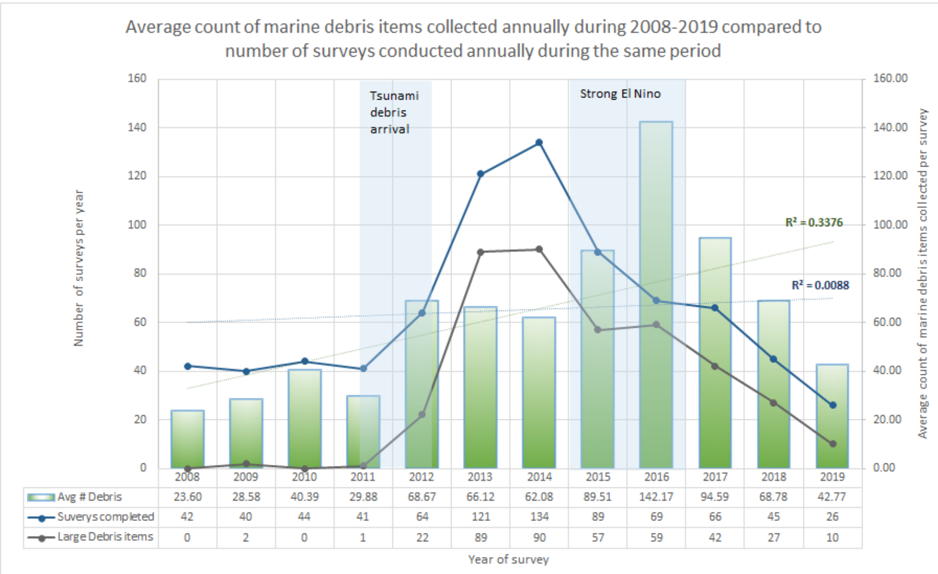


Figure S.P.4.2 West Coast Marine Mammal Stranding Network Whale Entanglement Summary (by area): blue-west coast, red-Washington State, green-adjacent to Clallam, Jefferson, and Grays Harbor Counties (representative of OCNMS area). Source: NOAA West Coast Marine Mammal Stranding Network Whale Entanglement Data.



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Avg # Debris	23.60	28.58	40.39	29.88	68.67	66.12	62.08	89.51	142.17	94.59	68.78	42.77
Suverys completed	42	40	44	41	64	121	134	89	69	66	45	26
Large Debris items	0	2	0	1	22	89	90	57	59	42	27	10

Figure S.P.4.3. Numbers of surveys per year and average count of marine debris items collected annually during 2008-2019. Data: OCNMS Marine Debris program. Graph: Chris Butler Minor.

Question 5: What are the levels of human activities that may adversely affect maritime heritage resources and how are they changing?

Status: Fair, Confidence - Medium; **Trend**: Undetermined, Confidence - High ~~(Table S.P.5.1).~~
Status Description: Selected activities have caused measurable impacts to maritime heritage resources, but effects are localized and episodic rather than~~not~~ widespread or persistent.
Rationale: Cumulative damage to shipwrecks from bottom-trawl fishing gear began when trawl gear was first introduced decades before the marine sanctuary was designated. The level of trawl activity has been relatively steady since 2008, but reduced from historic levels. Additional, but limited bottom disturbance exists from ocean dumping, lost vessels, and research activities.

Comparison to 2008 Condition Report

Maritime heritage resources include tangible resources such as historic shipwrecks, ~~and~~ prehistoric archaeological sites, and archival documents; intangible resources such as oral histories and stories of indigenous cultures that have lived and used the oceans for thousands of years; and natural resources with cultural value (OCNMS, 2008).

In the 2008 condition report, this question was rated "fair" with an "undetermined" trend (see Table S.P.2.1). The basis for judgement included fishing activities, offshore cable installations, and unauthorized salvaging. Since 2008, non-tribal trawling activity has remained steady, but with a general shift southward. Some areas in the north of the sanctuary have not been trawled by non-tribal fishers for several years (Figure S.P.5.1.). No new activity or information on existing cables has been documented, nor has -unauthorized salvage.

New Information in 2019 Condition Report

While the time period for evaluation in this condition report is from 2008 to 2019, impacts to maritime heritage resources are cumulative, as these resources cannot recover in the way that some habitats and living resources can. Impacts to shipwrecks from fishing activity have been documented in the sanctuary.

In June 2016, the Office of National Marine Sanctuaries (ONMS) partnered with Ocean Exploration Trust (OET) on a shipwreck survey of the SS *Coast Trader*, which was torpedoed and sunk in June 1942 by the Imperial Japanese Navy submarine I-26. The SS *Coast Trader* was previously believed to be located in OCNMS, but was found approximately three nautical miles to the north in the Canadian EEZ. -An analysis of remotely operated vehicle (ROV) survey footage showed that the *Coast Trader* was impacted in three ways from fishing activities: “nets snagged and twisted around parts of the superstructure; nets snagged on jagged areas of torpedo damage and ensnared on the wreck; and trawl gear wedged against the underside of the hull...” (Delgado et al. 2018).

Certain man-made debris on the ocean floor can cause impacts to maritime heritage resources through direct impact, and also complicates inventory activities. Of 46 vessels identified in a 2017 report on vessels lost in or near the sanctuary, 26 remain on the seafloor, likely in the sanctuary. There were five surveys conducted to locate some of these; two were located and charted. When possible the OCNMS attempts to locate vessels lost in the sanctuary to assess impacts to resources and to update nautical charts. While these wrecks may not be a navigation hazard in the traditional sense, they do represent hazards to fishermen who use gear on or near the seafloor (Galasso 2017).

Another source of debris is lost cargo, previously discussed under Question 3. Makah fishermen have recovered crushed cars in their nets on four occasions since 2011. Research on a recovered license plate identified the metal recycling yard that received one of the wrecks. Additional sanctuary research using vessel monitoring data identified additional transits with the same profile. The sanctuary continued to look for additional transits following this period, but through February 2018 was unable to identify a continuation of this practice (Figure S.P.3.5).

In 2015, OCNMS chartered a survey off Cape Flattery focusing on the area where Makah fishermen reported the debris. Using a combination of sidescan sonar and an remotely operated vehicle (ROV), a debris field of approximately 13 cars was identified. OCNMS believes that additional lost cargo exists along the identified route within the sanctuary. The presence of this debris in a traditional Makah fishing area prevents the Makah Tribe from accessing their treaty-protected fishing area. Other debris previously discussed can also have an impact on the traditional tribal fishing areas of all Coastal Treaty Tribes.

In consultation with subject matter experts on this question, it was clear that maritime heritage resources are much broader than shipwrecks, including both tangible and intangible resources, inclusive of both historic and cultural practices. Important work, such as language programs, tribal historic preservation programs, and tribal cultural landscape characterizations are being carried out by coastal tribes to prevent further loss of traditional cultural knowledge, and resources. There was a consensus that in addressing this question, impacts to cultural resources should be addressed in the future. The sanctuary's knowledge of these resources was identified as an important data gap. This finding is in concurrence with a broader internal survey conducted in 2019 by the ONMS Maritime Heritage Program, revealing that multiple sanctuary sites require additional assistance in engaging tribal and indigenous groups and appropriately considering cultural heritage resources (Barr 2019).

Sanctuary managers have deferred to tribal historic preservation staff in the protection of these resources, which are often shoreward of sanctuary boundaries. An example of this approach can be seen in oil spill response, where there is a requirement for a Qualified Historic Properties Specialist to assess emergency response strategies to protect historic properties or cultural resources (NWACP 2020). This helps to prevent sensitive location information from being known to the general public. This approach will be reevaluated as a result of recent conversations. Despite the consensus that this question should be considered in a broader context, the lack of available information resulted in the rating for this question being based primarily on human impacts on shipwrecks.

Conclusion

The rating of Fair was based on a number of factors, including bottom contact fishing and various sources of debris left on the sea floor from other human activities. Where they occur, particular human activities have measurable impacts, but they are localized. Following a large decrease in trawling activity in the first decade of the current century, most of it prior to the reporting period, activity levels have been more consistent with shifts in the location of trawling. Nevertheless, activities of concern due to their potential for impact include bottom-contact fishing gear, abandoned or lost vessels, and intentional or accidental ocean dumping. Cable installation and operations are also a concern, but were not discussed due to the lack of activity between 2008 and 2019. Data gaps identified in addressing human activities that adversely influence maritime heritage resources include, but are not limited to: the location and status of many historical shipwreck sites, and information on sensitive cultural resources.

Question 5 References

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Question 5 Tables

Table S.P.5.1. 2008 (left) and 2019 (right) status, trend and confidence ratings for the pressures questions, including question 5.

Questions		2008 Rating	Questions		2019 Rating			
					Status	Confidence	Trend	Confidence
	N/A	N/A	1	**Influential Drivers**				
4	**Human Activities & WQ**	–	2	**Human Activities & WQ**	G/F	Medium	–	Medium
8	**Human Activities & Habitat**	▲	3	**Human Activities & Habitat**	Fair	Medium	?	Medium
14	**Human Activities & LR**	▲	4	**Human Activities & LR**	G/F	?	▲	?
17	**Human Activities & MAR**	?	5	**Human Activities & MHR**	Fair	Medium	?	High

Question 5 Figures

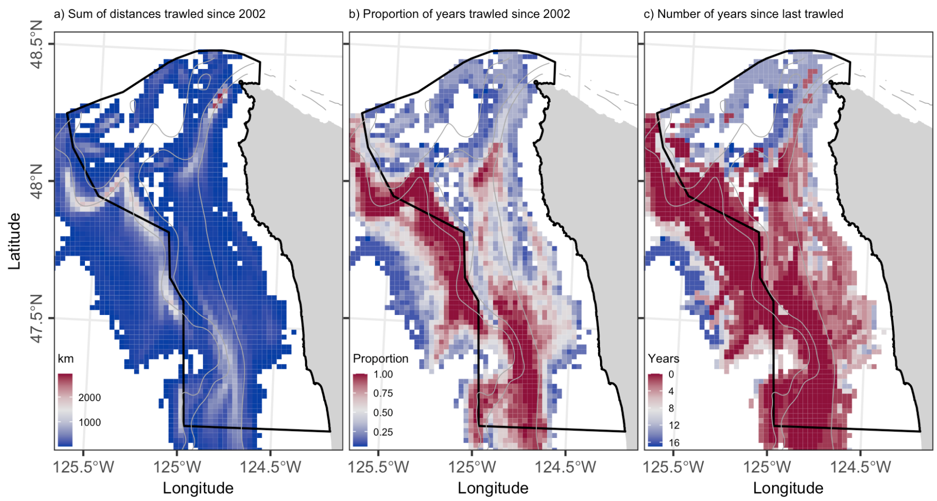

Figure S.P.5.1. Spatial representation of seafloor contact by bottom trawl gear from federal groundfish fisheries operating within the Olympic Coast National Marine Sanctuary and nearby areas. Grid cells with < 3 vessels operating within the time period (2002 - 2019) represented have been removed due to confidentiality. Data from NOAA's Northwest Fisheries Science Center's Fisheries Observation Science Program.

This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

State of Sanctuary Resources

This section provides summaries of the status and trends within four resource areas: water quality, habitat, living resources, and maritime heritage resources. An expert workshop was convened by sanctuary staff on January 14–16, 2020 to discuss and evaluate the following series of questions about each resource area presented in (Appendix D). Answers are supported by data and the rationale is provided at the end of each section for each resource area. Where published or additional information exists, the reader is provided with appropriate references and web links. Workshop discussions and ratings were based on data available at the time (e.g., through January 2020). However, in some instances, sanctuary staff later incorporated newly available data in order to more accurately describe the current status and trends of resources. Situations where data were used by sanctuary staff to support a rating, but were not presented or discussed during the workshop, are noted in the text.

In order to effectively consider all key indicators and relevant data sets, workshop experts were asked to consider each of the six major habitat types that are present in the Olympic Coast National Marine Sanctuary: rocky shores, kelp forest, sandy beach, sandy seafloor, deep seafloor, and pelagic (Figures ____ & Table ____).

Rocky Shores Habitat
Rocky shores are found primarily along the northernnly portion of the outer coast, typically characterized by steep rocky cliffs and rocky intertidal habitats that may have some interstitial sand. Many sea stacks lie just offshore of this area of the coast. Other prevailing features include high wave energy, large tidal exchanges, and a diverse community of hardy macroalgae, macrophytes, and benthic invertebrates distributed throughout subtidal, intertidal and supratidal zones. Fishes dwell around rocks, in tidepools, orand in the surf zone. The steep cliffs and isolated sea stacks provide refuge from terrestrial predators for colonial seabirds from terrestrial predators.

Kelp Forest Habitat
Kelp forests typically are associated with wave-exposed rocky reefs from the subtidal zone down to about 30m deepdepths. The dominant canopy-forming kelp species in Washington is bull kelp, which extends from rocky attachments to the surface during the growing season. Giant kelp is also present, along with many understory kelp species found beneath the canopy. Kelp provides three-dimensional habitat structure for many pelagic and benthic species at the margins of the intertidal and open ocean communities. This includes nursery habitat for young-of-the-year rockfishes. Both live and detached kelp provides detritus that is fed upon by grazers and scavengers; detached kelp subsidizes food webs in adjacent habitats.

Sandy Beach Habitat
Sandy beaches are the predominant habitat type along the southern and central Washington coast, although sandy beaches also exist in places along the northern Washington coast. Beaches may be composed of sediments of various grain sizes ranging from sand to gravel and cobble. They are characterized by unconsolidated sediments, twice-daily high and low tides, direct exposure to high wave energy, and relatively little in the form of habitat-structuring components such as macroalgae or seagrasses. Much of the productivity on beaches is

subsidized by production in adjacent systems. Olympic Coast beaches host many burrowing and tunneling invertebrates, a specially-adapted community of fishes and invertebrates in the highly active surf zone, and many species of birds. Bears and other terrestrial mammals are known to forage in beach habitats as well.

Sandy Seafloor Habitat
Sandy seafloor habitats are areas dominated by unconsolidated sediments (i.e., sand, mud, silt) at water depths shallower than ~30m. Sandy seafloor may harbor important species such as halibut and other flatfishes, Dungeness crab and other crab species, and a variety of invertebrates living on or in seafloor sediments.

Deep Seafloor Habitat
The deep seafloor habitat represents bottom features and waters close to the bottom at depths greater than 30m on the continental shelf and slope. The deep seafloor at OCNMS~~Olympic Coast~~ is dominated by soft sediments—sand, mud, and silt—with occasional rocky areas or other features, such as seamounts or submarine canyons. Sunlight is limited or absent in this habitat, and production is mostly subsidized from the overlying pelagic zone. A great variety of species inhabits the seafloor. Some prefer rocky habitats or live among sponges and corals, while others dwell on soft sediments; many make forays into the pelagic zone.

Pelagic Habitat
The pelagic habitat represents the water column off the coast of Washington, over the continental shelf and the upper reaches of the continental slope, and is roughly equivalent to the area covered by the deep seafloor habitat. Pelagic habitat is characterized by dynamic masses of open water that are constantly moving and changing, and is inhabited by planktonic and free-swimming species that range from the surface to the deep water near the seafloor. Many of these species occur in large schools or patches concentrated at different points in time or space. Some species make large vertical migrations each day (i.e., planktonic creatures that live at deeper depths in the daytime, ascending to shallower depths at night) or make long distance migrations on a seasonal basis (from Washington coastal waters to some other region).

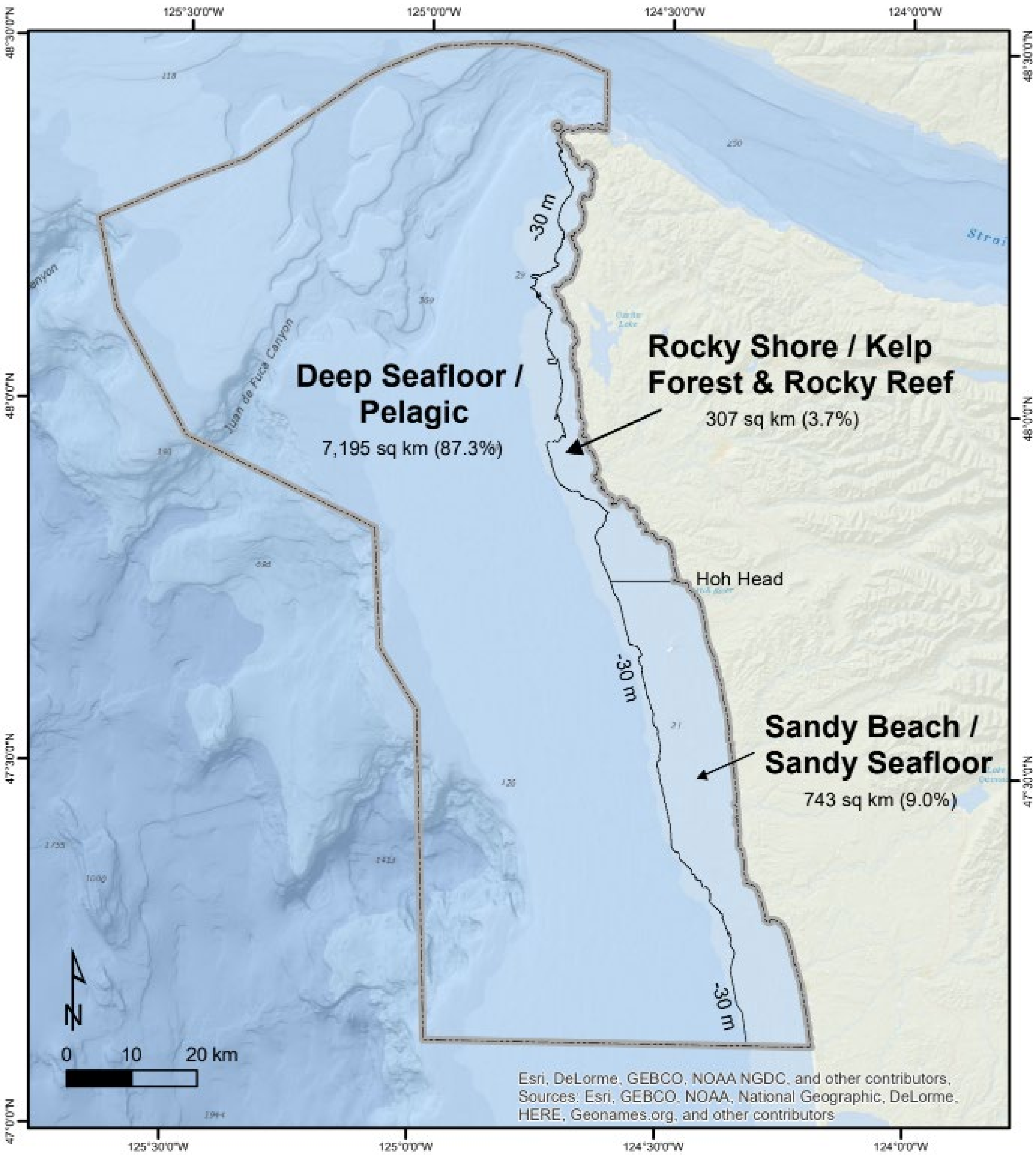

Figure ____. A map of Olympic Coast National Marine Sanctuary showing the general location and extent of the six major habitat types present. Map: Bryan Costa/NCCOS

Table ___. Square mileage and percent cover of the six major habitat types in OCNMS.

Habitat Type	sq km	percentage
Rocky Shores/ Kelp Forest	307	3.7

Sandy Beach/ Sandy Seafloor	743	9.0
Deep Seafloor	7,195	87.3
Pelagic	Same as deep seafloor	
Total	**8,245**	**100**

Figure ____. A conceptual overview map of the major habitat types in Olympic Coast National Marine Sanctuary.

This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

State of Sanctuary Resources

Table of Contents

Question 6: What is the eutrophic condition of sanctuary waters and how is it changing?

Question 7: Do sanctuary waters pose risks to human health and how are they changing?

Question 8: Have recent, accelerated changes in climate altered water conditions and how are they changing?

Question 9: Are other stressors, individually or in combination, affecting water quality, and how are they changing?

Water Quality (Questions 6–9)

Monitoring and assessing ~~the~~ water quality is one of the main objectives of the OCNMS management plan, which focuses on improving our understanding of water quality and ensuring protection of natural resources in the sanctuary. The following information provides an assessment of the status and trends of key water quality indicators in OCNMS for the period from 2008–2019.

Question 6 focuses on eutrophic conditions and their influence on primary production in sanctuary waters. Eutrophication is the accelerated production of organic matter, particularly algae, usually caused by an increase in the amount of nutrients (primarily nitrogen and phosphorus) from human sources in surface waters. Eutrophication can impact the condition of sanctuary resources, for example, by promoting nuisance and toxic algal blooms or impacting dissolved oxygen levels.

Question 7 focuses on parameters affecting public health. Human health concerns can arise from water, beach, and/or seafood contamination (bacteria, chemical, and biotoxins). Indications of health impacts may include shellfishery closures and shellfish consumption advisories. Such impacts can be devastating, both ecologically and economically, in affected coastal communities.

Question 8 focuses on shifts in water quality due to climate drivers. Climate indicators include indices of large-scale climate patterns, upwelling intensity, water and air temperature, dissolved oxygen, and acidity. Shifts in water temperature can affect species growth rates, phenology, distribution, and susceptibility to disease. Acidification can affect organism survival, growth, and reproduction. Upwelling influences oxygen content and nutrient cycling.

Question 9 assesses ~~other~~ biotic and abiotic stressors not addressed in other questions that, individually or in combination, may influence sanctuary water quality. Examples include nonpoint source contaminants, and hard-to-quantify stressors that influence the condition of habitats and living resources. Such inputs may include industrial~~y~~ discharges and emissions, fertilizers, pesticides, heavy metals, and sewage from diffuse sources.

Question 6: What is the eutrophic condition of sanctuary waters and how is it changing?

Status: Good, Confidence - High; **Trend**: Not Changing, Confidence - High ~~(Table S.WQ.6.1)~~
Status Description: Eutrophication has not been documented, or does not appear to have the potential to negatively affect ecological integrity.
Rationale: High primary productivity naturally occurs seasonally in OCNMS due to upwelling during the spring and summer. Human contributions to eutrophication (primarily via seasonal inputs of nutrients from the Salish Sea and Columbia River) appear to be negligible compared to natural cycles controlled by upwelling.

Definition and Description

Eutrophication occurs when high levels of nutrients from human sources fuel high rates of primary production and algal biomass accumulation, either as macroalgae or phytoplankton. On the Olympic Coast, upwelling plays a dominant role in high nutrient concentrations found in surface waters in spring and summer, which fuels ecosystem productivity and can contribute to harmful algal blooms (HABs). During the period from 2008 to 2019, the status of eutrophic conditions in OCNMS was rated good with an unchanging trend, both with a high degree of confidence (Table S.WQ.6.1). The rating of "good" indicates that eutrophication has not been documented, or does not appear to have the potential to negatively affect ecological integrity. These ratings were based on the fact that high primary productivity naturally occurs in OCNMS due to upwelling during the spring, summer and early fall. Human contributions to eutrophication, primarily via seasonal inputs of nutrients from the Salish Sea and Columbia River, appear to be negligible in comparison to nutrient inputs from upwelling;, however, freshwater outflow from the Columbia River may behave in different ways under certain conditions, potentially acting as a barrier or conduit for transport of harmful algal blooms along the coast (Figure S.WQ.6.1, Hickey et al. 2013).

Comparison to 2008 Condition Report

In the 2008 condition report, the rating for this question was "good", and the trend was "not changing" (Table S.WQ.6.1). There was no suspected human influence on eutrophication in the OCNMS. HABs occurred in the sanctuary as natural phenomena and were not believed to be enhanced by inputs of nutrients from land-based human activities or eutrophic conditions (OCNMS, 2008). However, the 2008 report was limited because there were no long-term, *in-situ* data on the status and trends for eutrophication indicators due to insufficient instrumentation in sanctuary waters (NOAA OCNMS, 2008).

Sanctuary staff and subject area experts assessed the current status and trend information for eutrophic conditions and concluded that 2009–2019 conditions were good and not changing, respectively, similar to the findings in the 2008 report. There was high agreement and confidence among the experts on this rating, although there was medium evidence to support their decision. The current report provides information and data analysis on critical indicators related to eutrophication from different sources that assisted experts in the assessment process. These indicators include:; phytoplankton, represented as chlorophyll in NASA MODIS and VIIRS satellite images; upwelling indices; nutrient~~s~~ loads in the Columbia River; and bottom dissolved oxygen from sanctuary moorings.

New Information in 2019 Condition Report

Experts agreed with high confidence that eutrophication in OCNMS was not documented and does not appear to affect ecological integrity. The assessment was mainly based on important indicators such as phytoplankton (chlorophyll concentrations), upwelling indices, and nutrients (i.e., total nitrogen and total phosphorus) in coastal rivers. However, experts also identified analysis gaps for key indicators like nutrients and turbidity that could be obtained from analyses of existing satellite data or other remote sensing capabilities. Additionally, the lack of long-term, *in-situ* datasets for some parameters was considered an important data gap for OCNMS. Table S.WQ.6.2 summarizes data gaps which would be beneficial to fill for the next condition report.

For phytoplankton, the LiveOcean model demonstrates seasonal variation using chlorophyll (mg m^{-3}) on the Olympic Coast. Beginning in approximately April of each year, upwelling-favorable conditions are produced by northerly (equatorward) wind patterns, which bring nutrients to the surface ~~water~~ along the coast, producing phytoplankton blooms and increasing chlorophyll concentrations to ~20 mg m^{-3} and ~~producing phytoplankton blooms~~ (LiveOcean, 2020). Trend analysis of information from the Spatiotemporal Data and Time Series Toolkit, previously known as "The COPEPODITE Toolkit" (NOAA NMFS, 2020) showed a significant increase in chlorophyll over the last ten years, with a high annual anomaly in 2015 corresponding to the HAB event that year (Figure S.WQ.6.2).

For nutrients, inputs to OCNMS from the Salish Sea and Columbia River are believed to be negligible compared to those from ~~the~~ upwelling (Hickey et al., 2013; McCabe et al., 2015; Trainer et al., 2017; Anderson et al., 2019). Upwelling plays an essential role in ecosystem productivity on the Olympic Coast. To describe it, three indices were selected to estimate upwelling in ~~the~~ OCNMS (48°N). The selected indices are~~include~~: (1) the Spring Transition Index (STI); (2) the Length of Upwelling Season Index (LUSI); and (3) the Total Upwelling Magnitude Index (TUMI), and they estimate timing, duration, and strength of coastal upwelling, respectively (Schwing et al., 1996). Tracking the status of these indices revealed that recent means for STI, LUSI, and TUMI are within one SD of the long-term mean, and trends for the last ten years were not changing (neutral) for all of them (Figure S.WQ.6.3 and Figure S.WQ.6.4, NOAA IEA 2020). We encourage future consideration of other newly available indices, including the Coastal Upwelling Transport Index (CUTI) and Biologically Effective Upwelling Transport Index (BEUTI; Jacox et al., 2018), and comparisons among them.

According to USGS (2020) and Oelsner et al. (2017), nitrogen and phosphorus (N&P) loads for the Columbia River probably decreased between 2002 and 2012. Previous work (USGS, 2012) modeled watersheds throughout Washington State to provide relative levels of streamflow~~,~~ and sedimentation, as well as estimates of total nitrogen and total phosphorus (Figures S.WQ.6.5), as part of the SPARROW effort, which are included here to illustrate the relative contribution of coastal river inputs to OCNMS. Additionally, upwelling and stratification (not eutrophication) are believed to be the main drivers of seasonal bottom hypoxia observed inside the sanctuary (see Question 8 for more detail).

Another potential source of nutrients include~~s~~ discharge from offshore fish processors. Typically, this discharge is limited to summer and restricted to offshore locations, and it is likely that the few boats processing fish onboard produce localized, temporary impacts (EPA, 2020). This activity is discussed in more detail in Question 2.

Commented [1]: The chlorophyll is inside phytoplankton, so a plankton bloom causes chlorophyll increase, not the other way around.

In terms of nutrient inputs from the atmosphere, the National Atmospheric Deposition Program (NADP) collects the only long-term dataset for total nitrogen concentration in deposition (1980–2018) at the Hoh River within Olympic National Park. Atmospheric deposition data show no trend in nutrient contributions from the atmosphere (McCaffery & Jenkins, 2018; NADP, 2020; Appendix Figure S.WQ.6.1).

JN Comment: While I agree with the status and trend and high confidence for each, I do think this analysis could be expanded to mention the effects of humans on climate change, for phenomena such as marine heatwaves, change ocean dynamics, including stratification. While this does not influence eutrophication per se, so I can see why it isn't here, it can influence the 'natural' uptake of nutrients, so our understanding of phytoplankton dynamics needs to take human-induced climate change effects into account.

Conclusion

In 2019, the status of eutrophic conditions in OCNMS was 'good' and the trend was 'not changing', both with high confidence. While the availability of certain datasets helped increase confidence in these ratings, there were still data and analysis gaps for OCNMS, including a lack of long-term, *in-situ* data for chlorophyll concentrations, nutrient concentrations and loads, and turbidity ~~in the OCNMS~~. Additionally, there is a need to process and analyze satellite and remotely-sensed data to develop additional relevant indicators such as for chlorophyll, N&P concentrations (NAUPLIUS Explorer, 2020), and turbidity (NASA, 2020).

Question 6 References

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Question 6 Tables

Table S.WQ.6.1. 2008 (left) and 202019 (right) status, trend and confidence ratings for the water quality questions, including question 6.

2008 Questions		2008 Rating	2020 Questions		2020 Rating			
					Status	Confidence (Status)	Trend	Confidence (Trend)
2	Eutrophic Condition	—	6	Eutrophic Condition	Good	High	—	High
3	Human Health Risks	—	7	Human Health Risks	Fair	High	—	Medium
1	Multiple Stressors (including climate)	?	8	Climate Drivers	Fair/Poor	Very High	▼	Very High
			9	Other Stressors	Good/Fair	Medium	▼	Medium

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Questions		2008 Rating	Questions		2019 Rating			
					Status	Confidence	Trend	Confidence
2	**Eutrophic Condition**	–	6	**Eutrophic Condition**	Good	High	–	High
3	**Human Health Risks**	–	7	**Human Health Risks**	Fair	High	–	Medium
1	**Multiple Stressors (including climate)**	?	8	**Climate Drivers**	F/P	Very High	▼	Very High
			9	**Other Stressors**	G/F	Medium	▼	Medium

Table S.WQ.6.2. Status and trends for individual question 4 indicators discussed at January 2020 Workshop.

Indicator	Source	Habitat	Data Summary	Figures

Phytoplankton - Chlorophyll Abundance	PNW HAB Bulletin COPEPOD Toolkit	All Habitats	Status: Phytoplankton blooms were recorded in OCNMS May, Aug. and Sept. 2019; Trend: increased in the last 10 years Parker: 2015 was a good year based on another satellite data source	S.WQ.6.2
Upwelling Indices LUSI, TUMI and STI	Jacox 2018, NOAA CCIEA	All Habitats	**Status:** recent mean (last 10 years) for LUSI, TUMI and STI are within 1 SD of the long-term mean **Trend:** LUSI, TUMI and STI are neutral	S.WQ.6.3
Bottom Dissolved Oxygen & Hypoxia	Alin et al. in preparation, OCNMS	All Habitats	Status:Hypoxic (<2 mg/L or <1.4 mL/L or <60 µmol/kg) conditions are frequently present at southern sites (Kalaloch and Cape Elizabeth) between June and Sept Trend: DO decreased in the southern sites (Kalaloch and Cape Elizabeth)	S.WQ.8.6-8; Appendix S.WQ.8.6
Nutrients (Conc. and Load) and Total Nitrogen Deposition	USGS and NADP	All Habitats	Status: data gap, nitrogen deposition exceeding critical loads for key resources (ONP); N & P loading from Columbia River is likely down; N from rivers is believed to be less significant than N from upwelling/ocean. Most N entering OCNMS from terrestrial sources is via the Salish Sea to the north and Columbia River to the south. Trend: data gap, nitrogen deposition had no trend over time(ONP)	S.WQ.6.4; Appendix S.WQ.6.1
Turbidity	ERDDAP	All Habitats	Status: annual composite maps available but analysis needed Trend: analysis gap	
Data Gaps	Long-term in-situ datasets for chlorophyll, nutrients (concentrations and loads), and turbidity.			
Analysis Gaps	Satellite images for turbidity and nutrients (N and P); comparisons of upwelling indices; examination of nutrient data collected in OCNMS during NOAA West Coast OA cruises (https://www.ncei.noaa.gov/access/ocean-carbon-data-system/oceans/Coastal/WCOA.html).			

Question 6 Figures

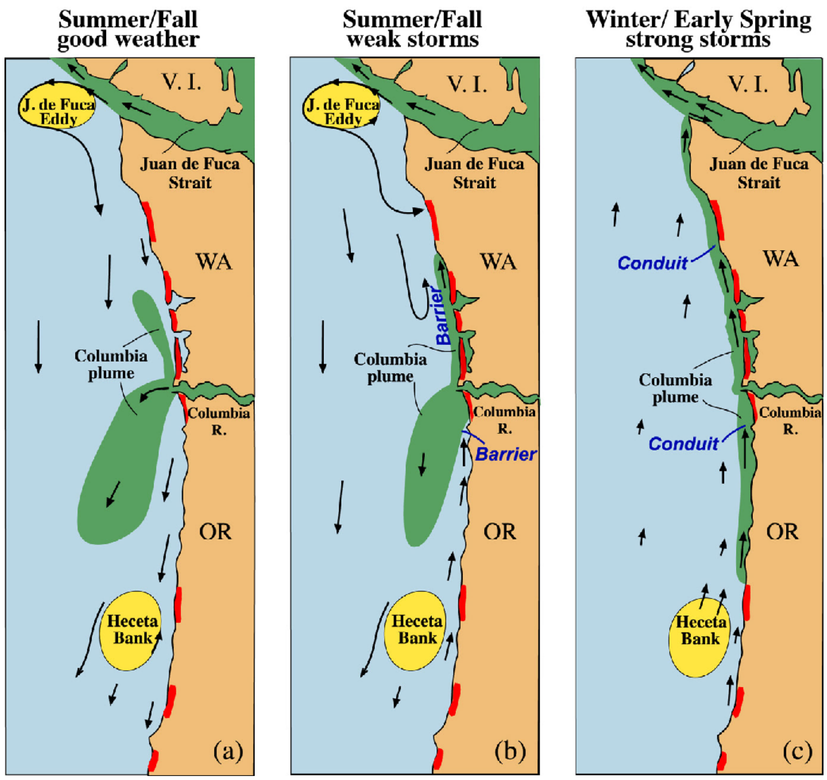

Figure S.WQ.6.1. Environmental conditions that transport toxic *Pseudo-nitzschia* (PN) southward from northern (the Juan de Fuca eddy) and southern (Heceta Bank) sources (shown in yellow) in summer/fall in the Pacific Northwest (a) under prevailing upwelling-favorable winds; (b) during a reversal to weak downwelling-favorable winds; and (c) in late winter/spring, prior to the spring transition. Surface currents are shown with arrows. Shaded areas on shore are clamming beaches. Shaded areas offshore indicate freshwater plumes from the Columbia River and the Strait of Juan de Fuca. Notations ''Barrier'' and ''Conduit'' refer to the role of the Columbia plume in transporting HABs to the Olympic Coast under different oceanographic conditions. Image: Hickey et al., 2013

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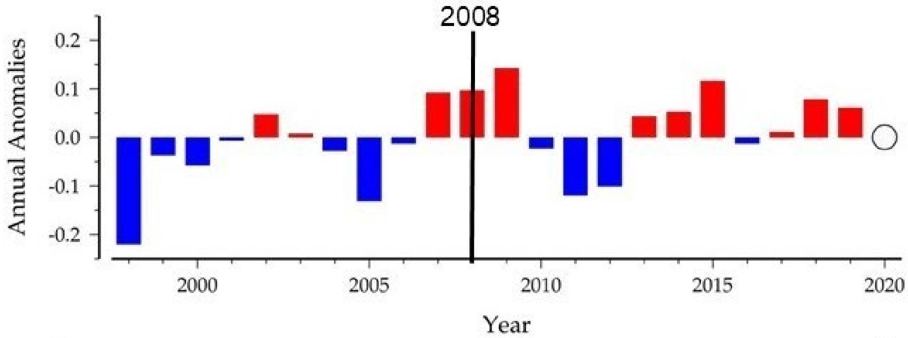

NASA-combo satellite Chlorophyll (mg/m3)																
Twin Year Range	Twin		**Annual**		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015 - 2019	TW05		(-)		(-)	(-)	-	(+)	(-)	(-)	(-)	(+)	+	(+)	(+)	nd
2010 - 2019	TW10		++		(+)	(-)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(+)	(+)
2005 - 2019	TW15		(+)		(+)	(+)	+	+++	(+)	(+)	(-)	(+)	(-)	-	(+)	(-)
2000 - 2019	TW20		+		++	(-)	++	+	++	(+)	(+)	(+)	-	--	(+)	(-)

Figure S.WQ.6.2. Annual anomalies for chlorophyll (mg/m3) log_{10}-transformed for 1998–2019. Vertical black line indicates the year of the last condition report (2008), red bars are positive anomalies, and blue bars are negative anomalies. Red box indicates the highly significant increasing trend for the year range 2010–2019, where decreases are denoted by blue with "(-)", and increases by red with "(+)". Significant changes do not have parentheses around the +/- sign. Source: NASA satellite chlorophyll data, extracted for OCNMS using Spatiotemporal Data & Time Series Toolkit NOAA/NMFS, A. Mabrouk

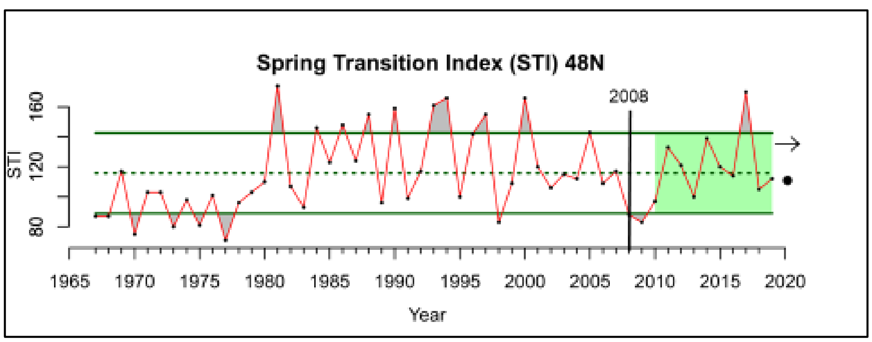

Figure S.WQ.6.3. Spring Transition Index (STI) at 48°N, recent mean (last 10 years) is within 1 SD of the long-term mean (black dot). During the last 10 years, the trend has not changed (→). Dashed green line is the long-term mean and continuous green lines are ±1 SD. Vertical black line indicates the year of the last condition report (2008). An explanation of index values (y-axis) and associated caveats are provided in Schwing et al.,1996. Image: NOAA IEA, 2020

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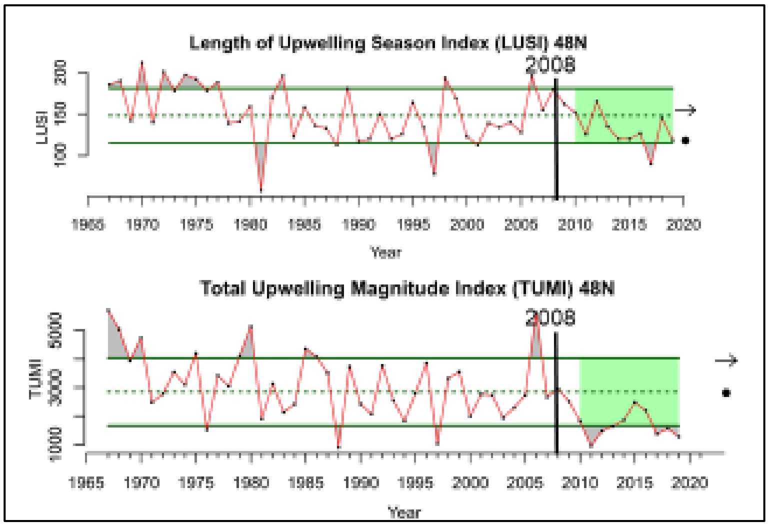

Figure S.WQ.6.4. Length of Upwelling Season Index (LUSI) and Total Upwelling Magnitude Index (TUMI) at 48°N. Recent means for the last 10 years (black dots) for both are within 1 SD of the long-term means (dashed green lines), and the trend has not changed over the last 10 years (→). Continuous green lines represent the ±1 SD.Vertical black line indicates the year of the last condition report (2008). An explanation of index values (y-axis) and associated caveats are provided in Schwing et al. 1996. Image: NOAA IEA, 2020

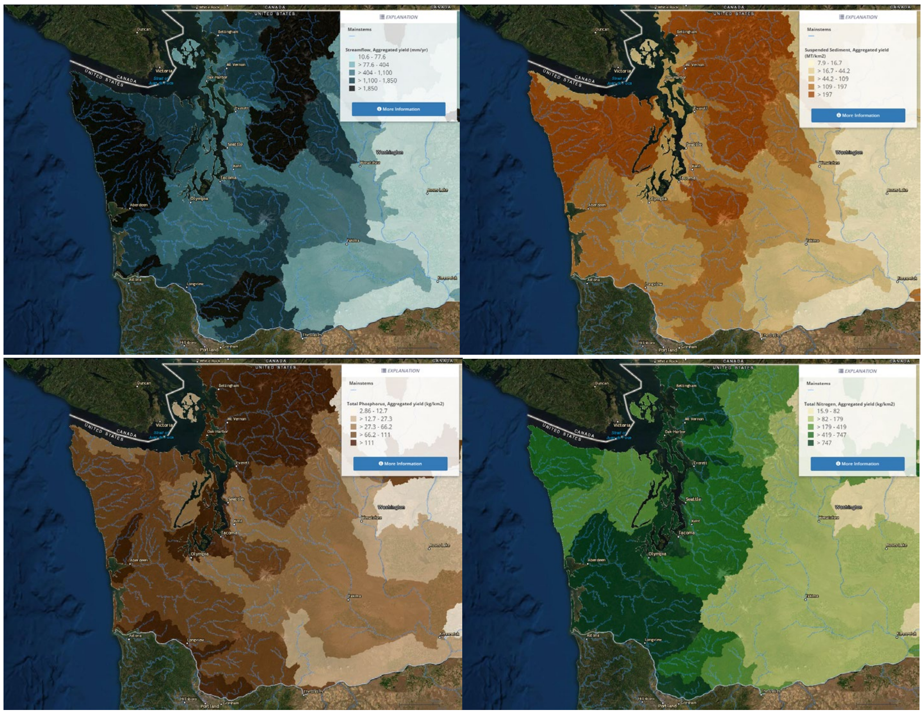

Figure S.WQ.6.5. Maps from the U.S. Geological Survey's SPARROW (SPAtially Referenced Regression On Watershed attributes) models depicting Washington watersheds and relative contributions of streamflow (upper left), suspended sediments (upper right), total phosphorus (lower left) and total nitrogen (lower right) in 2012. Data from USGS website

Question 7: Do sanctuary waters pose risks to human health and how are they changing?

Status: Fair, Confidence - High; **Trend**: Not Changing, Confidence - Medium ~~(Table S.WQ.7.1).~~
Status Description: Water quality problems have caused measurable human impacts, but effects are localized and episodic ~~and not~~rather than widespread or persistent.
Rationale: HABs occur naturally in OCNMS, and biotoxins are periodically detected in shellfish, sometimes resulting in trophic transfer of biotoxins to predators like marine mammals and seabirds. However, impacts on human health have been minimized due to effective seasonal monitoring and measures.

Definition and Description

Accounts of interactions between humans and Harmful Algal Blooms (HABs) have been passed down for centuries through Native American oral history in the Pacific Northwest (Horner et al., 1997; Shaffer et al., 2004; Dalton et al., 2016). HAB~~s~~ events are particularly noted by tribal members, due to their large economic, cultural, and health impacts (Shaffer et al., 2004; Dalton et al., 2016). For example, recollections from tribal members indicate periods of time where shellfish were not harvested and clams were tested by touching them to their lips to see if there was a burning sensation (an indication of biotoxins) to determine whether the clams were safe to consume (Shaffer et al., 2004). Today, the most concerning HABs for human health and the regional economy in this area are ~~the~~ dinoflagellates of the genus *Alexandrium* and *Dinophysis,* which cause Paralytic Shellfish Poisoning (PSP) and Diarrhetic Shellfish Poisoning (DSP), respectively, and ~~the~~ diatoms of ~~-~~the genus *Pseudo-nitzschia* (PN), which are responsible for production of domoic acid (DA) and can cause Amnesic Shellfish Poisoning (ASP). *Pseudo-nitzschia spp.* ~~*events*~~ are the most common HAB specie s on the outer Washington coast, occurring mainly in the spring and late summer (Trainer et al., 2017; Anderson et al., 2019). Impacts from ~~PSP and~~ HABs include ~~have been noted by tribal members as~~ a period of months during the year when clams are not collected or eaten by tribes (Shaffer et al., 2004); ~~or~~and when recreational and~~,~~ commercial~~, or~~ ~~subsistence~~ shellfish closures occur~~red~~ (Dalton et al., 2016).

Coordinated monitoring was established in 1999 through the Olympic Region Harmful Algal Bloom (ORHAB) program to protect the local community from the threat of various HABs on the outer Washington coast. ORHAB provides an early warning of HABs by monitoring harmful algal abundances (dinoflagellates and diatoms) and biotoxin concentrations in seawater (both onshore and offshore), from which member scientists produce the Pacific Northwest HAB Bulletin (PNW HAB Bulletin; http://www.nanoos.org/products/habs/forecasts/bulletins.php). The program is a partnership of academic (University of Washington), federal (NOAA NWFSC and NCCOS), tribal (Coastal Treaty Tribes), state (Washington DFW and DOH), and other researchers and managers, and was initially funded by NOAA. In 2016, NOAA and the University of Washington enhanced offshore HAB monitoring inside OCNMS with an advanced, remote, autonomous, near real-time HAB biosensor called the Environmental Sample Processor (ESP), which was moored 13 nautical miles offshore of La Push, adjacent to an oceanographic mooring known as Ćháʔba. Data from the ESP and the PNW HAB Bulletin are accessible through the Northwest Association of Networked~~s~~ Ocean Observing System~~s~~ (NANOOS, 2020) website at nvs.nanoos.org. In 2017, ORHAB began to regularly monitor PN abundance and particulate domoic acid (pDA) concentration in seawater along the Washington and Oregon coasts. These monitoring and analysis efforts have improved advanced forecasting of HABs and have reduced the negative health and economic impacts to communities on the Washington coast.

In the current condition report (2008–2019), the status of sanctuary waters and their threat to human health is rated as fair (with high confidence), and the trend is not changing (with medium confidence) (see Table S.WQ.6.1)~~Table S.WQ.7.1)~~. These ratings indicate that water quality problems "have caused measurable human impacts, but effects are localized and not widespread or persistent" (though a 2015 event was widespread, experts based their judgement on the lack of persistence).

~~Harmful algal blooms (~~HABs~~)~~ are known to occur naturally in OCNMS, and biotoxins (i.e., ASP, PSP, and DSP) are periodically detected in shellfish, sometimes resulting in trophic transfer ~~of biotoxins~~ to predators like marine mammals and seabirds. However, in recent years, marine heatwaves are believed to have accelerated the growth rates of HABs (McCabe et al., 2016) and contributed to the production of toxic hotspots, retentive areas of the coastal ocean

Commented [6]: Mostly it is ASP, but HABs covers it all.

Commented [7]: This is tribal, so it's included in the first list element.

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Commented [9]: We might also insert a feature text box or footnote on this topic

Commented [10]: Happy to help with that! thanks

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containing algae with high levels of the toxin domoic acid, at coastal locations to the north and south of OCNMS (Trainer et al., 2020).

Commented [12]: Not sure that this supports the concept that the 'status' is not changing. There is literature showing that MHWs will increase with time in frequency and severity.

Although threats to human health have been significantly minimized due to targeted monitoring, HAB events continue to cause disruptions and prompt fishery closures, and increasing evidence links HAB events to marine heat~~-~~waves and climate change (Trainer et al., 2020). Impacts on human health have been minimized due to effective seasonal monitoring, including real-time HAB monitoring offshore; good coordination among Washington state agencies, Coastal Treaty Tribes, and other ORHAB partners; and precautionary closures of shellfish harvesting activities in affected areas to protect public safety.

Comparison to 2008 Condition Report

In the 2008 condition report, status was “Good/Fair,” and the trend was “not changing.” HABs and biotoxins in shellfish are naturally occurring in the sanctuary and result in periodic shellfish closures. Prior to 2008, levels of biotoxins in shellfish exceeded the limits that affect human health once or twice a year on average (NOAA OCNMS, 2008). Selected conditions that have the potential to affect human health may exist, but human impacts were not reported (NOAA OCNMS, 2008). The assessment in 2008 was based mainly on the concentration of domoic acid in razor clams. In 2019, rating for the status was downgraded to fair, and the trend did not change. This rating was based on abundance of PN and DA concentration in seawater and shellfish; shellfish fishery closure days from the Washington State Department of Health; a HABs index developed to estimate closure impacts on coastal communities; and beach closures implemented by the Washington Department of Ecology as a result of high bacteria levels at swimming beaches. While increased monitoring of shellfish has largely resulted in a decrease in impacts to human health, which is the subject of this section, HABs continue to cause severe, persistent, and widespread problems on the Olympic Coast.

Commented [13]: This directly contradicts the Status Description at the top of this section. OCNMS occupies much of the Olympic Coast, so how can impacts within the sanctuary be localized while issues on the coast are severe, persistent, and widespread?

New Information in 2019 Condition Report

Experts agreed with high confidence that HABs and biotoxins in shellfish are naturally present in OCNMS. Although the status was fair with no trend, and no human health impacts were reported, HABs still pose a potential risk to human health as well as to other vertebrates that prey on contaminated shellfish. The assessment in 2019 was based on PN concentration and DA in seawater, long-term data on biotoxins (mainly DA in razor clams), closure days for shellfish fisheries, a HABs impact index, and levels of pathogenic bacteria at two swimming beaches on the Olympic Coast. Between 2007 and 2014, no closures from DA occurred in OCNMS or on the outer Washington coast (Trainer et al., 2017). However, in 2015–2016, a devastating fishery closure occurred due to the presence of high DA in razor clams and Dungeness crabs. These two species are highly important, both economically and culturally, for the coastal treaty tribes and adjacent coastal communities.

Commented [14]: While true, perhaps modify to "no acute human health impacts". I have heard from others that low-level chronic impacts may occur, but this is difficult to know. DOH had a statement on that that I heard before. It might be good to express that somewhere...

Pseudo-nitzschia

There are ~~were~~ no time-series data for the abundance of *Pseudo-nitzschia* (PN) and its toxin domoic acid (DA) in seawater covering the entire assessment period. Although beach sampling for PN between 2017 and 2019 shows low cell abundance, thresholds were exceeded, mainly in spring and fall, at Hobuck Beach and beaches adjacent to La Push (threshold values that trigger additional testing for DA: 50,000 cells/L for large PN; 1,000,000 cells/L for small PN; NANOOS/PNW HAB Bulletin, 2020; Figure S.WQ.7.1). Additionally, offshore sampling shows a high PN abundance at Hobuck in the years 2017, 2018, and 2019 (Appendix Figure S.WQ.7.1).

Biotoxins

Beach sampling for ~~domoic acid (~~DA~~)~~ concentration in seawater samples from OCNMS revealed levels that were low, and mostly below the toxic threshold of 200 ng per liter of seawater (NANOOS/PNW HAB Bulletin, 2020). However, offshore sampling shows high DA concentration near La Push and Hobuck Beach in fall 2017 and 2019, respectively (NANOOS/PNW HAB Bulletin, 2020; Appendix Figure S.WQ.7.2).

Razor clams and Dungeness crab are important fisheries species on the Washington outer coast, and biotoxins in animal tissues are closely monitored to prevent impacts to human health. In razor clams, DA concentrations detected from tissue samples were low at Kalaloch and Mocrocks beaches, and did not exceed the concern limit of 20 ppm for the years 2008–2014 and 2019. However, DA increased dramatically in 2015 due to the major HAB event that prompted devastating closures in 2015–2016. Additionally, DA concentrations exceeded concern limits in 2017 and 2018, causing short term closures at both beaches (Figures S.WQ.7.2 and S.WQ7.3; Washington Department of Fish and Wildlife, 2019). Trend analysis for maximum DA in razor clams did not change for Mocrocks between 2008 and 2018, although it increased for the Washington coast (Figures S.WQ.7.4 and S.WQ7.5; NOAA IEA, 2020). Similar results were found for DA concentrations in Dungeness crab; levels exceeded the concern limit (30 ppm) only during 2015 in samples collected between Toleak Point and Ocean Shores (Washington Department of Fish and Wildlife, 2019).

Shellfish Harvest

The devastating shellfish harvest closure in 2015 extended into 2016 due to ~~the~~ high concentrations of DA, which can cause ASP, detected in tissues of shellfish. However, the total number of harvest closures decreased from 14 recorded between 1991 and 2007 to six closures between 2008 and 2019 (A. Coyne, personal communication, January 16, 2020). These six closures occurred between 2015 and 2018 and were restricted to southern beaches (i.e., Kalaloch, Mocrocks, and Quinault) of OCNMS (Figure S.WQ.7.6). Closures due to PSP risk increased from nine recorded during the period from 1991 to 2007 to 14 closures during the period from 2008 to 2019, with the latter mainly affecting northern shorelines between Makah Bay and Ruby Beach. Additionally, five out of six closures due to DSP were also documented at the more northern beaches, but to a lesser extent (Figure S.WQ.7.6).

Commented [15]: Do you mean the closures spanned a shorter timeframe, covered a smaller geographic range, or both? Otherwise, I'm not sure what is meant by a "lesser extent."

Commented [16]: Yes, as written sounds like a closure to a lesser extent.... ??

To better understand the impact of HABs on coastal communities, a HAB index developed by Moore et al., 2016 was used to compare OCNMS to the rest of the U.S. West Coast. This HAB index identifies and attempts to quantify lost fishing opportunities (number of days the fisheries are closed) due to HABs. Higher index values indicate longer fisheries closures during the season. The HAB index for La Push, the only fisheries community in the OCNMS that was included in their study, was very low compared to the rest of the West Coast. However, the fishery offshore of this community was closed longer in 2015, and again in 2016, than in any other year since 2005 (Figure S.WQ.7.7).

Beach Advisories/Closures

Only two of the five beaches sampled on the outer Washington coast are adjacent to OCNMS (i.e., Hobuck and Tsoo-Yess beaches). Both beaches are in the far north, on the Makah Reservation, and are very popular for swimming and surfing in the summer. Tsoo-Yess beach did not meet Washington state swimming criteria in 2018 and was closed three times that year

(Figure S.WQ.7.8), based on action concentrations of fecal bacteria (*Enterococcus*; (>104 enterococci/100 ml) sampled by state, local, and tribal scientists. Data were acquired and assessed from the State of Washington Department of Ecology, WA Beach Program and Coastal Atlas tool (Washington Department of Ecology, 2020a, 2020b). For more detailed graphs of bacteria concentrations at these two beaches, see Appendix Figure S.WQ.7.3&4.

Conclusion

In 2019, the status of sanctuary waters and their threat to human health was fair (with high confidence), and the trend was not changing (with medium confidence). While the availability of certain datasets helped increase confidence in these ratings, many data and analysis gaps remain. Among them are data for critical indicators like contaminants (e.g., metals, persistent organic pollutants) in marine organisms in OCNMS, and time series for PN and DA in seawater. Analysis gaps include evaluating biotoxins other than DA in shellfish. Beach advisory/closure data are currently limited to two sites near the northern boundary of OCNMS. Consequently, additional data about beach advisories/closures would also improve the sanctuary's ability to understand conditions and trends. Table S.WQ.7.12 summarizes data gaps that would be beneficial to fill for the next condition report.

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Question 7 Tables

~~**Table S.WQ.7.1.** 2008 (left) and 2019 (right) status, trend and confidence ratings for the water quality questions, including question 7.~~

Questions		2008 Rating	Questions		2019 Rating			
					Status	Confidence	Trend	Confidence
2	Eutrophic Condition	–	6	Eutrophic Condition	Good	High	–	High
3	Human Health Risks	–	7	Human Health Risks	Fair	High	–	Medium
1	Multiple Stressors (including climate)	?	8	Climate Drivers	F/P	Very High	▼	Very High
			9	Other Stressors	G/F	Medium	▼	Medium

Table S.WQ.7.12. Status and trends for individual question 7 indicators discussed at January 2020

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Workshop.

Indicator	Source	Habitat	Data Summary	Figures
Pseudo-nitzschia (abundance in seawater)	PNW HAB Bulletin	All Habitats	**Status:** Exceeded the threshold mainly in spring and fall at Hobuck and La Push beaches between 2017 and 2019. **Trend:** No time-series data	S.WQ.7.1; Appendix S.WQ.7.1
Biotoxins (Domoic Acid in seawater Razor Clams)	WDFW, Moore et al 2016, and NOAA IEA	All Habitats	**Status:** Beach sampling shows low pDA in seawater between 2017 and 2019, while offshore sampling of Neah Bay (Hobuck) exceeded the threshold in fall 2019. Low domoic acid concentration in razor clams in 2019 at Kalaloch Beach and Mocrocks Beach. **Trend:** the maximum DA in razor clams did not change between 2008 and 2018, although it was increasing for the Washington coast. **Analysis gaps:** pDA in seawater and evaluating other biotoxins than DA in different shellfish.	S.WQ.7.2-5; Appendix S.WQ.7.2
Shellfish Harvest (closure days) & HABs Index	Washington Department of Health and Moore et al 2016	All Habitats	**Status:** There was no closure due to DA (which causes ASP) from 2007 to 2014. However, there was a devastating closure in 2015 extending into 2016. **Trend:** ASP closures decreased from 14 closures recorded between 1991 and 2007 to six closures between 2008 and 2019 at the southern beaches. PSP closures increased from 9 recorded between 1991 and 2007 to 14 closures between 2008 and 2019 at the northern beaches. Additionally, six DSP closures were also documented at these beaches, but to a lesser extent. HAB index increased at La Push 2015 and 2016	S.WQ.7.6; S.WQ.7.7
Beach advisories/ Closures	WA State Department of Ecology	Sandy Beach	**Status:** only two beaches are sampled (Hobuck and Tsoo-Yess), Tsoo-Yess didn't meet the swimming criteria in 2018 (data gap: this would be more informative if more beaches were monitored) **Trend:** limited data	S.WQ.7.8; Appendix S.WQ.7.3-4
Legacy Contaminant levels in shellfish*	NOAA Mussel watch	Rocky Shores	**Status:** DDT and PCBs levels are low in OCNMS shellfish Cape Flattery 2010 **Trend:** DDT and PCBs levels are decreasing in shellfish for the west coast **Data gaps:** No updates	S.H.11.2
Contaminant levels in pelagic fish*	EPA, WA DOE	Pelagic	**Status:** NA, PCBs have been measured above thresholds but no recent study (McBride et al. 2005) for the west coast **Trend:** NA **Data gaps:** No updates	S.H.11.1
Atmospheric Pollution (Sulfur)*	ONP	All Habitats	**Status:** above the EPA criteria for Sulfur **Trend:** increasing in Sulfur in precipitation	
Data Gaps	Time series of PN abundance in seawater; WA DoE sampling of water quality at Olympic Coast sites to ensure beaches are safe for swimming or closures/advisories can be issued; updates for contaminants data.			
Analysis Gaps	pDA in seawater and evaluating other biotoxins than DA in different shellfish.			

Question 7 Figures

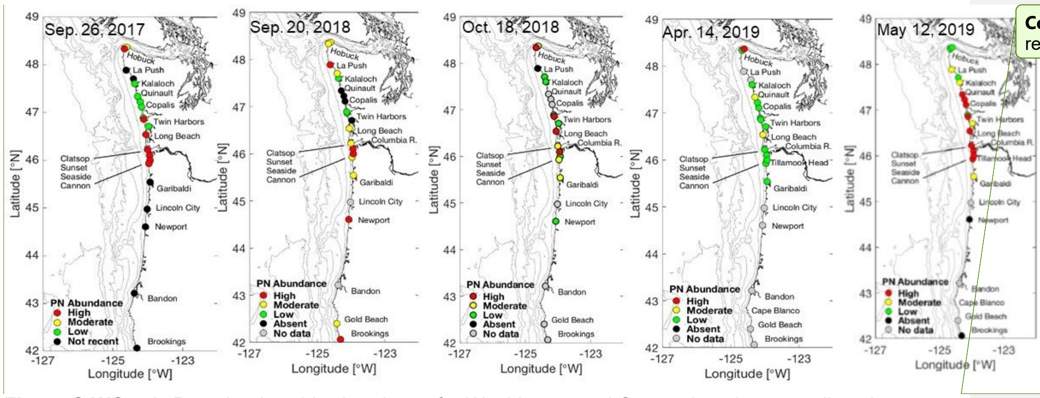

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Figure S.WQ.7.1. *Pseudo-nitzschia* abundance for Washington and Oregon beaches sampling sites. Red=high: high:; > threshold value for either cell morphology; Yellow=moderate: > 1/3 threshold; Green=low: < 1/3 threshold; Gray= no data; Black= No sampling. Graph compiled from Pacific Northwest Harmful Algal Blooms Bulletins, 2017–2019. http://www.nanoos.org/products/habs/forecasts/bulletins.php

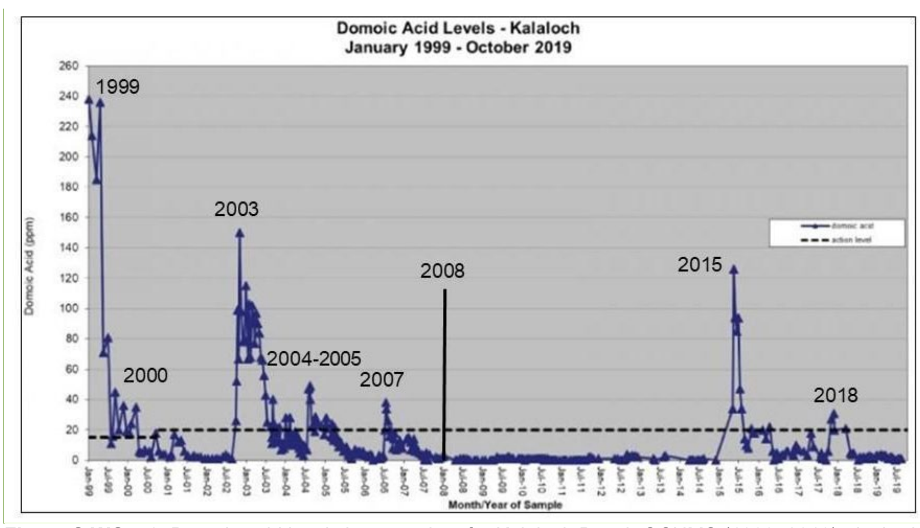

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Figure S.WQ.7.2. Domoic acid levels in razor clam for Kalaloch Beach OCNMS (1999–2019), dashed line shows domoic acid threshold (20 ppm), WDFW. Vertical black line indicates the year of last condition report (2008). Data Credit: Washington Department of Health. Image: Washington Department of Fish and Wildlife, 2019

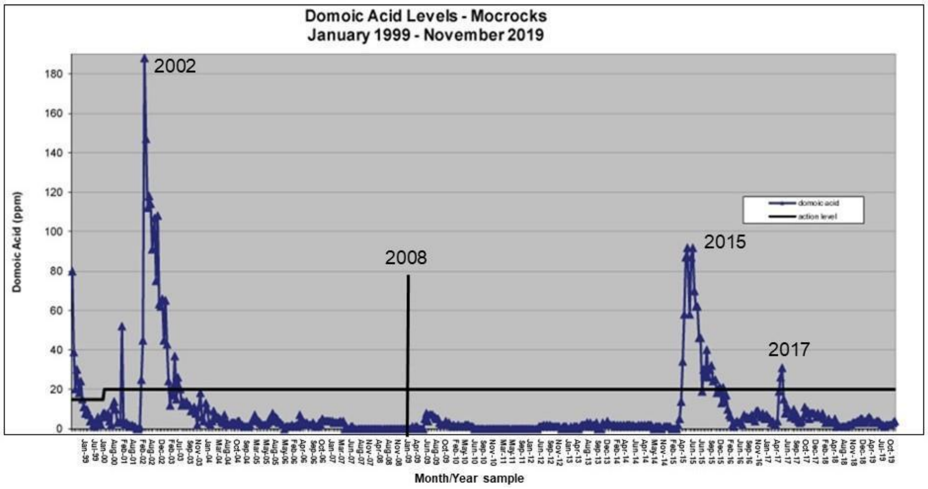

Figure S.WQ.7.3. Domoic acid levels in razor clam for Mocrocks Beach OCNMS (1999–2019), dashed line shows domoic acid threshold (20 ppm), WDFW. Vertical black line indicates the year of last condition report (2008). Image: Washington Department of Fish and Wildlife, 2019; Source: Washington Department of Health

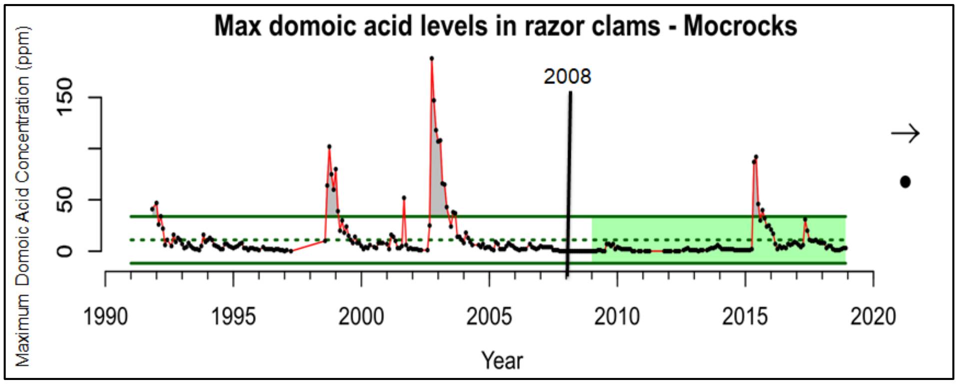

Figure S.WQ.7.4. Maximum domoic acid levels in ~~R~~razor ~~C~~clam for Mocrocks Beach OCNMS (1991–2019),vertical black line indicates the year of last condition report (2008). Recent mean (last 10 years, black dot) is within 1 SD of the long-term mean (green dashed line) and the last 10 years trend is not changing (→). Solid green lines are ±1 SD. Image: NOAA IEA, 2020

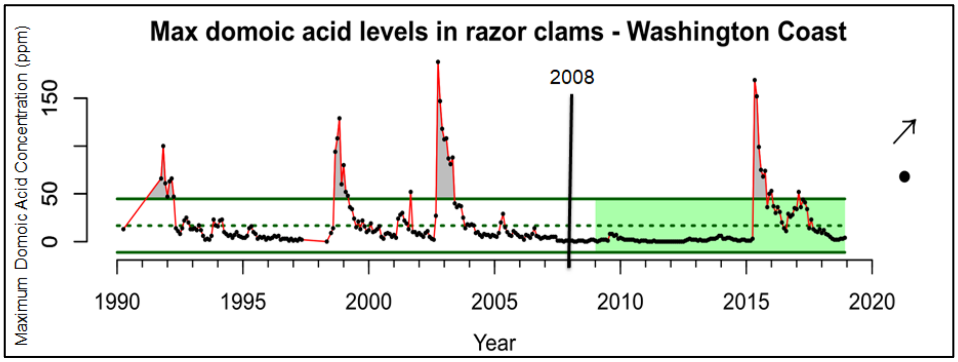

Figure S.WQ.7.5. Maximum domoic acid levels in ~~R~~razor ~~C~~clam for Washington Coast (1991-2019), Vertical black line indicates the year of last condition report (2008). Recent mean (last 10 years, black dot) is within 1 SD of the long-term mean (green dashed line), and the last 10 years trend is increasing (↑). Solid green lines are ±1 SD. Image: NOAA IEA, 2020

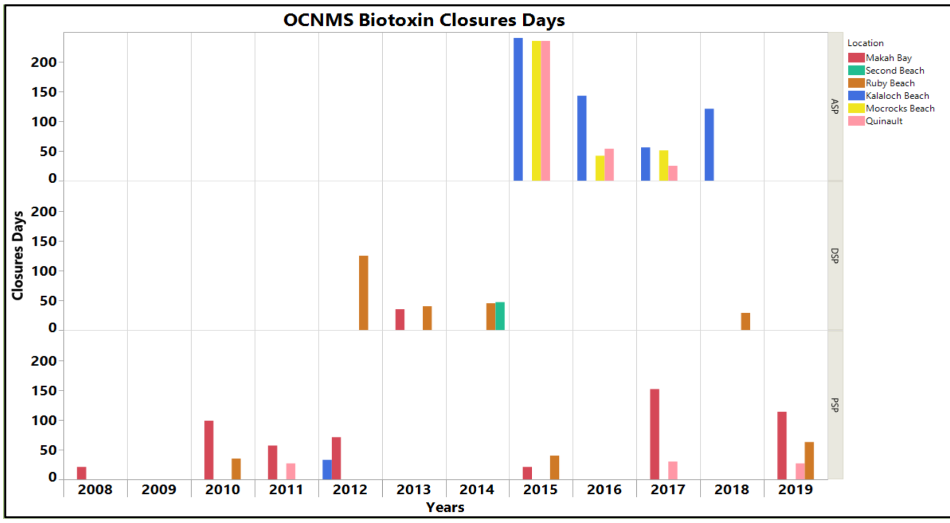

Figure S.WQ.7.6. Shellfish harvest closure days at OCNMS beaches due to risks of amnesic shellfish poisoning (ASP; top panel), diarrhetic shellfish poisoning (DSP; middle panel), and paralytic shellfish poisoning (PSP; bottom). Data Credit: Washington State Department of Health 2020. Image: A. Mabrouk/NOAA NCCOS

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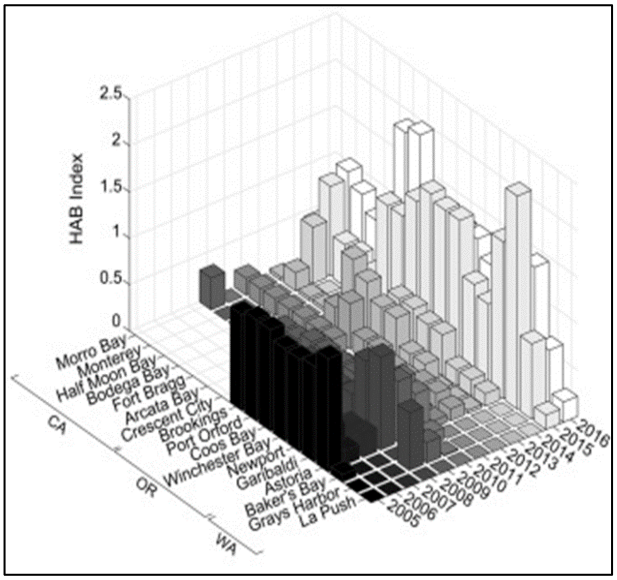

Figure S.WQ.7.7. HAB index (lost fishing opportunities due to HABs) for the 17 fishing communities from 2005 through 2016 for the West Coast, with La Push the only fishing community inside the OCNMS. Image: Moore et al., 2016

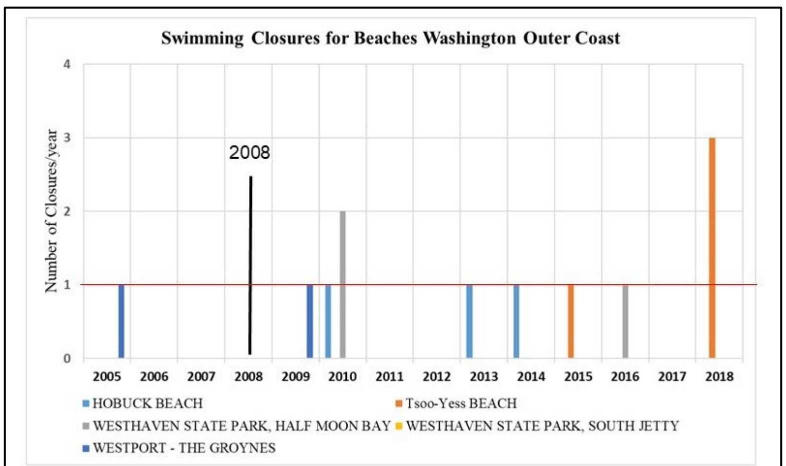

Figure S.WQ.7.8. Number of swimming closures for outer Washington coast beaches (2005-2018); only Hobuck and Tsoo-Yess Beaches are adjacent to OCNMS. ~~Westhaven and~~ Westport location~~s~~ is ~~are~~ approximately 15 miles south of the OCNMS boundary. Horizontal line shows the state swimming criteria (>1 closure/year). Vertical black line indicates the year of the last condition report (2008). Source: Washington Department of Ecology, 2020a; Image: A. Mabrouk/NOAA NCCOS

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Question 8: Have recent, accelerated changes in climate altered water conditions, and how are they changing?

Status: Fair/Poor, Confidence - High; **Trend**: Worsening, Confidence - High ~~(Table S.WQ.8.1).~~
Status Description: Climate-related changes have caused severe degradation in some but not all attributes of ecological integrity.
Rationale: Since 2008, concerning climate-related changes have been documented for several critical ocean indicators, including dissolved oxygen, aragonite ~~under~~saturation, pH ~~changes~~, and marine heatwaves, all of which ~~can~~ produce detrimental effects on ecosystems.

Definition and Description

OCNMS~~Olympic Coast National Marine Sanctuary~~ is located within~~part of~~ the northern California Current Ecosystem (CCE). It is a highly productive coastal ecosystem fueled by seasonal upwelling of cold, nutrient-rich water. This seasonal productivity supports the ~~many~~ marine ~~organisms in the~~ food web, starting from phytoplankton and zooplankton then building to large fishes, marine mammals, and seabirds (NOAA NMFS, 2017). ~~.~~The CCE has experienced exceptional climate variability that has affected OCNMS over the last ten years, including an unprecedented North Pacific marine heatwave between 2014 and 2016, coupled with a robust La Niña event in 2015–2016 that provided a flux of cool coastal waters and intense storms in the winter of 2016–2017. However, this strong El Niño event declined by the end of 2018, and the flux of cold, nutrient-rich subarctic water from the North Pacific Gyre also decreased to its lowest ever, causing below-average productivity in OCNMS and the CCE in general (Harvey et al., 2019).

Observations and impacts of climate change and/or changes in water conditions made by Coastal Treaty Tribe members on the Olympic Coast have been documented and provide extensive detail on the effects and the importance of these changes on economic, cultural, and subsistence resources (Shaffer et al., 2004; Dalton et al., 2016; Shannon et al., 2016). For example, climate change impacts like coastal erosion from increased wave action, increased riverine sediment loads, increased water temperature, and ocean acidification have multi-faceted impacts to coastal wildlife due to the connectivity and fluidity of the marine environment. The Olympic Coast comprises crucial habitats that harbor species of great cultural and economic importance. However, climatological disturbances to these ecosystems can result in habitat loss and degradation, and declines in abundance or redistribution of marine species important to tribal communities (Dalton et al., 2016, Shannon et al., 2016, Anderson et al., 2019).

It is, therefore, essential to study and assess climate and ocean indicators, regional upwelling indicators, and water chemistry indicators that play a critical role in characterizing ecosystem productivity and ecological integrity along the Olympic Coast. In 2019, the status of climate-altered water conditions was judged to be fair/poor, with a worsening trend in OCNMS, both with high confidence (see Table S.WQ.6.1)~~Table S.WQ.8.1~~). These ratings indicate that climate-related changes have caused severe degradation in some, but not all, attributes of ecological integrity. Since 2008, concerning climate-related changes have been documented for several critical ocean indicators, such as dissolved oxygen, aragonite saturation, pH ~~changes~~, and marine heatwaves. Independently, each of these changes can cause detrimental impacts to the marine ecosystem, and when operating together, they may produce additive or synergistic impacts.

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Commented [24]: Perhaps this is meant to say something like, "A subsequent ..." Otherwise, the jump from talking about La Niña to the El Niño phase is not quite clear.

Commented [25]: Something is wrong here....the blob coincided with an El Nino event. This needs attention.

Commented [26]: the 2015-2016 event was el nino not la nina, and you have it correct on Q8

Commented [27]: Also, doesn't mention the second MHW

Commented [28]: This could be a place to briefly state that if species important to tribes move out of established gathering areas, they could become inaccessible to tribal members.

Comparison to 2008 Condition Report

This question is new and was not assessed in the 2008 condition report. However, the topic of climate change was included in the response to Question 1 at that time: “Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?” and the question was rated “Good/Fair" with an undetermined trend (NOAA OCNMS, 2008). The 2008 report presented limited data on oceanographic indicators related to climate change, mostly related to hypoxic events (low dissolved oxygen) in the sanctuary. In the current report, experts assessed the impact of climate change on water quality and the ecological integrity of OCNMS since 2008. The status and trend ratings in the current report were “Fair/Poor" and ‘worsening’ respectively, based on robust evidence and high agreement among experts. This~~se current~~ rating is based on oceanographic indicators related to climate change; all have the ability to compromise productivity and food web dynamics within the ecosystem, and often work synergistically to exacerbate impacts. Indicators we pursued to illustrate recent developments include: basin-scale indices, upwelling indices, water/air temperatures, dissolved oxygen/hypoxia, $p\mathrm{CO_2}$, aragonite saturation, and pH.

New Information in 2019 Condition Report

There was high agreement among experts that changes in climate have accelerated changes in water conditions and caused severe degradation in some attributes of ecological integrity. The assessment was based mainly on robust evidence available for key climate change indicators: climate and basin-scale indices, upwelling indices, sea surface temperature (SST), air temperatures, hypoxia, and ocean acidification indicators ($p\mathrm{CO_2}$, aragonite saturation, and pH). Although data availability for climate change indicators has increased, analysis gaps remain for many key indicators. Existing data streams, including those from OCNMS moorings and several other regional oceanographic monitoring assets, could be used to provide more sophisticated synthesis information on climate-related variables.

Climate and Basin-Scale Indices

Three large-scale climate ~~basin~~ indices that affect productivity in ~~the~~ OCNMS were used to portray large-scale variability in the region. These indices were~~include~~: (1) the Pacific Decadal Oscillation (PDO); (2) the North Pacific Gyre Oscillation (NPGO); and (3) the equatorial El Niño–Southern Oscillation (ENSO), as described by the Oceanic Niño Index (ONI). Positive PDO and ONI values and negative NPGO values usually indicate conditions that lead to low CCE productivity. In contrast, negative ONI and PDO values and positive NPGO values are associated with periods of high CCE productivity (Harvey et al., 2019). Since 2008, assessments of the status of the three indices (PDO, ONI, and NPGO) revealed that recent means were within one standard deviation (SD) of long-term means. The trend for the same period shows that PDO and ONI were increasing while NPGO decreased, resulting in reduced productivity overall (NOAA IEA 2020, Figures S.WQ.8.1, S.WQ.8.2, and S.WQ.8.3).

Upwelling Indices

The status and trends of upwelling indices and their role in sanctuary productivity are ~~were~~ discussed in question 6 (NOAA IEA, 2020; Figure S.WQ.6.3 and Figure S.WQ.6.4).

Sea Surface Temperature ~~(SST)~~ and Marine Heatwaves

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Commented [31]: "basin" could be confusing to people...

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Commented [33]: Somewhere in this section it would benefit the reader if you defined a heat wave. How many SDs above the mean does the average SST have to be, and for how long, to be a heatwave?

Commented [34]: Yes, agree. This is published and Hobday et al. 2016 ref can be found at www.marineheatwaves.org

From In 2014–2016, the California Current Ecosystem (CCE) experienced an unprecedented marine heatwave (MHW), known as "the Blob." This event, which caused rapid and abundant positive sea surface temperature (SST) anomalies, began in early 2014 and persisted through mid-2016 (Figure S.WQ.8.4). It was coupled with the 2015–2016 El Niño event (Gentemann et al., 2017; Jacox et al., 2019), combining to create the largest marine heatwave detected since NOAA satellites started keeping track in 1981 (NOAA NMFS, 2020). Marine heatwave effects on the CCE were widespread, causing severe impacts on marine life (Holbrook, 2019). Warmer water associated with the event also contributed to an unprecedented harmful algal bloom on the U.S. West Coast in 2015 (McCabe et al., 2016). This HAB event increased domoic acid toxins in shellfish, closing fisheries for Dungeness crab and razor clams from 2015 to 2016, and poisoning seabirds and marine mammals (McKibben et al., 2017; Trainer et al., 2017; Anderson et al., 2019).

The Blob also caused many ecological changes in the CCE. Notably, the fish assemblage shifted to include species usually found farther south (e.g., skipjack tuna), and a massive number of subtropical and tropical colonial tunicates called 'pyrosomes' clogged nets in Oregon and Washington for months. Krill and forage fish abundance also declined. Humpback whale feeding locations shifted from offshore (krill) to closer inshore (anchovy), resulting in more whale entanglements in crab potstraps (NOAA, 2020). Due to these severe impacts, oceanographers from NOAA's Southwest Fisheries Science Center (SWFSC) developed the MHW tracker, an experimental tool to study and predict marine heatwaves expected to affect the West Coast (NOAA NMFS, 2020). Since then, another smaller and shorter-lived MHW developed offshore of the U.S. West Coast in the summer of 2019 but had declined by January of 2020 (Figure S.WQ.8.4). This MHW lasted for 239 days and officially became the second largest MHW in the northern Pacific Ocean since 1982 (L'Heureux, 2019).

To better understand SST, the Spatiotemporal Data and Time Series Toolkit, previously known as "The COPEPODITE Toolkit," was used to assess the status and trend of the SST anomalies withinof the OCNMS using satellite image data (COPEPODITE, 2020). These data showed that the recent (2009–2019) mean for SST anomalies was within one SD of the long-term mean (1979–2019) for this data set, but that the recent trend was significantly increasing. Annual average anomalies (Figure S.WQ.8.5) show the rapid positive increase of positive SST anomalies that persisted from 2014 to 2016 due to the Blob, the decline in 2017, and a second MHW in 2019. Seasonal variation graphs for SST and air temperature data from the National Data Buoy Center (NDBC) for Neah Bay, Destruction Island, and Cape Elizabeth, were retrieved from the NANOOS website (NANOOS, 2020) and included. However, more effort is needed to acquire, process, and analyze the data to compare with the results from satellite images. For more detail on the NDBC SST and air temperature data for these sites, see Appendix Figures S.WQ.8.1-5.

Dissolved Oxygen (DO) and Hypoxia

Historically (1950–1986), hypoxia (oxygen concentration <2 mg/L or <1.4 mL/L or <60 µmol/kg) has been reported in the northern portion of the California Current System over the summer upwelling season, particularly on the Washington shelf, and can negatively affect habitat and cause stress, or even mortality, in sensitive species (Connolly et al., 2010; Siedlecki et al., 2015; Harvey et al., 2019). Recently, hypoxic events were documented in 2017 and 2018 with the latter being more severe and spatially extensive on the Washington continental shelf during late June (Figure S.WQ.8.6). Hypoxic events in both years caused widespread die-offs of crabs and other benthic invertebrates, and redistribution of groundfish (Harvey et al., 2019).

Commented [35]: ??? what does this mean?

Commented [36]: correct. it is incorrectly stated as a la nina in Q7

Commented [37]: Called pots rather than traps in prior sections (3a and 3b).

Commented [38]: Yes, this should be mentioned in first paragraph at start of section.

Commented [39]: Again, if MHWs beget HABs, and MHWs are increasing, should HAB status be not changing?

Commented [40]: Odd wording, you aren't negatively affecting the habitat (water); you are negatively affecting the organism... Maybe say "and can cause stress, or even mortality in sensitive species, making less available suitable habitat.

Data from the sanctuary's long-term coastal oceanographic mooring array, which has been deployed at 10 locations seasonally for more than two decades (Figure S.WQ.8.7), provide a closer look at how ocean chemistry is changing in nearshore areas over time. For example, bottom dissolved oxygen data from 2019 (Figure S.WQ.8.8) can be used to represent current status in . The 2019 data show that hypoxia was detected at southern sites (i.e., Kalaloch and Cape Elizabeth) for most of summer 2019, and that dissolved oxygen continued to decrease over the summer. In reviewing bottom oxygen conditions over the period of 2006-2017, Alin et al (in prep) used calculated values from OCNMS moorings to identify a similar north-- south gradient, contrasting conditions at the northern sites near Makah Bay and Cape Alava, which largely remained above the hypoxia threshold, with conditions at southern sites like Kalaloch and Cape Elizabeth, where hypoxia is often more persistent and pronounced (Figure S.WQ.8.9). These results are calculated from OCNMS mooring data to document a north-south gradient in bottom oxygen concentration that shows seasonal progression and greater frequency of hypoxic conditions at the southern mooring locations.

Commented [41]: Status in what? Part of the sentence is missing.

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Ocean Acidification

Ocean acidification (OA), resulting from the absorption of anthropogenic carbon dioxide (CO_2) from the atmosphere into the ocean, reduces pH and carbonate ion levels in seawater, increasing acidity, and decreasing calcium carbonate saturation states. Aragonite saturation is considered a key indicator of OA that reflects the availability of carbonate ions in seawater available for synthesizing aragonite shells and skeletons. Aragonite is a more soluble form of calcium carbonate than calcite, and thus, conditions become corrosive to aragonite sooner than to calcite with increasing CO_2. CCE species including oysters, crabs, and pteropods have shells and carapaces containing calcium carbonate and are, thus, vulnerable to decreasing saturation states (and increasing corrosivity to calcium carbonate) in the CCE (Flee et al., 2008; Barton et al., 2012; Bednaršek et al., 2014; Feely et al., 2016, 2017; Marshall et al., 2017; Hodgson et al., 2018).

To evaluate ocean acidification, we used the analysis of OCNMS benthic mooring data by Alin et al. (in prep). Three main OA indicators were evaluated for the period from 2006 to 2017:, including (1) partial pressure of carbon dioxide (pCO_2; Figure S.WQ.8.10), (2) aragonite saturation state (Ω_{arag}; Figure S.WQ.8.11), and (3) pH from 2006 to 2017 (Figure S.WQ.8.12). Values were calculated based on *in-situ* oxygen, temperature, and salinity data from OCNMS moorings (27–42 m depth). Analysis revealed a north-south gradient and seasonal progression to higher pCO_2 (and lower Ω_{arag} and pH values), and a greater frequency of high pCO_2, low Ω_{arag} and pH conditions affecting southern sites (Alin et al., in prep). Aragonite saturation values show a greater frequency of corrosive conditions (aragonite saturation <1) in the south, with data from the 42-m Cape Elizabeth mooring indicating nearly continuous aragonite undersaturation during the May to October time frame, when moorings are deployed. Average values for pH fell between 7.5 and 7.7 across moorings (Alin et al., in prep). Preliminary analysis of pCO_2 data from a NANOOS-UW mooring near La Push and a specially instrumented NDBC mooring at Cape Elizabeth shows that air pCO_2 is increasing year after year. S, though seawater pCO_2 does not appear to be increasing; however, a longer time-series would be needed to detect the anthropogenic carbon signal in surface waters with the greater natural variability in surface pCO_2 based on moored time-series (Alin et al., 2020; Sutton et al., 2019). BHowever, based on observations from NOAA's West Coast Ocean Acidification (WCOA) cruises from XXXX through 2013, seawater from 0 to 110 m over the northern CCE shelf has accumulated an average of 43–60 µmol/kg of anthropogenic carbon dioxide since the pre-industrial era, which is enough to increase pCO_2 and decrease pH and aragonite saturation states substantially (Feely et al., 2016; Alin et al., in prep.).

Conclusion

In 2019, the status of climate-altered water conditions was fair/poor, and the trend was worsening in OCNMS, both with high confidence. While the availability of monitoring data helped increase confidence in these ratings, there were still data and analysis gaps identified. Specifically, sea surface temperature and air temperature datasets from the National Data Buoy Center (NDBC) need additional trend analysis. Datasets for pCO_2 and pH from the Pacific Marine Environmental Laboratory for La Push and Cape Elizabeth NDBC buoys need to incorporate new data and additional analyses. Additionally, $p$$CO_2$, aragonite saturation, pH, and O_2 datasets for OCNMS moorings need trend analysis. Data describing thermoclines and pycnoclines, especially from the NANOOS Cha'ba buoy and NEMO profiling mooring, also exist, but additional analysis is needed to estimate and track changes to these indicators over time. Table S.WQ.8.1~~2~~ summarizes data gaps that would be beneficial to fill for the next condition report.

Question 8 References

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Question 8 Tables

Table S.WQ.8.1. 2008 (left) and 2019 (right) status, trend and confidence ratings for the water quality questions, including question 8.

Questions		2008 Rating	Questions		2019 Rating			
					Status	Confidence	Trend	Confidence
2	Eutrophic Condition	–	6	Eutrophic Condition	Good	High	–	High
3	Human Health Risks	–	7	Human Health Risks	Fair	High	–	Medium
1	Multiple Stressors (including climate)	?	8	Climate Drivers	F/P	Very High	▼	Very High
			9	Other Stressors	G/F	Medium	▼	Medium

Table S.WQ.8.1. Status and trends for individual question 8 indicators discussed at January 2020 Workshop.

Indicator	Source	Habitat	Data Summary	Figures
Climate & Basin-Scale Indices	NOAA IEA/ CCIEA	All Habitats	**Status:** recent (last 10 years) means for PDO, NPGO, and ONI were within 1 SD of the long-term mean **Trend:** PDO increase, NPGO decrease, and ONI increase	S.WQ.8.1-3
Upwelling Indices LUSI, TUMI and STI	Jacox 2018, NOAA IEA/ CCIEA	All Habitats	**Status:** recent mean (last 10 years) for LUSI, TUMI, and STI are within 1 SD of the long-term mean **Trend:** LUSI, TUMI, and STI are neutral	S.WQ.6.3-4
Water Temperature	COPEPOD NANOOS Ian Miller	All Habitats	**Status:** needs more analysis; multiple anomalously warm years occur within the assessment period **Trend:** SST data show repeated elevated temperature anomalies during the assessment period	S.WQ.8.4-5; Appendix S.WQ.8.1-2
Air Temperature	NANOOS	All Habitats	**Status:** needs more analysis for coastal sites; for inland stations many of the warmest years are in the assessment period **Trend:** need more data analysis	Appendix S.WQ.8.3-5
Salinity	COPEPOD PMEL/NOAA	All Habitats	**Status:** very few buoys collecting these data - outputs from COPEPOD are suspect and conflict with data from OCNMS buoys; other sources of data exist but not yet analyzed **Trend:** need analysis	
Dissolved Oxygen & Hypoxia (benthic)	OCNMS Buoys Alin et al. in prep.	All Habitats	**Status:** frequent hypoxic conditions at southern sites (Kalaloch and Cape Elizabeth) for most of the summer (Jul.—Sep.) **Trend:** seasonal hypoxia tends to be more pronounced and persistent at southern sites (Kalaloch and Cape Elizabeth)	S.WQ.8.6-8; Appendix S.WQ.8.6
pCO_2 (benthic)	Alin et al. in prep, Sutton et al, 2019.	All Habitats	**Status:** north-south gradient and seasonal progression to higher pCO_2 values at southern OCNMS benthic mooring sites (sensors at 42 m) **Trend:** need analysis	S.WQ.8.9
Aragonite saturation (benthic)	Alin et al. in prep.	All Habitats	**Status:** north-south gradient with greater frequency and severity of corrosive conditions at southern OCNMS benthic mooring sites **Trend:** increasing frequency of corrosive conditions at 42 m depths	S.WQ.8.10
pH (benthic)	Alin et al. in prep. ONP	All Habitats	**Status:** north-south gradient with lower values toward southern sites. **Trend:** increasing frequency of low pH conditions at 42 m depths	S.WQ.8.11

Wind/Wave	Ian Miller ONP	All Habitats	**Status:** need analysis **Trend:** non-significant decrease in wind speed and no sig. difference in wave height and power	
Thermocline depth	NANOOS & Columbia Plume, Palacios et al. 2004, OCNMS Moorings	All Habitats	**Status:** NANOOS data needs analysis, historic multi-decadal shift in regional thermocline depth from 1950 to 1993 (Palacios et al. 2004). **Trend:** NANOOS data needs analysis, No consistent trend 1998-2014 assessment (Andrews et al. 2015). Analysis gap for 2015-2019.	
Pycnocline depth	NANOOS & Columbia Plume, OCNMS Moorings	All Habitats	**Status:** NANOOS data needs analysis. **Trend:** NANOOS data needs analysis, No consistent trend 1998-2014 assessment (Andrews et al. 2015). Analysis gap for 2015-2019.	
Data Gaps	additional information: decline in shell thickness, change in size of salmon, fish washing up on beaches/fish kills, southern sanctuary area has seen severe degradation of ecological integrity over last 10 yrs, northern area may be less impacted (referencing N-S gradient of some indicators)			
Analysis Gaps	Water temperature from OCNMS moorings, air temperature, salinity, pCO_2, wind/wave, thermocline depth, and pycnocline depth.			

Question 8 Figures

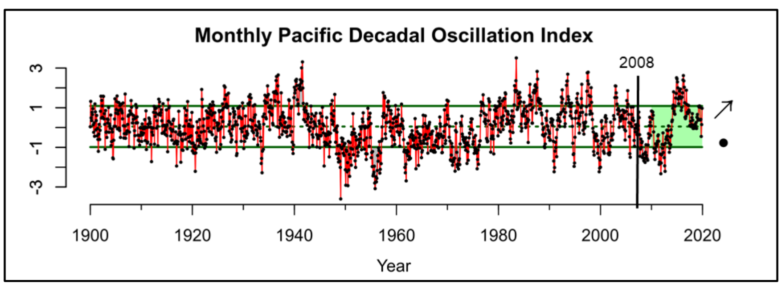


Figure S.WQ.8.1. Monthly Pacific Decadal Oscillation Index (PDO). The PDO describes sea surface temperature anomalies in the Northeast Pacific. Positive PDO values are associated with warmer waters and lower productivity, while negative PDO values indicate cooler waters and higher productivity. Vertical black line indicates the year of last condition report (2008). Recent mean (last 10 years) is within 1SD of the long term mean (black dot) and the last 10 years trend is increasing (↑). Dashed green line is the long term mean and solid green lines are ±1SD. Image: NOAA CCIEA, 2020

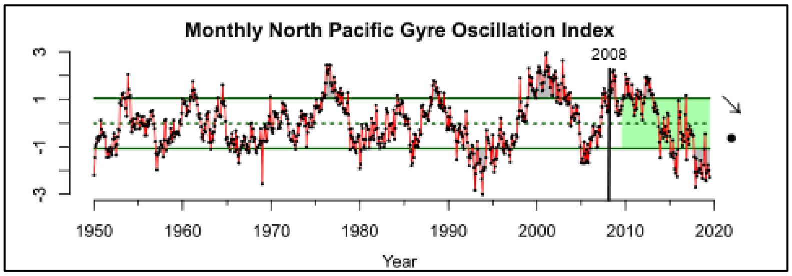


Figure S.WQ.8.2. Monthly North Pacific Gyre Oscillation Index (NPGO). NPGO indicates sea surface height, signaling changes in ocean circulation that affect source waters. Positive NPGO values are associated with increased equatorward flow and higher surface salinities, nutrients, and chlorophyll and higher productivity. Negative values are associated with less productive conditions. Recent mean (last 10 years) is within 1SD of the long term mean (black dot) and the last 10 years trend is decreasing (↓). Dashed green line is the long term mean and solid green lines are ±1SD. Image: NOAA CCIEA, 2020

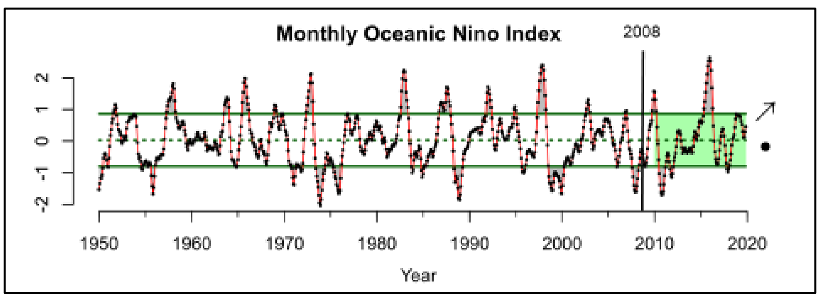


Figure S.WQ.8.3. Monthly Oceanic Nino Index (ONI). The ONI describes equatorial conditions related to the El Nino Southern Oscillation; a positive value reflects El Nino conditions with generally lower primary productivity, weaker upwelling, poleward transport of equatorial waters and species, and more storms in the southern portion of the California Current. A negative value indicates La Nina conditions, with generally higher productivity. Recent mean (last 10 years) is within 1SD of the long term mean (black dot) and the last 10 years trend is increasing (↑). Dashed green line is the long term mean and solid green lines are ±1SD. Image: NOAA CCIEA, 2020

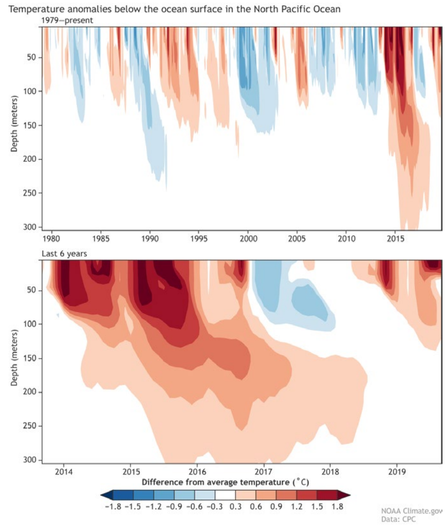
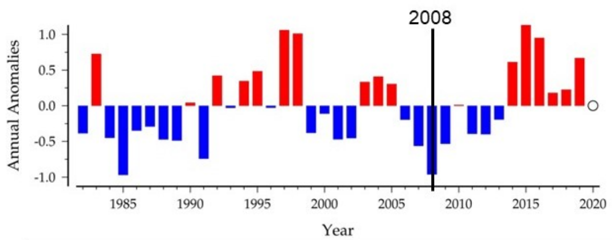


Figure S.WQ.8.4. Subsurface temperature anomalies averaged in the North Pacific Ocean (150°W-130°W, 40°N-50°N). Data from 1980 to present using an ensemble of ocean reanalysis from various agencies. Data Credit: NOAA Climate Prediction Center (CPC). Image: L'Heureux, 2019; C. Wen/NOAA CPC



Status: Recent (last 10 years) mean within 1 SD of the long term mean
Trend: For the Last 10 years is significantly increasing

Reynolds OI-SST-v2 Temperature (C)

Twin Year Range	Twin		Annual		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015 - 2019	TW05		--		(-)	--	--	(-)	+	(-)	(-)	(+)	(-)	-	-	-
2010 - 2019	TW10		+++		(+)	(+)	(+)	(+)	++	(+)	(+)	(+)	(+)	(-)	(+)	(+)
2005 - 2019	TW15		+++		(+)	(+)	(+)	(+)	++	(+)	(+)	+	++	(+)	(+)	(+)
2000 - 2019	TW20		+++		(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	+	+	(+)

Annual SST Anomalies (Reynolds OI-SST-v2) and Trends for OCNMS 1979-2018, NOAA/NMFS/COPEPOD Time Series Toolkit

Figure S.WQ.8.5. Annual SST Anomalies (Reynolds Optimum Interpolation SST-v2) and Trends analysis for OCNMS 1979-2018. Red box defines the highly significant increase trend for the year range 2010-2019; decrease is indicated by blue and ”(-)”; increase is indicated by red and “=(+)”;   significant decrease by “-” and significant increase by “+”. Image: COPEPODITE, 2020

Commented [45]: Again, what does the open dot tot eh right of the bar chart indicate? Lack of sampling?

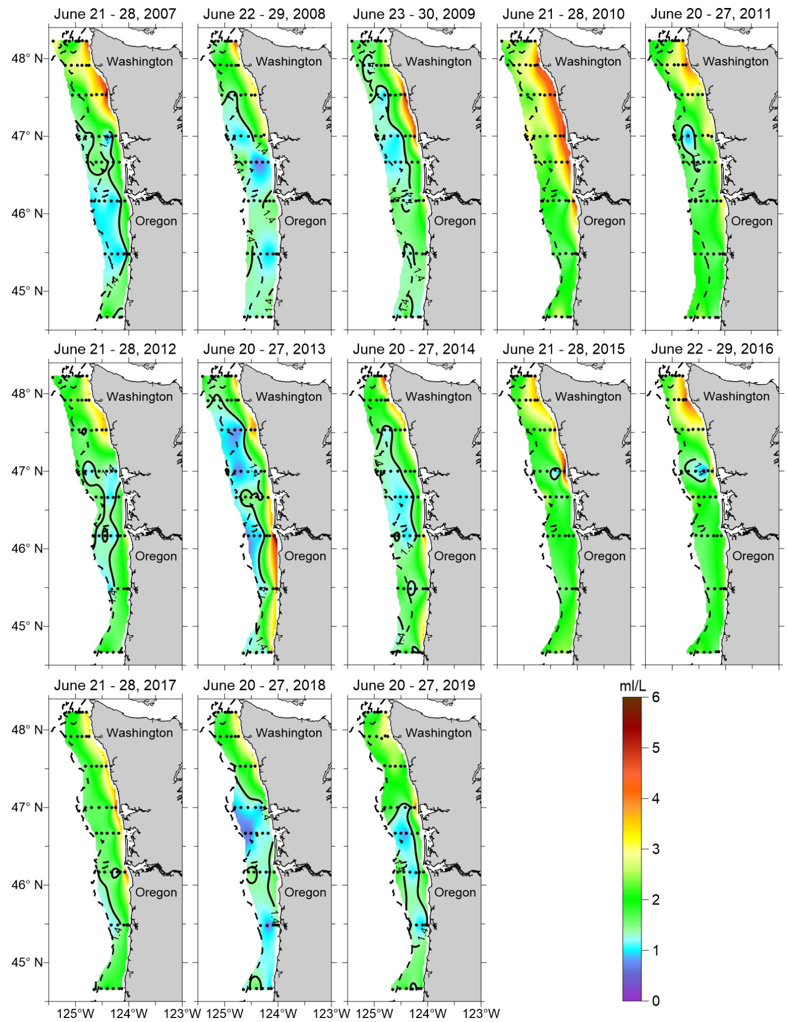


Figure S.WQ.8.6. Dissolved oxygen maps. Distribution of the minimum dissolved oxygen values (ml/L) during June from 2007 to present. A level of <1.4 ml/L (<2 mg/L) dissolved oxygen is generally used to identify hypoxic waters (outlined with bold contour line). Image: NOAA

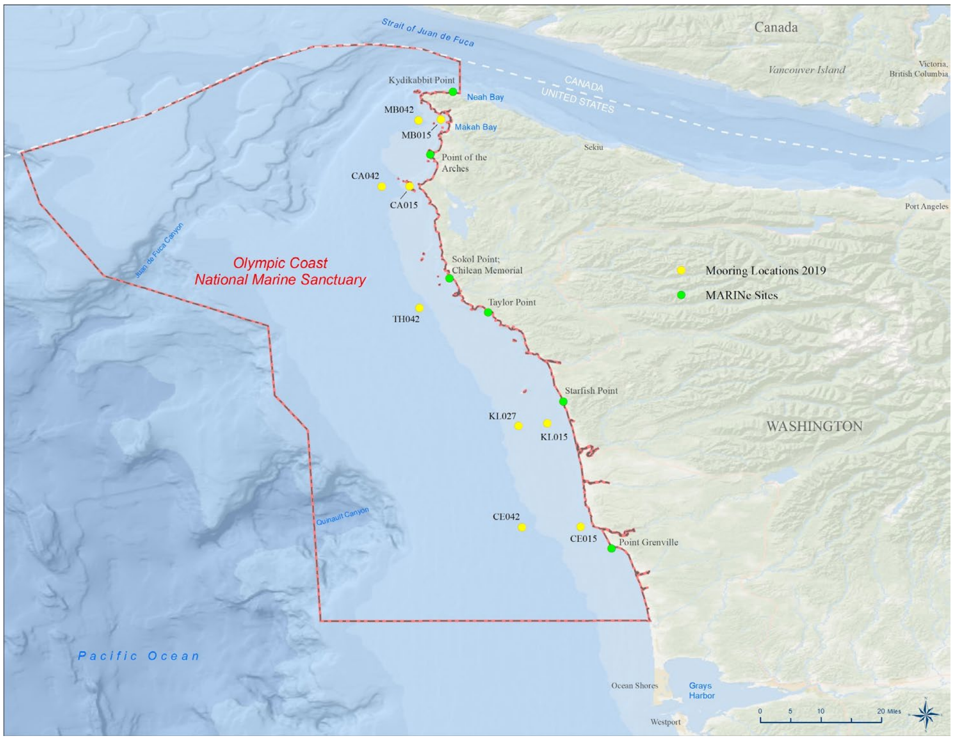


Figure S.WQ.8.7. OCNMS' ten long term coastal oceanographic mooring locations are deployed seasonally and are shown in yellow. Six long term intertidal sites on the Olympic Coast are monitored annually and are shown in green. Map: NOAA ONMS.

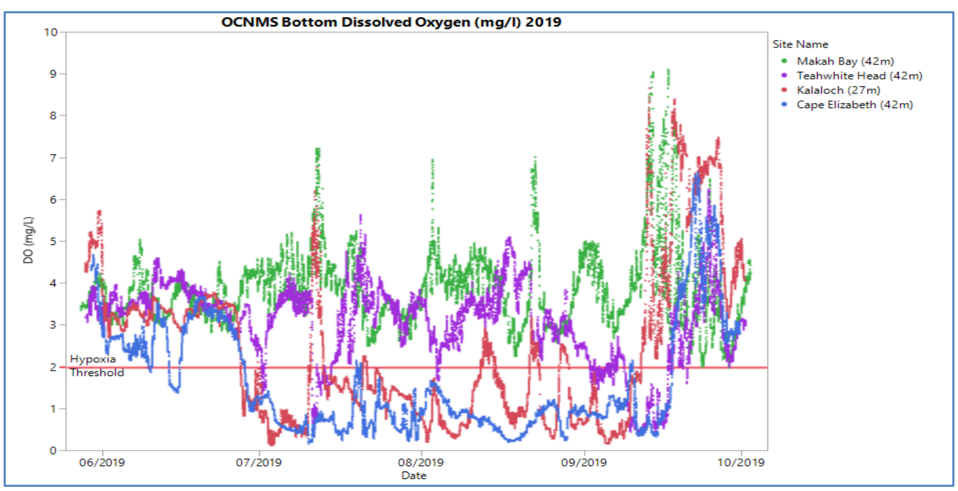


Figure S.WQ.8.8. OCNMS summer bottom dissolved oxygen in 2019 at four OCNMS mooring locations. These four locations span approximately 135 miles of coastline between Makah Bay in the North and Cape Elizabeth in the south. Horizontal line represents the hypoxia threshold (DO <2 mg/L or <1.4 ml/L). Data: NOAA OCNMS; Image: A. Mabrouk/NOAA

Commented [46]: OCNMS data; update for colorblind, correct spelling of Teahwhit Head

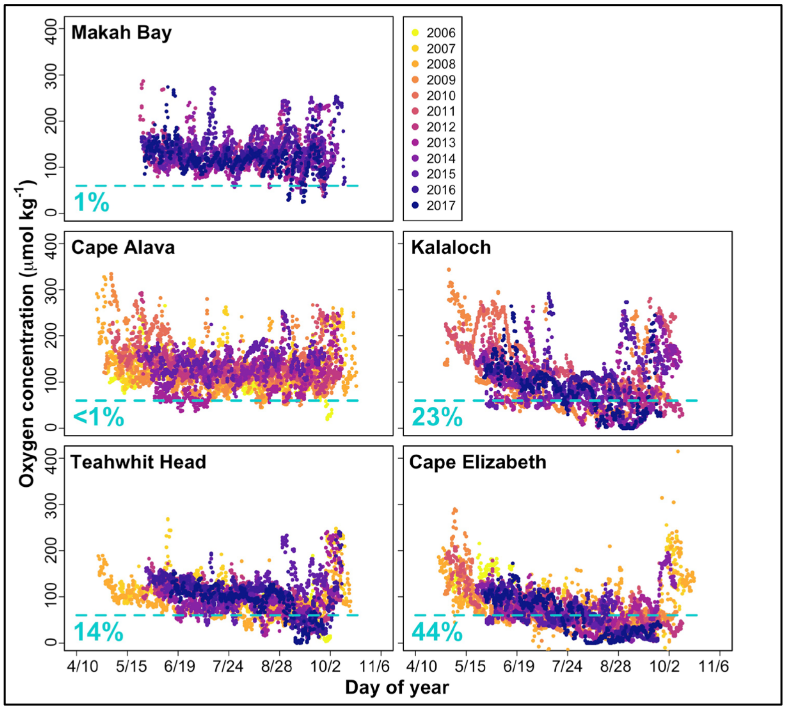


Figure S.WQ.8.9 Seasonal variability for near-bottom dissolved oxygen at locations spanning the Olympic Coast from Makah Bay in the north to Cape Elizabeth in the south (2006–2017). Results indicate a north-south gradient and seasonal progression of hypoxia, with greater frequency of hypoxic conditions at southern sites. Percentages estimate the proportion of the upwelling season when conditions are below the threshold for hypoxia. Calculated values and visualization: Alin et al., in prep.

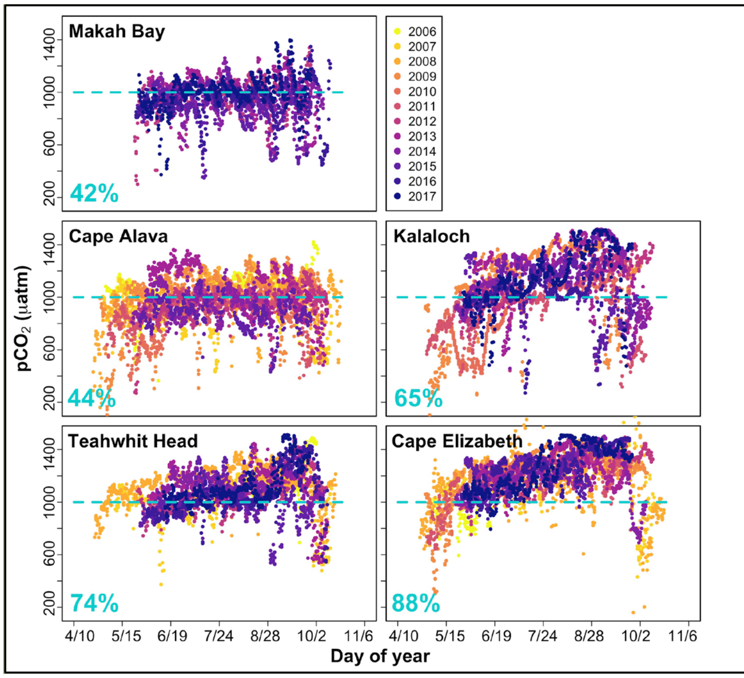


Figure S.WQ.8.10.Seasonal variability for pCO2 at locations spanning the Olympic Coast from Makah Bay in the north to Cape Elizabeth in the south (2006–2017) indicating a north-south gradient and seasonal progression. Calculated values and visualization: Alin et al., in prep

Commented [47]: Simone to remove references to hypercapnia, % and threshold

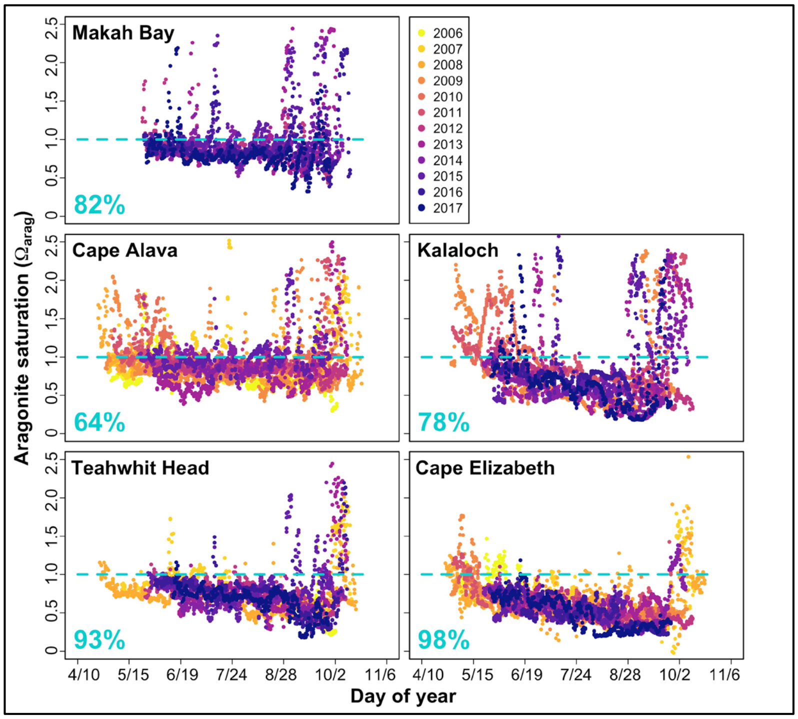


Figure S.WQ.8.11.Seasonal variability for aragonite saturation at locations spanning the Olympic Coast from Makah Bay in the north to Cape Elizabeth in the south (2006–2017). The dotted lines represent the saturation threshold, with values below 1 being undersaturated or "corrosive"; percentages indicate portion of the mooring record where values fell below the Aragonite saturation threshold. Calculated values and visualization: Alin et al., in prep

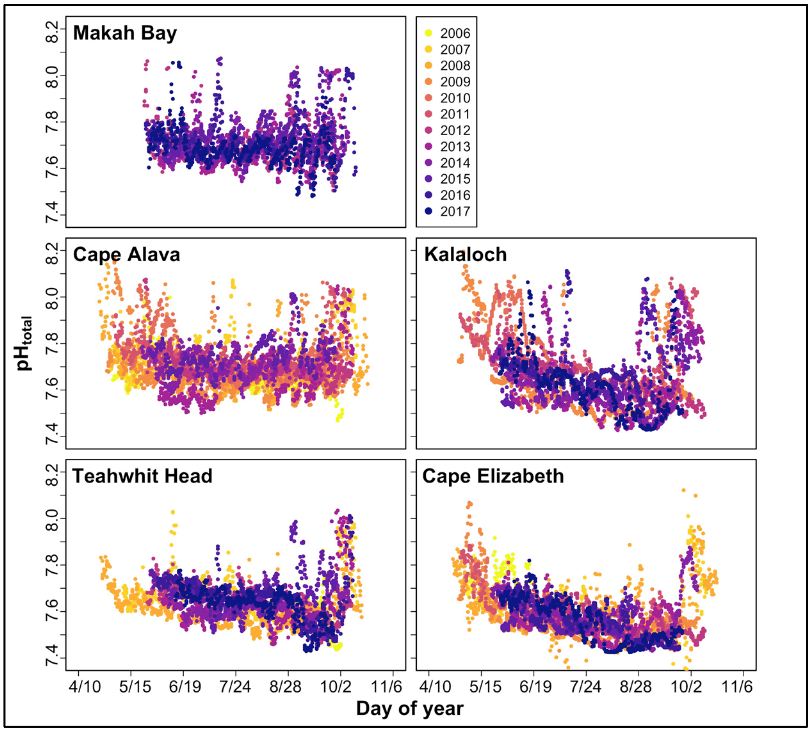


Figure S.WQ.8.12. Seasonal variability for pH values, reported on the total scale, at locations spanning the Olympic Coast from Makah Bay in the north to Cape Elizabeth in the south (2006–2017), and average pH at each site. Calculated values and visualization: Alin et al., in prep

Question 9: Are other stressors, individually or in combination, affecting water quality, and how are they changing?

Status: Good/Fair, Confidence - Medium; **Trend**: Worsening, Confidence - Medium ~~(Table S.WQ.9.1).~~

Status Description: Selected stressors are suspected and may degrade some attributes of ecological integrity, but have not yet caused measurable degradation.

Rationale: Limited data are available on the presence of persistent organic pollutants in forage fish and gray whales, and ubiquitous presence of microplastics in shellfish along the adjacent Oregon coast, but monitoring studies are lacking for OCNMS waters. The worsening trend determination was based on global trends in increasing ocean stressors.

Commented [48]: This is hard to tackle...b/c multiple stressors is very different than other stressors and you have not considered multiple stressors above with T, oxy, OA, HAB etc...
I think multiple stressors should have its own question. And other stressors should have its own question.

Commented [49]: This is hard for the reader to understand....The status description needs to define what other stressors were considered. "Selected stressors" only confused me and I think this should define what other stressors were considered. Selected can mean that you were selective, and maybe you should have considered more...

Commented [50]: ??

Commented [51]: "We considered Persistent organic pollutants, microplastics, and pharmaceuticals and found ... We did not consider...."

Comparison to 2008 Condition Report

In the 2008 condition report, “other stressors” were included in the question “Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality and how are they changing?” This combined question about multiple stressors received a "good" rating, with an "undetermined" trend. The basis for judgement was hypoxic conditions that were described as potentially increasing in frequency and spatial extent in nearshore waters. The current report considers climatic drivers of water quality and other stressors separately, in Questions 8 and 9 respectively; thus, hypoxia, and ocean acidification are addressed in Question 8 (see Table S.WQ.6.1).

Commented [52]: again, a conflated question

Commented [53]: Yes, but separately, not as multiple stressors, which is what the organism experiences. Next time, I would really argue for a multiple stressor (Its own line of research) and then an "other stressor" bin.

New Information in 2019 Condition Report

In addressing this question we considered contaminants, microplastics, and pharmaceuticals as important indicators of other stressors in the sanctuary. Limited data and no long-~~-~~term monitoring studies were identified, but experts considered the low number of potential sources adjacent to the sanctuary and the low frequency of reports related to these problems, and judged OCNMS water quality to be good/fair.

Commented [54]: Were there any findings related to the compounding effects of other stressors, e.g., heavier precipitation increasing the discharge of pollutants from runoff or storm surge exposing buried contaminants through shoreline erosion?

Commented [55]: I think this is an important consideration too.

A 2014 study investigated persistent organic pollutants (POPs) in forage fish and prey species of rhinoceros auklets on Protection Island, Tatoosh Island, and Destruction Island breeding colonies (Good et al., 2014). ~~-~~Protection Island is in the eastern Strait of Juan de Fuca (Puget Sound), 70 nautical miles from the sanctuary boundary, and Tatoosh and Destruction Islands are within the sanctuary. ~~-~~Overall patterns showed fish from the outer coast ~~Puget Sound~~ were 2–4 times less ~~more~~ contaminated compared to fish from Puget Sound, but ~~and~~ had similar contaminant profiles ~~compared to fish from the outer coast~~. H~~Unexpectedly h~~igh polychlorinated biphenyls (PCB) and polybrominated diphenyl ethers (PBDE) concentrations in Chinook salmon from the outer coast likely reflected Columbia River conditions (Good et al., 2014).

Commented [56]: The subject should be the outer coast, then compare to PS

A 2018 study investigated POPs in eastern North Pacific gray whale ~~(*Eschrichtius robustus*)~~ blubber from samples collected in 2003, 2010–2012, and 2015–2017 and found that mean concentrations were lower on average than previously reported levels for grays whales and some other baleen whales (Hayes, 2018). PCBs had the highest concentration, followed by dichlorodiphenyltrichloroethanes (DDTs), chlordanes (CHLDs), and hexachlorocyclohexanes (HCHs). However, the POP contaminant concentrations detected were all below the health effects threshold of PCBs in aquatic mammals (Hayes, 2018).

Commented [57]: Scientific names tend not to be used elsewhere. Choose one approach and use it consistently.

Commented [58]: I totally agree for consistency, but wonder if the species names should be used elsewhere, instead of deleted here?

Mercury (Hg) concentrations were studied in harbor seals ~~(*Phoca vitulina*)~~ in British Columbia and Puget Sound between 2003 and 2010. While samples were not collected within OCNMS, one site was at Point Renfrew, B.C., just north of the sanctuary. Harbor seal pups at Port Renfrew had significantly higher concentrations of mercury compared to sites sampled inside Puget Sound, the Strait of Georgia, and other sites along Vancouver Island. The authors found this surprising and surmised that perhaps the high upwelling in the region may contribute to increase methylmercury concentrations at the bottom of the food chain, which then biomagnified up the food chain into the seals and passeds via placenta and milk to the pups (Noel et al., 2015).

Microplastics are an ecological stressor of emerging some concern, with implications for ecosystem and human health when present in seafood (refs...what are the implications?). -They are found in nearly every environment on Earth (Thompson et al., 2004). Plastic debris in the marine environment contains organic contaminants, some added during manufacturing, and some absorbed from surrounding seawater (Teuten et al., 2009). A recent study quantified microplastic types, concentrations, anatomical burdens, geographic distribution, and temporal differences in Pacific oysters ~~(*Crassostrea gigas*)~~ and Pacific razor clams ~~(*Siliqua patula*)~~ from 15 Oregon coast sites. Microplastics were present in organisms from all sites and in 244 of 245 samples. The study notes that the degree to which microplastics pose a threat to coastal marine ecology or bivalve predators (including humans) is still unclear (Baechler et al., 2019).

Commented [59]: which is why I asked about support for your first sentence statement of "implications". At least give a reference there that discusses this.

Over the last 15 years, increasing attention has been paid to understanding the presence and impacts of pharmaceuticals entering or detected in freshwater ecosystems. By contrast, significantly less attention has been paid to understanding releases of pharmaceuticals from sewage and other routes into coastal environments and their potential marine impacts (Gaw et al., 2014). Pharmaceuticals are present and may be affecting marine species in Puget Sound (Meador et al., 2016). No studies or data were found specific to the outer coast of Washington.

Conclusion

Commented [60]: this is well written. the leading parts could use revision with this clarity.

Persistent organic pollutants, microplastics, and pharmaceuticals are likely present in the sanctuary. While these may degrade some attributes of ecological integrity, little information is available. What information was identified led to a rating of Good/Fair, with a worsening trend. This was based on the presence of persistent organic pollutants in prey fish of rhinoceros auklets, and the widespread presence of microplastics in Pacific oysters ~~(*Crassostrea gigas*)~~ and Pacific razor clams ~~(*Siliqua patula*)~~ along the Oregon Coast. While pharmaceuticals were reviewed, no relevant studies were identified, so they were not considered in the final rating. Limited monitoring for all of the mentioned contaminants in the sanctuary is a significant data gap.

Question 9 References

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~~Question 9 Tables~~

~~**Table S.WQ.9.1**. 2008 (left) and 2019 (right) status, trend and confidence ratings for the water quality questions, including question 9.~~

Questions		2008 Rating	Questions		2019 Rating			
					Status	Confidence	Trend	Confidence
2	Eutrophic Condition	–	6	Eutrophic Condition	Good	High	–	High
3	Human Health Risks	–	7	Human Health Risks	Fair	High	–	Medium
1	Multiple Stressors (including climate)	?	8	Climate Drivers	F/P	Very High	▼	Very High
			9	Other Stressors	G/F	Medium	▼	Medium

This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

State of Sanctuary Resources

Table of Contents

Question 10: What is the integrity of major habitat types and how are they changing?

Question 11: What are contaminant concentrations in sanctuary habitats and how are they changing?

Habitat (Questions 10–11)

Habitats within the sanctuary extend from the intertidal to the depths of its submarine canyons, and range along a large proportion of Washington's outer Pacific Coast. Information on these habitats comes from multiple sources, including long-term monitoring programs, discrete mapping surveys, and focused ecosystem research. The following sections provide an assessment of the status and trends of key habitat indicators in OCNMS for the period from 2009–2019.

Question 10 focuses on the integrity of major habitats within the sanctuary, including biologically (biogenic) and abiotically (physical) structured habitats. Physical habitats are abiotic structures, while biogenic habitats are composed of species that form structures used by other living marine resources. Biogenic habitats are layered on top of, and are often associated with, specific physical habitat types. Changes to both biotic and abiotic habitat can significantly alter the diversity of living marine resources and ecosystem services.

Question 11 examines concentrations and variability of contaminants in major sanctuary habitats. Like the other condition report questions, the status and trend ratings represent assessments by subject matter experts given readily available habitat data.

Question 10: What is the integrity of major habitat types and how are they changing?

Status: Good/Fair, Confidence - Low; **Trend**: Not Changing, Confidence - Very Low
Status Description: Selected habitat loss or alteration is suspected and may degrade some attributes of ecological integrity, but has not yet caused measurable degradation.
Rationale: Since 2008, the ecological integrity of major habitat types is mixed. There has been no evidence of degradation in kelp forests and rocky coasts, whereas the pelagic habitat has been degraded by marine heatwaves, ocean acidification, and hypoxic events. Data on the integrity of other habitat types in the sanctuary are not available.

Commented [1]: While this is only one habitat type, it has a huge geographic footprint relative to kelp forests and the rocky coast. That this habitat is degraded should be enough to result in a status downgrade to Fair or less.

Commented [2]: I agree! Also see my comment in conclusions. I do think there has been research on rocky coasts re MHW, OA, etc. Also, what about viruses or whatever caused seastar wasting disease?

Definition and Description

This question is intended to address acute or chronic changes in both the extent of habitat available to organisms and the quality of that habitat, whether non-living or biogenic. Non-living habitats are physical structures, such as rocky coasts, sand flats, and the water column. Biogenic habitats are structure-forming species that~~, which~~ create habitat ~~structures~~, like kelp forests, deep-sea corals and sponges, and mussel beds. Biogenic habitats are layered on top of, and often form in association with, particular non-living habitat types. Change and loss of habitat is of paramount concern when it comes to protecting marine and terrestrial ecosystems. Of greatest concern to sanctuaries are changes to habitats caused, either directly or indirectly, by human activities.

In 2019, the integrity of major habitat types was rated as good/fair with a trend characterized as not changing. This rating indicates that selected habitat loss or alteration is suspected and may degrade some attributes of ecological integrity, but has not yet caused measurable degradation. These ratings were justified by data showing kelp forests and rocky shores with very little degradation, some habitats over the continental shelf being degraded by hypoxic events, and a lack of information on deep seafloor, shallow sandy seafloor, and sandy beaches habitats. In addition, experts acknowledged that the impacts of marine heat waves in 2014–2016 and again in 2019–2020 are a concern. There was low confidence in the rating for habitat condition and very low confidence in the rating for temporal changes to condition. Confidence was low because there were several important data gaps and experts disagreed on how best to summarize sanctuary habitat conditions when some habitats (i.e., kelp, rocky shores) were doing well and others were not (i.e., habitats affected by hypoxia, especially the pelagic realm).

Commented [3]: But above you mention degradation of the pelagic habitat. Given the extent of this habitat relative to other habitat types how can the reader reconcile this?

Commented [4]: This helps explain the "not changing" designation but still doesn't go far enough, in my opinion. After discussion in other sections about changes in chemical aspects of the environment and the resulting biological response this seems out of synch.

Comparison to 2008 Condition Report

This question was addressed differently in 2008, when abiotic and biotic habitat types were assessed separately. The status of major abiotic and biotic habitats were rated as good/fair and fair, respectively, and corresponding trends were rated as not changing and undetermined (Table S.H.10.1). These previous ratings were based on observations that most habitats were undisturbed by human use and development, but were tempered by the acknowledgement that there was limited, localized habitat modification from disturbances such as trawling, cable installation, shoreline armoring, and human visitation.

Many of the habitats found in the sanctuary are relatively undisturbed, and in a similar healthy condition as in 2008. The sanctuary’s remote location and shorelines, buffered by the Olympic National Park and tribal reservations, offer protection from coastal development and other direct anthropogenic disturbances. However, more pervasive anthropogenic impacts to habitats from broadscale oceanographic hypoxia were recorded and impacts from recent marine heat waves are a concern. There is also the assumption that localized habitat modification from trawling the deep seafloor is an issue, but there is insufficient data to assess change to the condition of these habitats. Information on seafloor trawling in the sanctuary is provided in question 3.

Much of the information on habitat integrity within the sanctuary comes from long-term monitoring of kelp forests, rocky shores, and pelagic habitats. Kelp forests and rocky shores have been well studied and support some of the most productive and diverse communities in the California Current. The integrity of these two habitats appears to be in good and stable condition. However, researchers are concerned about future impacts from climate change.

Commented [5]: But these have only a small fraction of the footprint of the offshore benthic and pelagic environments. This is akin to saying that your yard is really well maintained while your house is on the verge of being condemned.

New Information in 2019 Condition Report

Bull ~~K~~kelp ~~are~~is a foundational species in the Pacific ~~n~~Northwest and there are extensive tracts of kelp forests within the sanctuary (Wagenan, 2015). They provide food and shelter for many invertebrates and fishes (Teagle et al., 2017), are exceptionally efficient primary producers (Mann, 1973), and are well-connected to adjacent ecosystems through energy and nutrient transfers (Hansell, 2013). The extent and integrity of kelp forests is intimately related to external ecosystem forces such as water temperature and upwelling regimes, and therefore kelp forests can vary substantially among ~~between~~ years and are sensitive to changes in ocean climate (Pfister et al., 2017).

Pfister et al. (2017) analyzed aerial censuses of two canopy kelp species, *Macrocystis pyrifera* and *Nereocystis*, in Washington State waters from 1989 to 2015, and compared these modern censuses with censuses in 1911 and 1912. They found kelp forests remained at historic high levels along the outer coast (Figure S.H.10.1) between 2008 and 2015, and there was no consistent change in kelp forest persistence among these years. The persistence of kelp forests within the sanctuary contrasts with downward trends in southern California (NOAA ONMS, 2016) and closer to Puget Sound. Although the assessment by Pfister et al. (2017) was overall positive, they also documented localized areas of high variability and low abundance, and areas of extirpation. These local losses align with kelp forest losses recorded by Quileute elders (Shaffer et al. 2004), and could be due in part to localized oil spills and intermittent influx of sediment from storms after timber harvest (Shannon et al., 2016). Pfister et al. (2017) concluded with a caution, ~~. But it was noted~~ that kelp forest viability remains a concern for the future because of the strong relationship between kelp and temperature, which is increasing.

Rocky shores are one of the most iconic and conspicuous marine habitats for people visiting the sanctuary because they occur at the dynamic interface between land and water and are the most accessible. The tide pools, boulders, and rocky outcrops provide habitat for a wide array of invertebrates, macroalgae, and intertidal fish, and these habitats in the sanctuary are among the most diverse in the California Current (Suchanek, 1979; MARINe, 2020). Rocky shores are monitored systematically by the Multi-Agency Rocky Intertidal Network (MARINe) at six permanent, long-term monitoring stations within the sanctuary. The network targets several species that are sensitive to degradation from human pressures like shoreline visitation or oil spills. Time series from long-term monitoring sites showed little change in the coverage of acorn barnacles (*Chthamalus fissus*, *Chthamalus dalli*, *Balanus glandula*, Figure S.H.10.2), California mussels (*Mytilus californianus*, Figure S.H.10.3), and surfgrass (*Phyllospadix scouleri*, *Phyllospadix torreyi*) between 2008 and 2019, even though there was some interannual variability within stations. Prior to 2007 MARINe also conducted biodiversity surveys in the sanctuary, which collected more detailed information about species diversity, abundance, and distribution to assess influences of climate change and coastal development. This information ~~That~~ would have been valuable for this assessment had sampling ~~they~~ continued, and this is a clear data need.

Additional data on mussel shell thickness and traditional ecological knowledge offer different perspectives on rocky intertidal areas in the sanctuary. Pfister et al. (2016) found that the shell thickness of California mussels collected from 2009–2011 was thinner than archival shells from the 1970~~'~~s or midden shells from the sanctuary radiocarbon dated to 1000–1340 years before present. Their results suggest changes in seawater pH and the availability of carbonate ions associated with anthropogenic carbon dioxide emissions are posing a challenge for California mussels and other calcifying marine species. In addition, Quileute elders have reported lower abundance and smaller sizes of blue mussels over time (Shaffer et al., 2004).

Commented [6]: Or "Kelps are foundational species . . . "

Commented [7]: Elsewhere in the report common names have been used.

Commented [8]: Not sure what this means. Are you indicating declining trends are also observed in Puget Sound, which is geographically closer to OCNMS than California?

The pelagic habitat supports a wide range of living marine resources (e.g., whales, fish, seabirds, plankton) and ecosystem services, and is inextricably connected to all other habitats in the sanctuary. It is studied using an array of mooring buoys, cross-shelf transects, and satellite sensors to measure physical parameters (e.g. temperature, salinity, turbidity) that determine the spatial and temporal distributions of organisms. Some of the parameters more commonly used to characterize water quality are addressed by questions 6, 8, and 9.

Frequent hypoxic events, characterized by low oxygen concentrations, have been recorded at the seafloor over the continental shelf in the sanctuary by mooring stations (Alin et al., in prep) and systematic oceanographic surveys (NMFS/NWFSC) going back to 2006. These datasets recorded hypoxic events during the mid-to-late summer, with the lowest oxygen concentrations occurring offshore in the southern half of the sanctuary. Although there is substantial interannual variability with some years showing little to no hypoxia, in other years hypoxic waters covered up to 62% of the continental shelf north of the Newport Hydrographic line. At a broader scale, the last comprehensive temporal study of oxygen concentration found persistently declining oxygen levels in the interior waters of the eastern subarctic Pacific over the last 50 years (Whitney et al., 2007). The specific impacts on species from these changes is under investigation, but presumably hypoxia will compress benthic and pelagic habitats and cause a range of negative effects on plants and animals, including slowed growth rates, metabolic impairments, and occasionally death.

An emerging issue of concern in the sanctuary is ~~are~~ periods of extraordinarily warm ocean temperatures, known as marine heatwaves (NOAA CCIEA, 2020). Marine heatwaves were observed in the Northeast Pacific in 2014–2016 and again in 2019–2020 (CalCOFI, 2019) (Figure S.H.10.4). The 2014–2016 heat wave was the greatest observed in the Northeast Pacific since at least the 1980s and possibly as early as 1900 (Bond et al., 2015). Although the documented marine heat waves were most prominent in the Gulf of Alaska and north-central Pacific, their impacts extended into the sanctuary. They had profound impacts on weather patterns, oceanographic productivity and mixing patterns, and major species distribution shifts (Whitney, 2015; Goddard, 2016; Santora, 2020). For example, a massive dieoff of Cassin's auklets, a small pelagic seabird, was linked to warmer ocean temperatures from the 2014-2016 marine heatwave, which shrank their cold-water foraging habitat and reduced their prey (Jones et al., 2018). Impacts from the 2019–2020 marine heat wave are currently being investigated (NOAA CCIEA, 2020).

Commented [9]: This paragraph could use a sentence or two linking the pelagic impacts of heatwaves to then benthic offshore communities, even in a theoretical sense where nutrient links are disrupted due to decreases in abundance of plankton and forage fishes. Also, it could benefit from a sentence getting at the "so what" element of the changes. Follow the example of the auklets through: when they died what downstream impacts occurred?

There are several habitats within the sanctuary where data were insufficient or unavailable to understand their integrity. Prominent habitat-wide data gaps exist for deep seafloor and shallow sandy seafloor. Although data characterizing sediment size composition and beach slope have been collected at sites in Olympic National Park such as Kalaloch and Rialto (Fradkin & Boetsch, 2012; Fradkin, 2014, 2015; Miller 2019a, 2019b), they have not yet been interpreted to assess habitat integrity. Table Table S.H.10.2 summarizes data gaps which would be beneficial to fill for the next condition report. In addition, it would be useful to reconsider what habitat indicators are suitable for sandy seafloor habitat, as none were identified by experts.

Conclusion

In 2019, the integrity of major habitat types was rated as good/fair with a non-changing trend . These ratings were justified by data showing mixed signals for different habitats. The integrity of kelp forest and rocky shore habitats was intact, with little to no degradation, whereas pelagic habitats were affected by extreme marine heatwaves and seasonal hypoxic events. These mixed conditions, along with data gaps for deep seafloor, shallow sandy seafloor, and sandy

Commented [10]: I disagree that a non-changing status is appropriate here when MHW, OA, affect benthic communities also.

beaches habitats, were reflected in experts' low confidence in the rating for habitat condition and very low confidence in the rating for temporal changes to condition.

Question 10 Tables

Table S.H.10.1. 2008 (left) and 2020~~19~~ (right) status, trend and confidence ratings for the habitat questions~~, including question 10~~.

2008 Questions		2008 Rating	2020 Questions		2020 Rating			
					Status	Confidence (Status)	Trend	Confidence (Trend)
5	Habitat abundance/distribution	–	10	Integrity of major habitats	Good/Fair	Low	–	Very Low
6	Condition of biologically structured habitat	?						
7	Contaminants	–	11	Contaminants	Good	Medium	?	Medium

Commented [11]: Graphic designer - please use the symbols you create. Thank you.

Questions		2008 Rating		Questions		2019 Rating			
						Status	Confidence	Trend	Confidence
5/6	Major/Biologically-structured	–	?	10	Integrity of Major Habitats	G/F	Low	–	Very Low
7	Contaminants in Habitat	–		11	Contaminants in Habitat	Good	Medium	?	Medium

Table S.H.10.2. Status and trends for individual question 10 indicators discussed at January 2020 workshop.

Indicator	Source	Habitat	Data Summary	Figures
Kelp canopy 2008-2019 (aerial extent)	WADNR surveys, Pfister et al. 2017, Shaffer et al. 2004	Kelp Forest	**Status**: Kelp canopy from 2008 to 2019 remained at historic high levels along the outer coast. Sensitivity to changes in ocean climate and SST suggest concern into the future (Pfister et al. 2017). **Trend**: No trend ↔ between 2008 and 2015.	S.H.10.1

Barnacles 2008-2019 (% cover)	MARINe (Miner M. 2019)	Rocky Shores	**Status**: There is no evidence of change in the percent area covered by barnacles since 2008. **Trend**: No trend ↔ between 2008 and 2019, although there is interannual variability.	S.H.10.2
Mussels 2008-2019 (% cover)	Miner M. 2019, Shaffer et al. 2004	Rocky Shores	**Status**: There is no evidence of change in the percent area covered by California mussels since 2008. Quileute elders have observed lower abundance and smaller sizes of blue mussels over time (Shaffer et al. 2004). **Trend**: No trend ↔ between 2008 and 2019, although there is interannual variability.	S.H.10.3
Marine heatwaves (frequency and duration)	CalCOFI 2019, Bond et al. 2015	Pelagic	**Status**: The 2014-2016 heat wave was the greatest observed in the Northeast Pacific since at least the 1980s and possibly as early as 1900 (Bond et al. 2015). **Trend**: Undetermined. Analysis gap.	S.H.10.4
Dissolved oxygen (frequency and duration of hypoxic events)	Alin et al. in prep, Whitney et al. 2007	Pelagic	**Status**: Frequent summer hypoxic events in the southern part of the sanctuary; no evidence to show there has been a significant change in the frequency or duration of events compared to before the 2008-2019 assessment period (analysis gap). **Trend**: Undetermined. Analysis gap.	-
Thermocline depth	Columbia Plume, Palacios et al. 2004, *OCNMS Moorings*	Pelagic	**Status:** No trend in 1998-2014 (Andrews et al. 2015). Historic multi-decadal shift in regional thermocline depth from 1950 to 1993 (Palacios et al. 2004). Analysis gap for 2015-2019. **Trend:** No consistent trend in 1998-2014 assessment (Andrews et al. 2015). Analysis gap for 2015-2019.	
Pycnocline depth	Columbia Plume, *OCNMS Moorings*	Pelagic	**Status**: No trend in 1998-2014 (Andrews et al. 2015). Analysis gap for 2015-2019. **Trend**: No trend in 1998-2014 (Andrews et al. 2015). Analysis gap for 2015-2019.	
Analysis Gaps	Pelagic, Beaches		Pelagic (Marine heatwaves, dissolved oxygen, thermocline depth, pycnocline depth, (Beaches) Beach position/slope, Sediment size composition	
Data Gaps	Beaches, Deep Seafloor, Kelp Forest		(Kelp Forest) Extent of bare rock, Extent of understory Kelp/Algae, (Deep Seafloor) Extent of biogenic invertebrates, Terrain complexity, (Beaches) Beach wrack/wood, Phytoplankton abundance	-

Question 10 Figures

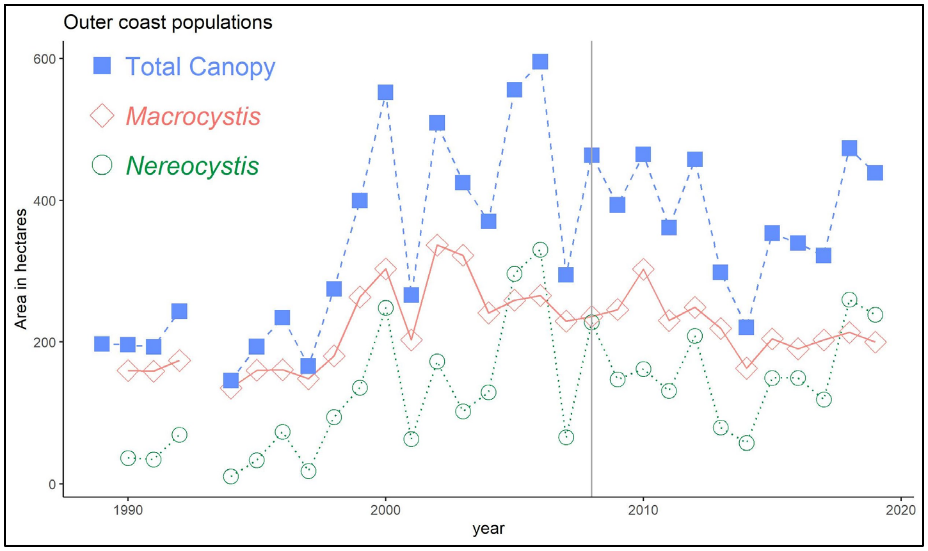

Figure S.H.10.1: The relative abundance (in hectares) of total kelp canopy, *Nereocystis*, and *Macrocystis* from 1989 to 2019 on Washington's outer Pacific Coast, based on aerial surveys. The vertical black line indicates the last condition report in 2008. Updated by WA DNR/H. Berry on 12 January 2021 from Pfister et al., 2017.

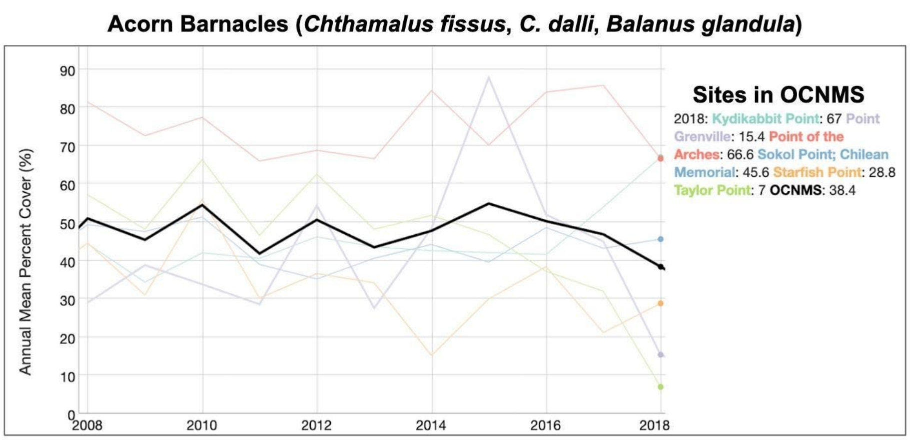

Figure S.H.10.2: Annual average percent cover of acorn barnacles (*Chthamalus fissus*, *Chthamalus dalli*, *Balanus glandula*) in plots targeting barnacles from 2008 to 2018 at MARINe monitoring stations in OCNMS (MARINe, M. Miner 2019). Black line shows annual average across all six sites. Source: MARINe/ONP/OCNMS; Image: MBON, 2019

Commented [12]: We will be working with Brown & MARINe to make this and the following 2 figures compliant for those with color blindness.

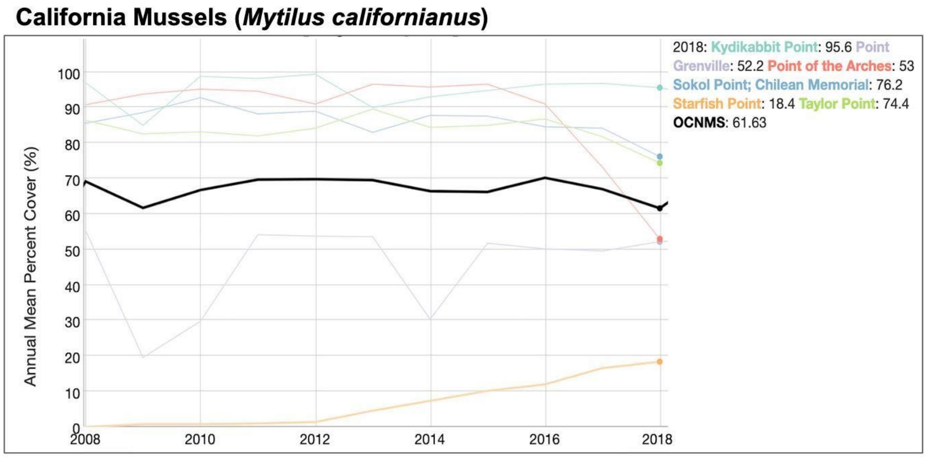

Figure S.H.10.3. Annual average percent cover of California mussels (*Mytilus californianus*) in plots targeting mussels from 2008 to 2018 at MARINe monitoring stations in OCNMS (MARINe, M. Miner 2019). Black line shows annual average across all six sites. Source: MARINe/ONP/OCNMS; Image: MBON, 2019

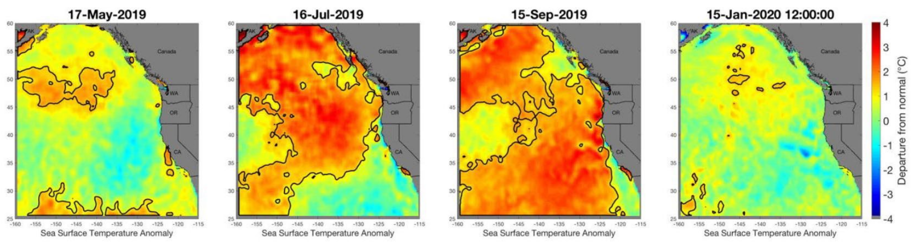

Figure S.H.10.4. These four maps show standardized sea surface temperature anomalies (SSTa) across the ~~Pacific~~ Northeast Pacific Ocean, including the sanctuary, for May, July, and September 2019, and January 2020. Dark contours denote regions that meet the criteria of a marine heat wave (see NOAA CCIEA 2020). The standardized SSTa is defined as SSTa divided by the standard deviation of SSTa at each location calculated over 1982-2019, thus taking into account spatial variance in the normal fluctuation of SSTa. Image: NOAA CCIEA, 2020

Question 10 References

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Question 11: What are contaminant concentrations in sanctuary habitats and how are they changing?

Status: Good, Confidence - Medium; **Trend**: Undetermined, Confidence - Medium (Table S.LR.11.1)
Status Description: Contaminants have not been documented, or do not appear to have the potential to negatively affect ecological integrity.
Rationale: Contaminant concentrations are considered to be generally low in the sanctuary and there is no evidence to suggest contaminants concentrations are increasing;, however, most data and published information preceded the assessment period.

Definition and Description

This question focuses on contaminants commonly found in benthic habitats, but also includes contaminants in the pelagic habitat which have been resuspended. The contaminants of concern include heavy metals, pesticides, hydrocarbons and other persistent organic pollutants. Some contaminants are also addressed in question 9, and are important indicators for answers to both questions. Toxins and bacteria found in water, such as harmful algal toxins (e.g., domoic acid) and *E. coli*, are reviewed in questions 7 and 8. Related impacts such as commercial shellfish closures and beach closures are also reviewed under questions 7 and 8. Many consider noise a pollutant, but in the interest of focusing here on more traditional forms of habitat degradation caused by harmful substances, the impacts of acoustic pollution are addressed within the living resource section.

In 2019, contaminant concentrations are considered to be generally low in the sanctuary and there is no evidence to suggest concentrations are increasing,; however, most data and published information preceded the assessment period. Experts rated contaminant concentrations in sanctuary habitats as good, and the trend undetermined.

Comparison to 2008 Condition Report

In 2008, the condition of contaminant concentrations in sanctuary habitats were rated as good and corresponding trends were rated as not changing because reports published before 2008 reported low levels of contaminants (see Table S.H.10.1). This rating was selected because the OCNMS is relatively remote, and separated from major urban developments and areas of high population density, which are common sources of habitat contamination. Both the wilderness designation of the Olympic National Park and restricted access to tribal reservations place controls on coastal development, and separate the sanctuary from inland industrial, commercial, and population centers. Consequently, anthropogenic nonpoint sources are minor and contaminant concentrations in sanctuary habitats are considered low.

New Information in 2019 Condition Report

There are several legacy contaminants in the sanctuary from past human uses that have deleterious impacts to habitats, ecosystems, and humans. The most significant sources come from now-banned use of pesticides and polychlorinated biphenyls (PCBs), military use of the Quinault range and bombing practice on offshore islands after World War II, and two oil spills that occurred off the Washington coast, one in 1988 (*Nestucca*) and the other in 1991 (*Tenyo Maru*). These noted contamination events occurred before the Olympic Coast National Marine Sanctuary was designated in 1994, but added enduring contaminants into sanctuary habitats. Pesticides such as dichlorodiphenyltrichloroethane (DDT), PCBs, and oil naturally decrease over time, but the sanctuary is also part of efforts to restore degraded habitats and plans to prevent future contamination (e.g., Final Restoration Plan and Environmental Assessment for the *Tenyo Maru* Oil Spill).

The most comprehensive survey of sediment contamination in the sanctuary was part of the 2000–2003 National Coastal Assessment (NCA) based on the Environmental Monitoring and Assessment Program. NCA was focused on legacy contaminants such as DDTs, PCBs, and heavy metals within sediments and benthic fish tissue. Even though it preceded this assessment period, it offers a sound contamination baseline of coastal habitats, particularly for deep seafloor and sandy seafloor. NCA sampled approximately 30 sites inside the sanctuary, and found no organic contaminants (i.e., PAHs, PCBs, DDT, pesticides), which contrasts with high levels found around urban areas of Puget Sound (Partridge, 2007). At several locations the levels of silver and chromium exceed the Effects Range-Low (ERL) toxicity thresholds, but anthropogenic sources for these metals are not known.

Another approach used to assess legacy contaminant concentrations in the sanctuary has been to test plant and animal tissues because they provide an integrated measure of bioavailability of compounds that are present at low or variable levels in the marine system. Tests of fish, whale, mussel, and otter tissues collected in the sanctuary revealed a community with generally low levels of contaminants (Good et al., 2014; Brancato, 2009; Sato, 2018; Hayes, 2018). One exception was unexpectedly elevated levels of DDTs, PCBs, and PBDEs found in Chinook salmon ~~(*Oncorhynchus tshawytscha*)~~ collected off of Destruction Island (Figure S.H.11.1; Good et al., 2014). Two of the three Chinook tested showed PBDE contaminant levels that fell in the range of increased disease susceptibility. One Chinook fell in the range for potential secondary poisoning related to DDT bioaccumulation and bioconcentration in estuarine systems (Good et al. 2014). These Chinook are believed to have been exposed to the contaminants while in the Columbia River rather than in the sanctuary.

NOAA's Mussel Watch program has monitored polycyclic aromatic hydrocarbons (PAHs), DDTs, PCBs, and another 180 contaminants in coastal mussels nationwide. Because the program is focused on providing regional and nationwide assessments, there is only a single monitoring site within the sanctuary. The site, located at Cape Flattery, offers a time series that should be interpreted with caution, as there is no spatial replication and the exact location sampled varied between years. Mussels collected at Cape Flattery showed very low levels of PAHs (Figure S.H.11.2), PCBs, and DDTs relative to other sites in Washington, and after a steep decline in the mid-1980's, declined slowly to the end of interpreted time series in 2010 (Lanksbury, 2010). In contrast, mussels collected from Puget Sound had PAH, DDT, and PCB levels well above the national median (O'Connor and Lauenstein, 2006).

Unlike species that migrate extensively, sea otters ~~(*Enhydra lutris*)~~ provide an unusual opportunity for study because both the sea otters and their principal prey are relatively sedentary; thus, their contaminant burdens should reflect localized contamination. In the late

1990s sea otter populations declined alarmingly along the California Coast and Aleutian Islands. Several reports at the time suggested an increased disease susceptibility resulting from contaminant-induced immunosuppression. To assess the threat, the sanctuary completed an assessment of contaminant levels in live captured sea otters and liver samples from beach-cast sea otter carcasses within the Sanctuary (Brancato et al., 2009). They showed low levels of metals, butyltins, and organochlorine compounds in the blood samples, with many of the organochlorines not detected (except PCBs), and a few aromatic hydrocarbons detected in the liver of the live captured animals. Aliphatic hydrocarbons were measurable in the liver from the live captured animals; however, some of these were likely from biogenic sources. A recent status review of sea otters in Washington State did not identify contaminants as a concern (Sato, 2018).

Contaminated sites upstream of the sanctuary pose risks to habitats in the sanctuary. The EPA and Washington State compile lists of contaminated sites according to the Clean Water Act, the Superfund program, and Washington State surveys of legacy contaminants like PCBs and DDTs. There are two listed sites adjacent to the sanctuary. This number lies in stark contrast to the hundreds of sites located in Puget Sound or at the mouth of the Columbia River (Washington State Water Quality Atlas).

Lake Ozette, which lies upstream of the sanctuary, was listed because of unusually high mercury flux rates and fish tissue concentrations associated with logging within the catchment area (Furl et al., 2010). The lake lies about one mile inland from the Pacific coast and drains into the sanctuary by way of the Ozette River. The Warmhouse Beach Dump Site was added to the Superfund National Priorities List (NPL) in December 2013 and is located at headwaters to two creeks that run into the sanctuary and traditionally significant shellfish beaches. Elevated levels of metals, perchlorate, and PCBs have been found in soil at the dump and in sediment in both creeks (EPA, 2016). Mussels at the beach also contain elevated concentrations of lead; however, it has not been determined whether this is from the dump or creeks. The EPA is in the early stages of the Superfund cleanup process, called the “Remedial Investigation”.

Two potential sources of contamination from distant sources are the Fukushima Daiichi nuclear disaster in 2011 (radionuclides) and atmospheric deposition of mercury from the burning of fossil fuels. From 2014 to 2016, Kelp Watch, a scientific monitoring campaign, sampled kelp forests along the U.S. West Coast, including within the sanctuary, to determine the extent of expected contamination. There was no indication that the radioactivity from Fukushima became incorporated in the coastal kelp beds sampled. The main source of mercury to the ocean and to habitats in the sanctuary is likely from marine-traffic residual fuel oil, biomass combustion emissions, and sea salt (Hadley, 2017). It is estimated that peak emissions of mercury in the Western U.S. occurred in the 1980s, but has since declined due to emission controls (Schuster et al., 2002), but this trend is counteracted on by increasing emissions from Asia (Pacyna et al., 2010). Surprisingly, an analysis of mercury wet deposition and mercury air concentrations on the Pacific Coast from 1997 to 2013 found no trends in either metric (Weiss-Penzias et al., 2016). It is likely that the lack of change in mercury is due to the counteracting effects of lower local emissions and greater amounts of mercury being transported to the United States from Asia.

There are notable data gaps in contaminant concentrations in habitats within the OCNMS. Most notable is a paucity of data within the 2009–2019 assessment period. Much of what we know about contamination in the sanctuary was collected prior to 2003. In addition, there are numerous indicators deemed by experts as important for assessing habitat contamination for which there are no data at all (Tables S.H.11.1; data gaps for contaminant levels in zooplankton krill, algae, infauna, seabirds and sediment in additional habitats were identified after the January 20, 2020 workshop).

Question 11 Tables

~~**Table S.H.11.1**. 2008 (left) and 2019 (right) status, trend and confidence ratings for the habitat questions, including question 11~~

Questions		2008 Rating		Questions		2019 Rating			
						Status	Confidence	Trend	Confidence
5/6	Major/Biologically-structured	–	?	10	Integrity of Major Habitats	G/F	Low	–	Very Low
7	Contaminants in Habitat	–		11	Contaminants in Habitat	Good	Medium	?	Medium

Table S.H.11.~~2~~1. Status and trends for individual question 11 indicators discussed at January 2020 Workshop.

Indicator	Source	Habitat	Data Summary	Figures
Contaminant levels in sediment	National Coastal Condition Assessment	Deep Seafloor	**Status**: Very low levels of contamination in sediments and flatfishes from 2003. Data gap after 2003. **Trend**: Undetermined. Data gap.	-
Contaminant levels in sediment	EPA, WA DOE	All habitats	**Status**: Several legacy military sites with localized impacts. **Trend**: Remediation underway at several degraded sites.	-
Contaminant levels in pelagic fish	EPA, WA DOE	Pelagic	**Status**: PCB and DDT concentrations in fish are relatively low and typically below action levels. **Trend**: Undetermined. Data gap.	S.H.11.1
Contaminant levels in shellfish	NOAA Mussel watch	Rocky Shores	**Status**: DDT and PCBs levels are low in OCNMS shellfish **Trend**: Regional DDT and PCBs levels are decreasing in shellfish	Figure S.H.11.2
Contaminant levels in sea otters	Brancato 2009, Washington Periodic Status Review 2018	Kelp Forest	**Status**: Low levels of metals, butyltins, and organochlorine compounds in collected tissues from early 2000s. Not a concern in 2018 status review. **Trend**: Undetermined. Data gap.	-

Data gaps	Kelp Forests, Sandy Beaches, Sandy Seafloor, Rocky Shore, Pelagic	(Kelp Forests) Contaminant levels in sea otters, kelp, kelp forest fish, (Sandy Beaches) Contaminants in sediment, (Sandy Seafloor) Contaminants in infauna, (Rocky Shore) Contaminants in sediment, (Pelagic) Contaminant levels in water, seabirds, marine mammals	-

Question 11 Figures

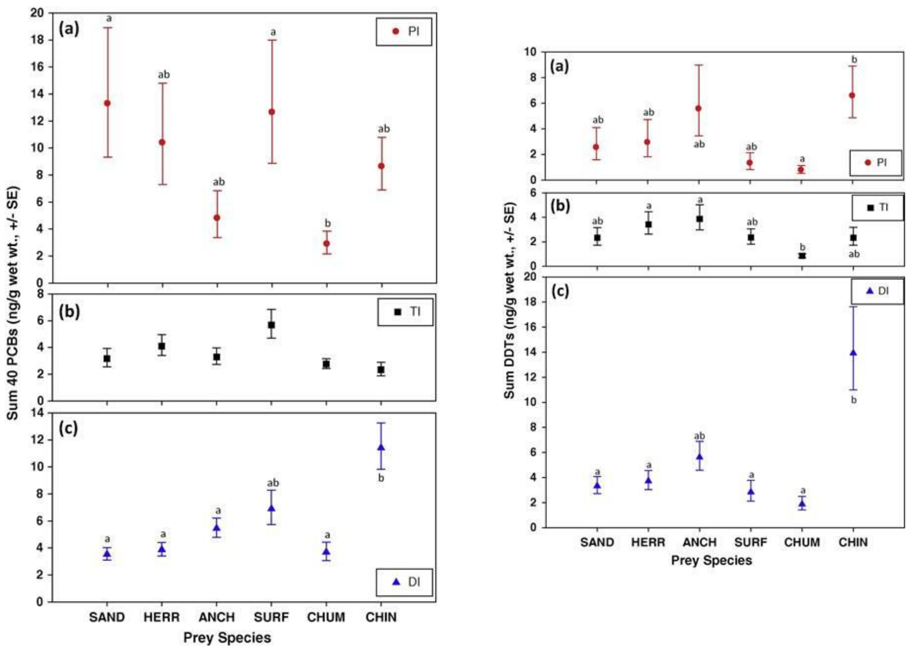

Figure S.H.11.1. Concentration of PCBs (polychlorinated biphenyls) [LEFT panel] and DDTs (dichloro-diphenyl-trichloroethane and five others) [RIGHT panel] in fish collected from rhinoceros auklets on (a) Protection Island (PI), (b) Tatoosh Island (TI), and (c) Destruction Island (DI) breeding colonies. Prey fish include Pacific sand lance (SAND), Pacific herring (HERR), surf smelt (SURF), Northern anchovy (ANCH), chum salmon (CHUM), and Chinook salmon (CHIN). Letters above whiskers denote significant post hoc differences among species using Bonferroni tests. Image: Good et al., 2014

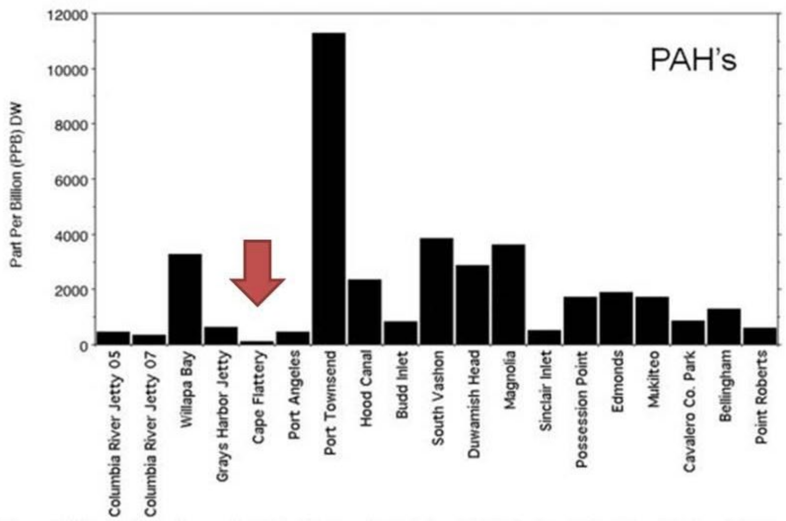

Figure S.H.11.2. Total polycyclic aromatic hydrocarbons (PAHs) from select Washington State Mussel Watch sites in 2006. A red arrow points to Cape Flattery, the only Mussel Watch site in the Sanctuary. Source: NOAA NCCOS National Status and Trends Mussel Watch Program; Image: A. Mearns/NOAA

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This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

State of Sanctuary Resources

Table of Contents

Question 12: What is the status of keystone and foundation species and how is it changing?

Question 13: What is the status of focal species and how is it changing?

Question 14: What is the status of non-indigenous species and how is it changing?

Question 15: What is the status of biodiversity and how is it changing?

Living Marine Resources (Questions 12–15)

The following information describes the status and trends of living marine resources inside OCNMS from 2008–2019. The term “living marine resources” encompasses a range of organisms in OCNMS, including keystone, foundation, focal, and non-indigenous species. The status for a species describes changes to their abundance compared to their historical abundance. The historical time period used for comparison depends on data availability and differs across indicators. The trend for a species describes changes to their abundances over the last 10 years. Each of the living marine resource questions focus on specific groups of species in OCNMS.

Question 12 evaluates changes to keystone (e.g., sea stars, kelp, sea otters) and foundation (e.g., mussels, anchovies) species, which are critical to maintaining OCNMS’s ecosystem structure, function, and stability over time. Question 13 is centered around focal species (e.g., razor clams, Dungeness crabs, groundfish, salmon, marine mammals, seabirds), which may not be abundant or be key to OCNMS’s ecosystem function, but their presence and health is important for the provision of economic, cultural, spiritual, recreational, ecological, or conservation-related values and services. Some focal species discussed here (e.g., eulachon, Southern Resident killer whales) are also threatened or endangered and protected under state and/or federal laws.

Question 14 focuses on the impacts of non-indigenous species (e.g., European green crab), which are not native to the region. Also called alien, exotic, non-native, or introduced species, these are animals or plants living outside their endemic geographical range. Often having arrived in the sanctuary by human activity, either deliberately or accidentally, their abundance in sanctuary habitats along with any known ecological impacts will be discussed. These species are of concern because they have the potential to impact OCNMS’s ecosystem structure and function, at which point they are called invasive species.

Lastly, question 15 addresses the status of biodiversity, which is defined as variation of life at all levels of biological organization, and commonly encompasses diversity within species (genetic diversity), among species (species diversity), and comparative diversity among ecosystems (ecosystem diversity). Biodiversity can be measured in many ways. The simplest measure is to count the number of species found in a certain habitat or ecosystem, termed species richness.

Other indices of biodiversity couple species richness with relative abundance to provide a measure of evenness and heterogeneity. When discussing “biodiversity” in response to Question 15, the report primarily refers to species richness and diversity indices, and the abundance of species that influence the integrity of food webs and other aspects of ecosystem function. Non-indigenous species were not included in estimates of native biodiversity.

Question 12: What is the status of keystone and foundation species and how is it changing?

Definition and Description

Status: Fair, Confidence - Medium; **Trend**: Undetermined, Confidence - High

Status Description: The status of keystone or foundation species suggests measurable, but not severe, degradation in some attributes of ecological integrity.

Rationale: Since 2008, some keystone species populations (e.g., purple and sunflower sea stars) and foundation species (e.g., California mussels) have declined while other keystone (e.g., kelp, sea otters) and foundation species populations (e.g., anchovies, pacific hake) are stable or increasing.

“Keystone” species are organisms on which a large number of other species~~-~~ in the ecosystem depend ~~in the ecosystem~~ (Paine, 1969). Their contribution to ecosystem function is disproportionate to their abundance or biomass. ~~-~~They can be habitat creators (e.g., kelp, corals), predators that control food web structure (e.g., sea otters, certain sea stars), herbivores that regulate benthic recruitment (e.g., certain sea urchins), and species involved in critical symbiotic relationships (e.g., cleaning or cohabitating species). “Foundation” species are single species that create locally stable conditions for other species (Dayton, 1972). These are typically dominant biomass producers (e.g., mussels, hake, anchovy, krill) in an ecosystem and strongly influence the abundance and biomass of many other species. Changes in either keystone or foundation species may transform ecosystem structure through disappearances of, or dramatic increases in, the abundance of dependent species.

The discussion for question 12 is limited to keystone and foundation species ~~(Table S.LR.12.2)~~. In OCNMS, keystone species include the purple sea star (*Pisaster ochraceus*), sunflower sea star (*Pycnopodia helianthoides*), purple sea urchin~~s~~ (*Strongylocentrotus purpuratus*), giant and bull kelp (*Nereocystis luetkeana* and *Macrocystis pyrifera*), and northern sea otter~~s~~ (*Enhydra lutris kenyoni*) because their contribution to ecosystem function is disproportionate to their abundance. Foundation~~al~~ species or functional groups discussed here include phytoplankton, copepods, California mussel (*Mytilus californianus*), Pacific hake (*Merluccius productus*), northern anchovies (*Engraulis mordax*), and northern Pacific krill (*Euphausia pacifica*). Other species were also considered during the January workshop, including lantern fish (myctophids), and key forage fish (i.e., Pacific sardine [*Sardinops sagax caerulea*] and Pacific herring [*Clupea pallasii*]) ~~(Table S.LR.12.2)~~. However, they are listed as data or analysis gaps because a lack of readily available long-term data or analysis prevented them from being included in the rankings.

~~In 202019, t~~The status of keystone and foundation species in OCNMS is fair (with medium confidence) and the trend is undetermined (with high confidence) ~~(Table S.LR.12.1)~~. The availability of monitoring data for the above indicators helped increase confidence in these

Commented [1]: "Phytoplankton" is not a species.

ratings. These ratings indicate that keystone and ~~or~~ foundation species have experienced measurable, but not severe, degradation in some attributes of ecological integrity. The trend is undetermined because some keystone species populations (e.g., purple and sunflower sea stars) and foundation species (e.g., California mussel) have declined while other keystone (e.g., sea otters) and foundation species populations (e.g., giant and bull kelp, northern anchovies, ~~p~~Pacific hake) have been stable or increasing since 2008. These declines and increases are likely to have changed community structure or ecosystem function.

Comparison to 2008 Condition Report

Because question 12 was changed following the 2008 report, a direct comparison is not possible between the two condition report ratings. That said, the indicators used to develop the 2008 ratings for question 12 and 13 overlap with the indicators used to develop the 2019 rating for question 12. Specifically, in 2008, the status and condition of focal species were rated as fair and good/fair, respectively, with undetermined trends. These ratings were based on prevalence of disease in sea otters, and the reduced abundances of selected focal species, including sea otters, common murres (*Uria aalge*) and rockfish (*Sebastes* spp.). In 2019, the updated rating accounted for the recovery of sea otter populations, which are at an all time high in Washington State ~~(at least~~ since monitoring began in 1989~~)~~. The status of rockfish and common murre populations were also evaluated in 2019, but they were incorporated into the rating for question 13 (other focal species) because they are important, but not considered keystone or foundation species (Table S.LR.12.1).

New Information in 2019 Condition Report

The 2019 status rating was based primarily on new information and expert opinions about known changes in specific keystone and foundation~~al~~ species abundances since 2008. These declines and resurgences have likely impacted rocky shore, sandy seafloor, kelp forest, deep seafloor, and pelagic ecosystems. Species from sandy beaches were not evaluated in this question because no appropriate keystone or foundation~~al~~ species were identified by experts during the workshops. Key indicators for these other habitats included phytoplankton, purple and sunflower sea stars, purple sea urchins, California mussels, giant and bull kelp, northern sea otters, northern Pacific krill, and Pacific hake. Although northern anchovies are included here, they represent only one of the many important forage fish species, thus their abundance may not provide a good indicator independent of complementary indicators for other forage fish--a critical data gap for the region. The overall trend for question 12 was undetermined because some keystone and foundation species are in decline while others are stable or increasing. These trends are described in more detail below.

Keystone Species

For keystone species, some species populations are stable or increasing while others are declining. One of the most notable declines has been in the abundance of sea stars, specifically purple and sunflower sea stars, which are among the populations monitored annually at six sites along the Olympic Coast (Figure S.WQ.8.7) using standardized protocols developed for the west coast by MARINe~~, the Multi-Agency Rocky Intertidal Network~~. The abundance of purple sea stars declined precipitously from 2013 through 2015 in rocky shore habitats and has since stabilized at a lower abundance than observed prior to 2013 (Figure S.LR.12.1). The decline in their abundance, coupled with recruitment of new individuals (in some areas) has caused their population size structure to shift to many more small (<50 mm) and very few large (>100 mm) sea stars (Appendix Figure S.LR.12.1).

Declines have occurred largely due to an outbreak of sea star wasting disease (SSWD) that began in 2013 and continued (generally at low levels) through 2020 (Miner et al., 2019). The impacts of SSWD might have been exacerbated by the 2014-2016 marine heat wave (McCaffery et al., 2018; Miner et al., 2019). Some data exist for purple sea stars in kelp forests inside OCNMS, but monitoring began after their decline in 2015. Since 2015, the recovery of purple sea stars has been slow at these locations, with the most variability observed at 5 m depths at Destruction Island (Appendix Figure S.LR.12.2).

Similarly, in kelp forest and deep seafloor habitats, the abundance of sunflower sea stars has declined precipitously since 2013 (Figure S.LR.12.2, Appendix Figure S.LR.12.3a). As with the purple sea star, declines of this keystone species have impacted ecosystem integrity, and occurred because of the 2013 outbreak of sea star wasting disease and the 2014-2016 marine heat wave (Montecino-Latorre et al., 2016; Harvell et al., 2019). NOAA NMFS and its partners began collecting data on sunflower sea stars in 2015, which will help OCNMS track changes in this important subtidal predator (Appendix Figure S.LR.12.3b).

Other keystone species populations are stable or increasing. In particular, giant and bull kelp canopy cover has remained stable compared to pre-2008 levels (Figure S.H.10.1; updated from Pfister et al., 2017). Kelp is also discussed in more detail in question 10. Purple sea urchin abundances increased in kelp forest habitats at Destruction and Tatoosh Islands from 2016-2019, although their densities remained low at other sites in OCNMS (Appendix Figure S.LR.12.4). No readily available data exist for purple sea urchins in kelp forests before 2015. Northern sea otter populations are also at their highest in kelp forest and sandy seafloor habitats since monitoring began in 1989 (Figure S.LR.12.3; Jeffries et al., 2019). The majority (~80%) of sea otters are located south of La Push. Current sea otter mortality rates suggest that population growth may continue (White et al., 2018) unless populations become resource limited (Hale et al., 2019).

Foundation Species

For foundation species, most populations are stable or increasing. In rocky shore habitats, California mussel populations have remained stable since 2008 (Figure S.H.10.3);. Hhowever, it is important to note that their shells have become thinner at Tatoosh Island and Sand Point, WA in recent times (2009–2011) compared to the past (i.e., in the 1970s and 1000–1340) (Figure S.LR.12.4; Pfister, 2016). Also, Quileute elders have noted a reduction in the abundance and individual size of blue mussels (*Mytilus trossulus*) along the northern Olympic Coast, making them too small to eat (Shaffer et al., 2004; Shannon et al., 2016). Mussels are also discussed in more detail in question 10.

In pelagic habitats, some foundation species, such as phytoplankton, copepods, northern anchovy, (*Engraulis mordax*) and Pacific hake populations, have remained similar to their long term means. Copepod anomalies were similar to historical ranges of variation with no 10-year trend. Copepods are critical because they are the basis of the food web, converting plankton into food for higher trophic levels. Because copepods move with ocean currents, their community composition in any given location changes over time. In warm conditions when water is being transported from the south or offshore, abundances of less nutritious southern copepods increase and abundances of the more nutritious northern copepod (i.e., *Calanus marshallae* and *Pseudocalanus mimus*) decrease (NOAA NWFSC, 2020). The reverse is true when water is transported from the subarctic Pacific. This change in community composition often leads to a cascade of effects, including unusual mortality events across multiple trophic groups (NOAA NWFSC, 2020). It is worth noting that offshore of Washington the copepod community remained in a warm state and never transitioned to a cold water (upwelling) community during the marine heat wave in 2015 and 2016 (NOAA NWFSC, 2020; Figure S.LR.12.5).

Although abundance of northern anchovies is provided in Appendix Figure S.LR.12.5, experts agreed that additional work is needed to interpret anchovies 'boom and bust' population cycles and questioned its use as a foundation species and ecosystem indicator, unless considered in concert with information about the abundance and timing of krill and other forage species, including Pacific herring, Pacific sardine, eulachon, whitebait and surf smelt, and American shad to name a few. An offshore forage indicator, such as the one proposed by Thompson et al.~~,~~ (2019) would likely provide a more comprehensive and representative indicator, despite likely undersampling of species such as sardine and anchovy that undergo a diel vertical migration. What is abundantly clear is that forage fish are collectively an important indicator because of their critical importance to higher trophic levels including fish, pinnipeds, whales, and seabirds. For example, Schrimpf et al. (2012) found that in some years, herring and surf smelt comprised more than 50% of the diet of common murres, followed by several other forage species, and that birds are able to shift among available species when provisioning their young. Forage fish ecology remains an important data and analysis gap for the Olympic Coast.

Pacific hake biomass (offshore of California, Oregon, and Washington) has increased since 2008 by more than 1 standard deviation (Figure S.LR.12.6). Northern anchovy abundances were anomalous in 2008 and 2014 offshore of Washington and Oregon (Appendix Figure S.LR.12.5; Duguid et al., 2019). Phytoplankton abundances were also anomalously high in 2008 and 2014, although plankton anomalies have not increased in frequency since 2008. Conversely, northern Pacific krill densities offshore of southern W~~A~~ashington have been low since 2015, following the 2013-2014 marine heatwave. Densities prior to that were several orders of magnitude higher than at present (Appendix Figure S.LR.12.6; Harvey et al., 2020). Data were not readily available showing Pacific krill densities in OCNMS.

Conclusion

In OCNMS, the status of keystone and foundation species i~~n OCNMS~~ is fair (with medium confidence) and the trend is undetermined (with high confidence) in 2019. While the availability of monitoring data helped increase confidence in these ratings, there are still data and analysis gaps inside OCNMS. Specifically, data gaps existed in the rocky shore habitat for black oystercatchers, and in the sandy seafloor for key forage fish. Analysis gaps also existed in pelagic habitats related to northern Pacific krill, lantern fish (myctophids) and key forage fish (e.g., sardines, herring, smelt). No indicators were selected for the sandy beach habitat due largely to a lack of available data.

For two declining species, purple and sunflower sea stars, there was not enough new information to predict if or when populations will recover to pre-2014 levels (Miner et al., 2018). Monitoring data are being collected for these species, but additional analyses are needed to understand temporal trends in OCNMS and the broader region (MARINe, 2019; REEF, 2020). Currently, neither seastar species is listed as threatened or endangered by Washington State, the United States, or the International Union for Conservation of Nature. Should their abundances continue to remain low, the loss of these species will likely change the community composition and shallow water seascape in some locations. In particular, the absence of the sunflower seastar may lead to an increase in red and green sea urchins (*Mesocentrotus* *franciscanus* and *Strongylocentrotus droebachiensis*), which would destroy ~~decimate~~ existing kelp forests and threaten biodiversity (Montecino-Latorre et al., 2016; Harvell et al., 2019).

Climate change is also a major concern for the future of keystone and foundation species in OCNMS because its potential impact on these species (and the cascading effects of their loss) is unknown. Such synergistic effects could be ecologically devastating, pushing the system to a tipping point and leading to significant changes in biodiversity and ecosystem function in OCNMS, and the services provided to coastal communities.

Question 12 Tables

Table S.LR.12.1. 2008 (left) and 2020~~19~~ (right) status, trend and confidence ratings for the living marine resource questions~~, including question 12~~.

Questions		2008 Rating		Questions		2019 Rating			
						Status	Confidence	Trend	Confidence
12/13	Key Species Status/Condition	?	?	12	Keystone & Foundation species	Fair	Medium	?	High
				13	Other Key Species	Fair	High	?	High
11	Non-indigenous Species	▼		14	Non-Indigenous Species	G/F	High	▼	High
9	Biodiversity	?		15	Biodiversity	G/F	Low	–	Medium

2008 Questions		2008 Rating	2020 Questions		2020 Rating			
					Status	Confidence (Status)	Trend	Confidence (Trend)
12	Status of key species	?	12	Keystone & Foundation Species	Fair	Medium	?	High
13	Condition/health of key species	?	13	Other focal species	Fair	High	?	High
11	Non-indigenous species	▼	14	Non-indigenous species	Good/Fair	High	▼	High
9	Biodiversity	?	15	Biodiversity	Good/Fair	Low	—	Medium

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Table S.LR.12.2. Status and trends for individual indicators discussed at January 2020 workshop.There are no confidence scores for individual indicator status and trends.

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Indicator	Source	Species Type & Habitat	Data Summary	Figures

Sea stars, purple (Abundance, Size Structure)	MARINe 2019; NOAA NWFSC 2019	Keystone - Rocky Shore, Kelp Forest	**Status**: Reduced abundance (-) and altered size structure due to SSWD warrant significant concern. **Trend**: Abundances declined ↓ 2013-2015 and have not recovered.	S.LR.12.1; Appendix S.LR.12.1-2
Sea stars, sunflower (Biomass, Density, Counts)	Harvell et al 2019; Montecino-Latorre et al. 2016; NOAA NWFSC 2019	Keystone - Kelp Forest, Deep Seafloor	**Status**: Reduced abundance (-) warrant significant concern. **Trend**: In kelp forest, *Pycnopodia* abundances decreased ↓ from 2013-2015. In the deep seafloor, *Pycnopodia* biomass decreased ↓ by 99.2%. No evidence of recovery.	S.LR.12.2; Appendix S.LR.12.3
Kelp, giant and bull (Aerial extent)	Pfister et al. 2017	Keystone - Kelp Forest	**Status**: Kelp canopy from 2008 to 2014 is similar to 1990s. Sensitivity to changes in ocean climate and SST suggest concern into the future (Pfister et al. 2017). Quileute elders have noticed the loss of kelp beds in recent history (Shaffer et al. 2004). **Trend**: No trend ↔ between 2008 and 2019	Question 10 - S.H.10.1
Sea urchins, purple (Density)	NOAA NWFSC 2019	Keystone - Kelp Forest	**Status**: Purple sea urchin densities low from 1999-2015. **Trend**: Densities increased ↑ from 2015-2019 at Destruction and Tatoosh Islands.	Appendix S.LR.12.4
Sea Otter, northern (Abundance)	Jeffries et al. 2019	Keystone - Kelp Forest, Sandy Seafloor	**Status**: Population south of La Push and in all of WA, at all time high (+) since monitoring began in 1989. Sea otter population is concentrated south of La Push (80%). **Trend**: Mean annual increase ↑ = 9.81%; rate lower north of La Push (may be at carrying capacity); densities are increasing (range not expanding)	S.LR.12.3
Mussels, California (Shell thickness, % cover)	Pfister et al. 2016; MARINe 2019; Shaffer et al. 2004	Foundational - Rocky Shores	**Status**: California mussel shell size thinner now than in the past (Pfister et al. 2016). Quileute elders have observed lower abundance and smaller sizes of blue mussels over time (Shaffer et al. 2004). **Trend**: No trend ↔ between 2008 and 2019	Question 10 - S.H.10.3; S.LR.12.4
Zooplankton (Copepod Biomass Anomaly)	NOAA NWFSC, 2020	All	**Status**: Recent mean similar to long term mean ● **Trend**: No trend ↔	S.LR.12.5
Pacific Hake (Biomass)	Grandin et al. 2020	Foundational - Deep Sea-floor, Pelagic	**Status**: Recent mean similar to long-term mean ● **Trend**: Increasing ↑ biomass. Need analysis inside OCNMS.	S.LR.12.6

Key Forage Fish, Northern anchovy, Pacific Krill (Abundance anomalies, CPUE)	Duguid et al. 2019; Harvey et al. 2020	Foundational - Pelagic	**Status:** Elevated abundances (+) for anchovy observed in 2004, 2009, 2015 and 2016. Limited data for anchovy in WA. No data for krill in OCNMS. **Trend**: No clear trend ↔ for northern anchovy. No data for krill in OCNMS.	Appendix S.LR.12.5-6
PhytoplanktonChlorophyll *a* (Abundance Anomalies)	NOAA NMFS 2020	Foundational - All	**Status:** More positive (+) chlorophyll-a anomalies compared to last assessment period. **Trend**: Increased ↑in the last 10 years.	Question 6 - S.WQ.6.2
Data Gaps	Kelp Forest, Sandy Seafloor		(Sandy Seafloor) Key forage fish (see below), Copepod and Zooplankton	-
Analysis Gaps	Pelagic		(Pelagic) Key Forage Fish (Pacific sardines, Pacific herring, eulachon, smelt species, krill, Lantern fish (*myctophids*)). etc	-

Question 12 Figures

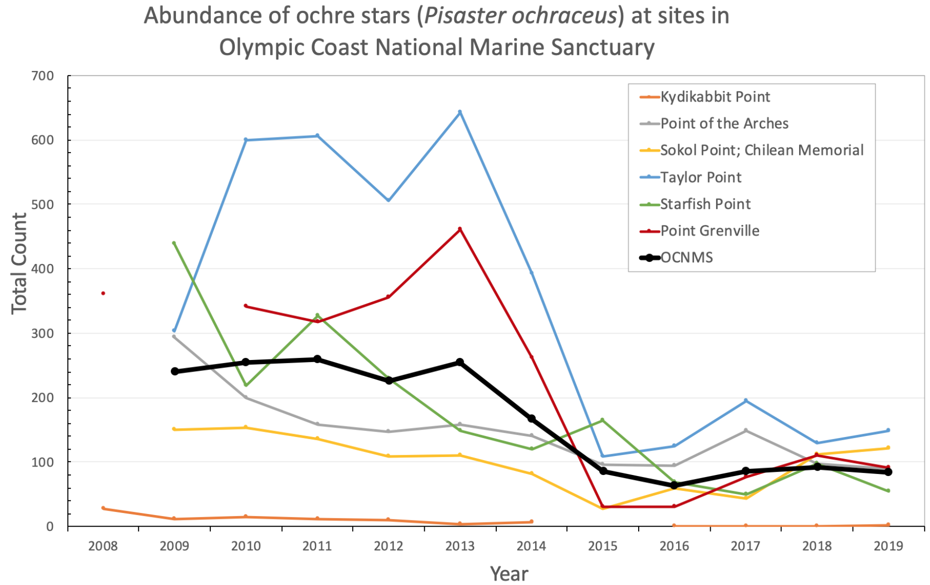

Figure S.LR.12.1. Abundance of *Pisaster ochraceus* in rocky shore habitats from 2009–2018/19 inside OCNMS. Source: MARINe, 2019; Image: J. Brown/NOAA

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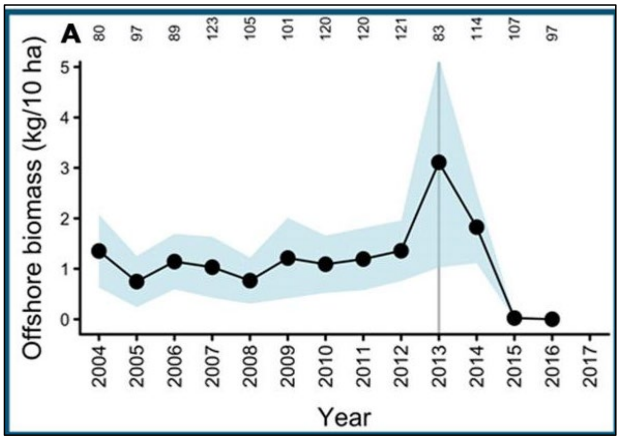

Figure S.LR.12.2. Mean biomass of *Pycnopodia helianthoides* calculated from NOAA NMFS deep trawls from 55-1280 m offshore Washington coast. The 95% confidence interval in light blue shading, and the gray line marks when seastar wasting disease began in 2013. Image: Harvell et al., 2019

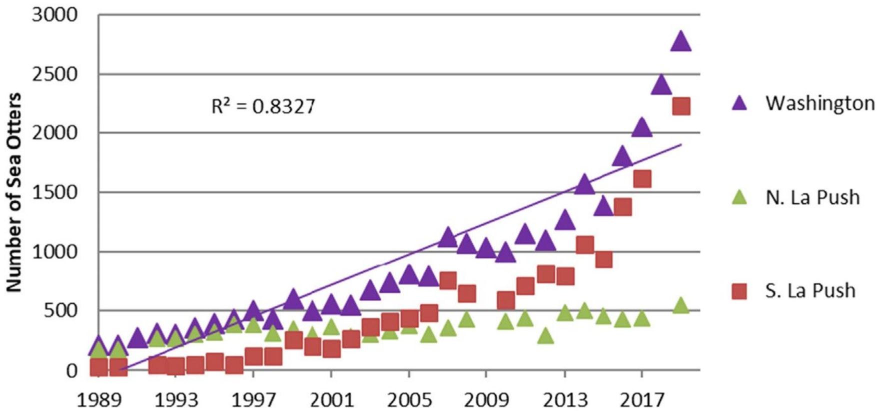

Figure S.LR.12.3. Uncorrected number of sea otters (from annual summer aerial surveys) in Washington, including areas north and south of La Push from 1989–2019. Line denotes the trend for Washington. Image: Jeffries et al., 2019

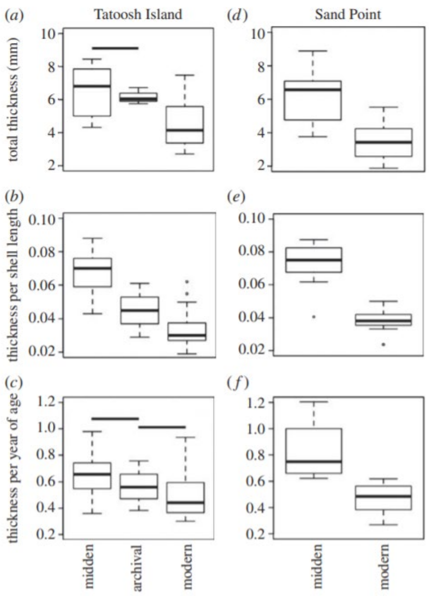

Figure S.LR.12.4. A comparison of California mussel relative shell thickness of modern (2009–2011, archival (1970s) and midden (radiocarbon dated 1000–1340) at two sites in Washington state: Tatoosh Island (a–c) and Sand Point (d–f); the total thickness (a,d), the thickness per shell length (b,e) and the thickness per year of age. Image: Pfister et al., 2016

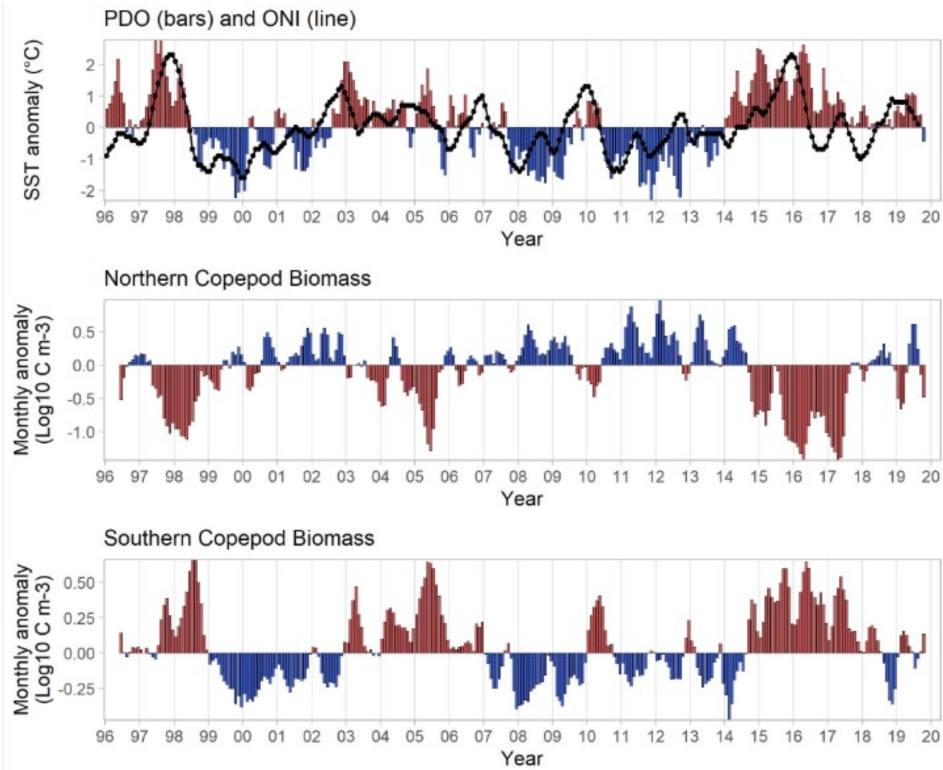

Figure S.LR.12.5. The Pacific Decadal Oscillation and ONI (upper), and monthly biomass anomalies of the northern (middle) and southern (lower) copepod taxa from 1969 to 2020 offshore of Newport, Oregon. Note that when SST is anomalously warm (i.e., PDO is +), northern copepod biomass is low (- anomaly) and southern copepod biomass is high (+ anomaly). Image: NOAA NWFSC, 2020

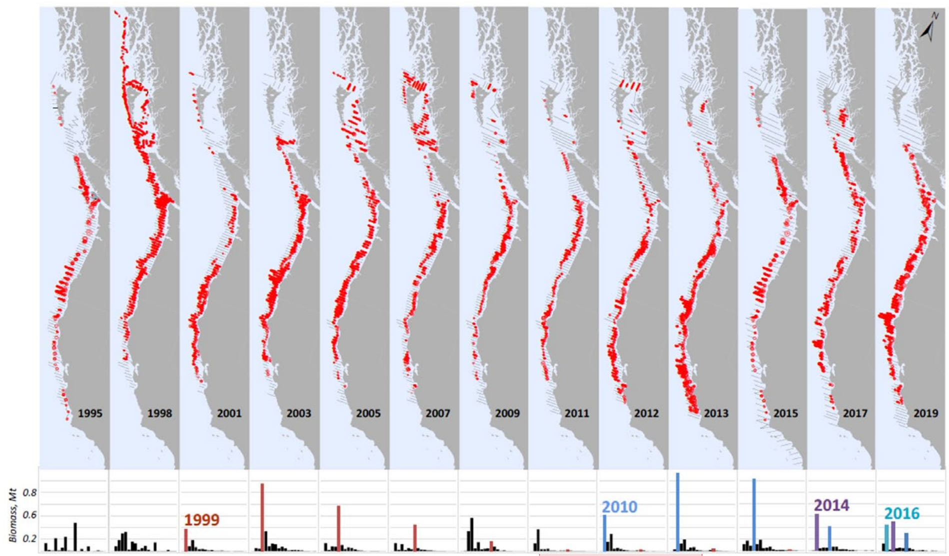

Figure S.LR.12.6. Spatial distribution of adult Pacific Hake (> than 2 years old) based on acoustic backscatter data. Image: Grandin et al., 2020; J. Clemons/NOAA

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Question 13: What is the status of other focal species and how is it changing?

Definition and Description

Status: Fair, Confidence - High; **Trend**: Undetermined, Confidence - High

Status Description: Selected focal species are at reduced levels, but recovery is possible.
Rationale: Since 2008, some focal species populations (e.g., razor clams, groundfish) are stable or have increased while others (e.g., Dungeness crab, chinook salmon, steelhead) and state and/or federal species of concern (e.g., eulachon, Southern Resident killer whale, humpback whale, fin whale, marbled murrelet, tufted puffin) have declined or remain critically endangered.

This question targets other species of particular interest from the perspective of OCNMS sanctuary management, Coastal Treaty Tribes, local partners and experts (~~Appendix~~ Table S.LR.13.1). These "focal species" (e.g., razor clam~~s~~, ~~d~~Dungeness crab~~s~~, salmon, groundfish, marine mammals, seabirds) may not be abundant or control ecosystem function, but their presence and health is important for the provision of economic, cultural, spiritual, recreational, ecological, and/or conservation-related values and services. Some species considered here are also threatened or endangered and are protected by state and/or federal laws. These species include: green sturgeon (*Acipenser medirostris*), eulachon (*Thaleichthys pacificus*), Southern Resident killer whales or SRKW (*Orcinus orca*), humpback whales (*Megaptera novaeangliae*), fin whales (*Balaenoptera physalus*), marbled murrelets (*Brachyramphus marmoratus*), and tufted puffins (*Fratercula cirrhata*).

In 2019, the status of other focal species in OCNMS is fair and the trend is undetermined, both with high confidence~~ (Table S.LR.13.1)~~. These ratings indicate that selected focal species are at reduced levels, but recovery is possible. The trend is undetermined because they are mixed; some focal species populations (e.g., razor clams, groundfish) are stable or have increased while other focal species (e.g., Dungeness crab, chinook salmon, steelhead, SRKW, marbled murrelet) have declined or remain critically threatened or endangered since 2008. Many of these species were also potentially impacted by the 2013–2014 marine heat wave, which is believed to have caused or contributed to persistent and widespread harmful algal blooms (HABs) and anoxic events offshore of Washington State. In some cases, population declines negatively impacted coastal communities and Coastal Treaty Tribes and were recognized as fisheries disasters.

Comparison to 2008 Condition Report

Since question 12 changed between 2008 and 2019, a direct comparison is not possible between the two condition report ratings. That said, the indicators used to develop the 2008 ratings for question 12 and 13 overlap with the indicators used to develop the 2019 rating for question 13. Specifically, in 2008, the status and condition of focal species were rated as fair and good/fair, respectively, with undetermined trends. These ratings were based on prevalence of disease in sea otters, and reduced abundances of selected focal species, including sea otters, common murres, and rockfish. The status of sea otter populations was also evaluated in 2019, but they were considered a keystone species and incorporated into the status for question 12. For question 13, the updated 2019 rating focused on several focal species, including rockfish and common murres, as well as other species of interest across all six habitats in OCNMS (see Table S.LR.12.1~~Table S.LR.13.2~~). Expert agreement was high for this question, and the availability of monitoring data helped increase expert confidence.

New Information in 2019 Condition Report

The 2019 status rating was based primarily on new information and expert opinions about known abundance changes among focal species since 2008. These changes occurred in all six habitats in OCNMS.

In pelagic habitats, important focal species include many wide-ranging marine animals such as seabirds--both residents that nest nearshore and forage in the pelagic zone, and seasonal visitors to the Olympic Coast--as well as salmonids, forage fish, and marine mammals. Data and information is introduced below to describe both positive (i.e. gray, fin, and humpback whales) and negative (i.e., Southern Resident Killer Whales) changes in the abundance of focal species of the pelagic zone, as well as highlight recent ecosystem perturbations that have resulted in unusual mortality events and increasing threats to animals that depend on the abundance and timing of the region's pelagic productivity.

In sandy beach habitats, the Pacific razor clam is an important focal species because it is harvested for subsistence, commercial, and recreational purposes. Razor clams are divided into pre-recruit (< 76 mm, below the preferable catch size), and recruit (>= 76 mm above the preferable catch size) populations. In OCNMS, razor clam populations have remained stable or have increased since 2008, with variability observed among years and sites. At Pt. Grenville and Mocrocks Beach, densities of recruits have been near the long term mean since 2008. Razor clam densities vary annually for both size classes, including large razor clam pre-recruit and recruit densities in 2010, 2014, and 2015 (Figure S.LR.13.1; Appendix Figure S.LR.13.1). At Kalaloch Beach, pre-recruit razor clams were abundant in 2015, 2017, and 2019 (Figure S.LR.13.2). Another sandy beach shellfish, the purple olive snail (*Olivella biplicata*), is important to the Makah Tribe for cultural and ceremonial reasons. In Makah Bay, purple olive snail populations have remained stable since 2008, despite a mass mortality event in June 2014 (Akmajian et al., 2017). Although the cause of this mortality event is still unknown, subsequent field surveys have shown that the Makah Bay olive snail population recovered from the event (Appendix Figure S.LR.13.2; Akmajian et al., 2017).

In sandy seafloor and deep seafloor habitats, Dungeness crab~~s~~ (*Cancer magister*) support an important fishery on the northern Washington coast. In deep seafloor habitats (55 to 1280 m), Dungeness crab stocks (CPUE) have not changed (compared to their long term means) and are increasing inside OCNMS (Figure S.LR.13.3). However, these deeper, offshore areas are not routinely fished by the Coastal Tribal communities. Tribal fishing grounds are generally closer to shore and in shallower (<55 m) habitats. Since 2008, Dungeness crab harvests in these shallow sandy seafloor habitats have not changed south of Point Grenville, but have declined significantly north of there. Recent harvests (2014–2019) north of Point Grenville were lower than from 2000–2013 (Figures S.LR.13.4) because of persistent seasonal hypoxic conditions and a massive and persistent toxic harmful algal bloom (HAB). This bloom closed the Dungeness crab fishery in order to protect human health. Consequently, a fisheries disaster was declared by the Department of Commerce in 2017 (NOAA NMFS, 2017) at the request of the Quileute Tribal Council (Woodruff, 2016). Please see question 7 for more detail.

In addition to Dungeness crab~~s~~, groundfish are an important fishery in sandy and deep seafloor habitats on the northern Washington coast. Some groundfish stocks were overfished pre-2008 but they have since been largely rebuilt (Table S.LR.13.~~2~~1). Groundfish CPUE has remained stable since 2008 with recent means within one standard deviation of long term means (Figure S.LR.13.5). The 10-~~-~~year trend is flat for groundfish CPUE. The status is the same for specific key groups of groundfish, including rockfish (Figure S.LR.13.6), flatfish (Appendix Figure S.LR.13.3), roundfish (Appendix Figure S.LR.13.4), and sharks and skates (Appendix Figure S.LR.13.5) in OCNMS. Expert opinion is that groundfish stocks are sustainably managed by the

Pacific Fishery Management Council and its partner entities. This opinion is supported by status and trends for individual species, including lingcod (*Ophiodon elongatus*), bocaccio (*Sebastes paucispinis*), and yelloweye rockfish (*Sebastes ruberrimus*). Specifically, recent mean abundances for these groundfish species have been within one standard deviation of their long term means. Their 10- year trends vary, with lingcod showing a decreasing trend (Sampson et al., 2017), yelloweye showing no trend (Gertevesa & Cope, 2017), and bocaccio showing an increasing trend (Appendix Figures S.LR.13.6-8). Bocaccio, while less common in Washington coastal waters, is included here because it is a conservation success story and example of how some groundfish stocks are rebounding from overfishing.

Steller sea lions (*Eumetopias jubatus*) and California sea lions (*Zalophus californianus*) are present in OCNMS. The focus here is on Steller sea lions because they are present and breed in Washington state year round, unlike California sea lions. Since 1989, Steller sea lion populations have increased in Washington state (Pitcher et al., 2007). Protections implemented during and after the 1970s have resulted in a period of sustained population growth in the eastern portion of their range, including the Washington coast (Wiles, 2015). As of 2019, Steller sea lion abundances are at all time high in OCNMS since monitoring began in 1989, and their abundances are continuing to increase (Figure S.LR.13.7; Wiles, 2015). Nine haulouts are located inside the sanctuary; however, OCNMS does not support any recognized rookeries (i.e., >50 pups born per year) (Wiles, 2015).

Also in rocky shore habitats, seabird populations are considered indicators of ecosystem health because they connect the land and ocean. The common murre (*Uria aalge*) is one such seabirds species that nests on coasts and islands, and favors cool ocean waters for foraging. Since 2008, common murre abundances have has increased, although they still remain below historical levels. From 1996–2015, common murre abundances at Washington colonies hassve increased by 8.8% annually. Northern colonies (White Rock to Quillayute Needles) increased by 11% per year, and are now larger than southern Washington colonies. Varying rates of increase have been observed at sites inside OCNMS, with the highest rates observed at sites from White Rock to the Bodelteh Islands. (Figure S.LR.13.8; Thomas & Lyons, 2017). The common murre nesting aggregation on Tatoosh Island has also grown since 1998, and is one of the larger nesting aggregations in Washington state (Thomas & Lyons, 2017). Although common murre abundances are is increasing, an unusual mortality event (UME) occurred in 2015–2016, potentially due to the 2014–2016 marine heat-wave (Appendix Figure S.LR.13.9; Gibble et al., 2018; Piatt et al., 2020). Over 62,000 common murres washed ashore from California to Alaska during this UME. Roughly 900 (mainly newly fledged) birds washed up on the shores of northern Washington (Piatt et al., 2020), and it is likely many more died but their carcasses did not make it onshore. Although many birds died, this UME did not appear to significantly impact the size of breeding colonies size, which continued to increase during this time period.

In pelagic habitats, the abundance and mortality of other focal seabird species have remained stable or declined since 2008. Cassin's auklet (*Ptychoramphus aleuticus*) have remained stable since 2008 compared to their long- term mean (Appendix Figure S.LR.13.10). While their abundances are is stable and there is no 10-year trend, Cassin's auklet did experience a UME in 2014 (Appendix Figure S.LR.13.11; Jones et al., 2017). Abundances of other focal seabird species, like the tufted puffin (*Fratercula cirrhata*) and marbled murrelet (*Brachyramphus marmoratus*), have decreased compared to long-term means in northern Washington (Figure S.LR.13.9, Figure S.LR.13.10). Both species are of particular concern because marbled murrelets are federally threatened (McIver et al., 2019), and tufted puffin populations are below the threshold for long-term viability (Hanson et al., 2019). These focal seabird species also still

Commented [6]: Already discussed above. Once the scientific names is used stick with the common name for broader readability.

Commented [7]: Tufted puffins are also state listed as endangered.

face a range of threats and challenges to their recovery in northern Washington (WA DNR, 2020; Hanson et al., 2019).

Pacific salmon and steelhead stocks are also facing a range of threats. These fish are critically important species for subsistence, recreational, and cultural purposes in Washington. Their stocks are managed individually, run by run and river by river, by state and tribal agencies. Since 2008, some salmon and steelhead stocks have declined in pelagic habitats along the northern Washington coast. In 2015 and 2016, disasters were declared for ocean salmon fisheries at the request of the state of Washington and the Makah, Hoh, Quinault, Quileute, Stillaguamish, Nooksack, Muckleshoot, Upper Skagit, and Suquamish Tribes (NOAA NMFS, 2018). These fisheries disasters resulted in millions of dollars in lost income for local communities. As of 2018, six stocks of Chinook and chum salmon were trending upwards; 56 stocks of chinook, chum, sockeye, coho and steelhead were stable; and 19 stocks of Chinook, coho and steelhead were trending downwards (WARCO, 2018a). Population data for these 81 stocks can be viewed online (WARCO, 2018b) to better understand unique temporal trends and challenges for each stock river by river and run by run. One stock important to note here is the Quinault blueback (sockeye) salmon. This stock is critical to the Quinault Tribe, and run sizes have decreased compared to pre-2008 levels (Figure S.LR.11a; Quinault Tribe, 2019; Nuggam, 2019). In 2019, the Quinault Department of Fisheries closed the blueback fishery because of two years of consecutive, historically low returns of spawning adults to the Quinault River (Brucas, 2019). Overall, Chinook salmon abundance on the Washington coast (north of Cape Falcon, Oregon) increased from ~~between~~ 2008–2016 (with a decline in 2016 likely linked to the marine heatwave); this includes runs from the Columbia River, Puget Sound, and other rivers in Oregon and California (Figure S.LR.11b; PFMC, 2020).

Another focal fish species, eulachon (*Thaleichthys pacificus*), has declined since 2008 and was listed as threatened under the Endangered Species Act in 2010. Eulachon ~~(like salmon)~~ are an anadromous species that return to rivers in schools to spawn. They have been traditionally harvested by coastal tribes and are a prized recreational species. Since its listing, eulachon abundances vary by year and among rivers. In 2007–2012, eulachon densities (and bycatch by the pink shrimp fishery) increased (Ward et al., 2015); however from ~~between~~ 2011–2018, the estimated number of spawning eulachon has not changed, and there is no consistent trend on the Washington coast (Appendix Figure S.LR.13.12; Langness et al., 2018). eDNA is beginning to be used to assess and monitor upriver spawning of eulachon.

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Although some focal species are depleted or in decline, other focal species in pelagic habitats in OCNMS have remained stable or increased since 2008. In particular, all marine mammal species that use ~~the~~ OCNMS, with the exception of SRKW~~Southern Resident killer whales (*Orcinus orca*)~~, had either positive growth or stable population sizes since 2008 (Appendix Figure S.LR.13.13-17; Nadeem et al., 2016; Becker et al., 2019). These include gray whales ~~(*Eschrichtius robustus*)~~, fin whales ~~(*Balaenoptera physalus*)~~, and humpback whales ~~(*Megaptera novaeangliae*)~~. Some feed in OCNMS, while others transit through the sanctuary during their north- and south-~~-~~bound migrations. Although these populations are stable or increasing, they still face multiple threats ranging from ship strikes to changing environmental conditions. Notably, gray whales are experiencing a UME ~~an unusual mortality event~~ throughout their range (Appendix Figure S.LR.13.18; NOAA NMFS, 2019). The Pacific Coast Feeding Group is a small subset of gray whales that do not make the full migration to the feeding grounds in Alaska and instead feed along the Pacific Coast between northern California and northern British Columbia. Body conditions of the Pacific Coast Feeding Group were assessed using photographs from 1996–2013 from northern Washington (Akmajian et al., 2020). Their body condition reflects things like reproductive status and food availability and ecosystem productivity over their feeding range. The previous 10 years (1998–2008) had a similar mean condition to the more recent years (2009–2013), although there were a few years of lower than normal condition (Akmajian et al., 2020). The recovery of SRKW remains a concern in northern Washington since their designation as endangered in 2005. Their abundance has remained stable compared to the long--term mean, but their 10--year population trend indicates declining abundance (Figure S.LR.13.14; Ruggerone et al., 2019). This species also faces several threats, including environmental contaminants, low prey abundance, sound pollution, and vessel disturbance, and remains in danger of extinction (NOAA, 2020). SRKWs have been observed along the coasts of Washington and Vancouver Island more in recent years.

Conclusion

In OCNMS, the 2019 status of focal species is fair and the trend is undetermined, both with high confidence. The stability, recovery, or increases in razor clams, groundfish, and specific marine mammal populations were positive signs for focal species in and around OCNMS. Declines in the Dungeness crab fishery catch north of Pt. Grenville and several salmonid stocks, including the Quinault blueback, are cause for concern. Associated fFisheries disasters associated with these declines caused millions of dollars in lost revenue for Washington Coastal Treaty Tribes and Washington coastal communities.

While the availability of monitoring data helped increase confidence in these ratings, there were data and analysis gaps identified during the expert workshops. Specifically, analysis gaps existed in the deep seafloor habitat (> 30 m depths) for biogenic invertebrates, green sturgeon, Pacific cod, and Pacific hake, as well as in the pelagic habitat for mid-water rockfish, other marine mammals, and other seabirds. Data gaps also existed for focal species in the sandy beach habitat (i.e., decapods, isopods, amphipods, shorebirds), in the rocky shore habitat (i.e., black oystercatchers, Pacific harbor seals (*Phoca vitulina richardii*), resident colonial seabirds), in the sandy seafloor habitat (i.e., flatfish, benthic invertebrates), in the deep (>30 m) seafloor habitat (benthic invertebrates, shrimp, shad), and in the pelagic habitat (sea turtles). In kelp forest habitats, there was more monitoring than in other habitats, although this was limited to recent years (2015–2019). Longer--term data are needed to establish trends for focal species like red sea urchins (*Mesocentrotus franciscanus*), black rockfish (*Sebastes melanops*), and striped surfperch (*Embiotoca lateralis*) (Appendix Figure S.LR.13.19-21).

Climate change, including marine heat-waves, poses a major concern for many focal species. Dramatic changes in organism abundances were documented during the 2014 marine heat wave (Morgan et al., 2019). These changes in abundance were due to organisms moving from south to north or from east to west. While these shifts were temporary, longer-term distribution shifts may result in novel trophic interactions with unpredictable ecological results (Naiman et al., 2012). Changes in animal distributions also pose challenges for living marine resource managers in particular, including at OCNMS. Consequently, there is a strong need for projections of how species might be impacted by and respond to future environmental changes during the 21st century (Morely et al., 2018).

Question 13 Tables

Table. S.LR.13.1. 2008 (left) and 2019 (right) status, trend and confidence ratings for question 13 and for the living marine resource questions.

Questions		2008 Rating		Questions		2019 Rating			
						Status	Confidence	Trend	Confidence
12/13	Key Species Status/Condition	?	?	12	Keystone & Foundation species	Fair	Medium	?	High
				13	Other Key Species	Fair	High	?	High
11	Non-indigenous Species	▼		14	Non-Indigenous Species	G/F	High	▼	High
9	Biodiversity	?		15	Biodiversity	G/F	Low	–	Medium

Table S.LR.13.12. Rebuilt groundfish and salmon stocks offshore of the continental U.S. West Coast as of December 2019. Image: NOAA NMFS, 2019

Rebuilt Stocks	Year Rebuilt
Pacific whiting	2004
Lingcod	2005
Chinook salmon, Klamath (fall)	2011
Widow rockfish	2011
Coho salmon, Queets	2011
Coho salmon, W. Strait of Juan de Fuca	2012
Chinook salmon, Sacramento (fall)	2013
Canary rockfish	2015
Petrale sole	2015
Bocaccio	2017
Darkblotched rockfish	2017
Pacific Ocean Perch	2017
Cowcod	2019

~~Appendix~~ **Table S.LR.13.12**. Status and trends for individual question 13 indicators discussed at January 2020 Workshop. There are no confidence scores for individual indicator status and trends. Asterisk indicates that the indicator was added after the January 2020 workshop.

Indicator	Source	Habitat	Data Summary	Figures

Commented [9]: Indicator tables were included in-document in the other sections

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Razor Clams (Density, Recruitment)	Quinault Tribe, 2019; WDFW, 2019; ONP, 2019	Sandy Beach	**(Pt Grenville) Status:** Interannual variability for both size classes. Recent densities of large size class at or above long-term mean ●. **Trend:** No clear recent trend ↔ **(Kalaloch) Status**: Interannual variability in densities of both size classes; **Trend:** No trend ↔ **(Mocrocks) Status:** Razor clam densities 2008-2019 at or above densities observed 1997-2007 ●; **Trend:** No clear recent trend ↔	(Pt. Grenville) S.LR.13.1 ; (Kalaloch) S.LR.13.2 ; (Mocrocks) Appendix S.LR.13.1
Olive Snails (Density)	Akmajian et al., 2017	Sandy Beach	**Status:** Mass mortality in June of 2014 in Makah Bay. Subsequent surveys (2015 to 2017) indicated apparent recovery of the population at site ●. **Trend:** Recent increase/recovery ↑	Appendix S.LR.13.2
Crabs - Dungeness (CPUE) 55 - 1280 m depths**	NOAA NWFSC, 2018; NOAA CCIEA, 2019	Deep Seafloor	**Status**: Recent mean similar to long-term mean ● in 55-1280 m depths. **Trend**: Dungeness CPUE increasing ↑ in 55-1280 m depths.	S.LR.13.3
Crabs - Dungeness (Metric Tons) < 55 m depths	Quinault Tribe, 2019; WDFW, 2019	Sandy Seafloor & deep seafloor	**Status:** Dungeness crab harvests 2014-2019 lower (-) than 2000-2013 in depths <55 m. **Trend**: Dungeness crab harvests declined ↓ since 2005 north of Pt. Grenville in depths <55 m. Harvests south of Pt. Grenville unchanged ↔ in depths <55 m.. Crab disasters declared in number recent years + domoic acid issues.	S.LR.13.4
Groundfish - Rockfish, Flatfish, Roundfish, Sharks/Skates (CPUE)	NOAA NWFSC, 2018; NOAA CCIEA, 2019	Deep Seafloor	**Status:** *All groups:* Recent mean similar to long-term mean ● for all groups. Generally noted that groundfish are sustainably managed so doing well. **Trend**: *All groups:* No trend ↔ in CPUE	Table S.LR.13.12, Figures S.LR.13.5-6; Appendix S.LR.13.3-5
Roundfish/ Rockfish - Lingcod, Bocaccio, Yelloweye (CPUE)	NOAA NWFSC, 2018; NOAA CCIEA, 2019	Deep Seafloor	**Status**: *All:* Recent levels within variability observed over time ● (data from yelloweye may be suspect because of low sample size) **Trend**: Decreasing ↓ trend for lingcod. Increasing trend ↑ for bocaccio. No clear trend ↔ for yelloweye.	Appendix S.LR.13.6-8
Pinnipeds - Steller sea lions, California sea lions*, Harbor seals (Counts)	WDFW, 2019	Pelagic, Sandy Beach, Rocky Shore	**Status:** *Steller sea lions:* Abundances at all time high (+) in OCNMS since 1989; *Pacific harbor seals***:** 2014 count similar to long-term mean ●. Also worth noting, northern elephant seals increasing (+), Guadalupe fur seals increasing (+) although UME 2019. **Trend**: *Steller sea lions:* increasing ↑ abundances in OCNMS; *Pacific harbor seals***:** No 10 year trend ↔.	(Stellar sea lions) S.LR.13.7; (Harbor seals) Appendix S.LR.13.13
Common Murres (Abundance,	Thomas & Lyons, 2017; COASST, 2020	Rocky Shore	**Status**: Increased (+) abundance at breeding colonies but still below historic levels **Trend**: Increasing ↑ from 2008–2015. UME in 2015 and	S.LR.13.8; Appendix S.LR.13.9

Encounter Rates)			2019.	
Seabirds - Tufted Puffin, Marbled Murrelet, Cassin's Auklet, Pink footed shearwater* (Density, Encounter Rates)	Hanson et al., 2019; McIver et al., 2019; COASST, 2020; NOAA CCIEA, 2019	Pelagic	**Status**: *Tufted Puffin*: Listed as endangered by state. Populations below (-) threshold for long term viability; *Marbled Murrelet*: Listed as endangered by state and threatened federally. Reduced (-) densities at-sea. Listed as threatened at federal and state levels.. *Cassin's Auklet*: Mean similar to long-term mean ● for density/mortality. **Trend**: *Tufted Puffin:* decreasing ↓ sightings; *Marbled Murrelet:* decreasing ↓ densities; *Cassin's Auklet*: No trend ↔ for density or encounter rates (UME in 2014); Also worth noting that *Rhinoceros auklet* had UMEs 2012, 2017, 2020.	S.LR.13.9-10; Appendix S.LR.13.10-11
Salmonids - Salmon, Steelhead, Blueback (Condition, Status, Run Size)	WARCO 2018a, 2018b; Quinault Tribe, 2019; Nuggam, 2019	Pelagic	**Status**: Overall, 56 stocks stable. 6 stocks trending up. 19 stocks trending down. **Trends:** Salmonid stocks managed river by river, run by run. Overall, no trend ↔. Blueback run size decreasing ↓ and fishery closed early in 2019. Chinook populations North of Cape Falcon are increasing ↑ since 2008.	S.LR.13.11a, S.LR.13.11b
Eulachon (Spawning numbers)	Langeness et al., 2018	Pelagic	**Status:** Listed as federally threatened in 2010. No change ● **Trend**: Abundances vary river by river and year by year. No trend ↔	Appendix S.LR.13.12
Cetaceans SRKW, Gray, Humpback, Fin (Abundance)	CCIEA, 2019; Scordino et al., 2017; Carretta et al., 2020; Nadeem et al., 2016; Calambokidis et al., 2017; Becker et al., 2019	Pelagic	**Status:** SRKW, Humpback and Fin whales listed as endangered by state and federally. *SRKW*: Recent mean similar to long-term mean ●; *Gray:* Above mean (+); *Humpback*: Above mean (+); *Fin*: Above mean (+) **Trend**: *SRKW*: decreasing ↓?; *Gray*: Stable ↔ (although UME in 2019); *Humpback:* stable ↔; *Fin*: stable ↔	(SRKW) S.LR.13.12, (Gray, Fin, Humpback) Appendix S.LR.13.14-18
Sea urchins, red (Density)	NOAA NWFSC, 2019	Kelp Forest	**Status:** Undetermined. No data available prior to 2015 for comparison. **Trend:** Same as above.	Appendix S.LR.13.19
Kelp Fish Assemblage black rockfish, striped surfperch (Abundance)	NOAA NWFSC, 2019	Kelp Forest	**Status**: *All:* Undetermined. No data available prior to 2015 for comparison. **Trend**: *All:* Same as above. However, important to note that black rockfish are in low abundance in southern region (J. Schumacker, pers.com)	Appendix S.LR.13.20-21

Data Gaps	Sandy Beach, Rocky Shore, Sandy Seafloor, Deep Seafloor, Pelagic	(Sandy Beach) decapods, isopods, amphipods, shorebirds; (Rocky Shore) pinnipeds, black oystercatcher, colonial seabirds; (Sandy Seafloor) flatfish, benthic invertebrates; (Deep Seafloor > 30m) shelled benthos, shrimp, shad; (Pelagic) sea turtles	-
Analysis Gaps	Deep Seafloor, Pelagic	(Deep Seafloor > 30 m) biogenic invertebrates, green sturgeon (listed as federally threatened), Pacific cod, Pacific hake; (Pelagic) mid-water rockfish, other marine mammals, Pink footed shearwater, other seabirds	-

*Indicates species not discussed at the January 2020 workshop. These species were suggested by experts during the June 2020 review period and were added after additional consultations with OCNMS.

**Because NMFS sampling is conducted in waters deeper than 55m, it does not provide abundance estimates for the nearshore populations frequently targeted by tribal and non-tribal fishers. For this reason, companion data describing nearshore catch in <55m is provided in figure 13.4.

Question 13 Figures

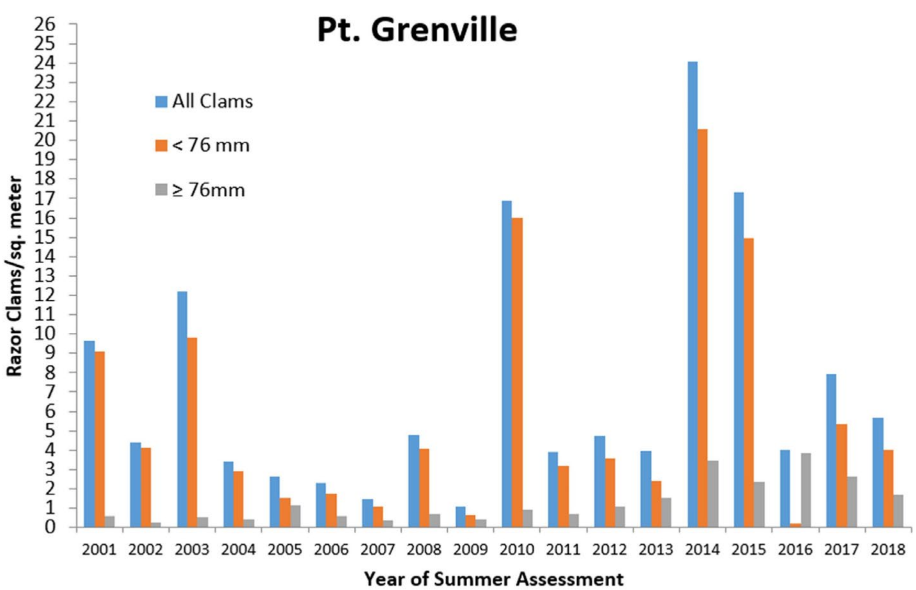

Figure S.LR.13.1. Average estimated summer density (clams per sq m) of razor clam recruits (>=76 mm) and pre-recruits (<76 mm) from 2001–2018 for Point Grenville, an important tribal harvest area within the 23 miles of coastline encompassed by the reservation of the Quinault Indian Nation. Population estimates are based on transect densities that are averaged and then expanded across the estimated habitat available on each beach; error estimates have not been calculated. Source: Quinault Indian Nation, 2019; https://docs.google.com/document/d/1yfkz6k4HkONK7m_sgaZnaqwepLsVhnNnizmKL_IRrLU/edit?usp=sharing Image: J. Schumaker/Quinault Tribe.

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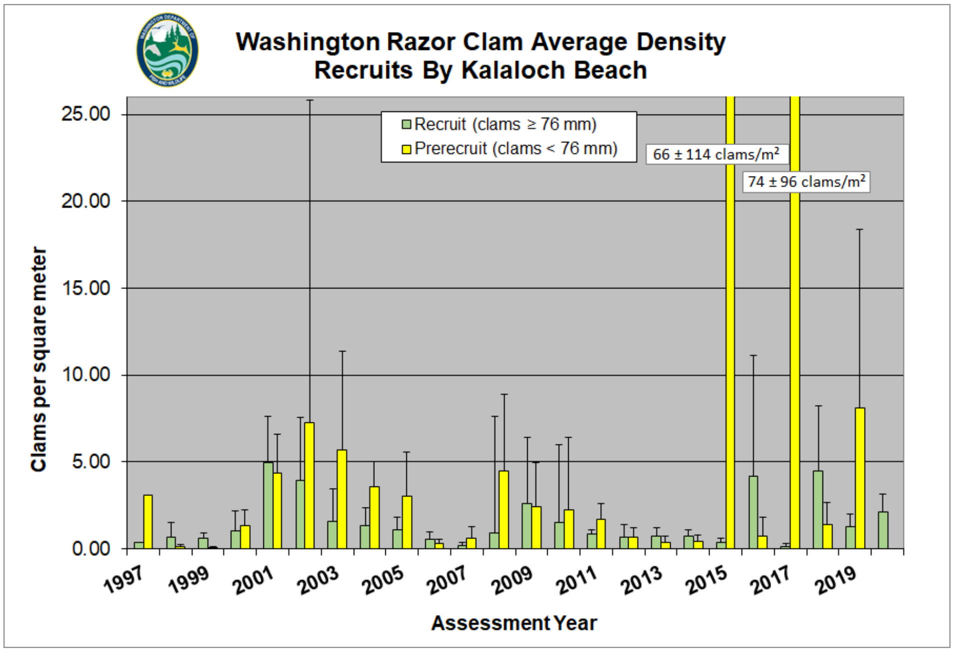

Figure S.LR.13.2. Average density (clams per sq m) of razor clam recruits and pre-recruits at Kalaloch Beach from 1997–2019. The Kalaloch razor clam management beach lies between Olympic National Park South Beach Campground and Brown's Point. Pre-recruits are below the preferable catch size and recruits are above the preferable catch size. Source: WDFW; ONP, 2019; Image: D. Ayres/WDFW

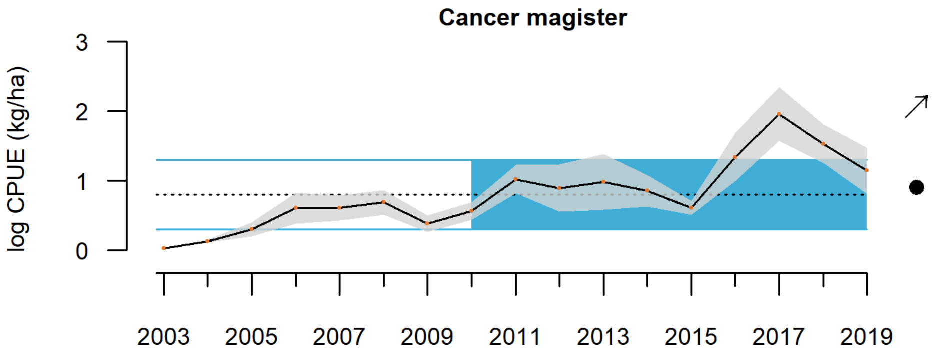

Figure S.LR.13.3. Log CPUE for Dungeness crabs (*Cancer magister*) from 2003-2019 in OCNMS in 55 - 1280 m depths. Black circle denotes that the 10-year mean (2010–2019) is within one standard deviation of the long term mean. The upward arrow denotes an increasing 10-year trend. Because NMFS sampling is conducted offshore, it does not provide abundance estimates for the nearshore populations frequently targeted by tribal fishers. For this reason, companion data describing nearshore catch in <55m is provided in figure 13.4. Source: NOAA CCIEA, 2021; Image: G. Williams/NWFSC.

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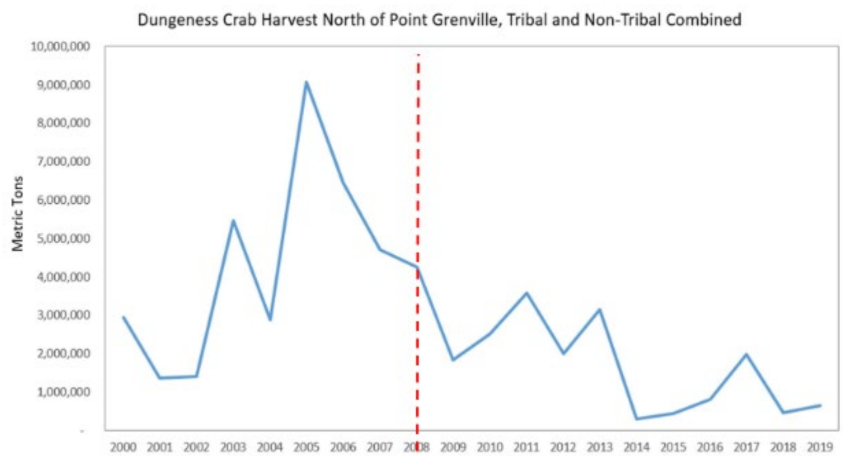


Figure S.LR.13.4. Dungeness crab harvest (in metric tons) from 2000–2019 from Point Grenville to Cape Flattery in <55 m depths. Counts reflect tribal and non-tribal harvest data combined. The vertical line at 2008 marks the beginning of the assessment period for this report. Source: WDFW, 2019; Quinault Indian Nation, 2019; Image: J. Schumacker/Quinault Indian Nation.

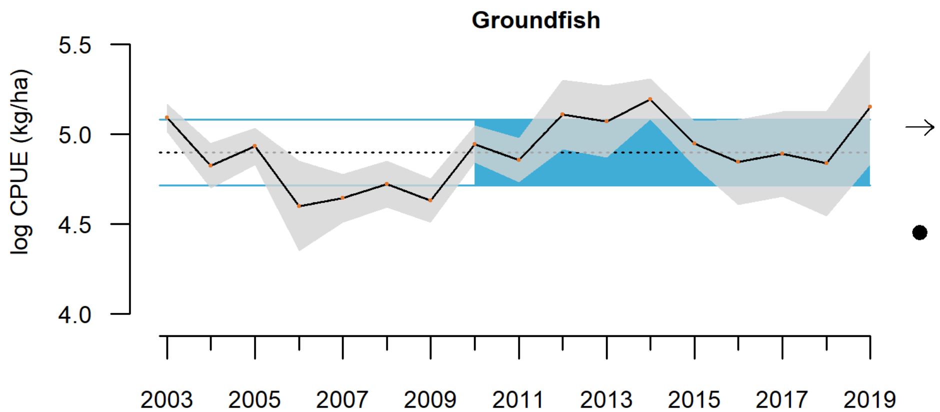
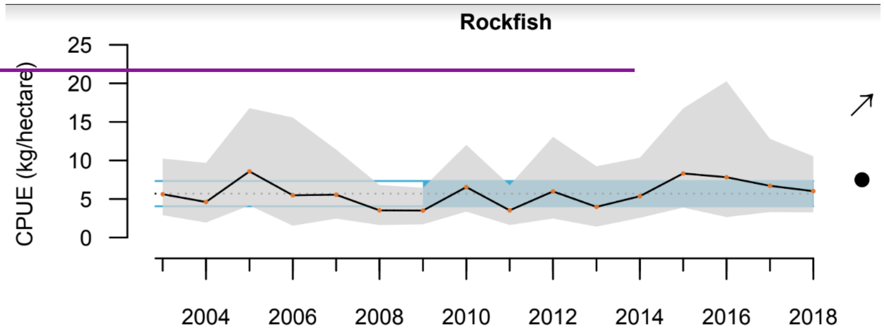


Figure S.LR.13.5. Log CPUE for groundfish, including rockfish, flatfish, roundfish, and sharks/skates, from 2003–2019 in OCNMS. Black circle denotes that the 10-year mean (2010–2019) is within one standard deviation of the long term mean. The horizontal arrow denotes a flat 10-year trend. Source: NOAA CCIEA, 2021; Image: G. Williams/NWFSC.



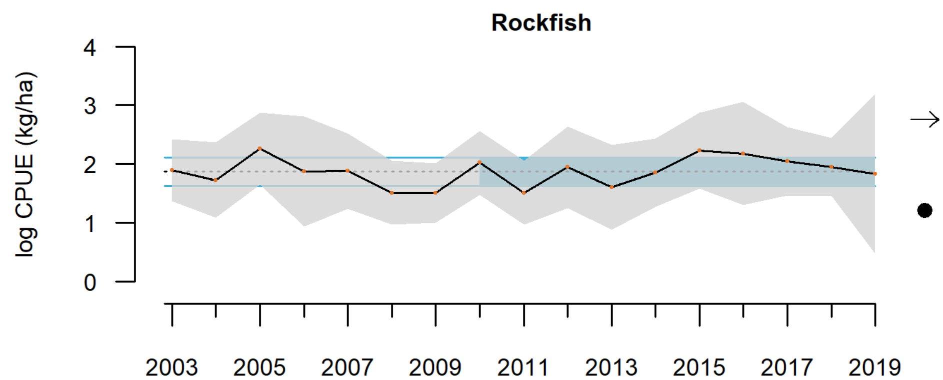


Figure S.LR.13.6. Rockfish catch per unit effort (CPUE) inside OCNMS from 2003–2019. Black circle denotes 10-year mean within 1 standard deviation of long term mean. The horizontal arrow denotes a flat 10-year trend. Source: NOAA NWFSC, 2018; Image: G. Williams; NOAA CCIEA, 2019

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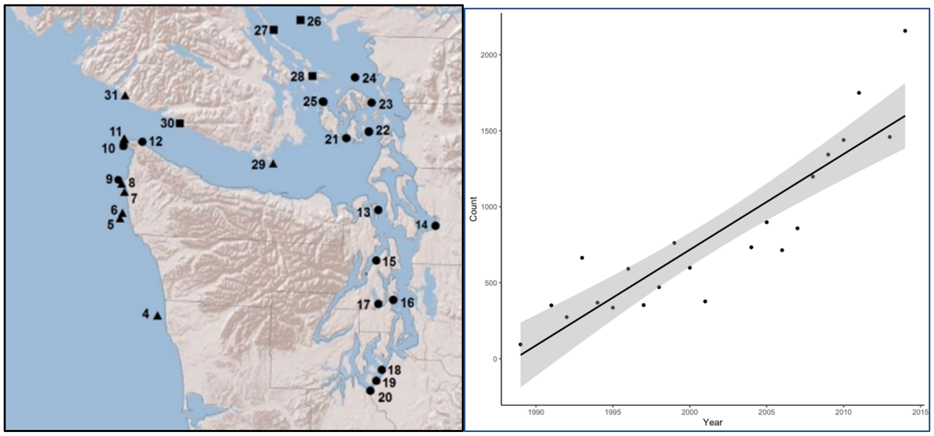

Figure S.LR.13.7. Location of Steller sea lion haulouts on the Olympic peninsula (left). Sites 4–12 are located inside OCNMS. Symbols denote haulouts with annual maximum numbers of >100 animals (triangles), <= 100 animals (circles) and those with no information (squares). Number of Steller sea lions ~~(*Eumetopias jubatus*)~~ counted during breeding season (June-July surveys) in OCNMS 1989–2013 (right). Source: WDFW, 2019; Image: S. Colosimo and S. Jeffries/WDFW

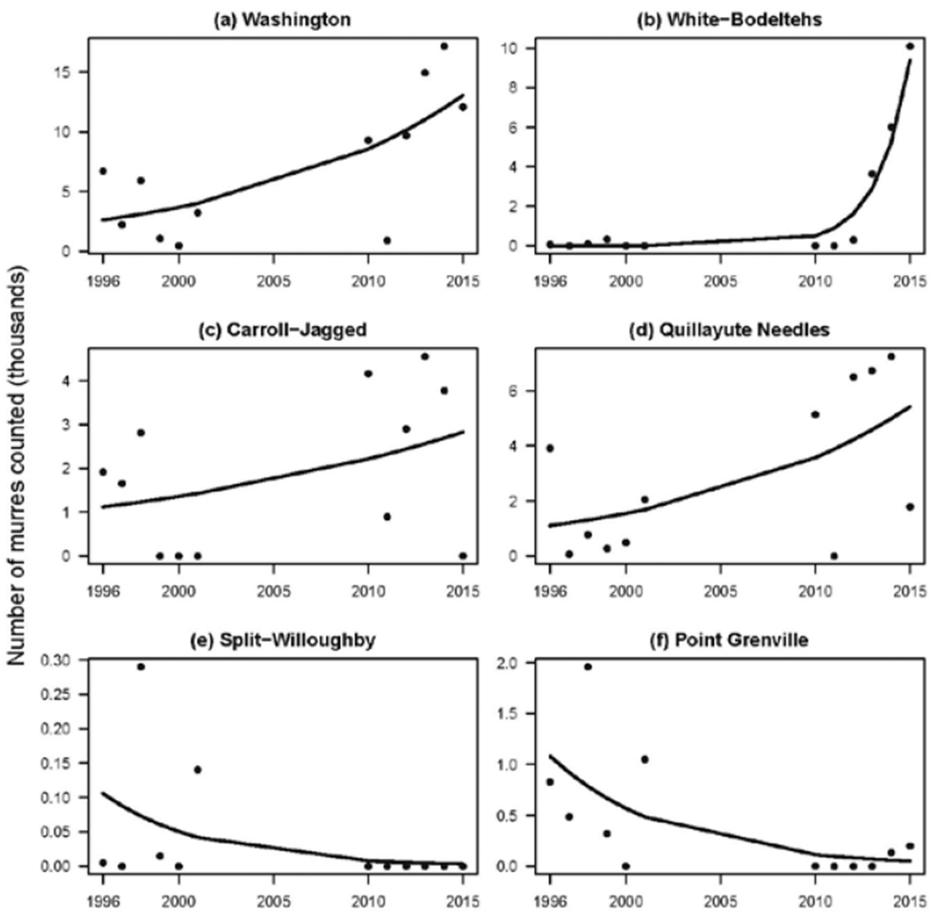

Figure S.LR.13.8. Whole-colony counts for common murres from 1996–2015 (except Tatoosh Island) in (a) Washington state and (b–d) northern Washington state (i.e., White-Bodeltehs, Carroll-Jagged and Quillayute Needles). Solid line in each panel is the trend in colony counts. Image: Thomas & Lyons, 2017

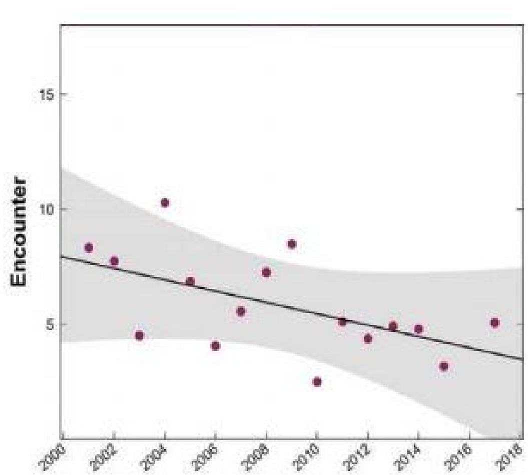

Figure S.LR.13.9. Encounters (birds/km) of tufted puffins ~~(*Fratercula cirrhata*)~~ during summer (May–July) at-sea surveys between Cape Flattery and Pt. Grenville from 2001–2018. Image: Hanson et al., 2019

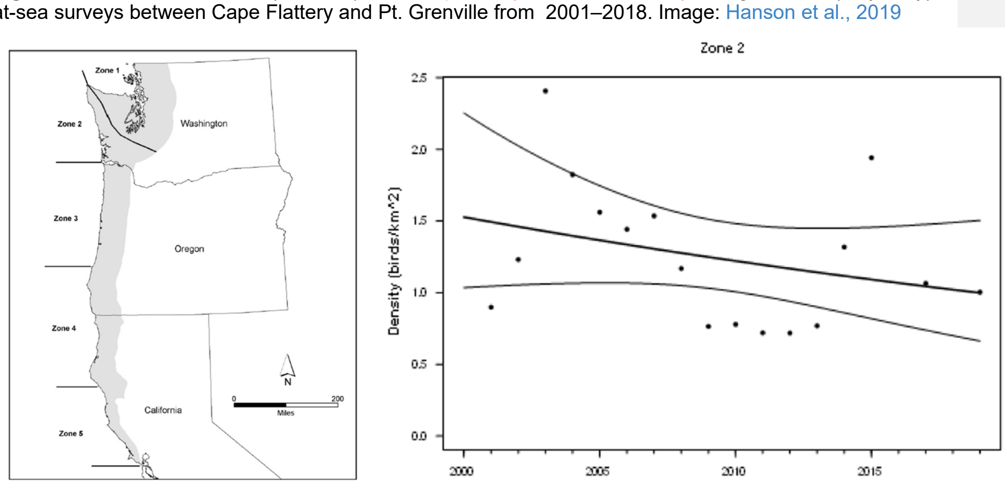

Figure S.LR.13.10. Marbled murrelet ~~(*Brachyramphus marmoratus*)~~ densities (birds/km^2) along the Washington coast (Zone 2, map left) from 2000-2019. Figure Credit: McIver et al., 2019

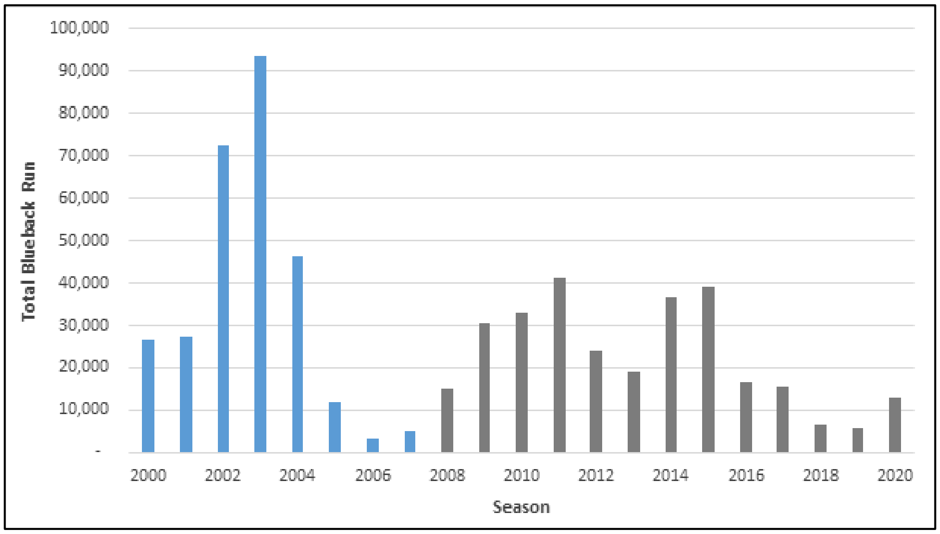

Figure S.LR.13.11a. Estimated Quinault blueback (sockeye) salmon run sizes from 2000–2020 highlighting the 2008-2020 assessment period for this report. The Quinault blueback salmon fishery was closed prior to each season in 2018, 2019, and 2020 because of historically low returns of wild adult salmon to the Quinault River following extremely poor ocean conditions beginning in 2014. Source: Larry Gilbertson, Quinault Indian Nation, 8 Jan 2021.

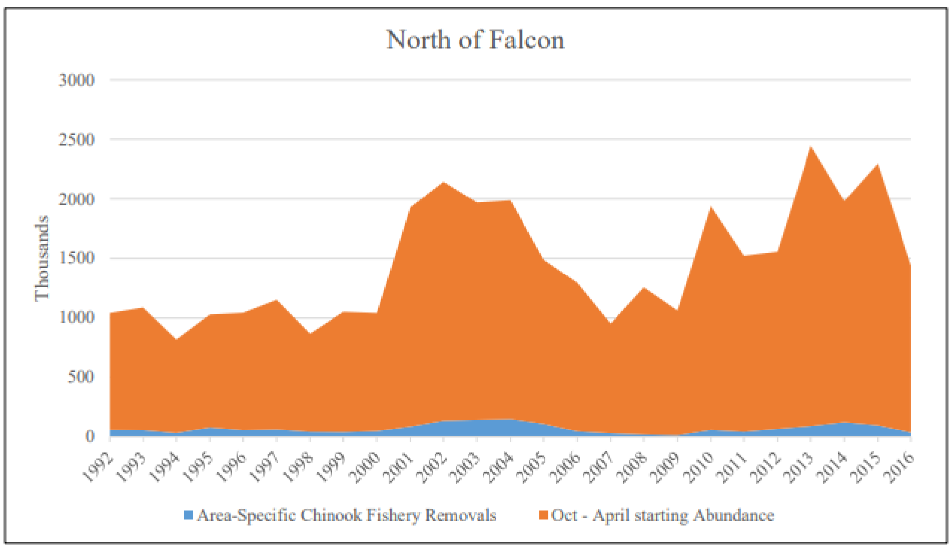

Figure S.LR.13.11b. North of Cape Falcon, Oregon trends in annual adult Chinook abundance (estimated annually to be present on October 1) and area-specific reduction in adult Chinook abundance modeled to result from all PFMC salmon fisheries (from October through the following September). Image: PFMC, 2020

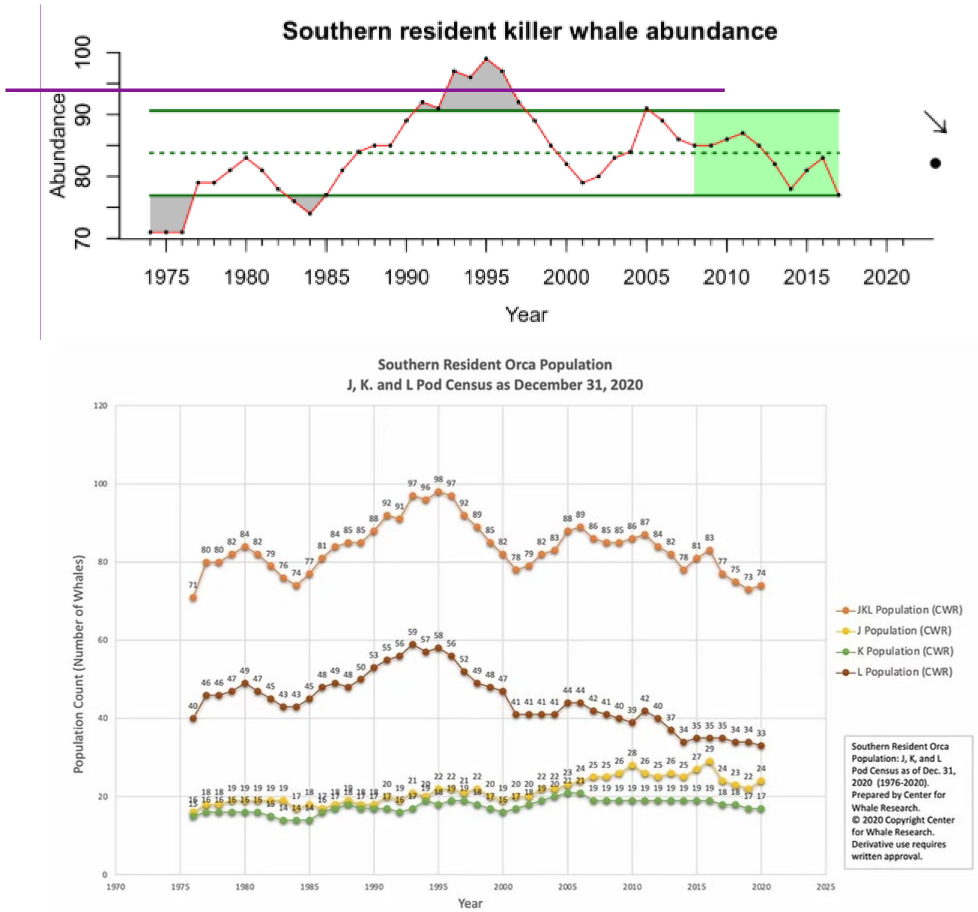

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Figure S.LR.13.12. Abundance for Southern Resident Killer Whales ~~(*Orcinus orca*)~~ in the Northeast Pacific, by pod, from 1975–2020. Orca numbers have continued to decline during the assessment period for this report (2008-2020). Source: Center for Whale Research.

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Question 14: What is the status of non-indigenous species and how is it changing?

Status: Good/Fair, Confidence - High; **Trend**: Worsening, Confidence - High
Status Description: Non-indigenous species are present and may preclude full community development and function, but have not yet caused measurable degradation.
Rationale: Non-indigenious species (e.g., *Sargassum muticum* and *Caulacanthus okamurae*) have existed at low abundances in OCNMS for decades~~. H~~; however, a greater number of non-indigenous species have been identified as a concern in or adjacent to OCNMS boundaries in the last 10 years. These ~~They~~ include the European green crab, 289 non-indigenous species introduced to the U.S. West Coast by the 2011 tsunami, and farmed Atlantic s~~S~~almon that escape from net pens ~~released~~ into Puget Sound ~~in 2017~~.

Commented [15]: The large salmon spill in 2017 was by no means the first of its kind, though it was among the largest. Atlantic salmon have been escaping from net pens in Puget Sound for decades.

Definition and Description

Non-indigenous species (also called alien, exotic, non-native, or introduced species) are organisms living outside their native distributional range, having arrived there by deliberate or accidental human activity. Those that cause ecological or economic harm in the new environment are called invasive species. In 2019, the status of non-indigenous species in OCNMS is good/fair and the trend was worsening, with high confidence ~~(Table S.LR.14.1)~~. This means that non-indigenous species are present and may preclude full community development and function, but have not yet caused measurable degradation.

The rating for this question was based on current information and trends for non-indigenous species from 2008-2019 (Table S.LR.14.1~~2~~). Non-indigenous species have existed at low abundances inside OCNMS (e.g., *Sargassum muticum* and *Caulacanthus okamurae*) for decades; however, an increasing number of these species have been identified as a concern in or adjacent to OCNMS boundaries in the last 10 years. These include the first reported presence and increasing abundance of European green crab (*Carcinus maenus*) (Akmajian & Halttunen, 2019), the introduction of 289 non-indigenous species to the U.S. West Coast by the 2011 tsunami in Japan (Carlton et al., 2017), and farmed Atlantic Salmon (*Salmo salar*) that have escaped from net pens ~~released~~ into Puget Sound. An especially large event occurred in 2017 when over 250,000 fish spilled out of a failing net pen near Cypress Island in northern Puget Sound (WDFW, 2017). The ecological impacts of these introductions are not fully understood. Non-indigenous species that do not directly impact species inside OCNMS (e.g., *Spartina alterniflora*; Civille et al., 2005) were not considered here.

Commented [16]: Here is the place to detail the escape of Atlantic salmon from net pens over the course of decades, not just in 2017. There have been long-term "slow spills" remarked upon in other documents as well as documentation of other large spills.

Comparison to 2008 Condition Report

While there were more non-indigenous species of concern in 2019, the status and trend ratings were the same in 2008 and 2019 (see Table S.LR.12.1). Specifically, the 2008 status was good/fair and the trend was worsening because the distributions of invasive *Sargassum muticum* and tunicates were expanding at sites inside OCNMS (NOAA OCNMS, 2008). In 2019, the ratings were not based on expanding *Sargassum* distributions, but rather on the first recorded presence and increasing abundances of European green crab ~~-~~(Akmajian & Halttunen, 2019) and the occurrence of non-indigenous species due to the 2011 tsunami in Japan (Carlton et al., 2017) in ~~the~~ OCNMS. While the 2008 rating focused on pelagic habitats, the 2019 status and trend looked across rocky shore and pelagic habitats as well as at estuaries and river mouths adjacent to the OCNMS boundary. While better monitoring data were available for rocky shore habitats, minimal monitoring data on non-indigenous species were available for sandy beach, kelp forest, and deep-sea habitats. Currently, there are no known non-indigenous species of concern in these habitats.

New Information in 2019 Condition Report

As noted above, new information about European green crab~~s~~ and the influx of non-indigenous species as a result of ~~by~~ the 2011 tsunami were the primary drivers of the 2019 ratings. European green crab~~s~~ (Figure S.LR.14.1) were first reported in WA in 1998 in Willapa Bay and Grays Harbor (Figlar-Barnes et al., 2002; Behrens & Gillespie, 2008). They were originally introduced by humans to California and then their larvae spread northward. Nineteen years later, the species was~~these crabs were~~ documented in estuaries and river mouths (i.e., Wa'atch and Tsoo-Yess River estuaries on the Makah Reservation) adjacent to OCNMS in late 2017. Since 2017, more than 2,500 European green crab have been captured in the two estuaries during aggressive trapping efforts. Catch per unit effort appears to be increasing, likely due both to increasing abundance as well as improved capture methods ~~for catching the crabs~~ (Figure S.LR.14.2; Akmajian & Halttunen, 2019; Yamada et al., 2019; Akmajian, 2020). Although little is known about the long~~-~~term impacts of this species inside OCNMS, European green crab~~s~~ were found to reduce eelgrass densities in British Columbia (Howard et al., 2019), which creates important habitat for Pacific salmon and Pacific herring populations (Hosack et al., 2006; Kennedy et al., 2018).

Around the same time that European green crab~~s~~ were discovered adjacent to the sanctuary, there was an accidental release of farmed Atlantic salmon into Puget Sound. Some of these farmed salmon were later caught in waters adjacent to and inside OCNMS (Figure S.LR.14.3; WDFW, 2017). In response to this release, Washington state banned new Atlantic salmon fish pens in 2018; however, only new pens are prohibited, and it may be several years before existing leases expire and facilities are removed. This accidental release was not the first such introduction of Atlantic salmon into Pacific Northwest waters, but it was the first that resulted in detection of this species in OCNMS.

Commented [17]: validate that this is true, but I'm not aware of any other Atlantic salmon captures in the area. Check Makah fishing records, as they'd likely be the first to intercept such fish coming out of the Sound.

In addition to European green crab~~s~~ and Atlantic salmon, several species that were transported from Japan to OCNMS by the 2011 tsunami are of concern. This tsunami was estimated to have introduced at least 289 non-indigenous species to W~~U.S. w~~est ~~c~~Coast waters and shorelines (Figure S.LR.14.4, Carlton et al., 2017). This non-indigenous biota included macro~~-~~invertebrates (235 taxa), fish (2 taxa), micro~~-~~invertebrates (33 taxa), and protists (19 taxa). The majority of these organisms rafted on debris and landed in Washington and Oregon between 2012 and 2014 (Figure S.LR.14.5). Ninety percent of larger debris items (e.g., boats and docks, Figure S.LR.14.6) were removed from beaches. These removal efforts appear to have been effective in preventing non-indigenous species from becoming established (Hansen et al., 2018; Murray et al., 2019); however, a long-term monitoring site has been set up in Grays Harbor~~, WA~~ to track whether any Japanese species become established (Murray et al., 2019).

While European green crab, Atlantic salmon, and tsunami-introduced species were of the highest concern, there are other known non-indigenous species inside OCNMS, including the algae *Sargassum muticum* and *Caulacanthus okamurae*. These two species are less of a concern than European green crab~~s~~ because their densities have remained low at specific sites since 2008 compared to pre-2008 levels (MARINe, 2019). Specifically, ~~Multi-Agency Rocky Intertidal Network (~~MARINe~~)~~ biodiversity surveys showed that *S. muticum* and *C. okamurae* were present at Cannonball Island before 2008. MARINe long-term monitoring surveys found that *C. okamurae* was also present at low levels (< 6% cover) at Point of the Arches every year between 2013 and 2018 (MARINe, 2019). Survey data from the Makah Reservation also documented the presence and low abundance of *S. muticum* in 2017, although it is unknown when it arrived (Akmajian, 2017).

Conclusion

In OCNMS, there is high confidence that the status of non-indigenous species is good/fair and the trend is worsening in 2019. This indicates that non-indigenous species are present and may preclude full community development and function in OCNMS, but have not yet caused measurable degradation. However, there were clear data gaps inside OCNMS, including understanding the presence and abundance of: (1) non-indigenous species in rocky shore habitats (including *Mytilus galloprovincialis*) from monitoring datasets other than MARINe; (2) tropical and subtropical gelatinous pyrosomes in deep seafloor habitats; and (3) Humboldt squid in pelagic habitats. There was also inadequate information to determine whether some species (e.g., European green crab) are permanently displacing or otherwise negatively affecting native species, and whether some species (e.g., subtropical and tropical pyrosomes) are temporarily present due to the 2013–2014 marine heat wave, or are permanently present due to range expansions associated with changing climate and oceanic conditions.

Question 14 Tables

~~**Table S.LR.14.1**. 2008 (left) and 2019 (right) status, trend and confidence ratings for the living marine resource questions, including question 14.~~

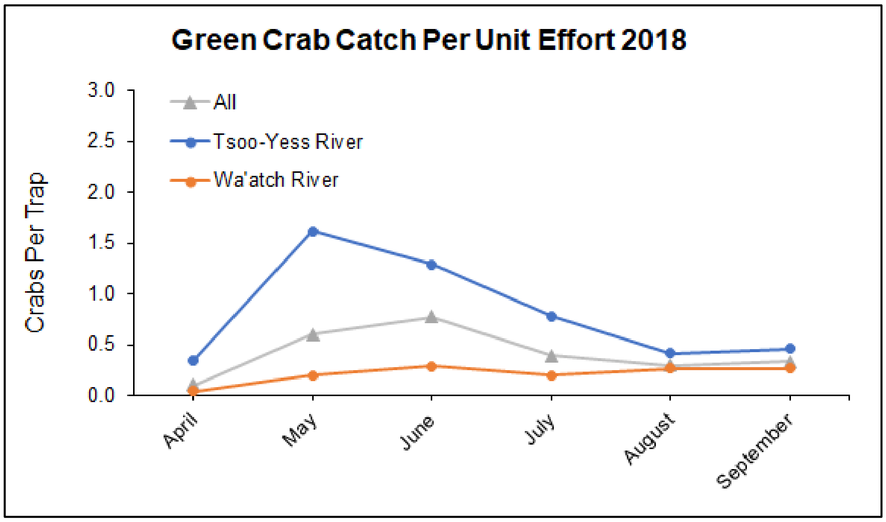
Questions		2008 Rating		Questions		2019 Rating			
						Status	Confidence	Trend	Confidence
12/13	Key Species Status/Condition	?	?	12	Keystone & Foundation species	Fair	Medium	?	High
				13	Other Key Species	Fair	High	?	High
11	Non-indigenous Species	▼		14	Non-Indigenous Species	G/F	High	▼	High
9	Biodiversity	?		15	Biodiversity	G/F	Low	–	Medium

Table S.LR.14.12. Status and trends for individual question 14 indicators discussed at January 2020 Workshop. There are no confidence scores for individual indicator status and trends.

Indicator	Source	Habitat	Data Summary	Figures
European Green Crab 2018-2019 (CPUE)	Akmajian, 2020; Akmajian & Halttunen, 2019	Estuary	**Status**: In 1998, European green crab first reported in WA, including in Willapa Bay and Gray's Harbor. In 2017, European green crab first observed near OCNMS in Wa'atch and Tsoo-Yess River. **Trend**: Increasing ↑ trend.	S.LR.14.1; S.LR.14.2
Atlantic Salmon (Presence)	WDFW, 2017	Pelagic	**Status**: In 2017, 250,000 farmed Atlantic salmon escaped into Puget Sound. Escaped salmon may be infected with PRV virus. **Trend**: Undetermined. Data gap.	S.LR.14.3
Tsunami introduced non-indigenous species (Species Richness)	Carlton et al., 2017; NOAA ORR, 2016; NOAA Marine Debris Program, 2012	All	**Status**: Tsunami introduced at least 289 non-indigenous species to the U.S. wWest cCoast and majority landed in WA and OR between 2012-2014. **Trend**: Undetermined. Data gap.	S.LR.14.4; S.LR.14.5; S.LR.14.6
Sargassum muticum (Presence/ absence)	MARINe, 2019; Akmajian, 2017	All, Rocky Shore	**Status**: *S. muticum* present in OCNMS pre-2007. Not observed in MARINe long term monitoring plots to date. Observed on Makah Reservation in 2017. **Trend**: Undetermined. Data gap.	-
Caulacanthus okamurae (Presence/ absence)	MARINe, 2019	Rocky Shore	**Status**: Low abundance in plots at Point of the Arches every year between 2013-2018. **Trend**: Undetermined. Data gap.	-
Data Gaps	Rocky shore, Deep seafloor, Pelagic		(Rocky Shore) Non indigenous species in rocky intertidal not well surveyed (including *Mytilus galloprovincialis*), (Deep Seafloor) Tropical and subtropical pyrosomes (species that are problematic in Puget Sound), (Pelagic) Humboldt squid	-

Question 14 Figures

Figure S.LR.14.1. European green crabs captured in a shrimp pot in the Tsoo-Yess River in 2019. Photo: Akmajian, 2020



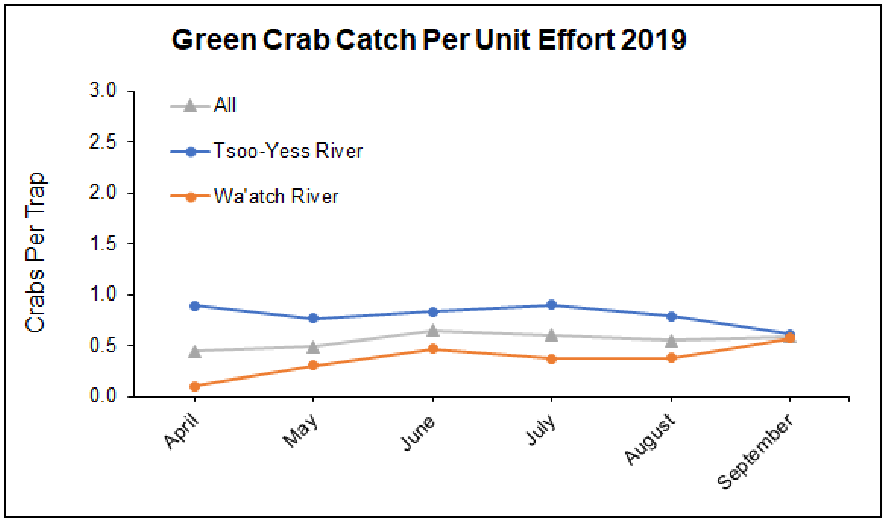


Figure S.LR.14.2. CPUE for European green crabs from trapping in coastal rivers adjacent to Makah Bay during 2018 (top) and 2019 (bottom). Image: Akmajian & Halttunen, 2019

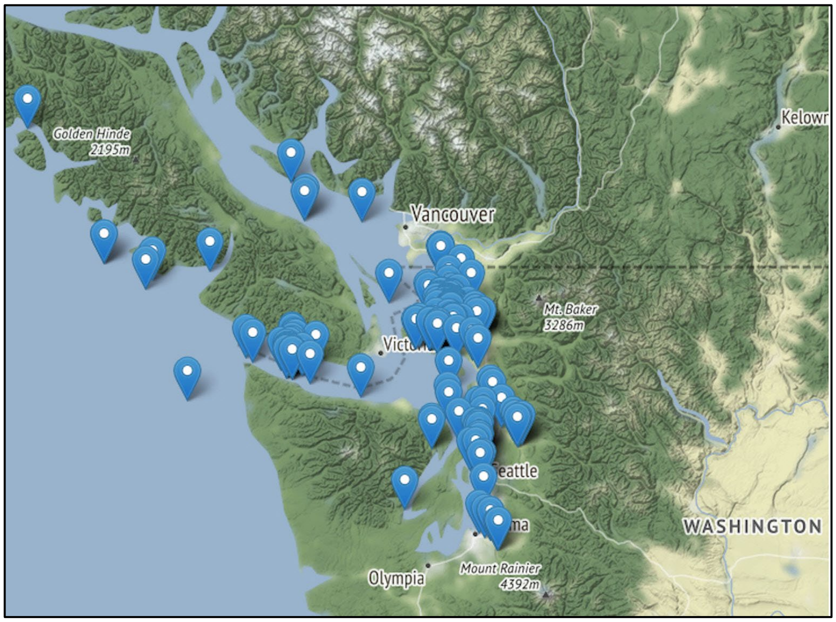


Figure S.LR.14.3. Locations where Atlantic salmon have been caught since their accidental release from a failing net pen near Cypress Island in 2017. Atlantic salmon have been caught in water adjacent to and inside OCNMS. Image: WDFW, 2017

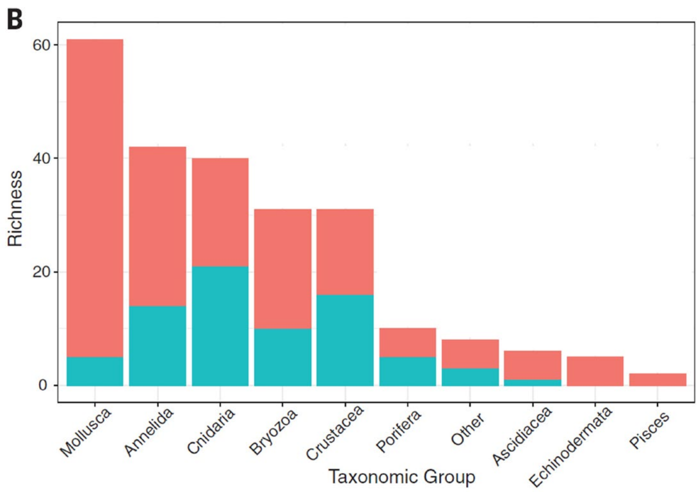


Figure S.LR.14.4.Living, non-indigenous species (by taxonomic group) introduced to the U.S. West cCoast as a result of the 2011 Japanese tsunami. The turquoise bars denote the number of non-indigenous species present before the tsunami. The coral bars denote the number of non-indigenous species introduced by the tsunami. Image: Carlton et al., 2017

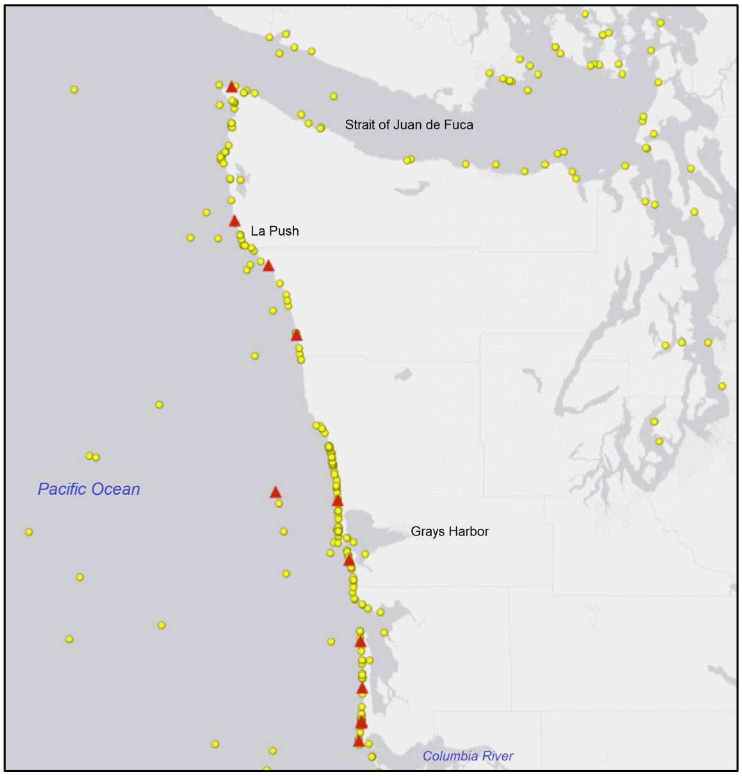


Figure S.LR.14.5. Confirmed (triangles) and potential (circles) marine debris from the 2011 tsunami reported from December 2011 to February 2016 in OCNMS. Image: NOAA ORR, 2016

Figure S.LR.14.6. In December 2012, a 66-ft floating dock, dislodged from Misawa, Japan during the 2011 tsunami, washed up on the Olympic Coast of Washington near Mosquito Creek. Photo: NOAA Marine Debris Program, 2012

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Question 15: What is the status of biodiversity and how is it changing?

Status: Good/Fair, Confidence - Low; **Trend**: Not Changing, Confidence - Medium
Status Description: Selected biodiversity loss or change is suspected and may preclude full community development and function, but has not yet caused measurable degradation.
Rationale: Over the last decade, no species are known to have been extirpated in OCNMS. Abundances of some foundation and keystone species, however, experienced significant declines after 2013, which may have altered biodiversity and affected community structure and function.

Commented [18]: I disagree based on the evidence provided below. If two of three groundfish indices indicate declining trends, plankton community composition has altered radically in response to The Blog, and SSWD has wiped out at least two species of sea star then this is should be a declining trend. If that's not the conclusion the expert panel reached, then additional justification for why is needed in this section.

Definition and Description

Biodiversity assessment in marine sanctuaries considers not only direct measures of community structure, which are calculated using numbers of species and their relative abundances (e.g. richness, evenness, Simpson's diversity), but also the status of functional interactions among ~~between~~ species. This may include the impacts of changing relative abundances on trophic relationships, competition, or symbioses. The objective is to ascertain whether observed conditions are within the expected range of natural variation of the ecosystem. In 2019, the status of biodiversity in OCNMS is good/fair (with low confidence) and the trend is not changing (with medium confidence) ~~(Table S.LR.15.1)~~. This rating suggests that selected biodiversity loss or change is suspected and may preclude full community development and function, but has not yet caused measurable degradation. The rating for this question was based on current information and trends for biodiversity from 2008-2019 (Table S.LR.15.1~~2~~). Over the last decade, no species are known to have been extirpated in OCNMS. That said, some foundation and keystone species abundances experienced significant declines after 2013, which may have changed community structure, function, or biodiversity (see question 12). Unfortunately, no data are available to quantify these community impacts.

Comparison to 2008 Condition Report

For question 15, the rating improved in 2019 compared to 2008. Specifically in 2008, the status was fair and the trend was undetermined (confidence was not recorded) (see Table S.LR.12.1). In 2019, the status was good/fair (with low confidence) and the trend was no change (with medium confidence). These low to medium confidence scores were due to several data and analysis gaps, including shorebirds, benthic invertebrates, flatfish, cetaceans, and seabirds. The rating change mainly reflects the recovery of several groundfish stocks over the last 10 years, rather than an increase in biodiversity inside OCNMS. The historical depletion of groundfish was an influential driver of the status rating in 2008. Since then, many groundfish stocks have ~~since~~ recovered in response to fisheries management actions, which should have a positive impact on the abundance component of groundfish biodiversity in OCNMS. These recoveries are juxtaposed with severe declines in certain keystone species abundances (e.g., purple and sunflower sea stars) over the last 10 years. Their declines (particularly the purple sea star) have or will likely negatively impact biodiversity in rocky shore and kelp forest ecosystems inside OCNMS; however, these impacts have not been well quantified due to insufficient monitoring data in these key habitats.

New Information in 2019 Condition Report

As noted above, the 2019 rating was primarily driven by the lack of species extirpations inside OCNMS since 2008, and new information about groundfish and (to some extent) plankton biodiversity metrics. For groundfish, no changes in biodiversity were observed in the last 10 years (2009-2018) compared to the long-term mean (2003-2018) (Figure S.LR.15.1, NOAA CCIEA, 2019). Over the last decade, groundfish species density and Simpson diversity show no trend, although species richness showed a downward trend. Species richness and diversity estimates are strongly influenced by sampling effort, and failure to account for this can provide erroneous conclusions about the status and trends for the groundfish community (Greenstreet & Piet, 2008). Therefore, the biodiversity metrics shown in Figure S.LR.15.1 are considered preliminary until more analyses are conducted to confirm the statistical power and robustness of the ~~w~~West ~~c~~Coast groundfish trawl survey's annual sampling effort within OCNMS boundaries.

Although the groundfish community did not likely change, ~~the~~ plankton community composition started to change in 2014 and was significantly different from 2011 offshore of Oregon and Washington (Figure S.LR.15.2, Figure S.LR.15.3). Plankton community changes were associated with the 2013-2014 marine heat~~-~~wave (Peterson et al., 2017; Brodeur et al., 2019). This marine heat~~-~~wave may also explain why phytoplankton species richness anomalies were more frequent over the last decade (Figure S.LR.15.2; Peterson et al., 2017), although data are insufficient to determine whether these plankton community shifts are likely to persist. The marine heat~~-~~wave also marks the beginning of significant declines in keystone species abundances (notably, purple and sunflower sea stars) since 2008 (MARINe, 2019). Biodiversity of organisms attached to the primary substrate has been shown to be positively correlated with the presence of purple sea stars (Wilkes, 2019). Therefore, declines in purple sea star abundances have or will likely negatively impact biodiversity in rocky shore and kelp forest ecosystems.

Conclusion

In OCNMS, the status of biodiversity is believed to be good/fair (with low confidence) and the trend is not changing (with medium confidence) in 2019. Limited evidence, as well as data and analysis gaps reduced expert confidence scores for the ratings. Experts also expressed concern that the limited biodiversity metrics available are insufficient to characterize and quantify the profound recurring environmental changes experienced on the Olympic Coast during this assessment period, and the differential potential impacts to mobile versus sessile organisms. Additionally, experts expressed concern about relying on biodiversity metrics like species numbers, when species composition has been clearly demonstrated to be more relevant to ecosystem function and productivity, such as with the composition of northern versus southern

Commented [19]: But both richness and Simpson's diversity index have decreasing trends, especially since 2013/14. Even with a ten-year mean within 1 SD of the long-term mean, this indicates biodiversity declines in the last five years for two out of three measures.

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copepods (Figure S.LR.12.5). Because few studies actually attempt to establish biodiversity metrics, developing such indicators is particularly challenging and considerable data gaps remain.

In particular, data gaps existed for beach habitats related to infaunal predators, and in kelp forests for benthic invertebrates. Biodiversity surveys of rocky intertidal habitats done by MARINe prior to the 2008 condition report were not repeated during the current assessment period. Analysis gaps existed for sandy beach habitats related to shorebirds, sandy seafloor habitats related to flatfish, deep seafloor habitats related to biogenic and benthic invertebrates, and pelagic habitats related to cetaceans and seabirds. There was not enough information to determine whether some warm-water species (e.g., of plankton or seabirds like the Manx shearwater) are temporarily present due to the 2013-2014 marine heat wave (Peterson et al., 2017; Brodeur et al., 2019), or will become permanent residents because of geographic range expansions due to climate change. Some of these data gaps may be filled by new monitoring programs coming online, including U.S. Navy funded seabird and mammal surveys on the U.S. west coast. Additionally, eDNA may be useful for understanding biodiversity more broadly in the future.

Question 15 Table

~~**Table S.LR.15.1.** 2008 (left) and 2019 (right) status, trend and confidence ratings for the living marine resource questions, including question 15.~~

Questions		2008 Rating		Questions		2019 Rating			
						Status	Confidence	Trend	Confidence
12/13	Key Species Status/Condition	?	?	12	Keystone & Foundation species	Fair	Medium	?	High
				13	Other Key Species	Fair	High	?	High
11	Non-indigenous Species	▼		14	Non-Indigenous Species	G/F	High	▼	High
9	Biodiversity	?		15	Biodiversity	G/F	Low	–	Medium

Table S.LR.15.1~~2~~. Status and trends for individual question 15 indicators discussed at January 2020 Workshop.There are no confidence scores for individual indicator status and trends.

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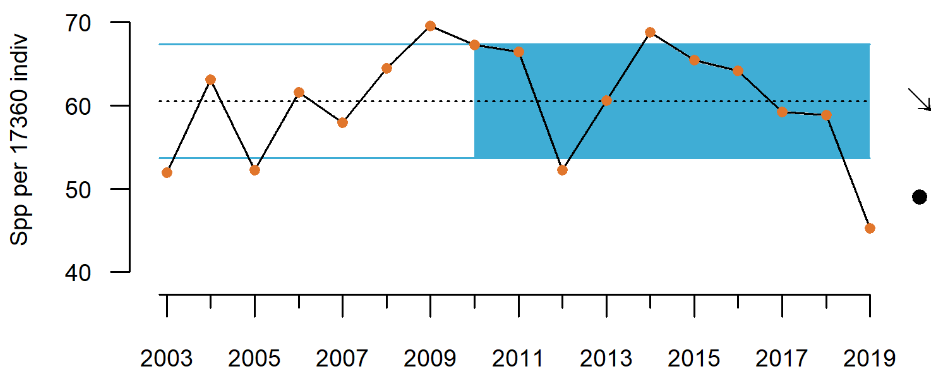
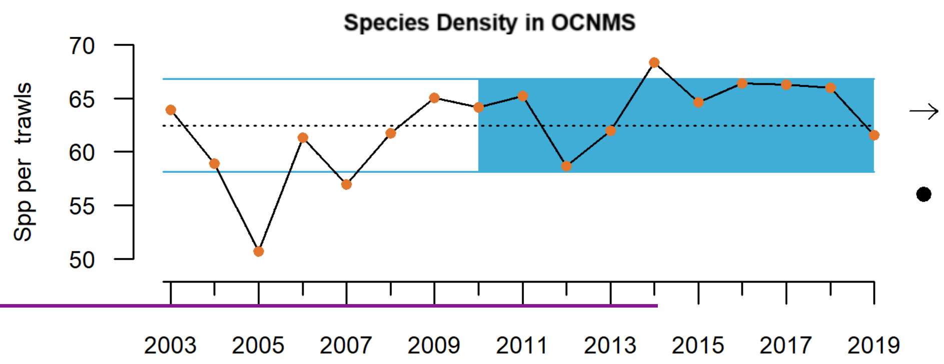
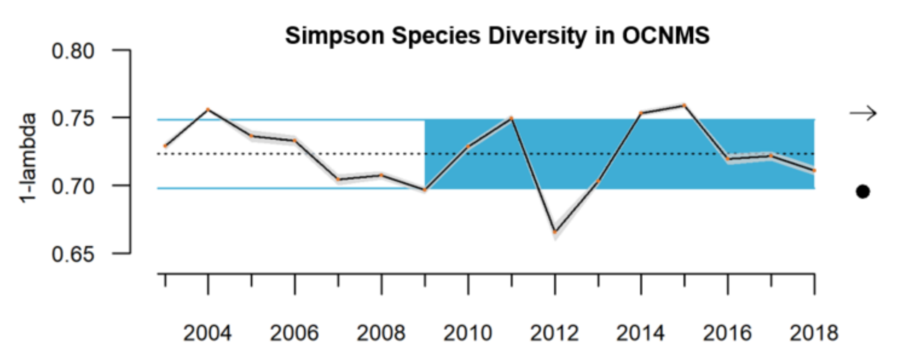
Question 15 Figures

Species richness in OCNMS







Commented [22]: updated panel shows declining trend; data presented previously showed flat trend for Simpson diversity

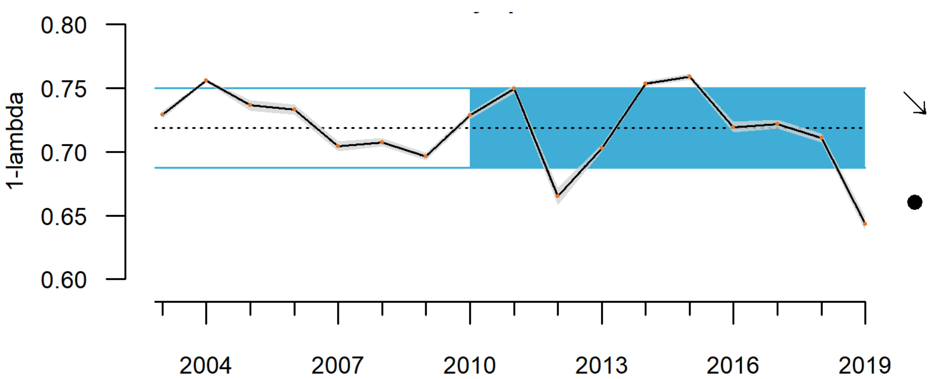


Figure S.LR.15.1 Species richness (top), species density (middle) and Simpson species diversity (bottom) for groundfish inside OCNMS through 2019. Blue window denotes the 10 year analysis window. The black circles denote that the 10-year mean is within 1 standard deviation of the long-term mean. The horizontal arrow denotes a flat 10-year trend. The downward arrows denote decreasing 10-year trends. Source: NOAA CCIEA, 2021; Image: G. Williams/NWFSC.

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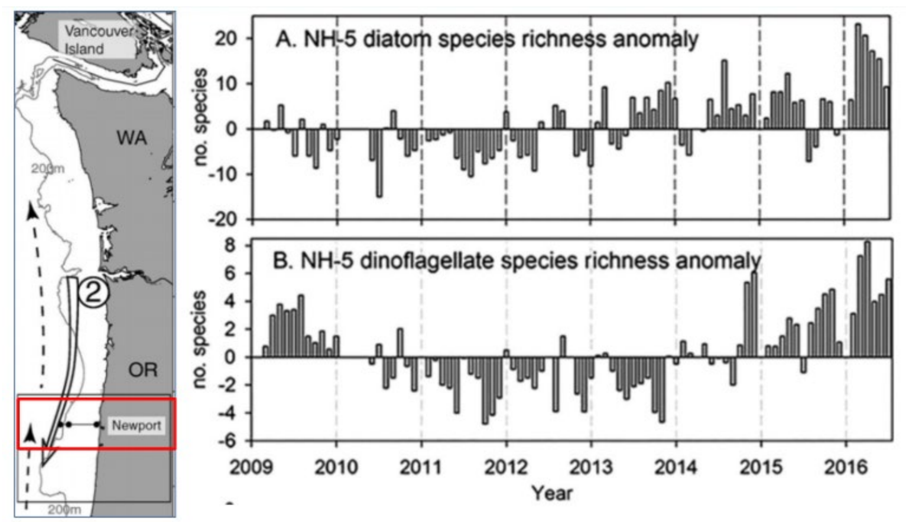

Figure S.LR.15.2 Diatom (top) and dinoflagellate (bottom) species richness anomalies for 2009–2016 offshore of Newport, OR. Image: Peterson et al., 2017.

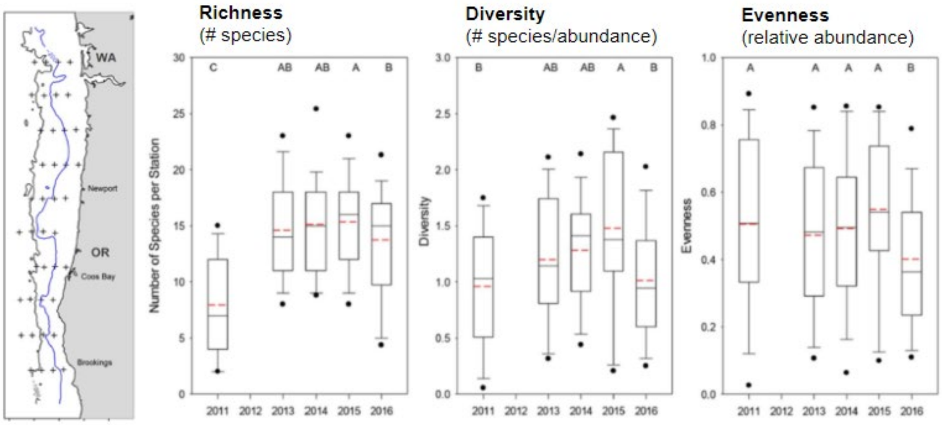

Figure S.LR.15.3 Box plots showing pelagic larvae and zooplankton species richness, diversity, and evenness for all trawls (map left) in southern Washington and Oregon (2011 and 2013–2016). Image: Brodeur et al., 2019.

Question 15 References

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Peterson, W. T., Fisher, J. L., Strub, P. T., Du, X., Risien, C., Peterson, J., & Shaw, C. T. (2017). The pelagic ecosystem in the Northern California Current off Oregon during the 2014–2016 warm anomalies within the context of the past 20 years. Journal of Geophysical Research: Oceans, 122(9), 7267-7290.

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This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

State of Sanctuary Resources

Maritime Heritage Resources (Question 16)

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The Maritime Heritage Resources section of this report addresses the condition and threats to heritage resources in the sanctuary. Maritime heritage can encompass a wide variety of cultural, archaeological, and historical resources. Archaeological and historical resources are material evidence of past human activities and include vessels, aircraft, structures, habitation sites, and objects created or modified by humans. Cultural resources may include specific locations associated with traditional beliefs or where a community has traditionally carried out economic, artistic, or other cultural practices important to maintaining its historic identity. The majority of existing site information currently describes shipwreck (archaeological/historical) resources. Question 16 assesses the integrity of known maritime heritage resources in the sanctuary. The integrity of a heritage resource refers to its ability to convey information about the past, and can be impacted by both natural events and human activities. Archaeological integrity is generally linked to the condition of the resource, whereas historical significance may rely on other factors.

Question 16: What is the condition of known maritime heritage resources and how is it changing?

Status: Good/Fair, Confidence - Low; **Trend**: Undetermined, Confidence - Low ~~(Table S.MAR.16.1).~~
Status Description: Selected maritime heritage resources exhibit indications of natural or human disturbance, but there appears to have been little or no reduction in aesthetic, cultural, historical, archaeological, scientific, or educational value.
Rationale: Shipwrecks in the nearshore, and to a lesser extent shipwrecks in deeper water, are degrading, primarily due to natural processes. Traditional canoe routes are actively being used during the annual Tribal Canoe Journeys.

Comparison to 2008 Condition Report

In the 2008 condition report, this question was rated "fair" with an "undetermined" trend (Table S.MHR.16.1). The basis for judgement included damage caused by fishing activities, cable installations, and unauthorized salvaging. Since 2008, trawling activity has remained steady, but with a southward shift in location. Since that report, no new activity or information on existing cables has been obtained, and no unauthorized salvage has been documented by OCNMS.

New Information in 2019 Condition Report

Similar to other ONMS sites, OCNMS has partial baseline data on maritime heritage resource conditions and impacts (Galasso, 2017). Of 197 reported vessel losses, nine have been located, and seven assessed. Appropriate data on cultural heritage resources and sites remain to be integrated.

In August 2017, the first archaeological survey of the deep water (242 meters) wreck of the ex-USS *Bugara* was conducted with a remotely operated vehicle (ROV). The survey provided eight hours of direct observation with video and still camera documentation of the wreck. The 2017 assessment added considerably to an understanding of changes to *Bugara* after it sank while under tow in 1971.

On June 1, 1971, the U.S. Navy tug *Cree* (ATF 45) had the ex-USS *Bugara* in tow en route from the Naval Ammunition Depot at Bremerton, Washington, to a disposal site approximately 100 miles off of Cape Flattery. The submarine was to participate as a target vessel in a live-warhead evaluation of the Mark 48 torpedo. Off Cape Flattery, near the mouth of the Strait of Juan de Fuca, the submarine began to take on water in the stern and started to sink. With USS *Cree* at risk of being pulled under, the steel hawser cable was cut. *Bugara* foundered shortly after.

Among the goals of the 2017 survey was determining ongoing processes of change to the wreck after nearly five decades on the bottom, including questions of biological colonization. *Bugara* lies upright, resting on its keel on an uneven, compact seabed. There is little burial of the hull. It has been colonized, although not extensively, by anemones, a variety of rockfish, and algae. *Bugara's* pressure hull appears intact, with all hatches closed, and there is no obvious source of the leak that sank the submarine. The steel superstructure that covers the pressure hull is more or less intact, although corroded, and the teak decking has been mostly consumed by marine wood-borers, leaving few remnants.

The sail was found to be substantially damaged, with much of the fiberglass and light steel frame that formed it detached, exposing the inner structure of the conning tower (which formed an integral part of the pressure hull), as well as the periscope shears and the snorkel with its exhaust (Delgado et al., 2018).

In addition to the *Bugara* ROV footage, diver videos by Frog Kick Diving of the *Temple Bar* and *Lamut* were reviewed. These videos showed the poor condition of these two nearshore wrecks.

The British freighter *Temple Bar* struck a reef near the Quillayute Needles and foundered in shallow water two miles south of La Push in the pre-dawn hours of April 8, 1939. The crew of 36 safely abandoned the ship in lifeboats, and were towed to shore by Coast Guardsmen from the Quillayute Coast Guard Station.

Visible from shore, the *Temple Bar* became a magnet for tourists. Although visible from La Push breakwater, a better view was to be had by walking two miles along muddy trails to Second Beach. From this vantage point the wreck was visible about a half mile offshore. The cargo of scrap iron and part of the hull were eventually salvaged, the remaining hull rests in 7m of water, no longer visible from the surface.

The *Lamut* encountered heavy seas and driving rain off the Olympic Coast. The captain, disoriented by the storm, took his ship too close to shore, and she ran aground in a narrow, steep-walled cove not far from the Quillayute Needles. The crew attempted to launch one of the lifeboats, but it was smashed by the waves, killing one crew member and injuring another. ~~In response to the captain's distress calls, the U. S. Coast Guard began searching for the vessel. The first rescue squad arrived in a small boat, but realized that the Lamut's position in pounding surf made rescue by sea impossible.~~

~~Meanwhile another rescue squad headed overland, making their way through several miles of wilderness to reach the cliffs above the ship. They were able to throw a line to the ship, and after securing it, crew members pulled themselves hand over hand to safety on a ledge part way up the face of the cliff. From there, Coast Guardsmen assisted them to the top of the cliff, then overland to safety.~~

Today the heavily damaged remains of the *Lamut* are in a surge channel immediately adjacent to Teahwhit Head, only accessible by experienced divers in unusually calm conditions.

In discussions with subject matter experts, there was a consensus that maritime heritage resources were broader than shipwrecks, and there was a desire to assess additional classes of resources that were more highly valued by Native American communities. Some of these important resources, such as middens, are located adjacent to, but just outside, the sanctuary and were not considered within the scope of the condition report. A number of options were discussed including paleo-landscapes, ancient canoe runs, and traditional canoe routes, -some possibly unchanged since contact with Euro-American explorers and traders. These routes are still used by Olympic Coast tribes as part of the annual Tribal Canoe Journeys. The value of Canoe Journeys will be discussed in the ecosystem services chapter. Here the “resource” being considered is not the event itself, but the specific location/route. Traditional cultural properties may meet National Register requirements because of the role they play in a community's traditional religion, beliefs, customs, and practices. Examples of properties possessing such significance include a location where a community has traditionally carried out economic, artistic, or other cultural practices important in maintaining its historic identity.

The annual Tribal Canoe Journey is an important event for indigenous peoples of the Pacific Northwest, where canoe families travel in traditional ocean going canoes, following traditional routes, to meet with other native nations at the hosting tribe's home. During the 2008–2019 condition report period, the Makah hosted in 2010, and the Quinault hosted in 2013. -The paddle to Quinault included nearly 100 canoes pulled by representatives from more than 75 tribes. Almost all the tribes are from the Washington/British Columbia region, but some came from as far away as Hawaii, New Zealand, and New York. An estimated 10,000 people celebrated. In all but one -year from 2008-2019 a canoe journey event was held.

Commented [2]: When? Dates are provided for the other wrecks.

Commented [3]: Interesting history, but not relevant to the current state of the wreckage or it's heritage value.

Conclusion

The rating of Good/Fair, with an undetermined trend, is an improvement from the 2008 rating of Fair. This rating was based not only on the condition of known shipwrecks in OCNMS, similar to the 2008 rating, but a discussion of the use of historical routes and culturally important locations for annual Tribal Canoe Journeys. The confidence ratings of Low for both metrics reflect the lack of comprehensive surveys to identify additional maritime heritage resource types and document their occurrence, which represents a major data gap.

Question 16 References

Delgado, J.P., Cantelas, F., Schwemmer, R.V. et al. Archaeological Survey of the Ex-USS Bugara (SS/AGSS331). J Mari Arch 13, 191–206 (2018). https://doi.org/10.1007/s11457-018-9198-y

Galasso, G. 2017. Review of Olympic Coast vessel incidents from 1995 – 2016. ONMS-17-07. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 85pp.

NOAA Procedures for Government-to-Government Consultation With Federally Recognized Indian Tribes and Alaska Native Corporations. 2013. NOAA 13175 Policy. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Silver Spring, MD.

Question 16 Table~~s~~

Table S.MH~~A~~R.16.1. 2008 (left) and 2020~~19~~ (right) status, trend and confidence ratings for the maritime heritage question.~~question 16~~.

2008 Question		2008 Rating	2020 Question		2020 Rating			
					Status	Confidence (Status)	Trend	Confidence (Trend)
15	MAR Integrity	?	16	MHR Integrity	Good/Fair	Low	?	Low

Questions		2008 Rating	Questions		2019 Rating			
					Status	Confidence	Trend	Confidence
15	Integrity of MAR	?	16	Integrity of MHR	G/F	Low	?	Low

This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

Call Out Boxes - Draft topics and text

Marine Heat ~~W~~waves

Marine heatwaves~~, or~~ (MHWs)~~,~~ occur when ocean temperatures are much warmer than usual for an extended period of time. In 2014-2016, the California Current Ecosystem (CCE) experienced a MHW popularly known as "the blob." This event began in early 2014 and persisted through mid-2016, causing a rapid onset of persistent ~~rapid and abundant~~ positive sea surface temperature (SST) anomalies from Alaska to California. These elevated SSTs coincided with the 2015-2016 El Nino event (Gentemann et al. 2017 and Jacox et al. 2019), creating the largest marine heatwave on record (NOAA 2020). Researchers documented many ecological effects associated with this MHW~~the blob~~, including unprecedented harmful algal blooms, shifting distributions of marine life, and changes in the marine food web (Morgan et al. 2019, NOAA CCIEA 2020). Since then, another smaller and shorter lived MHW developed off the U.S. West Coast, and researchers began tracking a third potential MHW in February 2020 (NOAA CCIEA 2020). For the latest information about MHW on the CCE, please see NOAA California Current Integrated Ecosystem Assessment's (CCIEA) Marine Heatwave Tracker: https://www.integratedecosystemassessment.noaa.gov/regions/california-current/cc-projects-blobtracker

Commented [1]: Throughout the various sections this is either two words or one. During final editorial review choose which it should be and update for consistency.

Commented [2]: This definition could use some specificity, and should be included in the section 4b where the broad discussion about heatwaves is had. How much warmer is "much warmer"? How long is an "extended period of time"? Draw from other resources, but something like "a marine heatwave is when the average monthly temperature remains greater than one standard deviation above the ten-year seasonal mean for a period of three months or more" is far more informative.

Commented [3]: Again, consult Hobday et al 2016 for the definition

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Commented [5]: www.marineheatwaves.org
is a great resource!
NANOOS Climatology app is too...but maybe that is too many.

Hypoxic Events

Hypoxia is the presence of low (<2 mg/L) dissolved oxygen in the water column. It can negatively affect habitat and cause sensitive marine species to be stressed or even die (Cannolly et al. 2010; Siedlecki et al. 2015; and Harvey et al. 2019). Hypoxia was historically reported (1950–1986) in the northern portion of the California Current ~~S~~Ecosystem over the summer upwelling season. In 2017 and 2018, the Washington continental shelf experienced two severe and geographically broad hypoxic events. Thesе~~y~~ caused widespread die-offs of crab~~s~~ and other benthic invertebrates, as well as the redistribution of groundfish (Harvey et al. 2019). I~~These i~~mpacts were more severe along the southern WA coastline, which ~~is~~ experiencesing progressively lower oxygen levels seasonally and a greater frequency of hypoxic conditions than in the north (Alin et al. 2020).

2011 Tsunami

In 2011, an earthquake off Japan created a massive tsunami that caused the Fukushima nuclear disaster and severe destruction to the eastern coastline of Japan. The resulting debris was swept into the Pacific Ocean and over a few years was carried thousands of miles, some ending up on the Washington coastline. The majority of this debris arrived between 2012 and 2014, ranging in size from plastic bottles to fishing boats. In total, more than 289 non-indigenous species (NIS) are believed to have arrived with the debris. Ninety percent of larger debris items (e.g., boats and docks) were removed from beaches. The removal efforts may have prevented some non-indigenous species from becoming established (Hansen et al. 2018 and Murray et al. 2019); however, a long-term survey site has been set up in Grays Harbor, WA to monitor the establishment of species introduced by the 2011 tsunami in Japan (Murray et al. 2019).

Traditional Knowledge

Traditional Knowledge (TK), as defined in Van Pelt et al. (2017) "...is...a cumulative body of scientific knowledge, passed through cultural transmission, that evolves adaptively through time as a result of Indigenous peoples living in and observing the local environment for many generations; it is a form of adaptive management." TK is a robust and dynamic knowledge system that is based on observations and experiences over thousands of years and should be considered the equivalent of peer-reviewed information in western science (Chang et al. 2019). Sharing TK should be based on free, prior, and informed consent with ownership and intellectual property rights belonging to the tribal communities or knowledge holders. The coastal treaty tribes have lived on the Olympic Coast for thousands of years, and each have cultivated a body of knowledge on ecosystem processes, timing, location of important habitats and species, and a variety of other topics over generations (Chang et al. 2019; Shannon et al. 2016).

This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

State of Ecosystem Services

Ecosystem services are the benefits that humans receive from natural and cultural resources. Generally, the taxonomy of the Millennium Ecosystem Assessment (MEA 2005) is used in ONMS condition reports. MEA (2005) was an initiative of the United Nations to assess ecosystem services, including cultural, provisioning, regulating, and supporting services. Categories of ecosystem services include "final" services, which are directly valued by people, and "intermediate" services, which are ecological functions that support final services (Boyd and Banzhaf 2007). In ONMS condition reports, only final ecosystem services are rated, which is consistent with the anthropogenic focus of the reports and highlights priority management successes and challenges in sanctuaries. The complete definitions of ecosystem services considered by ONMS are included in Appendix B.

Text Box 1.:
There are two categories of ~~intermediate and final~~ ecosystem services: intermediate and final. Ecosystem services that are evaluated in condition reports are final ecosystem services. Intermediate services support other ecosystem services, whereas a good/service must be directly enjoyed by a person to be considered a final ecosystem service. For example, nutrient balance leads to clearer water and higher visibility for snorkeling and scuba diving. Nutrient balance is an intermediate service that supports the final ecosystem service of non-consumptive recreation via snorkeling and scuba diving.

Text Box 2.:

Thirteen final ecosystem services may be rated in ONMS condition reports

Cultural (non-material benefits)

1. Consumptive recreation — Recreational activities that result in the removal of or harm to natural or cultural resources
2. Non-consumptive recreation — Recreational activities that do not result in intentional removal of or harm to natural or cultural resources
3. Science — The capacity to acquire and contribute information and knowledge
4. Education — The capacity to acquire and provide intellectual enrichment
5. Heritage — Recognition of historical and heritage legacy and cultural practices
6. Sense of Place — Aesthetic attraction, spiritual significance, and location identity

Provisioning (material benefits)

7. Commercial Harvest — The capacity to support commercial market demands for seafood products
8. Subsistence Harvest — The capacity to support non-commercial harvesting of food and utilitarian products
9. Water — Providing water for human use by minimizing pollution, including nutrients, sediments, pathogens, chemicals, and trash
10. Ornamentals — Resources collected for decorative, aesthetic, or ceremonial purposes

11. Biotechnology — Medicinal and other products derived or manufactured from sanctuary animals or plants for commercial use
12. Energy — Use of ecosystem-derived materials or processes for the production of energy

Regulating (buffers to change)

13. Coastal protection — Flow regulation that protects habitats, property, coastlines, and other features

Notably, some consider consumptive recreational fishing as a provisioning service, but it is included here as a cultural ecosystem service. Also, even though biodiversity was listed as an ecosystem service by both MEA (2005) and ONMS (2015), ONMS decided to remove it, recognizing that biodiversity is an attribute of the ecosystem for which many "final" ecosystem services depend (e.g., recreation and harvest); therefore, it is addressed in the State section of this report. Lastly, although ONMS listed climate stability as an ecosystem service in 2015, it is no longer considered an ecosystem service in ONMS condition reports, because national marine sanctuaries are not large enough to influence climate stability (Fisher et al. 2008, Fisher et al. 2011).

For OCNMS, nine of the 13 "final" ecosystem services were rated during the January 2020 workshop: consumptive recreation, non-consumptive recreation, science, education, heritage, sense of place, commercial harvest, subsistence harvest, and ornamentals.

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Ecosystem Services Indicators

The status and trends of ecosystem services are best evaluated using a combination of three types of indicators — economic, non-economic, and resource indicators. Economic indicators may include direct measures of use (e.g., person/days of recreation or catch levels) that result in spending, income, jobs, gross regional product, and tax revenues, or non-market economic values (the difference between what people pay to use a good/service and what they would be willing to pay). Non-economic indicators can be used to complement the economic indicators discussed above. These include importance-satisfaction ratings for natural and cultural resources, facilities and services for recreation uses, limits of acceptable change for resource conditions, social values and preferences (measured by polls), social vulnerability indicators, perceptions of resource conditions in the present and expectations for the future, and access to resources. Finally, resource indicators are also considered in determining status and trend ratings for each ecosystem service. To rate the status of each ecosystem service, resource indicators might result in a downgrade of a rating based on economic and human dimension non-economic indicators. Resource indicators are used to determine if current levels of use are sustainable and/or causing degradation to resources. Together, these three types of indicators should be considered when assessing the status and trends of ecosystem services.

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Consumptive Recreation — Recreational activities that result in the removal of or harm to natural or cultural resources

Rating: *Fair (high confidence), with undetermined trend (low confidence).*

Status Description: *Ability to provide ecosystem service is compromised, and existing management would require enhancement to enable acceptable performance.*

Rationale: *Consumptive recreation includes recreational activities that result in the removal of or damage to natural and cultural resources. For OCNMS, this activity is primarily recreational fishing and razor clam harvesting, activities that OCNMS does not manage. The number of charter boat angler trips had no clear upward or downward trend from 1998–2019, the number of private boat angler trips has increased during this same time period, and the number of razor clam licenses increased from 2011 to 2019. Although fishing has remained steady or increased for several species, some important or iconic salmon stocks have remained depressed and have yet to recover to provide the desired level of recreational fishing opportunities in the sanctuary.*

Recreational fisheries are an important service on the Olympic Coast, contributing to local economies for towns like Neah Bay, La Push, Westport, Pacific Beach, Forks, and Seiku as well as enhancing personal health and wellbeing for those who participate (Biedenweg et al., 2016). Shellfish harvesting and recreational fishing can result in or enhance place attachment (Donatuto et al., 2015).

From 1998 to 2019, the number of charter boat trips in OCNMS has seen no clear upward or downward trend. The year with the highest number of angler trips was 2003, with over 45,000 trips, and the year with the lowest trips was 1998, with about 28,000 trips. During this same time period, the number of private boat angler trips in OCNMS increased. The highest number of trips occurred in 2014, with almost 78,000; the year with the lowest number of trips was 1998, with about 33,000 (Figure ES.CR.1 and Figure ES.CR.2; RecFIN, 2020).

In 2019, charter boat fishing contributed $22.1 million in output, $9.6 million in income, and 234 full- and part-time jobs to coastal Washington[1]. Private boat fishing contributed about $15.8

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[1] Coastal Washington is defined as the region composed by the following counties: Snohomish, King, Whatcom, Pierce, Thurston, Mason, Skagit, San Juan, Island, Clallam, Jefferson, Grays Harbor, Pacific,

million in output, $5.9 million in income, and 88 full- and part-time jobs in this same year. While there were about 27,000 more private boat angler trips than charter boat trips, charter boats have a greater economic contribution due to the higher levels of spending associated with a charter boat trip. The economic contributions from charter boats remained relatively stable from 1998 to 2019, with the highest contributions levels occurring in 2003 and the lowest occurring in 1998. Private boat contributions increased during this time period with the highest contributions occurring in 2014 and the fewest occurring in 1998 (Tables A.1 and A.2; Figure ES.CR.3; RecFIN, 2020).

Jostad et al. (2017) gave fishing participation rates by different demographic categories for Washington State residents. Both saltwater fishing (by boat) and shell-fishing are more common among males (11% and 14%, respectively) than females (4% and 10%, respectively). Whites have the highest participation rate for saltwater fishing by boat with 8%, followed by Asians (5%), African Americans (4%), and Hispanics (2%). Whites also have the highest participation rate for shell-fishing with 12%, followed by Asians (11%), African Americans (9%), and Hispanics (1%). People over age 65 have the highest participation rate for both saltwater boat fishing and shellfishing (10% and 15%, respectively). People between the ages of 41 and 64 have the next highest participation rate for both types of fishing (8% and 12%, respectively), and people between the ages 18 and 40 have the lowest participation rates (4% and 8%, respectively). People with a master's degree or higher have the highest participation rate for saltwater boat fishing with 8%. Those with more than a high school degree but less than a master's, and those with a high school degree or less, have equal participation rates with 7%. People with a master's or higher have the highest participation rate for shell-fishing with 13%, followed by people with more than a high school degree but less than a master's (11%), and people with a high school degree or less (8%). People with an income over $60,000 have the highest participation rate for both saltwater fishing and shellfishing (10% and 14%, respectively), followed by people with an income between $25,000 and $60,000 (5% and 9%, respectively), and people with income below $25,000 (2% and 7%, respectively). These data show that recreational fishing is occurring at higher rates by those that have higher income and, thus, may be able to better afford access to the resources. Additionally, the data show that, if there is no recruitment of recreational anglers, there may be fewer people fishing in the future as a higher portion of people in the 65 and older age category reach a stage where engaging in the fishery is no longer possibleare engaged in recreational fishing.

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and Clark. This includes Puget Sound, the San Juan Islands, the Strait of Juan de Fuca, and the entire outer coast of the state.

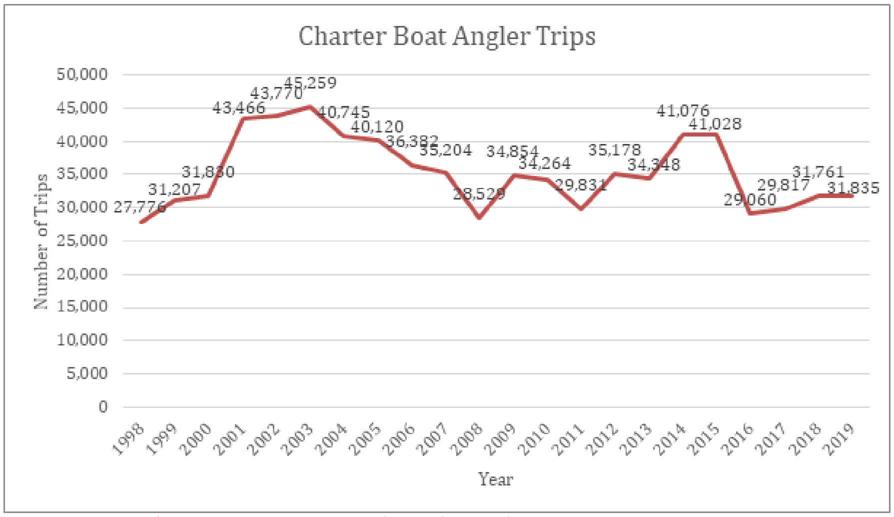

Figure ES.CR.1 Number of vessel trips and anglers for charter boats in statistical Areas 2, 3, 74, and 84 (1998–2016). Source: Pers. Communications, Erica Crust, WDFW, 2020

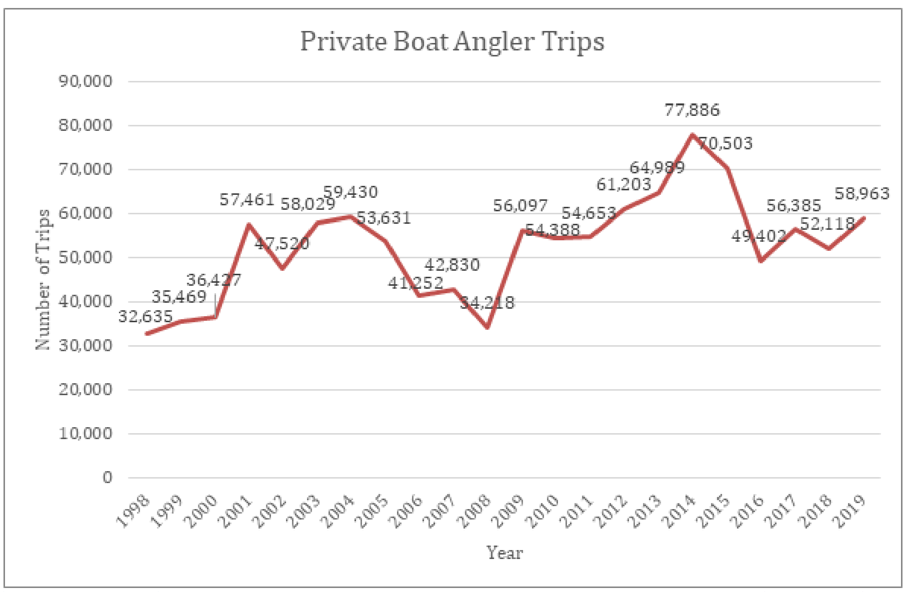

Figure ES.CR.2 Trend in number of vessel trips and anglers for party boats in statistical areas 2, 3, 74, and 84 (1998–2016) Source: Pers. Communications, Erica Crust, WDFW, 2020

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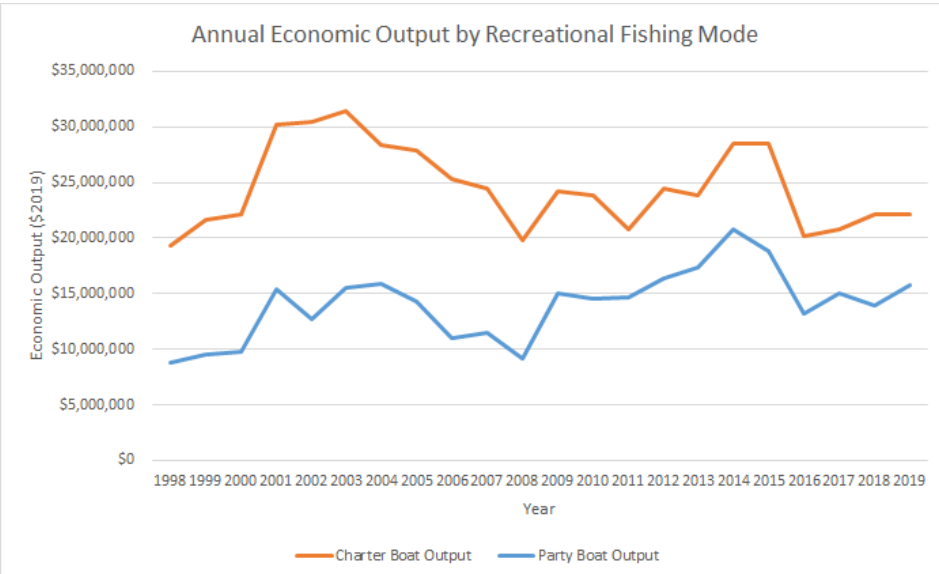

Figure ES.CR.3 Annual economic output from recreational fishing in and near OCNMS, 1998–2019. Source: Pers.~~onal~~ Communications,~~orrespondence with~~ Jerry Leonard, NOAA Fisheries - NWFSC. June 16, 2020.

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The top five species harvested by~~kept for~~ charter boat anglers between 1998 and 2019 were black rockfish, yellowtail rockfish, lingcod, tuna, and halibut (Table A.3 and A.4). The top five species for private boats were black rockfish, lingcod, tuna, halibut, and kelp greenling. Charter boats had a higher number of fish kept from 1998–2019 despite fewer angler trips over the same time period, which indicates that there are more fish caught per angler trip for charter boats than private boats (RecFIN).

The quantity of yellowtail rockfish, lingcod, and tuna kept by charter boats increased from 1998 to 2019. During this same period black rockfish catch remained stable and halibut catch declined (Figures A.1-A.5, RecFIN). For private boats, the quantity of black rockfish, yellowtail rockfish, lingcod, tuna, and halibut kept ~~all~~ increased from 1998–2019 (Figures A.1-A.6, RecFIN). Salmon catch data provided by the WDFW~~ashington~~ shows the lowest levels during the study period (2008-2019) occured in 2008 and 2016 for both charter and private vessels. Further, peak periods occurred in 2014 for both charter and private vessels. There is no clear linear trend in the data over time (Figure A.7).

Table 1.1 shows satisfaction levels for residents for saltwater fishing (including fishing by shore, boat, or fly fishing) and shell-fishing in Pacific, Wahkiakum, and Grays Harbor County. A majority of residents are satisfied with saltwater fishing in these three counties~~Pacific and Grays Harbor County~~, with 79% of respondents saying that they are either satisfied or highly satisfied. Residents are also satisfied with shell~~-~~fishing, with 65% of respondents saying that they are satisfied or highly satisfied (Jostad et al., 2017). It is worth noting that Pacific and Wahkiakum County are outside of the sanctuary and Grays Harbor county is partially outside of the sanctuary.

Table 1.1 Satisfaction levels for fishing in Pacific, Wahkiakum County, and Grays Harbor County (residents). Source: Jostad et al., 2017

Satisfaction Level	Saltwater Fishing	Shellfish Fishing
Highly Satisfied	22%	23%
Satisfied	57%	42%
Neither Satisfied nor Dissatisfied	13%	26%
Dissatisfied	3%	3%
Highly Dissatisfied	2%	2%
No Public Facilities Nearby	3%	3%

Another common recreational activity in OCNMS is razor clam harvesting; a license is required to participate in this activity. Figure ES.CR.4 shows the number of razor clam licenses from 2009 to 2011. The number of licenses rose from 2011 to 2019, although there was a sharp drop in 2016. The year with the most razor clam licenses was 2017, with 638,000, and the lowest year was 2016, with 544,000.

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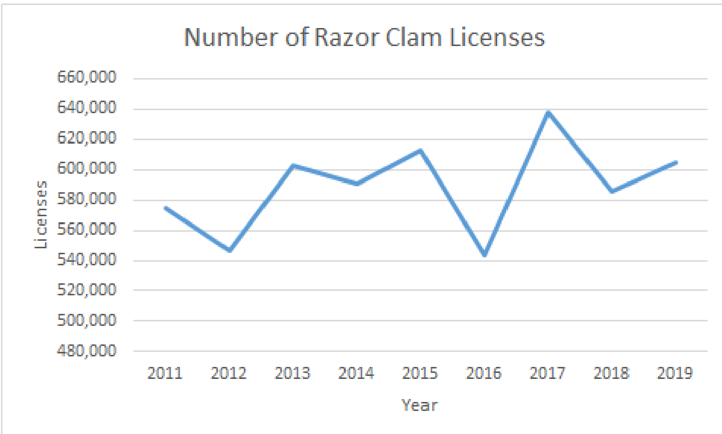

Figure ES.CR.4 Number of Razor Clam Licenses 2011–2019. Source: Pers. Communications, Dan Ayers, WDFW, 2020.

Figure ES.CR.5 shows the effort and value for the razor clam fishery within OCNMS (Mocrocks and Kalaloch beach). Both value and effort for razor clams increased from 1997 to 2020. The fishery was closed in 1998–1999 and 2002–2003 due to high levels of marine toxins, resulting in no catch or value reported for those years. The year with the lowest catch and value levels where the fishery was open was 1999–2000 with 319,000 clams harvested and $1.9 million in value. The year with the highest effort and value for razor clams was 2018–2019 with 1.1 million clams harvested and about $7.2 million in estimated fishery value. The 2019–2020 season was anticipated to reach record or near record levels in terms of effort and value, however, the COVID-19 pandemic forced an early closure to prevent the spread of the virus into coastal communities. The fishery was closed in 1998–1999 and 2002–2003 due to high levels of marine toxins, resulting in no catch or value reported for those years. The year with the lowest catch and value levels where the fishery was open was 1999–2000 with 319,000 clams harvested and $1.9 million in value.

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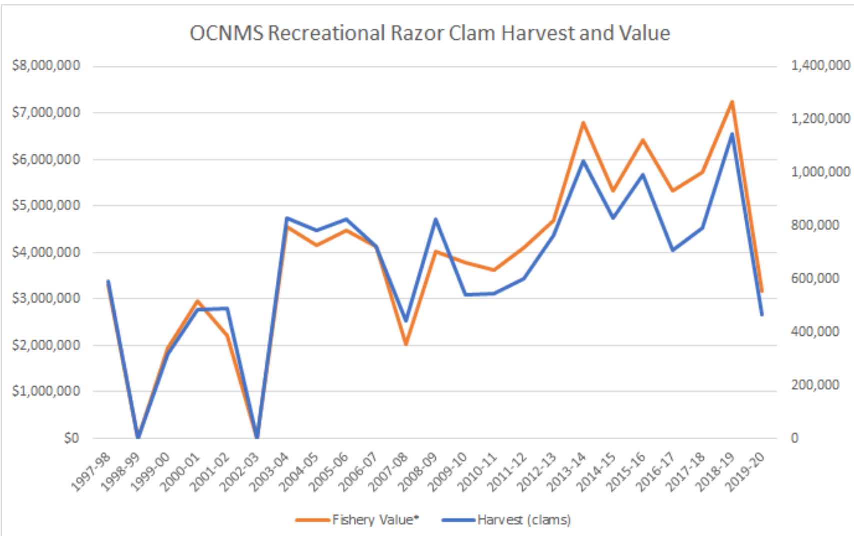

Figure ES.CR.5 Washington Recreational Razor Clam Harvest and Value; estimate of fishery value based on Dyson and Huppert (2010). Source: Pers. Communications, Dan Ayers, WDFW, 2020

Razor clams are one of the most sought after shellfish in Washington State. High densities of people (up to 1,000 per mi^2) visit the Washington coast to razor clam in periodic, short-term (several day) events, including some who have been coming for generations and some first timers.

> "It's beyond a recreational activity. We've been coming to the same beach generation after generation. I even use the same shovel my grandfather used to dig clams back in the 50~~'~~s. Clamming holds a cultural aspect tied to the tribes who have been around long before. I'm mindful of the traditional side, the patience and tranquility of being present. I see that evident with the traditional tribal side of shellfishing, too" (Fraizer, 2017).

Resource indicators help to determine whether current use is sustainable and if there is potential for the service to improve or decline. Many stocks have been stable or increasing since 2008, including razor clams (S.LR.13.1 and S.LR.13.3) and groundfish (S.LR.13.5). Pacific halibut biomass is increasing in Catch Area 2A (Washington, Oregon, and California, see ES.CM.App1). Salmon~~id~~ and steelhead populations on the coast are largely stable (56 of the 81 runs assessed), with six runs of ~~c~~Chinook, coho, and steelhead increasing and 19 runs declining (S.LR.13.12). Populations of harvestable (legal size) Dungeness crab ~~populations~~ have declined

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Commented [16]: Steelhead are also salmonids -- the grouping includes salmon, trout, chars, whitefish, and graylings.

north of Point Grenville since 2005 (S.LR.13.3), but the CPUE (including sub legal size crab) from NOAA trawl surveys in OCNMS has increased since 2008 (S.LR.13.4). Currently the trends for black rockfish, yellowtail rockfish, and tuna in the region are undetermined and the lingcod stock is declining (Appendix Figure S.LR.13.6). The living resources section shows more details about resource indicators.

APPENDIX

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Table A.1 Economic contributions from charter fishing boats 1998–2019.

Year	Employment	Income	Output
1998	204.0	$8,416,153	$19,314,325
1999	229.2	$9,455,749	$21,700,106
2000	233.8	$9,644,518	$22,133,316
2001	319.3	$13,170,237	$30,224,527
2002	321.5	$13,262,349	$30,435,917
2003	332.5	$13,713,517	$31,471,308
2004	299.3	$12,345,771	$28,332,452
2005	294.7	$12,156,529	$27,898,158
2006	267.3	$11,023,775	$25,298,589
2007	258.6	$10,666,958	$24,479,725
2008	209.6	$8,644,337	$19,837,987
2009	256.0	$10,560,757	$24,236,002

2010	251.7	$10,382,065	$23,825,920
2011	219.1	$9,038,698	$20,743,013
2012	258.4	$10,658,996	$24,461,451
2013	252.3	$10,407,562	$23,884,434
2014	301.7	$12,446,083	$28,562,658
2015	301.4	$12,431,390	$28,528,940
2016	213.5	$8,805,088	$20,206,897
2017	219.0	$9,034,453	$20,733,271
2018	233.3	$9,623,660	$22,085,447
2019	233.9	$9,646,082	$22,136,904

Multipliers for Washington were provided by Northwest Fisheries Science Center
Pers. Communications, Jerry Leonard, NWFSC, 2020

Table A.2 Economic contributions from private fishing boats 1998–2019.

Year	Employment	Income	Output
1998	48.7	$3,255,658	$8,733,674
1999	52.9	$3,538,377	$9,492,100
2000	54.3	$3,633,946	$9,748,477
2001	85.7	$5,732,292	$15,377,529
2002	70.9	$4,740,581	$12,717,150

2003	86.6	$5,788,955	$15,529,535
2004	88.6	$5,928,719	$15,904,466
2005	80.0	$5,350,184	$14,352,482
2006	61.5	$4,115,277	$11,039,701
2007	63.9	$4,272,720	$11,462,060
2008	51.0	$3,413,559	$9,157,263
2009	83.7	$5,596,189	$15,012,417
2010	81.1	$5,425,740	$14,555,169
2011	81.5	$5,452,188	$14,626,120
2012	91.3	$6,105,564	$16,378,873
2013	96.9	$6,483,293	$17,392,175
2014	116.2	$7,769,840	$20,843,484
2015	105.2	$7,033,373	$18,867,827
2016	73.7	$4,928,309	$13,220,754
2017	84.1	$5,624,999	$15,089,704
2018	77.7	$5,199,279	$13,947,660
2019	87.9	$5,882,117	$15,779,452

Multipliers for Washington were provided by Northwest Fisheries Science Center
Pers. Communications, Jerry Leonard, NWFSC, 2020

Table 1.3 Charter fishing boat landings by species in OCNMS 1998–2019.

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Species	Charter Quantity Kept	Percent of total Fish Kept
Black rockfish	2,948,521	72.3%
Yellowtail rockfish	379,643	9.3%
Lingcod	309,495	7.6%
Tuna	205,163	5.0%
Halibut	70,296	1.7%
Miscellaneous	32,208	0.8%
Canary rockfish	28,764	0.7%
Flatfish	28,576	0.7%
Blue rockfish	15,044	0.4%
Quillback rockfish	14,517	0.4%
Other	44,922	1.1%
Total	4,077,149	100.0%

Source: Pers. Communications, Erica Crust, WDFW, 2020

Table 1.4 Private fishing boat landings by species in OCNMS 1998–2019.

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Species	Quantity Kept	Percent of Total Fish Kept
Black rockfish	1,661,691	63.3%
Lingcod	287,114	10.9%
Tuna	150,542	5.7%
Halibut	108,928	4.1%
Kelp greenling	79,765	3.0%
Yellowtail rockfish	60,806	2.3%
China rockfish	50,305	1.9%
Cabezon	46,836	1.8%
Blue rockfish	32,873	1.3%
Quillback rockfish	27,563	1.0%
Other	119,359	4.5%
Total	2,625,782	100.0%

Source: Pers. Communications, Erica Crust, WDFW, 2020

Graph of Lingcod, Halibut, Black Rockfish, ~~and~~ Yellowtail Rockfish, and Tuna for Private Boats, Charter Boats

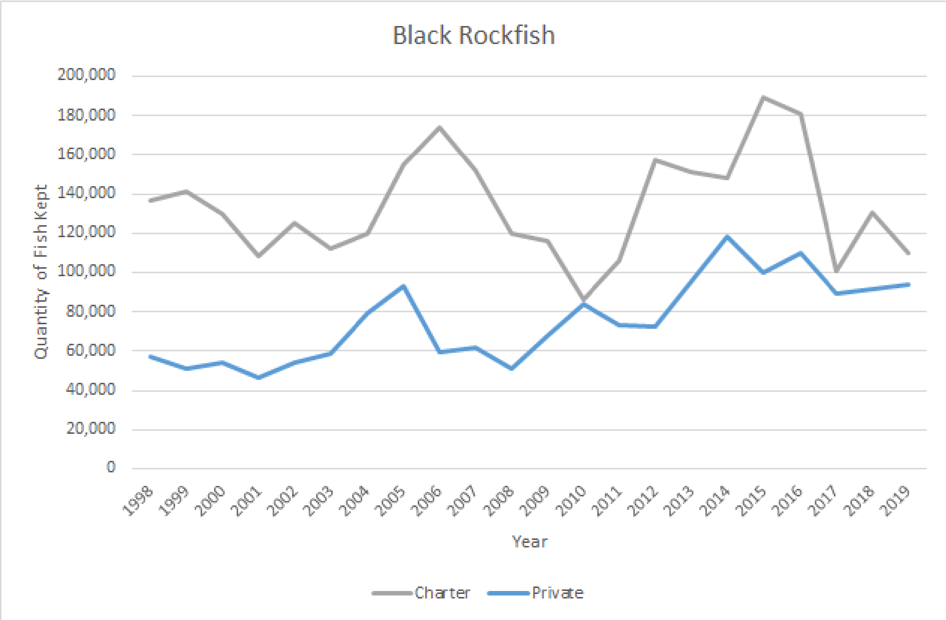

Figure A.1 Trend in the quantity of black rockfish kept for charter and private boats in statistical areas 2, 3, 4, and 4B (1998–2016). Source: Pers. Communications, Erica Crust, WDFW, 2020

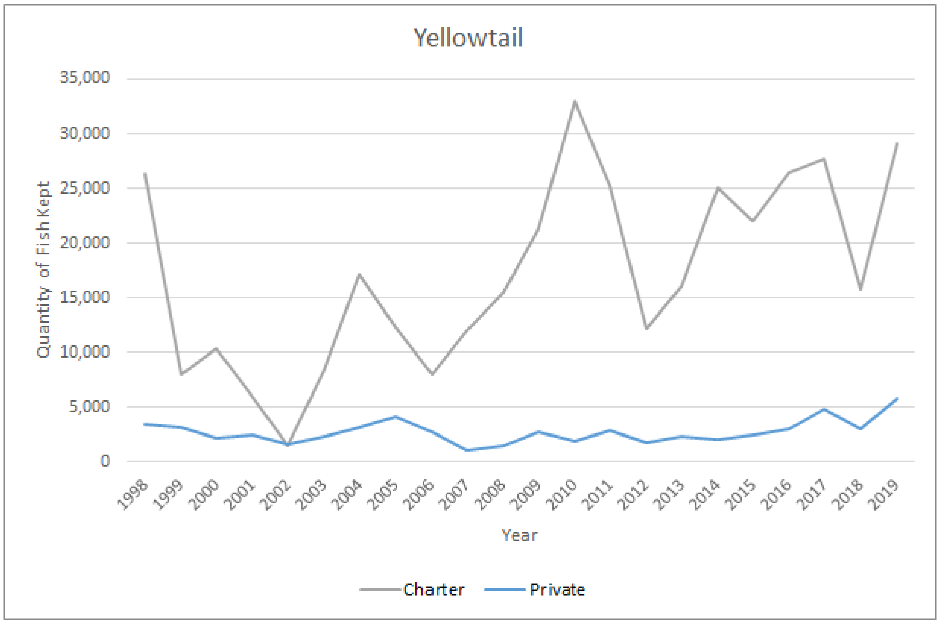

Figure A.2 Trend in the quantity of yellowtail rockfish kept for charter and private boats in statistical areas 2, 3, 4, and 4B (1998–2016). Source: Pers. Communications, Erica Crust, WDFW, 2020

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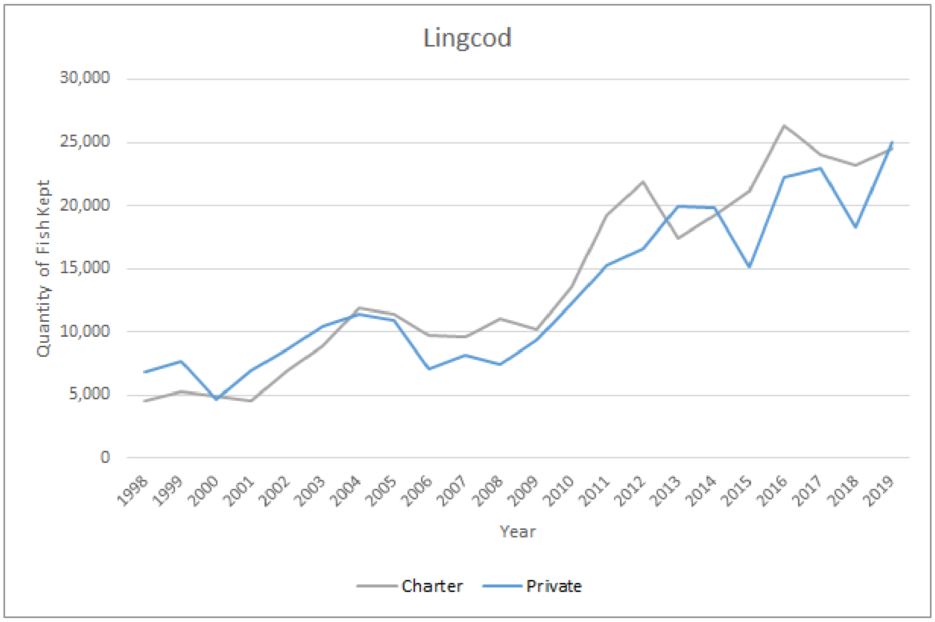

Figure A.3 Trend in the quantity of lingcod kept for charter and private boats in statistical areas 2, 3, 4, and 4B (1998–2016). Source: Pers. Communications, Erica Crust, WDFW, 2020

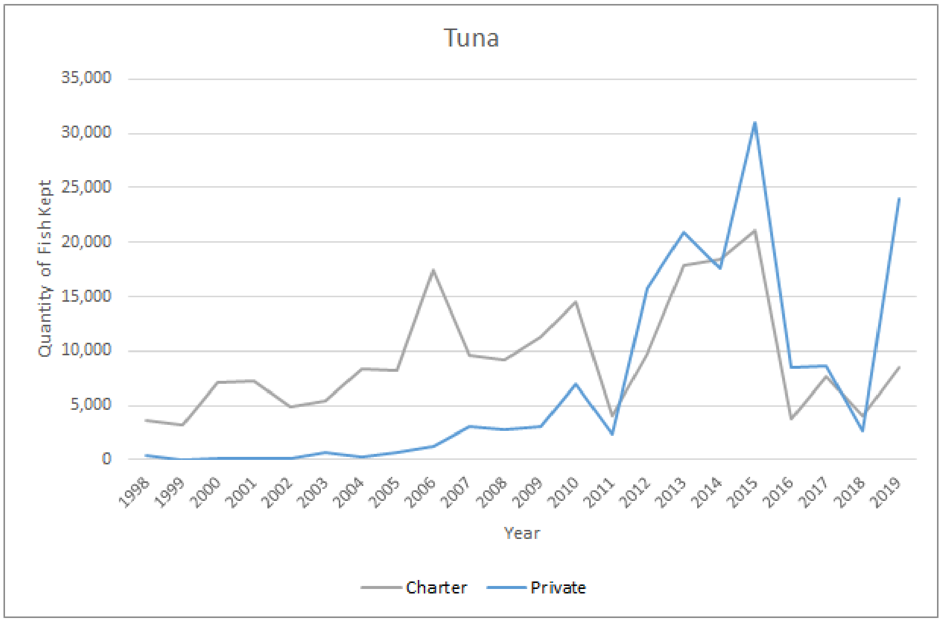

Figure A.4 Trend in the quantity of tuna kept for charter and private boats in statistical areas 2, 3, 4, and 4B (1998–2016). Source: Pers. Communications, Erica Crust, WDFW, 2020

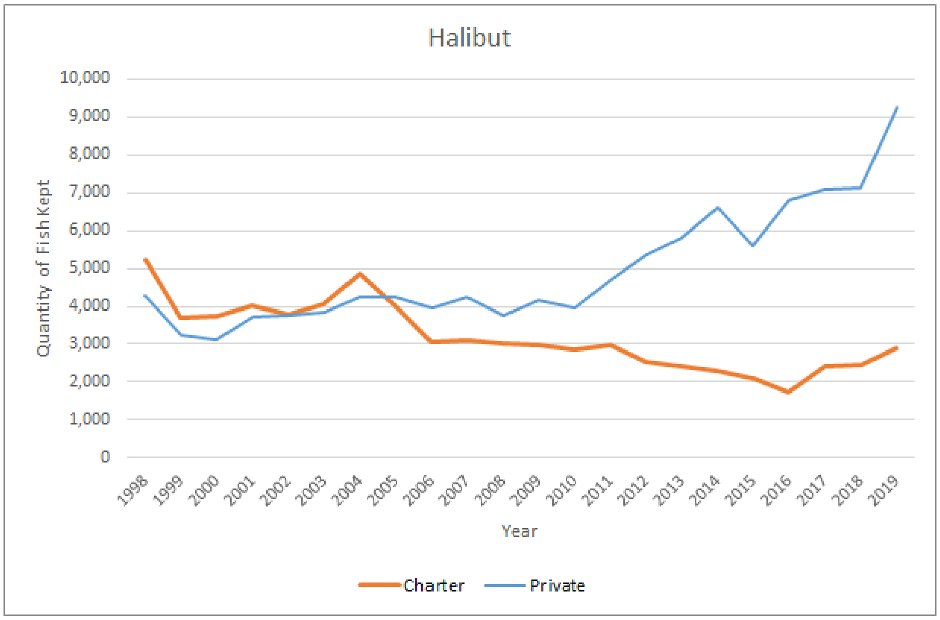

Figure A.5 Trend in the quantity of halibut kept for charter and private boats in statistical areas 2, 3, 4, and 4B (1998–2016). Source: Pers. Communications, Erica Crust, WDFW, 2020

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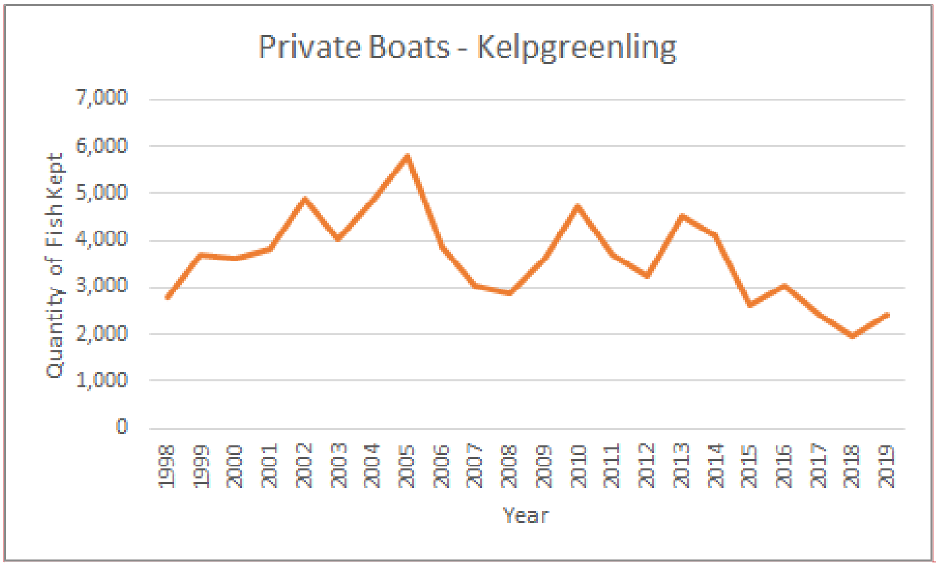

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Figure A.6 Trend in the quantity of kelp greenling kept for ~~P~~private ~~B~~boats in Statistical Areas 2, 3, 4, and 4B (1998–2016). Source: Pers. Communications, Erica Crust, WDFW, 2020

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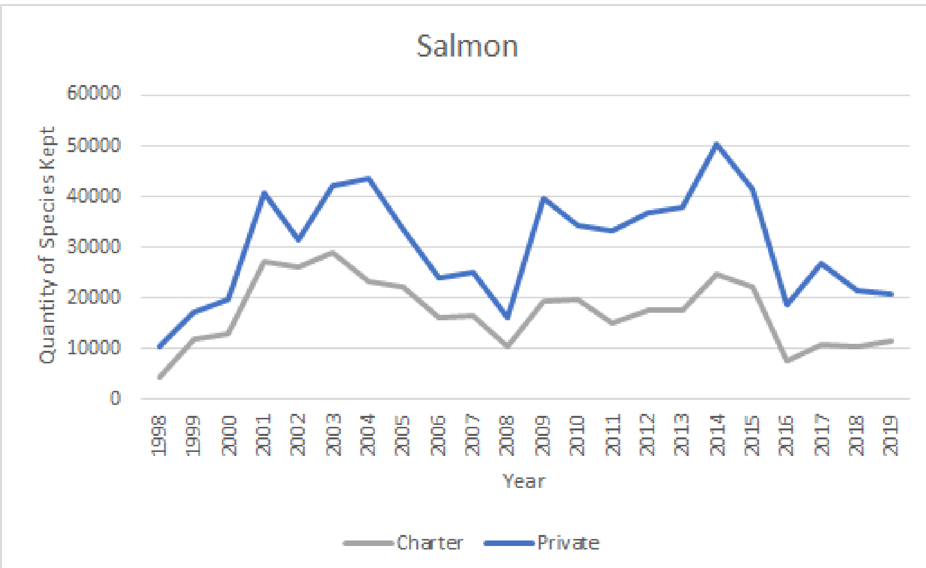

Figure A.7 Trend in the quantity of salmon kept by private and charter boats in Statistical Areas 2, 3, 4, and 4B (1998–2016). Source: Pers. Communications, Erica Crust, WDFW, 2020

Sources:

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Recreational Fisheries Information Network (RecFIN), 2020

This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

Non-Consumptive Recreation — Recreational activities that do not result in intentional removal of or harm to natural or cultural resources

Rating: *Fair (high confidence), with undetermined trend (low confidence)*

Status Description: *Ability to provide ecosystem service is compromised, and existing management would require enhancement to enable acceptable performance.*

Rationale: *Various measures of visitation have remained stable or increased from 2008 to 2018. Visitors and residents to the OCNMS area report engaging in a variety of non-consumptive recreational activities, including shore-based activities, wildlife viewing, sightseeing, and water-based sports. However, the popularity of recreational activities in OCNMS has led to significant concerns regarding the region's ability to support increased visitor use, which was a key factor in determining the "Fair" rating. The "Undetermined" trend was driven by uncertainty regarding the effects of increased use on the condition of sanctuary resources and the quality of non-consumptive recreation at some sanctuary locations.*

The status of non-consumptive recreation is "Fair" (high confidence) and the trend is "Undetermined" (low confidence). Recreational activities that do not result in the intentional removal of or damage to natural and heritage resources are considered non-consumptive. A variety of non-consumptive recreational activities occur in and adjacent to OCNMS, including whale watching (boat- and shore-based), visitation, shore-based recreational activities (e.g., tide pooling), watersports (e.g., surfing), and boating. Although museum and visitor center use may also be considered non-consumptive recreation, for OCNMS, this is a land-based activity, so this discussion is included in the maritime heritage and education ecosystem service discussions.

Washington Marine Spatial Planning (2020) provides information on the spatial distribution of human activities in the state of Washington's marine environments (Figure ES.NCR.1). Diving activities, including SCUBA diving, free diving, and snorkeling, are generally infrequent within OCNMS, although moderate use is reported at some sanctuary locations. Surface water activities, including boating, kayaking, and surfing, are concentrated toward the northern half of the sanctuary. Shore-based activities (e.g., beachcombing, beach going, hiking, and camping) and wildlife viewing/sightseeing (e.g., photography, scenic drives, and wildlife viewing frome shore or boats) are more frequently reported in the OCNMS region.

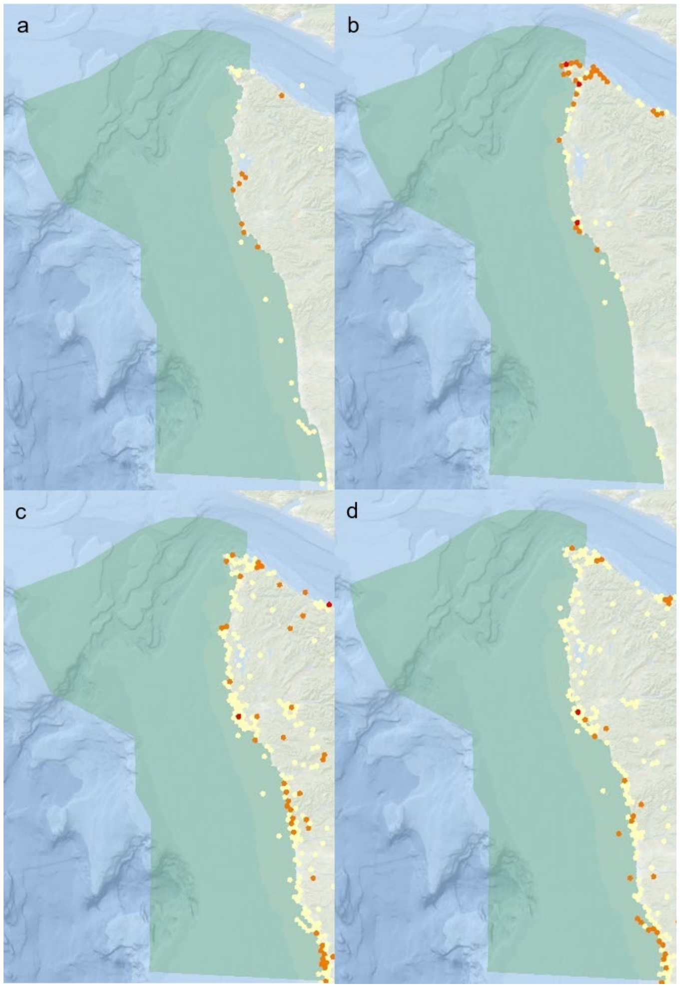

Figure ES.NCR.1. Spatial distribution of recreational activities in and adjacent to OCNMS. The green polygon represents OCNMS boundaries. Red points indicate high use, orange points indicate moderate use, and yellow points indicate low use. (a) Diving activities, including snorkeling, free diving, and SCUBA diving, from shore and boats. (b) Surface water activities, including boating and sailing, kayaking, kiteboarding, skimboarding, surfing, and windsurfing. (c) Shore-based activities, including beachcombing, beach driving, beach going, biking and hiking, camping, hang gliding and parasailing, horseback riding, and tide pooling. (d) Wildlife viewing and sightseeing activities, including photography, scenic drives, sightseeing, and wildlife viewing from shore and boats. Source: Washington Marine Spatial Planning, 2020.

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Households in the state of Washington were surveyed in 2014 to provide additional insight into use of the outer coast, including OCNMS, by state residents (Leeworthy et al., 2016). This study provides insight into the types of non-consumptive recreation that sanctuary visitors engage in.

Among shore-based activities, those surveyed engaged primarily in beach going (69.0%), collecting non-living resources (31.4%), and tide pooling (30.6%) within OCNMS. Sightseeing (64.5%), watching wildlife from shore (35.2%), and watching scenery from a car (26.4%) were also popular activities. Survey respondents also reported engaging in water-based sports, such as swimming or body surfing (17.7%), snorkeling (12.4%), and kayaking (11.7%), within the sanctuary. While this study provides important insight into recreational use of the sanctuary by Washington residents, additional data are needed to assess recreational use by out-of-state visitors to OCNMS.

A small percentage of Washington residents also reported watching wildlife from a private (9.0%) or charter (2.0%) vessel within OCNMS (Leeworthy et al., 2016). A limited number of commercial whale watching charters operate within OCNMS boundaries. In general, however, whale watching is an increasingly popular activity in the state of Washington; from 1998–2008, the number of whale watchers, whale watch operators, and total expenditures related to whale watching increased statewide (O'Connor et al., 2009).

Although commercial whale watching is limited within OCNMS boundaries, self-guided, shore-based whale watching opportunities exist. The Whale Trail is a Washington-based non-profit organization that has identified a series of sites for shore-based viewing of marine mammals. Nine Whale Trail sites are directly adjacent to the sanctuary (The Whale Trail, 2018). However, data on visitation and use at Whale Trail sites are unavailable.

Workshop participants noted that bird watching is another popular wildlife viewing activity in and adjacent to OCNMS. The Great Washington State Birding Trail - Olympic Loop identifies multiple key bird watching sites adjacent to OCNMS (United States Department of Agriculture Forest Service, 2020). Additionally, Olympic Birdfest, an annual bird watching event, includes birding tours in partnership with Audubon and the Makah Tribe at some sites adjacent to the sanctuary (e.g., Cape Flattery; Olympic Birdfest, 2020).

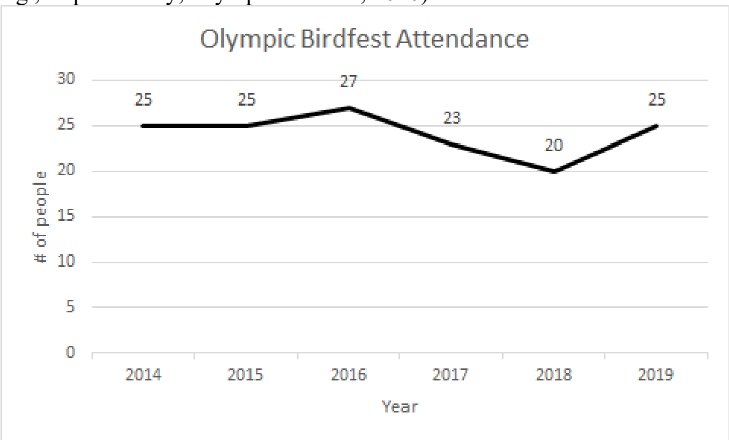

Figure ES.NCR.2. Olympic Birdfest Attendance, 2014–2019. Source: Dungeness River Audubon Center, personal communication, 2020.

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In addition to wildlife viewing, workshop participants noted that surfing is a popular and effective way to experience OCNMS. Warm Current, in partnership with the Makah Tribe, Quileute Nation, Hoh Indian Tribe, and Quinault Indian Nation, offers community surf camps for Native youth; these surf camps provide opportunities for youth to engage in recreation as well as exploration of their ancestral waters (Warm Current, 2020).

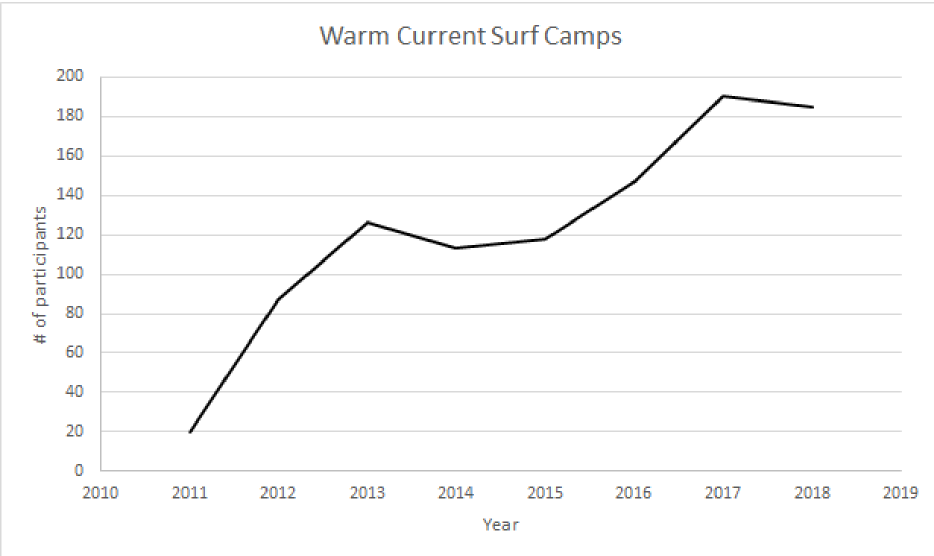

Figure ES.NCR.3. Warm Current Surf Camps Number of Participants, 2011–2018. Source: Warm Current, personal communication, 2020.

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Recreational boating is another non-consumptive ~~recreational~~ activity in OCNMS, and the number of recreational boat registrations over time provides insight into how this activity has changed over the study period. In the state of Washington, recreational boat registrations decreased from 2009 to 2014, but slowly increased from 2014 to 2018 (Figure ES.NCR.4; National Marine Manufacturers Association, 2020). Data are not available for the portion of registrations that use the outer coast and/or sanctuary, but it is assumed that though the majority of boating traffic occurs near more populated areas in Puget Sound, the fraction of boaters using the outer coast remains relatively constant over time.

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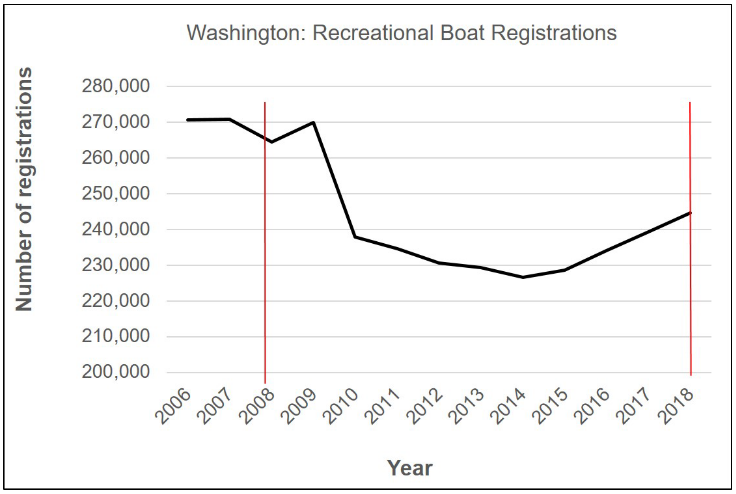

Figure ES.NCR.4. Number of recreational boat registrations in the state of Washington, 2006–2018. Vertical red lines indicate the time period of primary interest, 2008–2018. Source: National Marine Manufacturers Association, 2020.

Information is also available regarding visitation at Cape Flattery, the northern boundary of OCNMS and part of the Makah Reservation. The Makah Tribe offers interpretive talks about the area's natural history and marine wildlife for Cape Flattery visitors. Although visitation decreased from 2015 to 2016, the number of visitors to Cape Flattery steadily increased from 2016 to 2019 (Figure ES.NCR.5). In 2020 the Makah reservation was largely closed to non-residents as a result of the COVID-19 pandemic, thus data are not presented for that year.

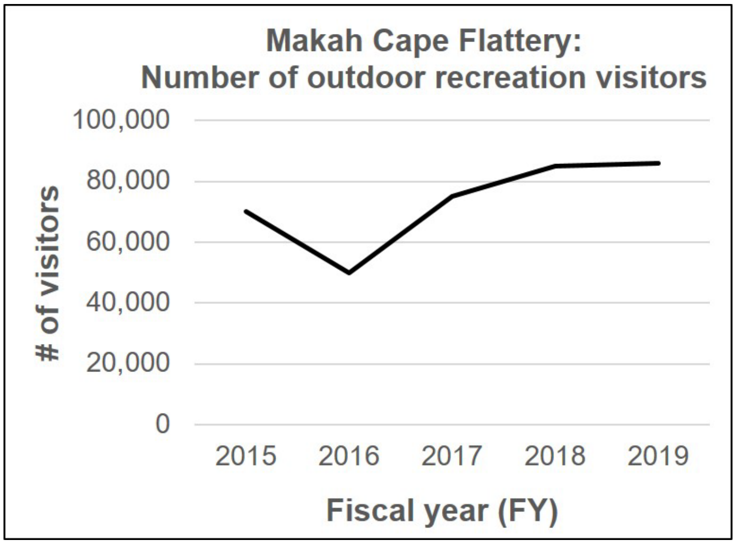

Figure ES.NCR.5. Annual number of outdoor recreation visitors to Cape Flattery, 2015–2019. Source: Makah Tribe/NOAA.

Visitation at Olympic National Park, which directly borders a portion of the sanctuary, can also provide insight into the number of people engaged in non-consumptive recreation in the adjacent portion of OCNMS. Visitation to Olympic National Park remained relatively stable from 2008 to 2018 (Figure ES.NCR.6). Coastal areas adjacent to OCNMS (including Mora, Kalaloch, and Ozette districts) were the second most visited regions of the Olympic National Park in 2015 (McCaffery, 2018). Additionally, the number of annual backcountry campers increased from 2008 to 2018 (Figure ES.NCR.7).

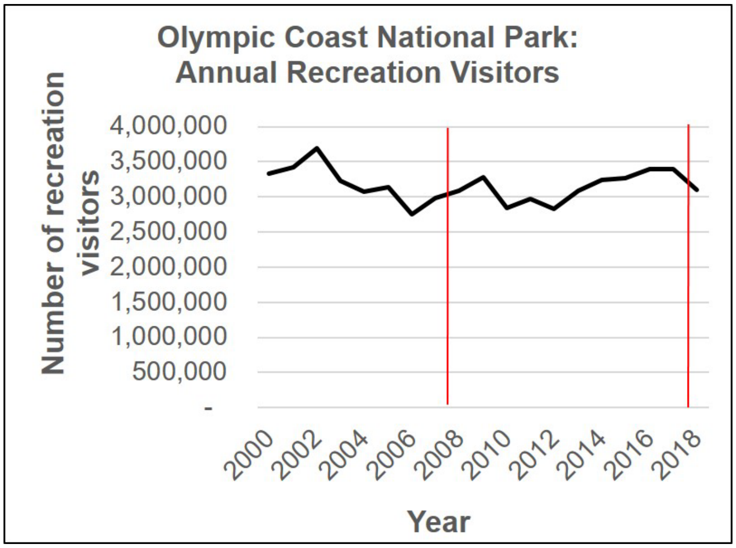

Figure ES.NCR.6. Annual visitation at Olympic National Park, 2000–2018. Vertical red lines indicate the time period of primary interest, 2008–2018. Source: NPS, 2020.

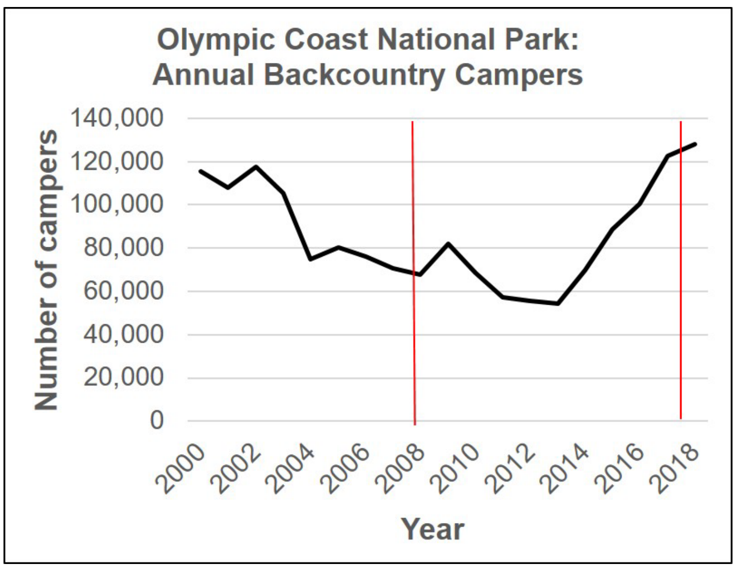

Figure ES.NCR.7. Annual number of backcountry campers at Olympic National Park, 2000–2018. Vertical red lines indicate the time period of primary interest, 2008–2018. Source: NPS, 2020.

Although people are able to engage in a wide variety of non-consumptive recreational activities in OCNMS, the volume of visitation at the sanctuary is a potential cause for concern in some areas. Thirty-four public access points to the sanctuary exist along the coast (Washington Marine Spatial Planning, 2020). While public access points are important for providing opportunities for residents and visitors to engage in non-consumptive recreation, they can also serve as indicators of increasing sanctuary use, which can affect the quality of non-consumptive recreational experiences and negatively impact sanctuary resources. Workshop participants noted that use has increased from 2008 to 2018 at a number of these public access points (Figure ES.NCR.8).

Figure ES.NCR.8. Photos depicting increasing visitor use of key OCNMS public entry points. (A) Overflow parking at Second Beach, La Push, WA. (B) Overflow parking on a highway shoulder near Third Beach, La Push, WA. (C) Footprints in the sand illustrate the recent presence of a number of visitors at Second Beach, La Push, WA. Photos: Jennifer Hagen/Quileute Tribe.

The primary resources supporting non-consumptive recreation in OCNMS are water quality (contaminants and risks to human health) and the presence of species valued for wildlife viewing, particularly marine mammals and seabirds. Poor water quality can result in beach advisories or closures, which can negatively impact a number of shore-based recreational activities. Few beaches adjacent to OCNMS are monitored, resulting in a key data gap for this indicator. Of the beaches that are monitored, closures were rare, although at least one beach closure occurred in 2018 due to pathogenic bacterial levels. See Question 7 for additional details.

Populations of many marine mammal species valued for wildlife viewing have remained stable or increased in the OCNMS region from 2008 to 2018. However, endangered southern resident killer whales declined over the 10--year period, and gray whales experienced an unusual mortality event in 2019. Additionally, while seabird species like Cassin's auklet remained stable from 2008-2018, a number of other key seabird populations declined during the study period, and multiple unusual mortality events were recorded. See Question 13 for additional details.

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This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

Science — The capacity to acquire and contribute information and knowledge

Rating*: Fair (high confidence) and Improving (high confidence)*

Status Definition*: The capacity to provide the ecosystem service is compromised, and existing management would require enhancement to enable acceptable performance.*

Rationale: *The fair rating was driven by the ~~that~~ fact that not all science needs are being met due to insufficient resource allocation. Limitations exist with regard to OCNMS capacity, staffing, resources, and infrastructure, including limited staff capacity in several areas; ~~,~~ aging research vessels (R/V Tatoosh); ~~,~~ and limited internet, lab space, and academic institutions on the coast to conduct all of the science activities required. However, research partnerships, collaboration, and coordination are improving, which is increasing the breadth of science conducted within OCNMS. New research programs have begun, including establishment of an ocean acidification sentinel site, kelp forest surveys, deep sea exploration, and ocean sound monitoring, while continuing oceanographic moorings, habitat mapping and seafloor characterization, and intertidal surveys. Furthermore, the extensive traditional ecological knowledge of the four coastal treaty tribes significantly enhances our shared understanding of the Olympic Coast.*

Commented [1]: This is a very high bar -- there is NEVER enough money to meet all needs. Can you say "several major" or "several critical" instead?

The coastal treaty tribes have lived on the Olympic Coast since time immemorial, and each has cultivated a body of knowledge on ecosystem processes, timing, location of important habitats and species, and a variety of other topics over generations. ONMS and OCNMS acknowledge and honor Traditional Knowledge (TK) as valued science that aids in understanding ecosystems and resources therein and contributes to successful ecosystem-based management, and agree that "respecting and embracing indigenous knowledge as important science benefits all of us" (Greene 2018).

In addition to TK, each of the coastal treaty tribes has developed research programs within their governments. This includes a variety of biologists and ecologists monitoring ecosystem components, as well as social scientists, historians, archaeologists, and cultural resource specialists who may serve in the formal role of Tribal Historic Preservation Officers. Together they gather relevant social and ecological data along the Olympic Coast, aligning TK and western science to inform management decisions. For example, in a recent study, the Makah Tribe tested the selectivity of traditional halibut hooks [*čibu·d* (chih-**bood)**] relative to modern circle hooks ~~to determine the selectivity of these hooks compared to modern circle hooks in~~ as a possible mechanism for reducing bycatch of rockfish (especially yelloweye rockfish, which are still overfished) in the recreational halibut fishery. Using Makah TK, Makah Fisheries

Management showed the *čibu·d* to be more selective for halibut than the modern circle hook, thus reducing bycatch and promoting sustainable fishery practices (Petersen et al., 2020).

Social science is an important area of study for the sanctuary. Novel research to pair social vulnerabilities of each tribal community with biological vulnerabilities of important marine species to ocean acidification along the Olympic Coast is underway (2018 to 2021) to better understand research and management needs. A research partnership with University of Washington Sea Grant – specifically a social science team with anthropology, ethnoecology, and socioeconomic expertise – is collecting and synthesizing new and existing data to help understand the importance of the marine ecosystem to community health and well-being, how ocean changes may adversely impact well-being, the range and distribution of multiple socioeconomic and ecological stressors, and effective strategies for social resilience and recovery.

The number of research permits issued by ONMS for studies in OCNMS waters from 2008 to 2019 increased nine-fold, with an average of twenty-five permits open each year (NOAA Office of National Marine Sanctuaries, 2020; Figure ES.S.1). Although the number of permits provides some insight about changes in the level of research activity in OCNMS, not all research requires permits. Recently, several agencies sought ONMS permits for the first time (fisheries stock assessments and marine mammal research), potentially inflating the apparent increase in permits. While the number of permits granted previously may not be a good reflection of past research effort, it may be useful for future OCNMS assessments and is presented below for reference.

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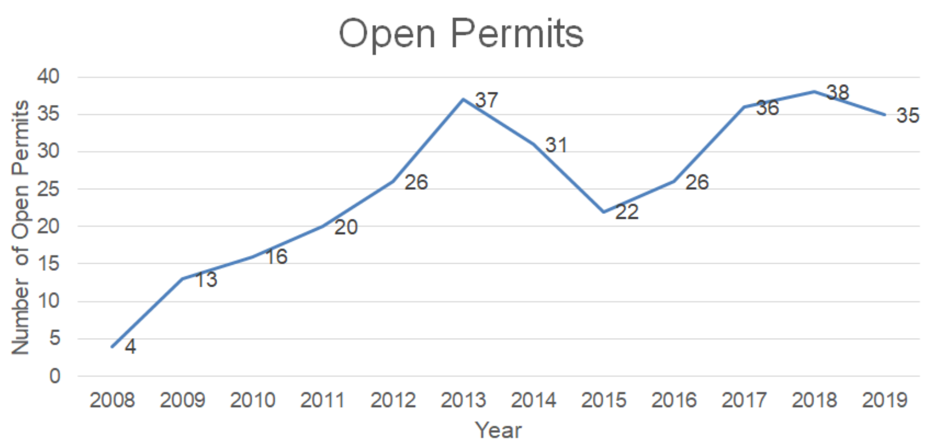

Figure ES.S.1. Open OCNMS permits, by year. OCNMS issues permits for otherwise prohibited activities, if it has been found that the proposed activity will not substantially injure sanctuary resources and qualities, and will further research related to those resources and qualities. The most common is a permit to conduct research in the sanctuary. Data from OSPREY, an internal ONMS permit database.

The R/V *Tatoosh* was the first research vessel built specifically for a National Marine Sanctuary. Prior to its construction, sanctuary vessels were mainly repurposed surplus vessels. The contract for the R/V *Tatoosh* was a considerable investment by NOAA, comprising a large portion of the sanctuary's initial 1994 budget, the year the sanctuary was designated. The vessel has been ~~was~~ upgraded repeatedly to provide additional capabilities; most significantly, in 2000 the vessel was lengthened (XX feet to XY feet), repowered and equipped with deck gear, including an A-frame to support additional oceanographic operations. In 2011, multibeam mapping sonar was added to provide seafloor mapping capability, a high priority for the sanctuary for several years. Even today OCNMS's R/V *Tatoosh* is one of very few science platforms operating in this region. However, the vessel has several limitations and is nearing the end of its working life, which has led ONMS to invest significant funds towards a new research vessel beginning in FY20.

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OCNMS also uses a small Rigid Hull Inflatable Boat (RHIB) to~~in the~~ conduct ~~of~~ some research activities. However, Olympic Coast's notoriously rough marine weather offshore, and the limited safe operational limits of the RHIB, mean that it is mostly used in protected waters such as the Strait of Juan de Fuca for work in nearshore habitats.

OCNMS conducts research from small boats, large research ships, and aircraft, engages community scientists, and collaborates with multiple partners. Since 2008, the number of hours and number of days the *R/V Tatoosh* has spent at sea fluctuated, but has not trended in a consistent direction (ES.S.2) despite a reduction of staff available to crew the vessel and limitations of the vessel regarding the amount and type of work that can be conducted within OCNMS.

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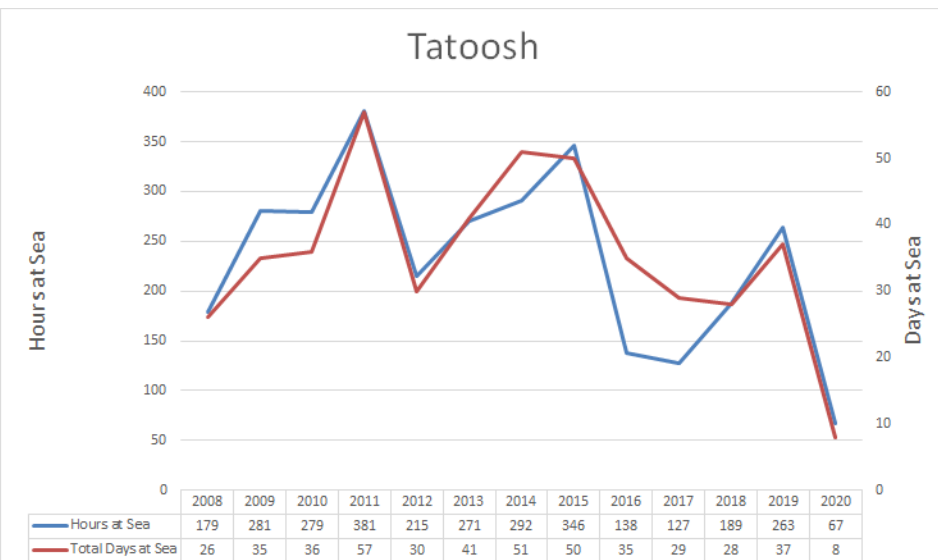

Figure ES.S.2. The R/V *Tatoosh* operates May to October on the Olympic Coast to accomplish sanctuary research efforts and facilitate research of collaborators. Vessel use data in the assessment period are presented above for hours at sea (blue line) and days at sea (red line). Source: OCNMS data, graph by LTJG Anna Hallingstad.

OCNMS engaged the public in sanctuary science and monitoring projects during the assessment period, usually as part of a broader effort, such as the coastal surveys for marine debris and beached birds, which accounts for 93% of the contributed hours (Figure ES.S.3).

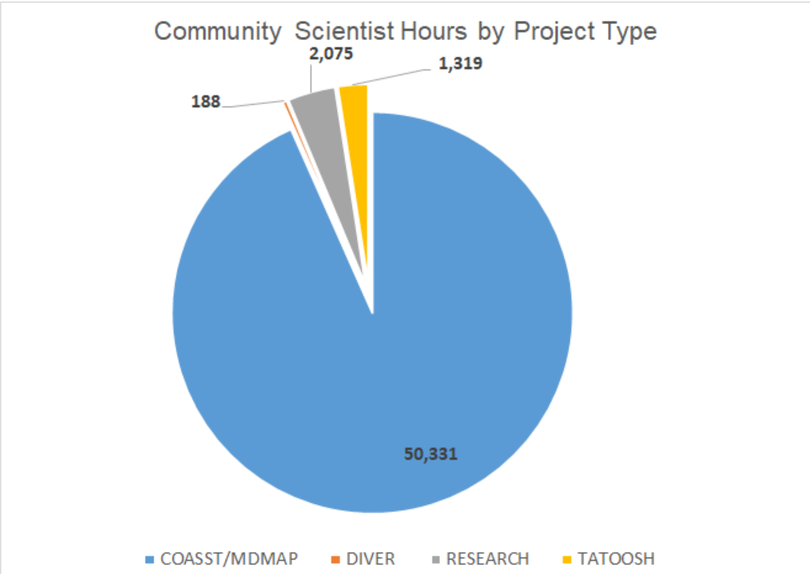

Figure ES.S.3 Between 2008 and 2019, community scientists contributed 53,913 hours towards a variety of activities. The majority (93%) of hours were associated with marine debris and beached seabird (COASST/MDMAP) surveys, with the remaining 3,582 hours contributed to dive surveys, research projects, and mooring operations aboard the R/V *Tatoosh*. Source: OCNMS data, graph by Chris Butler Minor.

Currently, OCNMS does not have dedicated staff or funding to coordinate community science efforts. The two major programs that previously accounted for the bulk of contributed hours were either transferred to outside groups, such as the beached seabird surveys (Figure ES.S.3) that were transitioned in 2015 to the Coastal Observation and Seabird Survey Team (COASST), or were discontinued, as with the marine debris monitoring program (MDMAP). Marine debris monitoring of the coast, which was initiated in response to the arrival of tsunami debris from Japan's March 2011 event, was slated to end in 2017; however, an extension was granted to support the remaining volunteers through fall of 2019, prompting a slight increase in hours in 2018. OCNMS staff continue to explore opportunities for volunteers, in addition to connecting them with the COASST, which initiated a marine debris monitoring program in 2015 to complement beached bird surveys.

Both the number of community scientists and the number of hours they contributed decreased between 2008 and 2018 (Figure ES.S.4). The number of volunteers varied over time, ranging from a high of 392 in 2014 to a low of 52 in 2018. The number of volunteer hours peaked in 2010 with 9,258 and experienced a low of 459 hours in 2017.

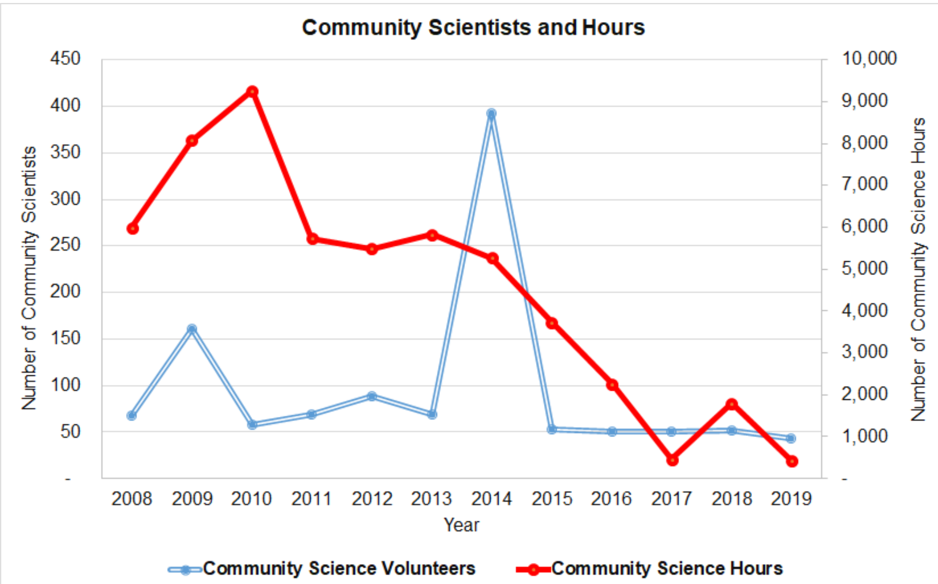

Figure ES.S.4 The number of volunteers participating in community science efforts and the hours of service provided has varied over the past decade, with the declining trend in number, and a pulse of activity in 2014 related to tsunami debris monitoring. Source: OCNMS data, graph by Chris Butler Minor.

The greatest percentage of volunteer hours (69.59%) relates to educational outreach, such as hours donated by volunteers serving as visitor center docents and supporting beach clean ups. However nearly a third have participated in community science projects, including coastal surveys of marine debris and stranded seabirds (COASST/MDMAP), research projects, and mooring operations on the R/V *Tatoosh*.

Natural challenges with community involvement in science and monitoring at OCNMS~~Olympic Coas~~t include a remote and rugged coastline that can be difficult to access, short days, challenging timing related to tide cycles, and frequent storms during winter months. This limits most field efforts to ~8 months of the year. Community demographics also play a role, given the small pool of potential participants living in rural coastal and tribal communities, and the long distances separating the coast from more densely populated areas surrounding Seattle and Tacoma. 2018 census data reveals about 11,100 people living in coastal zip codes along the sanctuary coastline (see Driving Forces section). Recruiting and retaining community scientists is further complicated by IT security protocols that can prevent community members from accessing data and computer systems.

Community members also participate in science efforts through volunteer activities, which are described in more detail in the Education Ecosystem Service section. Although volunteer and community scientists' hours are tracked separately, when viewed together (**Figure ES.S.5**), they reveal the importance of the International Coastal Cleanup -- a one-day event held twice yearly -- which accounts for nearly 62% of all hours contributed. Cleanup events held over weekends in April and September regularly draw thousands of people to the coast, often with salmon bakes, free camping, and other perks. Beached bird and marine debris monitoring make up 28% of the total. Approximately 2% of hours come from volunteers who support science and research efforts by participating in at-sea operations on the R/V *Tatoosh*, and nearly 7% provide educational and science interpretation to visitors at the Sanctuary's Olympic Coast Discovery Center in Port Angeles, WA.

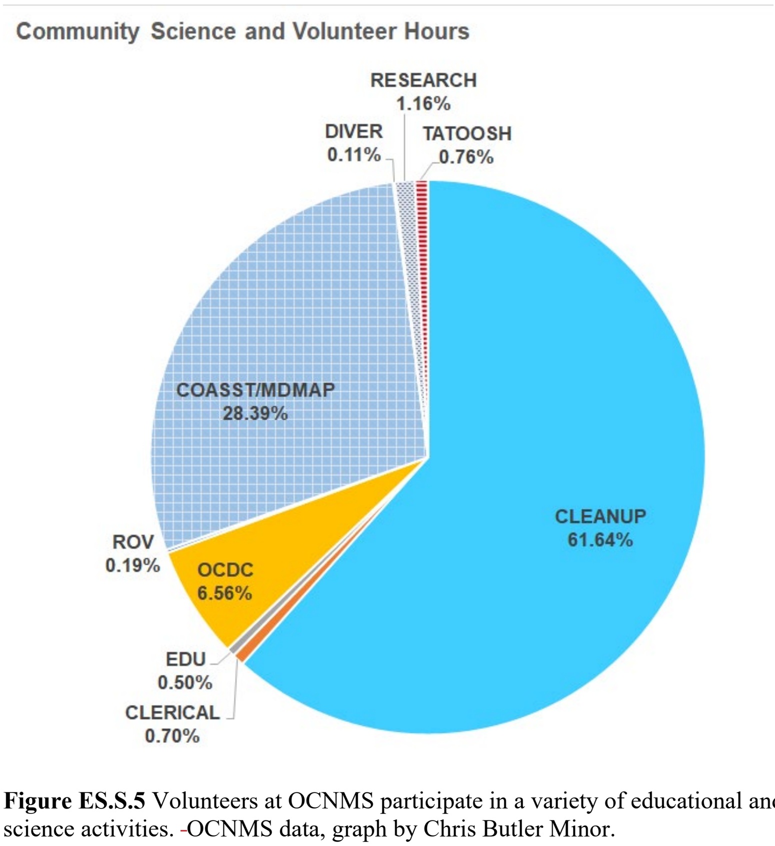

Figure ES.S.5 Volunteers at OCNMS participate in a variety of educational and community science activities. OCNMS data, graph by Chris Butler Minor.

The Olympic Coast has been studied by numerous researchers over the decades, with a variety of research and monitoring programs collecting time series data. Key research topics have included oceanographic conditions, intertidal monitoring, kelp ecology, deep-sea coral cruises, harmful algal blooms, and more. Tatoosh Island, for example, is considered one of the most well-studied field sites in the world, and was the site at which Dr. Robert Paine coined the ecological concept of 'keystone species' in the late 1960s. Long-term research that has taken place within OCNMS is summarized in Appendix ## and research cruises have been tabulated in Table ES.S.1.

Table ES.S.1 Summary of major research cruises organized/led by OCNMS staff, 2008-2020.

Date	Ship	Purpose	Key Partners
June 2008	NOAA Ship *McArthur II*	Survey of Cetacean Abundance and Pelagic Ecosystem (CSCAPE)	SWFSC
July 2008	Canadian Coast Guard Ship *Tully*	Deep sea coral and sponge ROV surveys associated with PCL submarine cables	DFO
June 2010	NOAA Ship *McArthur II*	Deep sea coral and sponge ROV surveys	DSCRTP
June 2010	NOAA Ship *Fairweather*	Seafloor mapping at Cape Alava	OCS
July 2011	R/V *Pacific Storm*	Seafloor mapping; ROV surveys of deep coral and sponge areas west of Olympic 2	OSU, DSCRTP
May 2016	NOAA Ship *Rainier*	Seafloor mapping--WA offshore priorities	IOCM, OCS
June 2016	E/V *Nautilus*	ROV dive to 'ground truth' seafloor data near Quinault Canyon (1 day at sea)	OET, OER, PMEL
Aug/ Sept 2017	E/V *Nautilus*	ROV and AUV surveys for deep sea coral and sponge habitats; USS *Bugara* (17 days at sea)	OET, NWFSC
Sept 2017	NOAA Ship *Rainier*	Seafloor mapping--WA offshore priorities (10 days at sea)	OMAO, IOCM
June 2018	NOAA Ship *Bell M. Shimada*	Juvenile Salmon Ocean Ecosystem Survey (7 days at sea)	NWFSC
July 2018	E/V *Nautilus*	Recovery of Quinault meteorite fragments (1 day at sea)	OET, NASA
June 2019	R/V *Falkor*	Recovery of Quinault meteorite fragments (5 days at sea)	NASA, Schmidt Ocean Institute
Sept 2019	NOAA Ship *Bell M. Shimada*	ROV surveys in deep sea coral and sponge habitats (7 days at sea)	DSCRTP, NWFSC

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July 2020	R/V *Rachel Carson*	Charter of UW vessel to recover/deploy NOAA ocean sound recorders (7 days at sea)	NOAA Ocean Acoustics (NMFS)
Sept 2020	E/V *Nautilus*	ROV surveys in deep sea coral and sponge habitats, methane seeps (12 days at sea)	OET, Oregon State University

Despite research efforts within OCNMS, until recently, only approximately a third of the sanctuary was mapped with either sidescan or multi-beam sonar. In some parts of OCNMS, the best available information is from 1920s leadline surveys, which is hardly adequate for contemporary research or management. Further, OCNMS has lost internal expertise and capacity (e.g., seafloor mapping, GIS, database management) and currently lacks the modern technology and equipment necessary to conduct this work in house.

In an effort to support ongoing coordination efforts for seafloor mapping, OCNMS has partnered with Washington State, NOAA's National Centers for Coastal Ocean Science, the Integrated Ocean and Coastal Mapping team, the U.S. Geological Survey, and others in an effort to identify and survey high-priority areas of the seafloor. To date, the three offshore priority areas originally identified by the group in 2015 have been largely mapped (Figure ES.S.5). Additional priority areas were proposed by the group during a workshop in 2018 and contributed by OCNMS staff to ongoing NOAA prioritization efforts, which are particularly important in light of the November 2019 Presidential Memo on Ocean Mapping (The White House, 2019) and development of a National Ocean Mapping Strategy released by NOAA's Office of Coast Survey (2020). Seafloor mapping priorities identified in shallow nearshore areas, which at Olympic Coast are laden with pinnacles, rocks awash, and other navigation hazards, remain largely unmapped, which reduces scientists' ability to conduct certain studies, including nearshore seismic hazard modeling -- a particular concern for coastal communities living in this tsunami-prone region.

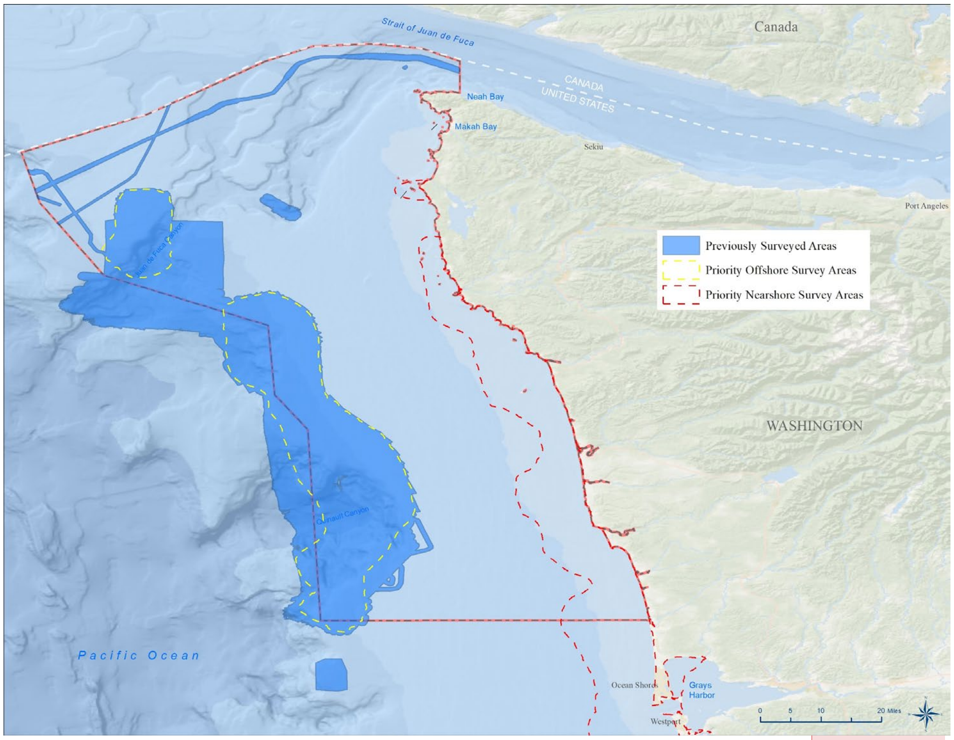

Figure ES.S.6. A 2015 seafloor mapping prioritization effort identified nearshore (dotted yellow line) and offshore (dotted red line) areas of the Washington Coast where new high-resolution seafloor mapping would best support resource management efforts ranging from coastal hazard mitigation to fisheries management (Battista et al., 2017). ~~ ~~Surveys conducted in 2016 and 2017 from the NOAA Ship *Rainier* and the E/V *Nautilus* largely completed data acquisition within identified offshore priority areas (blue shading). Additional seafloor mapping has been accomplished since 2017. Map: NOAA ONMS.

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Classification of seafloor data for habitat mapping purposes reached a milestone in 2016 with release of two of the four components of the Olympic Coast Habitat Framework, a habitat mapping program led by the Northwest Indian Fisheries Commission (NWIFC) and Intergovernmental Policy Council (IPC) with technical support from OCNMS, to develop a common understanding of marine habitats on the Olympic Coast based on NOAA's Coastal and Marine Ecological Classification Standard (CMECS), and serve as a shared ~~common~~ framework or language, for tribal, state, and federal resource managers (Goodin et al., 2016). CMECS is a standardized hierarchical system for classifying habitats that breaks the marine environment into four~~4~~ Components: Water Column, Geoform, Substrate, and Biotic. ~~ ~~The use of CMECS will establish~~allow for~~ a robust system that will allow policy makers to determine the importance of habitats and how different practices might impact different parts of the marine ecosystem. Work is underway to complete the remaining two components of the Habitat Framework.

NANOOS, based on input from the IPC and OCNMS, secured an award from the Murdock Charitable Trust to construct a oceanographic observing focus within OCNMS in 2009. This consists of the surface signature Cha'ba buoy, the subsurface NEMO profiler, and an autonomous Seaglider. Sustained operational funds are now provided annually by the U.S. IOOS Program via funding to NANOOS. Each of these assets reports data via the NANOOS Visualization System (NVS: www.nanoos.org). This capacity of these observational assets has been extended far from its original vision to include that Cha'ba is now a national OA buoy supported by NOAA's Ocean Acidification Program; NEMO has been adapted to include an Environmental Sensor Processor (ESP), supported by NOAA MEHAB and IOOS; the observational data provide critical input to calibration/validation of the LiveOcean and J-SCOPE models; and technology from the buoy real-time relays has been proposed for the OCNMS seasonal moorings.

In 2019, OCNMS was designated by NOAA as an Ocean Acidification Sentinel Site (OASeS) ~~in November of 2019~~. Sentinel sites, like national marine sanctuaries, are places where focused monitoring and research efforts take place to enhance understanding of ecosystems and how they are changing. The OASeS will expand coordination and collaboration on key science needs in OCNMS related to ocean acidification and the associated social and biological vulnerabilities of the Olympic Coast. In 2020, IPC members endorsed the sentinel site designation and will work to expand OASeS to the entire Washington outer coast.

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While it is recognized that significant research has been conducted in OCNMS by a variety of partners (see Appendix XX for a summary), the sanctuary's limited capacity and infrastructure to conduct research deemed necessary on the Olympic Coast were the drivers for the "fair" ~~this~~ rating. OCNMS has few staff to conduct research and there are gaps in capacity and expertise (e.g., GIS, seafloor mapping, database management). With fewer staff, OCNMS personnel are limited to focusing on high-priority initiatives, such as maintaining the oceanographic mooring program, continuing other critical long-term data collection, and planning major research cruises, as well as coordinating and facilitating research conducted by partners.

Science activities of partner organizations are essential in building collective understanding. Partner organizations include the natural resource management departments of tribal governments, Washington State agencies, academic researchers, Sea Grant, and non-governmental organizations, often in collaboration with partners from across NOAA and within the Department of the Interior (i.e., National Park Service, USGS, BOEM).

The technical challenges of research in this remote environment make research costly, and rough, open ocean conditions and unpredictable weather along a wilderness coastline with only two navigable harbors add to the complexity of vessel operations and field work. In the two ports adjacent to OCNMS (Neah Bay on the Makah Reservation and La Push on the Quileute Reservation), there are limited fueling locations or pump-out stations, and nearby lodging can also be expensive and/or challenging to obtain during the popular summer season . Many coastal lodging options have implemented a two-night minimum. Further, OCNMS has recently lost dedicated accomodations in Neah Bay due to mold issues. The Olympic Natural Resources Center has proven to be an invaluable lodging asset for researchers visiting the coast.

Due to harbor limitations, large--ship science efforts focused on the Olympic Coast must use distant ports like Astoria or Newport, OR, or Seattle, WA. Many NOAA/NMFS surveys, surveys by academic groups like the University of Washington and Oregon State University, and fishery surveys done by organizations like the International Pacific Halibut Commission fall into this category. In contrast to large--ship science efforts, locally-based science activities tend to benefit local economies through expenditures including lodging, provisions, fuel purchases, taxes, payment of recreation permits issued by the Makah Tribe, etc. However, because there is limited lab capacity on the outer coast to process or freeze collected samples, much of the research and analysis must be done in distant laboratories.

Overall, there is limited availability of ocean-going vessels, which often must be trailered to Neah Bay or La Push in order to access the Olympic Coast. Charter vessels are limited and some platforms, like *Windsong* based in Neah Bay, are often not available during the fishing season, which overlaps with the summer field season. Academic institutions also maintain ocean-going research vessels that provide science support for the Olympic Coast as part of the University-National Oceanographic Laboratory System (UNOLS fleet); some UNOLS ships spend only a small portion of their time on the Washington coast. However, the University of Washington and Oregon State University each operate two ocean going research vessels in the region, and OSU is presently working with the National Science Foundation to design the first of three new Regional Class Research Vessels, including the ship that will replace the R/V *Oceanus* in 2021.

Logistically, conducting research on the Olympic Coast can be quite challenging due to its remoteness and ruggedness. The communities on the coast are small and rural, with limited infrastructure (e.g., lodging, restaurants, internet access), which can pose challenges to researchers unfamiliar with the region. For example, finding locations to install high-frequency radar on the Olympic Coast has been challenging for the Northwest Association of Networked Ocean Observing Systems (NANOOS) due to lack of power and accessibility of ideal sites. Additionally, access to small ports or research stations are often on tribal reservations, for in which tribal permissions, permits, and/or guides may be required. Furthermore, limited internet access and shifts in cellular networks pose challenges on the Olympic Coast, demanding innovative solutions. For example, the real-time sensors that are deployed in OCNMS rely on cellular networks to transmit data,; however, recent changes implemented by cellular carriers have reduced spatial coverage and compromised real-time transmission of data..

Summary

Significant research has occurred over past decades in OCNMS. However, persistent information gaps were deemed significant enough to rank the status of the science ecosystem service as “fair.” The limited capacity to conduct desired research for OCNMS was a key factor in determining this status. Capacity and infrastructure are limited on the coast, and geographic and technological challenges reduce the ability to conduct all of the science activities that are needed. Research partnerships, collaboration, and coordination are expanding, which is increasing the breadth of science conducted within OCNMS, resulting in an “improving” trend. OCNMS is at the forefront of research focused on changing ocean conditions, seafloor mapping, deep sea corals, and ocean sound. Furthermore, the extensive traditional knowledge of the four coastal treaty tribes significantly enhances the collective understanding of the Olympic Coast.

Economic Indicators	Source	Figure or Table #	Data Summary
Not available	Not available	Not available	Not available

Non-Economic Indicators	Source	Figure or Table #	Data Summary
Open Sanctuary Permits	NOAA Office of National Marine Sanctuaries (2020). OSPREY database. Research Permits.	ES.S.1	The number of open permits has increased since 2008
R/V *Tatoosh* hours at sea and days at sea, 2008–2019	A Friel/OCNMS, personal communication, December 10, 2019	ES.S.2	R/V *Tatoosh* days and hours have remained stable from 2008–2018, RHIB has shown an increase in number of days and hours from 2011–2018
Total community science hours by project type	C. Butler-Minor, OCNMS, personal communication, November 2020.	ES.S.3	Community science hours by project type 2008-2018
Community scientists numbers and hours over time	C. Butler-Minor, OCNMS, personal communication, November 2020.	ES.S.4	The number of community scientists and hours contributed declined between 2008-2019
Total community science and volunteer hours by activity	C. Butler-Minor, OCNMS, personal communication, November 2020.	ES.S.5	Community science and volunteer hours are dominated by coastal cleanups and beach surveys for marine debris and stranded seabirds
OCNMS-led research cruises	J Waddell, December 2020	Table ES.S.1	Research cruises led by OCNMS staff, 2008-2020
Long-term research		Appendix Table 1	Significant long-term research has occurred in this area since the 1960s
Seafloor mapping	J Waddell, December 2020	ES.S.6	Progress towards seafloor mapping within priority areas identified by

priorities			partners in 2015
Coastal ports for research access		ES.S.7	Limited port access, remote location, lack of research institutions based on Olympic Coast
Infrastructure			R/V *Tatoosh*, internet limitations, limited lab capacity to store and process samples
Partnerships			Creation of OASeS, Habitat Framework, NANOOS
Resource Indicators	**Source**	**Figure or Table #**	**Data Summary**
Not available	Not available	Not available	Not available

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Appendix ##:

Researcher	Institution	Location	Topic	Time Period*
Bob Paine	University of Washington	Tatoosh Island	Intertidal research; 'keystone species' concept	1967 - 2005
Cathy Pfister and Tim Wooton	University of Chicago	Tatoosh Island; Strait of Juan de Fuca, Olympic Coast	Intertidal and kelp research; ocean acidification	1980 - present
OCNMS staff, Jenny Waddell	OCNMS	Olympic Coast	OCNMS Moorings; oceanographic data	2000 - present
Simone Alin	NOAA PMEL	Olympic Coast	Analysis of OCNMS oceanographic data	2015 - present
Jan Newton	NANOOS, UW APL, NOAA PMEL	Olympic Coast	Chá Bă and NEMO moorings; oceanographic data	2010 - present
NOAA PMEL/ Simone Alin and Adrienne Sutton	NOAA PMEL, NOAA NDBC	Cape Elizabeth, Olympic Coast	Carbon chemistry sensors (air and water) added to NDBC buoy 46041	2006-present
Dick Feely and Simone Alin	NOAA PMEL	West Coast	Ocean acidification cruises	2007 - 2016 (not annual)
Parker MacCready, Samantha Siedlecki (now at UConn)	UW and NANOOS	Pacific Northwest	LiveOcean Model forecasts near-term OA conditions in PNW; J-SCOPE provides seasonal forecasts. Use OCNMS data	2015-present with major upgrades in 2019
Vera Trainer and ORHAB group	NOAA NWFSC, tribes, etc.	Pacific Northwest	Olympic Region Harmful Algal Blooms (ORHAB)	1994 - present
Stephanie Moore, John Mickett	UW NWFSC	OCNMS	Environmental Sample Processor mooring (real-time HABs monitoring)	seasonal deployments 2016-present

Ed Bowlby, Jenny Waddell, et al	OCNMS	OCNMS	Deep-sea coral research cruises using ROVs, etc.	2006, 2008, 2010, 2011, 2017, 2018, 2019
Melissa Miner	MARINe	OCNMS	Intertidal monitoring (2 sites)	1996 - present
Julia Parrish	COASST	West Coast	Beached seabird monitoring	1999 - present
Lisa Ballance; Jeffrey Moore	NOAA Fisheries, SWFSC	West Coast	Cetacean Abundance and the Pelagic Ecosystem (CSCAPE)	1991 - 2005
Steve Fradkin	ONP	Olympic National Park	Intertidal monitoring (4 sites)	2004 (sandy), 2007 and 2008 (rocky) to present
Steve Fradkin	ONP	Olympic National Park	OA monitoring (2 sites)	2010 - present
Helen Berry; Tom Mumford; Ecoscan	WA DNR	Washington State	Kelp surveys - Aerial Extent	1989 - present
Jameal Samhouri, Ole Shelton, Greg Williams et al.; Steve Lonhart; Jenny Waddell	NWFSC, MBNMS, OCNMS	OCNMS (PISCO protocols); 5 core sites	Kelp forests - Dive surveys of benthic habitats, kelp, fishes, and invertebrates	2015 - present
Steve Jefferies; Deanna Lynch; Jenny Waddell	WDFW, USFWS	Olympic Coast	Sea otter and pinniped surveys	1985 - present
Christy Pattengill-Semmens	REEF (link)	West Coast	Distribution and abundance of common fish and invertebrates	1997 - present
National Status and Trends: Mussel Watch	NCCOS; WDFW	National (two sites in OCNMS)	Mussel Watch: Contamination in mussels	1996 - present
Chris Harvey, Greg Williams,	NOAA Fisheries,	California Current	California Current Integrated Ecosystem	2012 - present

Kelly Andrews, Toby Garfield	NWFSC & SWFSC		Assessment (IEA) Program	
U.S. West Coast Groundfish Bottom Trawl Survey (link)	NOAA Fisheries, NWFSC	U.S. West Coast trawlable shelf and slope habitats (>50 m)	Groundfish data collection, used to generate stock assessments for fisheries management	2003 - present
Juvenile Salmon & Ocean Ecosystem Survey; link Brian Burke, Cheryl Morgan	NOAA Fisheries, NWFSC	Newport, OR to Cape Flattery, WA	Surface trawls targeting juvenile salmon in nearshore ocean waters	1998-present
Coastal Pelagic Species (CPS) survey [Kevin Stierhoff, David Demer, Juan Zwolinski]	NOAA Fisheries, SWFSC	U.S. West Coast, Vancouver Island to San Diego, CA to 35nm offshore	Acoustic Trawl targeting northern anchovy, Pacific herring, Pacific sardine, Pacific mackerel, jack mackerel	2008, 2012-2019
Sardine and Hake survey	NOAA Fisheries, NWFSC & SWFSC			
Pre-recruit (RREAS) survey (northern region) Brian Wells	NOAA Fisheries, NWFSC	Newport, OR to Cape Flattery, WA		
Sue Thomas	USFWS	Wildlife Refuge	Nesting seabird colony surveys of offshore islands	
Melissa Poe, Melissa Watkinson, tribal liaisons	UW Sea Grant	Olympic Coast	Tribally important species; community health and well-being; vulnerability to ocean change; resilience; marine-based cultural practices	2017-present
Jennifer Sepez	UW	Neah Bay,	Political and Social	1998-2002

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	Anthropology and NOAA Fisheries	Makah Tribe	Ecology of Contemporary Makah Subsistence Hunting, Fishing, and Shellfish Collecting Practices	
Janine Ledford and many important contributors	Makah Cultural and Research Center	Ozette, Olympic Coast	Ozette archeological research	
Powell, Jay V and tribal contributors		Quileute and Hoh	Quileute language, place names, resource use, basketry	1970 to present
Jeff E. Moore, Robyn Angliss, Erin Oleson	NMFS	Offshore (WA/OR/CA)	PACMAPS Marine mammal density surveys**	2017-2018
Brad Hanson	NMFS	Offshore	Passive Acoustic and Visual Monitoring of SRKW seasonal movements**	2014-2017
Amanda Debich, Simone Baumann-Pickering, Ana Sirovic	Scripps Institution of Oceanography and NMFS	Offshore	Passive Acoustic monitoring for Marine Mammal and Soundscapes; seasonal movements & baseline data**	2012-2014
Brad Hanson	NMFS	Offshore	SRKW satellite tagging seasonal movements**	2012-2016
Brad Hanson, Robin Baird	NMFS/ Cascadia Research	Offshore, Inland	SRKW prey study**	2015

John Calambokidis	Cascadia Research	Offshore	Marine mammal tagging and movement**	2011-
Mariko Langness, Phillip Dionne, Erin Dilworth, Dayv Lowry	WDFW	Nearshore sand and gravel beaches	Evaluation of use of Washington coastal beaches by beach-spawning forage fish (smelt, sand lance)	2012-2014
Bruce Mate, Daniel Palacios	OSU/HDR	Offshore WA/OR	Fin whale tagging and distribution**	2013-2015
Bruce Mate, Daniel Palacios	Oregon State University	Offshore WA/OR	Gray whale tagging and distribution**	2012
Bruce Mate, Daniel Palacios	Oregon State University	Offshore WA	Humpback whale tagging and distribution **	2017-2019
Laura Heironimus	WDFW	Offshore, WA	Green sturgeon tagging and distribution **	2020-2022
Joseph Smith and David Huff	NMFS	Offshore WA and Gulf of Alaska	Ocean distribution and survivorship of salmon, steelhead, bull trout **	2018-2022
Scott Pearson, M.Lance	WDFW	Offshore	At-sea densities of Marbled Murrelet **	2017, 2019

* Many monitoring efforts were delayed or canceled in 2020 due to COVID-19.
** Supported by the US Navy; results available at https://www.navymarinespeciesmonitoring.us/

This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

Education — The capacity to acquire and provide intellectual enrichment

Rating: Good/Fair (Medium Confidence) and Improving Trend (High Confidence)

***Status Description**: The capacity to provide the ecosystem service is compromised, but performance is acceptable and improving.*

***Rationale**: Key indicators used to determine the status and trend of the education ecosystem service were willingness to pay for educational programs, funding for educational programs, the number of people receiving formal and informal education, the quality of the educational experience, the number of volunteers working with OCNMS, and the number and types of educational programs offered. Studies focusing on similar California-based Ocean Guardian School programs show that parents have a willingness to pay for hands-on ocean conservation and stewardship programs. The number of Twitter and Facebook followers (those who like the social media page) of OCNMS has increased over the past few years. Driven by sanctuary, tribal, and partner education programs, educational activities focused on OCNMS and related ocean science and stewardship have increased in quality over time and contributed to the public's awareness of OCNMS, enhancing ~~and understanding of~~ ocean literacy.*

OCNMS~~Olympic Coast National Marine Sanctuary~~ is a place of national, regional, and local significance. OCNMS staff engage audiences through education and outreach using a variety of methods, including:

- **pre-K-12** - providing in-school educational programs at field-based summer programs~~meaningful educational experiences~~ for students,
- **higher education** - promoting adult learning and career-building opportunities,
- **community outreach** - improving the general public's awareness of ocean ecology and encouraging ocean stewardship,
- **visitor services** - providing information and high quality educational experiences to Olympic Coast visitors, and working with local communities to encourage sustainable tourism in the sanctuary region.

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Although there are no economic valuation studies specific to OCNMS for the education ecosystem service, in 2017, ONMS completed a study estimating the economic value of the Ocean Guardian School (OGS) Program in California (Schwarzmann et al., 2017). This grant-based program is aimed at teaching students about ocean conservation and stewardship of local watersheds and special ocean areas like national marine sanctuaries. At the time of the study, the program was relatively new in the Pacific Northwest, and these regional schools were ~~therefore~~ not included in the study. (Ocean Guardian School Program has been established in Washington and Oregon since 2015 and is now implemented the same way as the schools that were included in the 2017 economic study). The study focused on California schools and estimated parents' willingness to pay for five pathways of hands-on educational experiences: 1) refuse/reduce/reuse/recycle/compost ($21); 2) reduce marine debris (cleanups and reducing single use plastic) ($26); 3) watershed restoration ($45); 4) schoolyard habitat/garden ($59); and 5) energy and ocean health ($34). Although these exact values may not apply to OCNMS, it is likely that parents would also value similar hands-on education programs in the sanctuary region. Figure ES.E.1 shows that the number of schools and grant funding for the Ocean Guardian School Program, supported by the sanctuary, has increased since 2015.

Another economic indicator that can be used to evaluate the education ecosystem service is the amount of Bay Watershed Education and Training (B-WET) funding (Figure ES.E.2). B-WET is an environmental education program that supports locally relevant experiential learning among K-12 students. Each year, approximately 8-9 funded projects in the Pacific Northwest (totaling approximately $450,000 in grants) provide students with Meaningful Watershed Educational Experiences (MWEEs), which blend outdoor- and classroom-based learning to build environmental literacy. B-WET projects also include professional development for teachers and help support regional education and environmental priorities in the Pacific Northwest. Because B-WET funding, which includes Ocean Guardian School program funding, is determined by Congress (and not OCNMS), it varies across years, which can influence the level of educational services offered (J. Laverdure, personal communication, April 20, 2020).

In addition to looking at proxy economic indicators, reviewing the types of programs offered and the number of people impacted is also useful.

Pre-K-12

These programs are summarized below and described in more detail in Tables ES.E.1 and ES.E.2. The outer coast of the Olympic Peninsula is a remote and economically depressed region, and the pre-K-12 schools in the area do not have access to the resources necessary to provide students with hands-on marine science education. OCNMS is one of very few organizations on the Olympic Peninsula with staff expertise in both marine science and environmental education. The sanctuary's pre-K-12 ocean literacy based programs fill a gap in educational services in the region. Additionally, OCNMS is the only national marine sanctuary in the Pacific Northwest and is seen as a significant regional resource for environmental education in Washington and Oregon.

Since 2008, OCNMS staff have engaged local and regional students in activities that promote ocean literacy in the field and in the classroom. Programming has expanded from year to year to increase student reach and quality of programs. NOAA B-WET and Ocean Guardian School program funding, enhanced NOAA Meaningful Watershed Educational Experience (MWEE) guidelines, easier access to students (e.g., longstanding programs are established in the school districts), and support provided as a result of higher education internship and in-service opportunities, such as NOAA Hollings Scholars and/or AmeriCorps members, have contributed to program expansion. Benefits of expanded programs include increased and more robust contact time with students (based on MWEE guidelines), programming over multiple school years, increased student reach, and increased opportunities for teacher professional development.

Since 2008, several place-based and STEAM (Science, Technology, Engineering, Arts, and Mathematics) programs focusing on ocean literacy are supported by OCNMS. Each year, the Ocean Science Program uses hands-on, inquiry and place-based activities to support approximately 15 teachers, 350 students (grades 3-6), and their families to better understand their local marine environment and make local cultural connections. The program provides summer in-service workshops with follow up support for teachers, classroom beach curriculum and resource kits, and beach field trips to monitor intertidal areas and collect debris.

The North Olympic Watershed (N.O.W.) Science Program , a partnership between OCNMS and Feiro Marine Life Center, Dungeness Audubon Center, Olympic National Park, and the City of Port Angeles, provides field science opportunities for approximately 800 4^{th} and 5^{th} grade students on the North Olympic Peninsula. Since 2008, the N.O.W Science Program has expanded from a three-hour marine science center field trip for 4^{th} grade students to MWEEs for 4^{th} and 5^{th} grade students with pre-classroom visits, watershed field investigations, stewardship action projects, post-field trip classroom visits, and outreach, as well as teacher professional development.

More recently developed programs include Sanctuary Splash: Discover the Olympic Coast and Big Mama Meet the Humpback Whale programs, reaching approximately 800 students annually. Discover the Olympic Coast is a resource for 3^{rd} grade students to discover the diverse habitats and organisms of the sanctuary through Florian Graner's underwater film *Discover the Olympic Coast*. Big Mama Meet the Humpback Whale is an interactive educational program, focusing on the 5^{th} grade level, that allows students to explore the life-sized, walk-inside model of a humpback whale, named "Big Mama." The program also includes hands-on, STEM-focused activities that support ocean science and promote stewardship.

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The Ocean Acidification pHyter and Plankton Monitoring Program is a West Coast Region national marine sanctuaries' education and citizen science pilot project that enables approximately four Olympic Coast teachers and 75 middle and high school students with innovative new tools and technology to monitor for ocean acidification and other oceanographic conditions.

Olympic Coast Marine Advanced Technology and Education (MATE) Robotics Clubs are offered both through in-school and afterschool programs to prepare approximately 100 students and 20 mentors for the annual Olympic Coast MATE Regional Competition held in Forks, Washington.

The Junior Oceanographer Summer Program youth camps, a partnership between OCNMS and Feiro Marine Life Center, provides K-9 students with experiential education programs focused on the local marine environment in order to improve ocean literacy and foster a lifelong respect for and understanding of the ocean.

Chalá·at Hoh River Watershed Adventure Camp, a partnership between OCNMS and the Hoh Tribe, began in 2015 as a four-day, three-night rafting and overnight watershed adventure summer camp with a focus on connecting tribal culture, treaty rights, traditional resources, harvesting, and climate change and its impact on resource sustainability and resilience. Due to loss of funding and support, the camp decreased in 2017 to four days and one night of camping and in 2018 to two days without overnight camping. OCNMS also supports other youth summer camps and programming in outer coast communities as requested.

Higher Education

Opportunities to learn basic and applied science skills in communities adjacent to OCNMS are limited, and pathways to science-based careers are scarce. OCNMS is in a unique position to lead the region in promoting adult learning and career-building opportunities in marine science, education, management, and policy. This is accomplished through opportunities such as Olympic Coast Discovery Center annual docent training, speaker series events (NMS Webinar Series, Feiro Marine Life Center, Peninsula College), and internships and scholarships (e.g., AmeriCorps Program, NOAA Hollings Scholarship Program, NOAA Nancy Foster Scholarship Program, and Peninsula College internships).

A number of other programs, while not directly supported by OCNMS, revolve around education and experiences related to resources found within and around the sanctuary. These programs include Washington Sea Grant and University of Washington programs such as fellowships, internships, and research assistantships, as well as programs that involve coastal students in the Orca Bowl and the Doris Duke Conservation Scholars Program, which partners with Quinault Indian Nation to facilitate learning about the coast. Additionally, the Makah Tribe offers a summer internship to high school and college students to work in the tribe's fisheries, forestry, wildlife, and environmental science departments. The Marine Resources Council also provides outdoor learning opportunities and other educational and outreach funding related to sanctuary resources and topics.

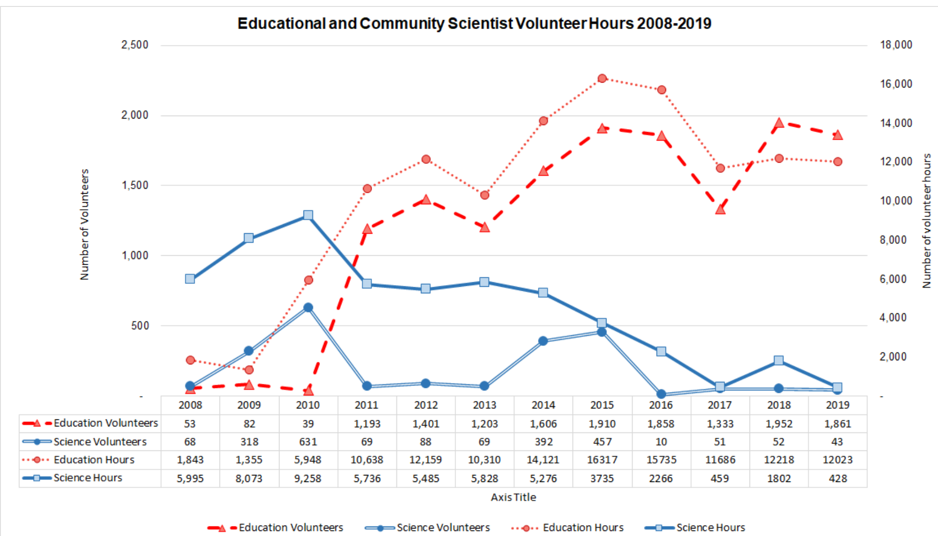
Community Outreach

OCNMS actively supports marine stewardship and citizen science volunteer programs with local and regional communities, and maintains a presence at community events and meetings in the sanctuary region. Examples of OCNMS community outreach include active engagement (such as participating in a steering committee and dedicated staff time) for programs with Washington CoastSavers, NOAA Marine Debris Monitoring Program, Coastal Observation and Seabird Study Team (COASST), and local marine resources committees. Additionally, OCNMS reaches the public through participation in special events and festivals (e.g., Makah Days, Grays Harbor Shorebird Festival, Dungeness Crab and Seafood Festival, Beachcombers Fun Fair), and live "ship to shore" science broadcasts when possible.

Visitor Services

Outreach initiatives are aimed at improving and enhancing the public's awareness of OCNMS. This is done through a variety of tools, such as the Olympic Coast Discovery Center (OCNMS visitor center in Port Angeles), coastal interpretive programs, interpretive signage, NOAA Olympic Coast kiosks, and the annual Get Into Your Sanctuary Day! (an ONMS-wide event that raises awareness about the value of national marine sanctuaries as iconic destinations for responsible recreation through a series of special activities) (Table ES.E.3). Table ES.E.4 shows that the number of walk-in visitors has been increasing at the various sites throughout the region, including the Olympic Coast Discovery Center and the Seattle Aquarium.

Additionally, media like Earth Is Blue, OCNMS and ONMS websites, 360° imagery, and social media are platforms for accessing up-to-date research, programs, and information about the sanctuary. Despite variation in social media data from month to month, Facebook reach has shown a decline overall since 2015 both for OCNMS and at the national level, but Twitter impressions have increased (Figure ES.E.3 and ES.E.4) (E. Weinberg, personal communication, April 20, 2020). Other forms of communication related to the sanctuary include print and online newsletters such as Nugguam and The Talking Raven (produced by the Quinault Indian Nation and the Quileute Tribe, respectively) and books such as *Native Peoples of the Olympic Peninsula: Who We Are* (Olympic Peninsula Intertribal Cultural Advisory Committee, 2003) and *The Northwest Coastal Explorer* (Steelquist, 2016). Lastly, OCNMS has a robust network of volunteers that help with everything from educational programming to citizen science to the visitor center. The number of volunteer hours has generally increased since 2008 with a peak in 2015 (VolunteerNet) It is also worth noting some of the challenges OCNMS faces in providing education services. These include the distance between the OCNMS headquarters office and many regional communities, limited sanctuary access points and infrastructure (e.g., poor to limited internet connectivity, limited boat launches and amenities, limited lodging), and limited staff time and resources to support programming.



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Education Volunteers	53	82	39	1,193	1,401	1,203	1,606	1,910	1,858	1,333	1,952	1,861
Science Volunteers	68	318	631	69	88	69	392	457	10	51	52	43
Education Hours	1,843	1,355	5,948	10,638	12,159	10,310	14,121	16317	15735	11686	12218	12023
Science Hours	5,995	8,073	9,258	5,736	5,485	5,828	5,276	3735	2266	459	1802	428

Figure ES.E.5 Volunteer hours and the number of hours contributed towards educational and community science efforts generally increased between 2008 and 2019. While educational hours and volunteers remain above the mean, science contributions slipped following discontinuation of program funding. Figure: Chris Butler-Minor, 13 January 2021.

Economic Indicators	Source	Figure or Table #	Data Summary

Ocean Guardian Parent WTP	Schwarzmann et al., 2017		Parents have a willingness to pay for hands-on science education aimed at teaching students about ocean conservation and stewardship of local watersheds and special ocean areas like national marine sanctuaries.
B-WET Funding	J. Laverdure, personal communication, April 20, 2020	Figure ES.E.2	B-WET is an environmental education program that supports locally-relevant experiential learning for K-12 students; funding has remained relatively stable since 2015.
Non-Economic Indicators	**Source**	**Figure or Table #**	**Data Summary**
Pre-K to 12 Education Programs	J. Laverdure, personal communication, April 20, 2020	Table ES.E.1	The quality of programs has been increasing, despite some decreases in total number of students reached.
Pre-K to 12 Education Programs	NOAA Office of Education, 2020 & OCNMS, 2018	Table ES.E.2	The data show an overall decline in the number of students reached, but the quality and length of programs is increasing.
Higher Education Programs	OCNMS, 2018 & J. Laverdure, personal communication, April 20, 2020		OCNMS has been successful in recruiting students to intern and create meaningful education experiences at the site.
Community Outreach	OCNMS, 2018 & J. Laverdure, personal communication, April 20, 2020		OCNMS has been expanding the variety of community outreach programs and special events to further engage with the community.
Visitor Service Programs	OCNMS, 2018 & J. Laverdure, personal communication,	Table ES.E.3	OCNMS has continued to work with partners and expand access to the sanctuary via remote visitor experiences.

	April 20, 2020		
Visitor Service Programs	NOAA Office of Education, 2020	Table ES.E.4	The number of walk-in visitors across all sites has increased since 2015.
Social Media	E. Weinberg, personal communication, April 20, 2020	Figure ES.E.3 and Figure ES.E.4	Facebook reach has declined overall since 2015, but Twitter impressions have increased over time.
Volunteers	C. Butler-Minor, personal communication, 12 January 2021	Figure ES.E.5	The number of volunteer hours has increased since record keeping began in 2014; the number of volunteers has decreased over the same time period.

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This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

Heritage — Recognition of historical and heritage legacy and cultural practices

Rating: *Good/Fair (high confidence) with a worsening trend (high confidence).*

Status Description: *The capacity to provide the ecosystem service is compromised, but performance is acceptable, though degrading.*

Rationale:
The existence, and in some cases resurgence, of traditional cultural practices reflecting heritage contribute to the Good/Fair rating of this ecosystem service. These practices include exercising treaty rights, revitalizing tribal languages, subsistence harvest, potlatches, canoe journeys, the publication of several books about tribal histories and culture, and interpretive programs that help to restore and preserve heritage. However, some key heritage practices are compromised due to declines, closures, or shifts in the resources (e.g., harvest of blueback salmon and other cultural keystone species). Cultural practices such as harvesting and sharing of knowledge (e.g., how and when to harvest) through the practice of harvesting are not as robust as they have been, indicating that improvements could be made.

Pre-contact
The Olympic Coast has strong historical and heritage legacy through coastal treaty tribes, historical maritime exploration and trade, timber harvest, recreational and commercial fisheries, wilderness protections, and long-term ecological research ~~of this region~~. Continued cultural practices and exercise of treaty rights by coastal treaty tribes are the strongest and most long-lived heritage ecosystem services for this region.

Coastal treaty tribes have inhabited this area since time immemorial. Archaeologists speculate that ancient tribal archaeological sites off Washington's coast are likely associated with paleo-shorelines. The sea level history of the Olympic Coast is complicated, with older paleo-shorelines likely occurring subtidally and more recent paleo-shoreline occurring above current sea level (Olympic Coast National Marine Sanctuary, 2018). The sea level 20,000 years ago was about 120 meters lower than present. Glacial melt caused a rise in sea level to a point approximately 20 meters below present by 8,000 years ago and reached modern levels about 2,000 years ago. Researchers believe that between 8,000 and 2,000 years ago, regional sea levels may actually have been at least four meters above modern sea level, a finding supported by tribal oral tradition.

European Settlement
Prior to and throughout the period of European settlement on the western Olympic Peninsula, the link between the land and the ocean has shaped history and the Olympic Coast. The first

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Commented [2]: This line is the only reference to over 10,000 years of tribal history in this section, as opposed to several paragraphs about European settlement and shipwrecks. In fact, the rest of this paragraph is about sea level changes and paleo shorelines and not about first peoples. The section below on Coastal Treaty Tribes is about the importance of cultural heritage and not about history. You could summarize and reference the details on first peoples in the Site History section. In general, it would be helpful to coordinate the Site History and Heritage sections a bit more to prevent duplication without downplaying the tribal cultural heritage aspects.

recorded European contact with coastal Indians was in 1775, which was quickly followed by other Europeans, and later Americans, all hoping to capitalize on the sea otter and fur seal trade. All coastal trade vessels working between California and Puget Sound, as well as vessels visiting the region for trans-Pacific trade, traversed the area that is now the sanctuary. European and American contact included disastrous impacts for many tribes, resulting in ~~the~~ decimation of tribal populations by ~~from~~ disease. By 1856, most ~~of the~~ tribes were consigned to reservations by the U.S. government, including on the Olympic Coast with the signing of the Treaty of Neah Bay and the Treaty of Olympia.

Through the latter part of the 1800s, settlers~~pioneers~~ moved into the Olympic Peninsula to farm, fish, and cut timber. The town of Forks had European settlers as early as the 1860s. People were originally drawn to Forks by gold prospecting, but timber became the mainstay of the economy of this,~~Forks~~ and other, west end towns. The lumber trade on the Pacific Coast is a long-lived and dominant~~very significant~~ aspect of maritime trade along the coast. Fishing continues to be an important commercial, ceremonial, subsistence, and recreational venture for coastal communities like Neah Bay and La Push and is identified as a key component of the coastal heritage (Washington State Department of Ecology, 2018). Early canneries, logging operations, and hotels reflected not just the economic opportunities offered by coastal resources, but the hardships imposed by the Olympic Coast's remoteness, such as lack of or limited road transport. Coast-wide maritime trade linked the productive Olympic Peninsula with Seattle and markets in California, Hawaii, Australia, and beyond. In addition, the completion of railroad links across the Continental Divide in both Canada and the United States made the ports of Vancouver, Seattle, Everett, Tacoma, and Victoria important sources of grain, timber, gold, and other resources for the world's economy. Today, commerce on the Olympic Coast still depends largely on commercial and recreational fishing, logging, and tourism.

Maritime Heritage Resources
There are nearly 200 shipwrecks known to have historical association with the sanctuary. In total, eight confirmed discoveries exist within the sanctuary. Of the located shipwrecks, the oldest are the clipper ships *Ellen Foster* and *Emily Farnum*, both built in 1852 and sunk in 1867 and 1875, respectively. The most recently built historic shipwrecks were the steamship~~;~~ *General M.C. Meigs* and a submarine, the USS *Bugara*, both naval vessels built in 1944 and sunk in 1972 and 1971, respectively (Olympic Coast National Marine Sanctuary, 2018). Through interpretive signage, museums, and online resources, the stories of these vessels continue to be known today.

Given the broad range of cultural expression, benefits of heritage may take many forms, such as traditional practices, coastal canoe routes, museum exhibits, historic post-European contact properties, etc. A number of studies have been conducted to assess how people value maritime heritage resources in national marine sanctuaries, with a heavy focus on shipwrecks. Although shipwrecks may provide both reef structure and historic properties, they often reflect specific ecosystem values that may not be widely shared at all sanctuaries.

Within the national marine sanctuary system, maritime heritage resources are valuable for generating visitation and tourism revenue (Schwarzmann et al., 2019), and surveys have found that people are willing to pay to protect these resources (Mires, 2014). While such data are not available for OCNMS, other metrics indicate that these resources are valued; for example, 28%

of Washington residents report sightseeing at outdoor cultural or historical facilities (Jostad et al., 2017) and the natural resource-based economy of the outer coast has been identified as an important cultural heritage to maintain (Washington State Department of Ecology, 2018). Although these past two studies are not specific to OCNMS, it is possible that visitors to this region also have demand and value for maritime heritage resources, such as shipwrecks, within and around the sanctuary, including opportunities offered on land. Opportunities on land may include museums and visitors centers that display heritage resources from the sanctuary.

Coastal Treaty Tribes

~~The coastal treaty tribes were instrumental in the designation of OCNMS.~~ For many indigenous communities, natural resources *are* cultural resources—inextricably connected to tribal heritage. These living resources, whether marine, riverine, or terrestrial, are the source of tribal origin stories, clan names, songs, art and technology, religion, subsistence foodways, clothing, and trade. For some marine sanctuaries, vibrant and active indigenous cultures remain a defining and dominant element of the cultural heritage of these special places. There are several terrestrial areas adjacent to the sanctuary that contain culturally significant sites important to maintaining the strong connection between the coastal treaty tribes and their heritage. They include historic villages, petroglyphs/pictographs, cemeteries and burial grounds, and landscapes and scenic features, as well as tribally owned and operated museums (ICF International et al., 2013). Consideration of heritage beyond sanctuary boundaries is important to understand the significance of the sanctuary itself, within an integrated cultural landscape.

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Ball et al. (2015, 2017a, 2017b) worked with the Makah Tribe to assess their tribal cultural landscape ~~of the Tribe~~ with funding from the Bureau of Ocean Energy Management. Their goal was to identify "any place in which a relationship, past or present, exists between a spatial area, resource, and an associated group of indigenous people whose cultural practices, beliefs, or identity connects them to that place" (Ball et al., 2015, p. 5). They found that the "Makah Tribe used the Makah Cultural and Research Center's (MCRC) wealth of historic documents, photographs, manuscripts, audio and video recordings, transcripts of audio recordings, legal records, cultural site reports, maps, pre-contact and historic artifacts and publications that relate to the area and resources" (Ball et al., 2017b, p. 32). These data were used to focus more narrowly on the Ozette tribal cultural landscape. Ball et al. (2017b) found that by connecting the resources to human use, the interdependence between land and water, technology and resource use, people, and place was apparent. Tribal cultural landscapes are not presented here for other coastal treaty tribes, as they have not been completed.

McLain et al. (2013) asked respondents (both tribal and non-tribal) to report meaningful places on the outer coast. Among other qualities, respondents were asked to spatially identify and rate places based upon the statement "I value this place because it has natural and human history that matters to me and it allows me to pass down the wisdom, knowledge, traditions, or way of life of my ancestors" (McLain et al., 2013, p. 5). Additionally, survey respondents were asked to select primary values associated with each meaningful place identified. The most frequently selected primary value associated with meaningful places in the Olympic Peninsula was recreation, followed by economic, aesthetic, home, and heritage (McLain et al., 2013).

A number of activities and events that reconnect people with their heritage, such as canoe journeys, have regained popularity in recent years and are important to many coastal tribes. Modern-era ~~C~~canoe journeys started in 1989 and became an annual event in 1995. Journey participants make predetermined stops along the way, where participants are welcomed by host tribes, and paddlers are able to rest, eat, and celebrate together. On the last day of the multi-day journey, there is a post-arrival ceremony based upon potlatch, a traditional ceremonial feast practiced by indigenous peoples of the Pacific Northwest. Canoe journeys are significant to coastal treaty tribes: "'One of the things it was supposed to be was a healing process, the return to culture and a healing to find the way that the elders did it and the ancestors did it,' said Red Eagle. 'The saying was that we put the knowledge into the canoe and the canoe teaches'" (Paul, 2019).

> **Commented [4]:** Or some other descriptor that acknowledges the long history of canoe journeys, in addition to their resurgence in recent years.

Marine mammals are a significant component of heritage for the Washington Coast, from the coastal treaty tribes utilizing whales, pinnipeds, and sea otters for subsistence and trade to historical commercial take of whales, sea otters, and fur seals by European settlers. The Makah Tribe has hunted whales for at least 1,500 years and whaling continues to be central to their culture (Renker, 2018). The right to take whales at usual and accustomed grounds is a Makah tradition secured by the 1855 Treaty of Neah Bay. However, due to significant population declines from non-tribal commercial whaling, the Makah Tribe ceased whaling in the 1920s to allow ~~for~~ populations to recover. In 1994, the eastern North Pacific gray whale ~~(*Eschrichtius robustus*)~~ was delisted from the Endangered Species Act and the Makah Tribe requested authorization to hunt. In 1999, the Makah successfully took a whale, the skeleton of which is on display in the Makah Museum. However, a lengthy legal process halted additional hunts. The U.S. Ninth Circuit Court of Appeals ruled in 2004 that to pursue any treaty rights for whaling, the Makah Tribe must comply with the process prescribed in the Marine Mammal Protection Act (MMPA) for authorizing the take of marine mammals otherwise prohibited by the MMPA take moratorium. On February 14, 2005, Makah submitted a request for a waiver of the MMPA take moratorium to NOAA Fisheries. In April 2019, NOAA Fisheries published a proposed rule to issue a waiver under the MMPA; that November an administrative law judge hearing took place. By September 2020, a final decision by NOAA Fisheries on the waiver request had not been made. The Makah Tribe has demonstrated the significance of this cultural and subsistence practice through consistent engagement at international and domestic processes (International Whaling Commission, MMPA, and NEPA processes), as well as investment into marine mammal research, monitoring, and management for more than two decades as they await a decision.

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There are several significant heritage events that take place to celebrate the establishment of treaties and treaty rights, becoming U.S. citizens, culture, and community, as well as connecting people to history and to the natural environment around them. These events include, but are not limited to, Makah Days, Quileute Days, Queets Days, Chief Taholah Days, First Salmon ceremonies, potlatches, a weekly drum ceremony at La Push, and the Quileute Welcoming the Whales ceremony. Traditionally, the Quileute hunted whales and would celebrate their return to their traditional area. In 2007, the Quileute Tribe began welcoming gray whales again as they reached Quileute's U&A during their migration north through traditional songs and dances.

T~~Additionally, t~~here are several writings and publications available related to coastal tribes and their connection to the ocean and peninsula. These titles include; *Native Peoples of the Olympic Peninsula: Who We Are* (Wray, 2015), *Gifted Earth: The Ethnobotany of the Quinault and Neighboring Tribes* (Deur, in press), *The Sea is My Country* (Reid 2015), and ~~,~~ *From the Hands of a Weaver Olympic Peninsula Basketry Through Time* (Wray, 2014). This list is not exhaustive, but exemplifies the extensive heritage, some, but not all of which, has been documented in writing. These books provide information from creation, to the significance of treaty signings, to more focused writings on the importance of plant life for food, medicine, and materials (including use in basketry).

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Changes in resource condition influence the ability of tribes to hold traditional ceremonies. For the Quinault Indian Nation, "the cultural importance of the salmon is represented in several traditional customs, including the First Salmon ceremony. The salmon must be treated with honor and respect so that they will return to the place of their birth. The Quinault understand that they are not simply the beneficiaries of the salmon as food; they also have responsibilities to carry out the practices of their ancestors" (Wray, 2015, p. 111). The conditions of several salmon stocks have declined, which can negatively impact cultural events, such as the First Salmon ceremony. Specifically, the blueback salmon is a unique sockeye run that exists in the Quinault River. Experts at the workshop noted that the Quinault people are indelibly connected to the river, and blueback salmon have immeasurable heritage value. Unfortunately, due to declines in blueback salmon, at times the Quinault have had to purchase salmon from others to hold the ceremony.

Another species with important tribal and non-tribal heritage value is ~~are~~ Pacific razor clams. Razor clams have been a key species to the Quinault people for millennia, and for non-tribal members for over one hundred years. Crossman et al. (2019) discussed "clam hungry"—the physical and emotional craving for traditional food, which connects tribal members with traditional places and connects them to childhood, family, and ancestry. Razor clams hold a great deal of significance in Quinault culture; they support intergenerational sharing and teaching of knowledge through harvesting together and also have health benefits. For these reasons, razor clams are considered cultural keystone species for the Quinault people. Designation as cultural keystone species indicates that razor clams are woven throughout the culture of the tribe.

Changing ocean conditions can impact tribes' ability to exercise treaty rights and practice their culture. For example, closures of shellfish harvest due to harmful algal blooms or lack of sockeye for a season due to warmer ocean temperatures shifting migration pathways~~,~~ may result in fewer opportunities to harvest for subsistence, practice culture, and share knowledge. Though natural variation in ocean conditions on both short- and long-term scales is woven into the oral history of tribal peoples, changes occurring as a consequence of anthropogenic climate change threaten to alter ecosystem structure and function, and thus cultural heritage, permanently. Recognizing the scope and scale of this concern is key to developing proactive measures to ensure critical cultural practices endure despite these changes.

Although many of the activities mentioned here are considered cultural practices, workshop participants also stated that these ceremonies, activities and practices are a natural part of daily life.

Heritage Designations
Special designations in and around the sanctuary are also important and can indicate the area's heritage legacy. At the state level, most of Washington state waters (which overlap with OCNMS) were designated a Maritime Washington National Heritage Area in 2019. At the national level, the Olympic National Forest was designated in 1897, the Olympic National Park was established in 1938 (with the coastal wilderness added in the 1950s), and Olympic Coast National Marine Sanctuary was established in 1994~~-~~. Further, there are three sites on the National Register of Historic Places: Tatoosh Island (est. 1972), Ozette Indian Village Archeological Site (est. 1974), and Wedding Rocks Petroglyphs (est. 1976). The Olympic Peninsula region has also been recognized internationally; the United Nations Education, Scientific, and Cultural Organization designated Olympic National Park as an International Biosphere Reserve in 1976, and as a World Heritage Site in 1981. The Olympic Coast is often referred to as the wilderness coast due to the relatively pristine coastline and the state and national designations aimed at maintaining the natural ecosystems and heritage services they provide.

Wilderness designations are a result of, and continue to inspire, a conservation ethic on the Olympic Coast. The long-time stewardship of this region by the coastal treaty tribes sets the foundation as they have sustained their communities on the bounties of the ocean and lands for thousands of years. Furthermore, the Olympic Peninsula was also the site of the northern spotted owl (*Strix occidentalis caurina*) ESA listing, which resulted from a~~a result of~~ loss of old-growth forest habitat due to timber harvest. The Northwest Forest Plan of 1994 focused on protecting spotted owls and old-growth forests while still allowing some timber harvest. The sanctuary was designated at the same time, with support from the coastal treaty tribes, to prohibit oil and gas exploration off of the Washington coast. Just as Supreme Court Justice William O. Douglas hiked the Olympic Coast in 1958 to protest a proposed highway, sixty years later Washington's Attorney General coordinated a protest against proposed offshore oil and gas exploration off the Washington coast by hiking the same undisturbed coast.[1]

Science Heritage
The Olympic Coast also has a strong science heritage, having been studied by numerous researchers over the decades. Considered one of the last relatively undeveloped coastlines in the contiguous U.S., it has drawn researchers and naturalists to its shores to study habitats and species, including the intertidal, kelp forests, and deep-sea ecosystems, marine mammals, seabirds, and changing ocean conditions. Tatoosh Island, for example, is considered one of the most well-studied field sites in the world, and was the site at which Dr. Robert Paine coined the ecological concept of 'keystone species' in the late 1960s. The science heritage of the Olympic Coast is significant and continues to grow and expand today; this aspect of heritage is summarized in the Science section.

Conclusion
This ecosystem service highlights the various indicators used to discuss heritage. It is not a complete accounting of the heritage of the Olympic Peninsula, and reflects only selected content from workshops, publications, and expert feedback for~~, and~~ the specific topics and indicators

[1] https://www.atg.wa.gov/news/news-releases/ferguson-lead-save-our-coast-hike-along-northern-olympic-peninsula

discussed here. What is clear is that there is a tremendously rich historical and living heritage in the area, whether from tribes who have existed since time immemorial or from settlers who came later. S~~For example, s~~everal books have been penned to document heritage and history; studies have been conducted to understand how heritage is practiced today and to identify the location and meaning of culturally significant sites; cultural practices still take place today that are part of everyday life to the tribes~~ who have existed since their arrival~~, including a resurgence of tribal language programs; shipwrecks have been studied and documented;~~,~~ and there is a history of long term science investigations and a persistent conservation ethic. The number of designations recognizing the heritage of the area, at a state, national, and international level, confirm the significance of this unique place. A~~Yet, a~~s some resource conditions decline (some salmon stocks) or experience boom and bust cycles (razor clams), the people of this area find ways to adapt and continue to practice their culture and heritage.

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This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

Sense of Place — Aesthetic attraction, spiritual significance, and location identity

Rating: *This ecosystem service was not assigned a status or trend rating (or accompanying confidence scores). The workshop participants determined that a context-specific narrative was more appropriate to discuss sense of place, particularly due to its many ~~un~~non- quantifiable aspects.*

Status Description: *N/A*

Rationale: *The Olympic Coast is a unique place that four coastal treaty tribes, who have reserved treaty rights to the resources and area, have inhabited since time immemorial. Additionally, there are non-native inhabitants with a rich history since their ancestors' arrival hundreds of years ago. Further, there are newer members of the community and many visitors to the area from around the world. Given the diversity of inhabitants and timeframes, rating sense of place for the sanctuary is not only difficult, but unsuitable for collectively describing these perspectives. There was high agreement among workshop participants that a context-specific narrative was better suited to examine the breadth of this service.*

The Olympic Coast hosts some of the most undeveloped natural coastline in the contiguous U.S., comprising tribal lands, Olympic National Park, Wildlife Refuges, Washington State Seashore Conservation Area, and the sanctuary. The wilderness coastline boasts sea stacks, cliffs, islands, tide pools, and sandy beaches coupled with a productive ocean ecosystem that has sustained native people for millennia and continues to draw visitors to its rugged shores today.

The benefits of sense of place are complex; some are quantifiable and some are not (Donatuto et al., 2015). Therefore, two categories of indicators are presented: measurable metrics and place identity. Measurable metrics may include willingness to pay for improvements to natural and economic resources, population and income changes, national and international designations, visitation, access to resources, and resource conditions. Other sense of place benefits cannot be assessed in this manner. Place identity[1] is a term used to describe the relationship between one's identity and the landscape and resources. This cannot be measured, but can be qualitatively discussed.

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Quantifiable Indicators

In 2014, Washington households were surveyed to determine their willingness to pay for various improvements in resource condition within the sanctuary. Notably, Washington households that recreate on the outer coast are willing to pay the most annually for improving water quality, maintaining viewscapes unobstructed ~~viewscapes from~~ by onshore and offshore developments,

1

marine mammal abundance and diversity, shoreline quality (reduced beach closures and marine debris), and the opportunity to see large predators (Table App SP.1). Additionally, wilderness lovers (people who prefer uncrowded conditions) are willing to pay more for improved conditions in comparison to crowd lovers (people who prefer crowded conditions) (Leeworthy et al., 2017).

These findings are consistent with other regional studies that have shown~~found that~~ people are willing to pay for marine protected areas (Wallmo & Edwards, 2008). For example, in Channel Islands National Marine Sanctuary, a 2016 study found that U.S. households are willing to pay a one-~~-~~time fee of roughly $70 to reduce the number of whale deaths due to ship strikes (Bone et al., 2016). A more recent study found that whale watching passengers have a consistently positive willingness to pay for improvements that benefit large baleen whales; finding~~these willingness to pay~~ values rang~~e~~ing from $181 to $221 acceptable depending on the amount of improvement (Schwarzmann et al., 2020). Although considering the monetary value of resource protection, these values do not take into account the value associated with place identity and the preservation of resources for the maintenance of culture. For some cultures, placing a monetary value on a place or resource may not be appropriate. Furthermore, associating sense of place strictly by monetary value via personal income or willingness to pay may alienate lower income populations.

Additional metrics that reflect a sense of place include population growth and per capita income. Population growth in the sanctuary study area was higher compared to that of the state of Washington as a whole in most years during the study period (2008–2019). In all study period years, population growth in the study area was higher than the average for the U.S. (Figure App.SP.1). When population growth in the study area was compared among ZIP~~zip~~ codes, the highest rate of growth was in the Port Townsend area, which is not directly adjacent to the sanctuary (Figure App.SP.2). Per capita income in the study area was higher in every year of the study period when compared to Washington and the U.S. (Figure App.SP.3). Additionally, per capita income increased in nearly every ZIP ~~zip~~ code within the study area from 2011 to 2014 (Figure App.SP.4). As population and per capita income grow, this may put pressure on resources (e.g., increased demand for infrastructure), which could impact sanctuary resources and influence how people are able to experience the sanctuary (Bureau of Economic Analysis [BEA], 2020).

The opinion polls described in the driving forces section show that attitudes of respondents are increasingly supportive of conservation and preservation. In addition, a 2019 Gallup poll asked U.S. residents whether the environment should be given priority, even at the risk of curbing economic growth, or whether economic growth should be given priority, even if the environment suffers. Although the number of respondents who prioritize the environment is not as high as when the poll started in the mid-1980s, over the Condition Report study period (2008–2019), environmental prioritization increased (Gallup, 2020; Figure App.SP.5).

Regarding landscape values, there are several areas within the Olympic Peninsula that hold high aesthetic, cultural, and economic value to the regional residents that overlap with or benefit from sanctuary viewsheds (McLain et al., 2013). Value of these areas varies by demographics. For example, there are notable differences when comparing value by gender and by tribal versus

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Commented [3]: Again, the data in this figure don't allow the reader to make this comparison. Data series are needed for Washington and the U.S. at large.

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non-tribal affiliationresidents, suggesting that sense of place is highly personal and dependent upon not only demographics, but also how long a person has had a relationship and history with a place.

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Special designations in and around the sanctuary are also important and can indicate the area's level of state, regional, national, and international significance. At the state level, most of Washington state waters (which overlap with OCNMS) were designated a Maritime Washington National Heritage Area in 2019. More regionally, the Pacific Northwest National Scenic Trail was designated in 2009 and runs along the coast of Washington and east into Montana. At the national level, the Olympic National Forest was designated in 1897, the Olympic National Park was established in 1938, and Olympic Coast National Marine Sanctuary was established in 1994. Further, there are three sites on the National Register of Historic Places: Tatoosh Island (est. 1972), Ozette Indian Village Archeological Site (est. 1974), and Wedding Rocks Petroglyphs (est. 1976). The Olympic Peninsula region has also been recognized internationally; the United Nations Education, Scientific and Cultural Organization designated Olympic National Park as an International Biosphere Reserve in 1976 and as a World Heritage Site in 1981.

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In 1958, Supreme Court Justice William O. Douglas referred to the park as "[t]he wildest, the most remote and, I think, the most picturesque beach area of our whole coast line … It is a place of haunting beauty, of deep solitude" (McKeown, 2018).

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Despite the number of designations and the region's recognition both locally and internationally, access to the sanctuary is limited. There are only 28 beaches adjacent to the sanctuary, which has roughly 300 miles of coastline (Washington State Department of Ecology, 2019) (Figure ES.NCR.3). Further, many of these access points have limited parking, which often overflows during peak season. Although limiting access can help to maintain a sense of place, it may also limit the number of people who can experience this truly iconic place and develop place attachment. Workshop participants noted that increased visitation to the area, coupled with declining enforcement, has impacted the way that both visitors and residents connect to the sanctuary.

UnqNon-Quantifiable Indicators

Place Identity

The discussion of factors that influence place identity is more personal, nuanced, and complex. Although there may be tangible places or measurements discussed here, quantifying place identity is difficult and highly subjective. Despite their intangibility, place identity and place attachment are crucial descriptors of the connection between peoples and the land.

> **Place identity** ishas been defined as a component of personal identity, a process by which people describe themselves as belonging to a specific place (Hernández et al., 2007). Identification between self/family/community and place develops over the long term and can run very deep, particularly where lineage is place-based, with genealogy going back many generations. Place identity is often expressed in reciprocal human-ecosystem relationships. This reciprocal relationship emphasizes that people are inseparable from the ecosystem, often seen with indigenous peoples, in which people derive benefits from the ecosystem (ecosystem services) and contribute to the maintenance or enhancement of the ecosystem (services to

ecosystems).

Place attachment is ~~has been~~ defined as a connection to locations that may develop and change over the short or long term, reflected in aesthetic attraction (e.g. books, film, artwork, national symbols), architecture, therapeutic rejuvenation, and even national iconic symbols. At both the personal and societal level, place attachment may evolve into place identity, with the timeframe for this to occur being highly variable.

The Olympic Coast is home to four coastal treaty tribes who have inhabited the area since time immemorial. Each tribe has their creation story, place identity, and sense of place. The Quinault, Queets, Hoh, and Quileute Tribes have lived at the mouths of the rivers that are now named for them, depending on the resources from the rivers and ocean.

> Chris Morganroth, Quileute elder: "It's been a great quality of life since the time of our beginning here, that all the things that were made available to us by the Creator, all the salmon, the cedar trees, just a wide variety of different life that's here on the coast" (Sreenivasan, 2012).
>
> Russell A. Svec, Makah Fisheries Director: "The Makah Tribe is truly blessed as Northwest Indigenous people. I continue to be amazed with the connection we have with our marine environment and how it has shaped this unique culture of ours. Makah have been accessing the ocean since time immemorial and we appreciate that in the spirit of true nature, everything is connected through space and time. During the negotiations of the 1855 Treaty of Neah Bay, Makah statements articulated a connection to marine space. For example, the leader from the Ozette village (a whaling village) Tse-kaw-wootl stated it clearest: 'I want the sea. That is my country.' Wanting to impress upon the governor the importance of this statement, Tse-kaw-woolth refused to even consider the terms of the treaty until Stevens joined him in a canoe on the saltwater. While the two leaders paddled around, Tse-kaw-wootl explained that the sea was his country. Historical declarations such as these allow us to remain strong as ocean going people. We continue to benefit from the mental, physical and spiritual wellbeing that comes from accessing our marine environment and its many resources.
>
> Having access to our ocean places allows us to protect our living culture. We understand that both traditional and scientific knowledge remain essential if we are to preserve and protect our sense of place and the environmental dynamics within. Today, environmental protection is one of our primary strategies in preserving our treaty fishing rights. This brings me back to when I worked as a Timber Fish and Wildlife technician in the 1980~~'~~s. At that time, I had the opportunity to review notes taken from an outsider in the early 1900~~'~~s which documented the response by a Makah river fisherman being asked: "How do you ensure that the salmon you are catching will return the following year" The Makah fisherman replied "If a rock was overturned you turned it back over". These values of our past will continue to endure and define the Makah Tribe's Fisheries Management Department in a way that supports an ecosystem-based management approach to all things. This strategy is essential if we are to maintain and protect a way of life that is rich in its connection to our traditional territory and its many environments.

These are environments that support a wealth of commercial fisheries that have sustained us since time immemorial.

Today, many aspects of the Makah Indian reservation and our community~~,~~ displays a modern-day society and a contemporary lifestyle. However, the Makah also remain a people who preserve a distinctive and old culture that is inextricably linked to the land and waters of this region, and we are a people with a history never too far from its present day" (R. A. Svec, personal communication, October 23, 2020).

Many non-tribal residents also call the Olympic Coast home and have their own unique sense of place.

Dan Ayres, WDFW Coastal Shellfish Manager and Grays Harbor Resident since birth (1955): "As a fifth-generation resident of the Washington Coast, I am humbled to live and work in this beautiful area. It has been a genuine honor to have spent 40 years of my life working to ensure that the native shellfish here are harvested sustainably and will be around for many generations to come. The deep peace that I experience simply walking along these wild and seemingly endless beaches cannot be replicated. The excitement of sitting in the warm cab of my truck while being rocked by a raging storm swirling around outside and watching a pounding ocean surf hit the beach in front of me is exhilarating. The satisfaction of digging razor clams by lantern light on a cold winter night while watching the lights of fellow harvesters flicker up and down the beach is beyond compare. At the same time, the joy it brings me to help my children perfect their digging skills, as my parents did for me and their parents did for them, reminds me of the gift this place has been to generations of coast dwellers. This is where I feel closest to God. While I love to travel, I could never live anywhere but right here near the Washington Coast. It is more than my home; it is my sanctuary" (D. Ayres, personal communication, August 6, 2020).

The U.S. Forest Service analyzed environmental quality, viewshed quality (including sound), remoteness from sights and sounds of people inside the wilderness, remoteness from occupied and modified areas outside the wilderness, facilities that decrease self-reliance, and management restrictions on visitor behavior within Olympic National Park and surrounding wilderness areas (Tricker, 2013). The study concluded that the soundscape has become somewhat degraded. Kuehne and Olden (2020) also found that 88% of audible air traffic was military, based on assumptions about flight schedules from nearby installations, with a substantial noise footprint that extended beyond the military operations area. ~~This was also confirmed by e~~Experts at the workshop~~, who described~~ confirmed having witnessed frequent, and loud, low aerial flyovers conducted by the U.S. Navy. Participants stated that these flyovers can interrupt cultural activities and peaceful use of wilderness, though the extent of these impacts has yet to be thoroughly documented. Remoteness from infrastructure shows limited degradation, but management activities have placed restrictions on behavior. Workshop participants also noted that management activities by different agencies, and in some cases private landowners, in the area have limited coastal treaty tribes' access to, and use of, traditional lands or resources for hunting, gathering, and other cultural purposes, as well as for research or monitoring efforts. For example, no hunting and limited gathering are allowed in Olympic National Park, which includes

Commented [7]: The Navy disagrees with the fundamental assumptions that produced this value and has noted that distinguishing military aircraft from commercial aircraft built on similar platforms is subjective at best. There is no need to focus on the controversy, but acknowledgment of the underlying assumption is key.

traditional lands of the coastal treaty tribes. Additionally, in some cases private timberland owners have restricted tribal member access for hunting (limited entry permits) and other private landowners have not allowed tribal staff to conduct monitoring on stream health.

With regard to historical sites, a study funded by the Bureau of Ocean Energy Management and partners identified multiple archaeological resources along the Olympic Coast (ICF International et al., 2013). Many of these resources are important to the coastal treaty tribes, as they are not only tangible cultural heritage resources, but also provide a connection to past generations. Resources include villages, middens, petroglyphs/pictographs, cemetery and burial grounds, and other cultural landscape features. Although there are no known sites within OCNMS boundaries, additional research into paleo shorelines may find significant sites.

There is an inherent relationship between indigenous people and place, it is part of indigenous languages, oral histories, river and place names, and village sites. In attempting to maintain this inherent relationship and exercise sovereignty, some coastal treaty tribes have restricted or limited access of non-tribal members to their lands. Beginning in 1969, Quinault Indian Nation closed 27 miles of beach to non-tribal members. ~~It was expressed d~~During the workshop it was expressed that~~the importance of~~ knowing ~~that~~this place is theirs and that they don't have to share it with tourists, even if it could be economically fruitful, is important to the tribe. The Quileute Tribe has also restricted non-tribal members on their beaches from dusk to dawn~~,~~ and, while it is challenging to enforce, banned beach fires by non-tribal members. The ability to find solitude on their lands has enhanced the sense of place for many tribal members. Furthermore, maintaining relatively pristine aspects of the environment, like dark skies, not only contributes to sense of place, but benefit~~s~~ the marine ecosystem by limiting light pollution.

Housing shortages and the imminent necessity to relocate tribal communities farther inland to protect them from earthquake and tsunami hazards and from storm damage worsened by the climate change will likely negatively impact sense of place. A report by the U.S. Department of Housing and Urban Development found that identifying land near existing infrastructure that is suitable for relocation is difficult for the Makah Tribe. The majority of their land is surrounded by forests used for timber production. Further, water shortages, exacerbated in the summer by limited groundwater storage capacity, limit the ability to expand development (American Indian and Alaska Native Public Witness Day 1, 2020). The necessity for tribal communities to relocate will likely be driven by changing ocean conditions, which can impact fisheries vital to maintaining culture, subsistence, and economic security. In addition, sixty percent of the Makah population, including the Makah village, clinic, schools, and other critical infrastructure, is located within a tsunami inundation zone. Not only is the population impacted by changing ocean conditions, but culturally significant sites like Hobuck Beach and Ozette Indian Village are at risk of erosion, threatening access to public beaches and culturally significant artifacts.

The Quinault Indian Nation also faces similar challenges from climate change. Nearly 1,000 people live in Taholah, which has experienced flooding, landslides, and culvert failures as a result of storm surge and rain, most recently in 2014, 2016, and 2018~~, from when storm surge and rains resulted in flooding, landslides, and culvert failures~~. Recently, Quinault Indian Nation declared a state of emergency due to the landslide risks threatening loss of reliable road access, which would devastate the community of Taholah. Of particular concern is an area 1 mile south of Taholah known as the "88 corner" where a slow-moving landslide has been identified as causing cracked pavement on SR 109 and could lead to collapse of the highway. Plans are in development to relocate the lower village of Taholah to higher ground (QIN, 2020).

The Hoh and Quileute Tribe are also experiencing flooding and sea level rise impacts on their communities, as well as the inherent risk of a tsunami on their coastal villages. Approximately 90% of Hoh tribal members on the reservation live in a flood zone. The Hoh Tribe is working to relocate to a safe elevation and, as such, the tribe has purchased land from adjacent landowners and some national park land was returned to the tribe, adding a total of 420 acres to relocate its village (Callis, 2008). An effort by the Quileute Tribe, titled Move to Higher Ground, describes a strategy to move their largest community out of the tsunami, earthquake, and flood zones to higher ground on the former national park land~~also on national park lands that were returned to the tribe~~ (Quileute Tribe, 2020). These efforts often take enormous time and resources commitments, and in some cases legislation (e.g., returning land to the Hoh and Quileute Tribes from Olympic National Park). These large-scale disruptions alter the ways in which tribal members interact with both their community and nature, can impact place identity, and alter tribes interactions with the Federal government. In some cases, elders may be more resistant to relocating, even knowing the risk of flooding or tsunami, due to place identity and the strong connections to their lands and viewscapes.

Despite these changes, workshop experts expressed a positive view of sense of place due to the vibrant tribal cultures, the level of conservation and protections, and long-term stewardship of the land and waters in the Olympic region. Quotes are included from the coastal treaty tribes to help communicate how their identity is interwoven with the land and waters of the Olympic Peninsula and sanctuary.

Conclusion:
This section closes with a poem written in the 1960s by Quinault cultural representative Clarence Pickernell and describes the tribe's association with their homeland (Storm et al., 1990, p. 274):

This is My Land

This is my land.
From the time of the first moon,
Till the time of the last sun. It was given to my people.
Wha-neh- wha-neh, the great giver of life,
Made me out of the earth of this land.
He said, "You are the land, and the land is you."
I take good care of this land,
For I am part of it.
I take good care of the animals,
For they are my brothers and sisters.
I take care of the streams and rivers,
For they clean the land.
I honor Ocean as my father,

For he gives me food and a means of travel.
Ocean knows everything, for he is everywhere.
Ocean is wise, for he is old.
Listen to Ocean, for he speaks wisdom.
He sees much, and knows more.
He says, "Take care of my sister Earth.
She is young and has little wisdom, but much kindness.
When she smiles, it is springtime.
Scar not her beauty, for she is beautiful beyond all things.
Her face looks eternally upward to the beauty of sky and stars,
Where once she lived with her father, Sky."
I am forever grateful for this beautiful and bountiful earth.
God gave it to me.
This is my land.

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Appendix:

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Table App.SP.1 Willingness to pay for resource condition improvement in OCNMS. Source: Leeworthy et al., 2017

Variable	Change in Resource Condition		
	Low to Medium	Medium to High	Low to High
Marine Mammals	$102	$37	$139
Seabirds	$47	-$29	$18
Large Predators	$73	$20	$93
Number Tidal Pool Organisms	$0	$0	$0
Tidal Pool Access	-$53	-$53	-$106
Water Quality	$97	$66	$163
Shoreline Quality - Marine Debris	$59	$40	$99
Shoreline Quality - Number of Beaches Open	$45	$66	$111
Obstructed views from Development	$102	$50	$152

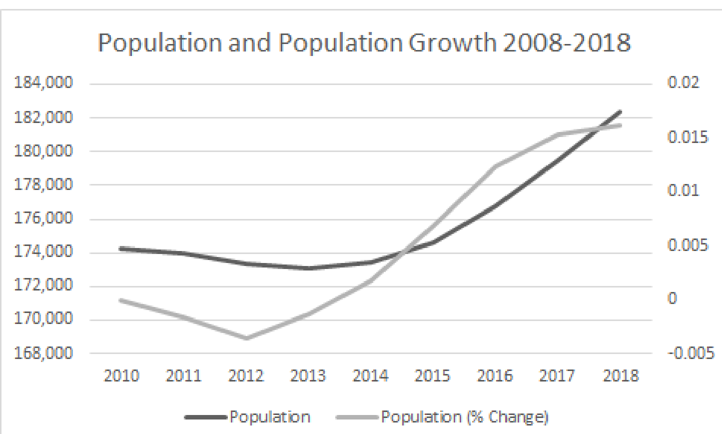

Figure App.SP.1. Population growth in OCNMS Study Area, 2008–2018. Source: BEA, 2020

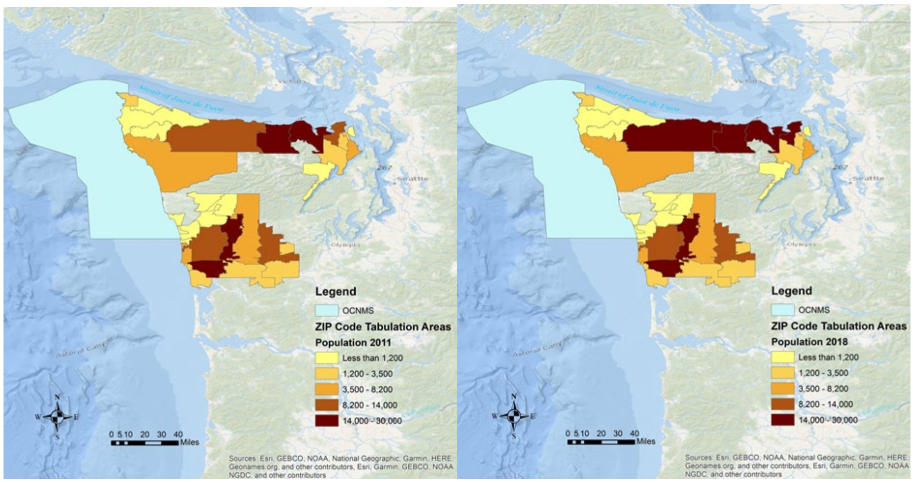

Figure App.SP.2. Population by zip code in 2011 (left) and 2018 (right). Source: BEA, 2020

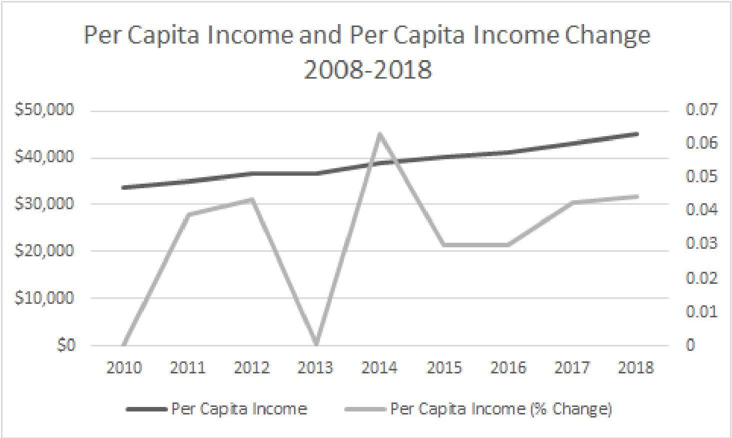

Figure App.SP.3. Per capita income in the study area, 2008–2018 Source: BEA, 2020

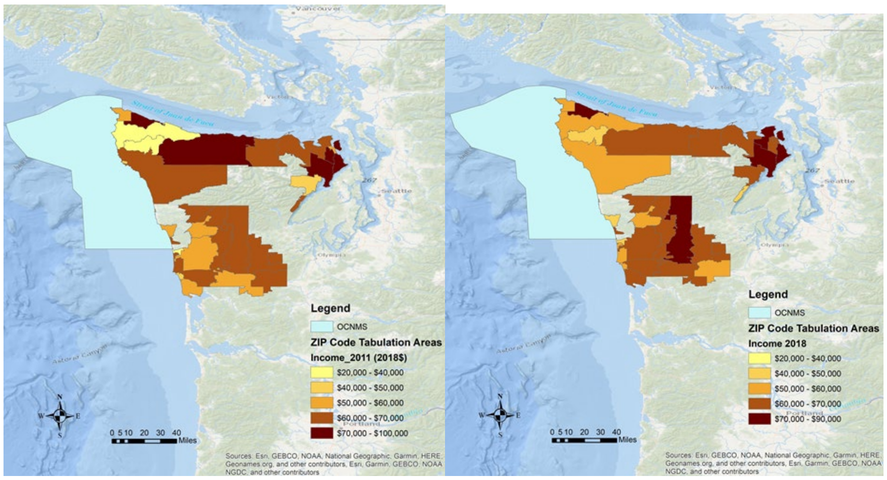

Figure App.SP.4. Per Capita Income by Zip Code 2011 (left) versus 2018 (right). Source: BEA, 2020

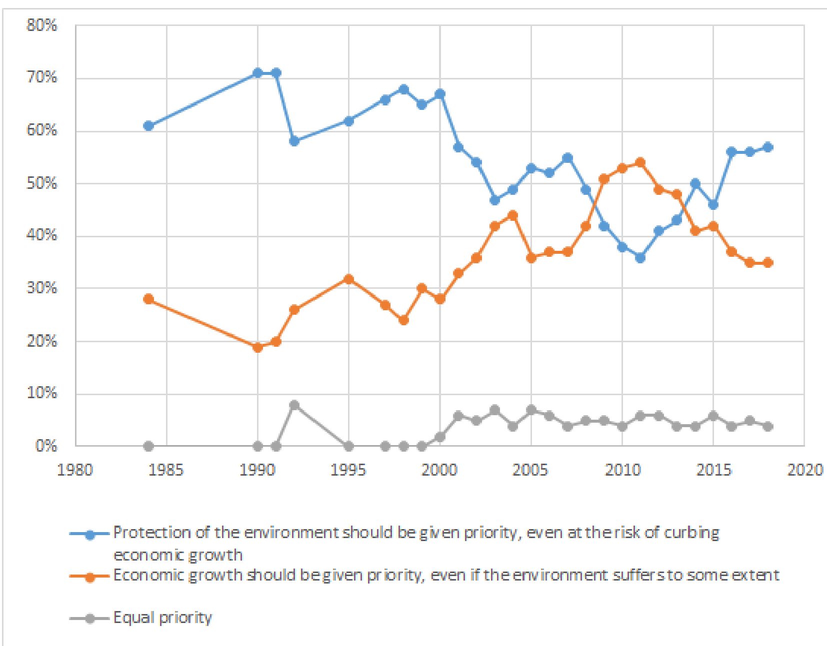

Figure App.SP.5. Responses to the question: "With which one of these statements about the environment and the economy do you most agree -- 'Protection of the environment should be given priority, even at the risk of curbing economic growth,' or 'Economic growth should be given priority, even if the environment suffers to some extent?'" Source: Gallup, 2020.

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This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

Commercial Harvest

Rating: *No Rating Assigned*

Status Description: *The workshop participants opted to not rate this service during the workshop due to complexity and dynamics among the human and natural factors affecting commercial fisheries.*

Rationale: *Throughout the study period (2008–2018), variability has been showcased by both high catches and fishery disasters. Although management seeks to reduce variability within this ecosystem service, changing ocean conditions and weather are key contributors to the variability of annual harvests.*

Commercial fishing is an important activity off of the Olympic Coast that provides a variety of services to local and broader communities through economic and non-economic benefits. The sanctuary is a highly productive ecosystem and many communities along the coast are strongly highly dependent on fisheries, as well as fish and shellfish resources within OCNMS,; however, the sanctuary does not manage fisheries. Fisheries are managed by federal, state, and tribal co-managers (see section 3b). Although the focus here is on how fish and shellfish resources are used to support commercial harvest, it is important to note that fish contribute to many other ecosystem services. For example, in addition to commercial harvest, salmon are important to the coastal treaty tribes in exercising their treaty rights, for food security and subsistence, ceremonies, maintaining food networks, and practicing their heritage, and are intimately intertwined into their identity. Salmon are also used for consumptive recreation by non-tribal people.

Several indicators are used in other ONMS condition assessments to inform the rating of the commercial harvest service, and were considered here despite the decision not to formally assign a rating. These include landings and ex-vessel value[1], jobs, output and income supported by commercial fisheries, the productivity of the region, fishery disaster declarations and their impacts, socio-economic studies of commercial fisheries and fishers, and the status of the resources (as determined in the State section). Data and information were provided for this report by the Washington Department of Fish and Wildlife (WDFW), Quinault Indian Nation, Quileute Tribe, and NOAA Fisheries, in addition to peer--reviewed studies that analyzed the economics of fisheries and the impact of fishery disasters. When possible, the analyses used were at the scale of the sanctuary. When that was not possible, data were used from larger management areas, such as state or federal waters off Washington.

The WDFW compiled data on the top species landed in the combined commercial catch reporting areas of 29, 58B, 59B, 59A-1, 59A-2 and 60A-1 for marine and shellfish and 4, 32, and

[1] A measure of the dollar value of commercial landings, usually calculated as the price per pound at first purchase of the commercial landings multiplied by the total pounds landed.

Commented [1]: But no rating was assigned of OCNMS. Is this information is used for other ONMS assessments state that for clarity.

Commented [2]: Already used elsewhere. During final editing, make a decision regarding whether an acronym/abbreviation will be defined once for the entire document or once in each section.

2 for salmon (Figure ES.CH.1). Data reported are based on trip tickets that commercial fishermen submit to the state and do not include tribal landings because . . .

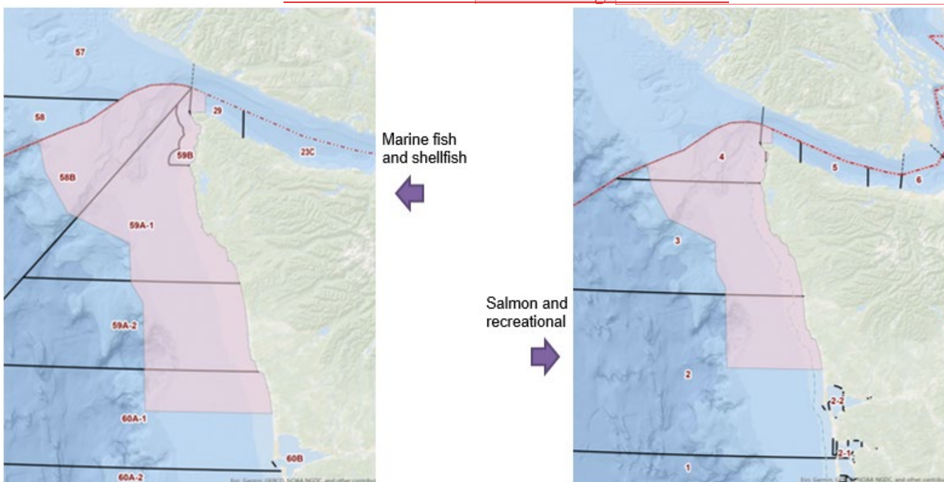

Figure ES.CH.1 Washington Department of Fish and Wildlife Commercial Catch Reporting Areas. Source: WDFW.

The top twelve species by pounds landed and ex-vessel revenue are shown in Figure ES.CH.2. The majority of landings from the catch areas during the study period were composed of three species categories: Pacific whiting harvested both at~~-~~-sea and shoreside (over 700 million pounds combined)~~;~~, coastal pelagics (sardine and other forage fishes; over 100 million pounds); and ~~Pacific pink~~ shrimp and spot prawn (predominantly Pacific pink shrimp; over~~both more than~~ 100 million pounds). Pounds landed for all other species were substantially lower.

With regard to nominal ex-vessel revenue, the top two species categories were ~~d~~Dungeness crab (close to $250 million) and ~~Pacific pink~~ shrimp and spot prawn (more than $75 million). Shrimp and spot prawn~~Pacific pink shrimp species~~ ranked second during the study period for both value and landings. Additionally, even though ~~d~~Dungeness crab ranks fifth in terms of pounds landed, it was by far the highest in terms of value. The third highest species category based upon value was non-trawled groundfish (with more than $40 million).

Commented [3]: Why are tribal landings not included in this section at all? The treatment of non-tribal commercial landings is thorough and does a great job of establishing the various shades of value attributable to these fisheries. Without data on tribal fisheries, however, the connects are not as solidly established. Looking below, Figure App.3 says it contains both non-tribal and tribal crab catch data. This needs to be made more explicit here.

Commented [4]: The label in the figure above the arrow for the panel on the right needs to be modified to read "Salmon." Yes, those areas are used for recreational summaries of marine fish and shellfish harvest, but this section is about commercial fisheries. Having 'recreational' on the label generates confusion.

Commented [5]: Both CPs and "shrimp" represent multiple species.

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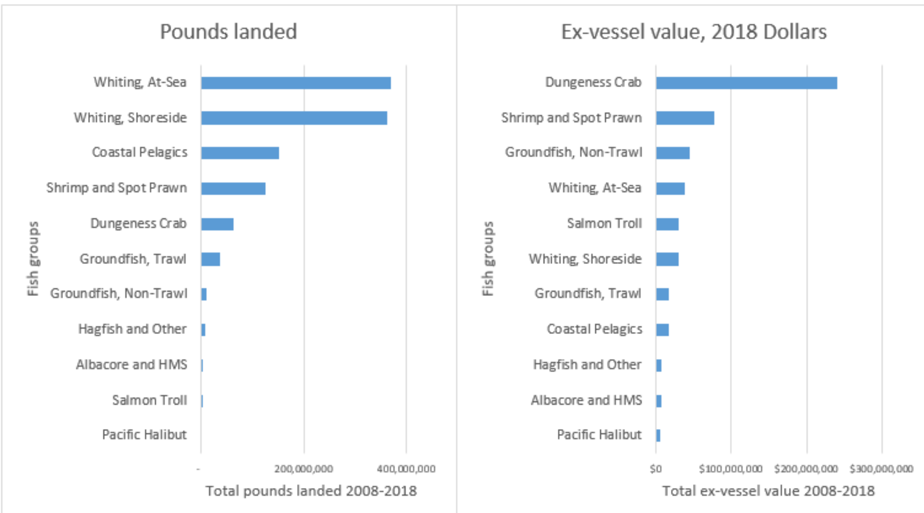

Figure ES.CH.2 Top twelve species categories by pounds landed and ex-vessel value (2018$) (This does not include all fisheries landing data). Source: WDFW, personal communication, 2020.

Trends for these species within the study period can also be informative, as fish populations and distributions exhibit substantial variability both within and across species over time. The high value for coastal pelagics, which ranked third overall, was largely driven by higher catches in the early years of the study period (Figure ES.CH.3). The shrimp fishery exhibited a boom during the study period (from 2014–2015) and has since declined. Further, most shoreside Pacific ~~shoreline~~ whiting, the second highest ranked species category in terms of pounds, were caught in just three years: 2016, 2017, and 2018. At-sea Pacific whiting showed more variation over the study period. Furthermore, most non-tribal landings of Pacific ~~W~~whiting were from outside the sanctuary. While the total catch of Pacific whiting has been increasing over time, the total non-tribal catch within the sanctuary remained stable over the study period (see Figure App.1).

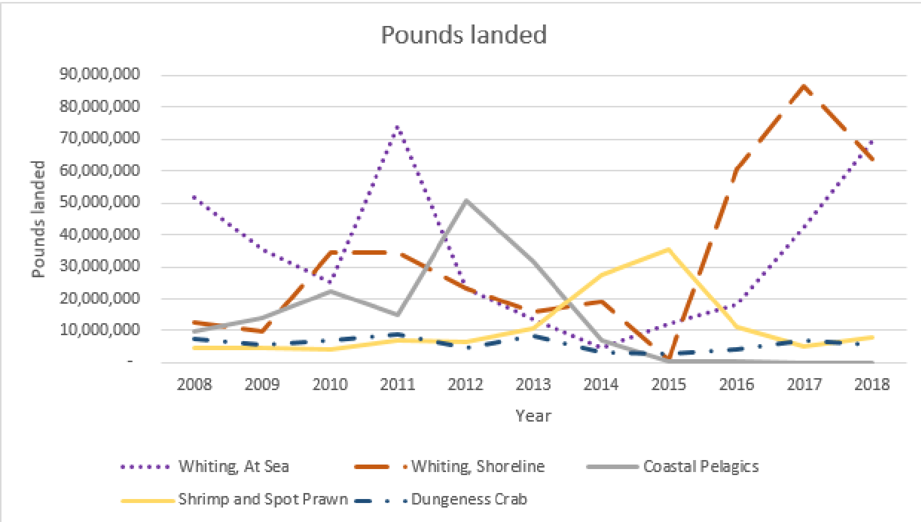

Figure ES.CH.3 Top five species categories ~~stocks~~ by weight and year. (This does not include all fisheries landing data.) Source:WDFW, personal communication, 2020.

Considering the annual ex-vessel value of the top five species categories landed, Dungeness crab varied substantially, with the top years by value occurring in 2010–2011 and 2012–2013 (see Figure App.2). Despite this variation in value, in ten of the eleven years, Dungeness crab had the highest ex-vessel value (Figure ES.CH.4) of all species caught. Shrimp and spot prawn~~Pink shrimp~~ was the only species category to exceed Dungeness crab value, and only ~~occurring~~ in 2015~~,~~ when crab catches were at their lowest during the study period.

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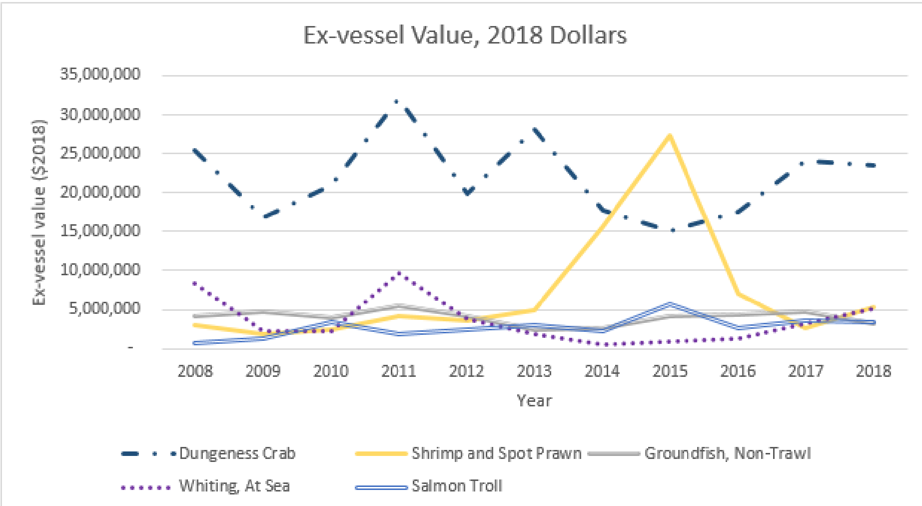

Figure ES.CH.4 Top five species categories stocks by ex-vessel value and year. (This does not include all fisheries landing data.) Source WDFW, personal communication, 2020.

Commented [8]: Again, explain. See comment above.

A West Coast Fisheries Participation Survey[2] was conducted in 2017 (Poe, 2020). For Washington State commercial fisheries participants, there is a "graying of the fleet," with over half (53.91%) of vessel owners being older than 60 years of age and only 20 percent under 50 years of age[3] (Figure App. 4). The graying of the fleet may threaten the future of commercial fisheries on the wWest eCoast and a common hurdle in entering the fleet is the sizable capital necessary (purchasing a vessel, quota, gear, maintenance, and fuel) (Silva et al. in prep.). There is a wide range of household incomes reported by fishermen who fish in Washington State waters, with nearly half (46.76%) earning more than $100,000, and for 41 percent of respondents fishing accounted for 100 percent of their income. Salmon and Dungeness crab were viewed as the most important fisheries economically and personally. Over 80 percent of commercial fishermen who took the survey strongly agreed that being a fisherman was important to them (Figure App. 5). A variety of factors contributed to their satisfaction with fishing as a job, such as being their own boss, setting their own schedule, producing healthy food, being on the water, and working outdoors generating the greatest satisfaction (Figure App. 6).

Commercial fisheries are of great importance to several of the coastal treaty tribes. As expressed by Dave Sones of the Makah Tribe, "fishing brings me back to my culture and makes me feel connected with my ancestors and my past. That's the best part of fishing for me, experiencing that connection" (Washington Sea Grant, 2020). Fisheries employ significant portions of the community, and are one way to exercise treaty rights that contribute to ceremonies, subsistence,

Commented [9]: The cultural significance is well established in the summary below, but the financial element is lacking because of a lack of landing data. Knowing which species are truly "critical" to the wellbeing of commercial tribal fisheries requires knowing what they harvest and sell.

Commented [10]: I think this statement is acceptable without detailed landing data since the importance of commercial fisheries to the tribes is well established by the tribes and those fisheries are integral to treaty rights.

[2] This survey was open to all commercial fishermen in Washington State and was not limited to those who fish only in OCNMS and, therefore, may not be reflective of those who fish commercially within OCNMS.
[3] This trend may not be reflective of tribal commercial fisheries, but we do not have data.

and spirituality. For some tribes, fishing generates a significant portion of their local economy, with the majority of families on the reservation engaged in commercial fishing. Members of the Quinault Indian Nation fish commercially both on the ocean and in the river systems within their treaty harvest area. The incomes generated by these fisheries are the sole, primary, or supplemental sources of annual revenue for a majority of Quinault tribal members. Coastal treaty tribes are place-based peoples with legally defined fishing areas, known as usual and accustomed fishing grounds (U&As). U&As limit where tribal members can exercise their treaty fishing rights, posing an additional challenge to accessing resources in response to management decisions or as species ranges or behaviors shift in response to conditions. For example, hypoxia events have implications for commercial fisheries, such as Dungeness crab and halibut. They can result in shifts in distribution, decreased fitness, or mortality. In 2017, the International Pacific Halibut Commission (IPHC) annual setline surveys were impacted by a hypoxic event off of the Washington coast; very few halibut were caught at locations where they are normally found (Figure ES.CH.5). This incident reinforced several concerns of local resource managers. First, the vulnerability of the coastal treaty tribes to changing ocean conditions and difficulties the tribes may face in maintaining access to fisheries with place-based rights as ocean conditions change. Second, the timing of fisheries surveys are important as this survey occurred later in the season than normal, which captured this hypoxia event and affected stock assessment models. Last, the ability of existing survey designs (i.e., IPHC setline and NOAA trawl surveys) to accurately reflect the biomass in the sanctuary due to the high heterogeneity of habitats influencing fish distribution.

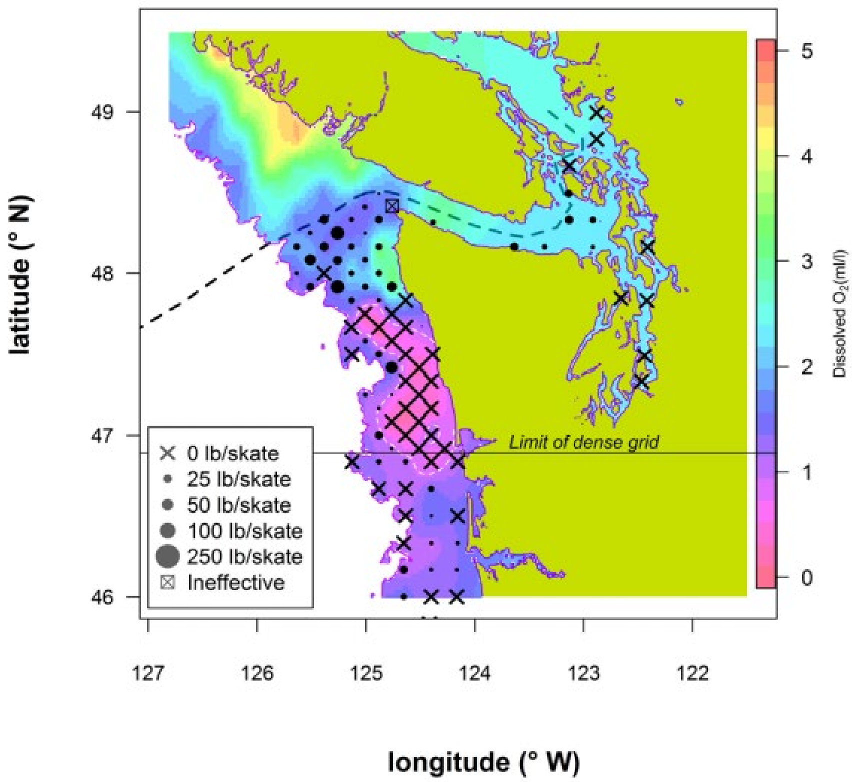

Figure ES.CH.5: Estimated dissolved oxygen in 2017 with weight per unit effort ~~WPUE~~ values from the IPHC setline survey overlaid with black symbols (IPHC 2018). No halibut were caught within the severely hypoxic area. Data and figure credit: IPHC.

Another example of the significance of commercial fisheries to coastal treaty tribes is the Pacific razor clam ~~(*Siliqua patula*)~~ commercial fishery of the Quinault. Despite razor clams not being among the top species by pounds or value, they are very significant to the Quinault Indian Nation (Weinberg, 2017). The Quinault people have harvested Pacific razor clams throughout their history and populations have remained relatively stable over the report period. They continue to be harvested from sandy beaches in the southern region of the sanctuary as a readily available food source. They have historically been harvested for subsistence and were used for bartering and trading for other food and items in the past. Razor clams have become an important commercial harvest product in recent times. Harvesting is conducted by individuals digging with narrow bladed shovels and requires minimal capital to enter the fishery. Any Quinault tribal member can be licensed to harvest clams during regulated openings. Clams are purchased by

Commented [11]: Tribal razor clam data are not included in the figures/summaries above, so the reader has no way of putting this statement in context. How many pounds are landed, by average, annually? Is this a tiny fraction of even the smallest of the species categories summarized above? If so, this truly speaks to the cultural, rather than strictly financial, significance of the species.

Commented [12]: As above, I think this statement is acceptable without detailed harvest data since the tribe has established the importance of the fishery and it is integral to treaty rights.

approved buyers on the beach and many are processed for sale to the public at the Quinault Pride Seafood facility in Taholah. Razor clam harvesting is a vital contributor to the economic livelihood of many Quinault tribal members. The primary threat to this fishery during the report period has been harmful algal bloom~~ (HAB)~~ events that eliminate or limit harvest opportunities.

Looking solely at landings, ex-vessel value, and the resulting economic contributions from the catch reporting areas that overlap with the sanctuary does not speak to the productivity of the sanctuary. The Olympic Coast is among the most productive fish-growing habitats in the world, driven by strong, nutrient-rich upwelling that fuels high primary productivity, a variety of habitats (submarine canyons, rocky reefs, and kelp forests), and coastal estuaries that serve as important nursery grounds for species like Dungeness crab (Hughes et al., 2014). Many commercial fishery stocks have been stable or increasing since 2008, including razor clams (S.LR.13.1 and S.LR.13.3), groundfish stocks that have recently been rebuilt (S.LR.13.5), and Pacific hake. While Pacific halibut are declining coastwide (Alaska-California), biomass is increasing in Catch Area 2A (Washington, Oregon, and California, see Figure App 1, IPHC 2020). Salmonid and steelhead populations on the coast are largely stable, with six runs of chinook, coho, and steelhead increasing and 19 runs declining (S.LR.13.12). Dungeness crab populations have also declined north of Point Grenville since 2005 (S.LR.13.3), but the CPUE from NOAA trawl surveys in OCNMS has increased since 2008 (S.LR.13.4).

Productive fishing grounds in OCNMS not only support local communities, but also communities outside of ~~the~~ OCNMS and outside of Washington. For example, Astoria, Oregon, bottom trawl observer data show roughly 70 percent of hauls being conducted ~~caught~~ off of Washington and roughly 30 percent occurring within ~~from~~ OCNMS, yet the vessel trip tickets do not reflect this (Corey Niles, pers. comm.).

Even with the high productivity of this system, there are multiple human and natural factors that contribute to the variability in commercial fisheries, including: supply, demand, and other market factors that affect fishery effort and profitability; permitting, management decisions, and court rulings (e.g., impacts on hatchery production)~~,~~; continued habitat loss outside of OCNMS (Puget Sound salmon recovery efforts);~~,~~ and changing ocean conditions that can shift species ranges for one or more seasons (i.e., warming waters within and outside OCNMS affecting migratory fish stocks). Changing ocean conditions have impacted, and will continue to impact, commercial fisheries. Warmer waters can have cascading effects throughout the food web (e.g., community shifts to lower-lipid copepods), causing changes in species ranges for both target~~ed~~ and non-target~~ed~~ species (e.g., higher pyrosome abundance, which can foul fishing gear; see Figure S.LR.14.7), and compressing habitat availability for pelagic species also experiencing benthic hypoxia. Mass mortality events evidenced by large fish kills on local beaches, caused by hypoxia, are also becoming more frequent (Figure ES.CH.6). The events occurred ~~in~~ from July through September of 2008, 2009, 2011, 2012, 2016, 2017 and 2018~~. The events are observable in the summer months, from July to September~~ when crab, groundfish, and pelagics washed up dead, primarily at the Pt. Grenville tribal beach. However, off~~-~~-reservation events also occurred~~occured~~ on Mocrocks and Copalis beaches in recent years. This correlates with OCNMS and OOI mooring data at those times. Shelf hypoxia is common but seems to come ashore more often in the Grenville region, potentially because of the adjacent Quinault canyon ~~adjacent~~. In

Commented [13]: Not used elsewhere in this section. general rule is to introduce an acronym or abbreviation only if it will be used at least two more times.

Commented [14]: https://www.pacificfishhabitat.org/wp-content/uploads/2017/09/tnc_ca_fishnurseries_lowres_min.pdf interviews, Quinault tribal elders do not recall ever seeing these types of mortality events (J. Schumacker, personal communication, November 20, 2020).

Figure ES.CH.6: A wolf eel washed ashore on Point Grenville beach following a mass mortality event due to hypoxia. Photo: J. Schumacker

Fishery disaster declarations highlight the variability that commercial fishers experience in the Pacifc Northwest and more specifically Olympic Coast. Table ES.CH.1 shows the fishery disasters by year, species, and ~~those~~ fisheries affected (Figure App.7 presents an infographic developed by NOAA Fisheries (2019), showing the ecological changes and ocean conditions, their impacts, and resulting fishery disasters). Fishery disasters can also affect access to subsistence resources, amplifying ~~the~~ economic and social impact to many communities.

Table ES.CH.1 Fishery Disasters Source: NOAA Fisheries, 2019

Disaster	Year	Hoh	Quileute	Quinault	Makah	Washington State
Fraser River sockeye	2008				X	X

Fraser River sockeye	2013				X	
Fraser River sockeye	2014				X	
Dungeness crab	2015		X			
Coho salmon	2015	X	X	X		X
Coho salmon	2016		X			
Ocean troll (coho and Chinook salmon)	2016				X	X

Although not all fishery disasters have been assessed for their socio-economic effects, some have. Richerson & Holland~~,~~ (2017) analyzed the impact of the 2008 salmon closure on vessels of the U.S. ~~w~~West ~~c~~Coast ~~vessels in the~~ salmon fleet. Roughly 209 vessels exited during the closure (17% of the fleet) and in 2016 the fleet remained roughly 10% smaller than prior to the 2008 closure (see Figure App.8). The authors found that vessels with higher revenue, a more diverse fishing portfolio, and more experience were likely to stay through the closure, while vessels that had a higher portion of their revenue from the salmon troll were more likely to exit. Not only has the number of vessels failed to recover, but the total revenue from salmon for vessels has also remained lower, on average, in the years after the closure (see Figure App.9).

In 2015, the presence of biotoxins as the result of a Harmful Algal Bloom (HAB) delayed the opening of the commercial Dungeness crab fishery for Washington, Oregon, and California. The closure resulted in a fisheries disaster declaration for the Quileute Tribe and California. Revenue of Dungeness crab on the west coast decreased by $97.5 million from the previous year, 2014 (Moore et al., 2020). Roughly 82% of participants indicated their income decreased. The mean decrease of income for fishery participants was $3,000-$9,999 and the mean decrease of income for non-fishery participants (such as the hospitality industry) was $1,000 to $2,900. The decrease in income forced slightly more than a third of fishing participants to borrow money from family and friends (37.1%), fish other species (33.7%) or apply for government assistance (17.1%) (Moore et al., 2020).

A study published in 2019 by Crossman et al. analyzed the impact of the 2016 and 2017 commercial razor clam fishery closure to the Quinault Indian Nation. The study found that roughly half of ~~the~~ tribal members participate directly in the razor clam harvest and others benefit from the harvest as employees of the processing plant. Much of the earnings from the harvest are spent locally at tribally owned businesses. The closure of the fishery reduce~~d~~s ~~the~~ income and increase~~d~~s food insecurity of many of the Quinault members. Additionally, the study found that closure reduces the ability to share knowledge between generations about razor clam harvest, preparation, and consumption.

Commented [15]: This follows logically form the next clause about specialization on troll-caught salmon.

The workshop participants for this report also recommended several ways the sanctuary can help to support the commercial harvest ecosystem service. They indicated improving the mooring program would help enhance the oceanographic monitoring within OCNMS and ~~to~~ better inform fisheries management. Additionally, continued protection from oil spills and maintaining shipping traffic farther offshore via the Area to be Avoided (ATBA) is also helpful. They also noted that some vessels operating in the sanctuary (primarily at-sea whiting processors) may also negatively impact water quality and this may be an area requiring active sanctuary management. Lastly, it was noted that more research of species at multiple life history stages, combined with year-round, real-time monitoring of ocean conditions, would help provide data to inform fisheries management. This information would also contribute to the Habitat Framework initiative[4] to better understand essential fish habitat. Experts also suggested increasing public awareness relative to the productivity and habitat of the sanctuary and the importance it plays in supporting fisheries.

Despite data and knowledge relative to the level of harvest, contributions to the economy, and reliance on commercial fishing of the tribes and Washingtonians, it was decided by workshop participants to not rate the status and trend of commercial harvest. Commercial fishing is managed by several governing agencies and for the North Pacific ecosystem, on a scale that exceeds sanctuary management. Despite improvements to some fisheries, primarily the bottom trawl groundfish fisheries, several other species experienced one or more disasters from 2008–2019 and are more variable over the study period. Further, not only do human actions and management influence the ability of the sanctuary area to provide commercial harvest, but there are several exogenous factors such as climate change, HABs, and marine heat~~-~~waves that not only impact species distribution and composition, but also suggest the need for dynamic management. By providing a status and trend, the experts felt the condition report may signal an oversimplification of the complexities of fisheries management and not do justice to the importance of cooperation among ~~between~~ federal, state, and tribal governments, as well as NGOs and other advocacy groups involved in West Coast fishery management.

Conclusion

Due to complexity and the present state of dynamics among the human and natural factors affecting commercial fisheries in OCNMS, this ecosystem service was not rated. The key factor supporting commercial fisheries and the local and broader economies that depend on them is the sanctuary's high productivity. The presence of coastal treaty tribes with reserved rights to fish, their continued ability to exercise those rights in their U&As, which encompass OCNMS, and the reliance of tribal communities on commercial fisheries are strong indicators of the value of this ecosystem service. Most of the key fisheries targeted are stable or increasing, with some in decline, as well as others with unprecedented high variability attributable to changing ocean conditions. The majority of Washington State commercial fishermen surveyed view fishing as

[4] The Olympic Coast Habitat Framework is a habitat mapping program led by the Northwest Indian Fisheries Commission and Intergovernmental Policy Council with technical support from OCNMS, to develop a common understanding of marine habitats on the Olympic Coast based on NOAA's Coastal and Marine Ecological Classification Standard, and serve as a common framework or language, for tribal, state, and federal resource managers.

being important to themselves and their community. The lack of fisheries data specific to OCNMS, specifically tribal landings and economic information, was a data gap identified in rating this ecosystem service. Recent fisheries disasters have demonstrated the adverse impacts communities experience and the difficult decisions some fishers face, including whether to remain in or leave the fishery. Such decisions may have far reaching consequences for tribal fishers, considering the cultural significance and community reliance on fishing, and the place-based nature of both fishing and tribal culture.

Table ES.CH.2 Summary Table of Indicators Used

Economic Indicators	Source	Figure or Table #	Data Summary
Top Species Categories by Landings & Harvest Revenue	WDFW, QIN and Quinalt, 2020.	ES.CH.2	The top three species categories by landings (from 2008-2018) are Pacific Whiting, shrimp and spot prawn~~Pacific Pink Shrimp~~, ~~Pacific Sardine~~and coastal pelagics. The top three species categories by ex-vessel value are Dungeness Crab, shrimp and spot prawn,~~Pacific Pink Shrimp~~ and Sablefish.
Top Five Species Categories by Weight and Year	WDFW, QIN and Quinalt, 2020.	ES.CH.3	Variation within the top five species categories varies by year. Pacific Whiting had the highest landings in 2016-2018, but were not present in the top five from 2008-2010.
Top Five Species Categories by Ex-Vessel Value and Year	WDFW, QIN and Quinalt, 2020.	ES.CH.4	In most years Dungeness Crab was the top species by value, but in 2015 and 2015, shrimp and spot prawn ~~Pacific Shrimp~~ was the top species category by value. There is less variation in the top five species by ex-vessel value from year to year than by landings.
Pacific Whiting	WDFW, QIN and Quinalt, 2020.	App Figure 1	The majority of non-tribal landings are outside of the sanctuary. Total catch within the sanctuary has remained stable over the study period, while total catch has been increasing overtime.
Dungeness Crab	WDFW, QIN and Quinalt, 2020..	App Figure 2	The highest seasons by value and catch occurred in 2010/11 and 2012/2013. Although the species remains one of the most valuable species landed annually, there is a declining trend in ex-vessel value and landings during the study period.
West Coast Fisheries Participation Survey	Poe et al., 2020	TBD	Twenty percent of WA commercial fishing vessel owners are under the age of 50. Roughly half of the participants earn more than $100K, while 41% rely solely on fishing income. Salmon and Dungeness crab were the most important to them from an economic perspective.

Razor Clams and Quinault Indian Nation		TBD	TBD
Non-Economic Indicators	**Source**	**Figure or Table #**	**Data Summary**
Fisheries disasters	Various	ES.CH.1 & App.3	Salmon, Dungeness crab and razor clams have all had fisheries disaster declarations at least once over the study period.
Salmon closure	Richerson & Holland, 2017	App.4	The 2008 salmon disaster resulted in 17% of the fleet exiting, and the fleet remains roughly 10% small (as of 2017).
Dungeness crab closure - 2015	Moore et al., 2020		Roughly 82% of respondents to the survey on the west coast saw their income decrease
Razor clam closure 2016-2017	Crossman et al., 2019		The closure primarily affected the Quinault (within the sanctuary) and resulted in a reduction of income to many QIN members and increased in food insecurity
Resource Indicators	**Source**	**Figure or Table #**	**Data Summary**
Razor clams	State section	S.LR.13.1 & S.LR.13.3	Razor clams have been stable or increasing since 2008
Pacific Hake	State section		An increase in biomass
Pacific Halibut	State section		Declining coastwide (AK-CA) biomass is increasing in catch area 2A
Salmonid & Steelhead	State section	S.LR.13.12	Populations on the coast are largely stable, with 6 runs of chinook, coho, and steelhead increasing and 19 runs declining
Dungeness crab	State section	S.LR.13.3 & S.LR.13.4	Populations have declined north of Point Grenville since 2005, but CPUE in OCNMS has increased since 2008
Groundfish	State section	S.LR.13.5	Populations recovered since 2008 for most groundfish species

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Commented [16]: Insert Hughes et al. (2014) citation before this IPHC reference using the link provided above.

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Appendix.

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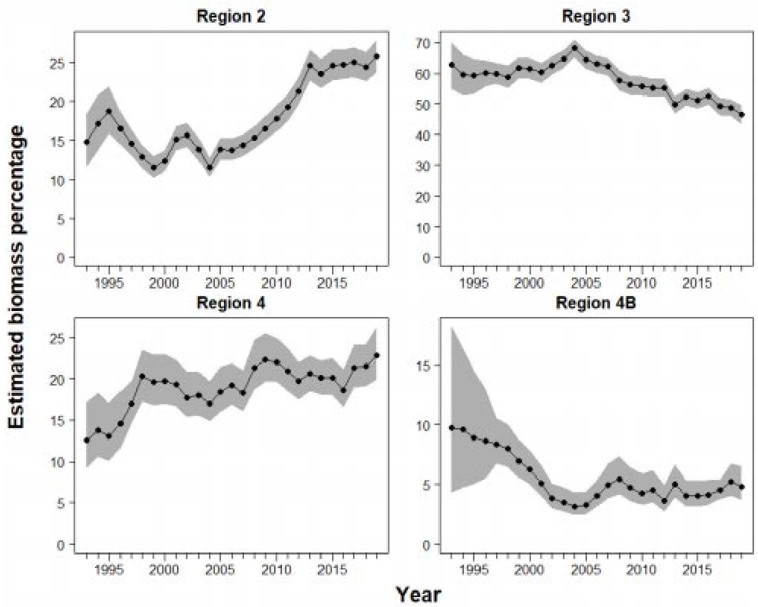

Figure App. 1. Biomass trends of Pacific Halibut by management area. Image: IPHC, 2020.

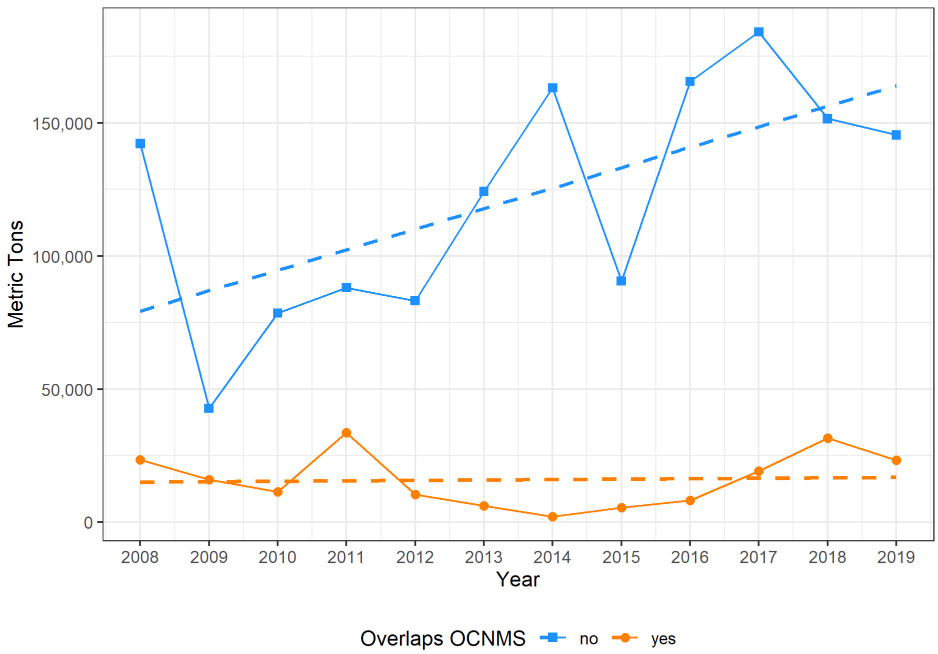

Figure App.2. Annual catches of Pacific whiting, 2008-2019, broken down by whether the haul was conducted in OCNMS waters (orange, circles) or not (blue, squares). The dashed lines are provided to show the 2008-2019 trend for each. The overall trend for catch in OCNMS is flat whereas catches outside OCNMS waters clearly show an increase. The hauls were represented in GIS as straight lines using start and end coordinates. A haul was considered to have occurred in OCNMS waters if the line intersected with the OCNMS GIS boundary layer. Source: At-Sea Hake Observer Program (ASHOP) Data provided via PacFIN's Comprehensive NPAC table.

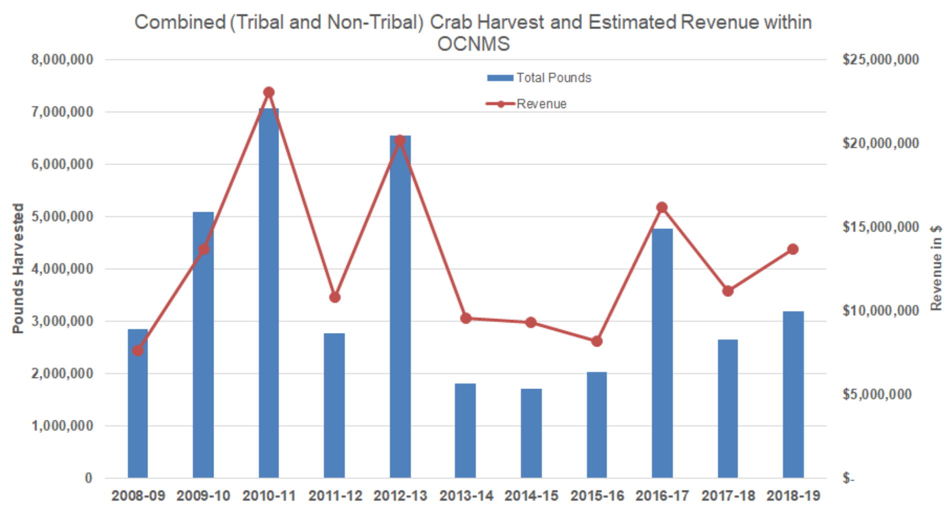

Figure App.3. Estimated Dungeness crab catch (pounds) and revenue ($) harvested from within the sanctuary. Source: WDFW, QIN, and Quinalt, 2020.

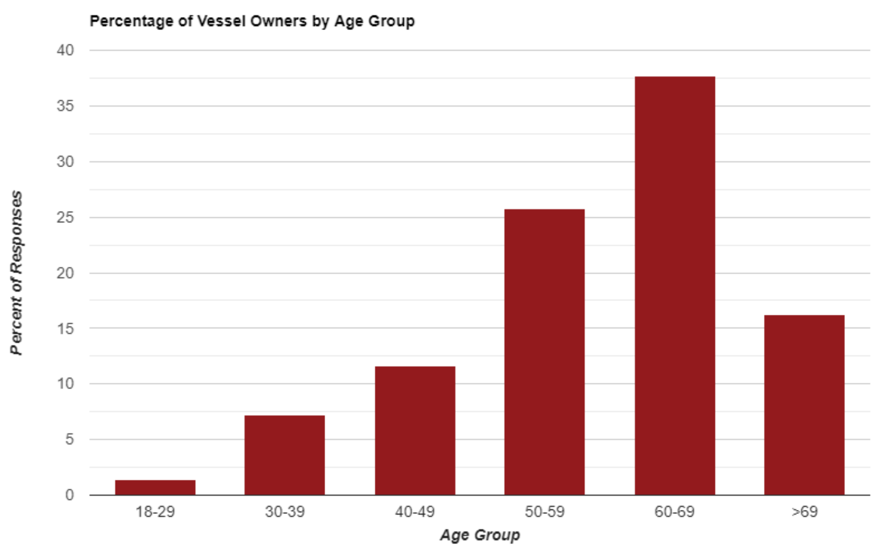

Figure App. 4. Participation survey results for Washington State commercial fishermen from 2017 for age demographics of vessel owners (Poe, 2020).

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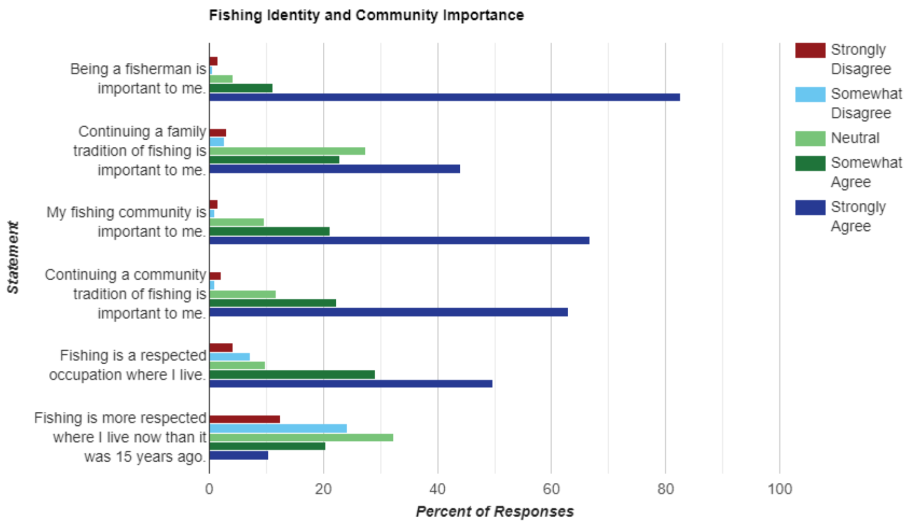

Figure App. 5. Commercial fishermen rated their agreement with a series of statements pertaining to fishing identity and community importance. Image: Poe, 2020.

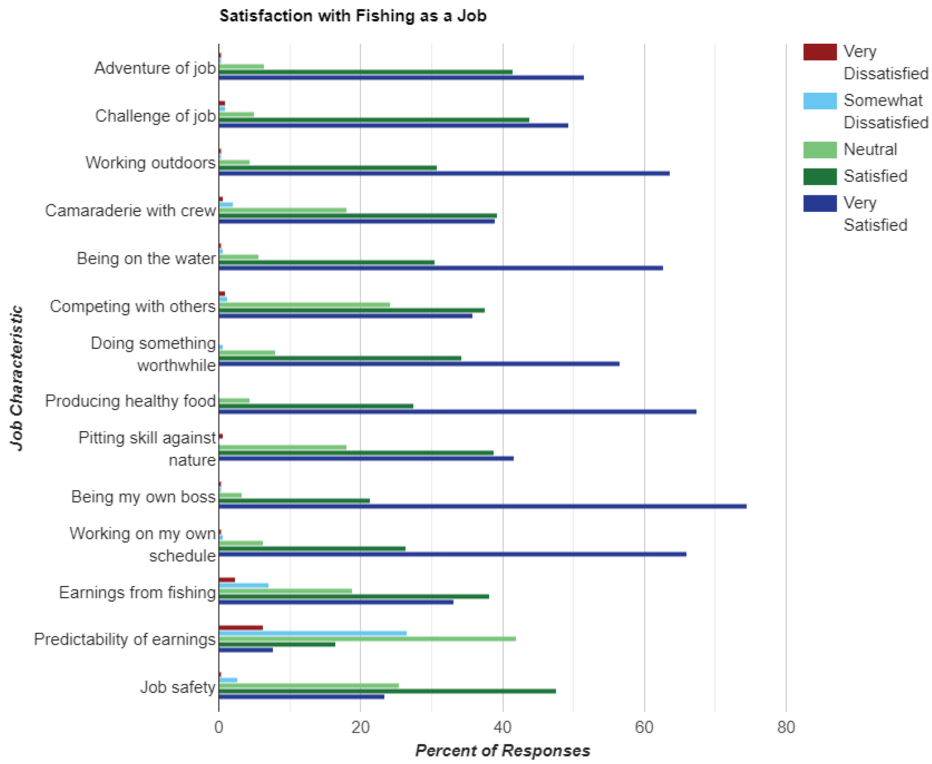

Figure App. 6. Commercial fishermen rated their satisfaction with various job characteristics, with being their own boss, setting their own schedule, producing healthy food, being on the water, and working outdoors generating the greatest satisfaction. Image: Poe, 2020.

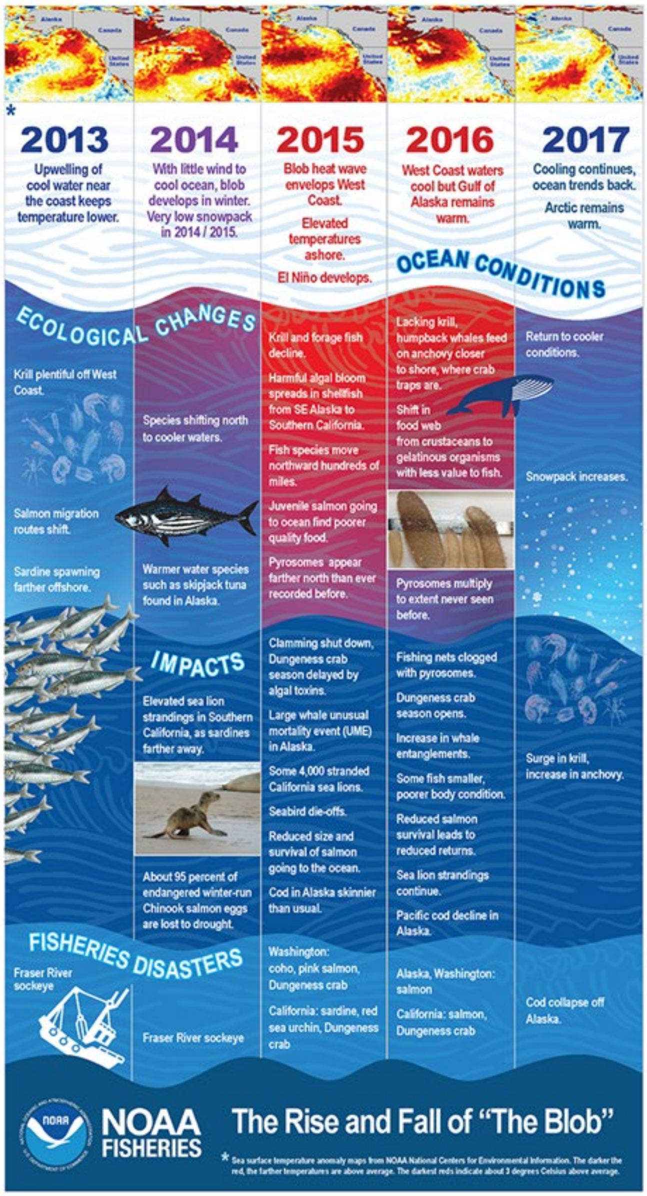

Figure App.7. Infographic of recent oceanographic conditions, ecological responses/impacts, and associated fisheries disasters. Image: NOAA Fisheries, 2019.

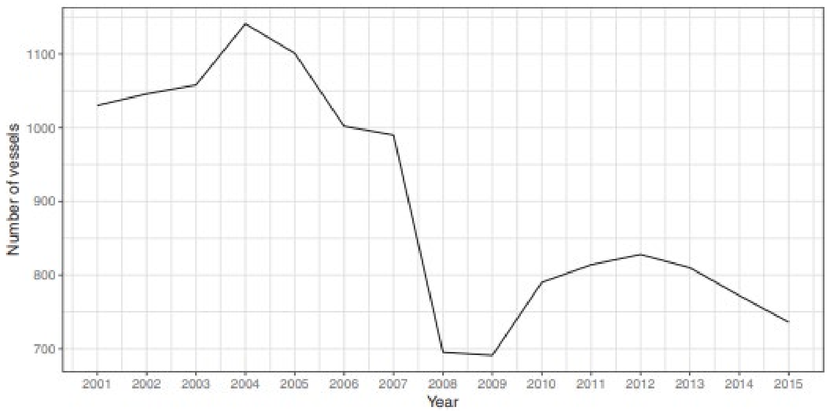

Figure App.8. Number of Focal Salmon Troll Vessels that Participated in Fishing Each Year
Source: Richerson & Holland, 2017.

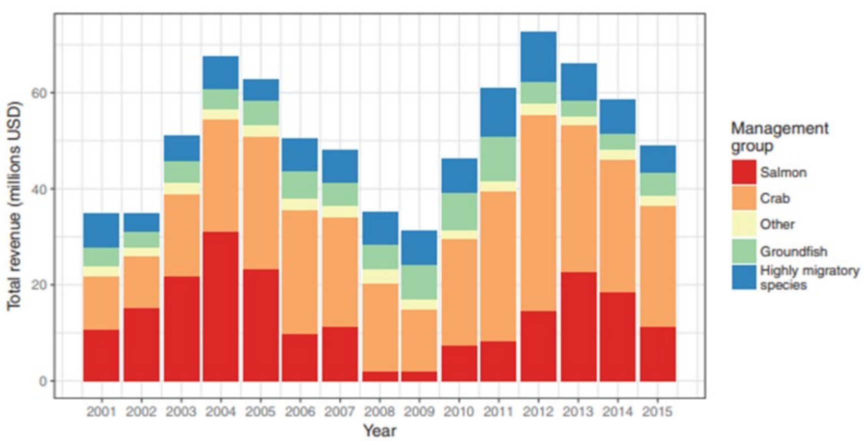

Figure App.9. Total annual revenue from each management group harvested by vessels in the salmon troll fleet. Source: Richerson & Holland, 2017.

This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

Subsistence Harvest — The capacity to support non-commercial harvesting of food and utilitarian products

Rating: Fair with Medium Confidence & Undetermined Trend with Medium Confidence

Status Description: *The capacity to provide the ecosystem service is compromised, and existing management would require enhancement to enable acceptable performance.*

Rationale - *Over the study period, razor clam subsistence harvest has remained relatively stable, while other species, such as the prized blueback sockeye salmon from the Quinault River, have been limited or entirely unavailable in recent years. Further, several participants across tribal communities have expressed concern about having enough species through the year to meet their needs and desires. Additionally, hard shell clams and octopus, which were gathered traditionally by Coastal Treaty Tribes, are reported to be less available. The status and trend were marked with high agreement and limited evidence yielding a confidence rating of medium for both.*

Since time immemorial the peoples of the Olympic Coast peninsula have relied upon the land and ocean for subsistence and survival. Many species are still used for subsistence by the coastal treaty tribes today. However, current diets generally include fewer locally sourced species than historically. These changes in diet, use, and access of marine species are complex and may result from management decisions or policy changes (e.g. MMPA, fisheries management~~, etc~~), social or societal changes, changes in species availability or distribution, and/or environmental changes. Poe et al. (unpublished data) found that at least 27 species of invertebrates, 34 species of fish, eight species of marine mammals, six types of kelp or algae, and nine species of birds are important for tribal subsistence today. These include, but are not limited to, salmon, halibut, clams, Dungeness crab, octopus, urchins, olive snails, gray and humpback whales, pinnipeds, bald eagles, gulls, bull kelp, as well as fish and bird eggs.

Commented [1]: For subsistence? All use of this term I've seen means consumption, but I don't know of any documentation of consumption of bald eagles by coastal tribes. If this is the case, showing Poe's data here would be enlightening. Maybe the evidence is for ceremonial use rather than subsistence?

This condition report evaluates the status and trend of subsistence harvest since 2008. The majority of the indicators summarized here are dependent upon survey data of both people and the species used for subsistence harvest. Much of the literature available on subsistence makes a distinction between tribal and non-tribal subsistence harvest. Accordingly, when available, results are reported for tribal and non-tribal populations.

There are a handful of studies that have sought to quantify the value of subsistence;~~,~~ however, this often is focused on a market value one-to-one replacement in protein costs. This type of quantification does not fully capture the value of subsistence harvest and it should ultimately be left to tribes to determine if and how to approach quantifying this sensitive topic. These studies are limited as they typically do not capture any of the spiritual or cultural significance associated with subsistence harvest, including the act of harvesting itself, sharing within the community, or any of the other numerous benefits that can’t be traded in a marketplace.

Poe et al., (2015) analyzed data from Washington and California commercial fishing operations, and found that the rates of subsistence harvest varied from zero for personal use to as much as 33% in a Puget Sound port. Roughly 85% (14.4 million kg) of the personal use harvest was from tribal landings in Washington State; the remaining 15% was from non-tribal Washington and California operators. Additionally, the study sought to determine whether the personal use of a species decreases when the market price of the fish increases. Of the top ten tribal species kept for personal use, only one, steelhead, fit the model for a price increase (Table ES.SH.1). This means that profit maximization is not a dependable predictor for subsistence behavior, and that some species have a greater value for home food and gifts than revenue generation.

Table 1: Top Ten Species Kept for Personal Use (1990–2010). Source: Poe et al., (2015).

Rank	Washington Tribal	KG of Seafood Landed	Washington Non-Tribal	KG of Seafood Landed
1	Chum salmon	10,511,301	Albacore	303,627
2	Chinook salmon	2,206,729	Pacific halibut	233,171
3	Coho salmon	663,038	Chum salmon	113,579
4	Steelhead	262,007	Dungeness crab	84,640
5	Sockeye salmon	255,318	Chinook salmon	77,063
6	Geoduck	129,024	Coho salmon	46,760
7	Dungeness crab	120,897	Sockeye salmon	33,942
8	Pacific halibut	87,797	Lingcod	22,833
9	Pink salmon	74,638	Sablefish	20,307
10	White sturgeon	30,918	Rougheye rockfish	15,609

A separate study sought to understand the motivations of keeping a portion of the harvest for personal use. Analyzing four separate fishing communities in 2018, including non-tribal communities, the majority of respondents (69%) kept the seafood for personal use (Figure ES.SH.1) (Poe et al., 2019).

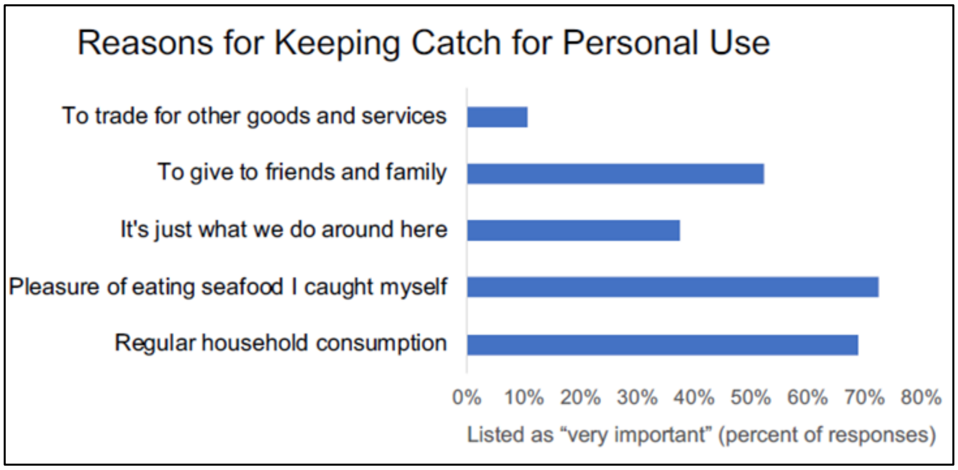

Figure ES.SH.1 Reasons for Keeping Catch for Personal Use. Source: Poe et al.~~,~~ (2019).

Marine mammals are a historical, and for some communities current~~continue to be~~, ~~an~~ important source of subsistence. Hunting whales, seals, and other marine mammals were dietary staples for the coastal treaty tribes for thousands of years. Makahs have hunted whales for subsistence purposes for at least 1,500 years (Renker, 2018). Whale and seal meat and oil are consumed~~,~~; marine mammal pelts have been and are used for clothing, blankets, or other purposes (e.g., harbor seal skin used for whale floats)~~,~~; and bones are used for tools and handicrafts (and historically other utilitarian purposes like drainage). The Makah Tribe has been working through the international and domestic regulatory processes to reestablish their gray whale hunt since the 1990s, with a successful hunt in 1999. The ceremonial and subsistence importance of marine mammals cannot be understated and are just as relevant today as they were pre-contact with European and American settlers.

Shellfish harvested by treaty tribes in western Washington State in ceremonial and subsistence fisheries are a necessary part of tribal culture and traditional diet (NWIFC, 2019). Shellfish include native littleneck, manila, razor, and geoduck clams~~,~~; Pacific oysters~~,~~; Dungeness crab~~,~~; shrimp; and other shellfish. Shellfish, like razor clams, can provide a reliable source of high quality, nutrient-rich subsistence year-round (Crossman et al., 2019). The importance of certain species was highlighted in Crossman et al. (2019). The concept is illustrated by the idea of clam hunger~~hungry~~, where the physical and emotional craving for traditional food is so strong that some may still eat them, despite warnings of health hazards (DeWeerdt, 2016).

It is hard to understate the importance of razor clams for Quinault Indian Nation. The topic has been featured in an *Earth is Blue* video and is featured occasionally in local media, such as when blooms of harmful algae cause harvest closures due to the increased presence of neurotoxins like domoic acid. While domoic acid events do not seem to affect the health of razor clams themselves or the Dungeness crab that prey on them, toxins can bioaccumulate in marine mammals and humans that consume toxic shellfish, resulting in injury, paralysis, or even death. One recent NPR story focused on the impacts of the latest coastal HAB event, capturing voices of tribal members and resource managers trying to convey the impacts of the closure on tribal and coastal communities. These disruptions not only produce negative economic consequences but also preclude important cultural and social traditions that exist around these family-centric activities.

~~In a previous study,~~ Sepez (2001) collected data in 1998 from a random sample of Makah households~~,~~ and found that over ~~roughly~~ 80 species were used for personal use including eight fish, three phyla of shellfish, and marine mammals. Finfish was the most common resource, followed by shellfish~~,~~ and marine mammals. Additionally, 76 to 100% of households reported using halibut, salmon, clams, and crab. This is not surprising given that, in 1998, fish composed roughly 55% of the meat diet of Makah, compared to 7% in the average U.S. diet.

The same study also considered attributes of subsistence. Common themes included tribal identity, work of subsistence (respect of self-reliance), fun in regards to the socialization aspect, health (local subsistence is perceived to be healthier than other foods), freshness, and the idea that you are what you eat. Specifically, current traditions emerge from heritage, and when practicing subsistence, you are connecting to your historical and ecological legacy.

Other resources were collected for more utilitarian uses, such as mussel shells for knife blades, whaling harpoon heads, scrapers, split for awls, jewelry, and tattoo needles (Shaffer et al., 2004). Purple olive snails are still used in Makah ceremonial regalia. Additionally, historically, many grasses, roots, and tree barks were collected to build baskets (Wray, 2014). Coastal treaty tribes in Washington use kelp directly for ceremonial and subsistence purposes, including but not limited to consumptive, cultural, spiritual, medicinal, artistic, and utilitarian uses (Northwest Straits Commission et al., 2020). Kelp habitats also support other cultural resources, like fish and invertebrates that are~~,~~ important for many tribes, and serve~~d~~ as navigational aids.

Changing resource conditions from year to year impact the ability to practice subsistence harvest and to harvest particular species. Climate change is also projected to impact access to subsistence resources (Dalton et al., 2016; Kruger, 2016; Shannon et al., 2016; Chang et al., 2020). There have been several fisheries disasters over the study period of the condition report (Table ES.CH.1) that have impacted various salmon populations and Dungeness crab. Sockeye in particular are often kept and canned for subsistence use throughout the year, so losing a season of sockeye can have a disproportionate impact on subsistence communities. Workshop participants expressed difficulty in accessing hard shell clams and octopus. Among other target subsistence species, razor clam populations have been stable or increasing since 2008, Pacific halibut are increasing in catch area 2A, salmon populations on the coast are mixed but largely stable (56 runs), with six runs of chinook, coho, and steelhead increasing and 19 runs declining. While populations of Dungeness crab have been stable or increased coastwide (Richerson et al., 2020), Dungeness crab have declined north of Point Grenville since 2005. Many groundfish populations have recovered from being depleted. Other species such as olive snails have seen a recent increase despite a mass mortality in 2014 in Makah Bay. Red urchin densities increased between 2015 and 2017 and decreased from 2017 to 2019 at multiple depths. Eastern North Pacific gray whales have a population numbering ~27,000, despite experiencing an unusual mortality event in 2019.

Conclusion

Subsistence harvest was determined to be fair with an undetermined trend as some species abundances are increasing and others are decreasing. It is worth emphasizing that this rating was assessing 2008–2019 and does not consider subsistence use or changes since time immemorial. However, there is high consistency in the species used by the coastal treaty tribes historically and at present. Coastal treaty tribe members and some non-tribal members rely on marine resources for subsistence. Fishery disaster declarations highlight ~~the~~ variability in the sanctuary's capacity to provide food security for peoples of the coast. At the same time, some species have increased in populations in this area, such as Pacific halibut and gray whales, and other species have remained fairly stable.

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This draft was archived on 2June2021 and contains all comments and edits received from Peer Reviewers.

Ornamentals — Resources collected for decorative, aesthetic, and/or ceremonial purposes

Rating: Good/Fair (high confidence); Undetermined trend (medium confidence)

Status Description: *The capacity to provide the ecosystem service is compromised, but performance is acceptable.*

Rationale: *A wide variety of marine resources have been, and continue to be, collected from OCNMS for decorative, aesthetic, and ceremonial purposes. However, shifts in distribution and abundance have occurred for some ornamental species from 2008 to 2018. Data gaps are present regarding the status and trends for a number of ornamental species.*

Ornamentals include items collected for decoration, display, or ceremonial purposes. Living and non-living resources from OCNMS are collected for a range of ornamental purposes. It is also worth noting that many items classified as ornamentals were historically produced for utilitarian purposes. This is especially true for basketry, which is discussed both here and in greater detail in the subsistence section.

The art of basketry reached a peak prior to the Great Depression, but has seen a resurgence in modern times among Coastal Treaty Tribes. Common marine resources collected to make baskets include cattail, sweetgrass, ~~and~~ other swamp grasses, and surf grass. While man-made dyes are more commonly used now, berries and seaweed were historically used to dye basket supplies, adding to the intricacy of the patterns used in weaving baskets. Basketry encompasses many forms, but ornamental baskets continue to be sold today at visitor centers and museums. For Coastal Treaty Tribes, basketry has cultural meaning and provides a vital link between past, present, and future artists. However, due to restrictions on removing resources, and thus access to basket making supplies, the ability to practice basketry has decreased (Wray, 2012).

Beachcombing for non-living resources (e.g., driftwood, sea glass) is popular in some areas of the sanctuary (Figure ES.O.1a; Washington Marine Spatial Planning, 2020). Similarly, shore-based collection and harvest of sea life also occurs in some parts of the sanctuary, but is generally less common than beachcombing (Figure ES.O.1b; Washington Marine Spatial Planning, 2020), and may include collection for non-ornamental purposes (e.g., subsistence harvest or consumptive recreation). Both beachcombing and harvest of sea life is regulated within Olympic National Park, and is, with few exceptions, prohibited (Olympic National Park, 2020). Furthermore, beachcombing on tribal reservations is also prohibited.

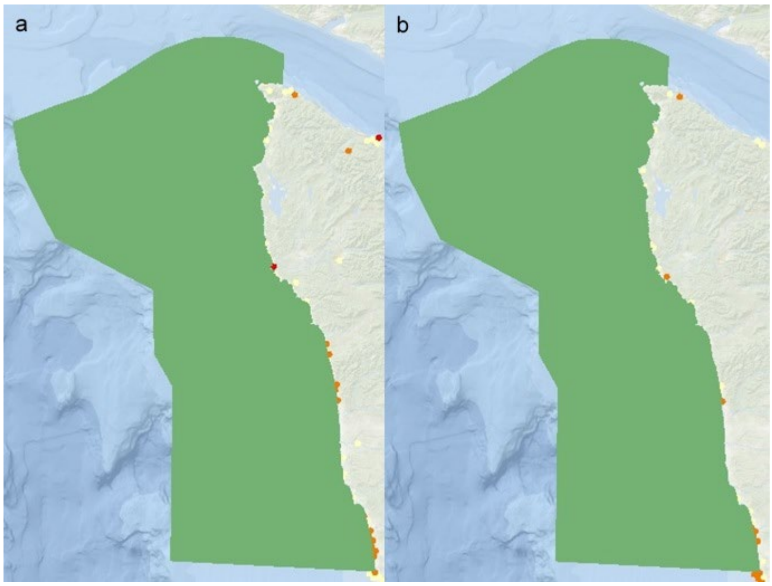

Figure ES.O.01. Spatial distribution of (a) beachcombing and (b) shore-based sea life collection and harvest activities in and adjacent to OCNMS. The green polygon represents OCNMS. Red points indicate high use, orange points indicate moderate use, and yellow points indicate low use. Image: Washington Marine Spatial Planning, 2020

In addition to spatial records of beachcoming and collection activities, museums and festivals dedicated to beachcombing also feature items collected adjacent to the sanctuary. These include John's Beachcombing Museum in Forks, founded in 1976, and the annual Beachcomber's Fun Fair in Ocean Shores.

Beyond beachcombing activities, which are popular among visitors and residents, workshop participants noted a number of resources that are collected from or adjacent to OCNMS for traditional ornamental and ceremonial use by Indigenous peoples of the Olympic Coast. These include kelp (used to make baskets and rattles) and shells from species such as blue mussels and olive snails (used to make clothing, jewelry, and regalia). Other shellfish, such as California mussels and~~, as well as~~ acorn barnacles, are also used for ornamental purposes. Marine mammal products, including whale bone, sea otter teeth and pelts, and sea lion pelts, have also been used for traditional ornamental purposes.

Although many resources are still successfully harvested for ornamental purposes in OCNMS, some species are becoming scarce. Workshop participants noted that *Dentalium* (Shaffer et al., 2004) and abalone shells were historically used for ornamental purposes, but are now difficult to find. Interviews with tribal members and elders from the Olympic Coast indicate that kelp is also scarce on beaches compared to its historical abundance (Shaffer et al., 2004). A mass die-off of olive snails was observed in Makah Bay in 2014, but the population subsequently recovered (Akmajian, 2018).

The abundance of acorn barnacles and California mussels varied across sites within the sanctuary, but generally remained stable during the study period (Figure ES.O.2). However, some observations suggest that changes in intertidal zoning of these species are occurring (J. Waddell, personal communication, January 16, 2020). Concerns exist regarding how changes in distribution or zonation may affect the ability of tribal communities to access these resources, as treaty rights only apply to specific locations, and would no longer apply if shellfish populations migrate outside treaty-delineated boundaries.

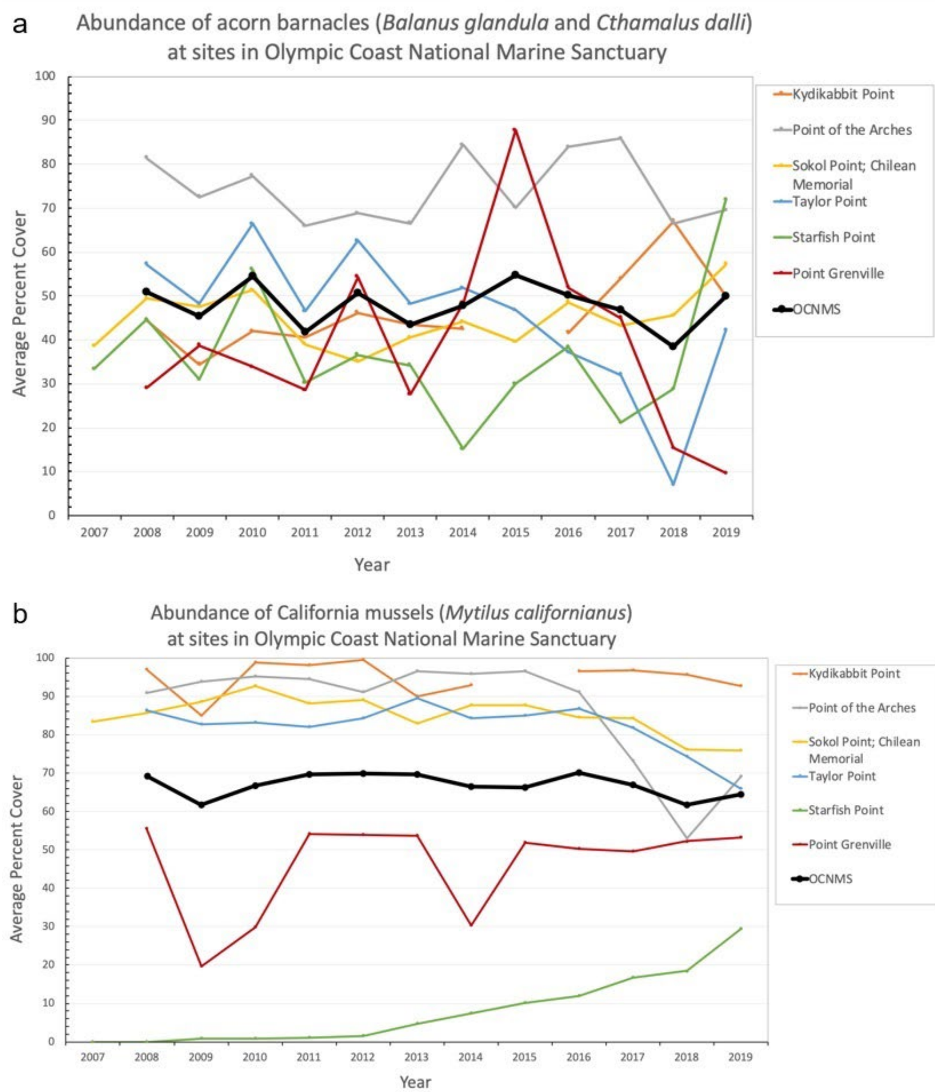

Figure ES.O.02. Average percent cover of (a) acorn barnacles (*Balanus glandula* and *Cthamalus dalli*) and (b) California mussels (*Mytilus californianus*) at six locations adjacent to OCNMS from 2007 to 2019. The bold, black line indicates the mean cover of each species or species group for OCNMS. Data from MARINe; figures by J. Brown/NOAA.

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Summary

While information is available for some species and locations, workshop participants ultimately noted that data gaps are present for the vast majority of species harvested for ornamental purposes, resulting in few available resource indicators for this ecosystem service.

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Response Section

The Driving Forces and Pressures section of this report describes a variety of issues and human activities occurring within and beyond the sanctuary that warrant attention, tracking, study, and, in some cases, specific management actions. Addressing any of these issues requires participation by and coordination with a variety of agencies and organizations. ONMS is fortunate to be able to work with many entities that contribute to managing human activities and addressing marine conservation issues. Central to that collaborative approach is the Olympic Coast Intergovernmental Policy Council (IPC) and the Olympic Coast Marine Sanctuary Advisory Council (AC).

The Olympic Coast Intergovernmental Policy Council was formed in 2007 to provide an effective and efficient forum for communication, exchange of information and policy recommendations regarding the management of the marine resources and activities within the boundaries of the Olympic Coast National Marine Sanctuary (OCNMS). The IPC is a forum where sovereigns with regulatory jurisdiction over marine resources and activities within the boundaries of the Olympic Coast ecosystem meet to enhance their communication, policy coordination and resource management strategies. Membership includes the Hoh, Makah, Quileute Tribes, the Quinault Indian Nation, and the State of Washington (IPC Charter, 2007).

The Olympic Coast National Marine Sanctuary Advisory Council was established immediately after the sanctuary's 1994 designation, under the authority of the National Marine Sanctuary Act. It was formed to serve as a forum for consultation and deliberation among its members and as a source of advice and recommendations to the sanctuary superintendent. (AC Charter, 2017). The Advisory Council includes governmental (i.e., tribal, state and federal agencies, and local government) and non-governmental (i.e., education, conservation, research, fishing, tourism, industry, marine resources committee, and citizen at large) seats.

In addition to these groups, OCNMS also consults on a government-to-government basis with the coastal treaty tribes individually.

For each of the main issues and human activities presented in the Driving Forces and Pressures section of this report, this Response Section provides a summary of related activities and management actions led or coordinated by sanctuary staff. The activities described below are not exhaustive of all the ways the sanctuary serves the community and the marine ecosystems encompassed within the sanctuary, but highlights significant contributions that are responsive to known or emerging pressures. Changes to management actions are not recommended in this section; however, in 2022 sanctuary staff will begin updating the sanctuary's management plan and this condition report's findings will serve as an important foundation on which to build new action plans designed to address priority needs.

Described below is a summary of actions that ONMS has taken, primarily since 2008, to address the issues and human activities that were described in the Driving Forces and Pressures section of this report.

Management Plan Call-out box

The sanctuary management plan serves as a non-regulatory policy framework for addressing the issues facing the sanctuary over a five to ten year period. It lays the foundation for restoring and protecting the sanctuary's ecosystem, details the human pressures that threaten the qualities and resources of the sanctuary, and recommends actions that should be taken both now and in the future to better manage the area and resources.

The original management plan was drafted during the sanctuary designation process, completed in 1994. The completion of the 2008 OCNMS Condition Report kicked off a three-year management plan review process. The resulting management plan was the result of a collaboration between the Advisory Council (AC), the Olympic Coast Intergovernmental Policy Council (IPC) and the public. The 20 action plans in the 2011 Management Plan (OCNMS, 2011) are grouped under five priorities:

- Achieve Collaborative and Coordinated Management
- Conduct Collaborative Research, Assessments, and Monitoring to Inform Ecosystem-Based Management
- Improve Ocean Literacy
- Conserve Natural Resources in the Sanctuary
- Understand the Sanctuary's Cultural, Historical, and Socioeconomic Significance

In 2017, OCNMS conducted an internal assessment of the progress made toward implementing the management plan. Based on this review, it was determined that no immediate or urgent revisions to the management plan or the regulations were needed at that time. The evaluation demonstrated the sustained relevance of the goals, objectives, and priorities of the existing management plan.

Changing Ocean Conditions

In 2013, OCNMS produced a report, Climate Change and the Olympic Coast National Marine Sanctuary: Interpreting Potential Futures, providing the best available science~~"state of the science"~~ (Miller et al., 2013) as it relates to the implications of climate change on the resources in the Olympic Coast National Marine Sanctuary (OCNMS). This climate change site scenario assessment was designed to assist OCNMS in adapting to climate change by 2100 by bridging the gap between the global projections provided by the Intergovernmental Panel on Climate Change (IPCC), and the regional and local implications of climate change. This study considered the direct consequences of climate change on the physical environment in OCNMS

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and, where possible, the direction and magnitude of change was estimated. These physical effects were divided into seven categories: increasing ocean temperature, ocean acidification, sea level rise, increasing storminess, changing ocean current patterns (with a focus on upwelling), increasing hypoxia or anoxia and altered hydrology in rivers draining into OCNMS. Following the completion of this climate change site scenario, work continued to refine a regional approach to address the identified issues.

In 2013, the AC and the IPC formed a joint Ocean Acidification Working Group. The working group was tasked with reviewing the recommendations of the Washington State Blue Ribbon Panel on Ocean Acidification, identifying recommendations most relevant to the outer coast of the Olympic Peninsula, and providing advice on potential responses and actions for consideration by OCNMS, the AC, IPC and other authorities on the outer Olympic Coast. In 2015 the working group identified seven priority recommendations for implementing climate-related activities, including "Work with partners to propose to NOAA leadership that OCNMS be designated as a NOAA Sentinel Site for Ocean Acidification and Sea Level Rise." The Working Group developed a Sentinel Site nomination letter and requested that it be sent to NOAA leadership and that sanctuary staff actively seek letters of support for this initiative from partner organizations and Tribes (OCNMS, 2016).

Building upon these efforts, in 2016 the OCNMS Advisory Council established the Ocean Acidification Sentinel Site (OASeS) Working Group, whose purpose was to help develop and plan a workshop to assist OCNMS in becoming a Sentinel Site for ocean acidification. The workshop facilitated discussion, identified efficiencies and highlighted potential collaborations, and began to collectively articulate the desired core components and capabilities of an Ocean Acidification Sentinel Site for the Olympic Coast.

The Sanctuary hosted a Washington Sea Grant Hershman Marine Policy Fellow from 2018–2019 to aid in establishing a steering committee for the sentinel site, including developing goals and objectives for the sentinel site. During the Fellowship year, draft terms of reference, goals, and objectives were reviewed and approved by the Advisory Council.

On November 6, 2019, John Armor, Director of NOAA's Office of National Marine Sanctuaries, working closely with tribal and state representatives on the Intergovernmental Policy Council and a Sanctuary Advisory Committee working group, designated OCNMS as a sentinel site for ocean acidification. National marine sanctuaries are places where focused monitoring and research efforts take place that enhance our understanding of natural and cultural resources and how they are changing. This allows sanctuaries to serve as sentinel sites that provide early warning capabilities for detecting changes to ecosystem processes and conditions.

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An Ocean Acidification Sentinel Site (OASeS) on the Olympic Coast of Washington state is focusing on related science and identifying trends in carbonate chemistry and hypoxia through collaborative monitoring, research, outreach and public engagement efforts. The sentinel site is helping to inform resource managers and coastal communities by telling the story of ocean acidification and its impacts on Washington coastal marine resources, cultures, communities, and economies. The sentinel site works to ensure that the Olympic Coast is well prepared for changing ocean conditions, with research and information that supports management responses and actions.

OCNMS is currently piloting a process to better integrate climate change into our management planning process. Occurring in tandem with the condition report, the sanctuary is drafting an addendum to the 2013 site scenario report and will plan to develop a rapid vulnerability assessment to better inform our management plan review on climate impacts to sanctuary resources. These efforts will leverage existing reports (i.e., condition report, 2013 site scenario) to ensure consistency and share lessons learned with other sites. We aim to holistically integrate climate change into our management plan to address climate and non-climate stressors as mandated.

Changing climatic conditions cannot be managed at the level of the sanctuary. However, the sanctuary can assist in documenting the direct effects of climatic changes by recording oceanographic properties such as water temperature and dissolved oxygen levels over time.

In order to understand and track how ocean conditions change on the Olympic Coast over time, the sanctuary has maintained an oceanographic mooring program since 2000 to document basic physical and chemical properties of the coastal ocean along approximately 130 miles of coastline. For most of the assessment period (2008–2019), ten moorings were deployed during the upwelling season (May to October) between Makah Bay and Cape Elizabeth, with moorings placed in water depths of 15m and 42m Although some nearshore sites record only temperature throughout the water column, OCNMS staff have continually worked to enhance these moorings with additional sensors and capabilities in an effort to collect similar data at all sites.

Data resulting from the OCNMS mooring program are utilized in a number of important ways, ranging from graduate student research and development of ocean temperature climatologies (Koehlinger, 2018) to synthesis into sophisticated regional ocean models that provide near-term and seasonal forecasts of ocean parameters like aragonite saturation state and other indications of ocean acidification. The unusual two decade-long time coastal series generated by OCNMS will provide a foundation for future work, including activities prioritized by steering committee members and working groups of the OA Sentinel Site.

One particularly concerning pattern documented by the OCNMS mooring program is related to severe and sometimes prolonged hypoxic events, which tend to worsen over the summer and often are more pronounced in the southern part of the sanctuary. In the late summer of 2017, the duration and intensity of a seasonal hypoxic event was unprecedented, causing a large number and wide diversity of animals to wash up dead on local beaches. The event also coincided with survey trawls by the International Pacific Halibut Commission to the extent that in some tows (or ‘skates’) no fish were caught over a large portion of the continental shelf and had to be repeated the following year. Hypoxic events and related widespread die-offs of marine organisms are alarming and a relatively new phenomenon affecting the Olympic Coast. Elders from the Quinault Indian Nation, a tribal community on the southern part of the Olympic Coast, have no record of such events occurring prior to 2006—traditional knowledge that helps validate the data record from OCNMS’ moorings offshore

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Commented [4]: While recording effects is indeed important, perhaps there are actions that OCNMS could take. OCNMS could explore management actions that promote adaptative capacity, buffer impacts, or enhance refugia. Even with regards to reducing greenhouse gas emissions, OCNMS could look for ways to increase energy efficiency and the use of clean energy in its own operations.

Harmful algal blooms or HABs are present on the Olympic Coast and associated neurotoxins can produce drastic negative consequences for human and animal health as well as prompt cascading negative economic impacts from the closure of recreational, commercial and subsistence harvest activities. HABs are addressed by OCNMS in a couple of ways, including as part of the mooring program. Working in partnership with Quileute Tribe's Natural Resources Department, staff routinely collect surface water samples adjacent to OCNMS' ten mooring sites during every visit, or approximately 5-6 times per season. Samples are analyzed by Quileute Tribe Natural Resources Department and shared with partners including the Olympic Region Harmful Algal Blooms partnership (ORHAB; http://www.orhab.org/)—a regional effort among tribal, state and Federal scientists and resource managers to coordinate and collaborate in support of a better understanding of HAB dynamics and impacts to fisheries and human health on the Olympic Coast.

Ocean Sound

Sound is a fundamental component of habitat that many ocean animals and ecosystems have evolved to rely on over millions of years. It is the most efficient means of communication over distance underwater. In just the last 100 years, human activity has increased along coasts, further offshore, and in deep ocean environments. Sound from this activity travels long distances underwater, leading to increases and changes in ocean noise levels.

Rising noise levels can negatively impact ocean animals and ecosystems in complex ways. Higher noise levels can reduce the ability of animals to communicate with potential mates, other group members, their offspring, or feeding partners. Noise can reduce an ocean animal's ability to hear environmental cues that are vital for survival, including those key to avoiding predators, finding food, and navigation among preferred habitats.

In 2010, NOAA developed an approach to managing ocean noise with the intention of reducing negative physical and behavioral impacts to living marine resources protected by the agency. This Ocean Noise Strategy is multi-faceted and includes studies on adverse physical and behavioral effects that exposure to certain noise types and levels can have on different species, as well as strategies to improve NOAA's ability to manage both species and the places they inhabit in the context of a changing acoustic environment (NOAA, 2016).

The Office of National Marine Sanctuaries' efforts in this area include a collaboration with the U.S. Navy on a program to characterize soundscapes within National Marine Sanctuaries, including three west coast sanctuaries: Olympic Coast, Monterey Bay, and Channel Islands. This program aims to measure and describe both comparable and site-specific underwater soundscape qualities within the U.S. National Marine Sanctuary System, in order to support developing the capacity to understand and protect acoustic habitats.

OCNMS has also actively engaged in the review of other federal agencies actions that may include the use of acoustic sources that are likely to injure sanctuary resources, e.g., Navy testing and training activities, and National Science Foundation's funding of a seismic study of the Cascadia subduction zone.

NMSA section 304(d) call-out box

Section 304(d) outlines the basic process by which federal agencies are to consult with NOAA on activities that trigger the need to consult. If a federal agency finds that a proposed action is likely to injure sanctuary resources, the agency is required to submit a "written statement" to the Office of National Marine Sanctuaries describing the potential effects of the activity on sanctuary resources at the earliest practicable time, but in no case later than 45 days before the final approval of the action, unless the agencies agree upon another schedule.

If the ONMS finds that the proposed action is likely to injure sanctuary resources, it must, within 45 days of receipt of complete information on the proposed action from the federal agency, develop and recommend "reasonable and prudent alternatives" for the agency to implement to protect sanctuary resources. Upon receipt of these alternatives, the agency is required to consult with the ONMS regarding plans for incorporating these recommendations into the proposed action.

If the agency decides not to follow the ONMS recommendations, it must provide a written explanation for that decision to the ONMS. If the agency takes an action other than an alternative recommended by the ONMS and the action results in the destruction of, loss of, or injury to a sanctuary resource, the head of the agency must promptly prevent and mitigate further damage and restore or replace the sanctuary resource in a manner approved by the ONMS (ONMS, 2020).

Maritime Transportation

The sanctuary lies at the entrance to the Strait of Juan de Fuca, a major international waterway linking the important North American ports of Seattle, Tacoma, and Vancouver, Canada, with trading partners all around the Pacific Rim. Every year. The uses of sanctuary waters for maritime transportation, along with commercial fishing, are the most significant commercial uses of the sanctuary. The area benefits from robust international management by a Cooperative Vessel Traffic Service (CVTS) jointly managed by the U.S. and Canadian Coast Guards. The purpose of the CVTS is to provide for the safe and efficient movement of vessel traffic while preventing collisions and groundings, and therefore minimizing the risk of environmental damage that would follow.

Washington State is also proactive in maritime transportation risk management, and oil spill prevention, planning and response. Most recently the Washington State Legislature passed the 2018 Strengthening Oil Transportation Safety Act and the 2019 ReducingThreats to Southern Resident Killer Whales & Improving the Safety of Oil Transportation Act.

There are a number of groups that also participate in vessel traffic management and safety issues including the Puget Sound Harbor Safety Committee, Salish Sea Shared Water Forum and the Pacific States - British Columbia Oil Spill Task Force.

Ship Strikes

At present, there have been limited management actions taken to address the risks to marine mammals from ship strikes in the sanctuary. Voluntary vessel slowdowns have been implemented in California waters and in nearby Canadian and U.S. waters. There are standard operating procedures that have been adopted by NOAA to minimize speeds in certain situations to minimize ship strike risk. Furthermore, only the Navy and USCG are required to report ship strikes.

Oil Spill Prevention

The sanctuary works closely with the U.S. Coast Guard, Washington Department of Ecology, Makah Office of Marine Affairs and other organizations on oil spill response and preparedness by participating in oil spill drills, supporting a rescue tug stationed in Neah Bay, participating in discussions of alternative response technologies, prioritizing allocation of oil spill restoration funds, and reviewing proposed legislation, regulations and documentation. Since 1999, Washington state has funded a seasonal rescue tug stationed at Neah Bay to quickly respond to vessels that may need assistance. As of February 2020, the tug has escorted, stood by or assisted 78 ships that were disabled or had reduced maneuvering or propulsion capability while fishing or transporting oil and other cargo through the sanctuary, along the Strait of Juan de Fuca, and even in Canadian waters (ECY, 2020).

Area To Be Avoided Monitoring and Compliance

At the time of designation, to mitigate against potential oil spills, NOAA worked with the U.S. Coast Guard and the U.S. delegation to the International Maritime Organization to establish an Area To Be Avoided (ATBA) as a buffer, to provide greater response time for assistance to foundering vessels along this rocky and environmentally sensitive coast. The ATBA was designated in 1995, and modified in 2002 and 2012. The ATBA originally applied to all vessels transiting with cargoes of oil or hazardous materials. Effective December 1, 2012, the applicability was extended to also include all vessels over 400 gross tons.

All ships transiting the area and carrying cargoes of oil or hazardous materials and all ships 400 gross tons and larger are requested to avoid this area. Since 1998, the sanctuary has been monitoring compliance to the ATBA, and started reporting monitoring results annually since 2004.

Letters are sent out under signature of the sanctuary superintendent and the Coast Guard Captain of the Port to non-complying vessels observed within the ATBA. The response by the maritime industry has been favorable, with an estimated compliance rate of 95.5 percent in 2019.

Vessel Discharge and Ballast Water

There are risks from vessel discharges in addition to oil spills. Interest in water quality and the effects of vessel discharges in the sanctuary were expressed during the MPR public scoping period and during subsequent public comment periods at AC meetings. Regulations on vessel discharges were considered, including a ban on the discharge of invasive species in the sanctuary through ballast water discharges. In one case discharges from cruise ships was addressed through OCNMS rule-making and is discussed in the following section.

In reviewing alternatives for an OCNMS Water Quality Protection Action Plan, modifications to sanctuary regulations were considered for both cruise ships and vessels 300 gross tons and above. OCNMS considered regulation banning all discharges (except when limited by sewage or graywater holding capacity) from vessels 300 gross tons and above into waters of the sanctuary, except clean vessel engine cooling water, clean vessel generator cooling water, clean bilge water, anchor wash (OCNMS, 2011). The sanctuary did not pursue the later regulation, deciding to focus instead on the estimated higher volumes from cruise ships. OCNMS has been working with local marinas to improve access to pump out stations to address sewage discharge and may be able to expand to include oily bilge discharge.

In reviewing alternatives for a Habitat Protection Action Plan modification to OCNMS regulations to ban the discharge of invasive species in the sanctuary was considered. The definition and list of invasive species of the Washington Invasive Species Council was adopted for the analysis. After reviewing existing state and regional regulations and policies related to invasive species, it was concluded an OCNMS regulation related to invasive, non-native species was unnecessary. This position may need to be reevaluated based on the results of EPA's proposed rulemaking on Vessel Incidental Discharge National Standards of Performance (85 FR 67818). The rule is intended to reduce the environmental impact of discharges, such as ballast water, that are incidental to the normal operation of commercial vessels; however, this rule may also preempt existing state regulations in federal waters.

Cruise Ship Discharges

As part of the 2011 management plan review it was decided to promulgate regulations banning discharges from cruise ships in the sanctuary. The related analysis found that cruise ships generated a variety of wastewater discharges on the scale of a small municipality with potential to harm the marine environment. The discharges of highest concern to OCNMS based on volume and potential contaminant loading were sewage, graywater, and bilge water. Sewage discharges from ships, particularly those not using Advanced Water Treatment Systems (AWTS), contain nutrients that create biological and chemical oxygen demand and could contribute to algae blooms that, in turn, could intensify low dissolved oxygen levels known to occur in the sanctuary. Pathogens from sewage have the potential to contaminate commercial or recreational shellfish beds (a human health risk) and to harm wildlife and humans directly (OCNMS, 2011).

The final rule (76 FR 67348; November 11, 2011), created a regulatory ban on all discharges within OCNMS from cruise ships (except clean vessel deck wash down, clean vessel engine cooling water, clean vessel generator cooling water, clean bilge water or anchor wash) that would have a direct, long-term, beneficial, less-than-significant impact on physical resources (i.e., water quality) because it would prohibit potentially harmful discharges by introduction of pollutants, such as bacteria, viruses, solids, pharmaceuticals, organics, nutrients, and metals.

Exhaust Gas Cleaning Systems

In evaluating illegally discharged Exhaust Gas Cleaning System (EGCS) effluents from cruise ships in OCNMS, it was determined that these discharges could have an adverse effect on sanctuary resources or qualities. There have been a number of self-reported violations of the cruise ship discharge regulation that have resulted in civil penalties.

Submarine Cables

Two submarine cables were installed by plow burial in the seafloor through Olympic Coast National Marine Sanctuary for the Pacific Crossing fiber optic telecommunications system in 1999 and 2000. At the time, there were no published studies on impacts of submarine cable installation to seafloor habitats or biological communities. As a result, the authorization to install the cable in Olympic Coast National Marine Sanctuary, required a post-installation field study to monitor the impact of cable installation on benthic habitats and biological communities and the extent of recovery over time.

A cable inspection survey contracted by the cable owners in 2001 revealed that significant portions of each cable in the sanctuary were not buried to 0.6 meter depth, and considerable lengths of cable were unburied or suspended above the seafloor. Protracted negotiations between the cable owner, cable installer, OCNMS, U.S. Army Corps of Engineers, and the Makah Tribe resulted in an agreement requiring cable re-installation throughout the sanctuary. Re- installation of the PC-1 cables was accomplished in 2006.

In 2018, an analysis from the surveys completed between 2000 and 2004 was published (Antrim et al., 2018). The information presented in the report provides useful scientific information about the sanctuary's benthic habitats as well as management implications and monitoring recommendations for cable installations. Effective cable route planning can help identify areas susceptible to significant or persistent impacts that could be avoided during project construction. In areas where user conflicts are clearly identified, such as where bottom contact fisheries are conducted, post-installation surveys of submarine cables are recommended to identify where exposed cables put fishers at risk of snagging gear or damaging submarine cables. The current permit end-date, and the anticipated end of life for the cable network, will both be in 2025. Monitoring of the cable continues and will inform what actions to take in 2025.

Fishing

The sanctuary does not directly manage fisheries within sanctuary waters; however, sanctuary research may inform fisheries management entities, particularly on habitats within sanctuary boundaries. In 2013, OCNMS and Washington State Department of Fish and Wildlife (WDFW) jointly responded to a Request for Proposals from the Pacific Fishery Management Council as part of its five-year review of Groundfish Essential Fish Habitat (EFH) along the west coast. The OCNMS/WDFW submission "Options for Potential Modifications to Olympic 2 Groundfish Essential Fish Habitat Conservation Area in Washington State" contained three options, applicable to non-tribal fisheries, to increase protection of sensitive biogenic and rocky reef habitats both within and adjacent to the existing Olympic 2 EFH Conservation Area.

Based on concerns expressed by coastal treaty tribes with how EFH protections might impact their "usual and accustomed" (U&A) areas, and for the purposes of broader ecosystem protection and the application of precautionary management principles, OCNMS and WDFW agreed to an alternative process to address broader ecosystem protection in the Olympic Coast National Marine Sanctuary. These efforts have resulted in an IPC Habitat Framework initiative, which is based on a need for a common understanding of all information sources regarding habitat and its role in supporting marine ecosystems.

Habitat

Information on habitat is needed for both fisheries and national marine sanctuary management, and a logical nexus for collaboration. OCNMS met a substantial milestone in 2015 with the release of the Washington State Seafloor Atlas (figure R.1), which shows the primary surficial substrate types from the Washington state shoreline to 700 fathoms. The Atlas was developed through a partnership between OCNMS, Washington State Department of Natural Resources and Oregon State University (OSU). Thirty-five OCNMS surveys conducted over 15 years were re-processed and edgematched by the OSU Active Tectonics Lab.

The data from the Atlas was also utilized by the Olympic Coast Intergovernmental Policy Council's (IPC) Habitat Framework. The Habitat Framework is a joint effort by the IPC and OCNMS to build a comprehensive catalog of marine and coastal data that will improve management initiatives such as ecosystem based management, marine spatial planning, habitat protection and contribute to integrated ecosystem assessments. Moreover, the Habitat Framework—based on the NOAA Coastal and Marine Ecological Classification Standard (CMECS)—can help identify knowledge gaps and coalesce multi-agency partners with shared priorities and available resources to address timely research and management issues. OCNMS is providing technical support and linkages with state and federal agencies and academic institutions. To date, OCNMS and the IPC have held focus group meetings where academic and agency experts provided observed and modeled data. Seafloor sediment data have also been classified using the CMECS scheme, bringing current and historic ocean bottom surveys into the Habitat Framework. More than 25 unique data sets have been identified for shoreline, nearshore, shelf, and offshore classification in CMECS. Since the Habitat Framework is one of the most significant applications of CMECS since its approval by the Federal Geographic Data Committee in 2012, OCNMS is currently networked with NOAA's National Marine Fisheries Service and Office of Coastal Management for ongoing support through the development, implementation, and distribution phases of the project.

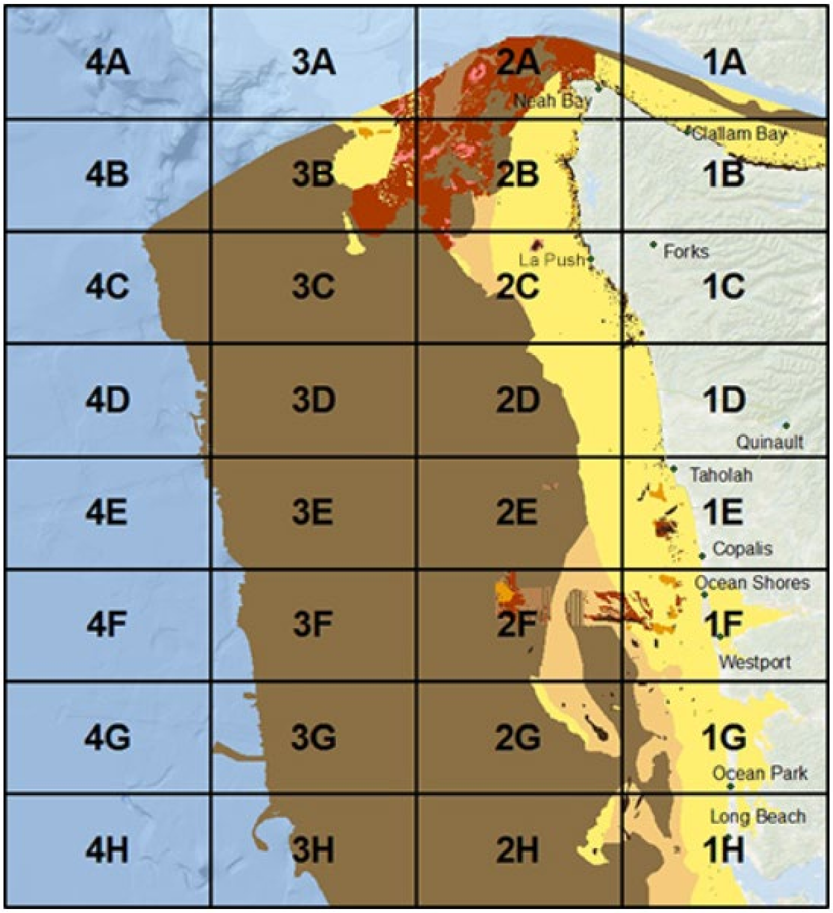

Figure R.1 Geographic extent of Washington State Seafloor Atlas. The Atlas overlays fine-scale seafloor data from Olympic Coast National Marine Sanctuary (2000-2013) on coarser-scale Surficial Geologic Habitat data from multiple sources compiled by Oregon State University Active Tectonics and Seafloor Mapping Lab (2003-2015).

Whale Entanglement

In response to a large increase in reported marine mammal entanglements during the assessment period, natural resource agencies have studied the problem and taken action. NOAA Fisheries has a West Coast Large Whale Entanglement Response Program that works to reduce the number of large whale entanglements and minimize the likelihood of large whales becoming entangled in fishing gear to promote the conservation of healthy whale populations along the U.S. West Coast (NMFS, 2020). The West Coast Region's Protected Resources Division oversees the Large Whale Entanglement Response Network and maintains entanglement records through the West Coast Marine Mammal Stranding Network.

Washington State and coastal treaty tribes are responsible for co-management of the commercial Dungeness crab fishery and have been looking at management measures to address the entanglement issue. Washington Department of Fish and Wildlife (WDFW) held workshops with coastal Dungeness crab fishers, and discussed potential management measure alternatives that resulted in new rules for Dungeness crab in an effort to reduce the potential for humpback whale entanglements on Washington's coast. Rule changes included requiring only the amount of line reasonably necessary, reducing the pot limit and requiring a summer buoy tag, replacing buoy tags, and requiring line marking specific to Washington.

Overfished and Depleted Stocks

Groundfish Protection/Designation of Essential Fish Habitat

Groundfish are managed through a variety of management measures, including quotas, trip and landing limits, temporal and spatial restrictions or closures, gear restrictions, and harvest guidelines. The sanctuary does not have a fisheries management mandate, but has engaged in research and recommendations for physical and biogenic habitat characterization and staff support for the Habitat Framework initiative that could be used to inform management decisions especially as it pertains to essential fish habitat.

Significant conservation actions applied to the west coast over the past two decades have enhanced sustainable fisheries management and include the establishment of conservation areas to protect groundfish habitat and minimize the bycatch of overfished species. Since 2000, the state of Washington has prohibited bottom trawling in state waters. In 2006, Pacific Fishery Management Council (PFMC) and NOAA Fisheries Service designated multiple areas along the West Coast as Essential Fish Habitat (EFH) areas with specific fishing restrictions to freeze the footprint of bottom trawling and to rebuild overfished stocks. Essential fish habitat is habitat necessary to fish for spawning, breeding, feeding, or growth to maturity. Five EFH areas were adopted off the coast of Washington that are closed to non-tribal bottom trawl fishing. One EFH area, the Olympic 2 EFH Conservation Area closure, is located within the boundary of the sanctuary and is closed to all types of non-tribal bottom trawl fishing gear, but not all types of bottom-contact gear, such as longline gear. Olympic 2 EFH covers 7 percent of the sanctuary area. The EFH measures also included a prohibition of bottom trawl activity deeper than 700 fathoms West Coast-wide. The EFH areas were implemented through Amendment 19 to the Pacific Coast Groundfish Fisheries Management Plan and went into effect in 2006. The 2007 reauthorization of the Magnuson-Stevens Act allows the Regional Fishery Management Council's discretionary authority to restrict fishing activities, protect deep-sea corals, and other management actions.

In addition, Trawl Rockfish Conservation Areas (RCA) are temporary, large-scale closed areas that extend along the entire length of the U.S. West Coast that are expected to be in place until key overfished rockfish species recover. Commercial trawl RCA boundaries approximate particular depth contours that can change during the year and are designed to minimize opportunities for vessels to incidentally take overfished rockfish by eliminating fishing in areas where and when those overfished species are likely to co-occur with healthier stocks of groundfish. In addition, there are specific area closures within the sanctuary that are permanent in nature and pertain to specific fisheries—the North Coast Commercial Yelloweye RCA that applies to fixed gear (e.g., longlines and pots) and recreational groundfish and halibut fisheries, the North Coast recreational RCA, and a small Salmon Troll RCA that lies within the North Coast Recreational RCA.

In 2011, NOAA Fisheries and PFMC also implemented Amendment 20 establishing "catch shares" management for portions of the commercial groundfish fishery, which allocates shares of allowable catch to each fisherman. The implementation of the EFH areas, catch shares, and other fisheries management changes have led to the full rebuilding of nearly every groundfish species listed as overfished, some of them a decade or more ahead of expectations (Table R.1).

Table R.1. Declaration and recovery years of depleted west coast groundfish species. Source: PFMC, 2019.

West Coast Groundfish Species	Declared Overfished	Declared Recovered
Bocaccio Rockfish	1999	2017
Canary Rockfish	2000	2015
Cowcod	1999	2019
Darkblotched Rockfish	2000	2017
Lingcod	1999	2005
Pacific Ocean Perch	1999	2017
Pacific Whiting (Hake)	2002	2004
Petrale Sole	2009	2015
Widow Rockfish	2001	2012
Yelloweye Rockfish	2002	Still being rebuilt

A review of EFH established under Amendment 19 took place from 2010–2014, PFMC decided to combine EFH and trawl RCA modifications into a single action. In 2018, Amendment 28 was approved to be implemented in 2020 which adjusted many EFH areas, with the exception of those within the treaty case area (which overlaps OCNMS) until completion of the Habitat Framework initiative, with the exception of expanding the Grays Canyon EFH area with agreement from the Quinault Indian Nation. Elsewhere, Amendment 28 closes new areas to bottom contact fishing gear, reopens some areas that were previously closed to bottom trawling, and closes waters deeper than 3,500m to bottom-contact gear, but does not affect EFH areas located within or adjacent to OCNMS. Under Amendment 28, EFH closures will cover approximately 33,670 km^2 of the management area with approximately 7,770 km^2 reopening to bottom trawling.

The sanctuary has been working since 2006 to characterize and map the abundance, diversity, and distribution of deep-sea corals and sponges, especially within and adjacent to EFH areas, through several research cruises (Table ES.S.1). In 2018, NOAA launched the West Coast Deep-Sea Coral Initiative, a four-year effort that aims to characterize and study deep-sea coral and sponge ecosystems offshore of the west coast, focusing on EFH areas that will be closing or reopening as a result of Amendment 28, areas of high coral and sponge bycatch in research trawls, and national marine sanctuaries.[1]

Offshore Seafood Processing

The EPA recently issued National Pollutant Discharge Elimination System (NPDES) General Permit to seafood processing vessels that discharge in Federal Waters off the coast of Washington and Oregon (NPDES Permit Number: WAG520000). The General Permit authorizes discharges of seafood processing waste from the vessels. This is the first issuance of this General Permit, and the first time this sector has received NPDES permit coverage off the coast of Oregon and Washington (84 FR 9794; March 18, 2019).

The Permit does not specify a target species or type of seafood processing to be covered; however, the sector seeking permit coverage is known to process Pacific Hake (or Pacific whiting, *Merluccius productus*). The EPA rule is independent from the management of the Pacific whiting fishery, which is managed under the authority of the Pacific Coast Groundfish Fishery Management Plan, the Magnuson-Stevens Fishery Conservation and Management Act, and the Pacific Whiting Act of 2006. Each year a U.S. Total Allowable Catch is determined and allocated between tribal and non-tribal sectors. The 2019 Pacific whiting allocation by sector is shown below (Table R.2) (84 FR 20578; May 10, 2019).

Table R.2. 2019 Pacific Whiting Allocations. (84 FR 20578; May 10, 2019)

Sector	2019 Pacific whiting allocation (mt)
Tribal	77,251
Catcher/Processor Coop Program	123,312
Mothership Coop Program	87,044
Shorebased Individual Fishing Quota (IFQ) Program	152,326.5

The general permit is applicable to two of the four sectors: at-sea mothership processors and catcher-processors.

[1] https://deepseacoraldata.noaa.gov/library/WCDSCI%20Science%20Plan_Final.pdf

The permit was originally proposed in 2015, and based on public comments and consultations, was re-proposed in 2017, and finalized in 2019. Under the requirements of the National Marine Sanctuary Act, section 304(d), EPA consulted with the sanctuary on this permit and accepted a recommendation from the sanctuary that permittees must provide a copy of a required annual report (Figure R.2) to the sanctuary if they operate within the sanctuary boundaries. The report will include, among other things:

- Reports of noncompliance
- Maps of processing areas
- Clearly labeled representative pictures
- Dates of discharge by month
- Type and amount (pounds) of discharged seafood processing waste residues by month

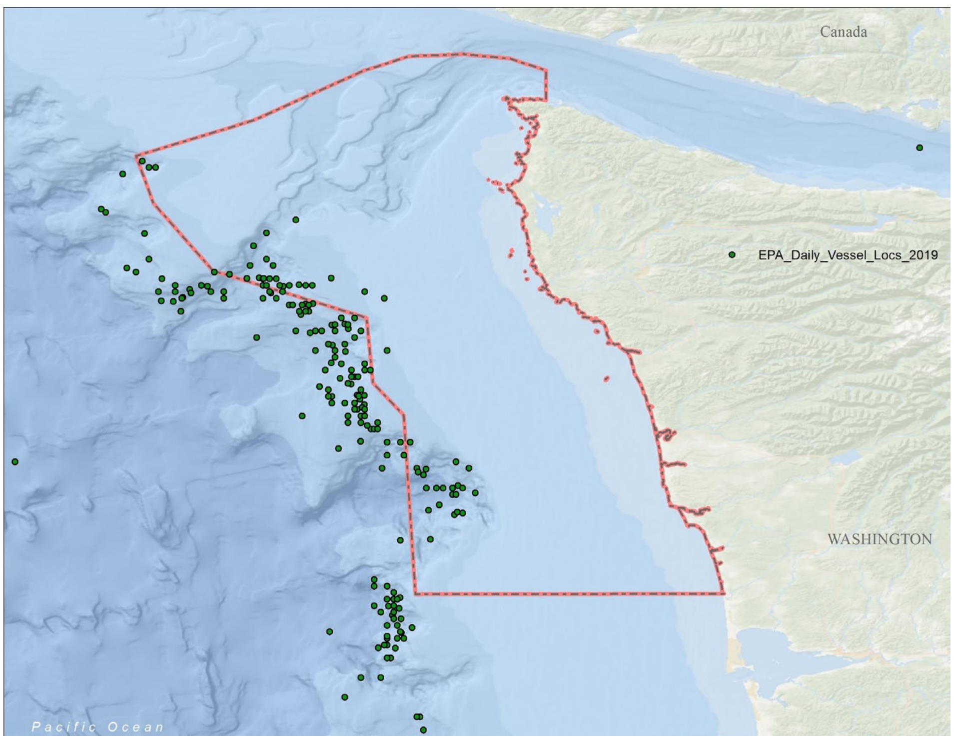

Figure R.2 EPA compilation of 2019 discharges of seafood processing vessels reported by industry. Each location is a single reported daily position for days when discharges occurred (discharges occur over a larger area then shown on map). Data from annual industry reports as required by NPDES General Permit WAG520000.

Derelict Gear

In 2009, the Washington Department of Fish and Wildlife (WDFW) initiated two efforts to recover abandoned crab-fishing gear off the Washington coast. WDFW administered a grant from NOAA's Community Based Marine Debris Removal Program. Commercial vessels were hired to sweep two large areas near Grays Harbor and the mouth of the Columbia River and remove all abandoned pots. In addition, WDFW developed a permit program that allows crab fishers to recover all of the gear from the fishing grounds at the close of the commercial crabbing season. These permits allow fishers to keep the pots they recover, including those owned by other fishers licensed by Washington State (WDFW, 2019).

Several of the coastal treaty tribes conduct similar crab pot recovery efforts for their fisheries receiving grant funding from the NOAA MArine Debris Program. Quinault Indian Nation (beginning in 2014) and Quileute Tribe (beginning in 2015) both partnered with the Nature Conservancy to develop their community-based derelict crab gear removal programs. The Makah Tribe (beginning in 2018) is still in the process of developing a community-based derelict crab gear removal program. These efforts aim to remove existing derelict crab gear and to establish management measures to reduce the accumulation of future derelict gear.

Military Activities

The Navy and OCNMS recognize the significance of each other's value to the country and have committed to work together to support our respective mandates. The Navy's use of the waters and airspace of the Olympic Coast for training and testing was pre-dates the OCNMS establishment, and was recognized during the sanctuary designation process. Along with this recognition is the requirement for the Department of Defense to carry out its activities in a manner that avoids to the maximum extent practicable any adverse impact on sanctuary resources and qualities.

Between 2008 and 2020, under the requirements of the NMSA section 304(d), the Navy consulted with OCNMS on three occasions in 2011, 2015 and 2020. On a fourth occasion in 2010, the sanctuary requested a section 304(d) on the Navy's proposed action related to the Northwest Training Range Complex. While the Navy did not initially concur that a consultation was required, they did respond to OCNMS comments on the subject.

In addition to consultations, the Navy provides a representative to the OCNMS Advisory Council and meets annually with the sanctuary to discuss topics of mutual interest. As a result of this working relationship the sanctuary began to include permit special conditions, requiring permit holders to notify the Navy of certain underwater operations, such as ROV dives, 48-hours in advance. The U.S. Navy also sponsors a variety of marine species monitoring efforts in the Pacific Northwest and across the country, primarily to address potential impacts to species and habitats in areas of Naval operations; more information and results of sponsored research can be found at https://www.navymarinespeciesmonitoring.us/.

Marine Debris

OCNMS's response to marine debris has followed a number of approaches, including support for beach cleanups, crab pot recovery efforts, investigating/responding to large discrete events, and monitoring.

Beach Cleanups

OCNMS's involvement in Olympic Coast beach cleanups efforts has evolved over time. Current efforts to involve the public in this important volunteer stewardship program are currently managed by the Washington CoastSavers. WA CoastSavers is made up of thousands of volunteers, an executive committee, a steering committee, and a program coordinator. The steering committee is comprised of representatives from private and non-profit organizations and government agencies, including individuals from Lions Club International, Discover Your Northwest, Grass Roots Garbage Gang, Surfrider Foundation, Olympic Coast National Marine Sanctuary, Clallam County Waste Management, Pacific Shellfish Growers Association, Clallam County Marine Resources Committee, NOAA Marine Debris Program, Olympic National Park, Washington State Parks and Recreation Commission, coastal treaty tribes, and Olympic Coast National Marine Sanctuary Foundation. Olympic Coast National Marine Sanctuary Foundation currently serves as the fiscal agent for Washington CoastSavers (Washington CoastSavers, 2020).

Incident Response

In addition to working with volunteer supported beach cleanups on persistent marine litter, OCNMS and other agencies must occasionally deal with larger more episodic incidents, such as sunken or grounded vessels (Figure R.3). The U. S. Coast Guard and Washington State Department of Ecology are the leads for dealing with oil spills, but once human and environmental impacts are mitigated vessels may be abandoned. In addition to responding to the release of pollutants, OCNMS is also concerned with the abandonment of wrecked vessels, which is prohibited by sanctuary regulations.

Since 2008, 21 vessels have been lost in the sanctuary, some were salvaged and some were lost, with many still sitting on the sanctuary sea floor. When first notified of an ongoing vessel incident, the sanctuary coordinates with other agencies and the responsible party on an appropriate response, including the removal of the vessel from the sanctuary.

Figure R.3 On October 6, 2016 the USCG responded to the S/V *Soteria*, which was disabled and taking on water in heavy weather, 17 nm off the coast. The USCG determined it was not safe to tow the vessel and evacuated the 3 person crew. The vessel was abandoned and was later sighted by the sanctuary vessel R/V *Tatoosh* grounded on Sand Point in Olympic National Park on October 9, 2016. The vessel subsequently broke apart, resulting in a debris field north of Sand Point and the original grounding location. Global Diving & Salvage, Inc. was contracted by the vessel owner to remove any fuel and hazardous materials, and then to proceed to remove the wreck by helicopter. Photo: OCNMS.

While responding to vessel incidents is the most common episodic marine debris response there have been other significant respondes, including the 2012 grounding of a large dock and reports of crushed cars fouling the trawl nets of Makah Fishermen. Each of these unusual incidents resulted in significant responses by the sanctuary and partners.

On December 14, 2012, a floating dock, one of the four washed out from Misawa harbor by the devastating tsunami that hit Japan on March 11, 2011, was spotted off the Washington coast and reported to the Coast Guard. Federal and state agencies and Indian Tribes responded quickly and collaboratively, and prepared for the response, at sea or on shore. NOAA generated trajectories to estimate the dock's movement and possible landfall. The Coast Guard launched over-flights to search for the dock, locating it on December 18 at a remote beach in Washington State, within the Olympic National Park and Olympic Coast National Marine Sanctuary.

State and federal agencies convened in Forks, Washington at an Incident Command Post, and along with aquatic invasive species (AIS) experts, conducted a site visit to assess the dock and attached a tracking buoy to it. In later visits the agencies removed all visible growth, greatly reducing further risk of AIS introduction. Once it was on shore, responsibility for removal of the dock shifted to the landowners, NOAA and National Park Service (NPS), who put together a funding package and managed the contracting efforts to remove the dock (Figure R.4). Work on communication and outreach continued throughout the response, with the state website serving as a conduit for information on the dock removal efforts.

On March 16, the removal contractor deployed equipment and supplies to the dock's location. Using concrete saws and mini excavators, the contractor cut the dock to pieces and flew concrete and foamed plastic by helicopters to a nearby landing site accessible to trucks, which hauled the dock pieces to a landfill for disposal and recycling. On March 26, all removal operations ended successfully, and the response to the floating dock was completed (NOAA Marine Debris Program, 2013).

Figure R.4 Salvage status of dock from the Japanese tsunami on March 21, 2013: 87% foam, and 25% concrete removed by helicopter. Photo: OCNMS.

Makah fishermen recovered crushed cars in their nets on four occasions, in 2011, 2013, 2016 and 2017 (figure R.5). A recovered license plate was researched and the registered owner reported delivering the car to a metal recycling yard in New Westminster, British Columbia, Canada in October 2007. OCNMS identified additional documented cases of scrap metal being lost from open deck barges. OCNMS reviewed vessel monitoring data and attempted to identify the transit that could have been involved in the loss of the vehicle delivered to the recycling yard in October 2007. Several potential transits were identified. OCNMS also identified additional transits with the same profile. This analysis identified 44 southbound transits between the New Westminster and Portland Recycling Yards in the period between October 2007 and February 2013.

In order to better assess the extent of the problem, OCNMS chartered a survey off Cape Flattery in September, 2015. The survey area was developed to take into account the locations of the cars snagged by Makah Fishermen. Using a combination of sidescan sonar and a remotely operated vehicle (ROV), a debris field of approximately 13 cars (Figure R.6) was identified.

In consultation with OCNMS and Transport Canada, Coast Guard Sector Seattle and Coast Guard Sector Columbia River initiated Operation Jalopy in 2018. This included hand-delivered correspondence to all potentially involved facilities and surveillance of the waterways looking for potentially overloaded and unsecured open hopper barges carrying scrap metal.

Figure R.5 On Four documented cases of Makah Tribal Fisherman fouling their trawl nets with crushed cars Photos: Makah Fishermen.

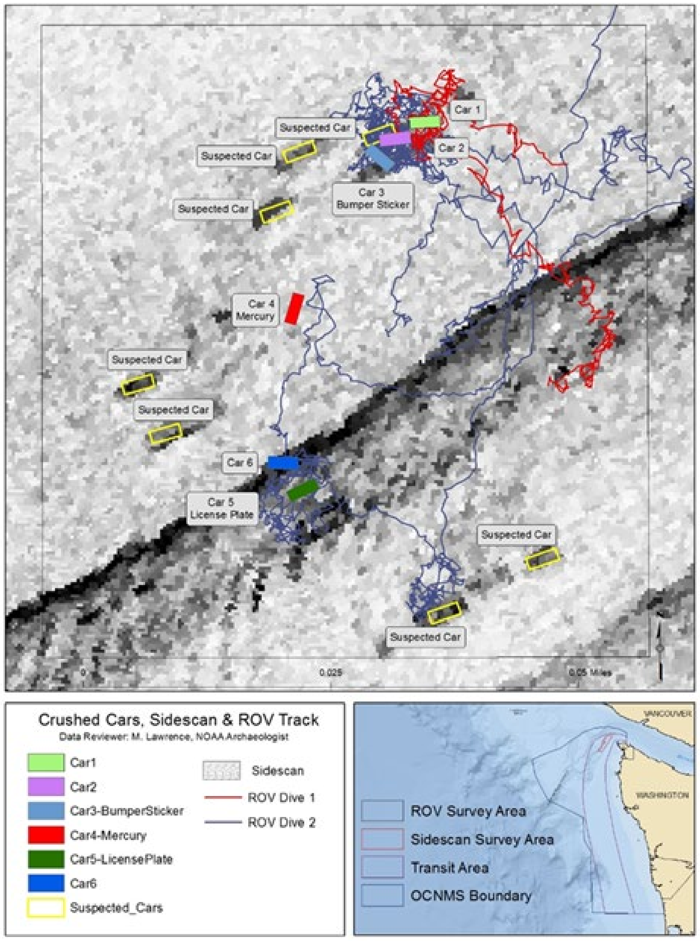

Figure R.6 Scaled map of the distribution and orientation of crushed cars located during the survey. Colored car symbol locations, one through six, were derived from the review of video data. Symbols outlined in yellow mark the location (OCNMS incident analysis).

Lost Vessels

In 2017, OCNMS conducted a review of the circumstances of vessels that have sunk, grounded or capsized since sanctuary designation. The resulting report focused on incidents that resulted in vessels being lost in or near the sanctuary. This included vessels that have sunk, grounded or capsized regardless of whether the vessel was salvaged or remnants of the wreck remain in the marine environment. The report documents the sanctuary's Incident Database, how the data were collected, processed and summarized. Out of all incident records, 46 vessels (figure R.7) were identified for further analysis. Data collected on those incidents was summarized to see if there were commonalities based on causes and vessel characteristics (Galasso 2017).

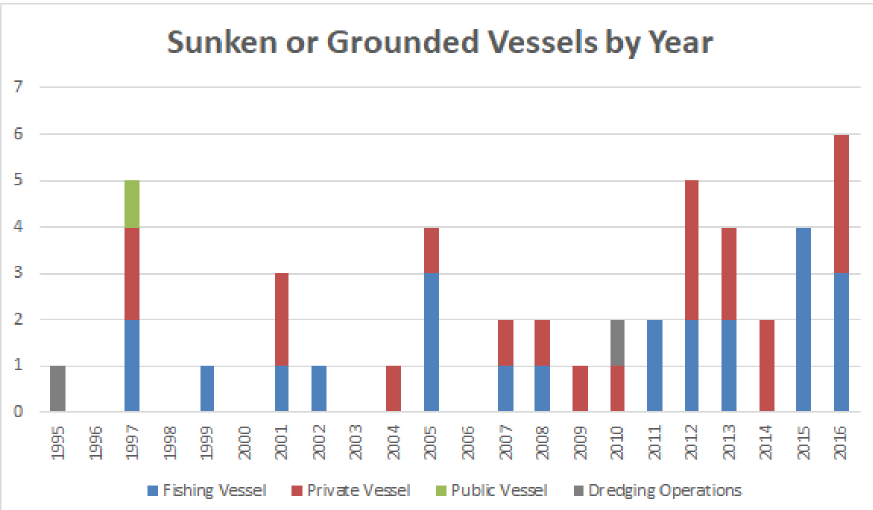

Figure R.7 Number of documented lost vessels in study area by vessel type and by year (Galasso 2017).

Following the completion of the report the OCNMS Advisory Council chartered the Vessel Incident Working Group which was tasked with reviewing the causes of vessels being lost in the sanctuary and to provide recommendations to the Sanctuary Superintendent on the prevention of, documentation of, and response to future incidents of lost vessels. The working group's report to the Sanctuary Superintendent (OCNMSAC, 2017) expressed concern about the loss of life, property and damage to resources within the sanctuary that result from vessels that are lost in OCNMS. They recognized that many of the contributing factors that result in vessels being lost were beyond OCNMS's control, but that their nine recommendations represented a responsible response from the sanctuary to the issue (OCNMS, 2017). One recommendation was for OCNMS to meet with regional marinas to investigate the potential of establishing kiosks/signage to educate mariners on safe boating practices and local conditions (figure R.8).

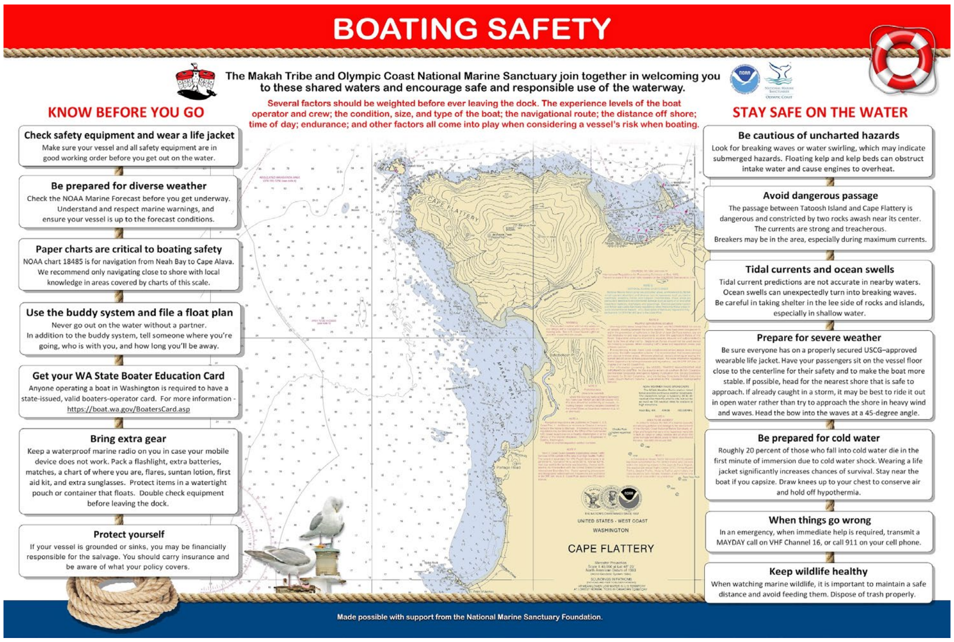

Figure R.8 In response to a recommendation from the Vessel Incident Working Group OCNMS staff collaborated with the Makah Tribe and Washington Sea Grant to create this sign, which will be posted at the Makah Marina.

Monitoring

OCNMS had a marine debris monitoring program from 2001 through 2019. Protocols changed in 2012 to better assess the accumulation of tsunami debris on the Washington coast following Japan's March 2011 earthquake. Using the revised protocols, between 2012 and 2019 community scientist volunteers regularly identified the types and quantities of shoreline marine debris found at 26 locations adjacent to the sanctuary along the outer coast of Washington and the Strait of Juan de Fuca.

Data were gathered to identify whether marine debris loads were noticeably higher as a result of the 2011 Japanese tsunami, in line with modeled predictions for high windage items and early reported observations. Volunteers utilized protocols developed through the NOAA Marine Debris Program to conduct monthly shoreline surveys over 100 meter transects of selected beaches. The largest quantities of any types of debris were plastic items ranging from large Styrofoam buoys to inch sized fragments. Although volunteers did encounter tsunami-related debris, cyclic phenomenon of oceanic weather-related patterns, such as El Nino-Southern Oscillation and beach aspect appeared to have a greater influence on depositions, indicating an ongoing need for public outreach to stem the flow of debris into marine environments (Butler-Minor, in press).

Non-indigenous and Invasive Species

As mentioned previously in the vessel discharge and ballast water discussion, OCNMS considered regulations on invasive, non-native species during management plan review, but did not pursue the effort based on the adequacy of state regulations. However, as mentioned in the above section in incident response, direct management intervention did occur during the Misawa Dock incident response, including the collection of samples, consultation with AIS experts, scraping visible growth on the sides and deck of the dock, hauling 400 lbs. of biota up the bluff and away from water access, and sterilizing the surface with a bleach solution, used sparingly and under a permit from OCNMS. Vertical and horizontal bumpers, providing shelter to living organisms, were removed and cleaned (NOAA Marine Debris Program, 2013).

In 2017, European green crabs were found in two estuaries on the Makah reservation, adjacent to OCNMS (Figure P.13). Several aquatic invasive species experts, agency and tribal government staff consulted and supported a dedicated trapping effort by Makah Fisheries Management, in which over 2,500 green crabs were trapped between 2017 and 2019, the most anywhere in Washington State up until 2020 when a new invasion was discovered near the Lummi Tribe in Puget Sound.

Contaminants

Despite the fact that there are no direct discharges of contaminants from land-based sources adjacent to the sanctuary, contaminants have been documented in sanctuary resources (Southern Resident Orca Task Force, 2018).

There is currently one active EPA Superfund site on the National Priorities List that lies adjacent to the sanctuary: the Warmhouse Beach Dump Superfund Site located on the Makah Indian Reservation. The site includes a former open dump on top of a ridge about three miles northwest of Neah Bay, and the two streams that originate within the dump flow to East Beach and Warmhouse Beach, and presumably into the sanctuary.

Municipal and household solid and hazardous wastes were disposed of at the dump from the 1970s until 2012 when the Makah Tribe began operating a solid waste transfer station on the reservation. Access to the 7-acre dump was then restricted by a locked gate on the unpaved road leading up to the dump, and signs were posted to discourage the community from entering the dump.

Elevated levels of metals, perchlorate and polychlorinated biphenyls (PCBs) have been found in soil at the dump and in sediment in both creeks. Mussels at the beach also contain elevated concentrations of lead; however, it has not been determined whether this is from the dump, creeks, or ambient seawater. The Warmhouse Beach Dump Site was added to the Superfund National Priorities List (NPL) in December 2013. The EPA is in the early stages of the Superfund cleanup process, called the "Remedial Investigation." During this stage, the EPA consolidates data previously collected from the site, determines if there are any data gaps, and collects any missing data (EPA n.d.).

One significant regional response to the issue of marine contaminants is the construction of a tertiary sewage treatment plan for the Canadian municipalities of Victoria, Esquimalt, Saanich, Oak Bay, View Royal, Langford and Colwood, and the Esquimalt and Songhees Nations (CRD 2014), which are located on the portion of Vancouver Island that borders the Strait of Juan de Fuca. This action follows decades of debate and four4 years of construction. The topic was a source of cross-border conflict, including calls for travel boycotts, as well as one of the best protest mascots in recent history (Banse, 2017: figure R.9).

Figure R.9 Victoria Mayor Lisa Helps and Mr. Floatie board a seaplane to fly to Seattle for the sewage treatment mascot's official retirement party. Photo: KNKX/Lisa Helps/Facebook.

Research Activities

OCNMS issues permits for a variety of research activities that could involve impacts to the seafloor, discharge within OCNMS (including ROV and AUVs), or low overflights within our overflight area. We consult on each permit application with the coastal treaty tribes to ensure their awareness on the proposal and to identify any potential concerns or conflicts. When potential conflicts do arise, OCNMS works directly with the tribe and the permit applicant to resolve issues and reduce conflicts through changing locations or timing of activities. For example, the SoundTrap project worked directly with the Makah Fisheries Department and

Makah fishers to identify locations for two SoundTraps that were proposed to be deployed within their U&A. Doing so reduced potential interactions or conflicts with tribal fisheries activities as well as improved the project by leveraging the Makah fishers' extensive local knowledge of ship movements in the area. In addition, OCNMS is increasingly scrutinizing projects that involve abandonment of anchors on the seafloor. We have transitioned OCNMS mooring operations to reduce or eliminate anchor abandonment, and we now require permit applicants to pursue alternatives to anchor abandonment, including use of anchor recovery systems or substitution of metal anchors with sandbags or other biodegradable materials.

Offshore Aquaculture

In 2011, NOAA Fisheries developed a NOAA Aquaculture policy, which encouraged and fostered sustainable aquaculture development that provides domestic jobs, products, and services and that is in harmony with healthy, productive, and resilient marine ecosystems, compatible with other uses of the marine environment, and consistent with the National Policy for the Stewardship of the Ocean, our Coasts, and the Great Lakes (National Ocean Policy) (NOAA, 2011).

The policy cited the statutory basis for NOAA's aquaculture activities as the Magnuson-Stevens Fishery Conservation and Management Act, the Marine Mammal Protection Act, the Endangered Species Act, the Coastal Zone Management Act, the National Marine Sanctuaries Act, and the Fish and Wildlife Coordination Act. Under these laws, in addition to the National Environmental Policy Act, NOAA is responsible for considering and preventing and/or mitigating the potential adverse environmental impacts of planned and existing marine aquaculture facilities through the development of fishery management plans, sanctuary management plans, permit actions, proper siting, and consultations with other regulatory agencies at the federal, state, and local levels.

In 2008, during the management plan public scoping period, ONMS received comments requesting aquaculture be banned in the sanctuary. Some comments focused on the potential adverse impacts associated with farming Atlantic salmon, a non-native species. Since sanctuary designation no aquaculture permit applications have been received nor issued by the OCNMS Superintendent, and no aquaculture activities are known to occur within sanctuary boundaries.

ONMS addressed one aspect of the aquaculture issue in alternative C (not preferred) of the Final Management Plan and Environmental Assessment. This alternative included the consideration of a regulatory ban on the introduction of invasive species in the sanctuary. Atlantic salmon and a few other cultured organisms are classified as invasive species by the state of Washington and, as such, project proposals with these species would receive rigorous scrutiny and installed facilities would require effective containment, as is the current practice in Washington state.

Similar to proposed alternative energy projects discussed in the next section, ONMS would treat any future aquaculture proposal as an offshore commercial development project that likely would be subject to the ONMS permitting process. It can be assumed any aquaculture project proposed in the sanctuary would require an ONMS permit based on OCNMS regulations related to seabed disturbance (for anchoring/mooring aquaculture structures) and discharge. During review of an aquaculture project's permit application, ONMS would consider all the potential impacts of any proposed aquaculture operation. Therefore, ONMS did not pursue specific regulatory actions related to aquaculture in any of the alternatives in the 2011 management plan (OCNMS, 2011).

Offshore Energy

Offshore energy development was a major issue during the sanctuary designation process and was analyzed in the original OCNMS Final Environmental Impact Statement/Management Plan (FEIS/MP) (NOAA, 1993). The FEIS/MP found that oil and gas development would generate conflicts that could harm sanctuary resources. Alternative energy development was briefly discussed during management plan review as a subject that came up in scoping, for which an alternative was not developed. It was also flagged for future analysis.

Oil and Gas Exploration

In 1992, outer continental shelf (OCS) oil and gas leasing within the boundaries of the (at the time) proposed Olympic Coast National Marine Sanctuary was being considered by the U.S. Department of Interior's Mineral Management Service (MMS)[2]. MMS had planned to conduct lease sale #132 in April 1992 for exploration and development off the Washington and Oregon coasts. The 1992 Reauthorization of the National Marine Sanctuary Act prohibits oil and gas leasing and development within the boundaries of the Olympic Coast National Marine Sanctuary (P.L. 102-587).

Marine Renewable Energy

In March 2010, the Washington State Legislature enacted the Marine Waters Management and Planning Act (RCW 43.372) a marine planning law to foster integrated coastal decision making and ecosystem-based management. One of the requirements for the to be developed Marine Spatial Plan was a series of maps that summarized locations with high potential for marine renewable energy production that have minimal potential for conflicts with other existing uses or sensitive environments. OCNMS staff supported the development of the plan and were asked to evaluate if the siting of marine renewable energy projects could be considered in the sanctuary.

As a result of those discussions Washington State Department of Ecology determined that the presence of the Olympic Coast National Marine Sanctuary (OCNMS) along the northern half of the coast lowered the likelihood for marine renewable energy projects, particularly for commercial-scale developments. However, marine renewable energy projects that are owned by a tribe could possibly be permitted within OCNMS (15 CFR Part 922). Tribes must still go through all applicable federal permit processes (ECY, 2017).

Any proposed offshore energy project in the sanctuary would be analyzed through the permitting process, in addition to being vetted through the state's Marine Spatial Plan

Increased Visitation

[2] In 2011 MMS was renamed the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) and placed within the newly established Bureau of Ocean Energy Management (BOEM).

Concerns related to visitor impacts on the Olympic Coast are not new. In 1969, the Quinault Indian Tribal Council closed 25 miles of ocean beaches to non-Indians, an action taken to protest vandalism, theft, and land damage caused by tourists, teenagers, and real-estate developers (Caldbick, 2011). Today controlling access remains the major means of controlling impacts from visitors. With the exception of its role in ATBA compliance (see previous discussion), OCNMS has no control over access within the sanctuary; however, adjacent land managers and tribal governments do exert such controls through permitting.

Other management approaches to reduce impacts of increased visitation include coastal interpretive programs of Olympic National Park and the Makah Cultural and Research Center, both of which are supported by the sanctuary. OCNMS also supports efforts to promote sustainable tourism and voluntourism, such as Get Into Your Sanctuary and WA CoastSavers beach cleanup events. While there are limited at-sea whale watching opportunities, the Whale Trail promotes shore-based whale watching with several sites along the Washington coast. These programs provide visitors with information including proper etiquette during visits.

Sanctuary Operations and Research Activities

Olympic Coast National Marine Sanctuary staff is not exempt from sanctuary regulations, permitting or other environmental compliance requirements. There are two Environmental Assessments that have recently reviewed sanctuary operations, the 2011 Management Plan (OCNMS, 2011) and the 2018 Programmatic Environmental Assessment of Field Operations in the West Coast National Marine Sanctuaries (ONMS, 2018). These analyses include sanctuary operations that are both allowed and prohibited under sanctuary regulations (15CFR§922.152).

Tribal Consultation

Working on a government to government basis with the Makah, Quileute, and Hoh Tribes and the Quinault Indian Nation (coastal treaty tribes) is a fundamental aspect of sanctuary management at Olympic Coast. The sanctuary works to accomplish this through a number of means, including but not limited to methods described in the NOAA Procedures for Government-to-Government Consultation with Federally Recognized Indian Tribes and Alaska Native Corporations (NOAA, 2013). In addition to the NOAA policy, when requested, OCNMS has developed more specific consultation protocols with individual tribes.

Permitting/Research

A valid permit is required from Olympic Coast National Marine Sanctuary when an individual wishes to conduct an activity within the sanctuary that is otherwise prohibited. Prohibited activities are defined in OCNMS regulations and are generally restrictive of seafloor disturbance, discharges and overflights in certain areas that may disturb wildlife--all activities that require a permit regardless of who conducts the work.

A permit is required when an individual wishes to conduct an activity within a sanctuary that is otherwise prohibited, including sanctuary staff. Permits may be issued if the activity will not substantially injure sanctuary resources and qualities, and will further certain sanctuary values such as research, education, resource protection and tribal self-determination. Most sanctuary permits are related to research projects; proposed research activities are analyzed and special conditions are imposed to mitigate impacts as appropriate. Coastal treaty tribes are consulted to minimize conflicts with access to treaty protected resources.

Programmatic Environmental Assessment

In 2018, as part of ONMS's environmental compliance policy, four Programmatic Environmental Assessments (PEA) were drafted to describe and account for ONMS field operations. The Programmatic Environmental Assessment of Field Operations in the West Coast National Marine Sanctuaries (ONMS, 2018) includes OCNMS operations.

The purpose of the PEA is to fulfill the requirements outlined in the NMSA to protect and manage the resources of each national marine sanctuary. Sanctuary field operations are one aspect of resource management that assists with the accomplishment of the goals, objectives and priorities of each sanctuary. Field operations are activities on, in or above the water that support NMSA's primary objective of resource protection, through direct management, research, and education. These field operations can include vessel, aircraft and scuba diving operations as well as deployment of instrumentation and presence of personnel. The field operations are evaluated on a regional basis taking into consideration the protected resources that may be present at each sanctuary.

Maritime Heritage

During management plan review, Washington State Department of Archeology and Historic Preservation (DAHP) requested that the sanctuary enter into an NHPA section 106 programmatic agreement. Following the completion of the management plan OCNMS, the ONMS Maritime Heritage Program and DAHP held a number of issues on the subject. As a result the sanctuary drafted a document, "Maritime Heritage Resource Management Guidance for Olympic Coast National Marine Sanctuary" (OCNMS, 2018). The primary purpose of the document is to ensure the sanctuary's compliance with the National Historic Preservation Act (NHPA). The document details how OCNMS complies with its federally mandated responsibilities regarding maritime heritage resource management by collaborating with partner agencies and tribes. Whereas the primary focus of the document is our responsibility under the NHPA, other aspects of OCNMS' maritime heritage are also discussed.

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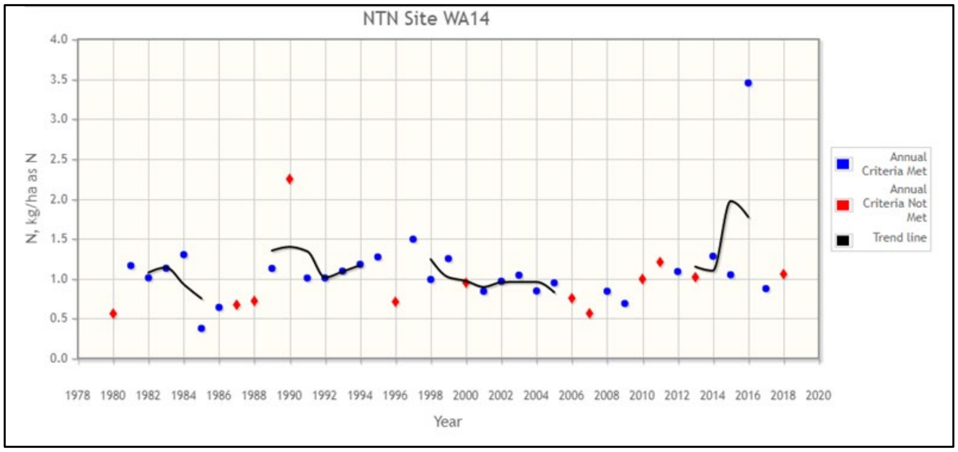
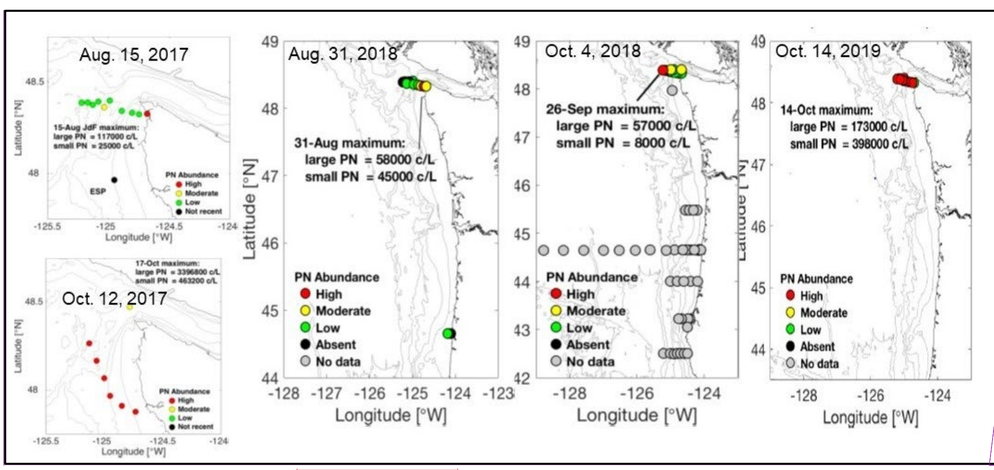
This draft was archived on 3June2021 and contains all comments and edits received from Peer Reviewers.

Appendix - Q06-09 Water Quality



Appendix Figure S.WQ.6.1. Total Nitrogen (nitrate plus ammonium) concentration in deposition (1980-2018), in Kg/ha at the mouth of the Hoh river at Olympic National Park. Blue points were annual criteria met and red points were annual criteria not met, black lines show the trend for at least 3 years when criteria met. Image: National Atmospheric Deposition Program, 2020

Commented [1]: Or wherever this was actually measured. Give a river mile if not at the mouth.



Commented [2]: Colors are not accessible. Please vary shapes of icons or change to colorblindness-friendly palette. http://mkweb.bcgsc.ca/colorblind/palettes.mhtml#page-container

Appendix Figure S.WQ.7.1. *Pseudo-nitzschia* abundance levels for WA and OR for offshore sampling sites. Red=high~~high~~: > threshold value for either cell morphology; Yellow =moderate: > 1/3 threshold;

Commented [3]: This name is hyphenated in the literature.

Green=low: < 1/3 threshold; Gray no data; Black= No sampling.~~;~~ G~~g~~raph was developed from the Pacific Northwest Harmful Algal Blooms Bulletin, 2017-2019.

Commented [4]: Does this correspond to specific documents? If so, I recommend including these as citations, e.g. "Source: Pacific Northwest Harmful Algal Blooms Bulletin, 2017, 2018, 2019"

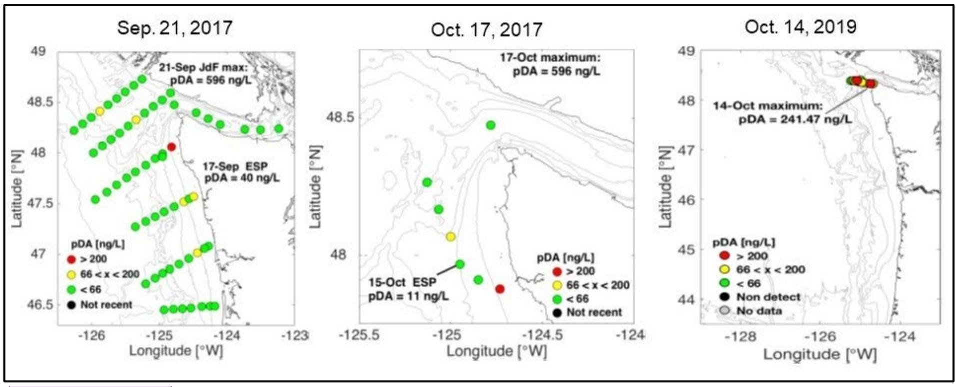
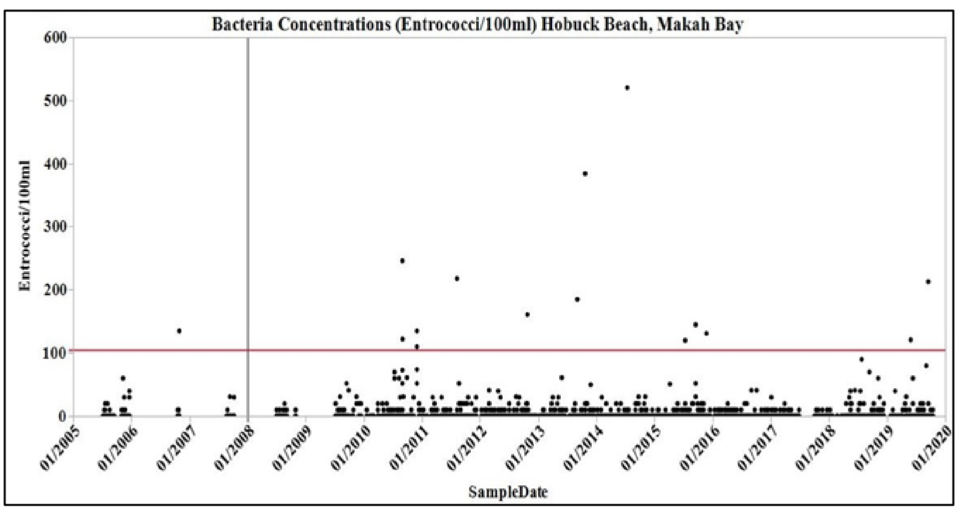
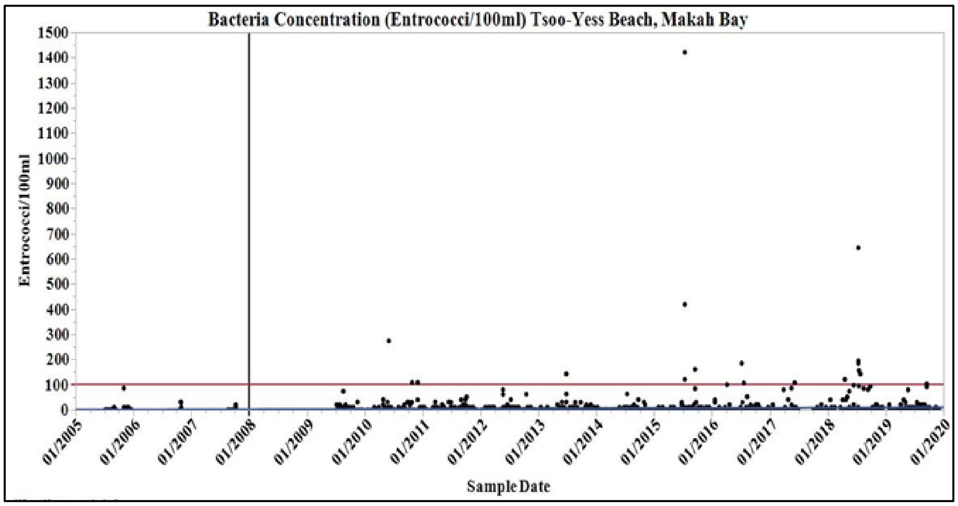


Figure S.WQ.7.2. Particulate Domoic Acid (pDA) levels for WA and OR for offshore sampling sites. Red=high ~~high~~: > threshold value for either cell morphology; Yellow =moderate: > 1/3 threshold; Green=low: < 1/3 threshold; Gray no data; Black= No sampling.~~;~~ G~~g~~raph was developed from the Pacific Northwest Harmful Algal Blooms Bulletin, 2017-2019.

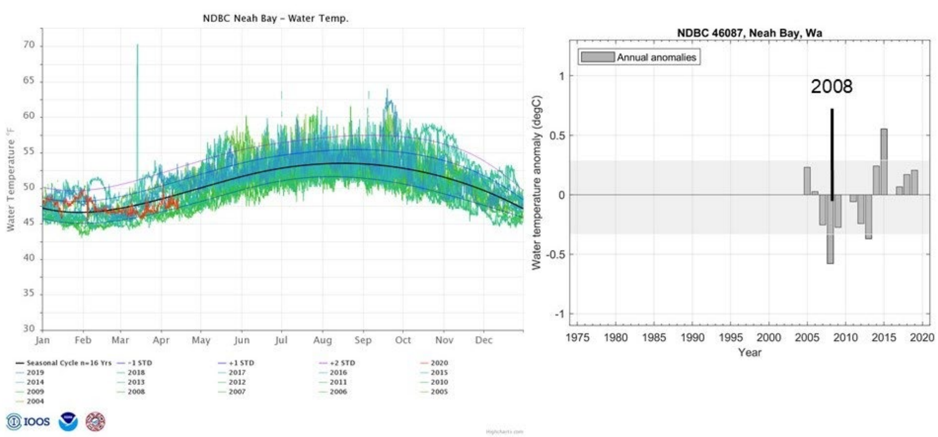
Commented [5]: Same comments as above re: accessibility and sources.



Appendix Figure S.WQ.7.3. Beach bacteria concentrations (enterococci/100ml) for Hobuck Beach, Makah Bay 2005–2019. Source: Washington Department of Ecology, 2020b; Image: A. Mabrouk/NOAA NCCOS



Appendix Figure S.WQ.7.4. Beach bacteria concentrations (enterococci/100ml) for Tsoo-Yess Beach, Makah Bay 2005–2019. Source: Washington Department of Ecology, 2020b; Image: A. Mabrouk/NOAA NCCOS



Appendix Figure S.WQ.8.1. Neah Bay (NDBC 46087) sea surface temperature (SST) seasonal variability (left) and annual anomalies (right), OCNMS 2004–2020. Source: National Data Buoy Center NDBC; Image: NANOOS, 2020

Commented [6]: These colors make it very hard to interpret anything. It looks as if it was tailored to show 2020 (orange that stands out from the other years).

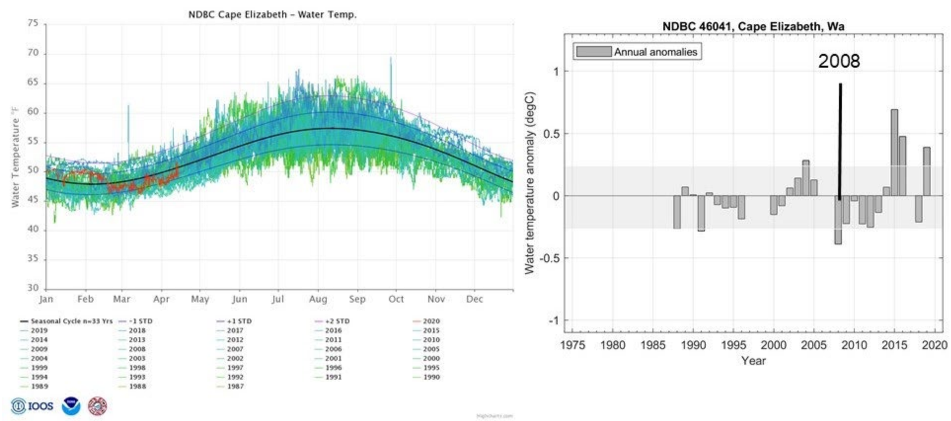
Same comment for the other figures like this one.

Commented [7]: Agreed. The font size of the legend is also not legible at 100% zoom.

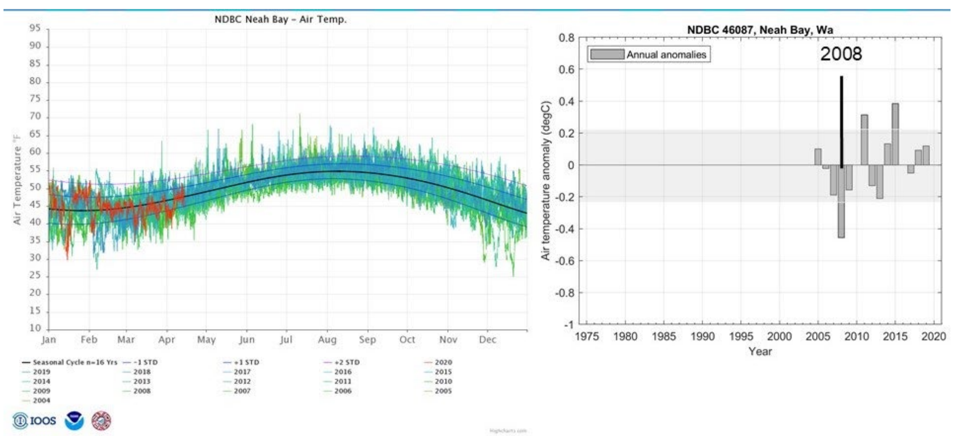
Commented [8]: These colors make it very hard to interpret anything. It looks as if it was tailored to show 2020 (orange that stands out from the other years).

Same comment for the other figures like this one.

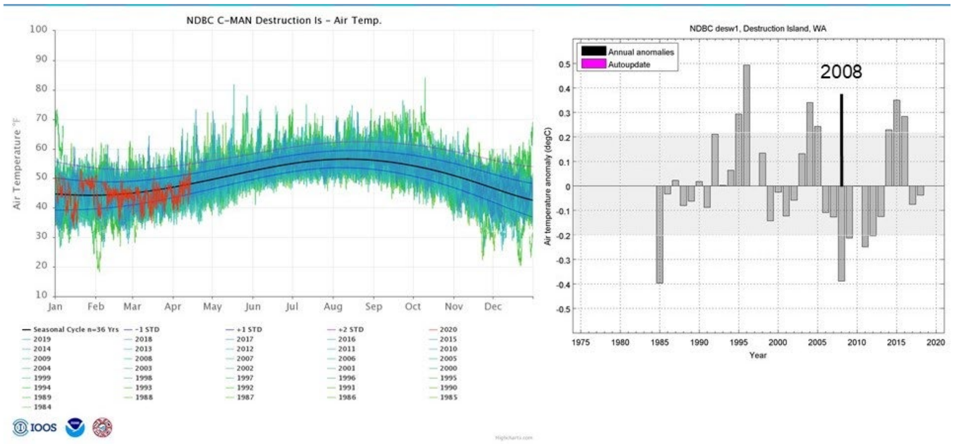
Commented [9]: Agreed. The font size of the legend is also not legible at 100% zoom.



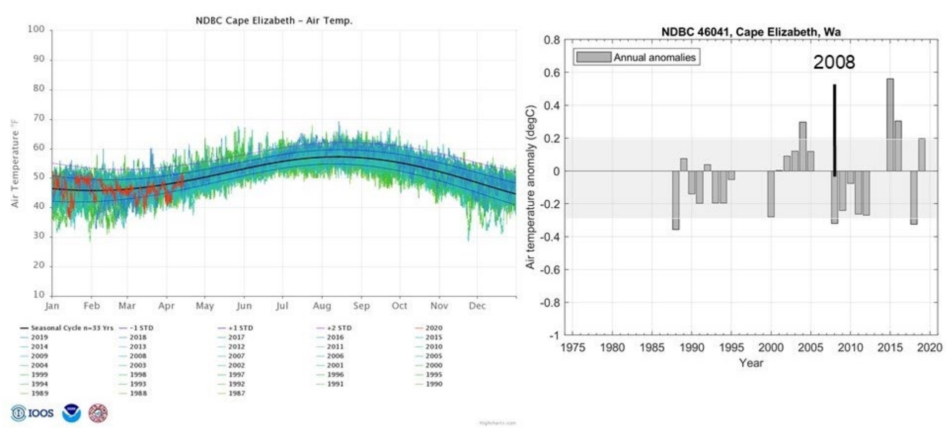
Appendix Figure S.WQ.8.2. Cape Elizabeth (NDBC 46041) sea surface temperature (SST) seasonal variability (left) and annual anomalies (right), OCNMS 1987–2020. Source: National Data Buoy Center NDBC; Image: NANOOS, 2020



Appendix Figure S.WQ.8.3. Neah Bay (NDBC 46087) air temperature seasonal variability (left) and annual anomalies (right), OCNMS 1987–2020. Source: National Data Buoy Center NDBC; Image: NANOOS, 2020



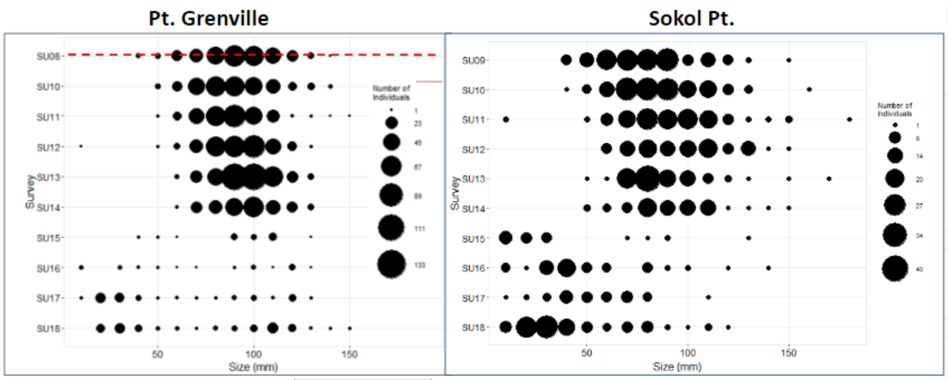
Appendix Figure S.WQ.8.4. C-MAN~~Man~~ Destruction Island (NDBC desw1) air temperature seasonal variability (left) and annual anomalies (right), OCNMS 1987–2020. Source: National Data Buoy Center NDBC; Image: NANOOS, 2020



Appendix Figure S.WQ.8.5. Cape Elizabeth (NDBC 46041) air temperature seasonal variability (left) and annual anomalies (right), OCNMS 1987–2020. Source: National Data Buoy Center NDBC; Image: NANOOS, 2020

This draft was archived on 3June2021 and contains all comments and edits received from Peer Reviewers.

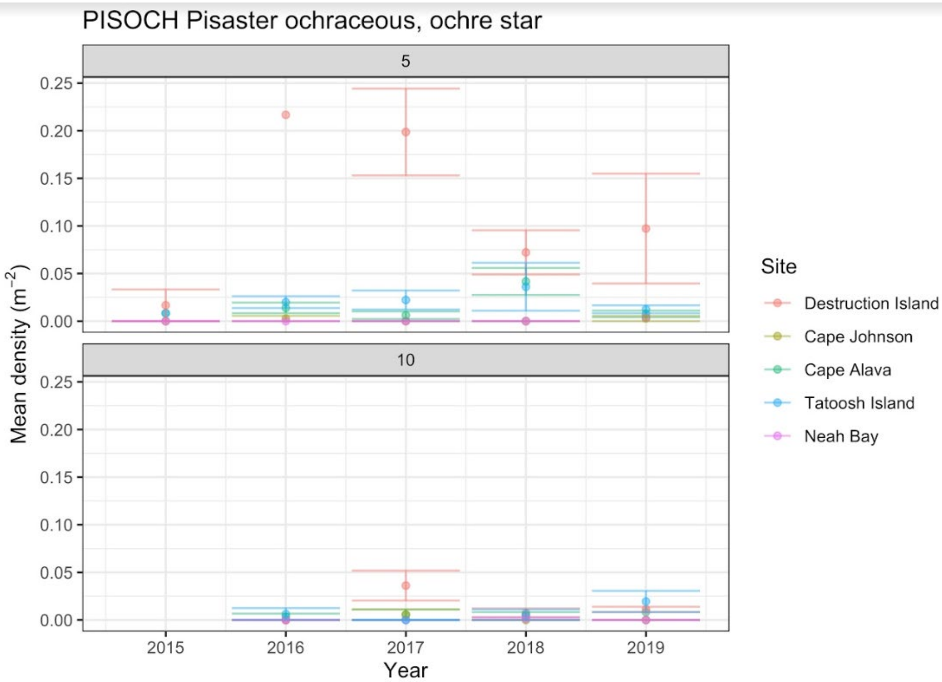
Appendix - Q12-15 Living Marine Resources



Appendix Figure S.LR.12.1. Size structure of *Pisaster ochraceus* population in rocky shore habitats at Pt. Grenville from 2008–2018 and Sokol Pt. from 2009–2018, Washington. Size structure data is also available for Point of Arches, Kydikabbit, Taylor and Starfish Points. Source: MARINe, 2019; Image: M. Miner/UC Santa Cruz

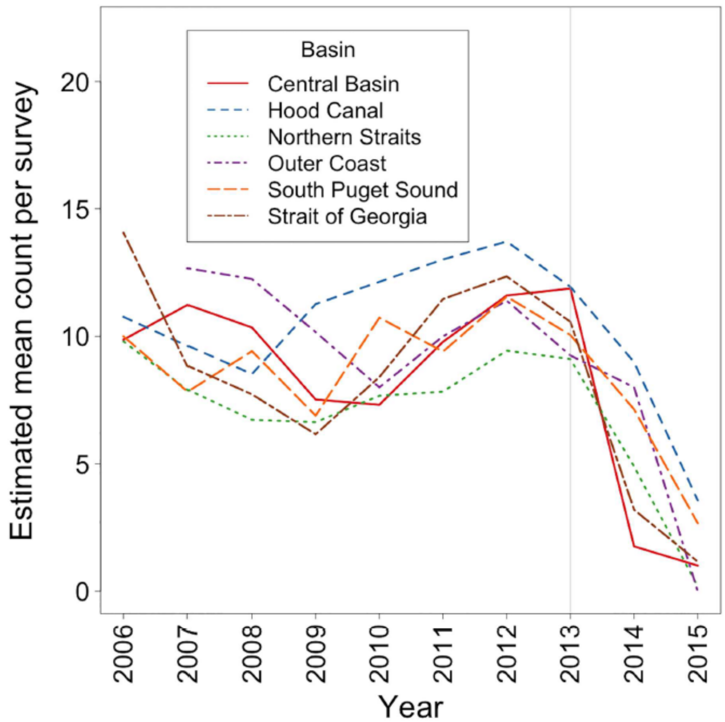
Commented [1]: Is this across the whole of the animal from arm tip to arm tip, or just the central disk width?

Commented [2]: What does the dashed line denote?

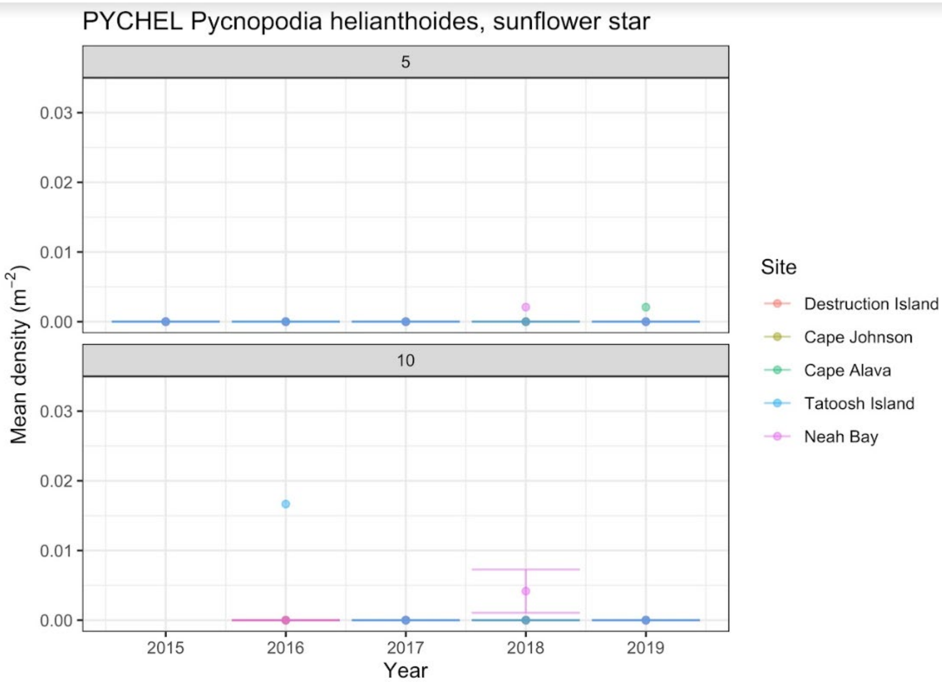


Appendix Figure S.LR.12.2. Average density of *Pisaster ochraceus* in kelp forest habitats from 2015–2019 at 5 and 10 m depths from ~~for~~ Neah Bay to Destruction Island, WA. Source: NOAA NWFSC, 2019 (unpublished data); Image: G. Williams/NOAA NWFSC

Commented [3]: Colors are not accessible, please vary icons for each site or change to a colorblindness friendly palette. http://mkweb.bcgsc.ca/colorblind/palettes.mhtml#page-container

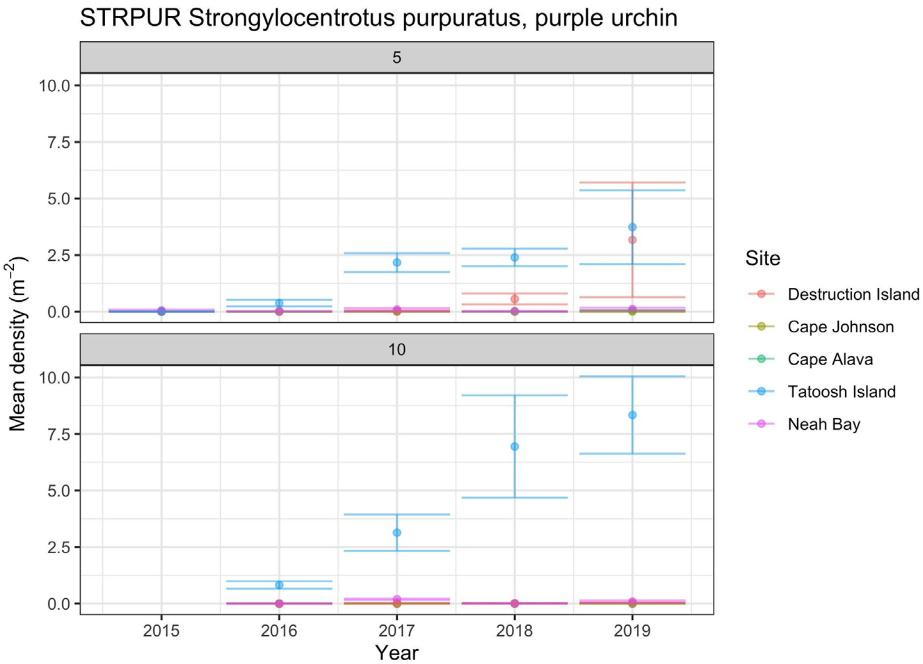


Appendix Figure S.LR.12.3a. Average counts of *Pycnopodia helianthoides* in rocky, shallow (5–30 m) habitats from 2006–2015 for Washington state. The dashed purple line denotes mean counts for the WA outer coast from Cape Flattery to the Columbia River. Source: Reef Environmental Education Foundation (REEF), 2015; Image: Montecino-Latorre et al., 2016

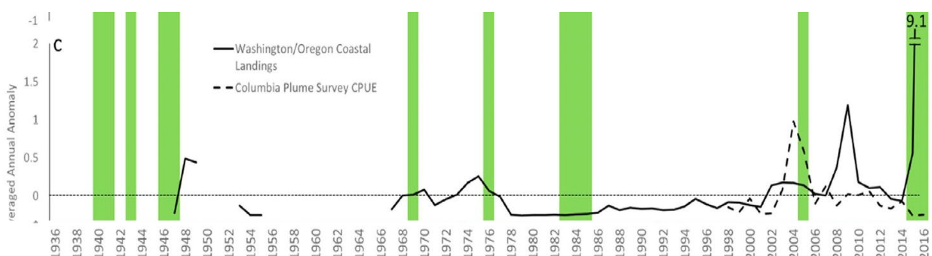


Appendix Figure S.LR.12.3b. Average density of *Pycnopodia helianthoides* in kelp forest habitats from 2015-2019 at 5 and 10 m depths from ~~for~~ Neah Bay to Destruction Island, WA. Source: NOAA NWFSC, 2019 (unpublished data); Image: G. Williams/NOAA NWFSC

Commented [4]: Same comment as above re: accessibility.



Appendix Figure S.LR.12.4. Average density of purple sea urchins from 2015-2019 at (Top) 5 m and (Bottom) 10 m depths from ~~for~~ Neah Bay to Destruction Island, WA. Source: NOAA NWFSC, 2019 (unpublished data); Image: G. Williams/NOAA NWFSC

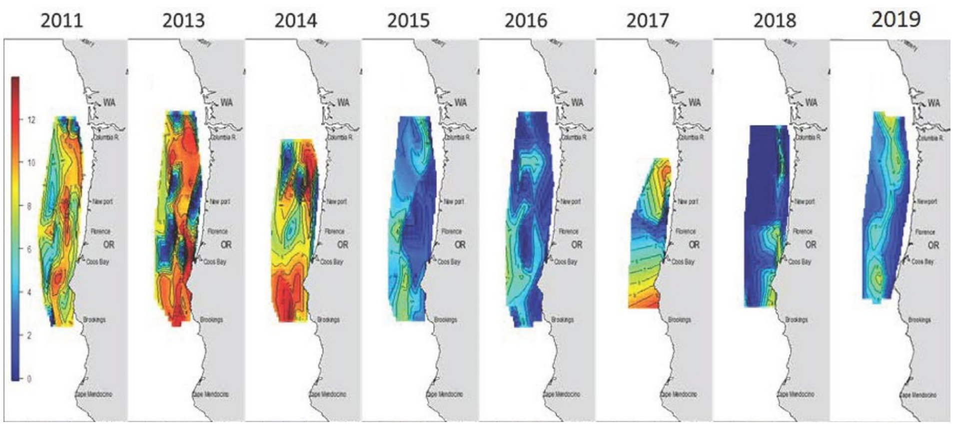


Appendix Figure S.LR.12.5. Abundance anomalies for Engraulis mordax northern anchovy off Washington and Oregon from 1936 to 2016. Green bars indicate more than 2 datasets that indicate positive anomaly. Image: Duguid et al., 2019

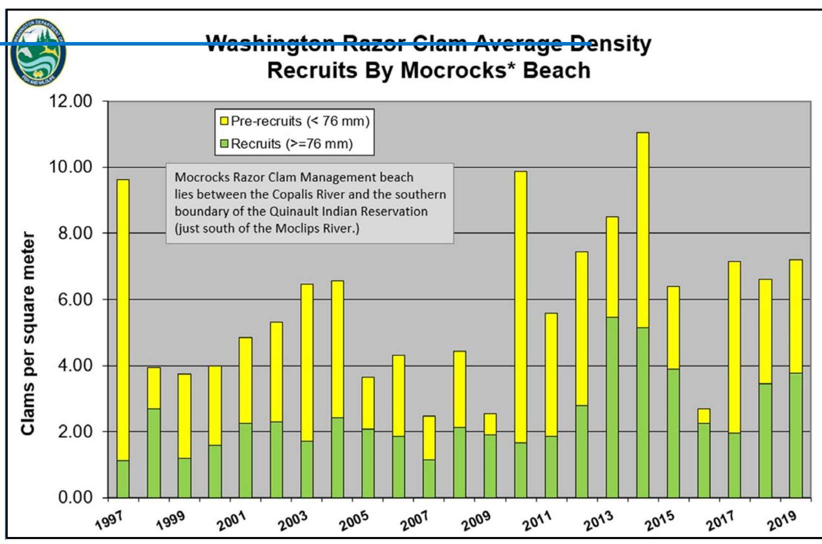
Commented [5]: Same comment as above re: accessibility.

Commented [6]: This doesn't match the format of the figure legends above. I like the differentiation of the top and bottom panels here.

Commented [7]: The "C" at the top left of the image needs to be scrubbed.



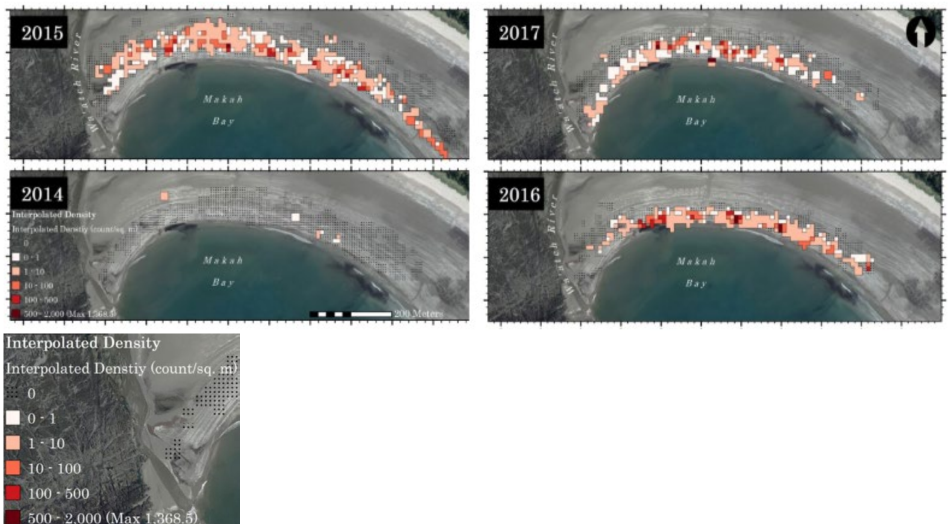
Appendix Figure S.LR.12.6. Distributions of northern Euphausia pacifica Pacific krill off Oregon and southern Washington from May/June 2011–2019. Colors represent CPUE per standardized tow. Source: R. Brodeur/NOAA NMFS; Image: Harvey et al., 2020



~~**Appendix Figure S.LR.13.1**. Average density of Siliqua patula razor clam recruits and pre-recruits at Mocrocks Beach from 1997–2019. Pre-recruits are below the preferable catch size and recruits are above the preferable catch size. Source: WDFW, 2019; Quinault Tribe, 2019; Image: D. Ayres/WDFW~~

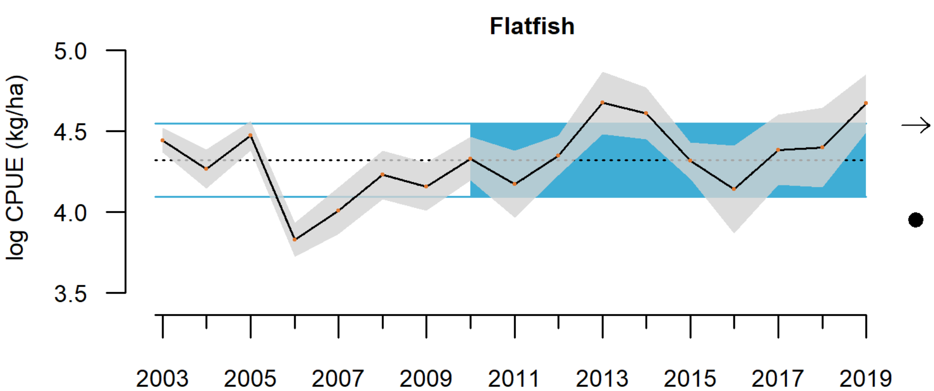
Commented [8]: This seems to be duplicative of panel in report: S.LR.13.2; graph in body of report is updated/better

Commented [9]: I checked and yes. Remove from here and I've renumbered those that follow.



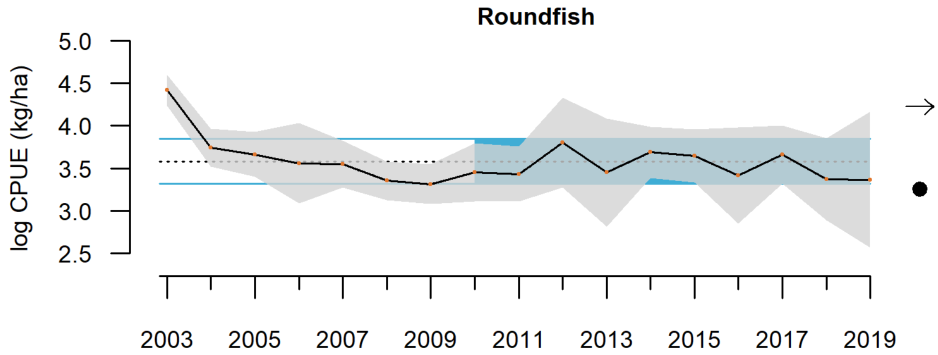
Appendix Figure S.LR.13.12. Olivella biplicata Purple olive snail densities (count/sq m) at northern Hobuck Beach, Makah Bay from 2014–2017. Source: Makah Tribe; Image: Akmajian et al., 2017

Commented [10]: The order of the panels doesn't make sense to me. Can they be reorganized to read chronologically in columns or rows? I would prefer 2014 in the top left, 2015 to the right, 2016 below 2014, and 2017 below 2015.

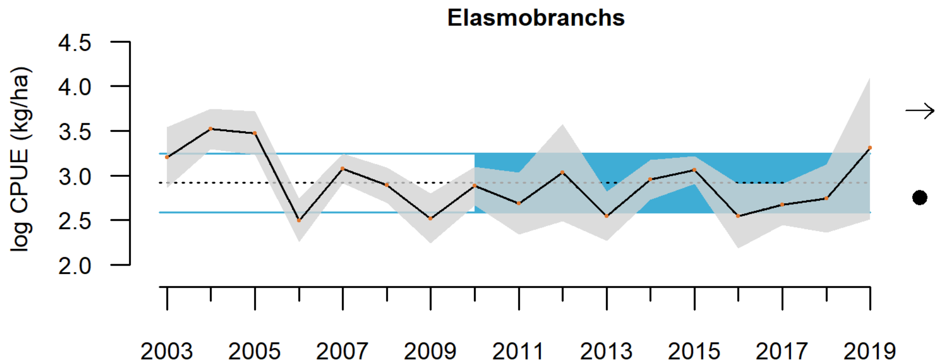


Appendix Figure S.LR.13.23. Log CPUE from scientific bottom trawling for flatfish from 2003–2019 in OCNMS. Black circle denotes that the 10-‑year mean (2010–2019) is within one standard deviation compared to the long-‑term mean.The horizontal arrow denotes a flat 10-year trend. Source: NOAA CCIEA, 2021; Image: G. Williams/NWFSC.

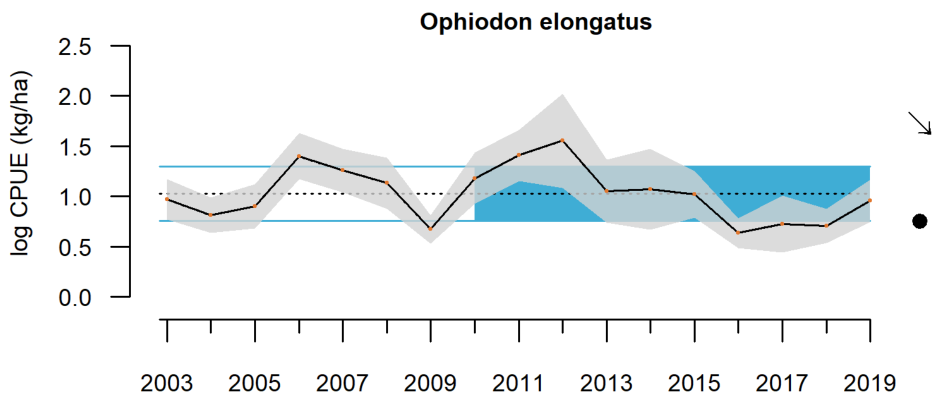
Commented [11]: Correct? Or is this fishery data? It's unclear.



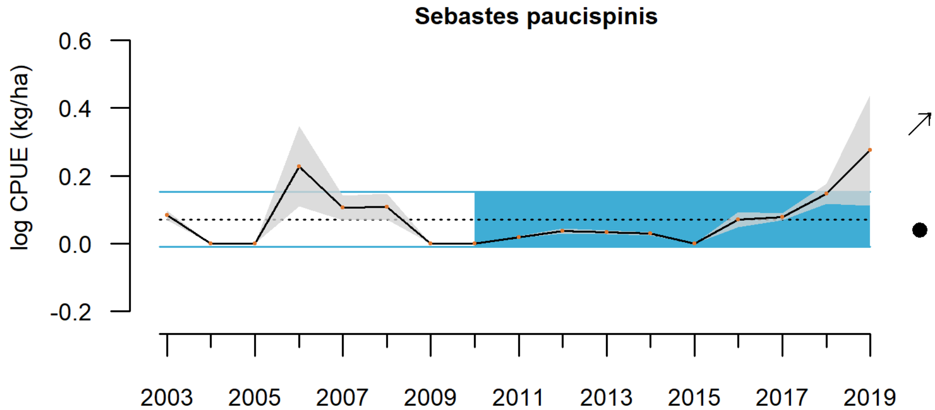
Appendix Figure S.LR.13.34. Log CPUE from scientific bottom trawling for roundfish from 2003–2019 in OCNMS. Black circle denotes that the 10-year mean (2010-2019) is within one standard deviation compared to the long-term mean.The horizontal arrow denotes a flat 10-year trend. Source: NOAA CCIEA, 2021; Image: G. Williams/NWFSC.



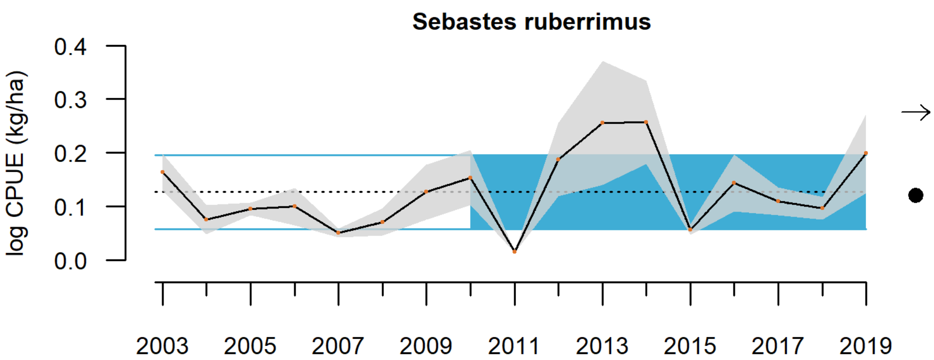
Appendix Figure S.LR.13.45. Log CPUE from scientific bottom trawling for sharks and skates (*Elasmobranchs*) from 2003–2019 in OCNMS. Black circle denotes that the 10-year mean (2010-2019) is within one standard deviation compared to the long-term mean. The horizontal arrow denotes a flat 10-year trend. Source: NOAA CCIEA, 2021; Image: G. Williams/NWFSC.



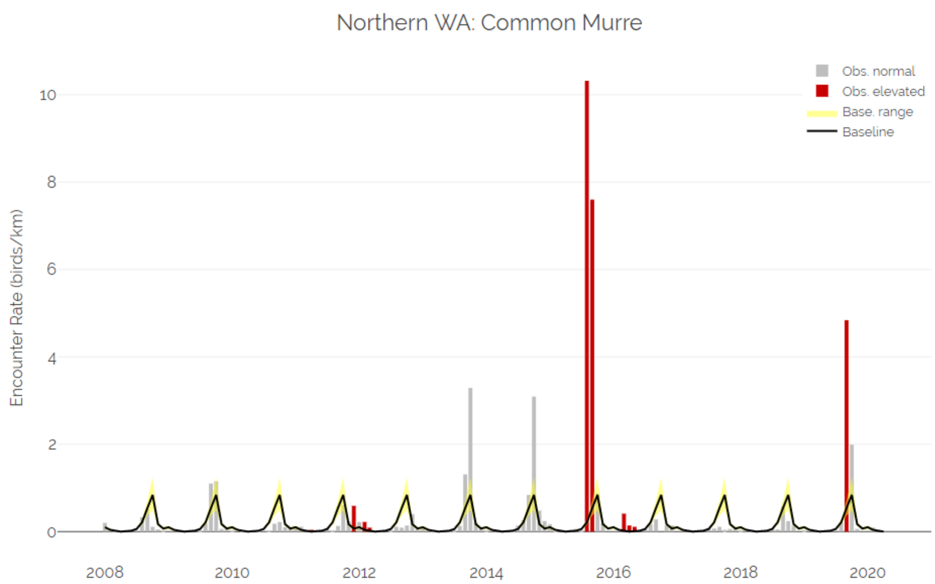
Appendix Figure S.LR.13.56. Log CPUE from scientific bottom trawling for lingcod (*Ophiodon elongatus*) from 2003–2019 in OCNMS. Black circle denotes that the 10-year mean (2010-2019) is within one standard deviation compared to the long-term mean.The down arrow denotes a decreasing 10-year trend. Source: NOAA CCIEA, 2021; Image: G. Williams/NWFSC.



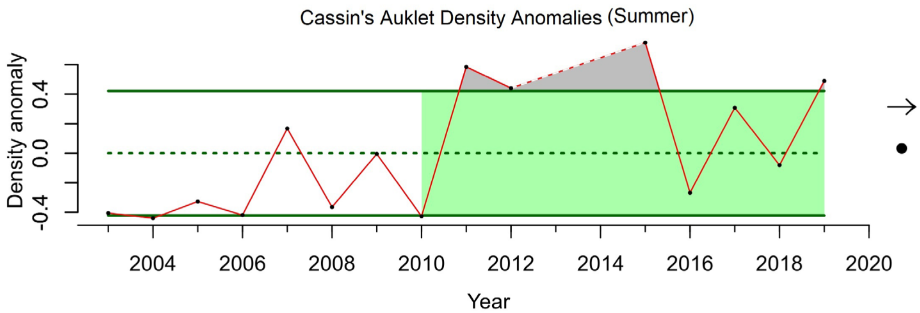
Appendix Figure S.LR.13.67. Log CPUE from scientific bottom trawling for bocaccio (*Sebastes paucispinis*) from 2003–2019 in OCNMS. Black circle denotes that the 10-year mean (2010-2019) is within one standard deviation compared to the long-term mean.The upward arrow denotes an increasing 10-year trend. Source: NOAA CCIEA, 2021; Image: G. Williams/NWFSC.



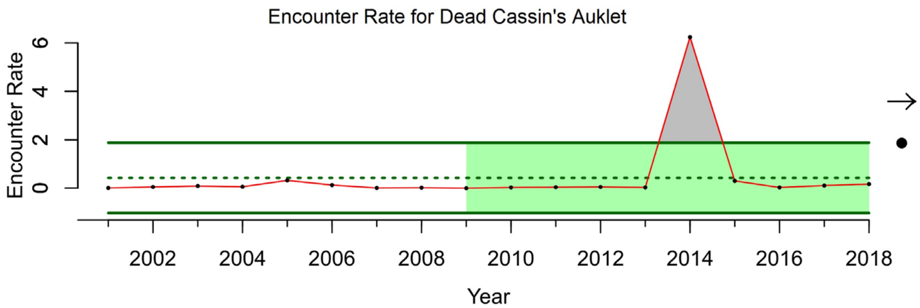
Appendix Figure S.LR.13.78. Log CPUE from scientific bottom trawling for yelloweye rockfish (*Sebastes ruberrimus*) from 2003–2019 in OCNMS. Black circle denotes that the 10-–year mean (2010-2019) is within one standard deviation compared to the long-–term mean.The horizontal arrow denotes a flat 10-–year trend. Source: NOAA CCIEA, 2021; Image: G. Williams/NWFSC.



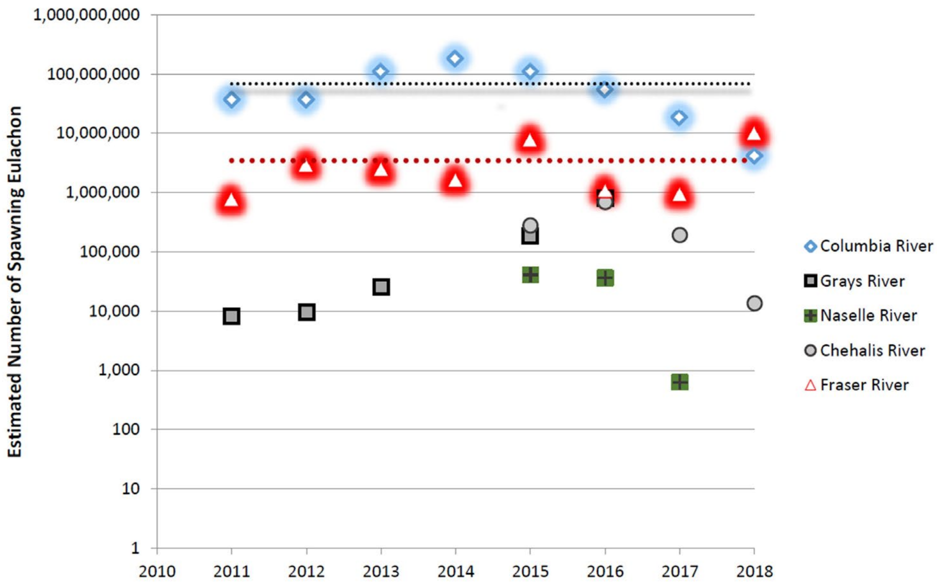
Appendix Figure S.LR.13.89. Encounter rates for dead Uria aalge common murres from 2008–2020 for northern Washington. Image: COASST, 2020



Appendix Figure S.LR.13.9~~10~~. Density anomalies (number of birds per sq km) for Ptychoramphus aleuticus Cassin's Auklet from Newport, OR to Cape Flattery, WA during the summer from 2003–2019. Black circle denotes that the 10-year mean is within one standard deviation compared to the long-term mean.The horizontal arrow denotes a flat 10-year trend. Source: NOAA NWFSC; J. Zamon/NOAA NWFSC BPA Plume Survey; Image: NOAA CCIEA, 2019

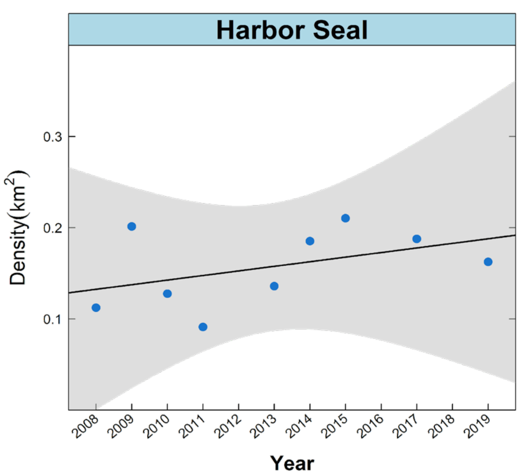


Appendix Figure S.LR.13.10~~1~~. Encounter rates for dead Ptychoramphus aleuticus Cassin's auklets from 2001–2018 from CA/OR border to Cape Flattery, WA. Black circle denotes that the 10-year mean is within one standard deviation compared to the long-term mean.The horizontal arrow denotes a flat 10-year trend. Source: COASST, 2020; Image: NOAA CCIEA, 2019



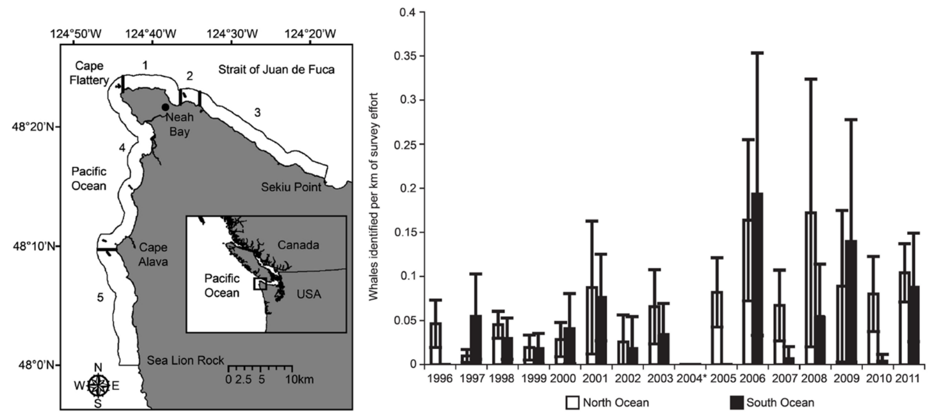
Appendix Figure S.LR.13.1~~1~~2. Estimated number of Thaleichthys pacificus eulachon spawning in Columbia, Fraser, Chehalis, Naselle, and Grays Rivers from 2011–2018. Image: Lang~~e~~ness et al., 2018

Commented [12]: What are the dashed lines?



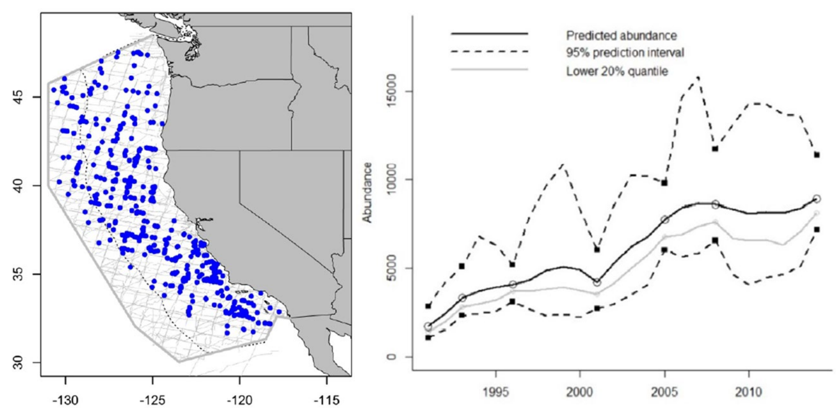
Appendix Figure S.LR.13.1~~2~~3. Number of Pacific harbor seals (*Phoca vitulina*) from at-sea surveys on the outer Washington coast from (May–July) 2008–2019. Source: WDFW, 2019; Image: S. Pearson/WDFW

Commented [13]: Describe the line and grey envelope.

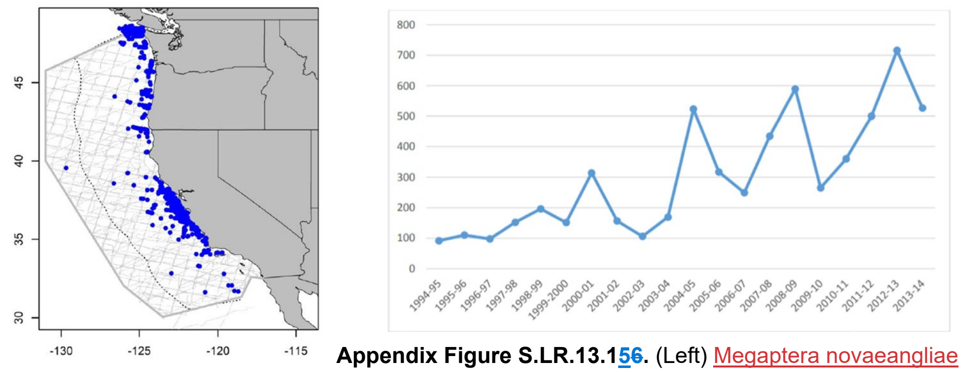


Appendix Figure S.LR.13.134. Map of Eschrichtius robustus gray whale survey region, including region 4 (North Ocean) and region 5 (South Ocean) (left). Sighting density of gray whales (per sq km) in North and South Ocean regions from June to November 2005–2011 (right). Error bars represent one standard deviation. No surveys were conducted in 2004. Image: Scordino et al., 2017

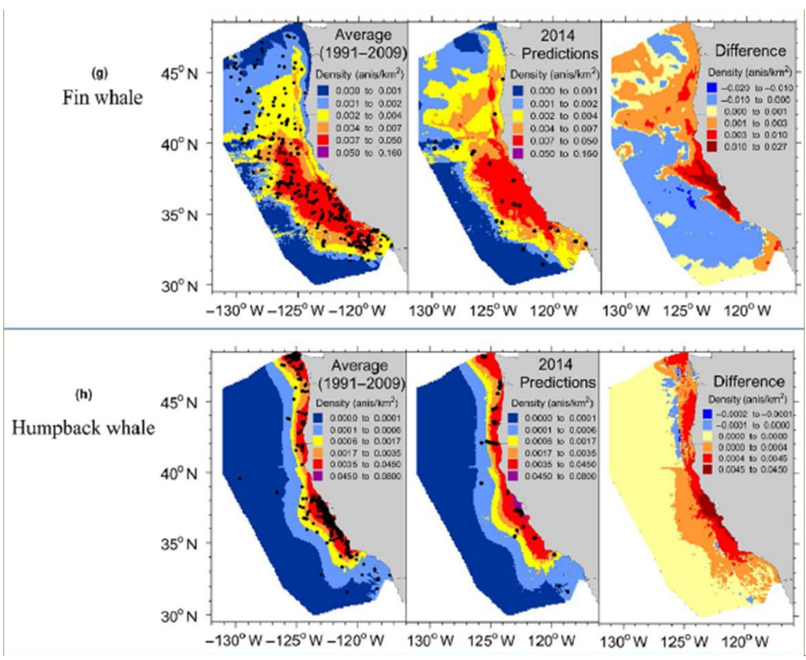
Commented [14]: I assume. Specify either way so it's clear.



Appendix Figure S.LR.13.145. (Left) Balaenoptera physalus Fin whale sightings from shipboard surveys from 1991–2014 on the U.S. West Coast. (Right) Fin whale abundance estimates from 1991–2014 on the U.S. West Coast. Image: (Left) Carretta et al., 2020; (Right) Nadeem et al., 2016

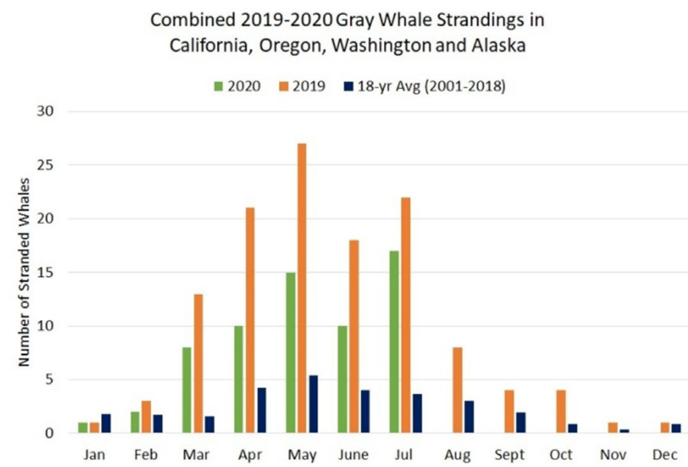


Appendix Figure S.LR.13.156. (Left) Megaptera novaeangliae Humpback whale sightings from shipboard surveys from 1991–2014 on the U.S. West Coast. (Right) Humpback whale abundance estimates off Washington and southern British Columbia. Image: (Left) Carretta et al., 2020; (Right) Calambokidis et al., 2017



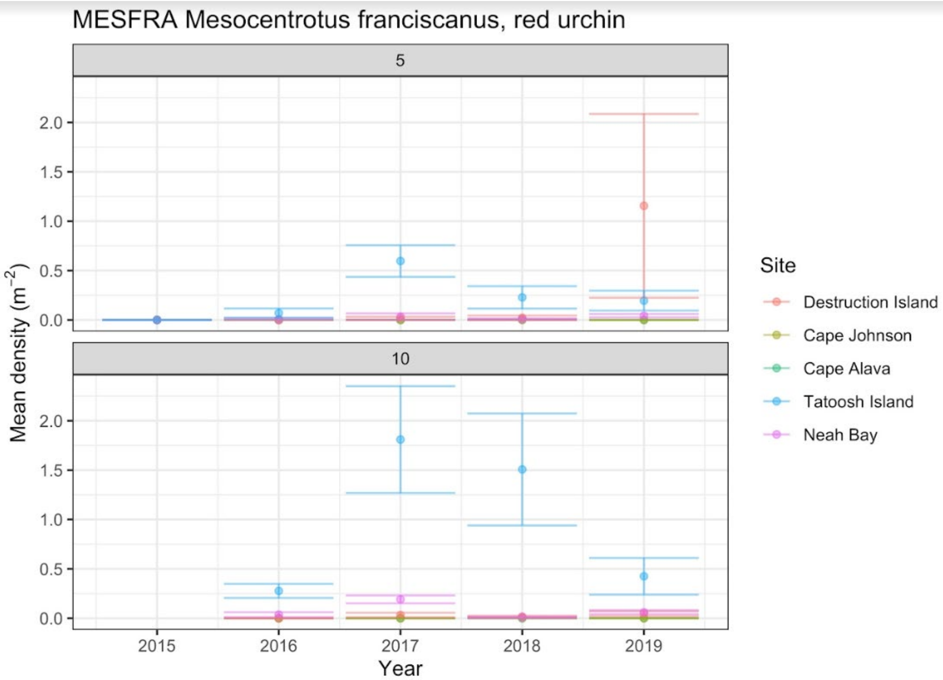
Appendix Figure S.LR.13.16~~7~~. Predicted mean densities from the 1991–2009 habitat-based density models compared to novel 2014 summer/fall density predictions for (top) Balaenoptera physalus fin whales and (bottom) Megaptera novaeangliae humpback whales. Left panel shows average prediction for 1991–2009. Middle panel shows prediction for 2014 and panel on the right shows the difference between the two predictions. Image: Becker et al., 2019

Commented [15]: The purple color in the center and left panels is not easily distinguishable from the dark blue with colorblindness filters. The color ramp on the right panels works very well - I recommend using that across all six panels to improve accessibility if possible.



Appendix Figure S.LR.13.17~~8~~. Combined 2019–2020 Eschrichtius robustus ~~G~~gray ~~W~~whale strandings by month in California, Oregon, Washington and Alaska. Image: NOAA NMFS, 2019

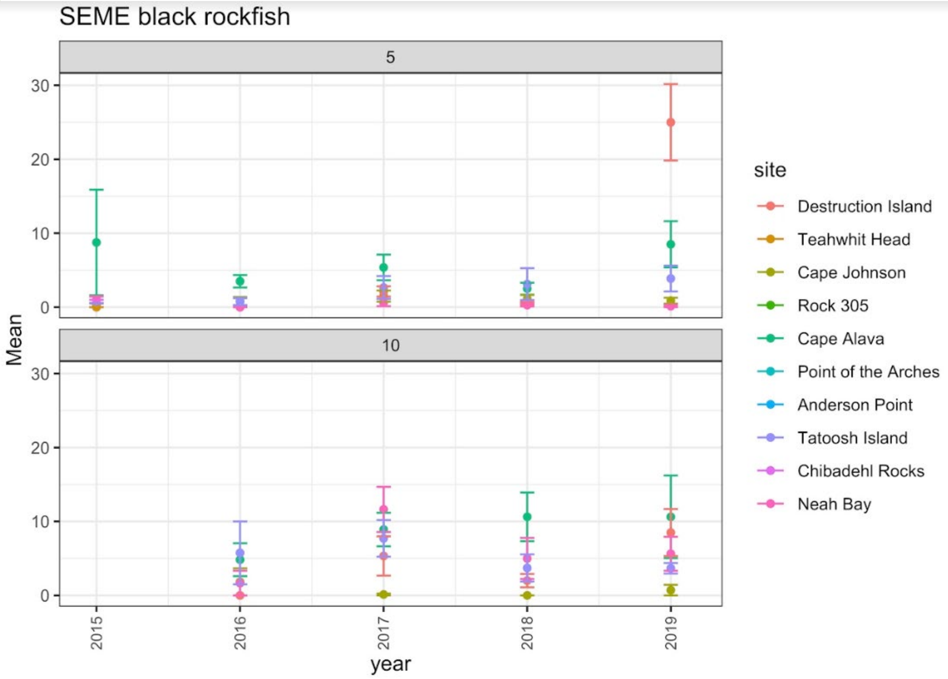
Commented [16]: Colors are not accessible (orange cannot be distinguished from green with colorblindness filters). Please add pattern or change to colorblindness friendly palette.



Appendix Figure S.LR.13.18~~9~~. Average density of Mesocentrotus franciscanus red sea urchins (per sq m) from 2015-2019 at 5 and 10 m depths for Neah Bay to Destruction Island, WA. Source: NOAA NWFSC dive surveys (unpublished); Image: G. Williams

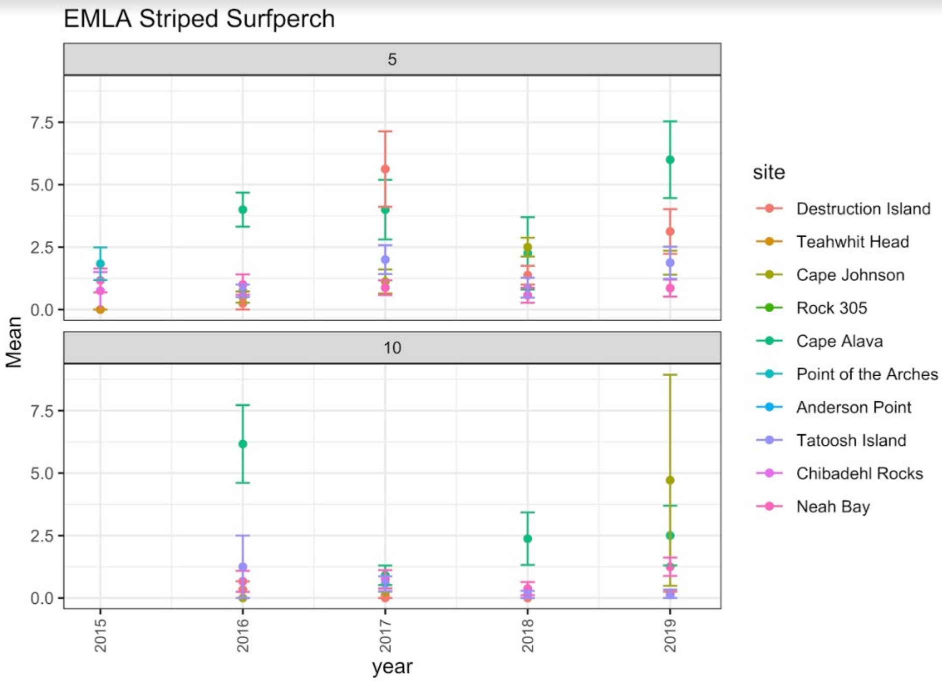
Commented [17]: Colors not accessible, please see comments on similar figures above.

Commented [18]: See note above about differentiating top and bottom panels.



Appendix Figure S.LR.13.~~20~~19. Average abundance of black rockfish (*Sebastes melanops*) from 2015-2019 at 5 and 10 m depths for Neah Bay to Destruction Island, WA. Source: NOAA NWFSC dive surveys (unpublished); Image: G. Williams

Commented [19]: Colors are not accessible, please vary symbols or use a colorblindness friendly palette.



Appendix Figure S.LR.13.201. Average abundance of striped surfperch (*Embiotoca lateralis*) from 2015-2019 at 5 and 10 m depths for Neah Bay to Destruction Island, WA. Source: NOAA NWFSC dive surveys (unpublished); Image: G. Williams

This draft was archived on 3June2021 and contains all comments and edits received from Peer Reviewers.

Appendix: Olympic Coast National Marine Sanctuary 2008 Condition Report Ratings

The following table summarizes the condition and trend ratings as presented in the 2008 Olympic Coast National Marine Sanctuary Condition Report.

Olympic Coast National Marine Sanctuary Condition Summary Table

The following table summarizes the "State of Sanctuary Resources" section of this report. The first two columns list 17 questions used to rate the condition and trends for qualities of water, habitat, living resources, and maritime archaeological resources. The "Rating" column consists of a color, indicating resource condition, and a symbol, indicating trend (see key for definitions). The "Basis for Judgment" column provides a short statement or list of criteria used to justify the rating. The "Description of Findings" column presents the statement that best characterizes resource status, and corresponds to the assigned color rating. The "Description of Findings" statements are customized for all possible ratings for each question. Please see the Appendix for further clarification of the questions and the "Description of Findings" statements.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends:
- Conditions appear to be improving .... ▲
- Conditions do not appear to be changing .... –
- Conditions appear to be declining .... ▼
- Undetermined trend .... ?
- Question not applicable .... N/A

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
WATER					
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality and how are they changing?	Good/Fair ?	Hypoxic conditions may be increasing in frequency and spatial extent in nearshore waters.	Selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.	Management focuses on oil spill and discharge preventative measures, including relocating ship traffic lanes offshore, tracking ships, enhancing spill response assets in the region, and reducing wastes discharged from ships; moored instruments track nearshore water quality; periodic shipboard surveys are conducted to investigate physical, chemical and biological linkages.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	Good –	No suspected human influence on harmful algal blooms or eutrophication.	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.	
3	Do sanctuary waters pose risks to human health and how are they changing?	Good/Fair –	Naturally occurring harmful algal blooms result in periodic shellfish closures.	Selected conditions that have the potential to affect human health may exist but human impacts have not been reported.	
4	What are the levels of human activities that may influence water quality and how are they changing?	Good/Fair –	Threat of oil spills from vessels.	Some potentially harmful activities exist, but they do not appear to have had a negative effect on water quality.	
HABITAT					
5	What are the abundance and distribution of major habitat types and how are they changing?	Good/Fair –	Reduction in habitat complexity by bottom-tending gear; short-term impacts from fishing gear and cable installation.	Selected habitat loss or alteration has taken place, precluding full development of living resource assemblages, but it is unlikely to cause substantial or persistent degradation in living resources or water quality.	Sanctuary and partners map and characterize deep habitats and the extent of human impacts and convey information to fisheries managers; large areas have been closed to fishing that uses bottom trawl gear to protect sensitive habitats; negotiated reburial of exposed fiber optic cable; began marine debris removal efforts.
6	What is the condition of biologically structured habitats and how is it changing?	Fair ?	Damage by bottom-tending gear in some deep biogenic habitats.	Selected habitat loss or alteration may inhibit the development of living resources, and may cause measurable but not severe declines in living resources or water quality.	
7	What are the contaminant concentrations in sanctuary habitats and how are they changing?	Good –	Prior studies indicate low levels of contaminants.	Contaminants do not appear to have the potential to negatively affect living resources or water quality.	
8	What are the levels of human activities that may influence habitat quality and how are they changing?	Fair ▲	Decrease in bottom trawling and presumably impacts to hard-bottom habitats.	Selected activities have resulted in measurable habitat impacts, but evidence suggests effects are localized, not widespread.	

Table is continued on the following page.

Olympic Coast National Marine Sanctuary Condition Summary Table (Continued)

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
LIVING RESOURCES					
9	What is the status of biodiversity and how is it changing?	?	Ecosystem-level impacts caused by historical depletion of fish, high-order predators, and key-stone species.	Selected biodiversity loss may inhibit full community development and function, and may cause measurable but not severe degradation of ecosystem integrity.	Sanctuary works with partners to monitor populations of seabirds and marine mammals, to detect non-indigenous species, to conduct regular intertidal monitoring; wide area closures by fisheries management authorities to allow populations to recover.
10	What is the status of environmentally sustainable fishing and how is it changing?	▲	Overexploitation of some groundfish species has led to wide area closures.	Extraction may inhibit full community development and function, and may cause measurable but not severe degradation of ecosystem integrity.	
11	What is the status of non-indigenous species and how is it changing?	▼	Invasive *Sargassum* and tunicate distrubutions are expanding.	Non-indigenous species exist, precluding full community development and function, but are unlikely to cause substantial or persistent degradation of ecosystem integrity.	
12	What is the status of key species and how is it changing?	?	Populations of Common Murres, sea otters, and numerous rockfish reduced from historic levels, with differing recovery rates.	The reduced abundance of selected keystone species may inhibit full community development and function, and may cause measurable but not severe degradation of ecosystem integrity; or selected key species are at reduced levels, but recovery is possible.	
13	What is the condition or health of key species and how is it changing?	?	Diseases detected in sea otters.	The condition of selected key resources is not optimal, perhaps precluding full ecological function, but substantial or persistent declines are not expected.	
14	What are the levels of human activities that may influence living resource quality and how are they changing?	▲	Commercial and recreational fishing pressure has decreased.	Selected activities have resulted in measurable living resource impacts, but evidence suggests effects are localized, not widespread.	
MARITIME ARCHAEOLOGICAL RESOURCES					
15	What is the integrity of known maritime archaeological resources and how is it changing?	?	Deepwater wrecks stable; shallow wrecks subject to environmental degradation; lack of monitoring to determine trend.	The diminished condition of selected archaeological resources has reduced, to some extent, their historical, scientific, or educational value, and may affect the eligibility of some sites for listing in the National Register of Historic Places.	Need to conduct inventories and monitoring, and to assess possible impacts of sea level rise on coastal archaeological resources.
16	Do known maritime archaeological resources pose an environmental hazard and how is this threat changing?	–	Historic wrecks did not carry substantial quantities of hazardous cargoes.	Known maritime archaeological resources pose few or no environmental threats.	
17	What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?	?	Fishing activities, cable installations offshore, and unauthorized salvaging.	Selected activities have resulted in measurable impacts to maritime archaeological resources, but evidence suggests effects are localized, not widespread.	

This draft was archived on 3June2021 and contains all comments and edits received from Peer Reviewers.

Appendix: Consultation with Experts, Documenting Confidence, and Document Review

The process for preparing condition reports involves a combination of accepted techniques for collecting and interpreting information gathered from subject matter experts. The approach varies somewhat from sanctuary to sanctuary in order to accommodate different styles for working with partners. Olympic Coast National Marine Sanctuary's approach was closely related to the Delphi Method, a technique designed to organize group communication among a panel of geographically dispersed experts by using questionnaires, ultimately facilitating the formation of a group judgment. This method can be applied when it is necessary for decision makers to combine the testimony of a group of experts, whether in the form of facts or informed opinion, or both, into a single useful statement.

The Delphi Method requires experts to respond to questions with a limited number of choices to arrive at the best~~-~~-supported answers. Feedback to the experts allows them to refine their views, gradually moving the group toward the most agreeable judgment.

In order to assess the standardized state of the ecosystem questions and ecosystem services that are addressed in condition reports (see Appendices A and B), ONMS selected and consulted outside experts familiar with water quality, habitat, living resources, maritime heritage resources, and socioeconomics in the sanctuary. A three-day workshop was held January 14–16, 2020 to discuss and evaluate the series of questions about each resource area. At the workshop, experts participated in facilitated discussions about the questions related to pressures (Questions 2–4), water quality (Questions 6–9), habitat (Questions 10 and 11), living resources (Questions 12–15), maritime archaeological resources (Question 16), and ecosystem services (consumptive recreation, non-consumptive recreation, science, education, heritage, sense of place, commercial harvest, subsistence harvest, and ornamentals). Experts represented various affiliations; a list of experts who provided input is available in the Acknowledgements section of this report. The content for the driving forces assessment was determined and reviewed by ONMS socioeconomists, ONMS conservation science staff, and OCNMS staff.

At the workshop, experts were introduced to the questions and ecosystem services and provided with relevant time series datasets ONMS had collected from experts prior to the meeting. Attendees were then asked to review the datasets, identify data gaps or misrepresentations, and suggest any additional datasets that may be relevant. Once all datasets were reviewed, experts were asked to provide status and trend recommendations and supporting arguments. In order to ensure consistency with the Delphi~~c~~ Method, a critical role of the facilitator was to minimize dominance of the discussion by a single individual or opinion (which often leads to "follow the leader" tendencies in group meetings) and to encourage the expression of honest differences of opinion. As discussions progressed, the group converged on ~~in~~ an opinion for ~~of~~ each rating that most accurately described the current resource condition. After an appropriate amount of time, the facilitator asked whether the group could agree on a rating for the question or ecosystem service, as defined by specific language linked to each rating (see Appendices A and B). If an agreement was reached, the result was recorded and the group moved on to consider the trend in

Commented [1]: @jenny.waddell@noaa.gov It occurred to me that we don't mention the Indicator Vetting workshop in the methods. Shall I add a paragraph? I don't think that will impact peer review.

Commented [2]: yes please! good catch

Commented [3]: can we acknowledge the funding and support from NCCOS and IEA prominently, i.e., somewhere they will see it?

Commented [4]: @jenny.waddell@noaa.gov great idea. I was thinking NCCOS should be listed as authors, too.

Commented [5]: Reminder to hyperlink the same manner. If agreement was not reached, the facilitator recorded the vote of individuals for each rating category and that information helped to inform the confidence scoring process.

After assigning status ratings and trends, ~~E~~experts were ~~then~~ asked to assign a level of confidence for each value~~status and trend rating~~ by: (1) characterizing the sources of information they used to make judgments~~,~~; and (2) their agreement with the selected status and trend ratings. The evidence and agreement ratings were then combined to determine the overall confidence ratings, as described in the table below.

Step 1: Rate Evidence

Consider three categories of evidence typically used to make status or trend ratings: (1.) data,(2.) published information and(3.) personal experience.

Evidence Scores		
Limited	**Medium**	**Robust**
Limited data or published information, and little or no substantive personal experience.	Data available, some peer reviewed published information, or direct personal experience.	Considerable data, extensive record of publication, or extensive personal experience.

Step 2: Rate Agreement

Rate agreement among those participating in determining the status and trend rating, or if possible, within the broader scientific community. Levels of agreement can be characterized as *"low," "medium"* or *"high."*

Step 3: Rate Confidence

Using the matrix below, combine ratings for both evidence and agreement to identify a level of confidence. Levels of confidence can be characterized as *"very low," "low," "medium," "high" or "very high."*

Agreement ↑			
	"Medium" High agreement Limited evidence	*"High"* High agreement Medium evidence	*"Very High"* High agreement Robust evidence
	"Low" Medium Agreement Limited evidence	*"Medium"* Medium agreement Medium evidence	*"High"* Medium agreement Robust evidence
	"Very Low" Low agreement Limited evidence	*"Low"* Low agreement Medium evidence	*"Medium"* Low agreement Robust evidence

Evidence (type, amount, quality, consistency) ⟶

An initial draft of the report, written by ONMS, summarized the new information, expert opinions, and levels of confidence expressed by the experts. Comments, data, and citations received from the experts were included, as appropriate, in text supporting the ratings and compiled in three appendices. This initial draft was made available to contributing experts and data providers, which allowed them to review the content and determine if the report accurately reflected their input, identify information gaps, provide comments, or suggest revisions to the ratings and text.

Following the expert review, the document was then sent to representatives of partner agencies, including members of the ________. These representatives were asked to review the technical merits of resource ratings and accompanying text, as well as to point out any omissions or factual errors. Upon receiving reviewer comments, ONMS revised the text and ratings as appropriate.

Commented [6]: Insert affiliations for Invited Review

In April and May 2021, a draft final report was sent to four regional science experts for a required external peer review. External peer review became a requirement when the White House Office of Management and Budget (OMB) issued a Final Information Quality Bulletin for Peer Review (OMB Bulletin) that established peer review standards to enhance the quality and credibility of the federal government's scientific information (OMB 2004). Along with other information, these standards apply to "Influential Scientific Information," which is information that can reasonably be determined to have a "clear and substantial impact on important public policies or private sector decisions." Condition reports are considered Influential Scientific Information and ~~. For this reason, these reports~~ are subject to the review requirements of both the Information Quality Act and the OMB Bulletin guidelines; therefore, every condition report is reviewed by a minimum of three individuals who are considered to be experts in their field, were not involved in the development of the report, and are not ONMS employees. Comments and recommendations of the peer reviewers were considered and incorporated, as appropriate, into the final text of this report. Furthermore, OMB Bulletin guidelines require that reviewer comments, names, and affiliations be posted on the agency website, http://www.cio.noaa.gov/. Reviewer comments, however, are not attributed to specific individuals. Comments by the external peer reviewers are posted at the same time as the formatted final document.

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In all steps of the review process, experts were asked to review the technical merits of resource ratings and accompanying text, as well as to point out any omissions or factual errors; however, the interpretation, ratings, and text in the condition report are ~~were~~ the responsibility of, and receive~~d~~ final approval by, ONMS. To emphasize this important point, authorship of the report is attributed to ONMS; subject matter experts are not authors, though their efforts and affiliations are acknowledged in the report.

Olympic Coast National Marine Sanctuary
Confidence Ratings from January 14–16, 2020 Expert Workshop

A summary table for the findings regarding confidence ratings for the questions pertaining to OCNMS is included below:

Q	**Rating**	**Evidence** **(Limited, Medium, Robust)**	**Agreement** **(Low, Medium, High)**	**Confidence** **(Very Low, Low, Medium,** **High, Very High)**
1	Rating not assigned			

2	Status: Good/Fair	Limited	High	Medium
	Trend: Not Changing	Limited	High	Medium
3	Status: Fair	Medium	Medium	Medium
	Trend: Undetermined	Limited	High	Medium
4	Status: Good/Fair	Medium	High	High
	Trend: Improving	Medium	Medium	Medium
5	Status: Fair	Medium	Medium	Medium
	Trend: Undetermined	Medium	High	High
6	Status: Good	Medium	High	High
	Trend: Not Changing	Medium	High	High
7	Status: Fair	Medium	High	High

	Trend: Not Changing	Medium	Medium	Medium
8	Status: Fair/Poor	Robust	High	Very High
	Trend: Worsening	Robust	High	Very High
9	Status: Good/Fair	Limited	High	Medium
	Trend:Worsening	Limited	High	Medium
10	Status: Good/Fair	Limited	Medium	Low
	Trend: Not changing	Limited	Low	Very Low
11	Status: Good	Limited	High	Medium
	Trend	Limited	High	Medium
12	Status: Fair	Medium	Medium	Medium
	Trend: Undetermined	Medium	High	High
13	Status: Fair	Medium	High	High

	Trend: Undetermined	Medium	High	High
14	Status: Good/Fair	Medium	High	High
	Trend: Worsening	Medium	High	High
15	Status: Good/Fair	Limited	Medium	Low
	Trend	Limited	High	Medium
16	Status: Good/Fair	Limited	Medium	Low
	Trend: Undetermined	Limited	Medium	Low

Ecosystem Service	**Rating**	**Evidence** **(Limited, Medium, Robust)**	**Agreement** **(Low, Medium, High)**	**Confidence** **(Very Low, Low, Medium, High, Very High)**
Consumptive Recreation	Status: Fair	Medium	High	High
	Trend: Undetermined	Medium*	Low	Low

Non-Consumptive Recreation	Status: Fair	Medium	Low	Low
	Trend: Undetermined	Medium	High	High
Science	Status: Fair	Robust	Medium	High
	Trend: Improving	Robust	High	Very High
Education	Status: Good/Fair	Medium	Medium	Medium
	Trend: Improving	Robust	High	Very High
Heritage	Status: Good/Fair	Medium	Medium	Medium
	Trend: Worsening	Medium	High	High
Sense of Place	Rating not assigned			

Commercial Harvest	Rating not assigned			
Subsistence Harvest	Status: Fair	Limited	High	Medium
	Trend: Undetermined	Limited	High	Medium
Ornamentals	Status: Good/Fair	Medium	High	High
	Trend: Undetermined	Limited	High	Medium

OLD VERSION

Description of Ecosystem Services and Methods to Determine Ratings

The following provides descriptions of the various ecosystem services considered in sanctuary condition reports and the process for rating them. The Office of National Marine Sanctuaries (ONMS) defines ecosystem services (ES) in a slightly more restrictive way than some other experts. Specifically, “ecosystem services” are defined herein as the benefits people obtain from nature through use, consumption, enjoyment, and/or simply knowing these resources exist (non-use). The descriptions below reflect this definition, and therefore, only those ecosystem services are evaluated in sanctuary conditions reports. In contrast, there are some supporting services, such as biodiversity, decomposition, and carbon storage, that are included in the State section of these reports instead. Specifically, these services are critical to ecosystem function and considered "intermediate" ecosystem services that are not directly used, consumed, or enjoyed by humans to meet the ONMS condition report definition of ecosystem services. In other words, these secondary or intermediate services support ecosystems and are not final ecosystem services in and of themselves.

As an example, biodiversity is often considered an ecosystem service, but ONMS recognizes biodiversity as an *attribute* of the ecosystem on which many “final” ecosystem services depend (e.g., recreation and food supply/commercial fishing). For this reason, it is considered a secondary ecosystem service and it is evaluated in the State section of the report.

In addition, ONMS does not consider climate regulation or stabilization in condition reports. The impacts of climate change on water quality and biodiversity, however, are considered separately in the State section of the report. While sanctuaries are not large enough to influence climate stability, they may locally buffer climate-related factors, such as temperature change and ocean acidity; thus, the extent to which they may locally buffer climate-related factors is reflected in resource conditions in the State section.

Certain other ecosystem services may not be assessed by individual sanctuaries because the activities required to achieve them are prohibited (e.g., collection of ornamentals) or there is simply no related activity underway or expected (e.g., energy production).

Below are brief descriptions of the ecosystem services considered within each sanctuary condition report (more complete descriptions are provided below the list).

***Cultural* (non-material benefits)**

1. Consumptive recreation — Recreational activities that result in the removal of or harm to natural or cultural resources
2. Non-consumptive recreation — Recreational activities that do not result in intentional removal of or harm to natural or cultural resources
3. Science — The capacity to acquire and contribute information and knowledge
4. Education — The capacity to acquire and provide intellectual enrichment
5. Heritage — Recognition of historical and heritage legacy and cultural practices
6. Sense of Place — Aesthetic attraction, spiritual significance, and location identity

***Provisioning* (material benefits)**

7. Commercial Harvest — The capacity to support commercial market demands for seafood products
8. Subsistence Harvest — The capacity to support non-commercial harvesting of food and utilitarian products
9. Drinking Water — Providing water for human use by minimizing pollution, including nutrients, sediments, pathogens, chemicals, and trash
10. Ornamentals — Resources collected for decorative, aesthetic, ceremonial purposes
11. Biotechnology — Medicinal and other products derived or manufactured from sanctuary animals or plants for commercial use
12. Renewable Energy — Use of ecosystem-derived materials or processes for the production of energy

***Regulating* (buffers to change)**

13. Coastal protection — Flow regulation that protects habitats, property, coastlines, and other features

Sanctuaries vary with regard to the ecosystem services they support, so each sanctuary is likely to have a different mix of services and information to support its assessment. To rate the status and trends for each relevant ecosystem service, the following was considered:

- the ecosystem services relevant to the sanctuary
- the best available indicators for each ecosystem service (economic, non-economic human dimensions, and ecological)

- the status and direction of change of each ecosystem service
- whether economic and non-economic human dimensions indicators yield the same conclusions about the status and trend for each ecosystem service
- whether economic indicators send a false signal about the status and trend of an ecosystem service (namely, conflicting ecological and economic indicators, suggesting that people are sacrificing natural capital for short-term economic gain)

The steps used to rate ecosystem services were adapted from the multi-year study "Marine and Estuarine Goal Setting for South Florida" (MARES) of three south Florida marine ecosystems, including Florida Keys National Marine Sanctuary. It used Integrated Conceptual Ecosystem Models (ICEMs) for each ecosystem under the Driving forces (Drivers)-Pressure-State-Ecosystem Services-Response (DPSER) Model (Nuttle and Fletcher 2013), and evaluation of three types of indicators: 1) economic; 2) human dimension non-economic (Lovelace et al. 2013); and 3) resource for each ecosystem service.

The discussion of ecosystem services should consider whether economic and non-economic indicators yield the same conclusions as resource indicators; this will enable consideration of the sometimes conflicting relationship between economic gain and the preservation of natural capital. For example, economic indicators (e.g., dive operator income) may suggest improving recreational services while resource indicators (e.g., anchor damage) suggest that natural resource qualities are being sacrificed for short-term gain, making the activity unsustainable.

The ONMS recognizes that the ES model is intentionally anthropocentric, designed to elicit a selected type of service-oriented rating useful in resource management decision making. Connections between ecosystems and culture and resource management are often more complex, beyond the scope of the condition report. Collectively, stakeholders may have multiple worldviews and ecosystem values equally important to consider, and some ecosystem elements may not be appropriate to rate in the ES approach (e.g., aspects of Heritage and Sense of Place). Sites may want to consider the option of including a "context-specific perspective" or narrative (as proposed by IPBES in Diaz et al 2018), without assigning a rating, for the purpose of providing appropriate information for management purposes. Cultural (non-material) ecosystem services are particularly intricate and have been undervalued in the past. Evaluators should remember that deliberative processes engaging local stakeholders and subject matter experts are critical, and adherence to the process demands both flexibility and creativity.

Rating Scheme for Ecosystem Services

Rating	Status Description

Good	The capacity to provide the ecosystem service has remained unaffected or has been restored.
Good/Fair	The capacity to provide the ecosystem service is compromised, but performance is acceptable.
Fair	The capacity to provide the ecosystem service is compromised, and existing management would require enhancement to enable acceptable performance.
Fair/Poor	The capacity to provide the ecosystem service is compromised, and substantial new or enhanced management is required to restore it.
Poor	The capacity to provide the ecosystem service is compromised, and it is doubtful that new or enhanced management would restore it.

The discussion of ecosystem services ratings within the written report should focus on the influence of drivers and societal values considered responsible for the ratings. This discussion may also consideration of whether economic and non-economic indicators yield the same conclusions; this will enable consideration of the sometimes conflicting relationship between economic gain and the preservation of natural capital. For example, economic indicators (e.g., dive operator income) may suggest improving recreational services while resource indicators (e.g., anchor damage) suggest that natural resource qualities are being sacrificed for short-term gain, making the activity unsustainable.

Descriptions of Ecosystem Services

Cultural (non-material benefits)

Consumptive recreation — Recreational activities that result in the removal of or harm to natural or cultural resources

Perhaps the most popular activity that involves consumptive recreation is sport fishing from private boats and for-hire operations. Targeted species and bycatch are removed from the environment, and those that must be released due to regulations and prohibitions (e.g., undersized or out of season) sometimes die due to stress or predation. Nonetheless, fishing for consumptive purposes is a highly valued cultural tradition for many people, as well as a popular recreational activity. Other consumptive recreational activities include beachcombing, clam digs and shell collecting.

Indicators of status and trends for consumptive recreation often include levels of use (direct counts or estimates made from commercial vessel records and catch levels, and fishing license registrations) and production of economic value through job creation, income, spending, and tax revenue. Public polls can also be used to assess non-market indicators, such as importance and satisfaction, social values, willingness to pay, and facility and service availability.

Non-consumptive recreation — Recreational activities that do not result in intentional removal of or harm to natural or cultural resources

Recreational activities, including ecotourism and outdoor sports, are often considered a non-consumptive ecosystem service that provides desirable experiential opportunities. Non-consumptive recreational activities include those on shore or from private boats and for-hire operations, such as relaxing, exploring, diving and snorkeling, kayaking, birdwatching, surfing, sailing, and wildlife viewing. Activities that may have unintentional impacts on habitats or wildlife including catch-and-release fishing and tidepooling which could result in mortality or trampling, respectively, are also considered in this category.

It should be noted that private boating often includes both non-consumptive and consumptive recreational activities (e.g., snorkeling and fishing during a single trip). Thus, field and survey data can be ambiguous, reflecting the heterogeneous preferences of boaters. This also has implications for interpretations of data regarding attitudes and perceptions of management strategies and regulations to protect and restore natural and cultural resources.

Indicators used to assess status and trends in market values for recreation can include direct measures of use (e.g., person-days of use by type of activity) that result in spending, income, jobs, gross regional product, and tax revenues. They can also be non-market economic values (the difference between what people pay to use a good/service and what they would be willing to pay). The data can be used to estimate the value a consumer receives when using a good or service over and above what they pay to obtain the good or service. Indirect measures are also used. For example, populations and per capita incomes at numerous scales influence demand for recreational products and services. Fuel prices can even serve as indirect measures of recreational demand because the levels of use by some recreational users tracks fuel prices.

Science — The capacity to acquire and contribute information and knowledge

Sanctuaries serve as natural laboratories that can advance science and education. NOAA provides vessel support, facilities, and information that is valuable to the research community, including academic, corporate, non-governmental and government agency scientists, citizen scientists, and educators that instruct others using research. Sanctuaries serve as long-term monitoring sites, provide minimally disturbed focal areas for many studies, and provide opportunities to restore or maintain natural systems.

Status and trends for science can be assessed by counting and characterizing the number of research permits and tracking the accomplishments and growth of partnerships, activity levels of citizen monitoring, and participation of the research community in sanctuary management. The number and types of research cruises and other expeditions conducted can also provide useful indicators. Indirect indicators, such as per capita income and gross regional or national product, may be helpful as higher incomes and better economic conditions often result in higher investments in research and monitoring.

Education — The capacity to acquire and provide intellectual enrichment

As with science, national marine sanctuaries' protected natural systems and cultural resources attract educators at many levels for both formal and informal education. Students and teachers often either visit sanctuaries or use curricula and information provided by sanctuary educators.

The status and trends for education can be tracked by evaluating the number of educators and students visiting the sanctuary and visitor centers, the number of teacher trainings, use of sanctuary-related curricula in the classroom, and levels of activity in volunteer docent programs. The number of outreach offerings provided during sanctuary research and education expeditions can also be a good indicator. Education can also follow trends in populations and per capita income locally, regionally, and nationally. Populations create demand for services, and higher incomes lead to investment, making these useful indirect indicators.

Heritage — Recognition of historical and heritage legacy and cultural practices

The iconic nature of many national marine sanctuaries or particular places within them generally means that they have long been recognized, used, and valued. Communities developed around them, traveled through them, and depended on their resources. This shared history and heritage creates the unique cultural character of many present-day coastal communities, and can also be an important part of the current economy. Recognition of the past, including exhibits, artifacts, records, stories, songs, and chants provide not only a link to the history of these areas, but a way to better understand the maritime and cultural heritage within the environment itself. Tangible and intangible aspects of heritage blend together to contribute to the history and legacy of the place.

For some marine sanctuaries, vibrant and active indigenous cultures remain a defining and dominant element of the cultural heritage of these places. Not only are they a direct and priceless connection to the past, but they frame and influence modern-day economies, cultural landscapes, and conservation ethics and practices. Their very existence is intrinsic to the heritage of these places.

Given this broad range of cultural expression, benefits of heritage may take many forms. Additionally, cultural heritage resources will often be part of, or overlap with, other ES categories, and may be understood from multiple perspectives (such as, a living resource keystone species that may also be identified as a "cultural" keystone species, one of exceptional significance to a culture or a people). The Heritage ES category defines benefits from resources primarily attached to historical and heritage legacy and culture. Heritage resources, including certain living resources and traditional medicines, may also provide other benefits that can be addressed in other ES categories.

Economic indicators that reflect status and trends for heritage value as an ecosystem service may include spending, income, jobs, and other revenues generated from visitation, whether it is to dive on wreck sites or patronize museums and visitor centers where artifacts are displayed and interpreted. Non-market indicators, such as willingness to pay for protection of resources, activity levels for training and docent interpretation, and changes in threat levels (looting and damage caused by fishing), may also be considered. Sites may determine that some aspects of Heritage may simply not be ratable using the framework of condition reports.

Sense of place — Aesthetic attraction, spiritual significance, and location identity

A wide range of intangible meanings can be attributed to a specific place by people, both individually and collectively. Aesthetic attraction, spiritual significance, and location identity all influence our recognition and appreciation for a place, as well as efforts to protect its iconic elements.

Marine environments serve as places of aesthetic attraction for many people, and inspire works of art, music, architecture, and tradition. Many people also value particular places as sources of therapeutic rejuvenation and to offer a change of perspective. Aesthetic aspects are often reflected as motifs in books, film, artworks, and folklore and as part of national symbols, architecture, and advertising efforts. These elements of “place attachment” may develop and change over the short and long term.

Many people, families, and communities consider places as defining parts of their “self identity,” especially if they have lived there during or since childhood. The relationship between self/family/community and place can run very deep, particularly where lineage is place-based, with genealogy going back many generations. “Place identity” develops over the long term, and is often expressed in reciprocal human-ecosystem relationships, and locations associated with spiritual significance. The recognition of very long term place-based stewardship, sometimes in excess of 10,000 years, provides a unique aspect of place identity.

Many people even incorporate water or water-related activities as habitual or significant parts of their lives and cultures. Different factors are considered to measure/assess sense of place, including level of uniqueness, recognition, reputation, reliance, and appreciation for a place. Accounting for sense of place can provide strong incentives for conservation, preservation, and restoration efforts.

Despite its value as a cultural ecosystem service, it is difficult to quantify sense of place with direct measures. Examples of indicators may include the quality and availability of opportunities to support rituals, ceremonies and narratives and the level of satisfaction knowing that a place exists. Polls or surveys are often used to evaluate public opinions regarding economic and non-economic values of a place. Non-economic values may include existence or bequest value, which use surveys to estimate the value people would be willing to pay for resources to stay in a certain condition even though they may never actually use them. To comprehensively evaluate sense of place, sites may find it useful to consider subcategories such as place attachment and place identity. Furthermore, sites may determine that some aspects of Sense of Place may simply not be ratable using the framework of condition reports.

Provisioning (material benefits)

Commercial Harvest - The capacity to support commercial market demands for seafood products

Humans consume a large variety and abundance of products originating from the oceans and Great Lakes for nutrition or for use in other sectors. This includes fish, shellfish, other invertebrates, roe, and algae. Seafood is one of the largest traded food commodities in the world. Commercial fishing provides food for domestic and export markets, sold as wholesale and retail for household, restaurant and institutional meals. Seafood based industries include those that fish and harvest directly from wild capture and cultivated resources, as well as other businesses with functions throughout the supply chain including production of commercial gear, processors, storage facilities, buyers, transport and market outlets.

Within this category we also include what many call artisanal fishing, which can include commercial sale, but is also conducted by individuals or small groups who live near their harvest sites and use small scale, low technology, low cost fishing practices. Their catch is usually not processed (although it may be smoked or canned), and is mainly for local consumption or sale. Artisanal fishing uses traditional fishing techniques such as rod and tackle, fishing arrows and harpoons, cast nets, and sometimes small traditional fishing boats.

Fisheries located in national marine sanctuaries are usually encompassed by larger regional fisheries that are regulated by fisheries management plans. Fisheries management plans may include sanctuary-specific restrictions to protect sanctuary habitats, living resources, and archaeological resources, and to fulfill treaty obligations. Data that can be used to assess status and trends for this ecosystem service include: catch levels by species and species groups; and economic contributions in the form of sector-related jobs, income, sales, and tax revenue. Indirect measures include data on licensing, fleet size, fishing vessel types and sizes, days at sea, and commodity prices.

Subsistence Harvest – The capacity to support non-commercial harvesting of food and utilitarian products

Subsistence harvesting is the practice of collecting marine resources (e.g., fish, shellfish, marine mammals, seabirds, roe, and algae) either for food or for creating products that are utilitarian in nature (e.g., traditional medicine, shelter, clothing, fuel and tools) that are not for sale or income generation. Subsistence is conducted principally for personal and family use, and sometimes for community use, and may be distributed through ceremony, sharing, gifting, and bartering. Some people depend on subsistence fishing for food security and may have few other sources of income to provision their food and nutrition needs. Harvesting for subsistence is also a cultural or traditional practice for some people. It typically operates on a smaller and more local scale than commercial fishing. Natural resources that support subsistence harvest may also be used as ceremonial regalia or for cultural traditions, and therefore support other ecosystem services, including Heritage, Sense of Place, and Ornamentals. Data from surveys, tribal and indigenous knowledge and the status of fishery stocks can be used to assess the status and trends of this service.

Drinking Water — Providing water for human use by minimizing pollution, including nutrients, sediments, pathogens, chemicals, and trash

Clean water is considered a final ecosystem service when the natural environment is improving water quality for human consumption or other direct use (e.g., irrigation). Although sanctuary ecosystems often function to improve water quality, most do not result in the final ecosystem service of clean water for human use. For most natural resources, improving water quality in a sanctuary is a supporting or intermediate ecosystem service that may, for example, result in better water quality for fish species that are then enjoyed by commercial or recreational anglers, safer water in which to swim, or improved water clarity for diving. These are aspects of other final ecosystem services and the water quality itself is an indicator that is inherently important to them; however, ONMS does not include this aspect of clean water in condition reports because it would result in a double counting of its ecosystem service value. Instead, ONMS evaluates clean water as a final ecosystem service, where the natural environment is improving water for human consumption, such as drinking water, or for irrigation (e.g., through filtration or suitability for desalination). In this way, the benefits of management policies and actions that improve water quality are captured separately, but in relation to the relevant final ecosystem services they support.

Ornamentals — Resources collected for decorative, aesthetic, or ceremonial purposes

In sanctuaries where the collection of ornamental products is not prohibited or is allowed under permit, they are taken for their aesthetic or material value for artwork, souvenirs, fashion, handicrafts, jewelry, or display. This includes live animals for aquaria and trade, pearls, shells, corals, sea stars, furs, feathers, ivory, and more. Some, particularly animals for the aquarium trade, are sold commercially and can be valued like other commodities; others cannot. Some products may be decorative and relatively non-functional, others culturally significant and specifically functional, such as ceremonial regalia. Status and trends for the use of ornamentals can also be evaluated using indicators such as the number of permitted or other collectors, frequency and intensity of collection operations, and sales.

Biotechnology — Medicinal and other products derived or manufactured from sanctuary animals or plants for commercial use

Biochemical and genetic resources, medicines, chemical models, and test organisms are all potential products that can be derived or sourced from national marine sanctuaries. Biochemical resources include compounds extracted from marine animals and plants and used to develop or manufacture foods, pharmaceuticals, cosmetics, and other products (e.g., omega-3 fatty acids from fish oil, or microbes for spill or waste bioremediation). Genetic resources are the genetic content of marine organisms used for animal and plant breeding and for biotechnology. Natural resources can also be used as a model for new products (e.g., the development of fiber optic technology, based on the properties of sponge spicules). Items harvested for food consumption are evaluated in Commercial and Subsistence Harvest.

Collections of products for biotechnology applications may be allowed under permit, and sanctuary permit databases can also be used to gauge demand and collection activity within a given national marine sanctuary. The value of commercially sold products associated with biotechnology may also be available.

Renewable Energy — Use of ecosystem-derived materials or processes for the production of energy

In the offshore environment, energy production sources are considered to be either non-renewable (oil and gas) or renewable (wind, solar, tidal, wave, or thermal). While oil and gas technically are ecosystem-sourced and may be renewable over a time frame measured in millions of years, as an ecosystem service, they are not subject to management decisions in human time frames; therefore, they are not considered an ecosystem service in this section. The activities and management actions related to hydrocarbon production are, however, considered elsewhere in condition reports, primarily with regard to resource threats, impacts, and protection measures.

In contrast, “renewable” forms of energy that depend on ecosystem materials and processes operating over shorter time periods are evaluated. Indicators of status and trends for these energy sources include the types and number of permitted or licensed experimental or permanent operations, energy production, revenues generated, and jobs created. Indirect indicators that inform trends and provide some predictive value include social and market trends, energy costs, and expected demand based on service market populations trends.

Regulating (buffers to change)

Coastal protection — Natural features that control water movement and/or wind energy, thus protecting habitat, property, heritage resources and coastlines

Coastal and estuarine ecosystems can buffer the potentially destructive energy of environmental disturbances, such as floods, tidal surges and storm waves, and wind. Wetlands, kelp forests, mangroves, seagrass beds, and reefs of various types all absorb some of the energy of local disturbances, protecting themselves, submerged habitats closer to shore, intertidal ecosystems, and emergent land masses. They also can trap sediments and promote future protection through shoaling. They can also become sources of sediments for coastal dunes and beaches that control flooding and protect coastal properties from wave energy and the impacts of sea-level rise.

The value of coastal protection can be estimated by evaluating the basis of the value of vulnerable coastal properties and infrastructure and modeled estimates of losses expected under different qualities of coastal ecosystems (replacement cost). Levels of historical change under different energy scenarios can be used to support these estimates. Public polls can also reveal information on willingness to pay that is used to value this service.

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Questions and Rating Schemes for Status and Trends of Sanctuary Resources

Below are descriptions of the questions and possible responses used to report the condition of sanctuary resources in condition reports for all national marine sanctuaries. ONMS and subject matter experts use this guidance, as well as their own understanding of the condition of resources, to make judgments about the status and trends of sanctuary resources.

The resource questions derive from the National Marine Sanctuary System's mission (Office of National Marine Sanctuaries, 2022) and a system-wide monitoring framework (National Marine Sanctuary Program, 2004) developed to ensure the timely flow of data and information to those responsible for managing and protecting resources in the ocean and coastal zone, and to those that use, depend on, and study sanctuary resources. The resource questions are used to guide ONMS and its partners at each unit in the sanctuary system in the development of sanctuary condition reports. Evaluations of resource status and trends are based on the interpretation of quantitative and, when necessary, non-quantitative assessments and observations by scientists, managers, and users.

In 2012, ONMS reviewed and edited the resource questions and their possible responses that were developed for the first round of condition reports (drafted between 2007 and 2014; National Marine Sanctuary Program, 2004). The questions that follow are revised and improved versions of those original questions. Although all questions have been edited to some degree, both in their description and status ratings, the nature and intent of most questions have not changed. Five questions, however, are either new or are significantly altered and are therefore not directly comparable to the original questions posed in the first round of condition reports. For these, a new baseline will need to be established.

- In the Water Quality section, one climate change question was added. This was necessary to address the increasing awareness and attention to the issue following the original design of the condition report process, which began in 2002.
- Two Habitat questions were combined due to feedback received during the development of the first round of reports. A single question regarding the "integrity of major habitat types" has been created and combines prior questions that separately inquired about non-biogenic and biogenic habitats. Experience showed that experts considered the condition of certain species (e.g., kelp, corals, and seagrass) critical to their assessment of most habitat, including those often considered non-biogenic; thus separating the two provided little added value.

- Among the Living Marine Resources questions, one used in the first round of condition reports was removed entirely. It asked about "the status of environmentally sustainable fishing." It was removed for a variety of reasons. First, it was the only question focused on a single, specific human activity rather than a particular resource. Second, considerations of fishing activity are already included in the question regarding "human activities that may influence living resources." Finally, living resources that would provide a basis for judgment for this question are typically considered as part of other living resource questions, and need not be covered twice. Another change to the Living Marine Resources questions pertains to the question about the "health of key species," which was previously addressed in a single question, but is now split into two. The first asks specifically about the status of "keystone and foundation" species, the second about "other focal species." In both cases, the health of any species of interest can be considered in the judgment of status and trends.
- One of the initial questions addressed potential environmental hazards presented by heritage resources like shipwrecks. While the assessment of such threats is important, it was decided that the question was more appropriately addressed in the water quality and habitat contaminant questions rather than apply specifically to historic maritime properties. Therefore, the question was removed from the Maritime Heritage Resources section of the report and the subject is discussed in the context of other questions.

Ratings for a number of questions depend on judgments of the "ecological integrity" within a national marine sanctuary. This is because one of the foundational principles behind the establishment of sanctuaries is to protect ocean ecosystems. The term ecological integrity is used to imply "the presence of naturally occurring species, populations and communities, and ecological processes functioning at appropriate rates, scales, and levels of natural variation, as well as the environmental conditions that support these attributes" (modified from national park vital signs monitoring [National Park Service, 2021]). Sanctuaries have ecological integrity when they have their native components intact, including abiotic components (i.e., the physical forces and chemical elements, such as water), biotic elements (such as habitats), biodiversity (i.e., the composition and abundance of species and communities), and ecological processes (e.g., competition, predation, symbioses). For purposes of this report, the level of integrity that is judged to exist is based on the extent to which humans have altered specific components of the system, and the effect of that change on the ability of an ecosystem to resist continued change and recover from it. The statements for many questions are intended to reflect this judgment. Reference is made in the rating system to "near-pristine" conditions, for which this report would imply a status as near to an unaltered ecosystem as can reasonably be presumed to exist, recognizing that there are virtually no ecosystems on Earth completely free from human influence.

Not all questions, however, use ecological integrity as a basis for judgment. One focuses on the impacts of water quality factors on human health. Two questions rate the status of keystone and key species compared with that expected in an unaltered ecosystem. One rates maritime heritage resources based on their historical, archaeological, scientific, and educational value. Finally, four ask specifically about the levels of ongoing human activities (i.e., pressures) that could affect resource condition.

During workshops in which status and trends are rated, subject matter experts discuss each resource question and relevant indicators, available data, literature (e.g., published scientific studies, reports), and experience associated with the topic. They then discuss the statements provided as options for judgments about status; these statements have been customized for each question. Once a particular statement is agreed upon, a color code and status rating (e.g., good, fair, poor) is assigned. Experts can also decide that the most appropriate rating is “N/A” (i.e., the question does not apply), “undetermined” (i.e., resource status is undetermined due to a paucity of relevant information), or “mixed” (i.e., conflicting signals from indicators prevent the selection of a single status rating). A subsequent discussion is then held about the trend. Conditions are determined to be improving, remaining the same, or worsening over the time since the production of the prior condition report. Symbols used to indicate trends are the same for all questions: “▲”—conditions appear to be improving; “▬”—conditions do not appear to be changing; “▼”—conditions appear to be worsening; “▲▼”—conditions appear to be mixed; “?”—trend is undetermined; “N/A”—the question does not apply.

Human Drivers

1. What are the states of influential human drivers and how are they changing?

Driving forces are those characteristics of human societies that influence the nature and extent of pressures on resources. They are the underlying cause of change in coastal marine ecosystems, as they determine human use. Drivers are influenced by demographics (e.g., age structure, population, etc.), demand, economic circumstances, industrial development patterns, business trends, and societal values. They operate at global, regional, and local scales. Examples include increasing global demand for agricultural commodities, which increases the use of chemicals that degrade coastal water quality; difficult economic times that reduce fishing efforts for a period of time within certain regions; or local construction booms that alter recreational visitation trends. Other drivers could be the demands that govern trends, such as global greenhouse gas generation, regional shipping or offshore industrial development, local recreation and tourism, fishing, port improvement, manufacturing, and age-specific services (e.g., retirement). Each of these, in turn, influences certain pressures on natural and cultural resources.

Integrated into this question should be consideration of societal values, which include such matters as levels of conservation awareness, political leanings, opinion about environmental issues relative to other concerns, or changing opinions about the acceptability of specific behaviors (e.g., littering, fishing). Understanding these values gives one a better understanding of the likely future trends in drivers and pressures, as well as the nature of the societal tradeoffs in different uses of the ecosystem resources (e.g., the effects of multiple changing drivers on each other and the resources they affect). This can better inform policy and management responses, and education and outreach efforts that are designed to change societal values with the intention to change drivers and reduce pressures.

In rating the status and trends for drivers, the following should be considered:

- the main driving forces behind each pressure affecting natural resources and the environment
- the best available indicators of each driving force
- the status and trend of each driving force
- societal values behind each driving force
- the best indicators of societal values
- the status and trend of societal values

Good	Few or no drivers occur that have the potential to influence pressures in ways that will negatively affect resource qualities.
Good/Fair	Some drivers exist that may influence pressures in ways expected to degrade some attributes of resource quality.
Fair	Selected drivers are influencing pressures in ways that cause measurable resource impacts.
Fair/Poor	Selected drivers are influencing pressures in ways that result in severe impacts that are either widespread or persistent.
Poor	Selected drivers are influencing pressures in ways that result in severe, persistent, and widespread impacts.

Human Dimensions

2. What are the levels of human activities that may adversely influence water quality and how are they changing?

Among the human activities in or near sanctuaries that affect water quality are those involving direct discharges and spills (vessels, onshore and offshore industrial facilities, public wastewater facilities), those that contribute contaminants to groundwater, stream, river, and water control discharges (agriculture, runoff from impermeable surfaces through storm drains, conversion of land use), and those releasing airborne chemicals that subsequently deposit via particulates at sea (vessels, land-based traffic, power plants, manufacturing facilities, refineries). In addition, dredging and trawling can cause resuspension of contaminants in sediments. Many of these activities can be controlled through management actions in order to limit their impact on protected resources.

Good	Few or no activities occur that are likely to negatively affect water quality.
Good/Fair	Some potentially harmful activities exist, but they have not been shown to degrade water quality.
Fair	Selected activities have caused measurable resource impacts, but effects are localized and not widespread or persistent.
Fair/Poor	Selected activities have caused severe impacts that are either widespread or persistent.
Poor	Selected activities have caused severe, persistent, and widespread impacts.

3. What are the levels of human activities that may adversely influence habitats and how are they changing?

Human activities that degrade habitat quality do so by affecting structural (physical), biological, oceanographic, acoustic, or chemical characteristics of the habitat. Structural impacts, such as removal or mechanical alteration of habitat, can result from various fishing methods (e.g., trawls, traps, dredges, longlines, and even hook-and-line in some habitats), dredging of channels and harbors, dumping dredge spoil, grounding of vessels, anchoring, laying pipelines and cables, installing offshore structures, discharging drill cuttings, dragging tow cables, and placing artificial reefs. Removal or alteration of critical biological components of habitats can occur due to several of the above activities, most notably trawling, groundings, and cable drags. Marine debris, particularly in large quantities (e.g., lost gill nets and other types of fishing gear), can degrade both biological and structural habitat components. Changes in water circulation often occur when channels are dredged, fill is added, coastlines are armored or other construction takes place. Management actions such as beach wrack removal or sand replenishment on high public-use beaches, may impact the integrity of the natural ecosystem. Alterations in circulations can lead to changes in food delivery, waste removal, water quality (e.g., salinity, clarity and sedimentation), recruitment patterns, and a host of other ecological processes. Chemical alterations most commonly occur following spills and can have both acute and chronic impacts. Many of these activities can be controlled through management actions in order to limit their impact on protected resources.

Good	Few or no activities occur that are likely to negatively affect habitat quality.
Good/Fair	Some potentially harmful activities exist, but they have not been shown to degrade habitat quality.
Fair	Selected activities have caused measurable resource impacts, but effects are localized and not widespread or persistent.
Fair/Poor	Selected activities have caused severe impacts that are either widespread or persistent.
Poor	Selected activities have caused severe, persistent, and widespread impacts.

4. What are the levels of human activities that may adversely influence living resources and how are they changing?

Human activities that degrade the condition of living resources do so by causing a loss or reduction of one or more species, by disrupting critical life stages, by impairing various physiological processes, or by promoting the introduction of non-indigenous species or pathogens. (Note: Activities that impact habitat and water quality may also affect living resources. These activities are dealt with in the following human activity questions, and some may be repeated here as they also directly affect living resources).

For most sanctuaries, recreational or commercial fishing and collecting have direct effects on animal or plant populations, either through removal or injury of organisms. Related to this, lost fishing gear can cause extended periods of loss for some species through entanglement and "ghost fishing." In addition, some fishing techniques are size-selective, resulting in impacts to particular life stages. High levels of visitor use in some places also cause localized depletion, particularly in intertidal areas or on shallow coral reefs, where collecting and trampling can be chronic problems.

Mortality and injury to living resources has also been documented from cable drags (e.g., towed barge operations), dumping spoil or drill cuttings, vessel groundings, or repeated anchoring. Contamination caused by acute or chronic spills or increased sedimentation to nearshore ecosystems from road developments in watersheds (including runoff from coastal construction or highly built coastal areas), discharges by vessels, or municipal and industrial facilities can make habitats unsuitable for recruitment or other ecosystem services (e.g., as nurseries or spawning grounds). And while coastal armoring and construction can increase the availability of surfaces suitable for hard bottom species, the activity may disrupt recruitment patterns for other species (e.g., intertidal soft bottom animals), and natural habitat may be lost.

Oil spills (and spill response actions), discharges, and contaminants released from sediments (e.g., by dredging and dumping) can all cause physiological impairment and tissue contamination. Such activities can affect all life stages by direct mortality, reducing fecundity, reducing disease resistance, loss as prey and disruption of predator-prey relationships, and increasing susceptibility to predation. Furthermore, bioaccumulation results in some contaminants moving upward through the food chain, disproportionately affecting certain species.

Activities that promote the introduction of non-indigenous species include bilge discharges and ballast water exchange, commercial shipping and vessel transportation. Intentional or accidental releases of aquarium fish and plants can also lead to introductions of non-indigenous species.

Many of these activities are controlled through management actions in order to limit their impact on protected resources.

Good	Few or no activities occur that are likely to negatively affect living resource quality.
Good/Fair	Some potentially harmful activities exist, but they have not been shown to degrade living resource quality.
Fair	Selected activities have caused measurable living resource impacts, but effects are localized and not widespread or persistent.
Fair/Poor	Selected activities have caused severe impacts that are either widespread or persistent.
Poor	Selected activities have caused severe, persistent, and widespread impacts.

5. What are the levels of human activities that may adversely affect maritime heritage resources and how are they changing?

Maritime heritage resources are the wide variety of tangible and intangible elements (archaeological, cultural, historical properties) that reflect our human connections to Great Lakes and ocean areas.

Some human activities threaten the archaeological or historical condition of maritime heritage resources. Archaeological or historical condition is compromised when elements are moved, removed, or otherwise damaged. Threats come from looting, inadvertent damage by recreational divers, improper research methods, vessel anchorings and groundings, and commercial and recreational fishing activities, among others. Other human activities may alter or damage heritage resources by impacting the landscape or viewshed of culturally significant places or locations. Many of these activities can be controlled through management actions in order to limit their impact to maritime heritage resources.

Good	Few or no activities occur at maritime heritage resource sites that are likely to adversely affect their condition.
Good/Fair	Some potentially damaging activities exist, but they have not been shown to degrade maritime heritage resource condition.
Fair	Selected activities have caused measurable impacts to maritime heritage resources, but effects are localized and not widespread or persistent.
Fair/Poor	Selected activities have caused severe impacts that are either widespread or persistent.
Poor	Selected activities have caused severe, persistent, and widespread impacts.

Water Quality

6. What is the eutrophic condition of sanctuary waters and how is it changing?

Eutrophication is the accelerated production of organic matter, particularly algae, in a water body. It is usually caused by an increase in the amount of nutrients (largely nitrogen and phosphorus) being discharged to the water body. As a result of accelerated algal production, a variety of interrelated impacts may occur, including nuisance and toxic algal blooms, depleted dissolved oxygen, and loss of submerged aquatic vegetation (Bricker et al., 1999). Indicators commonly used to detect eutrophication and associated problems include nutrient concentrations, chlorophyll content, rates of water column or benthic primary production, benthic algae cover, algae bloom frequency and intensity, oxygen levels, and light penetration.

Eutrophication of sanctuary waters can impact the condition of other sanctuary resources. Nutrient enrichment often leads to plankton and/or algae blooms. Blooms of benthic algae can affect benthic communities directly through space competition. Indirect effects of overgrowth and other competitive interactions (e.g., accumulation of algal-sediment mats) often lead to shifts in dominance in the benthic assemblage, oxygen depletion, etc. Disease incidence and frequency can also be affected by algae competition and changes in the chemical environment along competitive boundaries. Blooms can also affect water column conditions, including light penetration and plankton availability, which can alter pelagic food webs. HABs, some of which are exacerbated by eutrophic conditions, often affect other living resources, as biotoxins are consumed or released into the water and air, or decomposition depletes oxygen concentrations.

Good	Eutrophication has not been documented, or does not appear to have the potential to negatively affect ecological integrity.
Good/Fair	Eutrophication is suspected and may degrade some attributes of ecological integrity, but has not yet caused measurable degradation.
Fair	Eutrophication has caused measurable but not severe degradation in some attributes of ecological integrity.
Fair/Poor	Eutrophication has caused severe degradation in some but not all attributes of ecological integrity.
Poor	Eutrophication has caused severe degradation in most if not all attributes of ecological integrity.

7. Do sanctuary waters pose risks to human health and how are they changing?

Human health concerns are generally aroused by evidence of contamination (usually bacterial or chemical) in bathing waters or seafood intended for consumption. They also arise when harmful algal blooms are reported or when cases of respiratory distress or other disorders attributable to harmful algal blooms increase dramatically. Any of these conditions should be considered in the course of judging the risk to humans posed by waters in a marine sanctuary.

Some sanctuaries may have access to specific information about beach closures and seafood contamination. In particular, beaches may be closed when criteria for water safety are exceeded. Shellfish harvesting and fishing may be prohibited when contaminant or biotoxin loads or infection rates exceed certain levels. Alternatively, seafood advisories may also be issued, recommending that people avoid or limit intake of particular types of seafood from certain areas (e.g., when ciguatera poisoning is reported). Any of these conditions, along with changing frequencies or intensities, can be important indicators of human health problems and can be characterized using the descriptions below.

Good	Water quality does not appear to have the potential to negatively affect human health.
Good/Fair	One or more water quality indicators suggest the potential for human health impacts but human health impacts have not been reported.
Fair	Water quality problems have caused measurable human impacts, but effects are localized and not widespread or persistent.
Fair/Poor	Water quality problems have caused severe impacts that are either widespread or persistent.
Poor	Water quality problems have caused severe, persistent, and widespread human impacts.

8. Have recent, accelerated changes in climate altered water conditions and how are they changing?

The purpose of this question is to capture shifts in water quality, and associated impacts on sanctuary resources, due to climate change. Though temporal changes in climate have always occurred on Earth, evidence is strong that changes over the last century have been accelerated by human activities. Indicators of climate change in sanctuary waters include water temperature, acidity, sea level, upwelling intensity and timing, storm intensity and frequency, changes in erosion and sedimentation patterns, and freshwater delivery (e.g., rainfall patterns). Climate-related changes in one or more of these indicators can impact the condition of habitats, living resources, and maritime archaeological resources in sanctuaries.

Increasing water temperature has been linked to changing growth rates, reduced disease resistance, and disruptions in symbiotic relationships (e.g., bleaching on coral reefs), and changes in water temperature exposure may affect a species' resistance or the capacity to adapt to disturbances. Acidification can affect the survival and growth of organisms throughout the food web, as well as the persistence of skeletal material after death (through changes in rates of dissolution and bioerosion). Recent findings also suggest acidification impacts at sensory and behavioral levels, which can alter vitality and species interactions. Sea level change alters habitats, as well as their use and persistence. Variations in the timing and intensity of upwelling is known to change water quality through factors such as oxygen content and nutrient flow, further disrupting food webs and the natural functioning of ecosystems. Changing patterns and intensities of storms alter community resistance and resilience within ecosystems that have, over long periods of time, adapted to such disturbances. Altered rates and volumes of freshwater delivery to coastal ecosystems affects salinity and turbidity regimes and can disrupt reproduction, recruitment, growth, disease incidence, phenology, and other important processes.

Good	Climate-related changes in water conditions have not been documented or do not appear to have the potential to negatively affect ecological integrity.
Good/Fair	Climate-related changes are suspected and may degrade some attributes of ecological integrity, but have not yet caused measurable degradation.
Fair	Climate-related changes have caused measurable but not severe degradation in some attributes of ecological integrity.
Fair/Poor	Climate-related changes have caused severe degradation in some but not all attributes of ecological integrity.
Poor	Climate-related changes have caused severe degradation in most if not all attributes of ecological integrity.

9. Are other stressors, individually or in combination, affecting water quality, and how are they changing?

The purpose of this question is to capture shifts in water quality due to anthropogenic stressors not addressed in other questions. For example, localized changes in circulation or sedimentation resulting from coastal construction or dredge spoil disposal can affect light penetration, salinity regimes, oxygen levels, productivity, waste transport, and other aspects of water quality that in turn influence the condition of habitats and living resources. Human inputs, generally in the form of contaminants from point or non-point sources, including fertilizers, pesticides, hydrocarbons, heavy metals, and sewage, are common causes of environmental degradation. When present in the water column, any of these contaminants can affect marine life by direct contact or ingestion, or through bioaccumulation via the food chain.

(Note: Over time, accumulation in sediments can sequester and concentrate contaminants. Their effects may manifest only when the sediments are resuspended during storm or other energetic events. In such cases, reports of status should be made under in the habitat/contaminants question.)

Good	Other stressors on water quality have not been documented, or do not appear to have the potential to negatively affect ecological integrity.
Good/Fair	Selected stressors are suspected and may degrade some attributes of ecological integrity, but have not yet caused measurable degradation.
Fair	Selected stressors have caused measurable but not severe degradation in some attributes of ecological integrity.
Fair/Poor	Selected stressors have caused severe degradation in some but not all attributes of ecological integrity.
Poor	Selected stressors have caused severe degradation in most if not all attributes of ecological integrity.

Habitat

10. What is the integrity of major habitat types and how are they changing?

Ocean habitats can be categorized in many different ways, including water column characteristics, benthic assemblages, substrate types, and structural character. There are intertidal and subtidal habitats. The water column itself is one habitat type (Federal Geographic Data Committee, 2012). There are habitats composed of substrates formed by rocks or sand that originate from purely physical processes. And, there are certain animals and plants that create, in life or after their death, substrates that attract or support other organisms (e.g., corals, kelp, beach wrack, drift algae). These are commonly called biogenic habitats.

Regardless of the habitat type, change and loss of habitat is of paramount concern when it comes to protecting marine and terrestrial ecosystems. Of greatest concern to sanctuaries are changes to habitats caused, either directly or indirectly, by human activities. Human activities like coastal development alter the distribution of habitat types along the shoreline. Changes in water conditions in estuaries, bays, and nearshore waters can negatively affect biogenic habitat formed by submerged aquatic vegetation. Intertidal habitats can be affected for long periods by oil spills or by chronic pollutant exposure. Marine debris, such trash and lost fishing gear, can degrade the quality of many different marine habitats including beaches, subtidal benthic habitats, and the water column. Sandy seafloor and hard bottom habitats, even rocky areas several hundred meters deep, can be disturbed or destroyed by certain types of fishing gear, including bottom trawls, shellfish dredges, bottom longlines, and fish traps. Groundings, anchors, and irresponsible diving practices damage submerged reefs. Cables and pipelines disturb corridors across numerous habitat types and can be destructive if they become mobile.

Integrity of biogenic habitats depends on the condition of particular living organisms. Coral, sponges, and kelp are well known examples of biogenic habitat-forming organisms. The diverse assemblages residing within these habitats depend on and interact with each other in tightly linked food webs. They may also depend on each other for the recycling of wastes, hygiene, and the maintenance of water quality. Other communities that are dependent on biogenic habitat include intertidal communities structured by mussels, barnacles, and algae and subtidal hard-bottom communities structured by bivalves, corals, or coralline algae. In numerous open ocean areas drift algal mats provide food and cover for juvenile fish, turtles, and other organisms. The integrity of these communities depends largely on the condition of species that provide structure for them.

This question is intended to address acute or chronic changes in both the extent of habitat available to organisms and the quality of that habitat, whether non-living or biogenic. It asks about the quality of habitats compared to those that would be expected in near-pristine conditions (see definition above).

Good	Habitats are in near-pristine condition.
Good/Fair	Selected habitat loss or alteration is suspected and may degrade some attributes of ecological integrity, but has not yet caused measurable degradation.
Fair	Selected habitat loss or alteration has caused measurable but not severe degradation in some attributes of ecological integrity.
Fair/Poor	Selected habitat loss or alteration has caused severe degradation in some but not all attributes of ecological integrity.

Poor	Selected habitat loss or alteration has caused severe degradation in most if not all attributes of ecological integrity.

11. What are contaminant concentrations in sanctuary habitats and how are they changing?

Habitat contaminants result from the introduction of unnatural levels of chemicals or other harmful material into the environment. Contaminants may be introduced through discrete entry locations, called point sources (e.g., rivers, pipes, or ships) and those with diffuse origins, called non-point sources (e.g., groundwater and urban runoff). Chemical contaminants themselves can be very specific, as in a spill from a containment facility or vessel grounding, or a complex mix, as with urban runoff. Familiar chemical contaminants include pesticides, hydrocarbons, heavy metals, and nutrients. Contaminants may also arrive in the form of materials that alter turbidity or smother plants or animals, therefore affecting metabolism and production.

This question is focused on risks posed primarily by contaminants within benthic formations, such as soft sediments, hard bottoms, or structure-forming organisms (see notes below). Not only are contaminants within benthic formations consumed or absorbed by benthic fauna, but resuspension due to benthic disturbance makes the contaminants available to water column organisms. In both cases contaminants can be passed upwards through the food chain. While the contaminants of most common concern to sanctuaries are generally pesticides, hydrocarbons, and nutrients, the specific concerns of individual sanctuaries may differ substantially.

Notes: 1) Contaminants in the water column addressed in the water quality section of this report should be cited, but details need not be repeated here; 2) many consider noise a pollutant, but in the interest of focusing here on more traditional forms of habitat degradation caused by contaminants, ONMS recommends addressing the impacts of acoustic pollution within the living resource section, most likely as it impacts key species.

Good	Contaminants have not been documented, or do not appear to have the potential to negatively affect ecological integrity.
Good/Fair	Selected contaminants are suspected and may degrade some attributes of ecological integrity, but have not yet caused measurable degradation.
Fair	Selected contaminants have caused measurable but not severe degradation in some attributes of ecological integrity.

Fair/Poor	Selected contaminants have caused severe degradation in some but not all attributes of ecological integrity.
Poor	Selected contaminants have caused severe degradation in most if not all attributes of ecological integrity.

Living Resources

12. What is the status of keystone and foundation species and how is it changing?

Certain species are defined as “keystone” within ecosystems, meaning they are species on which the persistence of a large number of other species in the ecosystem depends (Paine, 1966). They are the pillars of community stability (among other things, they strongly affect both resistance and resilience) and their contribution to ecosystem function is disproportionate to their numerical abundance or biomass. Their impact is therefore important at the community or ecosystem level. Keystone species are often called “ecosystem engineers” and can include habitat creators (e.g., corals, kelp), predators that control food web structure (e.g., Humboldt squid, sea otters), herbivores that regulate benthic recruitment (e.g., certain sea urchins), and those involved in critical symbiotic relationships (e.g., cleaning or co-habitating species).

“Foundation” species are single species that define much of the structure of a community by creating locally stable conditions for other species, and by modulating and stabilizing fundamental ecosystem processes (Dayton, 1972). These are typically dominant biomass producers in an ecosystem and strongly influence the abundance and biomass of many other species. Examples include krill and other zooplankton, kelp, forage fish, such as rockfish anchovy, sardine, and coral. Foundation species exhibit similar control over ecosystems as keystone species, but their high abundance distinguishes them.

Changes in either keystone or foundation species may transform ecosystem structure through disappearances of or dramatic increases in the abundance of dependent species. Not only do the abundances of keystone and foundation species affect ecosystem integrity, but measures of condition can also be important to determining the likelihood that these species will persist and continue to provide vital ecosystem functions. Measures of condition may include growth rates, fecundity, recruitment, age-specific survival, contaminant loads, pathologies (e.g., disease incidence, tumors, deformities), the presence and abundance of critical symbionts, or parasite loads.

Good	The status of keystone and foundation species appears to reflect near-pristine conditions and may promote ecological integrity (full community development and function).
Good/Fair	The status of keystone or foundation species may preclude full community development and function, but has not yet led to measurable degradation.
Fair	The status of keystone or foundation species suggests measurable but not severe degradation in some attributes of ecological integrity.
Fair/Poor	The status of keystone and foundation species suggests severe degradation in some but not all attributes of ecological integrity.
Poor	The status of keystone and foundation species suggests severe degradation in most if not all attributes of ecological integrity.

13. What is the status of other focal species and how is it changing?

This question targets other species of particular interest from the perspective of sanctuary management. These "focal species" may not be abundant or provide high value to ecosystem function, but their presence and health is important for the provision of other services, whether conservation, economic, or strategic. Examples include species targeted for special protection (e.g., threatened or endangered species), species for which specific regulations exist to minimize perturbations from human disturbance (e.g., touching corals, riding manta rays or whale sharks, disturbing white sharks, disturbing nesting birds), or indicator species (e.g., common murres as indicators of oil pollution). This category could also include so-called "flagship" species, which include charismatic or iconic species associated with specific locations, ecosystems or are in need of specific management actions, are highly popular and attract visitors or business, have marketing appeal, or represent rallying points for conservation action (e.g., humpback and blue whales, Dungeness crab).

Status of these other focal species can be assessed through measures of abundance, relative abundance, or condition, as described for keystone species. In contrast to keystone and foundation species, however, the impact of changes in the abundance or condition of focal species is more likely to be observed at the population or individual level, and less likely to result in ecosystem or community effects.

Good	Selected focal species appear to reflect near-pristine conditions.

Good/Fair	Reduced abundances in selected focal species are suspected but have not yet been measured.
Fair	Selected focal species are at reduced levels, but recovery is possible.
Fair/Poor	Selected focal species are at substantially reduced levels, and prospects for recovery are uncertain.
Poor	Selected focal species are at severely reduced levels, and recovery is unlikely.

14. What is the status of non-indigenous species and how is it changing?

This question allows sanctuaries to report on the threat posed and impacts caused by non-indigenous species. Also called alien, exotic, non-native, or introduced species, these are animals or plants living outside their native distributional range, having arrived there by human activity, either deliberate or accidental. Activities that commonly facilitate invasions include vessel ballast water exchange, restaurant waste disposal, and trade in exotic species for aquaria. In some cases, climate change has resulted in water temperature fluctuations that have allowed range extensions for certain species.

Non-indigenous species that have damaging effects on ecosystems are called "invasive" species. Some can be extremely destructive, and because of this potential, non-indigenous species are usually considered problematic and warrant rapid response after invasion. For those that become established, however, their impacts can sometimes be assessed by quantifying changes in affected native species. In some cases, the presence of a species alone constitutes a significant threat (e.g., certain invasive algae and invertebrates). In other cases, impacts have been measured, and may or may not significantly affect ecosystem integrity.

Evaluating the potential impacts of non-indigenous species may require consideration of how climate change may enhance the recruitment, establishment, and/or severity of impacts of non-indigenous species. Altered temperature or salinity conditions, for example, may facilitate the range expansion, establishment and survival of non-indigenous species while stressing native species, thus reducing ecosystem resistance. This will also make management response decisions difficult, as changing conditions will make new areas even more hospitable for non-indigenous species targeted for removal.

Good	Non-indigenous species are not suspected to be present or do not appear to affect ecological integrity (full community development and function).
Good/Fair	Non-indigenous species are present and may preclude full community development and function, but have not yet caused measurable degradation.
Fair	Non-indigenous species have caused measurable but not severe degradation in some attributes of ecological integrity.
Fair/Poor	Non-indigenous species have caused severe degradation in some but not all attributes of ecological integrity.
Poor	Non-indigenous species have caused severe degradation in most if not all attributes of ecological integrity.

15. What is the status of biodiversity and how is it changing?

Broadly defined, biodiversity refers to the variety of life on Earth, and includes the diversity of ecosystems, species and genes, and the ecological processes that support them (Convention on Biological Diversity, 2006). This question is intended as an overall assessment of biodiversity compared to that expected in a near-pristine system (one as near to an unaltered ecosystem as people can reasonably expect, given that there are virtually no ecosystems completely free from human influence). It may include consideration of measures of biodiversity (usually aspects of species richness and evenness) and the status of functional interactions between species (e.g., trophic relationships and symbioses). Intact ecosystems require that all parts not only exist, but that they function together, resulting in natural symbioses, competition, predator-prey relationships, and redundancies (e.g., multiple species capable of performing the same ecological role). Intact structural elements, processes, and natural spatial and temporal variability are essential characteristics of community integrity and provide a natural adaptive capacity through resistance and resilience.

The response to this question will depend largely on changes in biodiversity that have occurred as a result of human activities that cause depletion, extirpation or extinction, illness, contamination, disturbance, and changes in environmental quality. Examples include collection of organisms, excessive visitation (e.g., trampling), industrial activities, coastal development, pollution, activities creating noise in the marine environment, and those that promote the spread of non-indigenous species.

Loss of species or changing relative abundances can be mediated through selective mortality or changing fecundity, either of which can influence ecosystem shifts. Human activities of particular interest in this regard are commercial and recreational harvesting. Both can be highly selective and disruptive activities, with a limited number of targeted species, and often result in the removal of high proportions of the populations, as well as large amounts of untargeted species (bycatch). Extraction removes biomass from the ecosystem, reducing its availability to other consumers. When too much extraction occurs, ecosystem stability can be compromised through long-term disruptions to food web structure, as well as changes in species relationships and related functions and services (e.g. cleaning symbioses). This has been defined as "ecologically unsustainable" extraction (Zabel et al., 2003).

Good	Biodiversity appears to reflect near-pristine conditions and promotes ecological integrity (full community development and function).
Good/Fair	Selected biodiversity loss or change is suspected and may preclude full community development and function, but has not yet caused measurable degradation.
Fair	Selected biodiversity loss or change has caused measurable but not severe degradation in some attributes of ecological integrity.
Fair/Poor	Selected biodiversity loss or change has caused severe degradation in some but not all attributes of ecological integrity.
Poor	Selected biodiversity loss or change has caused severe degradation in most if not all attributes of ecological integrity.

Maritime Heritage Resources

16. What is the condition of known maritime heritage resources and how is it changing?

Maritime heritage resources are the wide variety of tangible and intangible elements (archaeological, cultural, historical properties) that reflect our human connections to Great Lakes and ocean areas.

Maritime heritage resources include archaeological and historical properties, and material evidence of past human activities, including vessels, aircraft, structures, habitation sites, and objects created or modified by humans. The condition of these resources in a marine sanctuary significantly affects their value for science and education, as well as the resource's eligibility for listing in the National Register of Historic Places. The "integrity" of archaeological/historical resources, as defined within the National Register criteria, refers to their ability to help scientists answer questions about the past through archaeological research. Historical significance of an archaeological resource depends on its integrity and/or its representativeness of past events that made a significant contribution to the broad patterns of history, its association with important persons, or its embodiment of a distinctive type or architecture.

Maritime heritage resources also include certain culturally significant resources, locations and viewsheds, the condition of which may change over time. Such resources, often more intangible in nature, may still be central to traditional practices and maintenance of cultural identity. The integrity of both cultural resources and cultural locations are included within the National Register criteria.

Section 110 of the National Historic Preservation Act requires federal agencies to inventory, assess, and nominate appropriate maritime heritage resources ("historic properties") to the National Register. The Maritime Cultural Landscape approach, adopted by the sanctuary system, provides a comprehensive tool for the assessment of archaeological, historical and cultural (maritime heritage) resources.

Assessments of heritage resources include evaluation of the apparent condition, which results from deterioration caused by human and natural forces (unlike questions about water, habitat, and living resources, the non-renewable nature of many heritage resources makes any reduction in integrity and condition, even if caused by natural forces, permanent). While maritime heritage resources have intrinsic value, these values may be diminished by changes to their condition.

Good	Known maritime heritage resources appear to reflect little or no unexpected natural or human disturbance.
Good/Fair	Selected maritime heritage resources exhibit indications of natural or human disturbance, but there appears to have been little or no reduction in aesthetic, cultural, historical, archaeological, scientific, or educational value.
Fair	The diminished condition of selected maritime heritage resources has reduced, to some extent, their aesthetic, cultural, historical, archaeological, scientific, or educational value, and may affect the eligibility of some sites for listing in the National Register of Historic Places.

Fair/Poor	The diminished condition of selected maritime heritage resources has substantially reduced their aesthetic, cultural, historical, archaeological, scientific, or educational value, and is likely to affect their eligibility for listing in the National Register of Historic Places.
Poor	The degraded condition of known maritime heritage resources in general makes them ineffective in terms of aesthetic, cultural, historical, archaeological, scientific, or educational value, and precludes their listing in the National Register of Historic Places.