Puget Sound Kelp Conservation and Recovery Plan

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Prepared by the Northwest Straits Commission, NOAA National Marine Fisheries Service, Puget Sound Restoration Fund, Washington Department of Natural Resources, and Marine Agronomics.

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Cover Photo: Bull kelp forest. Image courtesy of Eiko Jones Photography.

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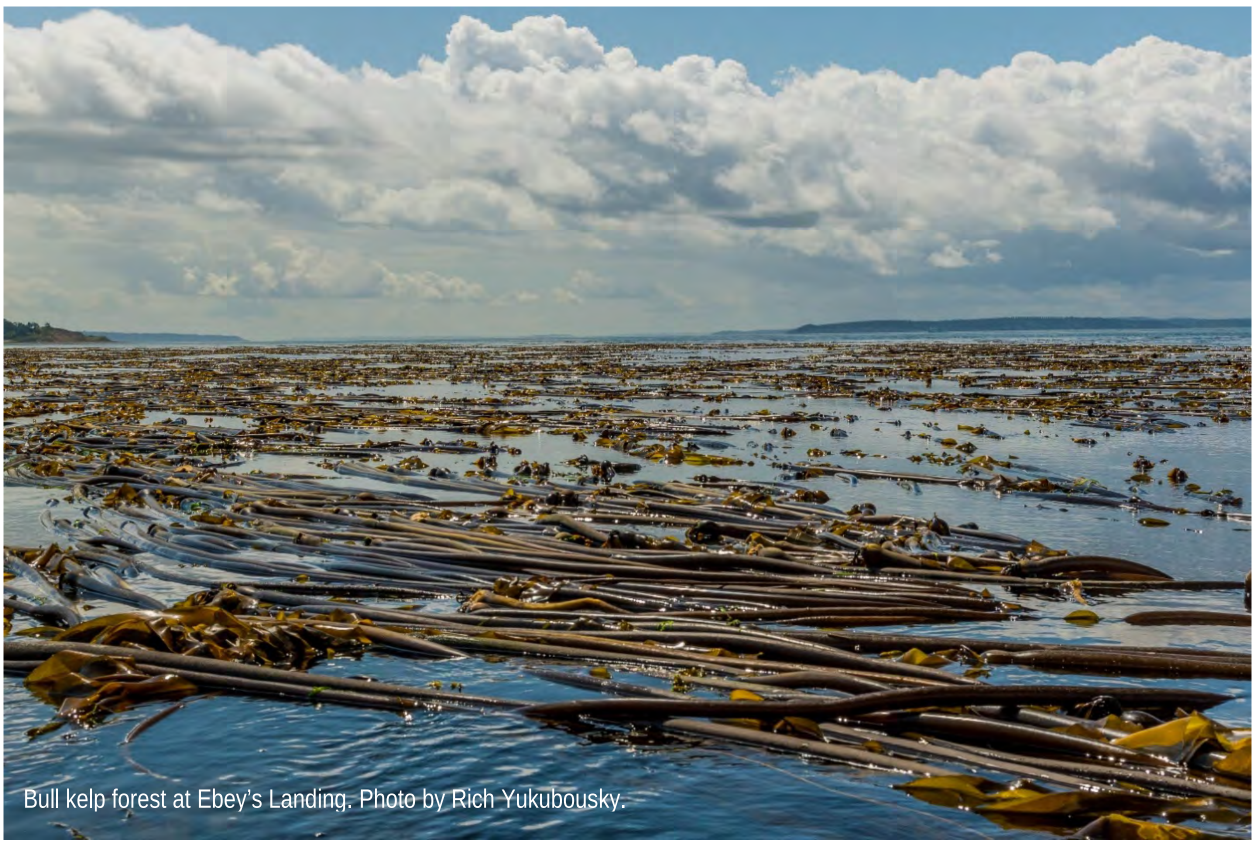


Bull kelp forest at Ebey's Landing. Photo by Rich Yukubousky.

List of Acronyms

CWA	Clean Water Act
DNR	Washington State Department of Natural Resources
DOE	Washington State Department of Ecology
EPA	United States Environmental Protection Agency
EFH	Essential Fish Habitat
ESA	Endangered Species Act
GMA	Growth Management Act
HPA	Hydraulic Project Approval
MRC	Marine Resources Committee
NGO	Non-Governmental Organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NWSC	Northwest Straits Commission
PSP	Puget Sound Partnership
PSRF	Puget Sound Restoration Fund
RCW	Revised Code of Washington
SMA	Shoreline Management Act
SMP	Shoreline Master Program
SRKW	Southern Resident killer whales
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WAC	Washington Administrative Code
WDFW	Washington State Department of Fish and Wildlife
WWTP	Wastewater Treatment Plant
YOY	Young of Year

I. Executive Summary

Kelp—some of the largest of all seaweeds—form extensive living structures that provide an array of valuable ecosystem goods and services to deep water and nearshore environments in Puget Sound. These underwater forests act as foundations for diverse and productive nearshore ecosystems, supporting food webs and providing critical habitat for a wide array of marine life.

Puget Sound is losing its kelp forests, according to both anecdotal observations and research. Extensive losses of bull kelp have been documented in South and Central Puget Sound, and localized declines have been observed throughout Puget Sound. Concerns also exist about potential losses to other kelp species, yet trends are unknown due to data gaps. Though kelp distribution and drivers of declines in Puget Sound are not well understood, data from kelp ecosystems in other temperate coastal regions indicate that widespread loss of kelp habitats would be devastating to the Puget Sound ecosystem. There is a consensus in the scientific community that coordinated action is needed to reverse downward trends in kelp populations by addressing both longstanding and emerging stressors. Cumulative impacts from human stressors threaten kelp, including water quality degradation (including but not limited to: pollution, nutrient loading, increased turbidity, sediment deposition), invasive species, and alterations to food-web dynamics from fishing pressure. Additionally, climate change and warming ocean waters pose new and intensifying threats to kelp resilience that often exacerbate the negative effects of other stressors.

This Puget Sound Kelp Conservation and Recovery Plan (Kelp Plan or Plan) provides a framework for coordinated research and management actions to protect these fundamental and iconic kelp species from a suite of global and local stressors. Successfully achieving kelp conservation and recovery will require a collaborative effort between our community of Tribes, managing entities, and stakeholders in Puget Sound. Additional collaboration with Canadian federal, provincial, and First Nation entities will support conservation and recovery efforts in the Puget Sound/Georgia Basin region.

Actions identified in this Kelp Plan address six strategic goals:

1. Reduce stressors;
2. Improve understanding of the value of kelp to Puget Sound ecosystems and integrate into management;
3. Describe kelp distribution and trends;
4. Designate kelp protected areas;
5. Restore kelp forests; and
6. Promote awareness, engagement, and action from user groups, Tribes, the public, and decision-makers.

We propose the following research, communication, and conservation actions to achieve these strategic goals.

1. **Reduce stressors**. Stressors on kelp from water quality degradation, urbanization/development, invasive species, and warming ocean temperatures are cumulatively affecting kelp and likely driving regional declines in bull kelp populations. These stressors are likely to increase in magnitude with continuing population growth and climate change.

   To reduce human impacts on water quality and kelp habitats:

   - Inform future management actions through continued research into the impacts of current and historic human activities on kelp forests (e.g., nutrient and sediment loading thresholds and impacts, turbidity effects on kelp recruitment, substrate availability).
   - Identify priority stressors negatively affecting Puget Sound kelp on a sub-regional scale in order to target management actions.
   - Fully implement and enforce available protections for kelp through existing regulations, programs, and policies. (e.g., Department of Ecology Shoreline Management Act Guidance, Local Shoreline Master Programs, Washington Department of Fish and Wildlife Hydraulic Project Approvals, Department of Natural Resources Aquatic Use Authorization, mitigation programs, National Marine Fisheries Service Endangered Species Act and Essential Fish Habitat consultations).
   - Increase protection for kelp populations by addressing key gaps in existing regulations and implementation programs.
   - Form interagency workgroups to increase collaboration and information sharing across management organizations, to improve implementation, and to address policy gaps.
   - Reduce anthropogenic nutrient and sediment loading (e.g., stormwater and wastewater treatment plant permitting, and total maximum daily load planning). Support sustainable kelp harvest by informing recreational harvesters about regulations and sustainable kelp harvest methods.

   To reduce impacts from biological stressors:

   - Strive to incorporate kelp and other trophic considerations into fisheries management planning.
   - Explore invasive macroalgae (*Sargassum muticum* and *Undaria pinnatifida*) control alternatives, ecological roles, and long-term management considerations with respect to climate change.

To reduce impacts from climate change:

- Investigate climate change impacts to better inform management decisions, such as prioritizing locations for kelp protected areas, restoration sites, and mitigation activities.
- Investigate climate-related benefits of kelp, and develop management opportunities for these benefits.
- Investigate temperature-tolerant strains of native kelp species for potential use in restoration and mitigation outplanting in regions where local stressors are reduced.

2. **Improve understanding of the value of kelp to Puget Sound ecosystems and integrate into management.** Kelp provides critical habitat as well as food and foraging opportunities for associated nearshore species in Puget Sound. Quantifying services provided by kelp will support management actions, especially for pinto abalone, and threatened and endangered species of rockfish salmon, and Southern Resident killer whales.

   To improve understanding of kelp value:

   - Quantify functional roles of kelp habitats for associated species and provide guidance to managers on regulatory implementation, such as endangered species habitat conservation.
   - Calculate the value of kelp ecosystem services for use in developing mitigation guidance.

3. **Describe kelp distribution and trends.** Successful implementation of existing regulations relies on accurate information regarding the distribution and trends. Consistent and coordinated multi-year monitoring is essential for establishing accurate inventories and understanding natural variation.

   To gain accurate information on kelp distribution and trends:

   - Update and expand information on the current extent of canopy-forming and understory kelp.
   - Make distribution and trends data available to agencies and the public for use in spatial planning, project planning, and regulatory implementation.
   - Coordinate strategic monitoring of canopy-forming and understory kelp throughout Puget Sound through expanding efforts and building collaborations between organizations.
   - Expand understanding of historical distributions and trends by compiling historical information sources and exploring traditional ecological knowledge.
   - Identify the genetic structure of kelp populations, including connectivity, dispersal, and population dynamics.

- Form research and monitoring workgroup to increase collaboration and information sharing across organizations.

4. **Designate kelp protected areas.** Puget Sound kelp recovery begins with the conservation and protection of kelp forests.

   To protect kelp habitat:

   - Protect special kelp habitat in existing and new reserves, refuges, and protected areas.
   - Assess the extent of recreational kelp harvest and its potential impacts. Develop spatial management plans and strategies for kelp harvest activities.

5. **Restore kelp forests.** Restoring historic kelp forests requires indirect habitat improvement through stressor reduction and direct kelp population enhancement in areas where natural recruitment is limited. In addition to reducing stressors responsible for declines, developing best practices will be critical for successful kelp restoration and mitigation projects.

   To restore kelp forests:

   - Develop spatial plan identifying regions and sites for priority restoration actions and mitigation.
   - Continue development of kelp restoration techniques for use in enhancement and mitigation projects.
   - Fund and implement restoration activities at priority sites.

6. **Promote awareness, engagement, and action from user groups, Tribes, the public, and decision-makers.** The success of this Plan and the conservation and recovery of kelp in Puget Sound depends on increased awareness, engagement, and support of actions to sustain kelp.

   To promote awareness, engagement, and support:

   - Share information on (1) the value and role of kelp ecosystems as critical nearshore habitat and food web support (for forage fish, rockfish, salmon, and killer whales) in Puget Sound; and (2) the growing concern regarding significant losses to bull kelp canopies.
   - Build research capacity through coordinated knowledge sharing of ongoing kelp recovery projects and research gaps.

At the heart of these strategic goals is the need for continued interagency coordination; communication between researchers and managers; and funding to support research, monitoring, education, outreach, implementation, and enforcement. The actions outlined in this Kelp Plan require a unified collaborative effort from federal and state management agencies, Washington State Tribes, Non-governmental organizations (NGOs), and local stakeholders. Raising awareness of the need to support kelp conservation and recovery will help further strengthen budding collaborative partnerships. This Kelp Plan is intended as a call to action, advocating that kelp be included as a necessary element of ecosystem-wide recovery planning, including prioritization of funding to support the actions outlined in this Plan.

Black rockfish swimming in bull kelp forest near Keystone Jetty.
Photo by Adam Obaza- Paua Marine Research.

II. Introduction

Kelp—groups of brown algae that include some of the largest of all seaweeds—provide valuable ecosystem goods and services to deep water and nearshore environments. Underwater kelp forests act as foundations for diverse and productive nearshore ecosystems, supporting food webs and providing critical habitat for a wide array of marine life (von Biela et al. 2016; Christie et al. 2009; Steneck et al. 2002).

Washington State is home to a diverse community of canopy and understory kelp, with 22 kelp species found along the outer coast and within Puget Sound (Appendix A provides a full list of these species). Puget Sound contains 17 species of kelp, which form extensive biogenic (living) structures that serve as critical habitat for many taxa, including several fish species listed as species of concern by Washington State and endangered or threatened under the federal Endangered Species Act (ESA). This Plan employs the term "kelp" to refer to multiple species in Order Laminariales, and common names to refer to individual species, such as bull kelp.

Most available information on kelp in Puget Sound pertains to bull kelp (*Nereocystis luetkeana)*. Despite a lack of systematic surveys, available data from multiple sources document long-term declines in the canopy cover of bull kelp within several areas of Puget Sound. While bull kelp forests are not declining everywhere, many historic Puget Sound bull kelp forests—especially in Central and South Puget Sound—have been entirely lost or reduced to vestiges of historic abundances. The consequences of these declines are not limited to the direct effects on kelp populations, but also influence, both directly and indirectly, the many species and ecosystem services that depend on the presence of kelp forests. Though the distribution and drivers of declines in Puget Sound are not well understood, data from kelp ecosystems in other temperate coastal regions indicate that large-scale loss of kelp habitats would be devastating to the Puget Sound ecosystem (Steneck et al. 2002; Graham 2004; Rogers-Bennett and Catton 2019).

2.1 Purpose of the Conservation and Recovery Plan

The Puget Sound Kelp Conservation and Recovery Plan (herein referred to as "the Kelp Plan" or "Plan") provides a framework for research, conservation, and recovery actions aimed at protecting and restoring Puget Sound kelp and the goods and services provided by them.

The Kelp Plan aims to address the following strategic goals:

1. Reduce stressors;
2. Improve understanding of the value of kelp to Puget Sound ecosystems and integrate into management;
3. Describe kelp distribution and trends;
4. Designate kelp protected areas;

5. Restore kelp forests; and
6. Promote awareness, engagement, and action from user groups, Tribes, the public, and decision-makers.

The Kelp Plan recommends research, communication, and conservation actions associated with these strategic goals. The overarching intent is to strengthen the implementation of existing regulatory and management policies and to develop additional tools to conserve and restore Puget Sound kelp habitats. Successfully achieving kelp conservation and recovery will require collaboration between the community of scientists, Tribes, managing entities, and stakeholders in Puget Sound.

Recommended management actions, particularly those focused on reducing stressors, support recovery plans for other species and issues of concern, including eelgrass (Goldmark et al. 2015), rockfish (NMFS 2017), and ocean acidification (Washington State Blue Ribbon Panel on Ocean Acidification 2012; Washington Marine Resources Advisory Council 2017). Actions identified in these plans and other actions that protect and improve Puget Sound ecosystem health benefit kelp, but kelp is often left out of local discussions pertaining to critical species that warrant protection and recovery measures. This Kelp Plan is intended as a call to action. It advocates for recognizing that kelp is an integral element of ecosystem-wide recovery planning, including the prioritization of funding to support the actions outlined in this Kelp Plan.

This Kelp Plan is a call to action! Kelp is a critical element of ecosystem-wide recovery.

2.2 Plan Development and Coordination

Efforts to develop a conservation and recovery plan for Puget Sound kelp began in 2017 after the need to conserve kelp habitats in Puget Sound arose as a priority during the development of the Rockfish Recovery Plan for Puget Sound and the Georgia Basin (NMFS 2017). Participants in the rockfish recovery planning process stressed the importance of kelp habitats that support the highest densities of most juvenile rockfish species as part of rockfish recovery. Consequently, the rockfish recovery plan outlines the need for synthesizing available research on kelp, improving understanding of kelp distribution, and developing conservation and restoration approaches for kelp habitats (NMFS 2017 Appendix V). Following the completion of the rockfish recovery plan, NOAA's National Marine Fisheries Service (NMFS) allocated funds for the development of the Kelp Plan.

Development of the Kelp Plan began in September 2017 and proceeded during a two-year process led by the Northwest Straits Commission (NWSC) with invaluable guidance and support from the Puget Sound Restoration Fund (PSRF), Marine Agronomics LLC, Washington Department of

Natural Resources (DNR), and NMFS. Activities included forming the Kelp Core Team to oversee plan development; synthesizing literature and current research on kelp in Puget Sound; holding workshops with researchers, agencies, tribes, and stakeholders; and facilitating peer review and public comment.

Kelp Core Team

The Kelp Core Team provided technical expertise during Kelp Plan development and workshop planning and reviewed deliverables. The Kelp Core Team includes the following organizations:

Puget Sound Restoration Fund,

Washington Department of Natural Resource,

Marine Agronomics LLC,

NMFS,

Northwest Straits Commission, and

Northwest Straits Foundation.

Knowledge Review and Data Gaps

Efforts in Year 1 of Plan development focused on synthesizing and communicating available data and current research on kelp in Puget Sound through a literature review and two workshops. In Year 2, technical experts were surveyed on needs for kelp recovery and the results were used to create a prioritized list of the knowledge gaps. This list was then used to guide decisions for kelp conservation and recovery strategies. The survey results are provided in Appendix C.

Workshops

Four workshops were held during the Kelp Plan development process. These workshops brought together technical experts to share current research, review data gaps, prioritize actions to address data gaps, and discuss management opportunities and needs. Workshop participants and notes are available for review in Appendix C.

Workshops in 2018 focused on discussing kelp status and trends, stressors, and ecosystem linkages, and then identifying data gaps and associated research and monitoring. Workshops held in 2019 focused on outlining actions to address high-priority knowledge gaps and identifying management and policy tools, gaps, and opportunities. Results from votes tallied at workshops revealed consensus among workshop participants on research and monitoring needs that support specific management actions.

Puget Sound Conservation and Recovery Plan Area

Recommended conservation and recovery actions in the Kelp Plan are specific to Puget Sound,[1] defined here as the southern arm of an inland sea located on the Pacific Coast of North America and connected to the Pacific Ocean by the Strait of Juan de Fuca. Puget Sound can be subdivided into basins including South, South Central, and North Central Puget Sound, Whidbey, Hood Canal, the San Juan Islands and Georgia Strait, and the Strait of Juan de Fuca. The western boundary for the Kelp Plan is the Victoria Sill, a significant oceanographic feature in the Strait of Juan de Fuca. Figure 1 shows the Puget Sound Kelp conservation and recovery plan area. Patterns of circulation created by the Victoria Sill create discontinuities in temperature, salinity (Masson and Cummins 2000), nitrogen (Mackas and Harrison 1997), primary production (Foreman et al. 2008), and water column organic carbon (Johannessen et al. 2008)—all of which combine to create habitat conditions within the basins of the Puget Sound that are distinct from the exposed coast.

Bull kelp forest. Image courtesy of Florian Graner.

[1] The Washington State Legislature defines Puget Sound as Water Resource Inventory Areas (WRIA) 1-19.

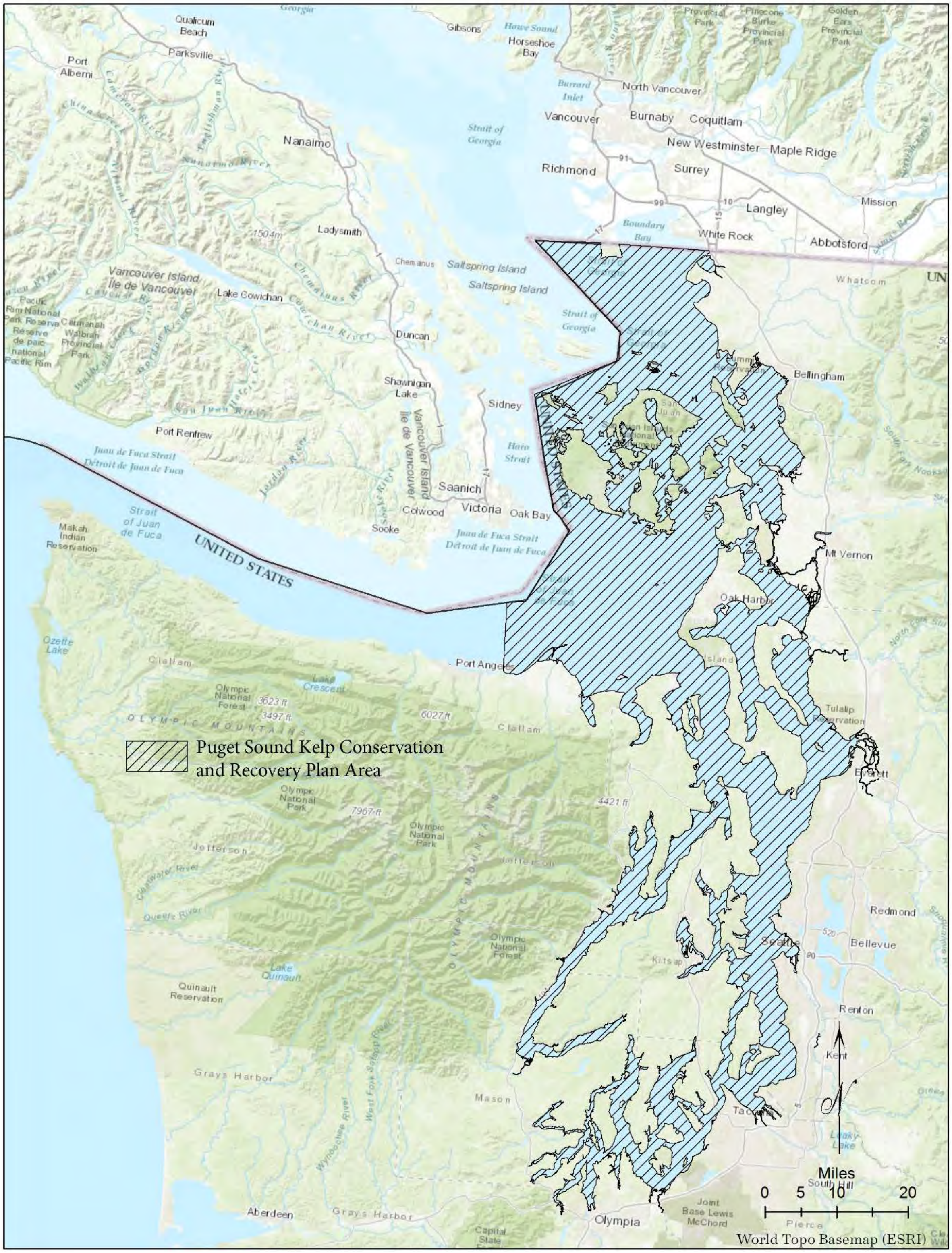


Figure 1. Map of Puget Sound Kelp Conservation and Recovery Plan Area. The Plan area is indicated by the cross-hatched area.

2.3 Precautionary Principle and Adaptive Management

The precautionary principle stresses the implementation of conservation measures for critical habitats even in the absence of scientific certainty (Brisman 2011; Harremoes et al. 2002). Available data document significant losses of bull kelp in several basins. The fact that other kelp species share similar environmental requirements with bull kelp raises concerns about losses to understory species as well (Dayton 1985). Additionally, research in British Columbia documented declines in multiple species of kelp, in addition to floating kelp (Starko et al, 2019). In light of this evidence, and given the importance of these habitats to threatened and endangered species, a precautionary approach that includes monitoring, conservation, and restoration actions (particularly for bull kelp) is warranted.

Kelp conservation and recovery planning will need to be reviewed and updated as research and actions improve our understanding of kelp distribution, key stressors, and priority management actions. Scientific uncertainties in Puget Sound kelp distribution and trends, and the impact of global and local stressors warrant adaptive management (Goetz et al., n.d.). Both the precautionary principle and adaptive management approaches are meant to be iterative processes, dynamically responding to the best-available-science as research improves our understanding of Puget Sound kelp ecosystems.

There is a rising concern across the research and management communities that without coordinated research and conservation actions, kelp abundance could decline beyond a critical threshold, below which natural recovery is not possible. Adaptive management approaches, including restoration activities, could lead to improved habitat function for kelp ecosystems.

The Precautionary Principle stresses the implementation of conservation measures for critical habitats even in the absence of scientific certainty.

III. Puget Sound Kelp Overview

3.1 Kelp Biology

Puget Sound is home to 17 species of kelp.

The term "kelp" broadly refers to large (10 cm to 30 m) brown macroalgae (Phylum Phaeophyta, Class Phaeophyceae) in the order Laminariales. Puget Sound, as defined by this Plan in Section 2.2, is home to 17 species of kelp (Appendix A). Giant kelp *(Macrocycsit pyrifera*) is excluded from the Kelp Plan because its range is restricted to the western Strait of Juan de Fuca, which is outside the Plan area.

In the macroscopic phase, kelp can be annual or perennial, depending on the species (Schiel and Foster 2006). Kelp species in Puget Sound are adapted to cold temperate waters and grow optimally at five to 15 °C (Bartsch et al. 2008; Maxell and Miller 1996; Tera Corp. 1982). Many common kelp species, such as bull kelp and sugar kelp, die back in the late fall and winter before appearing again as early as February (Allen 2018; Druehl and Hsiao 1977).

Kelp Life History

All kelp species have two distinct life phases, each with different environmental requirements and stress thresholds (Geange et al. 2014). In its macroscopic form kelp sporophytes produce reproductive patches (sori) along their blades that release microscopic zoospores that germinate into male and female microscopic gametophytes (Hurd et al. 2014; Schiel and Foster 2006). Male and female gametophytes produce spermatia and eggs, respectively, and eggs fertilized by spermatia produce microscopic sporophytes that typically grow to adult size within one season. Figure 2 illustrates the kelp life stages. In Puget Sound, where kelp forests are largely annual in nature, microscopic life stages overwinter until the spring (Carney and Edwards 2006). However, the ecology of the microscopic life stage(s) that overwinters is not well understood at this time.

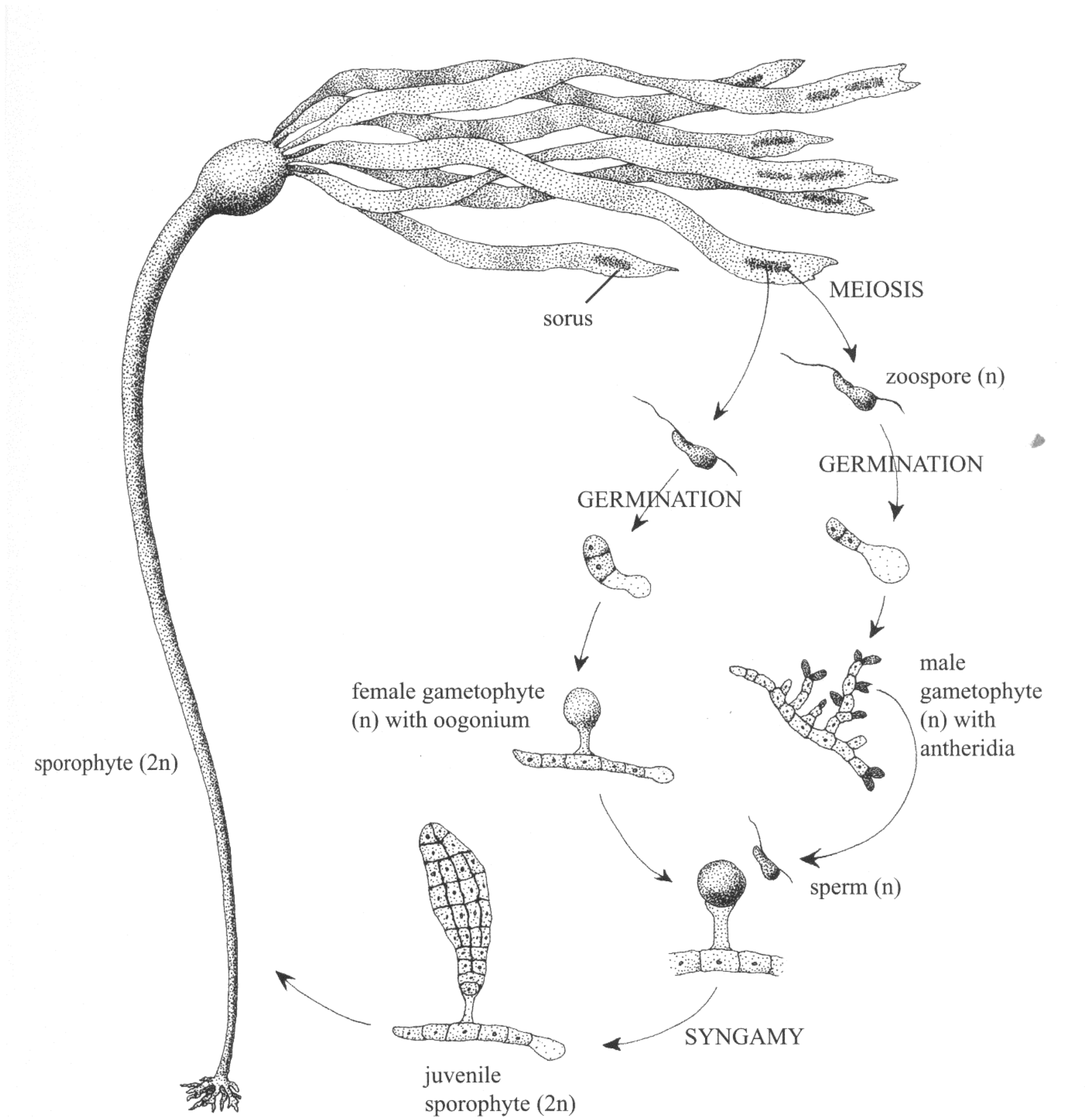


Figure 2. Diagram of kelp life stages. Illustration by Lisa (Scharf) Spitler. In: Mondragon J, and J. Mondragon. 2003. Seaweeds of the Pacific Coast: Common Marine Algae from Alaska to Baja California. Sea Challengers, Monterey California, 97 pages.

Kelp Forest Structure

The term “kelp forest” encompass the community and services provided by intact ecosystems dominated by kelp species. Kelp habitats are composed of multiple species and strata (stories) that rise above the benthos (seafloor) and can extend up to 10 to 20 meters to the surface (Steneck et al. 2002; Figure 3). Kelp sporophytes are organized into three types, shown in Figure 3, based on morphology:

- **Prostrate kelp** lack a rigid stipe or gas-filled buoy (pneumatocyst) and remain close to the seafloor, forming thick understories. For example *Saccharina latissima, Costaria costata and Agarum clathratum.*
- **Stipitate kelp** stand erect with the help of rigid stipes (stems), thus forming a midstory. For example *Pterygophora californica.*
- **Floating kelp** rely on pneumatocysts to hold the plant up in the water column and can create large, floating surface canopies. For example bull kelp (*Nereocysits luetkeana)* and giant kelp (*Macrocystis pyrifera*).

Kelp communities with all three morphological groups form the most structurally complex forests whose large volume of living habitat provides critical foundations for nearshore ecosystems and food webs (Teagle et al. 2017; Steneck et al. 2002). Prostrate kelp species are the most commonly distributed species in Puget Sound, providing important primary production, refuge, and habitat (DNR n.d.). In addition, kelp species host diverse microbial biofilms whose functional roles are not yet known and may play a role in future recovery efforts (Weigel and Pfister 2019).

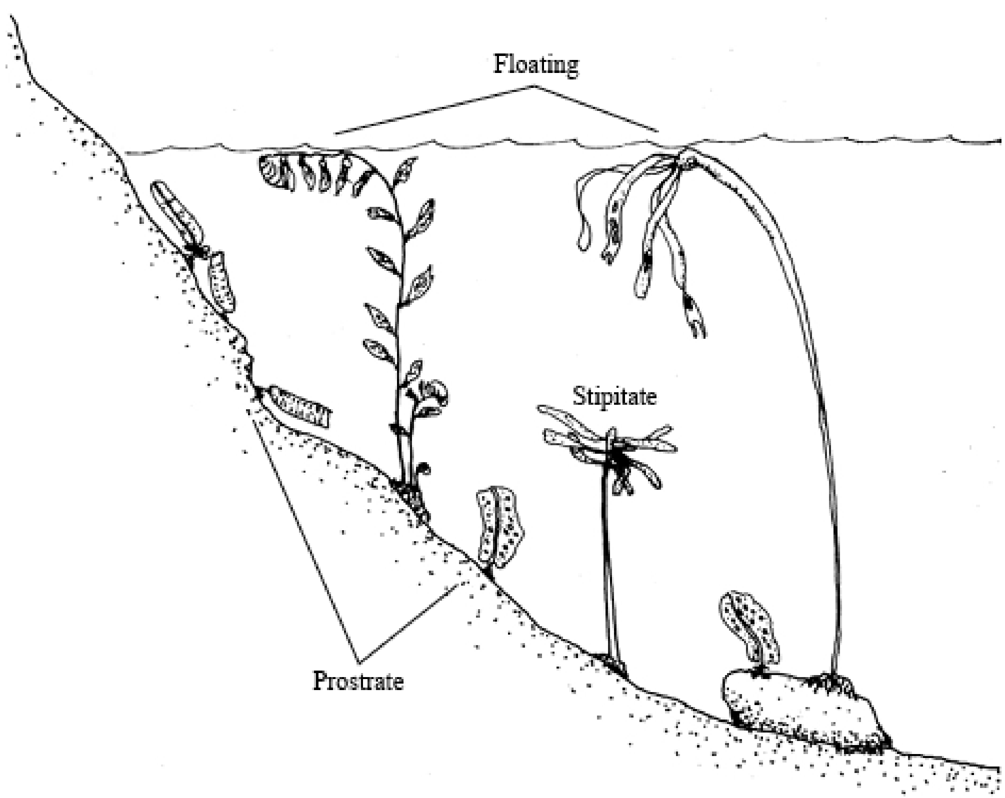


Figure 3. Kelp growth forms showing prostrate, stipitate and floating kelp species. Illustration by Tom Mumford, 2019.

3.2 Kelp Ecosystem Goods and Services

In Washington State, kelp forests uptake 27 to 136 metric tons of carbon per day. That is equivalent to the emissions of approximately 2,000 to 10,500 vehicles per year.

Kelp forests provide a variety of indirect and direct services for nearshore marine habitats and human coastal populations. In Washington State alone, kelp forests uptake 27 to 136 metric tons of carbon per day (Pfister et al. 2019), the equivalent of carbon emissions from between approximately 2,000 to 10,500 vehicles a year (EPA 2018). Like eelgrass, kelp ecosystems provide critical habitat that increases overall biodiversity. The ecosystems are important for many economically valuable species, including threatened salmon (*Oncorhynchus* spp.) and endangered rockfish (*Sebastes* spp.) (Shaffer et al. 2019; NMFS 2017; Shaffer 2004). Kelp ecosystems are an important base of the food web, eventually supporting marine mammals, including killer whale populations (Unsworth et al. 2018; Altieri and van de Koppel 2014). Kelp species are also powerful ecosystem engineers that at high densities can improve water quality by assimilating nitrogen (Kim et al. 2015) and slow the movement of water (Gaylord et al. 2007), potentially acting as natural breakwaters. This dampening of water motion increases the residence time of nutrients and particles (Eckman et al. 1989), potentially increasing larval densities and leading to greater food availability within kelp forests. Finally, kelp forests offer diverse recreation opportunities to local residents, including productive fishing grounds, and picturesque kayak and dive sites.

Kelp as Critical Habitat

Globally, kelp forests provide more biomass and surface area per unit area than seagrass meadows (Teagle et al. 2017). Kelp creates large volumes of high-quality habitat in areas with hard and rocky substrates unsuitable for eelgrass or saltmarsh vegetation, although the two habitats can and do mix in shallow cobble areas. Primary production in kelp forests often rivals that found in tropical rainforests per unit area (Krumhansl et al. 2016), and, in Washington waters, kelp biomass production is up to six times that of phytoplankton per unit volume (Pfister et al. 2019). This high productivity provides an important food source that supports trophic food webs inside kelp forests and contributes to food webs in neighboring deep-water and shoreline habitats (Olson et al. 2019; Schooler et al. 2019; Zuercher and Galloway 2019; Duggins et al. 2016; Filbee-Dexter and Scheibling 2016; Krause-Jensen and Duarte 2016).

The food and shelter benefits provided by kelp species increase at higher trophic levels (von Biela et al. 2016). For example, kelp forests in Norway harbor a greater abundance of marine invertebrates than other marine vegetated areas; in some cases, invertebrate abundance is five times higher than in eelgrass meadows (Christie et al. 2009). The high volume of habitat provided by kelp, creates refuges where juvenile salmon, young-of-year rockfish, and mid-trophic-level species like forage fish, can feed in relative safety, allowing for higher growth rates and greater survivorship (Olson et al. 2019; Shaffer et al. 2019; O’Brien et al. 2018; Shaffer 2004). Adult coho salmon, chinook salmon, and rockfish remain reliant on nearshore kelp habitats for foraging opportunities throughout their adult life (Shaffer et al. 2019; Koenigs et al. 2015; Johnson and Schindler 2009). Healthy populations of these fish, particularly salmon, provide important prey for iconic Puget Sound predators, including killer whales (particularly Southern Resident killer whales), birds, and other marine mammals (Southern Resident Orca Taskforce 2019; Harvey et al. 2012).

Kelp species provide 25 times more habitat biomass than eelgrass.

The Cultural Importance of Kelp for Pacific Northwest Tribes

The first human inhabitants of the Pacific Northwest likely followed a near-continuous band of floating kelp canopies dubbed “the kelp highway” that extended along the Pacific Rim from Asia to South America (Erlandson et al. 2015; Erlandson et al. 2007). Within the Pacific Northwest, bull kelp played a particularly prominent role in traditional subsistence knowledge and technology and was used in fishing, hunting, and food preparation and storage (Boas and Hunt 1921; Stewart 1977; Turner and Bell 1971; Turner 1995; Turner 2001). It was also put to more playful uses by both children and adults, who used the kelp for toys and target practice (Turner 1979, 2001).

Kelp plays an important role in the symbolic and spiritual aspects of traditional Northwest Coast cultures. In some oral histories, kelp represents the interdependence between indigenous people and the sea and the reciprocal ties of kinship between humans and supernatural beings. In other stories, however, murderous kelp beings remind people of the potential dangers of the ocean. Appendix B provides more detail on the cultural importance of kelp for Pacific Northwest Tribes.

3.3 Kelp Distributions, Trends, and Regional Changes

Kelp forest persistence is highly dynamic over time but evidence increasingly suggests that climate change stressors will lead to widespread and long-term declines in kelp populations (Connell et al. 2019; Smale 2019; Wernberg et al. 2019; Rogers-Bennet and Catton 2019). Kelp forests in many regions across the globe show declines. Persistent declines to kelp forests have been documented in North-Central California, Nova Scotia, the Gulf of Maine, Ireland, Norway, and South Australia (Wernberg et al. 2019). Recent kelp declines in Northern California (Rogers-Bennett and Catton 2019), Australia (Connell et al. 2019), and other locations (Wernberg et al. 2019; Filbee-Dexter and Wernberg 2018; Airoldi and Beck 2007) have been severe with little to no natural recovery. Causes of kelp loss vary by region but generally involve a combination of local and global stressors interacting additively or synergistically (Rogers-Bennett and Catton 2019; Filbee-Dexter and Wernberg 2018). Regardless of the cause, declines in the kelp populations can result in substantial losses to nearshore biodiversity and negatively impact fisheries, tourism, and coastal health (Bertocci et al. 2015; Koenigs et al. 2015; Graham 2004).

Losses in kelp populations result in losses to nearshore biodiversity and negatively impact fisheries, tourism, and coastal health.

Kelp Distributions and Trends in Puget Sound

Currently, most available information on kelp species in Puget Sound pertains to bull kelp. Traditional and local ecological knowledge from Tribes and residents, citizen-science surveys, and analysis of historical data suggest significant declines in the extent and density of bull kelp forests throughout Puget Sound. Little information exists regarding changes in distribution or abundance among the 17 Puget Sound kelp species (Mumford 2007).

Washington State kelp monitoring efforts focus primarily on floating bull kelp forests and include:

- DNR surveys of bull kelp linear extent in Central and South Puget Sound;
- Samish Nation analysis of San Juan Island bull kelp using aerial photography, remote sensing data, and kayak-based canopy area surveys;
- Annual DNR aerial photography of floating kelp canopies along the outer coast and Strait of Juan de Fuca;
- NWSC Marine Resources Committees (MRCs) citizen science kayak monitoring of bull kelp forest canopy area;
- Washington State Park and Washington State Department of Fish and Wildlife (WDFW) monitoring of recreational harvest;
- PSRF SCUBA monitoring of kelp forest communities at two sites in Central Puget Sound; and
- United States Geological Survey led SCUBA monitoring of kelp communities following removal of the Elwha River dams.

An analysis of bull kelp distributions in South Puget Sound conducted by DNR documents a 62 percent decrease in bull kelp forest linear extent since the 1870s, and almost complete disappearance along all shorelines except near the Tacoma Narrows. This decrease includes the entire loss of two bull kelp forests over the past decade and dramatic decreases in canopy area at several remaining forests (Berry et al. 2019). DNR is currently conducting a similar analysis of Central Puget Sound bull kelp linear extent, and other partner organizations have documented significant losses to kelp beds around Bainbridge Island and Edmonds (see Appendix A for more details on current distribution and trend data).

While evidence of kelp losses in Puget Sound is limited to bull kelp, recent research suggests that other kelp species are also vulnerable. Research in British Columbia found that multiple species of kelp declined in wave-sheltered areas compared to kelp in wave-exposed areas. The wave-sheltered environments of Puget Sound may be similarly vulnerable, with multiple species at risk, not just limited to bull kelp (Starko et al. 2019).

3.4 Stressors

Kelp species in Puget Sound require clear, cold water with sufficient nutrients to support growth (Wernberg et al. 2019). Sensitivity to changes in water quality makes kelp a potential sentinel or indicator species for nearshore environments, with losses often following the deterioration of local water quality and increased water temperatures (Smale 2019; Filbee-Dexter and Wernberg 2018; Reed et al. 2016). While there are areas of concern within Puget Sound, data are limited and more research is needed to understand embayment specific effects of local stress regimes (Berry et al. 2019; Calloway 2019; PSEMP Marine Waters Workgroup 2018).

Nutrient Loading

Kelp require a specific threshold of nitrogen to grow. Too little nitrogen and kelp will starve (Schiel and Foster 2015); too much nitrogen and other species, like plankton or turf algae, can reduce nutrient availability or displace kelp respectively (Khangaonkar et al. 2018; Falkenberg et al. 2013). Anthropogenic nutrient loading from wastewater treatment plants, stormwater, and other point- and non-point sources of water pollution can have serious indirect impacts on kelp forests but these impacts are unknown in Puget Sound (Feehan et al. 2019; Norderhaug et al. 2015; Falkenberg et al. 2013). High levels of nitrogen alone are not directly detrimental to kelp, but anthropogenic nitrogen can lend competitive advantages to turf species that displace kelp (Falkenberg et al. 2013; Russell et al. 2009). Turf algae include small filamentous and foliose green and red algae that provide fewer ecosystem services and lower biodiversity (Connell et al. 2014). Kelp nutrient requirements are further complicated by seasonal timing of nutrient availability in Puget Sound. Nutrient availability decreases in the summer (Berry et al. 2019) but excess anthropogenic nutrient loading fuels increased spring and summer microalgal blooms that quickly deplete already low nutrient concentrations (Khangaonkar et al. 2018). Kelp generally require $> 1\mu M$ of nitrogen for reproduction and growth (Bartsch et al. 2008; Schiel and Foster 2006) and algal blooms likely starve kelp of needed nutrients during peak spring recruitment and summer growth. Finally, large phytoplankton blooms also decrease the amount of light available for photosynthesis and growth (Burkholder et al. 2007).

Climate Change

Kelp forests are generally found in high latitudes and prefer cool water, therefore warming ocean temperatures threaten kelp forests across the globe (Smale 2019; Wernberg et al. 2019). The optimal temperature for many Puget Sound kelp species (for example, Laminaria) falls in the range of five to 15 °C (Bartsch et al. 2008; Tera Corp. 1982). Temperature stress makes kelp less tolerant and more vulnerable to other stressors (Rothäusler et al. 2009; Tera Corp. 1982; more discussion can be found in Appendix A). While little can be done at the local level to reduce global stressors, such as rising ocean temperatures, actions taken to reduce local stressors can help decrease overall stress to kelp species in Puget Sound.

Fine Sediment Loading

Human activities in Puget Sound have both increased and blocked upland sediment loading (i.e., logging and dams, respectively) (Rubin et al. 2017). Changes in fine sediment loading from river discharge, stormwater runoff, and in-water construction activities and coastal development can negatively impact kelp recruitment and microscopic life stage survival by burying suitable substrate and increasing suspended sediment (Airoldi 2003). However, the nature and severity of impact depend on the timing of sediment deposition as well as the level of exposure at any given kelp forest (Geange et al. 2014). In the short term, increased sediment loads can increase mortality of dormant microscopic kelp life stages (Watanabe et al. 2016; Deiman et al. 2012; Arakawa 2005), while higher turbidity from sediment loading may significantly delay spring recruitment and the associated turbidity can reduce the maximum depth of kelp forests (Glover et al. 2019). Finally, sediment dynamics in Puget Sound have also been altered by large-scale historic changes to upland and nearshore landscapes (Pearson et al. 2018; Perkins and Collins 1997). The effects of historic and current human-related alterations to nearshore sediment delivery on kelp habitat availability and population dynamics in Puget Sound are unknown and warrant further investigation.

Fisheries Impacts

The loss of kelp forests due to uncontrolled grazing from sea urchin populations is well documented in the popular and scientific literature (Rogers-Bennett and Catton 2019; Ling 2008; Steneck et al. 2002; Estes and Duggins 1995). Generally, removal of high-order predators from fishing pressure or other environmental stress results in expansions of urchin barrens (Rogers-Bennett and Catton 2019; Steneck et al. 2013). However, decreases in grazing pressure can also lead to significant changes in kelp forest composition, allowing annual species, such as bull kelp, to be replaced with perennial understory species (Duggins 1980).

In Puget Sound, historic cod, pollock, hake, salmon, rockfish, urchin, sea cucumber and abalone fisheries have significantly altered Puget Sound marine food webs (see Appendix A for more detail), but the impacts of these changes on kelp population distributions and dynamics are unknown. Puget Sound hosts three urchin species but no extensive urchin barrens have been documented by WDFW during urchin population surveys (personal communication with Henry Carson, WDFW, November 14, 2019). However, limited areas characterized by low macroalgae cover and high purple urchin densities have been documented along the outer coast of Vancouver Island, western Strait of Juan de Fuca, and San Juan Islands (personal communication with Helen Berry and Taylor Frierson, WDFW, November 14, 2019). Purple urchins have been responsible for recent large and persistent kelp losses in northern California (Rogers-Bennett and Catton 2019) and there is a concern that urchin barrens may be expanding north into Oregon (Flaccus and Chea 2019). Finally, with little data on understory kelp trends in Puget Sound, it is difficult to know whether bull kelp declines are tied to changes in grazing regimes.

Harvest

Recreational harvest of kelp is allowed for individual use, and jointly managed by DNR and WDFW. A recent study on Whidbey Island found that unsustainable harvest practices (clipping kelp too close to the stipe) precluded regrowth post-harvest and negatively impacted kelp densities for up to a year after harvest (Kilgo 2019). Statewide regulations restrict harvest to 10 pounds of kelp (regardless of species) per person per day and recommend sustainable cutting (above the plant growth area, or meristem) (RCW 79.135.410). Currently, there is no formal, statewide monitoring of recreational kelp harvest to document harvest locations, species, methods, and quantities to assess the potential impacts of harvest on kelp populations. In Washington State parks, the harvest is permitted in three parks during defined dates and sustainable harvest is required. In other areas, local regulations further limit or prohibit harvest.

Washington State does not allow commercial harvest of seaweed or kelp (RCW 79.135.410). There is one exception for giant kelp harvest for the traditional herring "spawn-on-kelp" fishery; however, giant kelp does not occur within the boundaries of the study area of the Kelp Plan, and this fishery has been closed for decades.

Shoreline Development and Activities

Human activities and shoreline development generate a wide range of potential stressors affecting kelp species. Shoreline development and activities include, but are not limited to, overwater structures, outfalls, shoreline armoring, dredging, marinas, and navigation. The impacts on kelp can be both direct and indirect. Potential impacts include, but are not limited to: dredging and construction in or near kelp forests, increased turbidity from increased sediment inputs, shading from overwater structures, and anthropogenic nutrient loading altering benthic communities. Because the exact nature and severity of these impacts to kelp species are not well understood, human activities and shoreline development typically are not managed and permitted with impacts to kelp in mind. Collaborative research in partnership with regulators and policymakers will better support the management of kelp in relation to human activities and shoreline development.

Invasive Species: *Sargassum muticum* and *Undaria pinnatifida*

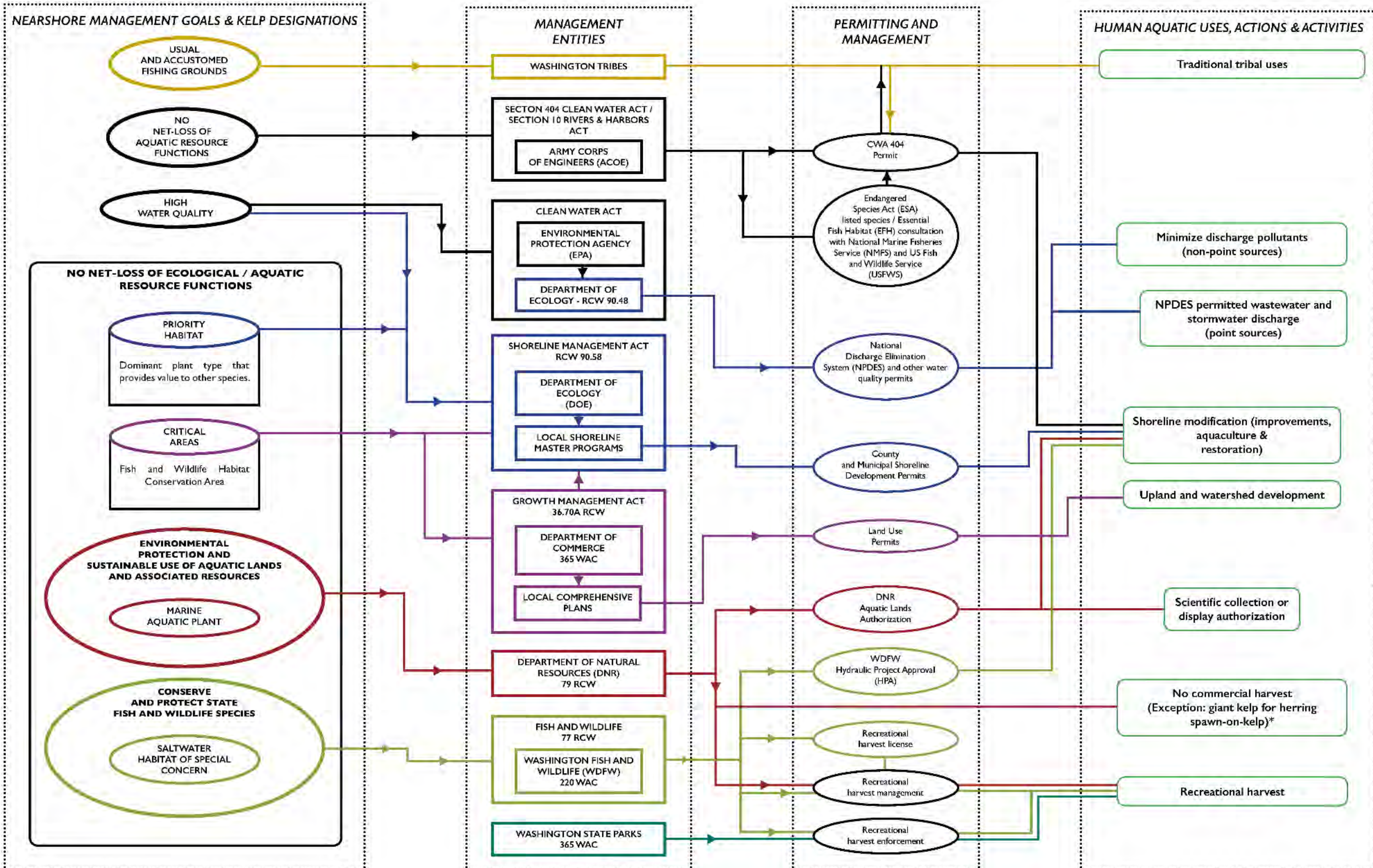
The invasive seaweed *Sargassum muticum* is known to displace native kelp species in Puget Sound (Britton-Simmons 2004). Puget Sound *Sargassum* displaces native species by relying on quick early growth in the spring to shade out competitors. *Sargassum* was estimated to span approximately 20 percent of the shoreline in Puget Sound in the late 1990s (DNR n.d.). In Barkley Sound along the outer coast of British Columbia, *Sargassum* distributions have increased in wave-sheltered areas in recent decades (Starko et al. 2019). There is a concern that the *Sargassum* range has also expanded in the wave-sheltered environment of Puget Sound since the late 1990s (personal communication with Brent Hughes, Sonoma State University, November 12, 2019).

Undaria pinnatifida has been encountered as far north as San Francisco along the California coast (Zabin et al. 2009) and there is concern regarding its potential presence in Washington State waters and Puget Sound. Currently, there is no evidence that *Undaria* has been introduced to Puget Sound, but in the absence of comprehensive understory kelp surveys, its presence is unknown. While *Undaria*, like *Sargassum*, is a common invasive species throughout the Pacific Coast, there is no consensus on its impacts on native kelp assemblages (South et al. 2017; Casas et al. 2004).

IV. Puget Sound Kelp Management Framework

Kelp and kelp-based ecosystems in Washington State are managed within a framework of ownership, regulations, and trust responsibilities. The management is split between Tribes, state and federal management agencies, and county and municipal governments. Figure 4 shows the management framework for kelp in Washington State.

Rockfish in understory kelp.
Photo by Adam Obaza- Paua Marine Research.

559 

560 Figure 4. Diagram of the management framework for kelp in Washington State.

4.1 Kelp Management Responsibilities

Several tribal and governmental agencies share responsibilities for managing Puget Sound kelp and their habitats.

Washington State Tribes

Washington Tribes have a reserved right to conserve and protect Puget Sound kelp habitats as critical habitat for a number of culturally and economically important species covered by treaty rights. Conserving and protecting critical fish habitat from environmental degradation was reaffirmed as a fundamental treaty right for all Washington Tribes under *Phase II* of the Boldt decision, and kelp restoration activities are now considered "fish habitat enhancement projects" by the WDFW (RCW 77.55.181). Kelp in and of itself also has significant historical and cultural value for Washington State Tribes (Appendix B).

Washington Department of Natural Resources

The Washington Department of Natural Resources is the manager and steward of 2.6 million acres of state-owned aquatic lands. The DNR manages aquatic lands in pursuit of five goals:

- Encourage direct public use and access;
- Foster water-dependent uses;
- Ensure environmental protection;
- Provide opportunities for utilization of renewable resources; and
- Generate income from the use of aquatic lands, when consistent with the previous goals.

State-owned aquatic lands include most subtidal areas (bedlands), nearly 30 percent of intertidal areas (tidelands), and unsold shorelands of rivers and lakes (shorelands). In general, bedlands below the extreme lower low water and within the three-mile state boundary are considered state-owned aquatic lands. Because kelp is generally found in subtidal waters and considered an attached resource, DNR manages the majority of Puget Sound kelp resources. In addition, kelp harvest is regulated under Washington State guidelines and regulations (RCW 79.135.410). State regulations prohibit commercial collection of natural set kelp and limit recreational collection to ten pounds per person per day. DNR and WDFW have established sustainable methods for recreational harvest of kelp, and WDFW requires a permit for these activities. Shellfish and seaweed aquaculture on state-owned aquatic lands requires a DNR use authorization, and DNR includes habitat stewardship measures to ensure the protection of kelp during construction and operations. DNR also has the authority to withdraw sites from leasing by Commissioner's order to promote native species conservation.

DNR manages recreational seaweed ("marine plant") harvest on state-owned aquatic lands in coordination with WDFW. See Recreational Harvest and Scientific Collection Permits Section below for details.

DNR established the Aquatic Reserve Program in 2002 to protect areas of “special educational or scientific interest, or of special environmental importance” (WAC 332-30-151). Eight Aquatic Reserves are currently managed by DNR (seven saltwater, one freshwater), and new aquatic reserves can be proposed according to DNR aquatic reserve implementation and designation guidelines. Kelp ecosystems are designated as priority marine habitats under DNR guidelines due to the critical functions and services they provide to associated marine species. Current aquatic reserves contain important areas of extensive and diverse kelp forests in the Strait of Juan de Fuca.

Shoreline Management Act: Department of Ecology and Local Shoreline Master Programs

The Shoreline Management Act of 1971 requires 41 coastal counties and municipalities to draft and implement local shoreline management plans (SMPs) in accordance with the Department of Ecology (DOE) guidelines and regulations (RCW 90). SMPs, in addition to meeting other requirements, must delineate and afford protections to “critical areas,” which include kelp and eelgrass beds as “fish and wildlife habitat conservation areas,” as defined by the state of Washington Growth Management Act (RCW 36.70A).

DOE guidelines also require that protections be given to priority habitat areas, which include kelp as a “saltwater habitat of special concern,” as defined by the WDFW (WAC 220-660-320). As a result, the designation and protection of kelp habitats can vary from locality to locality. However, all SMPs must ensure “no net loss” of ecological function for kelp and eelgrass (WAC 173-26-241; Appendix A). While existing regulations provide significant protections for kelp habitats, effective conservation depends on local implementation and enforcement.

Clean Water Act: Washington Department of Ecology

The DOE implements water quality standards in fulfillment of the federal Clean Water Act (CWA). Standards submitted by DOE must pass review from the EPA before being accepted. Water quality standards drafted by DOE are used in permitting non-point sources of pollution from stormwater discharge. The CWA requires states to develop a Total Maximum Daily Load (TMDL) plan for water bodies that exceed standards and are listed on the 303(d) list. In addition, DOE manages the state’s point-source pollution and waste discharge through the issuance of National Pollutant Discharge Elimination System (NPDES) permits. Current regulations do not include specific thresholds or pollution protections for kelp and it is unknown how effective these regulations are at protecting kelp (RCW 90.40.010).

Hydraulic Project Approval: Washington Department of Fish and Wildlife

The WDFW Hydraulic Project Approval (HPA) program is intended to ensure “no net loss” of ecological functions within “saltwater habitats of special concern,” specifically as they pertain to fish productivity (WAC 220-660-050). The objective is to minimize impacts of projects that “use, divert, obstruct, or change the natural flow or bed” of state waters. WDFW HPA guidelines outline specific survey and mitigation requirements (avoid, minimize, compensate impacts) for all project applications, and reserve the right to deny any applications. Current WDFW HPA regulations provide exemptions for SMP development permits for fish habitat enhancement projects, which include kelp restoration activities (RCW 77.55.181).

Recreational Harvest and Scientific Collection Permits

DNR and WDFW share the management of recreational seaweed harvest statewide (RCW 79.135.410). No commercial harvest of naturally growing seaweed is permitted in Washington State. WDFW issues recreational shellfish/seaweed collection licenses that allow for the harvest of up to 10 pounds (wet weight) of seaweed per day. This license does not require a catch record card, thus tracking seaweed harvests is left to on-the-ground enforcement and management officials from WDFW.

Kelp harvest for non-recreational uses is not well coordinated or tracked. DNR permits collection of kelp for scientific and display uses as a part of its “Aquatic Use Authorization” process on state-owned aquatic lands. The University of Washington’s Friday Harbor Laboratories tracks the scientific collection of organisms in San Juan County, including seaweeds (RCW 28B.20.320). Responsibility for scientific and display collection on other lands resides with the local land manager.

Army Corps of Engineers: Clean Water Act, Rivers and Harbors Act Section 10, and Endangered Species Act

The USACE is responsible for permitting construction activities within U.S. waters. Section 404 of the CWA regulates dredged and fill material discharged into U.S. waters in order to “restore and maintain … the integrity of waters of the U.S.” Section 10 of the Rivers and Harbors Act requires that construction activities do not interfere with navigable waters. In 1990, a memorandum added the goal of “no net loss” for aquatic resources to the USACE’s responsibilities, requiring that any activities impacting aquatic resources include mitigation actions for “special aquatic sites,” which include “vegetated shallows.” However, “vegetated shallows” are defined as waters that support rooted vegetation, and interpretation differs on whether this category includes kelp and other seaweeds that do not form roots. As a result, kelp is often excluded from federal mitigation guidelines. However, CWA Section 404 does provide protections against impacts to critical habitat for ESA-listed species, and kelp is considered an endangered Puget Sound rockfish habitat.

National Marine Fisheries Service and United States Fish and Wildlife Service: Endangered Species Act

The NMFS and USFWS designate critical habitat for ESA-listed species and require consultation under Section 7(a)(2) of the ESA with federal action agencies that propose actions that may affect listed species and their habitats. NMFS designated critical habitat in the nearshore for bocaccio, noting that “…substrates such as sand, rock and/or cobble compositions that also support kelp (families Chordaceae, Alariaceae, Lessoniacea, Costariaceae, and Laminaricea) are essential for conservation because these features enable forage opportunities and refuge from predators and enable behavioral and physiological changes needed for juveniles to occupy deeper adult habitats" (78 FR 47635).

National Marine Fisheries Service: Essential Fish Habitat

When a federal agency authorizes, funds, or undertakes an action that may adversely affect essential fish habitat (EFH), they must consult with NMFS on that action. An adverse effect on EFH is considered to be any direct or indirect effect that reduces the quality and/or quantity of the habitat and range from large-scale ocean uses to small-scale projects along the coast. NMFS provides advice and recommendations to federal agencies to avoid, reduce, or offset these adverse effects.

Canopy kelp is considered a "Habitat Areas of Particular Concern" (HAPC), which is a discrete subset of EFH. The canopy kelp HAPC includes those waters, substrate, and other biogenic habitat associated with canopy-forming kelp species (e.g., Macrocystis spp. and Nereocystis spp.). The HAPCs are considered high-priority areas for conservation, management, or research because they are important to ecosystem function, sensitive to human activities, stressed by development, or are rare. These areas provide important ecological functions and/or are especially vulnerable to degradation and can be designated based on either specific habitat types or discrete areas. The HAPC designation does not automatically confer additional protections or restrictions upon an area, but they help to prioritize and focus conservation efforts.

Kelp Aquaculture Regulations

A developed permitting framework for aquaculture of species in Puget Sound (RCW 19.135) is coordinated by the Shellfish Interagency Permitting Team. Kelp aquaculture falls generally within the aquaculture framework, although to date only one site has been permitted in Washington State. Kelp aquaculture regulations and practices are directly not addressed in the Kelp Plan, as this document is primarily focused on the conservation and recovery of naturally occurring populations. Separate efforts spearheaded by NMFS are working to develop resources for seaweed aquaculture development in Washington State. The Kelp Plan promotes the development of seaweed aquaculture practices that will not impact natural kelp populations.

Bull kelp.
Photo courtesy of Eiko Jones Photography.

V. Kelp Conservation and Recovery Actions

The Kelp Plan defines six strategic goals and associated actions as a framework for coordinated research and management to support kelp conservation and recovery in Puget Sound. These goals and actions are informed by the precautionary principle discussed in Section 2.3 and outline a precautionary approach that includes monitoring, conservation, and restoration actions. Adaptive management will play a key role, as our understanding of Puget Sound kelp populations, ecology and biology grow. Furthermore, successful kelp conservation and recovery will require continued coordination between user groups, and additional funding and resources to support outlined actions. The Kelp Plan includes the formation of workgroups for ongoing coordination among management and science groups.

Strategic goals and related actions for kelp conservation and recovery are identified below.

1. Reduce Stressors

Regional- and local-scale stressors in Puget Sound affecting kelp likely differ between sub-regions and are not well understood. Reducing stressors will require research into the dynamics of kelp populations relative to both individual stressors and cumulative stressor impacts on a regional and local scale. Managers often look to reduce stressors on an individual basis by targeting priority key stressors to kelp. However, the spatial scale and potential cumulative and synergistic impacts of stressors on kelp may require a more holistic approach. Adaptive management is critical to support management needs to address stressors individually while incorporating the latest scientific understanding of how individual stressors fit into the bigger picture of kelp recovery. Using the precautionary principle, even a partial understanding of critical thresholds for individual stressors on kelp and identification of top priority stressors can be used to target management actions. Failure to reduce stressors that have caused kelp losses will likely impede successful restoration and recovery efforts.

A number of agencies are tasked to reduce stressors using the tools and regulations outlined in Section IV. Moreover, the scientific and management communities have expressed a need to strengthen enforcement and compliance of existing laws and regulations, close loopholes, increase interagency coordination, and prioritize kelp conservation. Finally, reducing environmental stressors will provide benefits for kelp and the overall health of Puget Sound.

Failure to reduce stressors that have caused kelp losses will likely impede successful restoration and recovery efforts.

Human Impacts on Water Quality and Kelp Habitats

Globally, kelp forests rely on clean, cool waters for persistence – waters that are being lost to water quality degradation and warming ocean temperatures. Of specific concern are impacts to the nearshore environment from increased development, and growing populations, all of which can lead to excess nutrient loading, sediment delivery, and point and nonpoint sources of common pollutants and contaminants. Implementation of the following actions will help reduce human impacts on water quality and kelp habitats.

1.1. Form interagency workgroups to increase collaboration and information sharing across management organizations, to improve implementation, and to address policy gaps.

1.2. Inform future management actions through continued research on the impacts of current and historic human activities on kelp forests (e.g., nutrient and sediment loading thresholds and impacts, turbidity effects on kelp recruitment, substrate availability).

1.3. Identify priority stressors negatively affecting Puget Sound kelp on a subregional scale in order to target management actions.

1.4. Fully implement and enforce available protections for kelp through existing regulations, programs, and policies (e.g., DOE SMA Guidance, Local SMPs, WDFW HPA, DNR Aquatic Use Authorization, mitigation programs, NMFS ESA and EFH consultations).

- 1.4.1. Fully consider kelp in programs that respond to and prevent chemical and oil spills (e.g., DOE Geographic Response Planning).
- 1.4.2. Develop tools to support planners' ability to review/access policy regulations that assist in decision-making.
- 1.4.3. Develop and implement long-term research and monitoring actions using rigorous scientific and adaptive management principles to determine the effectiveness of current regulations and protection actions.

1.5. Increase protection by addressing key gaps in existing regulations and implementation programs.

- 1.5.1. Improve kelp-specific mitigation guidance and implementation.
- 1.5.2. Specifically name kelp in existing regulations, such as the CWA Section 404 definition of Vegetated Shallows and WDFW's Priority Habitats and Species.
- 1.5.3. Update survey guidelines and foster coordination among organizations conducting the site-level surveys, such as the WDFW Macroalgae Habitat Interim Survey Guidelines and the Coastal Zone Training Program.
- 1.5.4. Form an interagency workgroup to review the kelp aquaculture permitting process and develop best management practices, such as cultivating native species and avoiding the use of harmful pesticides and other chemicals.

1.6. Reduce anthropogenic nutrient and sediment loading (e.g., stormwater and WWTP permitting, and TMDL planning).

1.6.1. Coordinate and share research with the Nutrient Reduction Program planning and implementation program, led by the DOE.

1.7. Support sustainable kelp harvest by informing recreational harvesters about regulations and sustainable kelp harvest methods.

Biological Stressors

Human activity, historic and current, has altered the biological condition of Puget Sound. Fishing pressure has disrupted elements of the Puget Sound food web, impacting populations of cod, hake, pollock, salmon, rockfish, urchin, sea cucumber, abalone, and others (See Appendix A for more discussion). Fishing-related changes to marine food webs have the potential to impact kelp populations (See Section IV) but the connection between fishing pressure and kelp populations in Puget Sound is unknown. Human activities have introduced non-native macroalgal species, such as *Sargassum*, that compete with native kelp for space and light. Implementation of the following actions will help reduce biological stressors.

1.8. Strive to incorporate kelp and other trophic considerations into fisheries management planning.

1.9. Explore invasive macroalgae (including *Sargassum muticum* and *Undaria pinnatifida*) control alternatives, ecological roles, and long-term management considerations with respect to climate change.

Climate Change

The consequences of anthropogenic climate change pose a profound threat to marine environments all over the globe. For kelp in Puget Sound, increasing water temperatures pose a major potential concern because many of the inner basins generally naturally experience high temperatures (Burns 1985; Bos et al. 2015). Additional stress associated with climate change-related impacts to water quality (increased turbidity from increased storm severity and frequency, increased flooding and sea-level rise), increases in human development resulting from climate relation migration and ocean acidification related hypoxia also pose serious threats to Puget Sound kelp populations. Many of these climate-related stressors can be addressed by previously outlined actions to better understand and reduce their impacts on Puget Sound kelp populations. While there is no state or local policy action that can “lower the thermostat” on Puget Sound waters, it is important to note that temperature stress likely exacerbates the impacts of other stressors. Implementation of the following actions will help reduce impacts from climate change.

1.10. Investigate climate change impacts to better inform management decisions, such as prioritizing locations for kelp protected areas, restoration sites, and mitigation activities.

1.10.1. Include kelp habitat in regional and local climate adaptation strategies and planning.

1.11. Investigate local effects within kelp beds on seawater chemistry (Pfister et al. 2019) and consider potential management opportunities for these benefits.

1.12. Investigate temperature-tolerant strains of native kelp species for potential use in restoration and mitigation outplanting.

2. Improve Understanding of the Value of Kelp to Puget Sound Ecosystems and Integrate into Management

Available information indicates that kelp forests provide important ecosystem services to Puget Sound. While we have a general understanding of these ecosystem goods and services from other kelp ecosystems from around the world, our understanding of the magnitude of those services in Puget Sound is incomplete. Improving our understanding of the role of kelp in Puget Sound food webs and the essential ecosystem services it provides will support regulatory actions to better protect kelp. Additional research and management guidance are needed to demonstrate the link between healthy kelp forests and thriving populations of important species like salmon, rockfish, forage fish, and killer whales (particularly SRKW). Improved understanding will enhance our ability to advocate for kelp conservation as a necessity for improving the health of Puget Sound as a whole. Implementation of the following actions will improve our understanding of kelp habitats and their values.

2.1. Determine and quantify functional roles of kelp habitats for associated species and provide guidance to managers for regulatory implementation, such as endangered species habitat conservation.

2.1.1. Monitor the use of kelp forests as nurseries, migration corridors, refuges, and high-quality forage grounds for salmonids, resident rockfish populations, forage fish, pinto abalone and killer whales.

2.1.2. Utilize local ecological knowledge to assess the value of kelp forests as fishing areas.

2.1.3. Use isotopic and biochemical analysis of Puget Sound species and other tools to assess kelp contributions to nearshore, deep water, and terrestrial food webs.

2.2. Calculate the value of kelp ecosystem services for use in developing mitigation guidance.

3. Describe Kelp Distribution and Trends

Successful management relies on accurate information regarding the distribution and trends of species and populations of management concern. Currently, synoptic data on kelp distribution throughout Washington State is limited to the 1990s-era ShoreZone Inventory (Berry et al. n.d). More detailed and recent information is needed on the distribution of both canopy-forming and understory species. Additionally, due to the dynamic nature of kelp forests, information on short- and long-term trends is needed to tease apart natural variation and response to stressors. Kelp surface canopies are monitored by DNR and NWSC MRCs in some locations, but subtidal monitoring efforts are sparse in Puget Sound.

Updated information on distribution and trends are needed to inform point-in-time surveys and provide context for linking changes in kelp distributions to stressors. Additionally, continued and regular monitoring will allow for the detection of loss of kelp forests, informing policymakers and managers to more effectively target sites for conservation of stable kelp forests and recovery efforts at sites with measured losses. Finally, it will allow for regional tracking of kelp resources. Implementation of the following actions will provide new information on kelp distribution and trends.

3.1. Update and expand information on the current extent of canopy-forming and understory kelp.

3.2. Make distribution and trends data available to agencies and the public for use in spatial planning, project planning, and regulatory implementation.

3.3. Coordinate strategic monitoring of canopy-forming and understory kelp throughout Puget Sound by expanding efforts and building collaborations between organizations.

3.3.1. Continue and expand surface monitoring of Puget Sound canopy-forming kelp.

3.3.2. Develop Puget Sound-specific subtidal monitoring protocol, and establish a network of partners conducting subtidal kelp index site monitoring (e.g., REEFCheck, PSRF)

3.3.3. Encourage compatibility among protocols to support data synthesis, linking ecological functions, and relationships to local stressors.

3.3.4. Collaborate with the Puget Sound Partnership to expand the eelgrass Vital Sign to incorporate kelp indicators (such as kelp canopy area and understory kelp distributions).

3.4. Expand understanding of historical distributions and trends by compiling historical information sources and exploring traditional ecological knowledge.

3.5. Identify the genetic structure of kelp populations, including connectivity, dispersal, and population dynamics.

4. Designate Kelp Protected Areas

Puget Sound kelp recovery begins with the conservation and protection of kelp forests. In addition to implementing and strengthening current regulations to conserve kelp, the establishment of priority kelp habitat areas will support local and regional conservation efforts. Given that stressors and available management tools vary by location, we anticipate that enhanced protections will be site-specific. Coordination among multiple management organizations could increase the span of protections at a site (for example, limitation of harvest and land use activities). Implementation of the following actions will increase kelp protection.

4.1. Protect special kelp habitat in existing and new reserves, refuges, and protected areas.

4.1.1. Increase areas protecting existing kelp forests through organizations like DNR, and USFWS.

4.1.2. Use withdrawal letters and set standards for lease agreements to ensure the protection of kelp forests (DNR).

4.2. Assess the extent of recreational kelp harvest and its potential impacts, and develop spatial management plans and strategies for projected kelp harvest activities.

4.2.1. If necessary, identify priority enforcement needs relating to permits and recreational harvest activities to support existing protections.

5. Restore Kelp Forests

Restoring historical kelp forests can be achieved through a combination of indirect habitat improvement through stressor reduction and direct kelp population enhancement. Reestablishment of persistent kelp forests relies on first eliminating or minimizing stressors that contribute to current documented losses. Restoration methods and best practices are still being developed; therefore it is critical to monitor restoration and mitigation sites following project completion to accurately assess the success and efficacy of new methods. Restoration success could be increased through the identification of sites with the greatest potential to support kelp. Finally, we must work to shift current ideas around mitigation away from piecemeal actions towards a more holistic, total-ecosystem approach that takes into account kelp forest connectivity and large-scale issues of nearshore habitat connectivity. Implementation of the following actions will help restore kelp forests.

5.1. Develop spatial plan identifying regions and sites for priority restoration actions and mitigation.

5.1.1. Target management actions that reduce stressors at priority restoration sites.

5.1.2. Develop a mitigation bank of priority locations for kelp enhancement and restoration projects, and for when *in-situ* mitigation is not viable.

5.2. Continue development of kelp restoration techniques for use in enhancement projects and mitigation.

5.2.1. Develop best management practices for designing, installing, and maintaining compensatory mitigation sites and restoration projects.

5.2.2. Define measurable project success standards to include ecosystem goods and services and long-term persistence of kelp forest.

5.2.3. Develop monitoring protocols to verify project success/compliance.

5.3. Fund and implement restoration activities at priority sites.

5.3.1. Target restoration-funding sources for stressor reduction and population enhancement projects.

5.3.2. Reach out to restoration funding sources to include funding for kelp restoration.

5.3.3. Use compensatory mitigation as a tool to restore goods and services provided by kelp forests.

6. Promote Awareness, Engagement, and Action from User Groups, the Public, and Decision-Makers

The success of this Kelp Plan and the conservation and recovery of kelp in Puget Sound depends on increased awareness and engagement in support of actions to sustain kelp. To contribute to the persistence of Puget Sound kelp forests, we must improve the general understanding of the current status and ecological value of kelp, communicate the research and management needs that are articulated in the Kelp Plan, and educate individuals on how they can help. Implementation of the following actions will help increase awareness and engagement in kelp recovery efforts.

6.1. Share information on (1) the value and role of kelp ecosystems as critical nearshore habitat and food web support (for forage fish, rockfish, salmon, and killer whales) in Puget Sound; and (2) the growing concern regarding significant losses to bull kelp canopies.

6.1.1. Educate decision-makers (federal, state, and local entities) regarding the value of kelp, local declines, and the needs articulated in the Kelp Plan.

6.1.2. Work with Tribal partners to elevate the prominence of traditional ecological knowledge regarding kelp.

6.1.3. Encourage partners (e.g., Tribes, anglers, commercial fishermen, Washington Public Port Association, industry, recreational harvesting groups, and NGOs) to help tell the story of kelp to local communities and decision-makers.

6.1.4. Develop curricula and other educational tools focused on Puget Sound kelp ecosystems for K-12 classrooms and public locations (aquariums, parks, boat launches, etc.).

6.2. Build research capacity and coordinate knowledge sharing of ongoing kelp recovery projects and research gaps.

6.2.1. Create and maintain a regularly scheduled forum for information sharing and knowledge gathering between Tribal, federal, state, and local entities.

6.2.2. Coordinate kelp conservation actions and research activities with the Salish Sea International Kelp Alliance, British Columbia, Oregon, and California.

6.2.3. Coordinate knowledge sharing through regular participation in conferences, workshops, publications, social media, etc.

MRC kayak-based survey of bull kelp forest at Ebey's Landing.
Photo by Rich Yukubousky.

VI. Conclusions

Bull kelp forests have declined and disappeared from some areas of Puget Sound. There is a growing concern from the scientific community that this trend is not limited to bull kelp, and that threats to kelp species are intensifying. The development of the Kelp Plan brought together kelp scientists, ecosystem recovery experts, tribal resource managers, and local, state, and federal representatives to discuss current research, data gaps, and actions that support science-based regulation and management to conserve and restore kelp. The Kelp Plan defines six strategic goals and critical actions to initiate a regional response.

1. Reduce stressors;
2. Improve understanding of the value of kelp to Puget Sound ecosystems and integrate into management;
3. Describe kelp distribution and trends;
4. Designate kelp protected areas;
5. Restore kelp forests; and
6. Promote awareness, engagement, and action from user groups, Tribes, the public, and decision-makers.

At the heart of the six strategic goals is a need for ongoing coordination of research and interagency efforts; improved communication between researchers and managers; and additional funding to support research, monitoring, education, outreach, implementation, and enforcement. The actions outlined in the Kelp Plan require a unified effort from many people and organizations to carry out the strategic goals. Raising awareness of the need to support kelp conservation and recovery will help further build this network. The Kelp Plan provides the framework for coordinated actions for research and management to better support the persistence of kelp in the face of global and local stressors, and to ensure these iconic native species continue to thrive in our local waters.

At the heart of kelp recovery efforts is a needs for ongoing interagency coordination of research, better communication between researchers and managers; and additional funding to achieve the strategic goals.

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