

Conservation Plan: Alaskan Giant Kelp Forests

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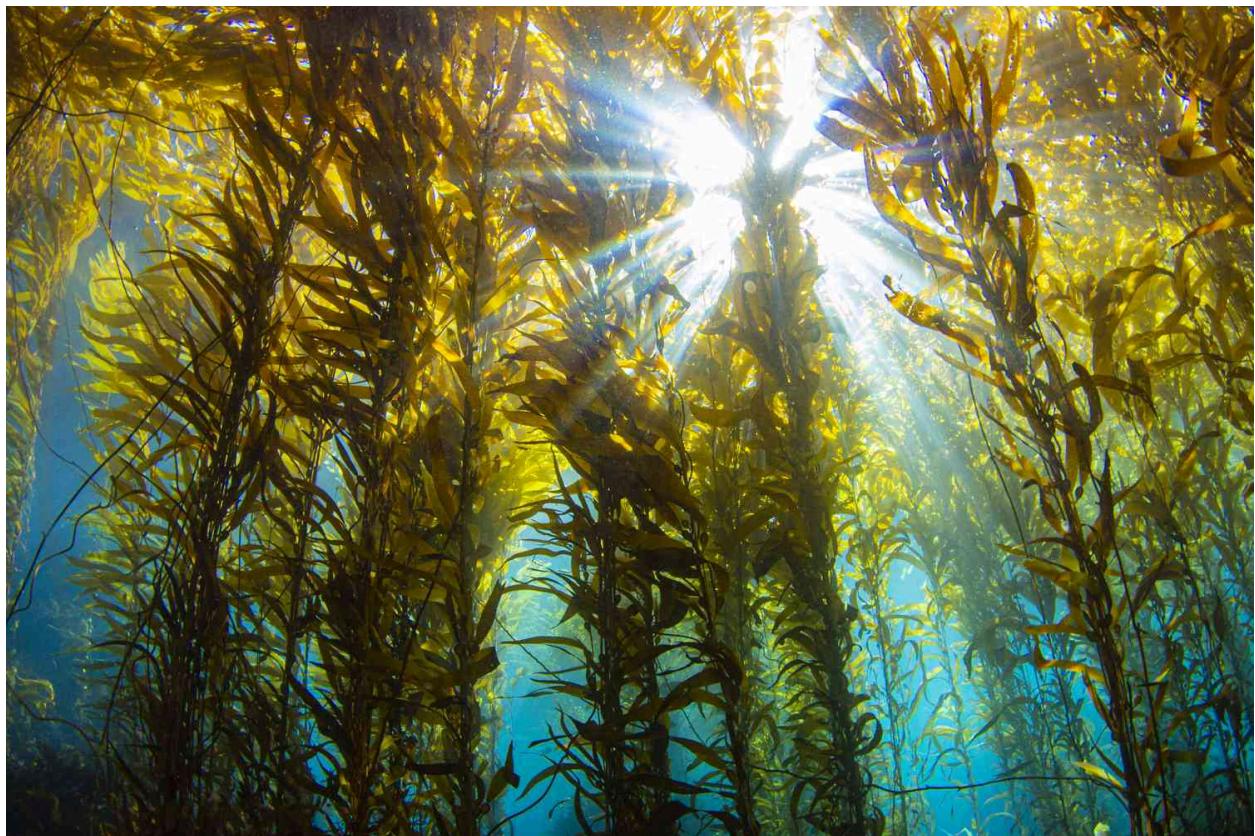


Figure 1: Giant kelp (*Macrocystis pyrifera*) in an Alaskan giant kelp forest. (Source: Getty Images, taken by Douglas Klug)

Executive Summary

Along the Alaskan coastline, specifically through the western Gulf, Aleutian Islands, and Eastern Bering Sea, is a reservoir of extraordinary ecological wealth and natural beauty known as the Alaskan Giant Kelp Forests. The impressive capacity of these unique ecosystems to foster biodiversity and ecological productivity has made them integral to the broader environment and local communities. However, the biotic function of the Alaskan Giant Kelp forests has suffered a steep decline as over-exploitation, climate change, and pollution threaten their integrity and facilitate their conversion into urchin barrens. The following conservation plan intends to restore the health of this ecosystem and promote resilience by focusing on three primary conservation targets: kelp canopy extent, sea otter population, and human livelihoods.

To ensure success, the Planning Team involves diverse groups with knowledge spanning expert, local, and traditional sources. Project partners include the Alaskan Government, environmental administrative agencies, Indigenous groups, public and local interest representatives, and the cruise ship and oil industry. This breadth of perspectives will secure a more comprehensive plan that supports both the ecosystem and public needs. Guided by the values and input of the team, the plan was ultimately structured around seven key fundamental objectives: decreasing sea urchin populations, increasing sea otter populations, improving water quality, increasing coastal buffer capacity, increasing ecotourism revenue, increasing sustainable kelp harvesting methods, and increasing Indigenous involvement in kelp forest management.

These objectives provided direction for strategy development and selection, with six primary strategies being identified. First is implementing a Marine Protected Area to provide broad protection and reduce disruption within the kelp forests as they regenerate. Other strategies were more tactical, including increasing fines for pollution and increasing cruise ship monitoring to encourage environmentally responsible practices by local industries while limiting interference with economic affairs. Additionally, the plan targets great whale population recovery to remedy the trophic cascade that has led to sea otter population declines. Finally, the plan includes promoting local education and outreach, as well as Indigenous involvement to foster value for these ecosystems and honor existing, specialized knowledge, respectively. These strategies have been assessed using a consequence table and multi-criteria decision analysis in order to determine their capacity to meet plan goals and prioritize implementation.

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Planning Context

Introduction and Rationale

The Alaskan coastline is characterized by cold, nutrient-rich, open, and rocky waters, which enable it to support biodiverse kelp forests. Forests of giant kelp dominate the western Gulf, Aleutian Islands, and Eastern Bering Sea, spanning from 45 to 60°N (Figure 4). Providing underwater architecture up to 15 meters tall, this ecosystem supports the function of the surrounding marine environment by increasing habitat and niche space. It is home to a diverse assemblage of fauna (Figure 2), including crustaceans, marine snails, sea urchins, starfish, sea otters, and more than 20 species of fish, all contributing to the broader complex and dynamic food-web (Alaska Ocean Observing System, n.d.). Giant kelp forests are also integral to localized patterns of coastal erosion, sedimentation, upwelling, and benthic productivity (IUCN, 2013). With high levels of biodiversity and productivity, these kelp forests sustain local communities through ecosystem services such as shoreline protection, sustenance, and economic opportunities. For instance, fisheries in the southeastern Bering Sea and Bristol Bay alone land several million tons annually utilizing biodiversity resources of the nearby giant kelp ecosystems (Estes et al., 2009).



Figure 2. Giant kelp forest canopies can provide critical habitat for a diverse array of marine species (Source: IUCN, 2013)

However, these complex ecosystems are becoming increasingly simplified as



Figure 3. Kelp forests provide habitat for sea otters, a key stone species and primary predator of sea urchins (Source: Alaska Ocean Acidification Network, 2024)

due to various anthropogenic stressors, including competition with fisheries, direct take, and killer whale predation after whaling activities removed other diet sources (Estes et al., 2009). As

over-exploitation of marine species, climate change, and pollution degrade the kelp forests and facilitate their conversion into unproductive urchin barrens. Sea otters, a keystone predator in the ecosystem (Figure 3), have witnessed a 75-95% population decline throughout the kelp forests since 1750 (IUCN, 2013). This decline is

sea otter populations dwindled, the region suffered trophic cascade effects that enabled the proliferation of sea urchins, resulting in mass ecosystem-type conversion from kelp forests to urchin barrens. This turnover has eliminated the forests' structural complexity, thus removing critical habitat for much of the region's characteristic biodiversity. Climate change is also threatening this ecosystem, as increased ocean temperatures and shifted oceanic currents are altering the nutrient availability and temperature regime required to support and regenerate giant kelp forests (IUCN, 2013). Finally, direct human disruption from oil spills and other forms of pollution is causing localized water contamination, which further degrades the habitat and poses consequences for the species reliant on this ecosystem (IUCN, 2013).

Conservation Plan Purpose

Collectively, these aforementioned threats have resulted in a decline in biotic function of 50-95% severity across the entire Alaskan Giant Kelp Ecosystems during the past fifty years, ultimately leading to its Endangered classification under the IUCN's Red List of Ecosystems (IUCN, 2013). Accordingly, these reduced kelp forests are unable to support the typical marine biodiversity of the region, as well as the coastal human populations that rely on these ecosystems. Given this rapid and significant decline, this plan seeks to address the decreased kelp canopy extent and reduced abundance of sea otters within the Alaskan Giant Kelp Forests, helping to restore the health of this critical ecosystem and the human livelihoods it supports.

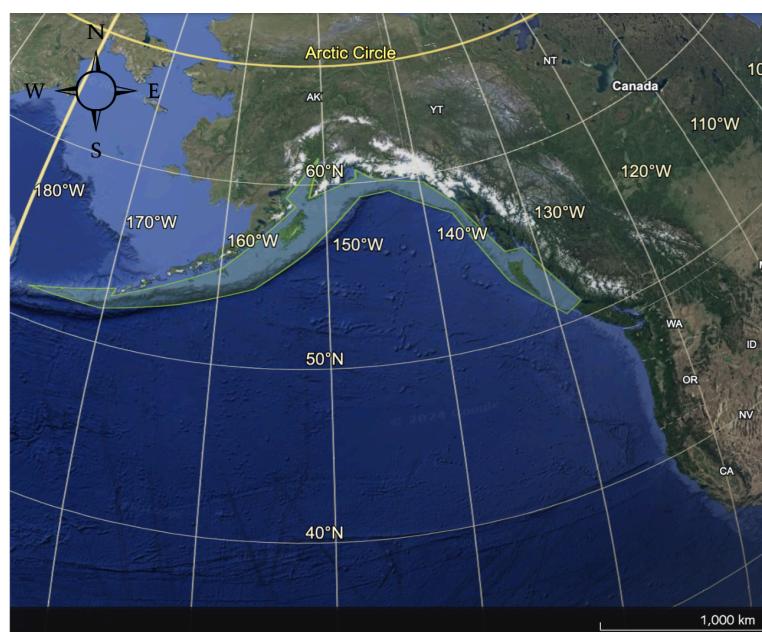


Figure 4. Map of the general location of the Giant Kelp Forest Ecosystem off of the Alaskan Coastline (Map developed on Google Earth, adapted from IUCN)

Planning Team and Management Process

Decision Makers and Target Audience

The primary decision makers for the Alaskan Giant Kelp Forest conservation plan include Indigenous peoples, state government officials, other federal government departmental officials from U.S. Fish and Wildlife Service (U.S. FWS) and the Environmental Protection Agency (EPA), and representatives from the non-profit Alaska Public Interest Research Group (AkPIRG). Indigenous people have a strong cultural connection to the kelp forest, and the traditional ecological knowledge possessed by them, in conjunction with the history of marginalization and silencing of Indigenous voices, presents the importance of centering them in the decision-making process (Smith, 2021). State government officials will provide oversight and have a general wide-sweeping knowledge of any laws and regulations, as well as an idea of the economic value of various industries. The U.S. FWS and the EPA are two major federal government organizations knowledgeable about the marine ecosystem and the biotic and abiotic factors, as well as any specific environmental rules and regulations beyond the knowledge of state representatives. AkPIRG has a foundational understanding of the interests of the general public, making the organization a major player in the decision-making process to ensure public interests are accounted for. Therefore, these four sectors—Indigenous people, state government officials, national department representatives, and public interest researchers—compose the target audience for the conservation plan.

Planning Team

The planning team is the group working to construct and implement the conservation plan for the Alaskan Giant Kelp Forests. Each team member possesses a specific skill set that provides them with the tools to collaborate in building a comprehensive conservation plan (see Table 1). From government officials to cruise ship industry representatives to Indigenous culture experts, the planning team encompasses a wide range of perspectives to ensure that the conservation plan does the most for the environment while ensuring the livelihoods and well-being of humans aren't lost in the process.

Table 1. Planning Team

Member	Skillset	Organization	Role
State Representative(s)	Historical knowledge of the legal system and restrictions from govt	Alaska State Government	Evaluate state-led contributing factors, address legal methods of conservation
Fish and Wildlife Regulation Official(s)	Site-specific knowledge of the current environmental setting and legal restrictions of marine area	US Fish and Wildlife Service (U.S. FWS), Alaska Department of Fish and Game (ADFG), and Environmental Protection Agency (EPA)	Altering and increasing legal regulations to protect the marine area in question
Marine biologist(s)	Knowledge of marine ecosystems	National Oceanic and Atmospheric Association (NOAA)	Design specific marine species conservation plans (sea otters, great whales, etc.)
Indigenous Culture and Knowledge Expert(s)	Traditional Ecological Knowledge, Indigenous Cultural Knowledge	Unangaq, Alutiiq/Sugpiaq, Eyak, Tlingit, Haida, Tsimshian, Nuxalk, Heiltsuk, Nuu-chah-nulth, Tsimshian, and Kwakwaka'waka Tribes	Designing conservation plans with a comprehensive understanding of marine systems and the cultural importance of biotic and abiotic factors of the region
Environmental Lawyer(s)	Comprehensive knowledge of existing environmental laws and regulations	Natural Resources Defense Council (NRDC)	Research ways to expand environmental legal protections in conservation plan
Public Interest Representative(s)	Knowledge of locals' interests from various surveys and research	Alaska Public Interest Research Group (AkPIRG)	Apply research and conduct plan-specific research from
Local Fishers Interests Representative(s)	Understanding of seafood abundance on the economy and the interests of on-the-ground fishers	Alaska Longline Fishermen's Association (ALFA)	Designing sustainable seafood harvesting that allows for industry and its fishers to thrive
Cruise Ship Industry Representative(s)	Understanding of tourism, specifically cruises, on the economy; routes follow large parts of Alaskan kelp forests	Royal Caribbean Cruises Alaska, Princess Cruises Alaska, Celebrity Cruises Alaska, Regent Seven Seas Cruises, etc.	Redesign cruise ship routes to avoid protected areas; reduce the size and scale of cruise expeditions

Oil Industry Representative(s)	Understanding of the oil industry's impact on the local economy and the occurrences and risks of oil spills in the Gulf	ConocoPhillips, ExxonMobile, Chevron, Alyeska Pipeline Service Company, etc.	Research causes of oil spills and impacts to the environment, work on plans to reduce accidents
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State Representatives

State representatives have an understanding of the legal system and regulations that are set in place by the state government. This would include any laws or regulations imposed by state-level agencies and restrictions based on state parks, forests, and other protected areas under Alaska's jurisdiction. The state representatives also likely understand the commerce and day-to-day economic operations supporting the Alaskan economy. These are important insights that will help create a conservation plan in line with the existing regulatory system.

Fish and Wildlife Regulation Officials

Fish and Wildlife Regulation Officials include any representative from both federal and state fish, wildlife, or game departments—U.S. Fish and Wildlife Service and Alaska Department of Fish and Game, respectively. These officials hold a specific understanding of protections and regulations surrounding the use, capture, harm, and hunting of wildlife, which is important in understanding the current state of the marine ecosystem and how to best support the populations moving forward (U.S. FWS, 2024). The Environmental Protection Agency would also provide representatives to ensure the conservation plan aligns with federal environmental regulations.

Marine Biologists

Marine biologists provide the planning team with expertise in marine life and the systems required to keep them thriving. The strategy selection for the conservation plan hinges on the interactions between wildlife, from the kelp forest to great whales, and otters to sea urchins (Estes et al., 2009). The food web of kelp forests is heavily intertwined, all of which also depend on abiotic factors, such as pH, salinity, temperature, etc., to maintain a healthy and stable population. Due to their field of study, it is necessary to include marine biologists in the planning team to guarantee accurate and relevant knowledge is applied to restore the health of Alaskan Giant Kelp Forests.

Indigenous Culture and Knowledge Experts

Indigenous tribes of Alaska have utilized kelp as a food source, as a finishing sealant, and for cultural importance (Smith, 2021). Historically, the practices of kelp forest management and utilization have been purposely disrupted by colonization to marginalize Indigenous populations in the U.S. further (Smith, 2021). To remedy the past and continued marginalization of Alaskan Indigenous Tribes, Indigenous voices need to be amplified and considered when forming the conservation plan. Moreover, as these people are indigenous to the Alaskan coast and have historically sustainably used and managed its kelp forests, their Traditional Ecological Knowledge of the area is beneficial (Stern, 2022). Specifically, they will provide knowledge on sustainable harvesting methods and ecological changes over time.

Environmental Lawyers

The planning team would also include environmental lawyers from the Natural Resources Defense Council who specialize in environmental law and using existing legislation to protect ecosystems. Environmental lawyers wouldn't hold the same biases that governmentally appointed or elected officials might, which is important to avoid when creating a conservation plan. Moreover, while the U.S. FWS, ADFG, and EPA all understand environmental laws and regulations, their jurisdiction focuses on maintaining economic prosperity and contains bureaucratic red tape. Environmental lawyers have specialized knowledge of the loopholes and shortcomings to help best form a conservation plan that protects the ecosystem outside of the guise of political agendas.

Public Interest Representative

Public Interest Representatives would join the planning team because of their experience surveying the public and historical records of general public opinions. These representatives would be hired from the Alaska Public Interest Research Group (AkPIRG) and would provide baseline information on public opinion regarding conservation, expanding marine protected areas, the importance of maintaining fishing and tourism industries, etc. They would also conduct new research on public interest in areas lacking information and on the conservation plan itself once formed. This would ensure that the general interests of the public are taken into account during the planning process.

Local Fishers Interests Representatives

Fishing accounts for a large portion of Alaska's economy supporting an estimated 102,400 full-time-equivalent jobs in the U.S., with workers earning about \$6.1 billion in total annual labor income (McKinley Research Group, 2022). Due to its impact on the economy and the importance of sea life abundance and biodiversity in kelp forests, local fishers should be represented in the planning process. The Alaska Longline Fishermen's Association can provide insight into the opinions of fishers, who depend on harvesting seafood for their livelihoods. Including representatives from this organization will help in creating a conservation plan for kelp forests that guarantees the prosperity of the seafood industry.

Cruise Ship Industry Representatives

Cruise ship industry representatives are included on the planning team because of their contribution to the local economy. Cruise ships are a major portion of the Alaskan economy, generating \$1.35 billion annually, and directly employ almost 15,000 Alaskans (Alaska Alliance for Cruise Travel, 2024). However, cruise ships are also a source of pollution in Alaskan waterways from dumping of treated wastewater and exhaust gas scrubber wastewater. Therefore, having cruise ship representatives can allow for the implementation of restrictions on pollutants in a way that ensures the viability of the industry.

Oil Industry Representatives

Oil industry representatives are included in the planning team due to its relationship to environmental degradation and simultaneous large contribution to the Alaskan economy. Kelp forests are at risk from oil spills, which stem from onshore accidents as opposed to offshore wells in this region. Almost 85% of the state's budget is supplied by oil revenues, so there is a great desire to protect the economic value of oil in the conservation plan (State of Alaska, 2024). Therefore, including representatives from various oil companies would ensure their voices aren't ignored in the conservation planning process, decreasing resistance to plan implementation.

Stakeholders

A stakeholder is a person or group that has a direct connection to a project that will bring change to an ecosystem and/or will be affected by a change in the ecosystem. In the context of an environmental conservation plan, it is someone who has an interest or concern in the conservation of a particular environment or natural resource. Some examples of stakeholders in

this project include locals who are directly influenced or are affecting the ecosystem where the conservation plan occurs (Table 2). Groups such as fisheries, tourists, NGOs, and indigenous groups are some of the members needed to approach this plan in an effective and well-rounded manner. The stakeholder's insight and understanding of the conservation plan will provide beneficial information for project planners and facilitate awareness and inclusivity for all parties involved or affected.

Table 2. Stakeholders

Member	Skillset	Organization	Role
Indigenous People	Traditional Ecological Knowledge	Unangaq, Alutiiq/Sugpiaq, Eyak, Tlingit, Haida, Tsimshian, Nuxalk, Heiltsuk, Nuu-chah-nulth, Tsimshian, and Kwakwaka'waka Tribes	Designing conservation plans with a comprehensive understanding of marine systems and the cultural importance of biotic and abiotic factors of the region
Alaskan Government	Historical knowledge of the legal system and restrictions from govt	State of Alaska	Evaluate state-led contributing factors, address legal methods of conservation
Commercial Fishing Industry	Understanding of seafood abundance on the economy	Blue Ocean America, Samuels and Son Seafood, Grand Hale Marine Products Co., Wild Harvest Seafoods	Designing sustainable seafood harvesting that allows for industry to thrive still
Recreational Sports Industry	Understanding of recreational rentals and permits on the economy; Understanding of fish populations and factors that affect them (kelp forest health, sea urchin abundance, etc.); Understanding of recreational fishing on economy	Alaskan Sea Kayak, Sitka Sound Ocean Adventures, Alaska Kayak Company; J-Dock Fishing Co, Iliamna Fish Co, Underdog Sport Fishing	Designation of site-specific spots for recreating to continue economic development, while maintaining a healthy ecosystem; Designing conservation plans for fish in the region to support biodiversity while maintaining economic abundance from fishing
Governing Bodies	Site-specific knowledge of the current	U.S. FWS, ADFG, EPA	Altering and additional legal regulations to

	environmental setting and legal restrictions of marine area		protect the marine area in question
Cruise Industry	Understanding of tourism, specifically cruises, on the economy; routes follow large parts of Alaskan kelp forests	Royal Caribbean Cruises Alaska, Princess Cruises Alaska, Celebrity Cruises Alaska, Regent Seven Seas Cruises	Redesign cruise ship routes to avoid protected areas; reduce the size and scale of cruise expeditions
Marine Biologists and Researchers	Understanding of marine environments, what components are necessary for survival; Specialized knowledge of the marine areas of Alaska, heavily important in maintaining kelp forests	NOAA, Alaskan Fisheries Science Center, Institute of Marine Science (U of A, Fairbanks)	Designing conservation plans with a comprehensive understanding of marine systems
Oil Industry	Understanding of the oil industry's impact on the local economy and the occurrences of oil spills in the Gulf	ConocoPhillips, ExxonMobile, Chevron, Alyeska Pipeline Service Company, etc.	Research causes of oil spills and impacts to the environment, work on plans to reduce accidents
Non-profit groups (NGOs)	Conservation practices for endangered wildlife, public engagement, outreach, and awareness	NRDC, Kelp Forest Foundation	Research on ecosystem change and environmental predictions, work on public engagement and support strategies

Indigenous People

Alaskan Indigenous Tribes, including the Unangaq, Alutiiq/Sugpiaq, Eyak, Tlingit, Haida, Tsimshian, Nuxalk, Heiltsuk, Nuu-chah-nulth, Tsimshian, and Kwakwaka'waka Tribes, are important stakeholders in the conservation of giant kelp forests. Giant kelp forests have been used for generations as food, building materials, and in cultural practices (Smith, 2021). The connection between Indigenous people and the Alaskan Giant Kelp forests makes them a major stakeholder in the conservation plan. Understanding the stake Indigenous Tribes have in the conservation of these ecosystems ensures that their rights, culture, and traditional ecological knowledge are not degraded in the process.

Alaskan Government

The Alaskan Government holds stake in the conservation plan because the Giant Kelp Forests ecosystems that are endangered are off the southern coast of their state (IUCN, 2010). They are the main regulatory authority of the area as they have the power to create and enforce laws and regulations that would impact the kelp forests. States are responsible for managing their natural resources, which includes the marine life in this ecosystem. There is an important economic value of Giant Kelp Forests, as commercial fishing, oil, recreational sports, and cruise ship industries rely on the prosperity of the ecosystem. The state has a responsibility to ensure economic prosperity of the states, thus proving their stake in the conservation of Alaskan Giant Kelp Forests.

Commercial Fishing Industry

The commercial fishing industry has a stake in the conservation of Alaskan Giant Kelp Forests because the prosperity of the ecosystem has a direct impact on fish abundance. The heavily interconnected food web of Alaskan Giant Kelp Forest marine life populations demonstrates the need to maintain a healthy ecosystem to ensure the abundant populations of commercially-fished species (Estes et al., 2009). Moreover, if there is a reduction in the quality of the ecosystem, all marine life will decline, resulting in lower catch rates and a decline in revenue. Therefore, the commercial fishing industry holds a significant stake in the conservation of Alaskan Giant Kelp Forests.

Marine Recreational Sports Industry

The marine recreational sports industry demonstrates their stake in conserving Alaskan Giant Kelp Forests. Marine recreational sports including kayaking, fishing, and diving, contribute to Alaska's economy and rely on the prosperity of this ecosystem to bring interest. Without the beauty and abundance of wildlife of the kelp forest ecosystem, there would be little to no interest in marine recreation. Recreational fishing relies on the health of the ecosystem the same way commercial fishing does, as previously described. Consequently, the marine recreational sports industry holds a stake in the conservation of the Alaskan Giant Kelp Forest ecosystem.

Governing Bodies

Governing bodies, including the U.S. FWS, ADFG, and EPA, have a stake in conserving Alaskan Giant Kelp Forests because each of these departments are dedicated to ensuring

environmental conservation or protection. The central mission of the U.S. Fish and Wildlife Service is “conserving, protecting, and enhancing fish and wildlife and their habitats for the continuing benefit of the American people”, which demonstrates the stake it holds in protecting this ecosystem (U.S. FWS, 2024). The Alaskan Department of Fish and Game is the state-equivalent agency, thus holding a similar stake in the protection of the kelp forests off the Alaskan coast. Lastly, the Environmental Protection Agency’s mission to protect human health and the environment demonstrates a clear stake in the conservation of Alaskan Giant Kelp Forests (EPA, 2024).

Cruise Industry

The cruise industry are stakeholders in the conservation of kelp forests in Alaska because many of the cruise ship routes pass through the southern coastline, where the kelp forest populations are abundant. The industry relies on the prosperity of this ecosystem because many people attend cruises to see the natural beauty and biodiversity of the area. Seeing as the cruise industry provides for the livelihood of over 62,000 people, they hold stake in ensuring their businesses stay afloat through the conservation of Alaskan Giant Kelp Forests (Alaskan Alliance for Cruise Travel, 2024).

Marine Biologists and Researchers

Marine biologists and researchers hold stake in the conservation of Alaskan Giant Kelp Forest ecosystems because their careers rely on the biodiversity and health of marine ecosystems. As previously mentioned, the food web of kelp forests is heavily intertwined, so even researchers or biologists that focus on one species hold stake in maintaining the health of the entire ecosystem (Estes et al., 2009). The degradation of the ecosystem would result in the inability to conduct research on its inner workings, functions, abiotic components, and biotic factors. Hence, the conservation of Alaskan Giant Kelp Forest ecosystems is of interest to marine biologists and researchers due to the stake held.

Oil Industry

The oil industry holds stake in the conservation of Alaskan Giant Kelp Forests because of the past occurrences of ecosystem degradation from oil spills. The public opinion of the oil industry is heavily influenced by the occurrence and response to pollution, and the public drives the economy. It would behoove the oil industry to support conservation of Alaskan Giant Kelp

Forests to demonstrate to the general public that they will reparate for their actions. The oil industry in Alaska is dependent upon world oil prices, controlled by consumer demand which is based on industry perception (State of Alaska, 2024). Therefore, there is a clear connection between the prosperity of the oil industry and the protection and conservation of Alaskan Giant Kelp Forests.

Non-profit Groups

Non-profit groups, such as the NRDC and Kelp Forest Foundation, are also stakeholders in the conservation of Alaskan Giant Kelp Forest ecosystems. These non-profit organizations share a mission of protecting Earth's natural resources, with the Kelp Forest Foundation having an ecosystem-specific focus. Seeing as these organizations' missions are heavily related to the prosperity and health of Giant Kelp Forests in Alaska, they hold stake in the conservation of said ecosystems.

Decisions, Opportunities, Sideboards, and Constraints

When making decisions about optimal ways to protect an at-risk habitat, there are often predetermined factors that influence As of the most recent assessment performed in 2010, the Alaskan Giant Kelp Forest is listed as Endangered on the International Union for Conservation of Nature (IUCN) Red List of Ecosystems. Under the Endangered Species Act (ESA), some reaches of this endangered ecosystem are protected by proxy through the designation of Steller Sea Lion Critical Habitat (Figure 5) (NOAA, n.d.). Moreover, the waters a few miles off the coast of Glacier Bay National Park are included in the project scope, providing further proximal preservation. Despite these fragmented areas of sanctuary for the ecosystem, the kelp forests themselves do not have direct legal protections. Therefore, an opportunity is presented to protect Alaskan Giant Kelp Forests through the creation of a Marine Protected Area off the coast of Alaska where this endangered habitat occurs.

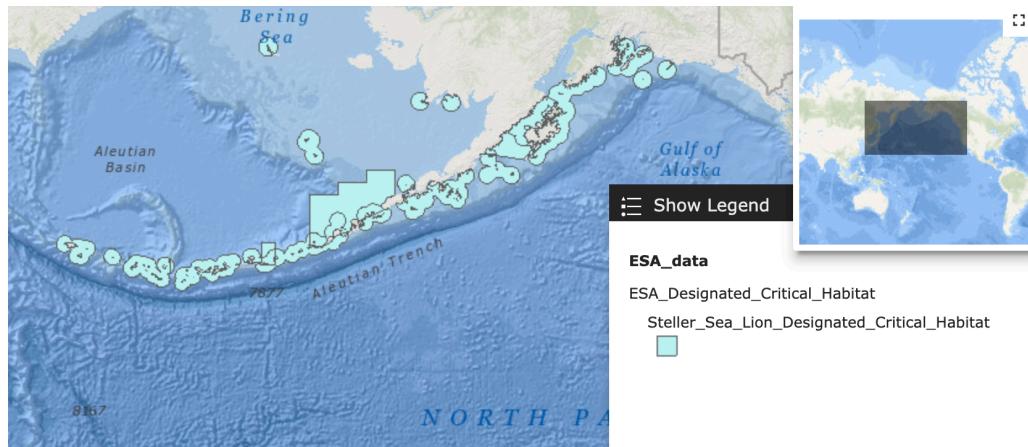


Figure 5. ESA designated Steller Sea Lion Critical Habitat (Map from NOAA)

Situation Analysis

Introduction

A situation analysis is a tool used to highlight linkages between elements of a conservation plan. It is fundamental to showing how impacts and threats function as drivers and causes of change within an ecosystem, allowing conservationists to identify key intervention points for strategies. A situation analysis for the Alaskan Giant Kelp Forest ecosystem is depicted in Figure 6 below.

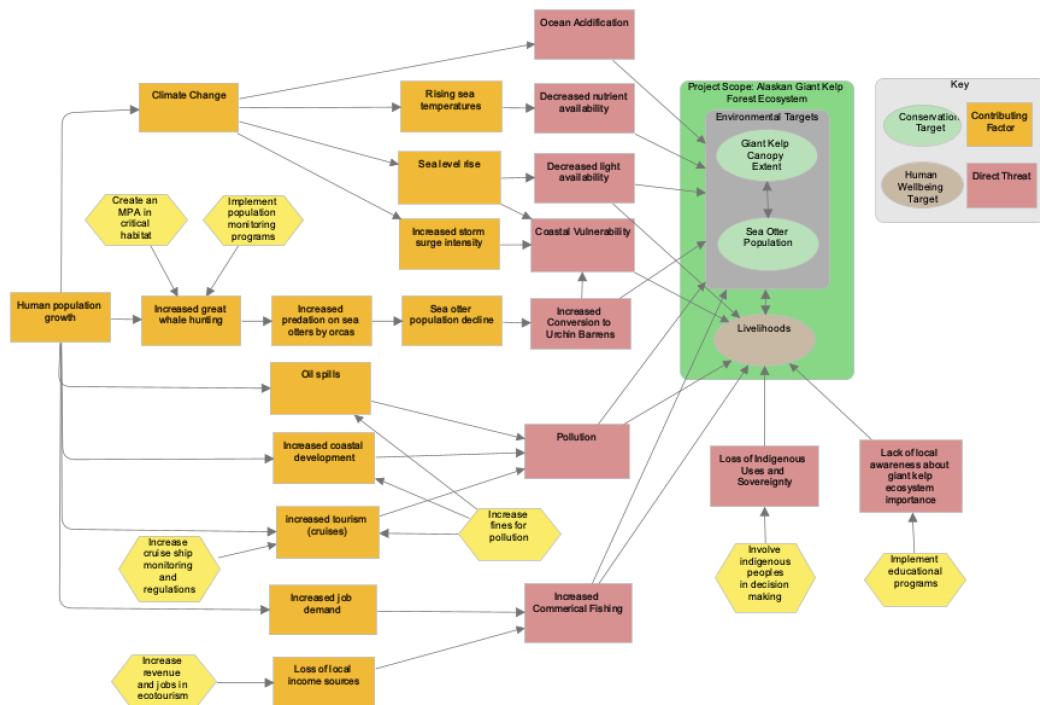


Figure 6. Situational Analysis of Alaskan Giant Kelp Forest Ecosystem (Figure created using Miradi)

Socio-Ecological Context

Human population growth has served as a driving force behind many ecological harms, and the situation of the Alaskan Giant Kelp Forest is no exception. Anthropogenically-induced climate change has led to many threats upon the Alaskan Giant Kelp Forest, including increased ocean acidification, increased storm intensity, and rising sea temperatures and sea levels (IUCN, 2010). Higher ocean temperatures means there is less nutrient availability, as upwelling processes that bring nutrient rich water to the surface rely on cold water temperatures (IUCN, 2010). Additionally, sea level rise decreases light availability for kelp to photosynthesize because the light can't penetrate as deep into the water. Lastly, more frequent and intense storm surges increase coastal vulnerability, which poses a threat to humans living along coastlines where Alaskan Kelp Forests occur (IUCN, 2010).

An indirect anthropogenic impact upon the ecosystem has ultimately led to rapid conversion of Alaskan Giant Kelp Forests to urchin barrens (Estes et al., 2009). A recent increase in great whale hunting off the Alaskan coast has had an unexpected impact on the trophic levels of the ecosystem – orcas historically have targeted great whales as prey, but with increased whaling off the Alaskan coast, this food supply has dwindled. Therefore, orcas have turned their attention to hunting sea otters as an alternate food source (Estes et al., 2009). Sea otters are keystone species that prey upon sea urchins, preventing their populations from proliferating and over consuming giant kelp. With a declining sea otter population, ecosystem type conversion from kelp forest to urchin barren is being widely observed. Urchin barrens are significantly less diverse and productive than kelp forests, and also contribute to a positive feedback mechanism of increased carbon in the atmosphere, as it takes away the carbon sink functionality provided by kelp forests. Additionally, human interference via oceanic pollution, oil spills, a growing fishing industry and increased harvest of kelp exacerbates harm on the already vulnerable ecosystem (IUCN, 2010).

Human wellbeing is greatly affected by the health of the Alaskan Kelp Forest Ecosystem, as it provides revenue from ecotourism, fishing and harvesting, as well as provides coastal protection from storms like previously discussed. Moreover, consumption of kelp has cultural significance to indigenous populations of the Alaskan coastline (Smith, 2021). As a result, the loss of this ecosystem would subsequently harm human livelihoods and biodiversity alike.

Project Scope

The conservation plan focuses on preserving and expanding the giant kelp forest ecosystem off the southern coast of Alaska, which ranges from Attu Island to Kunghit Island. The boundaries of our project are set between 45-60°N and 170-130°W.

This conservation plan is a 20-year project. The first five years will involve strategy implementation to facilitate the ecological goals of the plan. The subsequent 15 years will be the monitoring period to ensure the environmental and human well-being targets are being adequately addressed. If certain strategies are not leading to intended desirable outcomes, adaptive management techniques will be utilized. After the initial 20-year project period, five-year intervals to conduct a comprehensive ecological health survey will be used to passively track ecosystem recovery and progress.

Fundamental Objectives and Desired Outcomes

The conservation plan's desired outcomes, based on the stakeholders values and goals, were categorized into three main parts: environmental, social, and economic (Table 3).

Table 3. Fundamental Objectives and Desired Outcomes for Alaskan Kelp Forest

Alaskan Kelp Forest Ecosystem Conservation	Fundamental Objectives	Features	Indicators	Targets
	What & Direction	What can be measured	How will 'what' be measured	Goal/time
Environmental – Biodiversity	Decrease Sea Urchin Populations	Abundance of Sea Urchin Populations	Count number of sea urchins per 10 meter transect quadrat	Decrease numbers of sea urchins by 40% in 4 years
	Increase Sea Otter Populations	Abundance of Sea Otter Populations	Count number of otters in aerial surveys over 1 hectare of land	Increase number of sea otters by 50% in 2 years
Environmental – Ecological Processes	Improve Water Quality	Water Quality	Water Quality Index	Increase Water Quality Index by 30 points in 5 years
Environmental – Ecosystem Services	Increase coastal buffer (shoreline protection)	Kelp Forest Canopy Extent	Kelp biomass via Remote Sensing Technology	Increase Kelp Forest Canopy by 20% in 2 years

Economic	Increase Ecotourism Revenue	Tours/diving opportunities from recreational companies	Count number of reservations made by tourists	Up to 30,000 reservations annually in 6 years
Social	Increase Sustainable methods of Kelp Harvesting	Educational Courses and workshops Provided	Count number of students attending courses and workshops	Number of students should reach 25 in four years
	Increase Indigenous involvement in Kelp Forest Management	Indigenous people on NOAA fisheries boards	Count number of individuals from Native Alaskan Tribes on decision-making boards in NOAA fisheries	Number of individuals involved should increase by 70% in five years

Environmental–Biodiversity

Decrease Sea Urchin Populations

A key fundamental objective is to monitor sea urchin populations since it is intrinsically linked to kelp forest stability. A high amount of sea urchins is detrimental to kelp vitality since too many sea urchins can overgraze the kelp, leading to a decrease in the biological foundation for diversity in the kelp forest. Kelp is the biological foundation for the diversity of organisms they harbor in the kelp forest ecosystem (Foster, et al., 1988). Additionally, keeping a stable population of kelp plants is necessary for one of the stakeholders mentioned in Table 3, the Kelp Harvesters which rely on this plant for their livelihoods. Therefore, decreasing sea urchin populations to a sustainable size will provide room for kelp forests to regenerate, providing benefits to the ecosystem and surrounding communities alike.

Increase Sea Otter Populations

Another key fundamental objective necessary to maintain the biodiversity in the Alaskan Kelp Forest is to increase the declining population of sea otters. Sea otters are a keystone species meaning they play a critical role in maintaining the structure of the ecosystem. They prey upon invertebrates and detritivores including mussels, crabs, and clams, which if too many exist, can overgraze primary producers including algae and plankton (Estes et al., 1978). Consequently, if sea otter populations are not abundant, then sea urchins and other grazers are able to proliferate and degrade kelp forests, leading to the destruction of the ecosystem. By increasing sea otter

populations to a healthy size, the balance necessary for proper ecosystem function will be restored and this keystone species will be able to perform its essential role.

Environmental –Ecological Processes

Improve Water Quality

The Alaskan Kelp Forest houses high levels of aquatic biodiversity and functions as a key habitat along the Alaskan coastline. Due to its strong structural nature, this kelp forest provides shelter from predators, as well as a safe environment for mating and raising young for multiple marine species. Consistent ecosystem upkeep is required to provide these services. Multiple environmental impacts have negatively altered the water quality of this area, such as pH, salinity, and temperature change, all which disrupt this ecosystem and decrease biodiversity (Kachur et al., 2019). These changes leave the ecosystem prone to collapse and proceeding cascading effects on neighboring environments and ecosystems. As mentioned in Table 3, stakeholders must address the improvement of water quality for the sake of marine life and the benefits it provides not only for aquatic organisms, but for humans as well. An increase in 30 points of the Water Quality Index in 5 years will provide sufficient change that will help the ecosystem withstand global ocean acidification, temperature change, and salinity uptake.

Environmental –Ecosystem Services

Increase coastal buffer (shoreline protection)

Increasing the biomass of the kelp forests is essential to provide an ample ecosystem area for marine animals. This is achieved by increasing coastal buffer areas to provide sufficient space for the kelp forests to regenerate with minimal disturbance. A 20% increase in kelp forest canopy extent in a timeline of two years (Table 3) is essential to ensure the forest is sufficiently protected and resilient enough to avoid ecosystem disruption. With an increased canopy cover, the ecosystem can support more biodiversity by expanding space to mate, raise young, and have protection from the open ocean. Additionally, the ecosystem service of coastal protection from waves and storm surges is essential to the communities living alongside kelp forests. Kelp functions as a shield that slows down large waves, reducing coastal erosion – a threat that grows more pertinent to coastal communities as climate change continues to progress. This goal will be monitored using remote sensing technology as a non-invasive method to measure kelp canopy extent (Stekoll et al., 2007). Although this fundamental objective will inherently decrease

commercial kelp harvesting, potentially impacting the economic market, the environmental benefits yielded largely outweigh the economic losses.

Economic

Increase Ecotourism Revenue

While limiting human interference in the kelp forest ecosystem will allow it to properly regenerate, it is also beneficial to maintain sustainable levels of recreational ecosystem services. Benefits to the local job market can be derived by increasing ecotourism revenue through guided tours and diving opportunities. This method of human interaction is favored compared to commercial fishing or other non-monitored human activities, as it can be conducted in a way that allows tourists to safely observe and minimally interact with the kelp forest, without instilling negative effects or ecosystem disruption (Lopez et al., 2017). This goal will stimulate local economic endeavors, while still supporting the conservation and health of the Kelp Forest. To have 30,000 visitors annually in six years will significantly increase ecotourism revenue, along with the creation of new jobs, and spread educational awareness about the importance of protecting kelp forests.

Social

Increase Education on Sustainable Kelp Harvesting and Sea Otter Conservation

Increased environmental awareness of the significance of the Alaska Giant Kelp Forest is critical to harboring local support for conservation efforts of this ecosystem. By providing educational courses and workshops, the importance of the Kelp Forest and its qualities that benefit both humans and aquatic organisms can be emphasized to foster support for conservation (Lopez et al., 2017). The goal of instructing 25 students within the next four years will serve as a baseline of educational material that could potentially be expanded upon in the future. These courses can range in topics such as kelp reproduction and methods to augment their biomass, to technical courses on remote sensing and collecting field data, to aquatic mammal importance and knowledge on keystone species, such as sea otters (Estes et al. 1995). This goal is meant to be interactive to locals and tourists alike by creating a curriculum that sparks their interest and also effectively teaches on the importance of ecosystem conservation. This platform will become a focal point for visiting the Alaskan Kelp Forest and will give opportunities for locals to participate in citizen science.

Increase Indigenous Involvement in Kelp Forest Management

Pacific Northwest Indigenous Tribes native to the surrounding areas of the Alaskan Kelp Forest including the Unangaq, Alutiiq/Sugpiaq, Eyak, Tlingit, Haida, Tsimshian, Nuxalk, Heiltsuk, Nuu-chah-nulth, Tsimshian, and Kwakwaka'wakw which have existed for thousands of years, up to 15,000 years (Turner, 2020). Land allocation laws and regulations, without fail, manage to neglect Indigenous groups rights to their land. In order to circumvent this problem, indigenous tribe members native to areas adjacent to the Alaskan Kelp Forest deserve seats allocated to them on the NOAA decision-making board. These tribes have relied on kelp for food and support for millenia and understand the complexities, patterns, and behaviors of the Alaskan Kelp Forest in an unparalleled manner with their thousands of years of experience. Native Alaskan Tribes are also one of the stakeholders in Table 3, and they possess knowledge of sustainable methods for harvesting and managing marine resources. This traditional ecological knowledge can be utilized by stakeholders such as Kelp Harvesters and Sea Urchin Harvesters, fostering less intrusive methods for harvest. Incorporating and listening to native tribes is significant because it highlights sustainable use of the kelp forest, as well as preserves cultural uses of kelp forest resources.

Conservation Features

Features, Indicators, and Targets

The fundamental objectives in Table 3 have corresponding conservation features, indicators and targets to outline how this conservation plan seeks to accomplish the said objective. Conservation features serve to monitor the progress of achieving the goals the conservation plan sets and describe what aspects of the fundamental objective can be measured. Indicators are measurable features used to detect if the progression of the fundamental objective has been met. The targets are goals the conservation plan aims to achieve in a given timeframe for each fundamental objective. Each objective ensures incorporation of stakeholder values so all parties involved with the Alaskan Kelp Forest are ultimately benefited by the implementation of the conservation project.

Features, Indicators, and Targets for Environmental Objectives

For the biodiversity fundamental objective “Decrease Sea Urchin Populations”, the feature that will be measured is the abundance of sea urchin populations. The corresponding

indicator in this case is the number of sea urchins per 10-meter transect quadrat (**Direct**). This objective is to reach a 40% population decrease of sea urchin biomass in four years.

Another biodiversity fundamental objective is to “Increase Sea Otter Populations”, which has the feature of sea otter population abundance. The indicator associated with this objective is to monitor the number of sea otters in aerial surveys in one hectare of land (**Direct**). Aerial surveys are recommended in order to minimize human interactions and potential disturbance while still getting an accurate count of present sea otters in the area. This goal is to increase the sea otter population size by 50% in two years.

For our team's ecological processes fundamental objective, the corresponding feature is “Improve water quality”, which is featured by the water quality of the kelp forest. A Water Quality Index will serve as its indicator (**Constructed**) in order to keep track of the patterns and trajectory of the water quality over time. The target assigned for this objective is to increase the Water Quality Index by 30 points (out of 100) in five years.

The ecosystem service fundamental objective is addressed through increasing coastal buffer and shoreline protection. The feature associated with this objective is the kelp forest canopy extent. The indicator will be measured kelp biomass using remote sensing technology (**Proxy**). Remote sensing will be an effective measurement tool that can reflect the varying densities throughout the forest, along with data on the forest's depth and kelp health (NDVI reflectance measurement). This objective's target is to increase kelp forest canopy by 20% in two years.

Features, Indicators, and Targets for Economic and Social Objectives

For the economic objective “increase ecotourism revenue”, the feature that will be measured is tour/diving opportunities from recreational companies. The corresponding indicator will be to count the number of reservations made by tourists (**Proxy**). This objective has a target to receive up to 30,000 reservations per year in six years.

The first social fundamental objective is to “Increase sustainable methods of kelp harvesting”, which will be measured by the feature of educational workshops and courses. Developing an understanding of kelp harvesting and the economic benefits it yields is crucial for establishing a sustainable harvesting practice. The indicator used will be the number of students attending courses and workshops (**Proxy**). This objective's target is to reach a number of 25 enrolled students in four years.

The second social objective is to “Increase Indigenous Involvement in Kelp Forest Management”, which will be measured by the feature of Indigenous people on NOAA fisheries board. The indicator will be to count the number of individuals from Native Alaskan Tribes on the decision-making boards for NOAA fisheries (**Proxy**). The target goal is to have the number of indigenous individuals involved increase by 70% in five years.

Range of Strategies

Many approaches exist for the preservation of the Alaskan Giant Kelp Forest. Below, several strategies are outlined alongside their respective targets and goals, facilitating a comparative analysis. Additionally, a senceria depicting inaction towards kelp forest preservation is presented, discussing its consequences to establish a baseline for evaluating the efficacy of other strategies.

Marine Protected Area

The designation of a marine protected area (MPA) legally safeguards sensitive ecosystems like the Alaskan Giant Kelp Forest. Some threats faced by the kelp forest include unsustainable fishing practices and habitat degradation from human interferences. By designating the area covered in this project’s scope as an MPA, a protected zone from human impact is created, allowing the ecosystem to regenerate. Moreover, MPAs contribute to the broader conservation efforts, ensuring the resilience of the Alaska Kelp Forest against the impacts of climate change and anthropogenic disturbances.

Increased fines for Pollution

The Alaskan Kelp Forest relies on clean, nutrient-rich waters, and any contamination can disrupt its fragile balance. Pollution, whether from industrial runoff, oil spills, cruise ship dumping, or marine debris, poses a threat to the Alaskan Giant Kelp ecosystem. By increasing fines, polluters will be incentivised against practices that lower water quality and cause harm to marine life. Higher penalties will not only discourage polluters, but also have the added benefit of creating funds and resources that can be put towards mitigation and restoration efforts.

Increase Cruise Ship Monitoring

Stricter monitoring of cruise ships is key in safeguarding the Alaskan Kelp Forest. While cruises bring tourists and contribute largely to the local economy, they also pose environmental

risks, from sewage discharge to fuel spills. Enhanced monitoring of ship activity promotes adherence to environmental regulations, minimizing the impact of these vessels on the kelp forest habitat. Monitoring techniques would include tracking ship movements and enforcing compliance with guidelines, allowing authorities to address any potential threats, pollution and disturbances. Additionally, cruise ship monitoring encourages sustainable tourism practices.

Localized education and outreach programs about kelp forest ecological and social significance

Localized education and outreach initiatives foster a deeper understanding of the ecological and social significance of the Alaskan Giant Kelp Forest ecosystem among local communities, stakeholders, and visitors. As a result, a shared sense of responsibility and stewardship is created within the community, increasing support for conservation efforts and initiatives. Through workshops, interpretive signage, and community events, individuals gain insight into the intricate connections between kelp forests and the broader marine environment, appreciating their role in supporting biodiversity, mitigating climate change, and sustaining livelihoods. Furthermore, ecological knowledge can increase a sense of pride and connection to nature, inspiring collective local action in preserving the Alaskan Kelp Forest.

Recover Great Whale Populations

The recovery of great whale populations holds an indirect benefit for the Alaskan Kelp Forest by facilitating the recovery of sea otter populations. Great whales, such as humpback and grey whales, serve as critical prey for killer whales, without that prey source the killer whales feed on sea otters causing the reduction of their population. By restoring great whale numbers, the predation pressure on sea otters from killer whales will be alleviated, allowing space for the sea otter population to recover. As a further benefit derived from this strategy, sea otters help regulate urchin populations, preventing overgrazing of kelp forests.

Involve local Indigenous peoples in decision-making/planning

Involving local Indigenous populations in decision-making and planning processes of human uses in the Alaska Kelp Forest promotes holistic and culturally-relevant conservation efforts. Indigenous communities possess invaluable traditional ecological knowledge pertinent to the local area, offering insight into the intricate relationships between humans and the kelp forest ecosystem. By engaging Indigenous voices, we honor their deep connection to the land and sea, ensuring that management strategies are culturally sensitive, sustainable, and inclusive.

Moreover, collaboration with Indigenous communities fosters stewardship initiatives rooted in respect for nature and indigenous rights, leading to more effective conservation outcomes. By embracing Indigenous perspectives and practices, we forge partnerships that will nurture the resilience of the Alaska Kelp Forest and enrich the cultural heritage of the region in tandem.

No Action

The absence of conservation action would significantly impact Alaska's kelp forests. Without proactive measures, this marine ecosystem would face increasingly heightened threats from factors depicted in the situational analysis (Figure 6). This scenario would disrupt the balance of marine biodiversity supported by kelp forests, jeopardizing species vitality and compromising the resilience of the ecosystem as a whole and undermine their ecological and socio-economic significance.

Strategy Selection

Consequence Table

Two tools were utilized to assess strategies and pinpoint the most effective methods for kelp forest conservation: a consequence table (Table 4) and a Multi-Criteria Decision Analysis (MCDA) (Table 5). These tables pinpoint key strategies in relation to the identified fundamental objectives, ensuring alignment between stakeholder values and ecosystem needs. These potential strategies are evaluated compared to “No Action” (business as usual), providing valuable insights for decision-making and the importance of implementing a conservation plan.

informing decision-making processes. Among the seven strategies considered, Education and Outreach is identified as most impactful in achieving the objectives outlined in this proposal, with a score of four. Conversely, the No Action pathway is identified as largely inadequate in realizing any of the project goals, with a score of negative three.

Multiple Criteria Decision Analysis

A Multi-Criteria Decision Analysis (MCDA) establishes a rating for specific strategies based on their efficacy in fulfilling core objectives (Table 5). This tool aids the planning team in determining the prioritization and sequence of optimal strategy implementation. Initially, sixteen proposed strategies were narrowed down to seven, as depicted in the consequence table (Table 4). The Fundamental Objectives are assessed on a scale to one to five based on stakeholder and planner priorities, with one representing the lowest priority and five indicating the highest. Meanwhile, Strategy Options are evaluated on a scale of one to ten, with one indicating the least effective and ten the most effective in advancing the project's fundamental objectives. To derive the total score, the weight of the fundamental objectives is multiplied by the rating assigned to each strategy option. The resulting values are summed for each strategy in the Total column, with higher totals indicating greater effectiveness in advancing fundamental objectives while maintaining alignment with stakeholder and planner priorities.

Table 5. Multiple Criteria Decision Analysis table quantifying the effectiveness of each Strategy

Fundamental Objectives Weight (1-5) Strategies Weight (1-10)	Decrease Sea Urchin Populations (2)	Increase Sea Otter Populations (2)	Improve Water Quality (3)	Increase Coastal Buffer (shoreline protection) (2)	Increase Ecotourism Revenues (4)	Increase Sustainable Methods of Kelp Harvesting (5)	Increase Indigenous Involvement in kelp forest management (5)	Total
Marine Protected Areas	4 (8)	10 (20)	8 (24)	10 (20)	10 (40)	0 (0)	10 (50)	162
Increased fines for pollution	0 (0)	0 (0)	10 (30)	0 (0)	8 (32)	0 (0)	0 (0)	62
Increase cruise ship monitoring	0 (0)	3 (6)	10 (30)	0 (0)	3 (12)	0 (0)	0 (0)	18

<i>Education and outreach</i>	5 (10)	6 (12)	7 (21)	4 (8)	0 (0)	3 (15)	3 (15)	81
<i>Recover great whale populations</i>	9 (18)	10 (20)	0 (0)	7 (14)	10 (40)	4 (20)	4 (20)	114
<i>Involve local indigenous peoples</i>	7 (14)	10 (20)	5 (15)	2 (4)	8 (32)	10 (50)	10 (50)	185
<i>No Action</i>	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0

Examination of this table indicates that among the seven strategies under consideration, Marine Protected Areas, the recovery of great whale populations, and the engagement of local Indigenous peoples in decision-making processes were deemed most effective in achieving the outlined objectives. Conversely, the "no action" pathway is deemed insufficient in meeting any of the project goals.

Implementing a multi-faceted approach combining marine protected areas (MPAs), heightened fines for pollution, increased cruise ship monitoring, education and outreach programs, recovering great whale populations, and involving local Indigenous peoples represents the most comprehensive strategy for conserving the Alaskan Kelp Forest. An MPA would provide protected space for at-risk populations to naturally recover. Heightened fines would deter pollution, preserving water quality and habitat integrity. Increased cruise ship monitoring would promote alignment with environmental regulations, minimizing disturbances to the kelp forest. Education and outreach efforts foster community understanding and support for conservation initiatives, while involving local Indigenous peoples ensures kelp forest management is both sustainable and culturally sensitive. Together, these measures promote ecosystem recovery, resilience and biodiversity, contributing to the long-term health of the Alaskan Kelp Forest.

Data and Knowledge

Data

Data enables the team to define current conditions for natural resources, such as limitations and the potential for its desired use to support stakeholder values and the sustainability of the kelp forest. Data provides baseline conditions needed to analyze conservation effectiveness. A variety of data types should be included in the Alaskan kelp forest conservation plan, including biological data (ex. Species composition and population dynamics for sea otters), environmental data (ex. changes in temperature, salinity, currents, or water quality that affect the health of the kelp forest), geospatial data (ex. maps or spatial data that shows the range of the kelp forest, where threats are located, and different conservation zones), historical data (ex. past events and circumstances pertaining to the kelp forest that caused changes in its structure or dynamics over time), and social data (ex. human activities like tourism, fishing practices, urban coastal development and more that impact the kelp forest).

Knowledge (expert, local, traditional)

Expert, local, and traditional sources of knowledge comprise a fundamental pillar of an effective conservation plan. Expert knowledge benefits the Alaskan kelp forest observation plan because it provides skills and specialized knowledge obtained through education, training, and experience in a specific field, such as ecological dynamics of kelp forests and its various interactions between the different species and in nutrient cycling. Expert knowledge from sources such as ecologists or marine biologists ensures the conservation plan is based on sound scientific principles and practices that increase overall project success. Expert knowledge from sources like the United States Fish and Wildlife Service (USFWS), Natural Resources Defense Council (NRDC), Environmental Protection Agency (EPA), Kelp Forest Foundation (KFF), Alaska Department of Fish and Game, and the National Oceanic and Atmospheric Administration (NOAA) provide important information pertaining to conserving the Alaskan Kelp forest and its biodiversity.

Local knowledge refers to insights and knowledge that is possessed by people who live near, or interact closely with, the environment. These include nearby coastal residents, indigenous communities, or fishers who can provide valuable information about the Alaskan kelp forest. This information includes seasonal changes, distribution of species, local uses of

resources, changes in fishing practices, identifying emerging threats to the Alaskan kelp forest like urban developments, shifts in weather patterns, sustainable harvesting practices, and current community-based conservation initiatives. Incorporating local knowledge helps to foster community engagement which increases the long-term success of the conservation project.

Traditional ecological knowledge includes the skills, practices, and knowledge that is developed, upheld, and passed down through generations of indigenous communities. Sources of traditional knowledge in this project can come from many of the Pacific Northwest Tribes such as Nuxalk, Haida, Heiltsuk, Nuu-chah-nulth, Tsimshian, and Kwakwaka'wakw because they rely on the Alaskan kelp forest for food and support. Traditional knowledge is important because indigenous and local peoples hold detailed information of the natural world, like the behavior of species, seasonal patterns, and relationships within the kelp forest ecosystem. Indigenous and local people have been coexisting for centuries with nature and have created sustainable practices for harvesting and managing marine resources. Incorporating traditional knowledge helps create a comprehensive plan that promotes the health of the kelp forest while upholding equitable conservation outcomes, and cultural traditions, medicines, practices, and ways of life.

Associated Metadata

Metadata refers to the information about data that describes the context of who, what, where, when, why, and how. The metadata included in the conservation plan for the Alaskan giant kelp forests is a description of the data used in the project, definitions of attributes, the period of time that is covered in the data, any restrictions that could prevent access, or use, of the data, the contact information of the organizations or people who developed the data, and certain keywords that will help the audience search or find the data.

Risks and Uncertainties

Risk and uncertainty is inherent in conservation because ecosystems are complex systems with overlapping associations and relationships between abiotic and biotic factors. This is further complicated by environmental variability, data limitation, and socio-economic factors. Below are some identified risks present in the Alaskan Giant Kelp Forest, listed from the highest level to the lowest level of uncertainty:

- 1) Global Climate Change
- 2) Insufficient Funding

3) Community Resistance

Risk #1 → Global Climate Change

The Alaskan giant kelp forest sustains a rich diversity of species, all of which are threatened by climate change. As climate change intensifies, the effects of ocean warming, acidification, sea level rise, erosion, weather extremes, changes to precipitation patterns, and increase of invasive species may diminish the giant kelp's growth, photosynthesis rate, and nutrient content. This further impacts all the species that rely on it for food and shelter. Climate change directly impacts the end-goal of the conservation project and creates high uncertainty for long-term success.

Risk #2 → Insufficient Funding

In order to implement the Alaskan giant kelp forest conservation plan, funding must be secured. A lack of funding hinders the effectiveness and long-term success of the project which is why it is a risk with fairly high uncertainty. Without sufficient funds, the scope of the project, its goals, and activities would need to be scaled back. Reducing the scope and scaling back the project would reduce its overall effectiveness in achieving the conservation outcomes we desire. Implementing the fundamental objectives involve decreasing sea urchin populations and increasing sea otter populations, improving water quality, increasing the coastal buffer, increasing ecotourism revenue, increasing sustainable kelp harvesting methods, and increasing indigenous involvement in kelp forest management, which needs sufficient funding to be conducted properly. Conservation is an ongoing process, and funding is needed to consistently monitor species and other data in the Alaskan giant kelp forest. Ensuring that key decision-makers and stakeholders are involved in discussions and decisions will help to limit the uncertainty and risk of insufficient funding

Risk #3 → Community Resistance

The Alaskan giant kelp forest conservation plan involves many strategies intended to protect the species already there and prevent future declines in population, quality of habitat, and more. However, there may be some community resistance since Alaska has approximately 606,100 coastal residents living on its 33,904 miles of coastline ("Alaska"). The strategies may change how coastal residents are able to interact with the waters near the Alaskan giant kelp forest. Community residents may have economic concerns since the conservation project will

alter or limit activities that generate revenue like fishing or tourism. There also may be community residents concerned that the conservation project would interfere with local traditions and cultural practices. Community resistance can be reduced by ensuring to not disrupt traditional land use patterns and maintaining access to culturally significant uses. Additionally, it is important to educate the community on the purpose and benefits of conserving the Alaskan giant kelp forest. When locals understand the importance and long-term benefits of the conservation project, they will be more supportive of proposed actions. Even more importantly, incorporating the community in discussions and decision-making will help them feel included and involved in the long-term success of the project.

Conclusion

The success of conserving the Alaskan Giant Kelp forest ecosystem hinges on the collective efforts of local stakeholders and the efficacy of selected strategic initiatives to maintain the kelp forest and its biodiversity. Despite inherent risks and uncertainties – including climate change, enforcement challenges, and outreach limitations – advocating for the conservation of giant kelp and its role as a keystone species remains imperative. Such conservation efforts not only benefit the diverse array of species inhabiting the kelp forest but also contribute to the sustainability of the local economy and uphold the heritage of Indigenous communities in the region. By conserving the Alaskan Giant Kelp Forest and its ecosystem using strategies outlined in this plan, both ecological resources and human livelihoods can be protected in tandem.

Bibliography

- Alaska Alliance for Cruise Travel. (n.d.). *Economic Benefits*.
<https://www.alaskaact.com/economic-benefits#:~:text=In%20Alaska%2C%20the%20cruise%20industry,wages%20to%2014%2C500%20Alaska%20workers>.
- Alaska Ocean Observing System. (n.d.). *Kelp Forests*. Alaska Ocean Acidification Network.
<https://aoan.aoos.org/impacts/species-response/kelp-forests/#:~:text=Kelp%20forests%20in%20Alaska%20are,more%20marine%20animals%20and%20invertebrates>.
- Alaska Seafood Marketing Institute. (2017). *Directory of Alaska Seafood Suppliers*.
<https://www.alaskaseafood.org/wp-content/uploads/2017-Supplier-Directory-Final.pdf>.
- California Department of Fish and Wildlife. (n.d.). *Metadata Guidelines*.
<https://wildlife.ca.gov/Data/BIOS/Metadata>.
- Christensen, S., Potouroglou, M., & Pedder, K. (2023, May 2). *What Is Kelp and Why Is it Vital to People and the Planet?* World Resources Institute.
<https://www.wri.org/insights/what-kelp-forests-protect#:~:text=However%2C%20over%20the%20last%2050,an%20the%20benefits%20they%20provide>.
- Estes, J. A., Doak, D. F., Springer, A. M., & Williams, T. M. (2009). Causes and consequences of marine mammal population declines in southwest Alaska: a food-web perspective. *Philosophical Transactions of the Royal Society of London. Series B. Biological Sciences*, 364(1524), 1647–1658. <https://doi.org/10.1098/rstb.2008.0231>.
- Estes, J. A., & Duggins, D. O. (1995). Sea otters and kelp forests in Alaska: generality and variation in a community ecological paradigm. *Ecological monographs*, 65(1), 75-100. <https://doi.org/10.2307/2937159>
- Estes, J. E., Smith, N. S., & Palmisano, J. F. (1978). Sea otter predation and community organization in the western Aleutian Islands, Alaska. *Ecology*, 59(4), 822-833. <https://doi.org/10.2307/1938786>.
- Foster, M. S., and D. R. Schiel. (1988). Kelp communities and Sea Otters: Keystone species or just another brick in the wall? In: VanBlaricom, G.R., Estes, J.A. (eds) The Community Ecology of Sea Otters. *Ecological Studies*, 65, 92–115. https://doi.org/10.1007/978-3-642-72845-7_5.

Ingram-David, A. (2024, February 4). *Underwater forests focus of new study in Alaska*. Alaska's News Source.

<https://www.alaskasnewssource.com/2024/02/05/underwater-forests-focus-new-study-ala-ska/>.

IUCN. (2010). *Giant kelp forests*. IUCN Red List of Ecosystems.

<https://assessments.iucnrl.org/assessments/6>.

Kachur, A. N., Kozhenkova, S. I., Shulkin, V. M., & Arzamastsev, I. S. (2019). Comparative effects of pollution stress on the West Bering Sea and Sea of Okhotsk Large Marine Ecosystems. *Deep Sea Research Part II: Topical Studies in Oceanography*, 163, 65-71. <https://doi.org/10.1016/j.dsr2.2019.04.010>.

Lopez, G., & Pearson, H. C. (2017). Can whale watching be a conduit for spreading educational and conservation messages? A case study in Juneau, Alaska. *Tourism in Marine Environments*, 12(2), 95-104. <https://doi.org/10.3727/154427316X14779456049821>

McKinley Research Group, LLC. (n.d.). *The Economic Value of Alaska's Seafood Industry*.

https://www.alaskaseafood.org/wp-content/uploads/MRG_ASMI-Economic-Impacts-Report_final.pdf.

NOAA. (n.d.). *Alaska*. NOAA Office for Coastal Management. Retrieved May 28, 2024, from <https://coast.noaa.gov/states/alaska.html>.

NOAA. (n.d.). *Alaska Protected Resources Division Species Distribution Mapper*. Retrieved May 19, 2024, from Alaska Protected Resources Division website: <https://alaskafisheries.noaa.gov/portal/apps/webappviewer/index.html?id=446543503a2e4660b0f5ee55e6407d27>.

Smith, J.R. (2021, June 11). *Reclaiming Native Knowledges Through Kelp Farming in Cordova, Alaska*. Vogue.

<https://www.vogue.com/article/reclaiming-native-knowledges-through-kelp-farming-in-cordova-alaska>.

Southeast Alaska Conservation Council. (n.d.). *Cruise Ship Dumping*.

<https://seacc.org/water-quality/cruise-ship-dumping/#:~:text=The%20two%20primary%20sources%20of,take%20through%20Southeast%20Alaska%20increases>.

- Stekoll, M. S., Deysher, L. E., & Hess, M. (2006). *A remote sensing approach to estimating harvestable kelp biomass*. In: Anderson, R., Brodie, J., Onsonyen, E., Critchley, A.T. (eds) Eighteenth International Seaweed Symposium. *Developments in Applied Phycology*, 1, 97-108. Springer Netherlands.
https://doi.org/10.1007/978-1-4020-5670-3_13.
- Stern, E. R., & Humphries, M. M. (2022). Interweaving local, expert, and Indigenous knowledge into quantitative wildlife analyses: A systematic review. *Biological Conservation*, 266 (109444). <https://doi.org/10.1016/j.biocon.2021.109444>.
- The State of Alaska. (n.d.). *Economy*. Official Alaska State Website.
<https://alaska.gov/kids/learn/economy.htm>.
- Turner, N. J. (2020). From “taking” to “tending”: learning about Indigenous land and resource management on the Pacific Northwest Coast of North America. *ICES Journal of Marine Science*, 77(7-8), 2472-2482. <https://doi.org/10.1093/icesjms/fsaa095>.
- U.S. Environmental Protection Agency. (n.d.). *Our Mission and What We Do*. EPA. Retrieved May 31, 2024, from <https://www.epa.gov/aboutepa/our-mission-and-what-we-do>.
- US Fish and Wildlife Service. (n.d.). *Mission and Vision*.
<https://www.fws.gov/about/mission-and-vision#:~:text=The%20U.S.%20Fish%20and%20Wildlife%20Service%2C%20working%20with%20others%2C%20is,interjurisdictional%20fish%20and%20marine%20mammals%2C>.