Conservation Plan for the Giant Sea Bass in California Kelp Forests

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Group Project Team: Isabella Bishop, Niyaz Hinze, Riley Clark, Zack Brady, Rachel Brody, Anthony Trimble

University of California, Santa Barbara, Environmental Studies Department

Executive Summary

The Giant Sea Bass (*Stereolepis gigas*), is a critically endangered apex predator, is facing population decline due to decades of overfishing and habitat degradation along California's coastline. This conservation plan aims to address these threats through targeted strategies to restore Giant Sea Bass populations, protect kelp forest ecosystems, and ensure the long-term health and resilience of the marine environment.

The main objectives for this plan include increasing Giant Sea Bass population size, minimizing kelp forest habitat degradation, maximizing profits from a healthy ocean and fishing industry, and increasing awareness and appreciation of the Giant Sea Bass, especially as a flagship species. Targets include increasing Giant Sea Bass numbers by 10% in 50 years, increasing Kelp forest coverage by 10% in next 50 years in California, maintaining a stable profit from the fishing industry, and increasing the number of non-profit organizations focused on Giant Sea Bass conservation.

The conservation plan for the Giant Sea Bass involves a comprehensive collaborative effort coordinated by a Planning Team, consisting of stakeholders from various sectors. This team includes marine biologists, policy analysts, ecologists, outreach coordinators, economists, and more, each contributing specialized expertise. Key stakeholders such as fishermen, coastal communities, NGOs, tourism industries, educational institutions, indigenous communities, government agencies, , and MPA managers play critical roles. Their collaboration is essential for implementing sustainable practices, advocating for responsible development, enforcing regulations, and raising public awareness.

There were many potential strategies discussed, with the selected strategies, habitat restoration, waste management improvement, and expanding marine protected areas being chosen because of their efficiency, effectiveness, and feasibility. The combination of these approaches addresses every fundamental objective, making them the best options for conserving the Giant Sea Bass.

Implementing the strategies proposed above will help rebuild and stabilize the Giant Sea Bass population in California. As a flagship species, the health of the Giant Sea Bass' is important to protect its cultural associations. Additionally, the Giant Sea Bass play a crucial role in the kelp forest ecosystem, and without them, many other marine species could become endangered.

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Planning Context

Introduction

The Giant Sea Bass (*Stereolepis gigas*) is critically endangered due to decades of overfishing and habitat degradation. This iconic species, which was once abundant along California's coastline, can grow over seven feet in length and weigh seven-hundred pounds (National Park Service, 2019). Within kelp forest ecosystems, the Giant Sea Bass plays a crucial role in maintaining the balance; the loss of this apex predator has led to negative cascading ecological effects. The need for a comprehensive conservation plan to protect and restore Giant Sea Bass populations is essential because, as a flagship and keystone species, further population decline could cause disruptive trophic cascades, disrupt nutrient cycling and cause biodiversity loss across the entire ecosystem (Blincaw 2022).

Figure 1. Focus Area

Our focus area encompasses the kelp forests along the entire California coastline as seen in Figure 1. The region's kelp forests provide essential spawning and feeding grounds for numerous marine species, including the Giant Sea Bass. However, these habitats are increasingly under threat from both anthropogenic and natural factors.

The California coastline has experienced significant ecological changes over the past few decades. In this region, overexploitation, including over-fishing, pollution, tourism, and climate change, have resulted in habitat degradation and population decline. The warming of ocean waters and increased frequency of extreme weather events have led to shifts in marine ecosystems, adversely affecting kelp forest health and resilience. Additionally, coastal development and pollution have further degraded these vital habitats. As a result, there has been a noticeable decline in biodiversity, with some species becoming rare or locally extinct.

Currently, the IUCN estimates there are less than 500 breeding individuals of Giant Sea Bass, although the status of the population is unclear (Aquarium of the Pacific) . Several key threats have contributed to the critical endangerment of the Giant Sea Bass. Overfishing, particularly during the 20th century, drastically reduced their numbers. Between the early 1900s to 1981, Giant Sea Bass populations had decreased by up to 95% (CA.gov). Despite fishing restrictions, illegal poaching and bycatch continue to pose significant risks. Habitat loss and degradation due to coastal development, pollution, and climate change further exacerbate the situation. Kelp forests are particularly vulnerable to ocean warming, which can lead to kelp die-offs and a reduction in habitat complexity, essential for the survival of many marine species.

Given the critical status of the Giant Sea Bass and the cascading effects of their decline on marine ecosystems, this conservation plan aims to address the urgent need for effective management and restoration strategies. By focusing on the preservation and rehabilitation of Giant Sea Bass populations, we can promote the recovery of kelp forest ecosystems and the species that depend on them. This plan seeks to implement targeted conservation actions to restore and protect Giant Sea Bass populations within California's kelp forests. By addressing key threats and promoting ecosystem resilience, we aim to ensure the long-term survival of this iconic species and the health of their marine habitats.

Planning Team and Management Process

Decision Makers and Target Audience

Governmental agencies and fisheries management agencies at the local, state, and federal levels often have the authority to make decisions regarding the conservation and management of marine species like the Giant Sea Bass. Their decisions are influenced by many sources including legislators and policy-makers, international agreements, local authorities, indigenous communities, NGO's, stakeholders, and of course scientists. Stakeholders and audiences include fishermen, the general public, scientific researchers, tourism industries, local communities, and decision making government officials as well.

Planning Team

The Planning Team (PT), whose members and contributions are listed in Table 1, serves as a crucial collaboration between various stakeholders and decision-makers, guiding the process and conservation in planning decisions. While lacking funding or approval authority, the PT still plays a vital role in shaping the overall direction of planning decisions. Drawing input from advisory committees, stakeholders, regional agency representatives, and experts, PT's offer comprehensive insights into conservation complexities. This approach provides collaboration and enhances the potential for successful and sustainable outcomes. Ultimately, as facilitators and advisors, the PT's role is necessary in navigating the complexities of conservation decision-making

Member	Skillset	Organization	Role
Marine Biologist	Expertise in marine biology, ecology, and conservation biology	NOAA, Ocean Conservancy, etc.	Lead scientific research efforts, conduct population surveys, study the habitat requirements and behavior of Giant Sea Bass
Policy Analyst	Knowledge of environmental policy, regulations, and governance structures	Environmental advocacy organizations like the Natural Resources Defense Council, government agencies responsible for marine conservation, etc.	Analyze existing policies and regulations related to Giant Sea Bass conservation, identify gaps, collaborate with policymakers to develop and enforce regulations
Fisheries Scientist	Knowledge of fisheries management, population dynamics, and marine resource conservation	California Department of Fish and Wildlife, NOAA Fisheries, etc.	Provide expertise in designing fisheries management strategies, monitoring fishing activities, assessing the

			impacts of fishing on Giant Sea Bass populations
Marine Ecologist	Understanding of marine ecosystems, habitat dynamics, and ecosystem modeling	Research institutions like the Marine Conservation Institute, environmental consulting firms specializing in marine ecology, etc.	Identify critical habitats of the Giant Sea Bass, evaluate potential impacts of habitat degradation, develop habitat restoration and protection plans
Community Outreach Coordinator	Experience in community engagement, outreach, and education	Non-profit organizations like the Surfrider Foundation, government agencies with outreach programs, etc.	Engage, educate, and raise awareness for local communities, fishermen, recreational divers, and other stakeholders in conservation efforts
Economist	Understanding of natural resource economics, cost-benefit analysis, and economic valuation techniques	Economic research institutions, consulting firms with expertise in environmental economics, local agencies, etc.	Assess the economic value of Giant Sea Bass conservation, evaluate the costs and benefits of conservation measures, provide recommendations for policy implementation

Table 1 - Planning team members, skill sets, organizations and roles

The planning team for the conservation of Giant Sea Bass comprises experts from diverse fields. Marine biologists from institutions like NOAA lead scientific research, conduct population surveys, and study habitat requirements. Policy analysts from organizations such as the Natural Resources Defense Council analyze existing regulations and collaborate with policymakers for effective enforcement. Fisheries scientists from agencies like California Department of Fish and Wildlife provide insights into management strategies and monitor fishing activities. Marine ecologists, often from research institutes, identify critical habitats and develop restoration plans. Community outreach

coordinators, typically from NGOs, engage stakeholders and raise awareness. Economists evaluate the economic value of conservation measures and recommend policy implementations. Together, a multidisciplinary team like this ensures comprehensive conservation efforts.

Stakeholders

Stakeholders are individuals directly impacted by a project, whose involvement and perspectives are vital for its success. The stakeholders for this conservation plan, listed and described in Table 2, encompass a diverse range of people and organizations. Stakeholders advocate for their interests and may need to find common ground through compromises for a project's success. Additionally, some stakeholders may also serve on the planning team, further ensuring their perspectives are integrated into the project's development.

Member	Skillset	Organization	Role
Commercial fisherman	Expertise in fishing techniques, knowledge of local marine ecosystems	Fishing cooperatives, commercial fishing associations, individual fishing businesses, etc.	Provide input on fishing practices, participate in collaborative research projects to minimize bycatch, adhere to sustainable fishing guidelines
Scuba Diving Operators	Dive leadership skills, knowledge of marine ecosystems	Dive shops, dive tour operators, dive training agencies, etc.	Educate divers about the importance of conservation, promote sustainable diving practices, collect data on Giant Sea Bass sightings, support habitat protection efforts
Recreational Fisherman	Skill in fishing techniques, understanding of fish behavior, awareness of fishing regulations	Recreational fishing clubs, online angling communities, individual anglers, etc.	Engage in catch-and-release practices, report sightings of Giant Sea Bass for data collection, advocate for responsible fishing practices
Coastal Communities	Community organizing skills, knowledge of local environmental issues, communication skills	Community associations, environmental groups, local government bodies, etc.	Advocate for sustainable coastal development and fishing, support marine protected areas, engage in dialogue with policymakers to represent community interests

Environmental NGOs	Advocacy skills, scientific expertise in conservation biology, fundraising abilities	Environmental non-profits, conservation organizations, advocacy groups, etc.	Advocate for stronger conservation measures, conduct outreach and education campaigns to raise awareness, provide scientific expertise for conservation planning
Tourism Industries	Marketing skills, knowledge of tourism trends, customer service expertise	Tour operators, travel agencies, hospitality businesses, etc.	Incorporate conservation education into tourism activities, promote eco-friendly tourism practices, support research and monitoring efforts through eco-tourism partnerships
Educational Institutions	Research capabilities, teaching expertise, science communication	Universities, research institutions, educational non-profits, etc.	Conduct scientific research on Giant Sea Bass, develop educational programs about marine conservation, engage students and the public in citizen science initiatives
Indigenous Communities	Traditional ecological knowledge, cultural preservation skills, community leadership abilities	Indigenous tribal councils, cultural heritage organizations, community-based groups, etc.	Share traditional ecological knowledge about Giant Sea Bass and their habitats, advocate for Indigenous perspectives in conservation planning, promote cultural values related to marine biodiversity conservation
Government Agencies	Regulatory expertise, enforcement capabilities, initiating scientific research	Environmental regulatory agencies, fisheries management bodies, marine conservation departments, etc.	Develop and enforce regulations to protect Giant Sea Bass, conduct monitoring and research to inform management decisions, provide funding and logistical support for conservation projects
Media and Communication Professionals	Journalism skills, multimedia production abilities, public relations expertise	News outlets, communication agencies, etc.	Raise public awareness through news coverage, documentaries, and social media campaigns, also highlight success stories and conservation

			initiatives
Coastal Engineers	Expertise in coastal engineering design, coastal hazard mitigation	Engineering consulting firms, government agencies, research institutions, etc.	Assess coastal infrastructure impacts on marine ecosystems, develop engineering solutions to mitigate habitat degradation and promote resilience to climate change
Marine Protected Area (MPA) Managers	Knowledge of marine conservation principles, experience in protected area management	NOAA, MPA agencies, conservation organizations, government departments, etc.	Design and implement MPA's to safeguard Giant Sea Bass habitats, monitor compliance with regulations, evaluate the effectiveness of protected area management strategies

Table 2 - List of stakeholders, including organizations, skill sets, and roles.

Various stakeholders play critical roles in the conservation of Giant Sea Bass. Commercial fishermen, scuba diving operators, and recreational fishermen contribute through their expertise and engagement in sustainable practices, while coastal communities advocate for responsible development and marine protected areas. Environmental NGOs and educational institutions provide scientific expertise and outreach, while indigenous communities offer traditional knowledge and cultural preservation. Government agencies enforce regulations and conduct research, with media professionals amplifying awareness efforts. Coastal engineers and Marine Protected Area (MPA) managers contribute specialized skills in habitat protection and conservation management. Collaborative efforts among these stakeholders are essential for effective conservation strategies.

Situation Analysis

A Situation Analysis (SA) is a strategic tool that is used to understand the dynamics and key elements of a specific context or plan, mapping out the contributing factors, their interrelations, and strategies. It is especially helpful in the field of conservation, as it aids in finding intervention points. The SA in Figure 2 helps to visualize how various pressures like pollution, climate change, and historical fishing practices impact species and ecosystems, thereby guiding effective conservation

strategies. This model allows stakeholders to identify critical areas for action and optimize efforts for sustainable outcomes.

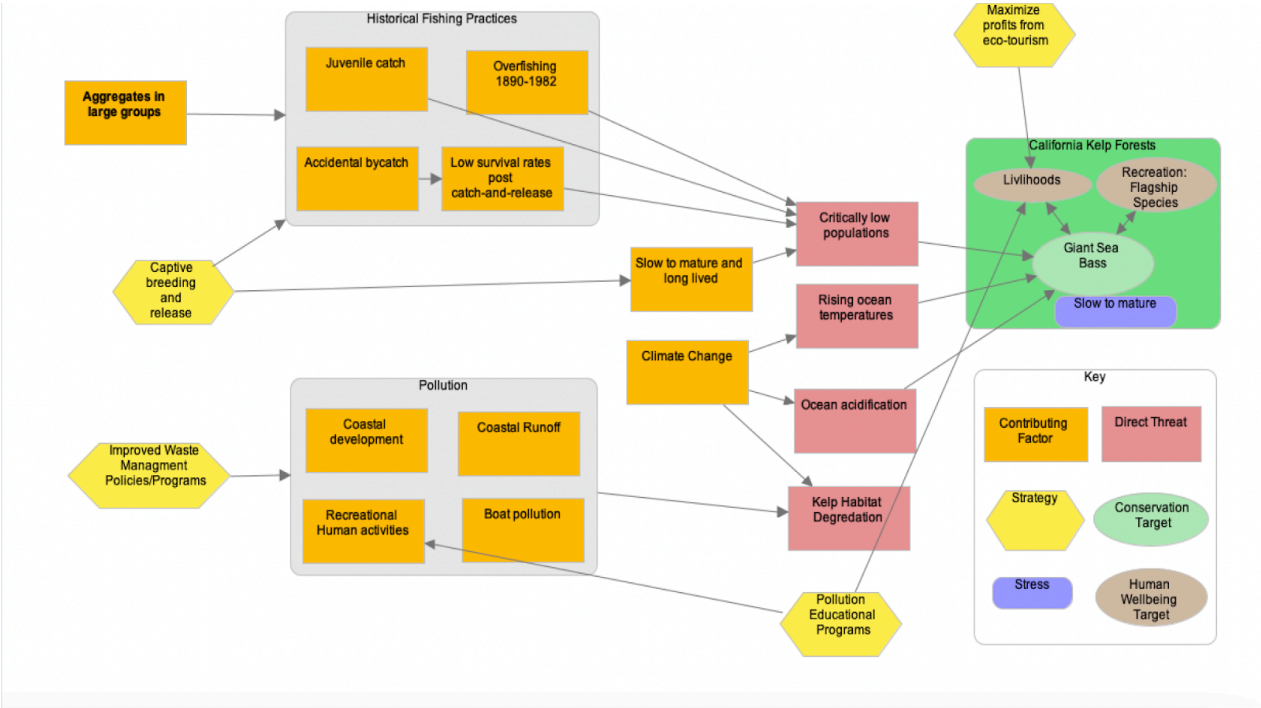

Figure 2. Situation analysis of conservation and human wellbeing targets, including direct threats, contributing factors, stresses, and strategies

The primary environmental target in this conservation plan is the Giant Sea bass in kelp forests along the California coastline, a critically endangered species with populations potentially as low as 500 or fewer breeding individuals (Aquarium of the Pacific). The human well-being targets are directly related to this, with many livelihoods being impacted by the potential extinction of this apex predator and keystone species (Catalina Island Marine Institute), such as the fishing and tourism industries. Local communities also rely on the subsequent ecosystem services provided by this vital species. Human well being is also directly related in that recreationally, giant sea bass are a flagship species.

Direct and Indirect Threats

Giant sea bass are primarily directly threatened by their critically low populations. This has been fueled primarily by historical practices of overfishing. Commercial fishing of giant sea bass peaked in the 1930s, with recreational peaking in the 60s, but was forced to decline as fisheries began to target giant sea bass spawning aggregations. This consistent juvenile bycatch led to a population collapse

(Spotting Giant Sea Bass). Today, whilst overt fishing of the fish is illegal, approximately 97 giant sea bass are caught and sold as bycatch every year; numbers critical to an already endangered population (Spotting Giant Sea Bass).

Climate change is also a major threat to giant sea bass, more directly through rising temperatures, ocean acidification, and subsequently degrading kelp habitats. However, climate change is a larger issue that of course does not solely influence the protection of giant sea bass; likely, this aspect should be handled by the current suggested climate mitigation tactics on state, federal, and global scales, such as the United State's current goal to have 100% clean energy by 2035, and net-zero emissions by 2050 (The White House).

Pollution is another indirect threat to the giant sea bass species, as it degrades the kelp habitats they reside in. Coastal development, runoff, boat pollution, and recreational human activities all contribute to ocean pollution. This pollution causes lower odds of reproductive success and reduced growth rates for kelp, with studies on microscopic stages of kelp suggesting it is sensitive to sewage, industrial waste discharges, and various other causes of poor water quality (NOAA). Being that California Kelp Forests are giant sea basses habitat, the degradation of the kelp will majorly impact the ecosystem's apex predator.

All in all, giant sea bass, along with human well being in regard to the species, are primarily affected by the species's historical overfishing, slow maturity, aggregation, and subsequently low populations, along with pollution and climate change. Strategies to combat the stresses, direct, and indirect threats will be discussed in a later section.

Project Scope

Spatial Scope

The conservation plan for the giant sea bass in kelp forests spans the entire California coastline, from the northernmost regions near the Oregon border to the southern U.S.-Mexico border. This extensive area includes approximately 840 miles of California's coastline.

Temporal Scope

The conservation plan is designed to be implemented over a fifty-year period, from 2025 to 2075. This time frame allows for immediate and long-term conservation actions, including habitat restoration, population monitoring, and community engagement initiatives. A fifty period is necessary for achieving measurable progress in the recovery of giant sea bass populations and the restoration of kelp forest ecosystems. This time also allows the opportunity to adapt conservation strategies based on ongoing research and monitoring results, ensuring that the plan remains responsive to ongoing challenges and opportunities.

Strategic Scope

The strategic scope of this plan aligns with our mission to protect marine ecosystems and ensure the sustainability of marine species by addressing the primary threats to the giant sea bass. We propose a range of strategies designed to increase the abundance of giant sea bass, enhance the health of kelp forest ecosystems, boost the profits of the fishing industry, and support recreational activities. These strategies include habitat restoration, expansion of marine protected areas, stronger fishing regulations and enforcement, captive breeding, improving waste management, and promoting ecotourism and education. By implementing these comprehensive strategies, we aim to mitigate the immediate threats and foster long-term sustainability and resilience of the marine environment, ultimately ensuring the protection and growth of the giant sea bass population.

Fundamental Objectives and Desired Outcomes

A fundamental objective table provides a structured framework for conservation planning, guiding decision-making processes by clarifying objectives, features, indicators, and targets.
The fundamental objective table for this plan, Table 3, outlines key objectives, indicators to measure those objectives, and specific targets for conserving the giant sea bass.

	Fundamental Objectives	*Features*	*Indicators*	*Targets*

	What & Direction	*What can be measured*	*How will 'what' be measured*	*Goal/time*
Environmental-Biodiversity	Increase Giant Sea Bass abundance	Giant Sea Bass	Number of giant sea bass using acoustic telemetry	Increase giant sea bass abundance by 10% in 50 years
Environmental –Ecological Processes	Minimize kelp forest habitat loss and degradation	Kelp forest area and health	Kelp forest area in hectares and kelp forest primary production	Increase kelp forest coverage and primary production by 10% in next 50 years in California
Economic	Maintain revenue of fishing industry	Revenue from fish sales (non giant sea bass) per year	Annual revenue from fish sales	Profit from fishing remains stable over next 50 years
Social	Increase appreciation and awareness of giant sea bass	General public's fondness of giant sea bass	Number of hashtags relating to giant sea bass on social media	Increase number of hashtags related to giant sea bass conservation by 10% in next 10 years

Table 3. Fundamental Objective Table including fundamental objectives for the plan, indicators, targets and goals.

This fundamental objective table represents the different stakeholder values and how they would be accomplished by the conservation plan. The fundamental objectives are divided into into two categories: environmental objectives and human well-being objectives. The environmental objectives

are categorized by biodiversity and ecological processes. The human well-being objectives are categorized by economic and social components. In the environmental objective category of biodiversity, the fundamental objective is to increase giant sea bass abundance. The indicator for this objective is the number of giant sea bass present in California's kelp forest, as determined by acoustic telemetry. In the environmental objective category "ecological processes", the fundamental objective is to "minimize kelp forest habitat loss and degradation. The indicator is total kelp forest coverage. For the human well-being category, the economic objective is to maximize profits from the fishing industry, measured by the indicator of the revenue from fish sales. The second human well-being objective category is social. The fundamental objective is to increase appreciation and awareness of giant sea bass and is measured by a proxy indicator, the number of hashtags used on social media relating to the giant sea bass.

Conservation Features

Conservation features are measurable variables that contribute to achieving the fundamental objective. Indicators are the method with which these measurable variables are measured. Conservation features and indicators are important to measure how successful the strategies and solutions implemented by the conservation team are.

For the fundamental objective of increasing giant sea bass abundance, the feature that will be measured is the giant sea bass and the indicator is to measure the number of giant sea bass in the area using acoustic telemetry. The target is to increase the giant sea bass numbers in California by 10% in the next 50 years. For the fundamental objective of minimizing kelp forest habitat loss & degradation, the feature that will be measured is the kelp forest and its health. The indicator of total hectares of kelp forest in California's waters addresses the area, while measuring primary productivity addresses ecosystem health. The target is to increase kelp forest coverage and primary productivity by 10% in the next 50 years. To maximize profits from the fishing industry, the feature that will be measured is the profit made from the catch and sale of other fish species like halibut or white sea bass. The indicator is dollar revenue from fish sales in California annually. The target is to maintain the revenue of the fishing industry, as without the keystone species of giant sea bass, a trophic cascade would occur,

decreasing numbers of a multitude of financially profitable species. It is vital that we maintain this industry. To increase awareness and appreciation for giant sea bass, the feature that will be measured is the general public's fondness of giant sea bass and the indicator is to measure the number of hashtags relating to giant sea bass on social media. The target is to increase the number of hashtags focused on giant sea bass conservation by 10% in the next 10 years.

Range of Strategies

A range of strategies could be used to accomplish the fundamental objectives identified in Table 3. As seen in Figure 2, the Situation Analysis, the main threats to these fundamental objectives are pollution, habitat degradation, and being caught as bycatch. A range of strategies are proposed to mitigate these threats and increase giant sea bass abundance, kelp forest ecosystem health, profits of the fishing industry, and appreciation and awareness of giant sea bass.

No Action

Undertaking no action to address the threats impacting giant sea bass may lead to population decline and, more probably, result in further degradation of the kelp forest ecosystems of California's coast. Since recent data indicates that giant sea bass populations are increasing, they are still below a healthy and sustainable level that would optimize ecosystem function, maintain trophic dynamics, and maximize population resilience. And, since the main factors halting the complete rebound of giant sea bass populations are intensifying, if no action is taken, it is likely that giant sea bass abundance will decrease and its entire ecosystem will suffer consequences.

Habitat Restoration

Habitat restoration, or improving the functionality and integrity of the degraded kelp forest ecosystems off the coast of California would have positive effects on Giant Sea Bass populations. Restoration processes that would support recovery of kelp forests include removing invasive species, grazing control, replating kelp, reintroducing lost species, and removing debris (Eger et. al., 2022). One of the main threats to California kelp forests is the intense grazing pressure of sea urchins, which are increasingly abundant now due to reduction of their predators. Successful restoration projects might focus on removing and controlling herbivory from urchins. Invasive species, particularly, *Sargassum*

horneri and *Undaria pinnatifida,* in southern California have become a concern and should be targeted for removal to allow for native kelp species to thrive and be the basis of a sound ecosystem (Hamilton et al., 2022). There are many techniques to reforest damaged kelp forests, but the two with the most success are transplanting kelp plants from other ecosystems and seeding (Eger, 2022). Both would be good options to help California kelp forests regain kelp cover. Additionally, artificial reefs should be considered to assist in successful transplanting depending on the seafloor conditions. Popular in Japan and Koreas, artificial reefs have faced criticism in the US for placing artificial materials into the ocean, however, there is evidence that artificial reef deployment can enhance the settlement and growth of existent kelp propagules or act as a base for transplanting or seeding because it creates new rocky reef substrate (Schroeter, Reed & Raimondi, 2015).

Expansion of Marine Protected Areas

Increasing the area designated as Marine Protected Areas (MPAs) has the potential to significantly bolster efforts to increase the population of giant sea bass in California kelp forests as well as promote an overall healthier ecosystem. The passing of the Marine Life Protection Act in 1999 required California to create a statewide network of protected areas in the ocean and coastal waters that are managed with the goal of conserving marine life and habitats while allowing for compatible recreational and commercial activities (California Department of Fish and Wildlife, 2016). These areas can vary in size and level of protection, ranging from fully protected reserves where no extractive activities are allowed to areas with more flexible regulations (California Department of Fish and Wildlife, 2016). Currently, MPA's encompass around 16% of California's state waters (the current network is picture in Figure 3) and have proven to be an effective strategy for safeguarding fish populations and there is reason to believe expansion would provide evenmore benefits for many marine species and ecosystems, including the giant sea bass (California Department of Fish and Wildlife, 2016). Establishing more no-take zones would be most efficient at increasing giant sea bass populations, particularly when strategically located in areas where these fish aggregate for breeding purposes (Blincow, 2023). Only about 20% of California's kelp habitat is protected under an MPA, however onlyTwo known aggregation sites around Santa Catalina Island, Little Harbor and The V's,

containing the highest abundance of both juvenile and adult giant sea bass are currently in unprotected areas where fishing is still allowed (House et al., 2016). Establishing an MPA around those sites would elevate breeding success and lead to species population growth. More research and data collection is necessary to identify these aggregate sites and other areas critical to the giant sea bass's life history that may warrant protection.

Figure 3. Map of Marine Protected Areas in California as of 2016 from California Department of Fish and Wildlife's 2016 Master Plan for Marine Protected Areas.

Stronger Fishing Regulations and Enforcement

The giant sea bass population has recovered slightly since the 1960's, when fishing of them was most intense. This rebound is in large part due to the California Department of Fish and Wildlife's implementation of a ban on commercial and sport fishing of giant sea bass in 1981. Despite these laws, giant sea bass are still sometimes incidentally caught in gill or trammel net operations or by recreational

fishers (Blincow, 2023). It is estimated that from 2000 to 2020, commercial fishers in the US landed an average of 2.76 metric tons of giant sea bass per year, which is significantly less than before restrictions were implemented, but still enough to mediate the full recovery of the species (Blincow, 2023). Additionally, while it's the responsibility of recreational and commercial fishers to ensure the survival of incidentally caught giant sea bass, effectively releasing fish of their size with barotrauma can be challenging, especially when caught from larger vessels with raised decks (Parker et al., 2006). Improper handling can result in the fatality of the fish due to barotrauma (Parker et al., 2006). Reducing giant sea bass as bycatch through establishment of more restrictive regulations for the use of gill and trammel nets in commercial fishing and increased enforcement of protocol to properly release incidentally caught giant sea bass could expedite population growth.

Captive Breeding

Captive breeding is a conservation strategy that entails breeding individuals of a species in controlled environments with the intention of releasing mature offspring into the wild. Controlled breeding programs allow for optimization of breeding conditions, monitoring of reproduction, and rearing of offspring in a protected environment free from natural predators and environmental threats to maximize breeding success and survival of young. Although captive breeding has the potential to contribute to giant sea bass population growth, it has limitations because it doesn't address the root causes of population decline, poor environmental conditions. Though likely not enough on its own, captive breeding could prove to be helpful by supplementing wild populations as other strategies work to lessen the threats to giant sea bass. Captive breeding programs often fail because they are unable to establish self-sufficient captive populations, have poor reintroduction success, are too expensive, preempt other recovery techniques, experience disease outbreaks, or don't maintain administrative continuity (Bessinger, et al., 1996). So, for a giant sea bass captive breeding program to be successful, it would have to be meticulously designed based on research and data collection and with the ability to overcome the aforementioned challenges. In 2019 and 2020, California State University, Northridge, the Aquarium of the Pacific, and Cabrillo Marine Aquarium collaborated to successfully raise giant sea bass eggs and release juveniles into the ocean (Aquarium of the Pacific). They released 200 juvenile

giant sea bass into Santa Monica Bay (Aquarium of the Pacific). Many of the released fish were fitted with trackers so the researchers could monitor the fish in the wild, however, that data has not yet been released (Aquarium of the Pacific).

Improving Waste Management

The improving waste management strategy includes methods like implementing some kind of filter in drainage systems to remove pollutants before reaching the ocean, restoring wetlands that act as natural water filters, installing more trash cans in urban areas to decrease litter, and enacting laws to restrict fishing waste and dumping of sewage from boats, all with the aim of reducing pollution released into the ocean. Pollution is defined as any natural or human-derived substance or energy that is introduced into the environment by humans and that can have a detrimental effect on living organisms and natural environments and includes but is not limited to substances such as toxic chemicals, excessive nutrients, and garbage (Anderson, et al., 2021). Pollution can decrease ecosystem health and functionality in a variety of ways. For example, one study revealed that when toxins, such as copper from industrial waste and mine drainage, finds its way into kelp forest ecosystems, the rate of germination of several kelp species declines (Contreras et al., 2007). Marine debris endangers marine life as organisms may get tangled in nets, lines, and plastic bags or confuse garbage for food.

Furthermore, a large percentage of marine debris is plastic, a substance that doesn't fully decompose and instead breaks into smaller and smaller pieces, becoming microplastics that can become embedded in marine life tissue and have a multitude of known harmful effects on marine ecosystems and may that aren't fully known yet. Toxic chemicals and excessive nutrient pollution harms kelp forest ecosystems, and, by consequence, the giant sea bass. Agricultural runoff is the primary source of nutrient pollution that can cause harmful algal blooms and deplete nutrients available in kelp forest ecosystems, so agricultural runoff needs to be managed to minimize ocean eutrophication (Anderson, et al., 2021). Toxic chemicals are also common in agricultural runoff but also found in stormwater runoff and in waste water from industrial processes (Anderson, et al., 2021). Filtering out these pollutants before they enter the ocean, whether through man-made mechanisms or naturally, would provide many benefits for the marine ecosystem (Anderson, et al., 2021). Pollution also harms other

viable fisheries, potentially decreasing revenue of the fishing industry, and limiting ecotourism opportunities. Implementing waste management strategies to reduce marine pollution would benefit all the fundamental objectives of this plan.

Increasing Ecotourism, Education, and Research

Increasing ecotourism and education are ways to foster awareness and appreciation of the giant sea bass. Many people, including coastal dwelling Californians, are unfamiliar with the giant sea bass. Awareness may prompt them to think more about how their actions are affecting marine ecosystems and take action accordingly. The support of the general public, through voting, volunteering, and funding, is integral to a successful conservation plan. Some methods to promote education on giant sea bass, kelp forest ecosystems, and the threats they face include school programs, the production of a documentary about the subject, and the construction of educational signs on the shores of their habitat. Perhaps the best way to increase appreciation and awareness is with first hand experience. That's why facilitating the growth of sustainable ecotourism in kelp forests may be a useful strategy. If not controlled, ecotourism can negatively impact ecosystems, so expansion of the industry should be done carefully and with the health of the ecosystem as a priority. So, recreational activities like SCUBA diving, snorkeling, and boating should be encouraged, but measures should be in place to ensure recreationists know and follow the rules meant to protect the ecosystem. Removing parts of the ecosystem should be strictly prohibited and waste and pollution (including sound and light) should be tightly managed.

Furthermore, continued research on giant sea bass including their life history, population count, role in the ecosystem, behavior, and spatial distribution are integral to understanding how to best conserve them. A lot is left to be learned about how giant sea bass and kelp forests are adapting to a changing world and how they might be affected by climate change in the future.

Strategy Selection

Strategy selection is the process of choosing strategies to implement from the range of possible strategies. Strategy selection is based mainly on effectiveness at fulfilling the fundamental objectives presented in Figure 2 and Table 3.

To narrow down the range of strategies, a consequence table, Table 4, that showcases the broad impact each strategy would have on the fundamental objectives is used. In Table 3, a (+) indicates a positive impact and a (–) indicates a negative impact. If a strategy is neither positive nor negative it is indicated by a (/). A summation representing the net-total positive or negative impact is displayed in the right-most column of the table. This consequence table will direct which strategies will be prioritized in a Multiple Criteria Decision Analysis table next.

Fundamental Objectives	Increase Giant Sea Bass Abundance	Minimize kelp forest habitat loss and destruction	Maintain revenue of fishing industry	Increase awareness and appreciation of Giant Sea Bass	
Indicators **Strategies**	Number of Giant Sea Bass as measured by acoustic telemetry	Area of kelp forest coverage Primary production from kelp forest	Revenue from fishing industry	Number of hashtags relating to Giant Sea Bass on social media	**Net Totals**
No Action	–	–	–	–	-4
Captive Breeding	+	/	/	+	+2
Habitat Restoration	+	+	+	+	+4

More Enforcement of Fishing Rules	+	+	–	/	+1
Improve Waste Management	+	+	+	/	+3
Expand MPAs	+	+	–	/	+2
Promote education and ecotourism	/	+	/	+	+2

Table 4. Consequence table for giant sea bass conservation strategies in California kelp forests

The strategy that scored the highest, receiving a +4 in the MCDA was habitat restoration. This strategy would positively contribute to all four of our fundamental objectives. The option to improve waste management to reduce pollution entering the ocean also scored high, receiving a +3, positively affecting giant sea bass abundance, kelp Forest habitat, and fishing industry profits, while not impacting awareness and appreciation of the fish. No action would be the worst course of action, as it would likely lead to a decrease in all indicators.

After selecting the best candidates, a Multi-Criteria Decision Analysis (MCDA) is employed to produce an analysis that better encapsulates the nuances of each strategy's effect on the fundamental objectives in practice. An MCDA takes into account the effectiveness of each strategy at fulfilling each fundamental objective and how important each fundamental objective is. In the MCDA table, Table 5, each fundamental objective is weighted on a scale from 1 to 5 by importance, with 1 being low priority and 5 being highest priority. Each strategy is given a rating of 1 to 10 based on how well it is expected to achieve each fundamental objective. Strategies that received less than a +2 were excluded from

consideration. The weight of each fundamental objective is then multiplied by the effectiveness rating and the product is displayed in parentheses beside each strategy rating. The sum of those products represents the relative overall effectiveness of that strategy at accomplishing the fundamental objectives as a whole. These total scores are compared to each other to determine the best course of action. A higher total score indicates a higher effectiveness at achieving the fundamental objectives.

Fundamental Objectives	**Weight** (1-5)	**Strategies** (rated 1-10)				
		Habitat Restoration	Improve Waste Management	Expand MPAs	Captive Breeding	Promote education and ecotourism
Increase Giant Sea Bass Abundance	5	9(45)	7(35)	8(40)	8(40)	2(10)
Minimize kelp forest habitat loss and destruction	5	10(50)	8(40)	8(40)	1(5)	2(10)
Increase profits of fishing industry	1	5(5)	2(2)	2(2)	0(0)	1(1)
Increase awareness and appreciation of Giant Sea Bass	2	2(2)	0(0)	0(0)	3(6)	10(20)

Totals	N/A	104	77	82	51	41

Table 5. Multiple Criteria Decision Analysis of strategies for giant sea bass conservation in California kelp forests

The total scores for the range of strategies considered in this MCDA table range from 41 to 104. The strategy that received the highest total score, suggesting it does the best job at addressing the most pressing objectives, is habitat restoration. Kelp forest habitat restoration has the potential to significantly increase giant sea bass abundance and minimize kelp forest habitat loss and degradation, which are the two most important goals of this conservation plan. It would also contribute to increasing the profits of the fishing industry, since a healthy kelp forest habitat would boost many fish species. Although habitat restoration itself wouldn't do much to increase awareness and appreciation of giant sea bass, that fundamental objective is not a priority.

The strategy that scores the lowest overall (of those considered in the MCDA) is promoting education and ecotourism. It would increase awareness on issues facing giant sea bass, but it wouldn't do much to progress the other objectives of the plan. In theory, awareness could prompt people to change their behavior and enact changes that would contribute to giant sea bass populations and kelp forest ecosystem health, but that is not guaranteed. In addition, this strategy could come with costs. If not implemented correctly, unsustainable levels of tourism could actually harm giant sea bass and kelp forests. The low score does not necessarily mean it should not be considered as a potential strategy to implement, since it could potentially be imperative to fulfill the fundamental objective of increasing awareness and appreciation, and could be helpful in achieving the other objectives when used in coordination with other strategies.

Improving waste management and expanding MPAs have total scores that fall between habitat restoration and promoting education and tourism. They received the same effectiveness rating for each fundamental objective, except that expanding MPAs received one more point towards increasing sea bass abundance. Both would be effective solutions and should be implemented to support habitat

restoration. They likely would not do much to increase awareness and appreciation of giant sea bass, but they would contribute greatly to the two most important objectives, increasing sea bass abundance and minimizing kelp forest habitat loss and degradation.

Based on the insight from this MCDA, our team has chosen to implement the strategies of habitat restoration, improving waste management systems, and expanding MPAs since, this combination of strategies is likely to have the greatest positive effect on our two most critical fundamental objectives, increasing giant sea bass abundance and reducing the loss and degradation of kelp forest habitat, and offers many avenues for funding and implementation. Giant Sea Bass conservation is a multifaceted issue and requires a multifaceted response.

Data and Knowledge

1. Population Surveys: Regular surveys conducted by marine biologists and local authorities to monitor Giant Sea Bass populations. These surveys utilize various methods such as underwater visual censuses, acoustic telemetry, and tagging programs to estimate population size and distribution. These methods provide crucial data on population trends, which inform conservation actions and policy decisions.
2. Habitat Assessments: Detailed mapping of kelp forest habitats along the California coastline using satellite imagery, underwater drones, and diver-based observations. These assessments help identify critical spawning and feeding grounds, as well as areas of habitat degradation. Understanding the spatial distribution and health of these habitats is essential for targeted conservation efforts.
3. Fisheries Data: Historical and current catch data from commercial and recreational fisheries provide insights into fishing pressures on Giant Sea Bass populations. This data is crucial for understanding trends in overfishing and bycatch, and for evaluating the effectiveness of existing fishing regulations.
4. Environmental monitoring: Continuous monitoring of oceanographic conditions such as water temperature, salinity, and pH levels. Data from institutions like the National Oceanic and Atmospheric Administration (NOAA) and local research initiatives contribute to

understanding the impacts of climate change on kelp forests. These environmental parameters are critical for assessing the broader ecological changes affecting Giant Sea Bass habitats.

Risks and Uncertainties

The conservation plan for the Giant Sea Bass in California's kelp forests must consider a multitude of risks and uncertainties to mitigate negative impacts. The following sections identify and describe these risks and uncertainties.

Risk 1: Climate Change (severe)

Climate change poses significant risks to the Giant Sea Bass and the kelp forest ecosystems they inhabit. The primary threats include rising ocean temperatures, ocean acidification, and increased frequency of extreme weather events. These factors can lead to habitat degradation, including kelp die-offs and a reduction in habitat complexity, which are essential for the survival of many marine species.

- *Ocean acidification:* Increased levels of CO2 in the ocean can weaken the structural integrity of kelp forests and other marine organisms that rely on calcium carbonate.
- *Rising Temperature:* Warmer waters can affect the distribution and reproductive success of the Giant Sea Bass, potentially forcing them to move to less suitable habitats.
- *Extreme weather:* More frequent and severe storms can damage kelp forests and disrupt the Giant Sea Bass's habitat, making it harder for the population to recover.

Risk 2: Overfishing (severe)

Overfishing remains a critical threat to the Giant Sea Bass population despite existing regulations. Illegal poaching and bycatch continue to pose significant risks.

- *Illegal poaching:* Despite a ban on commercial and sport fishing of Giant Sea Bass, illegal fishing activities still occur, reducing the already critically low population.
- *Bycatch:* Giant Sea Bass are often caught unintentionally in gill nets and trammel nets used for other species, leading to fatalities due to barotrauma and improper handling.

Risk 3: Pollution (Moderate)

Pollution includes toxic chemicals, plastic waste and coastal runoff which significantly impact the health of the Giant Sea Bass and kelp forests.

- *Coastal runoff:* Nutrient pollution from agricultural runoff can lead to harmful algal blooms, depleting oxygen levels in the water and affecting kelp health.
- *Marine debris:* Marine debris, particularly microplastics, can be ingested by marine organisms, causing physical harm and disrupting biological processes.
- *Toxic chemicals:* Industrial waste and sewage discharge introduce harmful substances into the ocean, reducing water quality and affecting the reproductive success of kelp and the species that depend on it.

Ecosystem Services

The Giant Sea Bass (Stereolepis gigas) plays a crucial role in maintaining the health of California's kelp forests. As an apex predator, it helps regulate the populations of prey species, which is essential for keeping the ecosystem balanced. This balance supports a diverse range of marine life, ensuring the overall health and stability of the kelp forest ecosystem.

By controlling the populations of species that graze on kelp, the Giant Sea Bass helps maintain the structural integrity of kelp forests. Healthy kelp forests provide habitat and shelter for a variety of marine organisms, including fish that are important for local fisheries. This, in turn, supports local economies that rely on commercial and recreational fishing.

Furthermore, the Giant Sea Bass contributes to nutrient cycling in the ecosystem. Its activities help distribute nutrients throughout the kelp forest, enhancing productivity and fostering a thriving marine environment. Additionally, as a flagship species, the Giant Sea Bass draws attention to the importance of conserving these ecosystems, promoting eco-tourism and educational opportunities that benefit local communities both economically and socially.

Conclusions

Conserving giant sea bass centers on the fundamental objective of increasing their abundance, nurturing the health and expansion of kelp forest habitats, enhancing awareness and appreciation for the species and its ecosystem, and maintaining the revenue from fishing industries. Ultimately, community engagement and collaboration with stakeholders are essential for the successful

implementation of habitat restoration, waste management improvements, and expansion of MPAs to reach the targets set in this conservation plan.

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