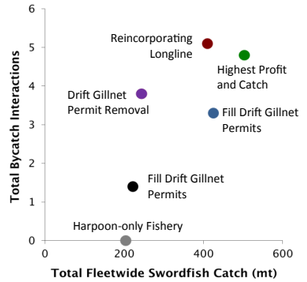
3 Which management scenarios increase the total swordfish catch and the total fleetwide profit under the proposed bycatch hard cap? We explored the following most relevant management scenarios that did not exceed the Council-preferred annual hard caps: 1) status quo with constant drift gillnet and harpoon effort, 2) highest profit and catch, 3) longline reincorporated with constant harpoon and drift gillnet effort, 4) harpoon-only fishery, 5) drift gillnet permit removal with longline reincorporated and harpoon effort kept constant, and 6) activation of drift gillnet latent permits. The catch, profit, and effort for each as compared to the status quo are included below.



Status Quo
Drift Gillnet: **35** vessels
Harpoon: **24** vessels
Longline: **0** vessels
Profit: $1.48 million
Catch: 222 metric tons

Reincorporating Longline
Drift Gillnet: **+ 0** vessels
Harpoon: **+ 0** vessels
Longline: **+ 7** vessels
Profit by $740,000
Catch by 188 metric tons

Drift Gillnet Permit Removal
Drift Gillnet: **- 35** vessels
Harpoon: **+ 0** vessels
Longline: **+ 7** vessels
Profit by $20,000
Catch by 22 metric tons

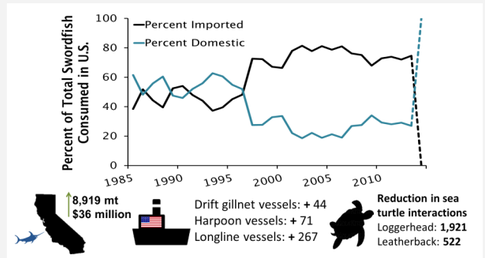
Highest Profit and Catch
Drift Gillnet: **+ 30** vessels
Harpoon: **+ 0** vessels
Longline: **+ 3** vessels
Profit by $1.16 million
Catch by 281 metric tons

Fill Drift Gillnet Permits
Drift Gillnet: **+ 44** vessels
Harpoon: **+ 0** vessels
Longline: **+ 0** vessels
Profit by $850,000
Catch by 203 metric tons

Harpoon-only Fishery
Drift Gillnet: **- 35** vessels
Harpoon: **+ 71** vessels
Longline: **+ 0** vessels
Profit by $950,000
Catch by 18 metric tons

Thought Experiment

A thought experiment was conducted to determine the number of California fishing vessels and California-caught swordfish required to completely replace all imported swordfish. The profit, swordfish catch, and net number of turtle interactions reduced globally were calculated (see graph on right) to simulate a complete displacement of imported swordfish with domestically-caught swordfish.



Discussion & Recommendations

- A fishery with multiple gears would achieve the highest profit and swordfish catch and provide a steady supply of domestically-caught swordfish throughout the year.
- Harpoon is not a viable gear type to increase swordfish catch on a commercial scale.
- The Council should lift the ban on longline to assess the viability and bycatch performance off of California.
- Attention should be paid to fishery participation and domestic swordfish catch when considering the implementation of bycatch hard caps as an additional regulation.
- If bycatch hard caps are implemented, the PFMC should implement bycatch hard caps that are (1) based on science and (2) incorporate uncertainty to reduce the risk of high bycatch interactions.

Takeaways

Fisheries managers must take into account the tradeoffs between profit, catch, and bycatch interactions when making decisions regarding the fishery. Our model may be used in management as a decision-making tool that can be adapted for other gear types – such as deep-set buoy gear and deep-set longline – and different effort levels while considering bycatch interactions. Management should consider creating opportunities for local success in order to decrease reliance on imports and reduce bycatch interactions globally.

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NOAA FISHERIES
The Nature Conservancy — Protecting nature. Preserving life.

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California SWORDFISH

EVALUATING MANAGEMENT SCENARIOS TO REVITALIZE THE CALIFORNIA COMMERCIAL SWORDFISH FISHERY

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Clients: National Oceanic and Atmospheric Administration and The Nature Conservancy

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Group Project Brief
Photos: Brian J. Skerry

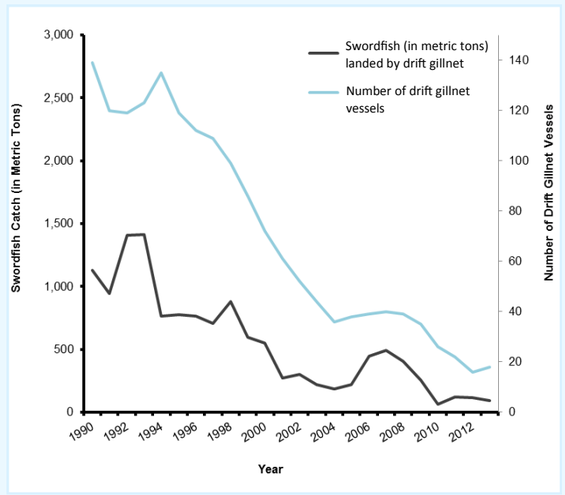
Overview

Fisheries management is often complicated by the challenge of providing a sufficient supply of seafood while simultaneously protecting sensitive species that may be caught as bycatch. In the California commercial swordfish fishery, participation has declined in recent decades, resulting in decreased domestic swordfish catch and an increased reliance on imported swordfish from countries with relatively higher bycatch rates. The goal of our project was to evaluate different management scenarios composed of the main gear types used to catch swordfish to simulate an increase in domestic swordfish catch while incorporating current and proposed conservation regulations in the California swordfish fishery. Our analysis revealed that utilizing a gear portfolio of drift gillnet, harpoon, and longline would achieve the highest profit and swordfish catch without exceeding bycatch constraints to reduce reliance on imports with the goal of reducing bycatch interactions on a global scale.

California Swordfish Fishery

The global fishing effort and associated catch of swordfish has risen progressively since the 1950s, with dramatic increases in the early 1980s linked to increased demand driven by the expansion of the swordfish market [1]. The U.S., which only contributed 4% of all swordfish caught in 2012, is the world's largest swordfish consumer market on an individual country basis [2,3]. Despite the high demand for swordfish in the U.S., participation in the California swordfish fishery has been declining over the years.

As of 2015, drift gillnet and harpoon are the only allowable gears in the California fishery. The drift gillnet fishery has a limited entry permit system and is regulated by various seasonal and area closures. One significant time-area closure (dark shading on map to right) was implemented in 2001 and is in effect annually from August 15 – November 15. Shallow-set longline was previously an allowable gear type in California, but was banned in 2004 due to concerns over interactions with endangered species. Other U.S. shallow-set longline fisheries, such as the Hawaii fishery (which lands swordfish to California ports), have since mandated bycatch reduction measures that have decreased sea turtle bycatch interactions by 86%.



Increased regulations have been effective at reducing bycatch and maintaining a healthy swordfish stock over time, but have resulted in a significant decline in drift gillnet fishing and total California swordfish landings (figure on left) [4]. Even though the annual catch rates are well below the estimated exploitable biomass of swordfish, over the past two decades the number of drift gillnet vessels decreased by 88% and the catch plummeted 96% [2]. It is possible that the fishery will disappear, and with it, years of knowledge and experience, as well as the harvest potential from a healthy fishery resource [1, 2]. Although management has lessened the local environmental impacts of the fishery, the California fishery now plays a much smaller role in providing swordfish to meet U.S. consumer demand [1].

Imported Swordfish

One consequence of a declining domestic swordfish supply is that California is relying on increasingly more imported swordfish from countries with relatively higher bycatch rates in order to fill consumer demand (table on right) [1, 2, 5]. As a result, the U.S. may be contributing to negative impacts to marine ecosystems and sensitive species on a global scale [6, 7].

Decade	Average Tons of Swordfish Consumed in U.S.	Average Percent Imported	Average Percent Domestic
1985–1994	13,741	45%	55%
1995–2004	19,205	69%	31%
2005–2013	13,368	75%	25%

Observed Historical Bycatch	Leatherback Turtle	Loggerhead Turtle	Sperm Whale	Humpback Whale
Drift gillnet (2001–2013) ~20% observer coverage	2	2	2	1
Longline (2006–2013) 100% observer coverage	17	7	0	1

Bycatch Interactions

Despite the efficiency and profitability of drift gillnet fishing, this gear has interactions with non-target fish, marine mammals, sea turtles, and sharks on rare and random occasions (table on left) [8]. These species, some of which are threatened or endangered with extinction, are also caught incidentally within other commercial swordfish fisheries internationally, each with different degrees of impact to swordfish stocks and bycatch species. Harpoon has no observed bycatch.

Global Market Transfer Effect

Increased imports may have an unintended consequence due to a market transfer effect, wherein the following occurs:

1. Decline in California swordfish fishery effort and catch
2. Increased reliance on imported swordfish from foreign countries to meet U.S. demand
3. Potential unintended consequence of a net increase in sensitive species bycatch interactions by fisheries globally

1. Despite the decline in domestic swordfish production, U.S. consumer demand for swordfish remains high.

2. Swordfish imports have increased to compensate for the decrease in domestic swordfish. As fisheries operate in the global market, it is estimated that reducing catch in one part of the world results in a transfer of increased catch to another region in the world in order to meet consumer demand [9].

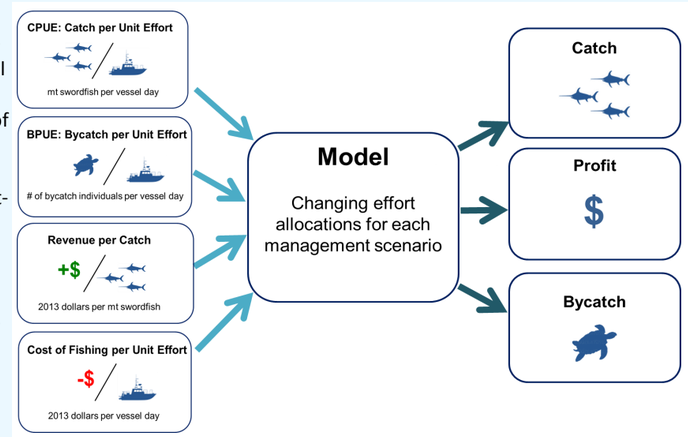
3. It is theorized that reducing bycatch due to a decline in domestic fishing will not cause an overall reduction in bycatch, but rather that this bycatch will be transferred to swordfish fisheries in other regions of the world from which the swordfish demand will need to be met [7]. When compared to the relative amount of bycatch to swordfish caught by domestic fisheries, swordfish imported to the U.S. are from countries that have a higher rate of bycatch due to less stringent and enforceable regulations [7, 10, 11]. Therefore, increasing swordfish imports from these foreign sources is expected to result in a net increase in the overall impact to sensitive species globally [1].

Project Objective

Evaluate different management scenarios to simulate an increase in the domestic California swordfish supply, with the goal of decreasing reliance on foreign swordfish imports in order to decrease the impact to sensitive species on a global scale.

Approach & Methods

We developed a model to simulate and compare different management scenarios for a productive California commercial swordfish fishery. The management scenarios explored different combinations of three gear types – drift gillnet, harpoon, and longline – at various fishing effort allocations, in two areas – inside and outside the Exclusive Economic Zone (EEZ) off of California.

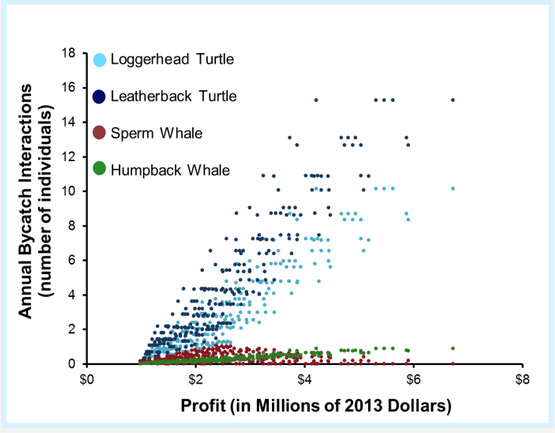


We used four model input parameters (see figure on right) and considered four bycatch species of concern: humpback whale, sperm whale, leatherback turtle, and loggerhead turtle. Because the Pacific Fishery Management Council (PFMC) has proposed the implementation of bycatch hard caps for these four bycatch species, our project constrained the management scenarios by using different hard cap levels to evaluate how fleetwide profit and swordfish catch varies with different bycatch restrictions.

Research Questions & Results

1 What are the resulting swordfish catch, profit, and bycatch interactions of feasible management scenarios?

Our model generated 252 possible management scenarios representing leatherback and loggerhead turtles and humpback and sperm whales as a function of profit, represented in the figure below. Each scenario has an associated swordfish catch, profit, and bycatch interactions. The number of whale interactions was significantly lower than turtle interactions, thus, the main driver of exceeding the proposed bycatch hard cap within the California swordfish fishery was due to turtle interactions, specifically leatherback turtles.



2 Do different bycatch constraints impact swordfish catch and fleetwide profit?

When the annual leatherback hard cap increased from 2 to 3, 3 to 4, and 4 to 5 individuals, swordfish catch increased by an additional 64 mt, 35 mt, and 140 mt, respectively. The resulting additional fleetwide profits generated by increasing the hard caps in these increments are seen in the figure below.