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An Analysis of Global Fisheries and Factors Limiting Sustainable Practices for U.S. Seafood Imports

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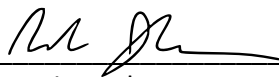
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ABSTRACT

This paper assesses the sustainability practices of wild-caught fisheries by analyzing the Monterey Bay Aquarium Seafood Watch (SFW) ratings database. U.S. domestic fisheries are held to federal sustainability standards via the Magnuson-Stevens Fishery Conservation and Management Act, the Marine Mammal Protection Act, and the Endangered Species Act. However, since the United States imports 65-85% of its seafood, this study focuses on the foreign fisheries that export to the U.S.'s import-dependent seafood market. SFW assesses fisheries using performance-based metrics based on four criteria; Impacts on Species Under Assessment, Impacts on Other Capture Species, Management Effectiveness, and Impacts on the Habitat and Ecosystem. Over 65% of U.S. imported seafood evaluated by SFW is rated as "Avoid," largely due to management ineffectiveness, bycatch, and the overarching issue of data deficiency. Through rating and criterion analysis, our study finds that bycatch and overall management are limiting for U.S. import fisheries. The forthcoming implementation of the Marine Mammal Protection Act import provisions has the potential result in improved bycatch management in foreign fisheries. However, there are risks of unwanted transfer effects if these fisheries are unsupported in their efforts to comply with the new regulations.

1. Introduction

A 2018 report by the United Nations Food and Agriculture Organization (FAO) estimates that the global fishing industry is worth approximately \$151 billion USD and employs an estimated 39 million people [1]. In response to the growing, global demand for seafood and higher landings resulting from technological innovations, the sustainability of global fish stocks has dropped from an estimated 90% sustainable in 1974 to 68% sustainable in 2017 [1]. Managers are tasked to regulate the seafood industry to be both economically viable and environmentally sustainable. The Monterey Bay Aquarium Seafood Watch (SFW) program assesses fisheries using performance-based metrics and provides this information to stakeholders. SFW's mission is to "help people make better seafood choices for a healthy ocean," and they work towards this mission by rating fisheries based on a predetermined set of criteria [2]. These criteria include Impacts on the Species Under Assessment, Impacts on Other Capture Species, Management Effectiveness, and Impacts on Habitat and Ecosystem [3]. Each criterion has a subset of scoring measures, and the fisheries are scored based on the combination of all the criteria. Final ratings are portrayed as stoplight colors – red/avoid; yellow/good alternative and green/best choice. In a 2015 paper, Pelc et al. examined the SFW ratings data to assess United States fisheries for both successes and areas of improvement [4]. The study found that the majority of domestic fisheries rated in the Good Alternative category and that bycatch and management of bycatch were the most common limiting factors preventing the mid-range fisheries from being rated as Best Choice. The authors suggested several management tactics that U.S. fisheries could take to improve [4]. The following study builds on the work by Pelc et al. by analyzing SFW data to determine the limiting factors to the sustainability of U.S. import fisheries. Seafood consumption in the United States is increasing, and based on 2018 data, the United States is now estimated to be the second largest consumer of seafood in the world by total volume [5]. The United States imports 65-85% of its seafood, thus global fisheries are directly feeding residents of the United States [5] [6]. Assessing the fishing practices of both domestic and international fisheries and collecting data to empower stakeholders to achieve sustainability goals will lead to healthier oceans and a more viable ocean economy for future generations.

2. Methods

2.1 Seafood Watch Scoring System

The Monterey Bay Aquarium Seafood Watch program (SFW) rates fisheries based on four criteria: the Species under Assessment, Impacts on Other Capture Species, Management Effectiveness, and Impacts on Habitat and Ecosystem [Table 1]. Based on these criteria and their associated subfactors, the fishery is given an overall rating: Best Choice (green) fisheries are those that earned more than a 3.2, Good Alternative (yellow) score higher than a 2.2, and Avoid (red) are those that score a 2.2 or lower. In addition, certain decision rules may override the numeric score to impact the overall rating.

Table 1. Summary of Seafood Watch criteria for wild fisheries. Full Seafood Watch criteria are available at <http://www.seafoodwatch.org/seafood-recommendations/our-criteria>.

Criterion and factor	Guiding principle
Criterion 1: Impacts on the Species Under Assessment	
Factor 1.1: Abundance	Stock abundance and size structure of native species is maintained at a level that does not impair recruitment or productivity
Factor 1.2: Fishing Mortality	Fishing mortality is appropriate for the current state of the stock.
Criterion 2: Impacts on Other Capture Species	
Factor 2.1: Abundance	Stock abundance and size structure of all main bycatch species/stocks is maintained at a level that does not impair recruitment or productivity.
Factor 2.2: Fishing Mortality	Fishing mortality is appropriate for the current state of all main bycatch species/stocks.
Factor 2.3: Discards and Bait Use	Fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss. For fisheries that use bait, bait is used efficiently.
Criterion 3: Management Effectiveness	
Factor 3.1: Management Strategy and Implementation	Management strategy has a high chance of preventing declines in stock productivity by taking into account the level of uncertainty, other impacts on the stock, and the potential for increased pressure in the future.
Factor 3.2: Bycatch Strategy	Management strategy prevents negative population impacts on bycatch species, particularly species of concern.
Factor 3.3, 3.4, and 3.5: Scientific Research and Monitoring, Enforcement of Management Regulations, and Stakeholder Inclusion	
Criterion 4: Impacts on the Habitat and Ecosystem	
Factor 4.1: Physical Impact of Fishing Gear on the Habitat/Substrate	The fishery does not adversely impact the physical structure of the ocean habitat, seafloor or associated biological communities.
Factor 4.2: Mitigation of Gear Impacts	Damage to the seafloor is mitigated through protection of sensitive or vulnerable seafloor habitats, and limits on the spatial footprint of fishing on fishing effort.
Factor 4.3: Ecosystem-Based Fisheries Management	All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web.

2.2 Data preparation and analysis

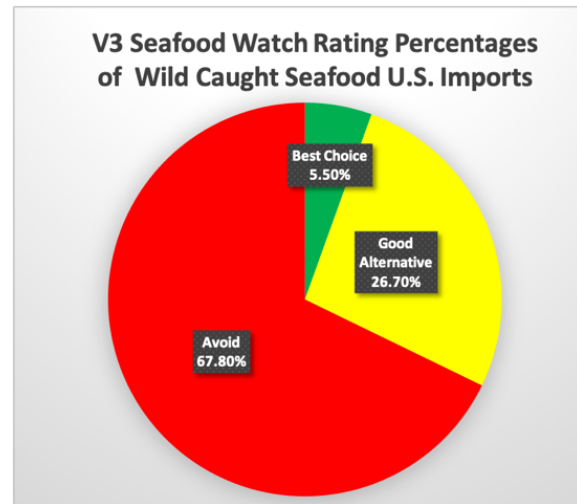
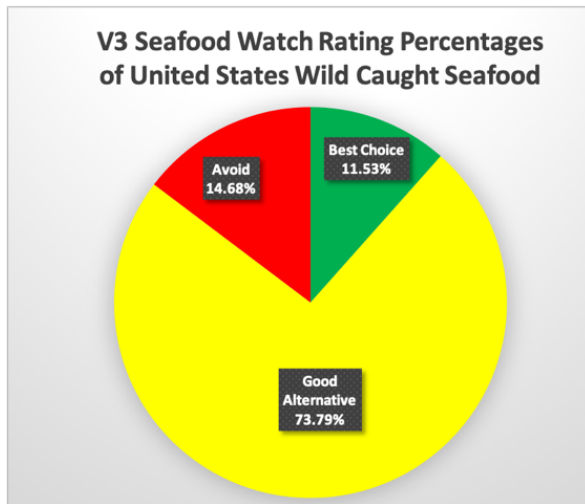
A 2015 study analyzed SFW sustainability data of federally managed, U.S. wild-caught fisheries to ascertain limiting factors for sustainability [4]. The following study employs a similar methodology using the most recent SFW data to investigate the driving factors of SFW ratings of imported, wild-caught seafood. Updated information on U.S. federally managed fisheries was also investigated and compared to import fisheries.

We prepared the dataset for analysis by excluding all duplicate, test, retired, and reference reports, leaving only the ratings that have been published or approved to be published. We examined fisheries that were assessed using Version 3 of the Seafood Watch Standard for Fisheries (Jan. 1, 2016-Mar. 31, 2020) in addition to 71 salmon fisheries using Version 2 of the Standard for Fisheries, which were not assessed using Version 3. The original dataset contained 21,976 records, which were reduced to 896 records: 477 from U.S. fisheries and 419 from import fisheries. For ease of analysis and discovering patterns in the data, we grouped the species into assemblages and classified fishing methods into FAO gear categories [7].

As per the methodology described by Pelc et al. (2015), we grouped fisheries by overall ratings and calculated the mean numerical score for each overall rating group to reveal potential scoring patterns [4]. To illuminate trends in criterion scoring, we calculated the median score for every criterion within the rating groups of Best Choice, Good Alternative, and Avoid for both United States domestic and imported fisheries and calculated the percentages of green, yellow, and red criterion scores within each overall rating. We also examined gear type, region, species groups, and bodies of water in relation to their ratings. SFW reports provided detailed information and justifications of subfactor scoring and the potential explanations of the driving factors.

3. Results

Based on the number of ratings in each category, 73.79% of wild-caught fisheries in the United States achieve a Good Alternative rating, while 14.68% are rated Avoid and 11.53% are Best Choice [Figure 1]. The same analysis on international fisheries that export to the United States shows that 67.8% are rated Avoid, 27% are rated Good Alternative, and 6% are Best Choice [Figure 2].



Figures 1 and 2. Percentages of ratings that scored in each group, based on the number of records in the SFW database. The majority of U.S. domestic fisheries score in the Good Alternative category, while U.S. imports largely score in the Avoid category. This analysis was based on the number of assessments, resulting in a pie chart that shows slightly different percentages of Best Choice and Avoid than the 2015 study analyzing percent landings.

Table 2. Comparison of mean criterion scores for all domestic and import fisheries. The color of the cell indicates if the score is high (green), medium (yellow), or low (red). Based on median calculations, United States domestic fisheries continue to be limited by bycatch rates and bycatch management, as previously noted in a 2015 study by Pelc et al. Criterion 1: Impacts on the Species Under Assessment, Criterion 2: Impacts on Other Capture Species, Criterion 3: Management Effectiveness Criterion 4: Impacts on the Habitat and Ecosystem.

Best Choice	U.S.A	IMPORT	Good Alternative	U.S.A	IMPORT	Avoid	U.S.A	IMPORT
Overall	3.8	4.0	Overall	2.8	2.7	Overall	1.9	1.8
Criterion 1	4.1	4.1	Criterion 1	3.7	3.1	Criterion 1	2.0	2.3
Criterion 2	3.4	4.7	Criterion 2	1.9	2.4	Criterion 2	1.3	1.3
Criterion 3	4.4	3.5	Criterion 3	3.2	2.9	Criterion 3	2.1	1.4
Criterion 4	3.7	3.7	Criterion 4	3.4	3.3	Criterion 4	3.0	3.2

The comparison of mean criterion scores for all U.S. domestic and imported fisheries [Table 2] highlights that bycatch is the limiting factor for domestic fisheries to achieve a Best Choice rating, as previously noted by Pelc et al. in a 2015 study [4]. The 67% of U.S. import

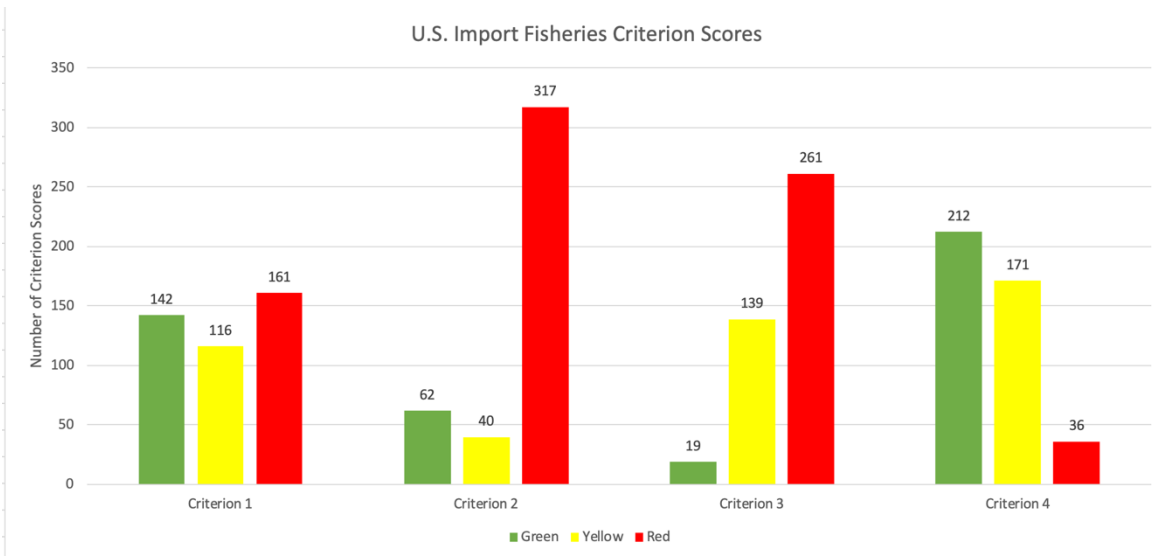
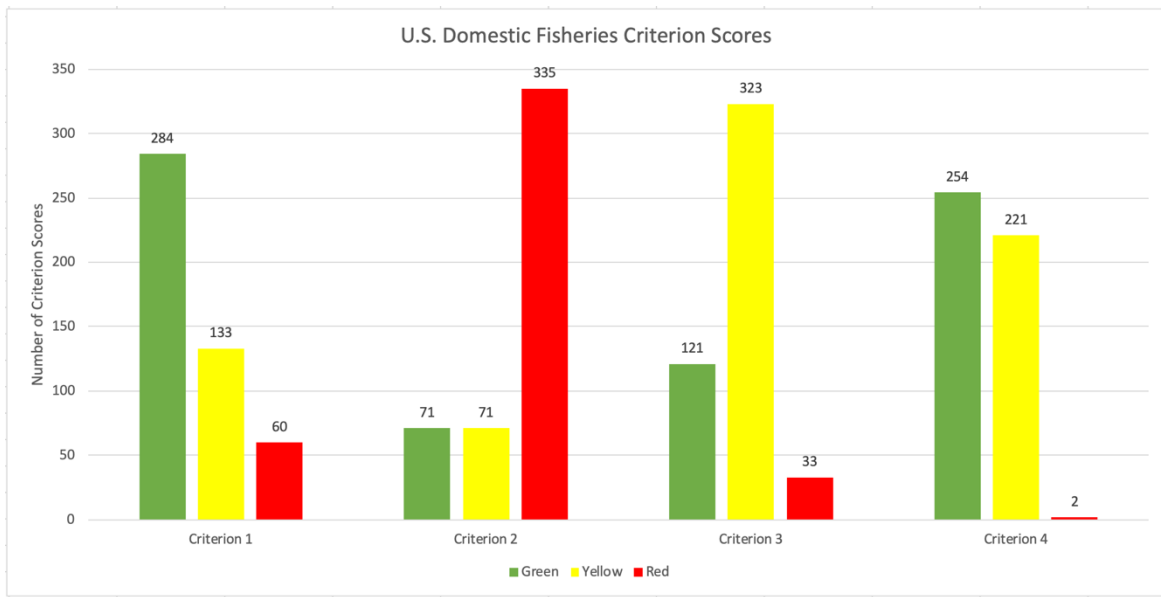
fisheries that earned an Avoid score overall have the lowest scores in both Criterion 2, Impacts on Other Species, and Criterion 3, Management Effectiveness. Comparisons of the criterion score percentages [Table 3] illuminates this point further. The Avoid column shows similar scores between the United States and U.S. imports, with the largest exception in C3. The black box surrounding the C3 scores in the Avoid column highlights the large discrepancy between the U.S. domestic and imports in the red category, where 87% of the Avoid imports are rated red, as compared to only 44% of U.S. domestic Avoid fisheries. Over half of the Avoid U.S. import fisheries in this category are rated as ineffective in Management Strategy and Implementation (Subfactor 3.1), whereas over 75% of the U.S. domestic fisheries in the same category scored as highly or moderately effective. In Bycatch Strategy (Subfactor 3.2), over 75% of both U.S. and import fisheries score ineffective.

When looking at Tables 2 and 3, it is pertinent to remember that 67% of import fisheries have an overall “Avoid” rating, while only 15% of U.S. fisheries earn the same rating.

Table 3. Ratings of US domestic and imported fisheries depicting Criterion percentages per overall assessment score. Criterion 1: Impacts on the Species Under Assessment, Criterion 2: Impacts on Other Capture Species, Criterion 3: Management Effectiveness Criterion 4: Impacts on the Habitat and Ecosystem.

Scoring Percentages of SFW Criterion per Rating								
Best Choice			Good Alternative			Avoid		
Percentages			Percentages			Percentages		
C1	Imports	U.S.A	C1	Imports	U.S.A	C1	Imports	U.S.A
	0%	0%		7%	5%		54%	60%
	0%	11%		49%	30%		21%	30%
	100%	89%		44%	65%		25%	10%
C2	Imports	U.S.A	C2	Imports	U.S.A	C2	Imports	U.S.A
	0%	0%		54%	77%		90%	93%
	0%	47%		19%	11%		7%	3%
	100%	53%		28%	12%		3%	4%
C3	Imports	U.S.A	C3	Imports	U.S.A	C3	Imports	U.S.A
	0%	0%		12%	1%		87%	44%
	65%	16%		82%	78%		11%	56%
	35%	84%		6%	21%		1%	0%
C4	Imports	U.S.A	C4	Imports	U.S.A	C4	Imports	U.S.A
	0%	0%		4%	1%		11%	0%
	22%	29%		39%	42%		43%	81%
	78%	71%		57%	57%		46%	19%

While both U.S. domestic and imported fisheries overall have over 70% of Criterion 2 scores rated as red, the scores in Criterion 3 indicate that the primary limitation for imported fisheries to earn a Good Alternative score is in their management effectiveness [Table 3]. Sixty two percent of all imported fisheries assessed, regardless of their overall rating, scored Avoid in Management Effectiveness [Figure 3]. Imports overall only have 5% Best Choice scores for Management Effectiveness, as opposed to 25% of U.S. ratings [Figure 3]. Further subfactor analysis indicates that management of both target species (C3.1) and bycatch (C3.2) are necessary to improve the score in the category, as 46% of import fisheries scored ineffective for management of target species, and 47% scored ineffective for bycatch management.



Figures 3 and 4. The number of SFW ratings per criterion for US domestic and imported fisheries. While Criterion 2, Impact on Other Capture Species, has a majority of Avoid scores for both U.S. and imports, the divergence in

Criterion 3, Management Effectiveness, illuminates a limiting factor for import fisheries from achieving higher SFW scores.

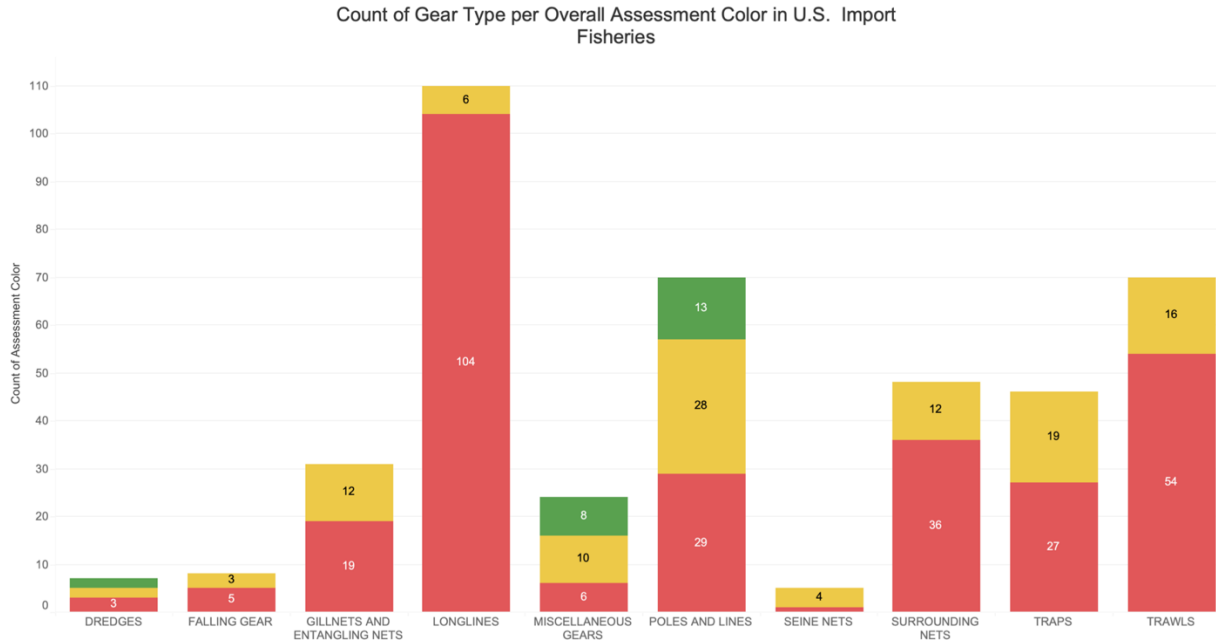
4. Discussion

4.1 Caveats

SFW's scoring system tries to incentivize data collection by scoring fisheries that lack information more conservatively than data rich fisheries; a fishery with more data will score higher than a fishery with no data at all. Management is also heavily weighted in the overall rating. SFW ratings intentionally reward fisheries with strong management practices and governance, as the majority of the SFW Guiding Principles require management of fisheries to achieve sustainability goals [3]. These biases contribute to the findings of this study and are congruent with the guiding principles SFW uses when evaluating fisheries.

4.2 Gear Selectivity

SFW scores tend to vary by gear type, where less selective gears typically score worse than more selective ones [Figure 5 and 6]. For example, all Best Choice ratings for US imports are for selective gears and fishing methods, such as diving, hand implements, and hand-operated poles-and-lines. In addition, all of the import fisheries rated as Best Choice score 100% green for Criterion 2, Impacts on Other Capture Species, meaning that there is zero bycatch in the fishery and gear is selective for only the desired target species catch [Table 3]. The majority of fishing gears, however, are un-selective, which account for 70% of the Avoid scores in Criterion 2 for all U.S. domestic ratings and 76% of the import ratings in the same category [Figures 3 and 4]. Bycatch mitigation efforts in both domestic and international fisheries have varying degrees of success, but innovations in this sector can effectively address bycatch. Some gear modifications include deterrents such as pingers, modifications to increase the rate of survival for a species that has been caught, like using circle hooks, and changing the gear so that animals don't get caught at all, like ropeless gear [8].



Figures 5 and 6. Count of gear type per overall assessment score in U.S. and U.S. import fisheries. In U.S. import fisheries, only dredges, miscellaneous gears, and poles and lines scored in the “Best Choice” (green) category. The majority of “Avoid” (red) import ratings are from longline fisheries, whereas the majority of longline fisheries in U.S. fisheries achieve a “Good Alternative” (yellow) score.

4.3 US Fisheries Management Legislation

The United States has had dedicated fisheries management legislation since 1976, when the Magnuson-Stevens Fishery Conservation and Management Act (MSA) was voted into law [9]. The MSA was originally intended to protect U.S. waters from foreign fishing fleets by setting the boundary of national waters to 200 nautical miles offshore. It also established eight regional fisheries management councils, tasked to create fishery management plans that comply with set national standards, of which there are now ten. The Sustainable Fisheries Act of 1996 shaped the MSA to what it is today and requires U.S. fishers, managers, and other stakeholders to focus on the issues surrounding overfishing and overfished fisheries, particularly as it relates to rebuilding plans and stock assessments. A 2007 amendment to the MSA solidified the role of accurate scientific information informing U.S. fisheries management, establishing catch limits and new ways to manage fisheries such as catch shares, and increasing the role of the U.S. internationally to advocate for sustainable fishing practices [9].

The Marine Mammal Protection Act of 1972 (MMPA) was created to protect marine mammal populations and ensure their preservation through measures such as Take Reduction Plans (created by stakeholders to address marine mammal bycatch), special permitting requirements for interacting with marine mammal species, and monitoring through frequent stock assessments [10]. Through the MMPA, the United States is also mandated to attempt to influence international marine mammal agreements to comply with MMPA standards [10].

The Endangered Species Act of 1973 (ESA) also significantly impacts U.S. fisheries and mandates special precautions for species on the Endangered Species List [11]. NOAA currently

manages over 165 endangered and threatened marine species. The ESA outlines several ways to manage these species, including the development and implementation of recovery plans, the designation of critical habitat, and close monitoring and data collection on the status of the species [11]. The green sea turtle has benefited from the protections of the ESA, and bycatch mitigation of the species has included gear modifications such as the required usage of Turtle Exclusion Devices, observer coverage, and time and area closures [11].

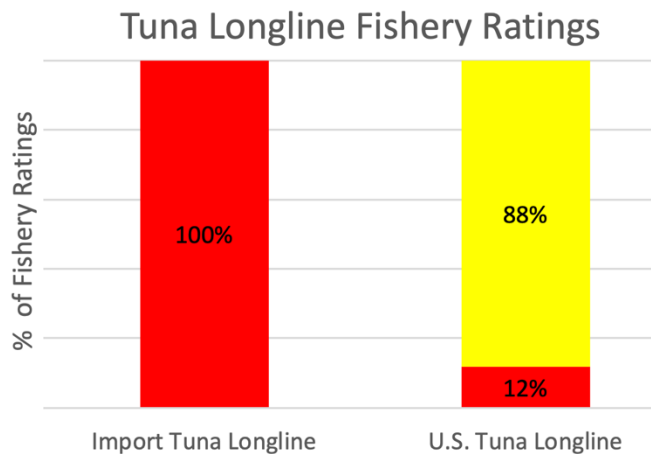
Fisheries laws vary by country, and the difficulty of regulation and enforcement makes fisheries management particularly challenging [12]. The cost of monitoring, surveillance, and enforcement limits the effectiveness of management. Some countries need to develop fishery management initiatives, while others may not have the necessary financial resources. In addition, foreign, distant-water fleets are overfishing waters of some countries but these foreign fleets provide money to the government whose water are being overfished, which decreases the incentive of those governments to regulate their domestic waters [13].

Adherence to international fishing laws on the high seas is voluntary, and the mandates created by international bodies are often insufficient to mitigate pressing issues, as is the case of bycatch in tuna longline fisheries.

4.4 Management as a Limiting Factor Case Study: Tuna Longlines

Tuna are a highly migratory, pelagic species and are typically caught in the high seas (international waters). Their management is under the jurisdiction of Regional Fisheries Management Organizations (RFMOs). RFMOs work at an international scale with countries invested in the conservation and management of fish stocks in a particular region [14]. There are five tuna RFMOs, and their jurisdiction covers 91% of the ocean [14]. RFMOs set catch limits and are responsible for their implementation, and in addition to the target catch species, some RFMOs manage other species in the ecosystem that are impacted by the fishery. While caught with several types of gear, including harpoons and poles and lines, tuna are frequently caught with drifting longlines. Longlines are an unselective gear that can incidentally catch a variety of taxa, including sea birds, sea turtles, and marine mammals. RFMO bycatch management varies by region, but includes mitigation measures such as switching from J-hooks to circle hooks, choosing two seabird bycatch mitigation options such as setting lines at night and using dyed bait, and mandated 5% observer coverage of the fishery. However, these mitigation strategies, while better than nothing at all, do not have enough observer coverage to determine if they are effective and some options are not scientifically proven to effectively mitigate bycatch in their implemented regions [15]. These measures are also typically voluntary because the RFMOs do not have any enforcement authority. The United States domestic drifting longline fisheries, while under the jurisdiction of RFMOs, are also managed under U.S. law, which includes the previously discussed MMPA and EPA. To comply with these laws, U.S. drifting longline fisheries require 20%-100% observer coverage, 100% use of circle hooks with fish bait, bycatch caps, and other initiatives. While both U.S. domestic and import tuna drifting longline fisheries score red for Impacts on Other Capture Species (Criterion 2) because of the interactions with endangered, threatened and protected bycatch species, they diverge in their scores in Management Effectiveness (Criterion 3) and thus the overall score [Figure 7]. Fisheries that follow the baseline RFMO guidelines score red for bycatch management, with the lowest score

of “ineffective management,” while U.S. tuna longline fisheries score “moderately effective or



highly effective management” in that category. To improve scores in bycatch management, fisheries managers can implement mitigation measures that are scientifically proven to significantly lower bycatch rates. International fishery managers will soon be required to make some of these improvements based on new import provisions created to implement the seafood import provisions (section 101(a)(2)) of the MMPA (16 U.S.C. 1371(a)(2)) [10] [16].

Figure 7. Percentage of rating scores for U.S. import and domestic tuna longline fisheries.

4.5 Transfer Effects and the MMPA Import Provisions

The new Marine Mammal Protection Act (MMPA) provisions regarding the import of seafood from all foreign nations were published to the Federal Register on August 15, 2016 [16]. These provisions are slated to begin in November of 2022, with the aim to hold foreign fisheries to the same marine mammal bycatch management standards as domestic fisheries. There are a variety of potential impacts and ramifications that stricter parameters on imported seafood will have on international fisheries, both economically as well as environmentally. The assumed intention behind these newly enforced regulations- which were written into the original version of the MMPA in 1972- are to hold foreign fisheries to domestic standards in an effort to make imported seafood “cleaner” and to incentivize consumption of domestically-caught species, which are already in compliance with MMPA regulations. The many potential outcomes for these regulations are speculative as the regulations are not yet put into place. Fisheries could choose to not comply with the import standards and instead sell their products to new markets. However, the U.S. market pays top dollar for seafood products, which can incentivize fisheries to comply with new regulations to continue to have access to this market. Increased management and data collection efforts are potentially cost-prohibitive, and import fisheries unable to pay for entry to the U.S. markets will have to search for new markets to sell their products. Other markets could be flooded with seafood products and the fishers may be forced to increase their fishing effort to earn the same income they earned selling less fish to the U.S. market, exacerbating the bycatch issue and creating more problems for international fisheries, both economically and biologically. For foreign fisheries who do continue to export their products to U.S. markets, presumably the increased management and data collection necessary to be privy to this market should be noticeable in future Seafood Watch scores.

4.6 Data Deficiencies

By applying a precautionary approach to ratings, Seafood Watch scoring standards incentivize data collection by scoring a lack of data more harshly than data that shows a need for improvement. Data deficiency is a common problem for fisheries, and the majority of global fish stocks lack proper assessments [17]. The prevalence of stock assessments varies greatly between developed countries and undeveloped countries, with the fraction of fish stocks assessed in the latter ranging between 5% and 20% [18]. The sustainability of the seafood industry benefits from increased transparency in all areas. In the SFW scoring system, lack of data can cause lower scores in all criteria, but often Criterion 2 scores are most affected by this lack of complete information. If a fishery records interactions with particular species without specifics, SFW must then score the fishery with the most cautious scores. If data collection were more complete and included all the necessary information, the same bycatch interaction could result in a higher score. Increased data collection for bycatch and target species helps fishery biologists, managers, and industry workers collaborate, providing them with complete information to make decisions about the best fisheries management practices. The MMPA import provisions intend to bolster data collection as it pertains to marine mammal bycatch, and future data analysis will show if controlling imports in this manner has the desired impact on seafood sustainability.

5. Conclusion

Based on our assessment using Seafood Watch scoring standards, foreign fisheries that export to the U.S. market have much room to improve sustainability practices, and the major limiting factor to improve scores is ineffective management, particularly in regards to bycatch. This is most apparent when foreign fisheries are compared to U.S. domestic fisheries, which because of strong legislation like the MSA and the MMPA generally score well in overall management practices. Accurate assessment of U.S. import fisheries can be difficult due to a lack of transparency and traceability, and the precautionary approach employed by SFW standards leads to over 65% of U.S. import fisheries scoring as Avoid. Therefore, increased data collection efforts will contribute to a more accurate score and can help fisheries pinpoint specific actions necessary for increased sustainability. The MMPA import provisions show that there is power in receiving markets and creating external pressure for bycatch reform in foreign fisheries. This effort by the export fisheries must be supported by the import nation to further global sustainability goals. United States domestic fisheries have the power to continue to lead in sustainability by putting bycatch management at the forefront: while strong management generally gives the United States a better score than foreign fisheries in the SFW rating system, bycatch mitigation efforts need to be further expanded and implemented.

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Appendix A. Supporting information

Supplementary data (see attached document)

[Seafood Watch website](#) and [full ratings criteria](#)