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# Governance and science implementation in fisheries management in Japan as it compares to the United States

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ABSTRACT

Japan's fisheries, among the largest in the world, are currently facing overcapacity. As of 2017, approximately half of the 37 stocks with abundance estimates were either overfished or subject to overfishing. In response, in December 2018, the government of Japan enacted revisions to the Fisheries Act which was modeled partly on the systems used in the United States and the EU. Implementing these changes will take time, as lessons learned from other countries are incorporated. Over the past 26 years, the United States has undergone a similar succession of amendments to its fisheries law, yielding a system that has been largely successful in reducing overfishing and rebuilding overfished fisheries. We compare the Japanese and U.S. approaches to fisheries management in four areas that may explain the differences in the number of stocks that are overfished: 1) overall structure of fisheries management and who is responsible for conducting the management, 2) the specificity and goals of fisheries laws in each country, 3) the role and independence of science in the management process, and 4) the approach to scientific and management uncertainty.

## 1. Introduction

The United Nations Decade of Ocean Science for Sustainable Development [1] began in 2021, building on the United Nations' Sustainable Development Goal #14, "Conserve and sustainably use the oceans, seas and marine resources for sustainable development" [2]. This, combined with the increasing challenges that nations face with declining resources and climate change, makes it the right time to examine nations' approach to sustainable fisheries. Alarms have been raised about the state of the ocean's fisheries. Fortunately, despite a previously dire outlook, there is evidence that proactive management can result in reduced fishing pressure, which in turn can yield improved stock abundance [3,4]. Japan's fisheries, among the largest in the world [5], are currently facing overcapacity [6]. As of 2017, approximately half of 37 stocks with abundance estimates were either overfished or subject to overfishing [7]. In response, in December 2018, the government of Japan enacted revisions to the Fisheries Act modeled partly on the system used in the United States, increasing the amount of national government oversight of catch limits in hopes of reducing fishing pressure enough for the stocks to rebound [8,9]. But implementing these changes will take time, with details needing to be worked out by consensus. This provides an opportunity for a closer comparison with the U.S. system that provided a model for the Japanese fisheries reform, and the evolution of that fisheries management system, to see whether there are lessons learned that could be helpful if applied in Japan. While there is a growing body of literature examining fisheries governance, and comparisons between various countries' fisheries management systems, there is not yet, with the exception of a discrete comparison of U.S., Japan and Iceland fisheries as it pertains to applying Individual Transferable Quota systems, an explicit comparison between the U.S. and Japanese marine fisheries governance [10–13]. The U.S. fisheries management system was chosen as a comparison for several reasons: a) Because it underwent a similar fisheries reform b) Because that reform was largely successful in reducing overfishing, and c) Because the U.S.

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was a model for the Japanese fisheries reform,

Over the past 26 years, the United States has undergone a succession of amendments to its fisheries law, yielding a system that has been largely successful in reducing overfishing and rebuilding overfished fisheries [14,15]. The United States faced different challenges than Japan does now, and the two countries have distinct cultural heritages and societal structures, but both aspire to strike a balance between preventing overfishing and protecting the livelihoods of citizens in the fishing industry.

With a focus on stocks under the management authority of the national governments, the Japanese and U.S. approaches to fisheries management are compared in four areas that may explain the differences in the number of stocks that are overfished today, recognizing that the U.S. system has been in place for many more years. First, to give a foundation for the comparison, the overall structure of fisheries management, the type of management tools used, and who is responsible for implementing the management are briefly described. Secondly, the specificity and goals of fisheries laws in each country are compared to one another. The U.S. Magnuson Stevens Fisheries Conservation and Management Act (MSA) is explicit in its goals to prevent overfishing with a focus on resource sustainability, while Japan's fisheries laws are more general with a focus on food security and the economic well-being of fishing communities. Thirdly, the role and independence of science in the management process differs in Japan and the U.S. The U.S. management system has evolved to include a distinct separation between the scientific process and the management process, which is designed to allow unbiased science to be transparently provided to the management process. In the Japanese system, the separation is less distinct and until very recently, management and stakeholder views had a stronger impact on the scientific input into the management process. And finally, the approach to management uncertainty is different in the U.S. and Japan. Relating to the first two areas, the MSA lays out the expected approach to management uncertainty built on the precautionary principle favoring the health of fisheries resources with an emphasis on transparency. The Japanese approach to scientific uncertainty can result in less stringent or no management measures being put into place [16].

Data collection for this study began in 2015 and continued in 2019, just as the legislation for the fisheries reform was being passed. Because the architects of Japan's fisheries reform used the U.S. system as a model, a comparison of the current U.S. system and the pre-reform system was requested by the Japanese government as both a record, and potentially useful source to draw lessons on how to implement the new reform law.

These areas of comparison were developed through conversations over the course of several years with experts in both Japan's and the U.S. fisheries management system (names listed in Appendix C) and intended as an initial qualitative description. Topics 3–4 were important areas that were modified during the last revision of the U.S. MSA and whose revision resulted in reduction in overfishing of U.S. fishery stocks. Topics 1 and 2 provide necessary background for exploring topics 3 and 4, but do not necessarily impact the sustainability of fisheries management. Two other areas that would be productive areas of comparison would be the structure of fisheries subsidies and compliance/ enforcement.

In December 2018 Japan passed legislation reforming their fisheries management system and is in the process of implementing these changes. Many of the topics discussed in this paper have changed under the new law, but as Japan begins to implement these changes, it is useful, particularly for those impacted by the reforms to explore these comparisons with the U.S. system on which much of the reforms were based.

While both Japan and the U.S. have amongst the largest economies in the world, have developed fisheries, and are key trading partners with one another, the two countries differ significantly in geography, demographics, and culture. Japan is an island country, made up of 6852 islands, with much of the land being mountainous and forested (only 4.9 % is considered flat). It has 29,751 km of coastline and 4,464,772 km$^2$ of ocean in its Exclusive Economic Zone (EEZ). The country has a relatively homogenous population, with 125,502,000 in 2021, with 97.9 % of the population being of Japanese origin[1] [17–19]. It has a more collectivist culture, with a large emphasis on human relationships. The first fisheries regulation dates to the year 701 [20,21]. Japan's per-capita consumption of seafood has been declining falling from 40.2 kg in 2001 to 23.8 kg in 2019. Still, it is almost three times that of the U.S. [22].

Both the U.S. and Japan have commercial fishery catch levels in the millions of tons, but the main targets differ. Japan's commercial catch (by volume) is dominated by short-lived, small pelagic fish, while the U. S. main targets are a mix of groundfish, small pelagics, salmon and shellfish, many with slightly longer lifespans (Appendix Table A.1). Both countries also have similar reported number of commercial fishermen. In 2020, Japan reported 135,660 fishery workers who have worked more than 30 days at sea in the previous year, and the U.S. reported 138,342 commercial harvester jobs, but given the larger population of the U.S., fishermen represent approximately 0.1% of the population in Japan, and 0.04% of the U.S. population [24,25].

In FY 2017 Japanese domestic landings were estimated at 3,258,020 metric tons. Even with the decrease in per-capita consumption, this does not meet the demand, and Japan Fisheries Agency calculated its self-sufficiency rate at 56 %. Japan imported 2.48 million tons of fish and fishery products in 2017 [16,27]. (More information can be found in Appendix Table A.2).

The U.S. has 153,645 km of coastline, and an 11,661,154 km$^2$ EEZ. It had a population of 331,893,745 in 2020, representing a multitude of races and ethnicities.[2] The U.S. per-capita consumption of seafood was 8.66 kg (19.1lbs) in 2017. The U.S. commercial landings in 2017 were 4,688,385 metric tons. The U.S. imported 2,846,801,749 kg of fish and fishery products, worth $21,939,227,278. In 2017 the U.S. exported 1,671,821,766 kg ($5,930,136,464 USD) [28].

On the cultural note, Japanese political or corporate decision making can be characterized by the process of reaching consensus through repeated face-to-face meetings, often private or small in size, and the desire to reduce conflict, or at least the appearance of conflict [29–32]. An interesting study comparing interdependence between Japanese and American cultures measured two separate aspects: harmony-seeking and rejection-avoidance [33]. No significant differences between American and Japanese cultures were observed on harmony seeking, but Japanese participants scored higher on rejection avoidance. The authors surmised that while to goal of achieving mutual cooperation is common across many cultures, the strategies for achieving that cooperation differ. They conclude that in collectivist societies "avoiding being excluded from close relations is critical for survival and success". They compare this to individualistic societies "where social order depends less on the mutual monitoring and threats of exclusion and more on the legal system" [33].

## 2. Governance

### 2.1. Management structure

#### 2.1.1. Japan

Japan's domestic fisheries management framework is based on historical bottom-up management, where upper levels of government act mainly as mediators in conflicts among fishers. The current system is

[1] While the government of Japan historically advocated for a policy of monoculturalism, it recently recognized the Ainu as an Indigenous people, native to the northern island of Hokkaido [23].

[2] 2020 U.S. Census data results of self-identified race and ethnicity were as follows: White American/European American/Middle Eastern American = 58.1 %, Hispanic or Latino = 18.8 %, Black or African American = 11.8 %, Asian = 5.7 %, Native American or Alaska Native = 0.5 %, Native Hawaiian or Other Pacific Islander = 0.2 %, Some other race = 0.6 %, Two or more races = 4.3 % [34].

built on top of this framework with the national and prefectural governments beginning to take on more authority [35]. The management of Japan's domestic fisheries is loosely split into three categories: coastal fisheries, offshore fisheries, and distant water fisheries. Coastal fisheries are provided territorial use rights[3] and are managed primarily by the fishermen themselves through local Fishery Cooperative Associations (FCAs). These groups have representation at Prefectural level Area Fishery Coordinating Committees (AFCCs) and at the large Wide-Area Fisheries Coordinating Committees (WFCCs) for fish stocks that cross boundaries [21]. Offshore fisheries, comprised of vessels between ~20–150 tons [36], are granted licenses and divided into two types: minister-licensed fisheries which are industrial, large-scale fisheries operating in offshore and distant waters; and governor-licensed fisheries, which are medium-scale fisheries, operating in both coastal and offshore areas [21].

In both coastal and offshore fisheries, a variety of input control measures (net mesh size, soak time, effort, etc.) and, to a lesser degree, some output control measures are utilized by FCAs, prefectural governors, and MAFF but only 20 stocks of 8 species are subject to output controls in the form of national catch limits, or Total Allowable Catch (TAC) established at the Ministry level. In 2016, this accounted for 41 % of the total catch in Japan.

These TAC limits are set by the national government (Japan Fisheries Agency under the Ministry of Agriculture, Forestry, and Fisheries) with input from scientists from the Japan Fisheries Research and Education Agency (FRA) and under advisement of a panel called the Fishery Policy Council. The Council, made up of fishers, academics, distributers, and NGOs, provide the final consultation on setting catch limits. Greater details on the process of setting catch limits will follow. The TAC amounts are then distributed to either prefectures, local fishing cooperatives, or Fishery Management Organizations (professional organizations representing groups of fishermen such as the Purse Seine Association or the Trawl Fishery Association) who are responsible for ensuring their members stay under the specified catch level. In some instances, a fishery management organization may reserve a portion of the TAC at the beginning of the season in the event that a vessel hits its limit while at sea (they can then call in for permission to exceed their allotment which will normally be granted if it is within the reserve limit) [38].

Distant water fisheries, such as the Pacific bluefin tuna fishery, are managed at the international level through Regional Fishery Management Organizations (RFMOs) and are not discussed in this paper.

#### 2.1.2. U.S.

In the U.S., fisheries management has a flatter structure, split into state and federal jurisdictions, with coastal states managing the waters from 0 to 3 nautical miles (nm) from shore and the federal government managing 3–200 nm,[4,5] with some exceptions. Domestic federal marine fisheries are managed by the National Marine Fisheries Service (NMFS), part of the National Oceanic & Atmospheric Administration, under the Department of Commerce, and in partnership with 8 Regional Fishery Management Councils (RFMCs) and three interstate Fishery Commissions [39]. A majority of the responsibility for developing fishery management plans rests with the RFMCs, with oversight from NOAA [40].

RFMCs develop fishery management plans for either individual fish stocks or stock complexes that must be consistent with 10 national standards [40]. National Standard 1 specifies that all Fishery Management Plans contain a mechanism for establishing Annual Catch Limits (ACLs) [41]. These catch limits are informed by science provided by the National Marine Fisheries Service and partners, and set by the RFMCs [39,42]. The limits are then approved by the Secretary of Commerce to ensure they are in line with the requirements of the MSA [43]. There is flexibility in how the RFMCs set catch limits, but decisions must fit within the parameters set by MSA.

Each RFMC is made up of the Regional Administrator of the relevant NOAA Fisheries Regional Office, principal state officials, and up to 17 members appointed by the Secretary of Commerce from a list provided by the governor of each state. These members are expected to have expertize in fisheries [39,44]. Non-voting members of each RFMC include a representative from the U.S. Coast Guard, the U.S. Department of State, and the regional or area director of the U.S. Fish and Wildlife Service.

Depending on the regional fisheries and politics, some parts of the U.S. implemented MSA differently [45,46].

### 2.2. Objectives and specificity of laws

When comparing two countries' legal and management systems, it is also important to evaluate the relative objectives of each country [47]. Measuring the success of one system against the other is difficult if the goals of each system are different. Japan's (pre-reform) fisheries management system focused on food security, the well-being of its citizens and fishing communities, and the preservation of its fishing culture. The U.S. defines success in terms of resource sustainability and maximizing yield. Ultimately, these two goals are not mutually exclusive; resource sustainability should improve food security and the well-being of citizens and fishing communities is a benefit of well-managed resources. But when resources are declining and tough decisions need to be made, these two definitions of success result in different paths taken.

#### 2.2.1. Japan

Japan's fisheries management history stretches back to the 8th century where the Taiho Code specified that marine areas were open to all, and, contrary to the case with agricultural lands, not subject to taxation [20,21].

For Japan's pre-reform fisheries, the two most relevant laws are the Fisheries Law of 1949 which establishes the system of fishery rights and licenses, and the Law on Preservation and Control of Living Marine Resources, which introduced TAC limits (1997). Currently, TAC is applied mainly to ministry-licensed fisheries and several large-scale prefectural level fisheries (e.g., coastal purse seine fisheries), while fisheries rights are provided to coastal small-scale fishery associations. The policy framework for fisheries is laid out in two Acts: The Fisheries Basic Act of 2001 and the Basic Act on Ocean Policy of 2007.

Japan's Fisheries Basic Act (Act No. 89 of June 29, 2001) consists of 39 articles and begins (Article 1) with a focus on its citizens, "The purpose of this Act is to comprehensively and systematically promote policies for fisheries by setting forth basic principles and matters fundamental for the realization of those principles, and by clarifying the responsibilities of the national and local governments, thereby stabilizing and improving the lives of the public and promoting the sound development of the national economy." [48]. The language demonstrates an emphasis on the life of its citizens and the national economy. This act provides more details on the type of management in which the state should engage; it does not specify specific targets or processes.

Article 2, Maintenance of Stable Supply of Marine Products, focuses essentially on food security and stability of supply, the need to

[3] Fishery rights enable right holders (usually FCAs and members) to exclusively utilize the littoral resource of designated fishing ground. Fishery rights are considered real property rights and at their expiration they usually are renewed to same owner. The Prefectural governor is responsible for issuing permits to the rights fisheries, and is authorized to regulate them. This authority is limited to establishing framework for types, areas and durations of rights. The owner of right responsible for technical management measures such as operational periods and types of gear [21,37].

[4] The states are not required to follow the MSA and develop their own set of rules.

[5] Not all valuable wild-capture stocks are federally managed in the U.S. For example, on the U.S. west coast shrimp, crab, and abalone are highly valuable and are not included in federal fishery management plans.

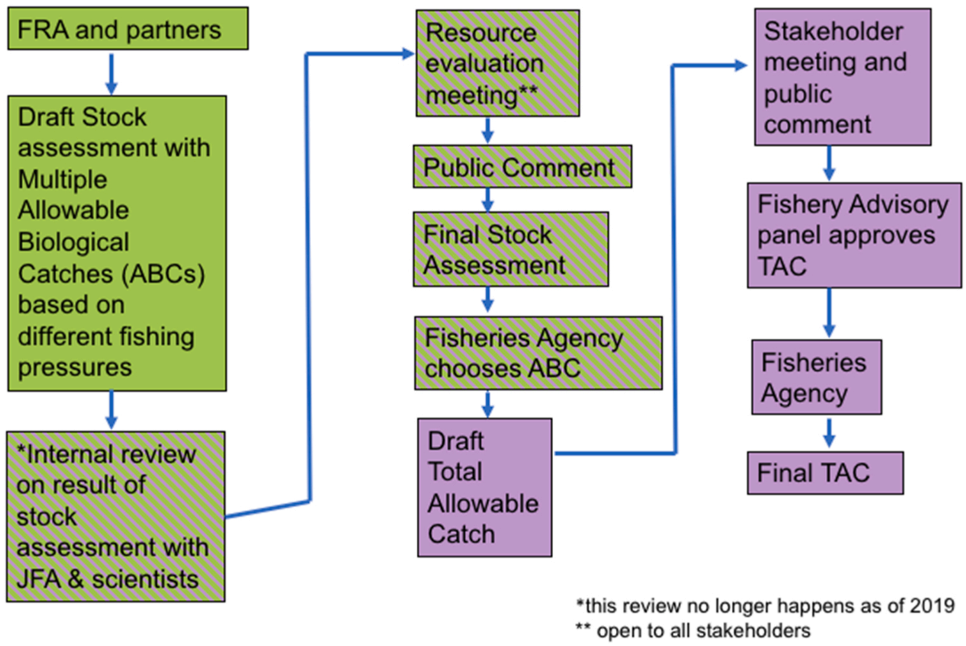


**Fig. 1.** How fishery catch limits (TAC) were determined in Japan (always with data) with green representing science and purple representing management. Stock assessments are always conducted for TAC stocks. Note the overlap of science and management input in the middle of the process.

sustainably use marine resources through preservation and management per the United National Convention on the Act of the Sea, and on the increase of domestic fishery production combined, when appropriate with imports [48].

Article 3, Sound Development of Fisheries, is very clear in its objective to maintain a supply of marine products to Japan's citizens through sustainable use of resources by management of the combination of fishery production, fishery processing, and distribution. The second part of Article 3 focuses on the importance of fishing villages as "foundation for the sound development" that should improve the welfare of its citizens through the development of the fishery [48].

In order to prevent exceeding a catch limit, in this case a TAC, the Minister of Agriculture, Forestry, and Fisheries would prohibit the directed fishing for the stock when the Minster has determined that the TAC of the stock has been or will soon be reached. In case of the quota being allocated to prefectures, the governor of the prefecture determines when the TAC has been reached.

*2.2.2. U.S.*

Overexploitation of fisheries in the U.S. EEZ by foreign fishing interests prompted the passage of the MSA in 1976. During its initial years, the MSA succeeded in excluding foreign fleets from the U.S. EEZ but failed to prevent a subsequent overcapitalization of the U.S. fleet [44]. The focus then shifted from securing resources for the U.S. fleet to what would be needed to prevent the collapse of U.S. fisheries and conserve them for the long-term success of U.S. fishermen.

The MSA's National Standards were too vague and the regulations too lax to prevent a large number of stocks from being overfished or exposed to overfishing. There was concern that the fishing industry still held too much power, with some calling NOAA, the fishing industry, and one of the RFMCs, "poster children of ineffective fisheries management" [49]. The two subsequent amendments of MSA (1996 and 2007), spurred along by numerous court cases initiated by conservationists, aimed to address these concerns [49].

First, with the passing of the Sustainable Fisheries Act in 1996, new requirements were introduced to minimize bycatch and standardize reporting of bycatch, and deadlines for ending overfishing and rebuilding stocks were introduced [14,50]. Secondly, with the reauthorization of the MSA through the Magnuson-Stevens Fisheries Conservation and Management Reauthorization Act in 2006, RFMCs were required to develop ACLs for all managed fisheries "at a level such that overfishing does not occur in the fishery, including measures to ensure accountability" and that these catch limits could "not exceed the fishing level recommendations of its Scientific and Statistical Committee (SSC) or the peer review process" [14,41]. By stating that managers could not set catch limits above the scientific recommendations elevated the role of the SSC, further delineated the separation of science and management, and gave added strength to the scientific recommendations.

Elevating the importance of scientific recommendations, in combination with enforcing deadlines on ending overfishing, and ensuring accountability[6] "begat a revolution in fisheries management" and moved US fisheries away from input control measures such as gear and effort restrictions, and heavily into the realm of output control [50]. This allowed for a greater ability to track and manage for the status of the resource, rather than simply managing effort.

National Standard 2 mandates that management decisions be made with the best scientific information available. Every stock assessment presented to the RFMC's Science & Statistical Committees are evaluated based on this criteria. Independent peer-review processes are in place to support meeting this mandate. Due to the power given to both science and the SSCs by this standard, some fishery associations have hired their own scientific staff to evaluate the stock assessments provided by NOAA and its partners.

National Standard 1 reads, "Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry." It, along with National Standard 2, drives a majority of the federal fisheries management in the U.S. While preventing overfishing will ultimately benefit the fishing communities, in practice, sometimes that connection has been lost. Despite language in the MSA promoting long-term health of the fishing industry, some will argue that it is

[6] Per the revised NS1 guidelines (2009), there are two types of accountability measures: in-season accountability measures, and accountability measures for when a season's catch exceeds the ACL. All 8 FMCs currently implement accountability measures throughout their Fishery Management Plans [14].

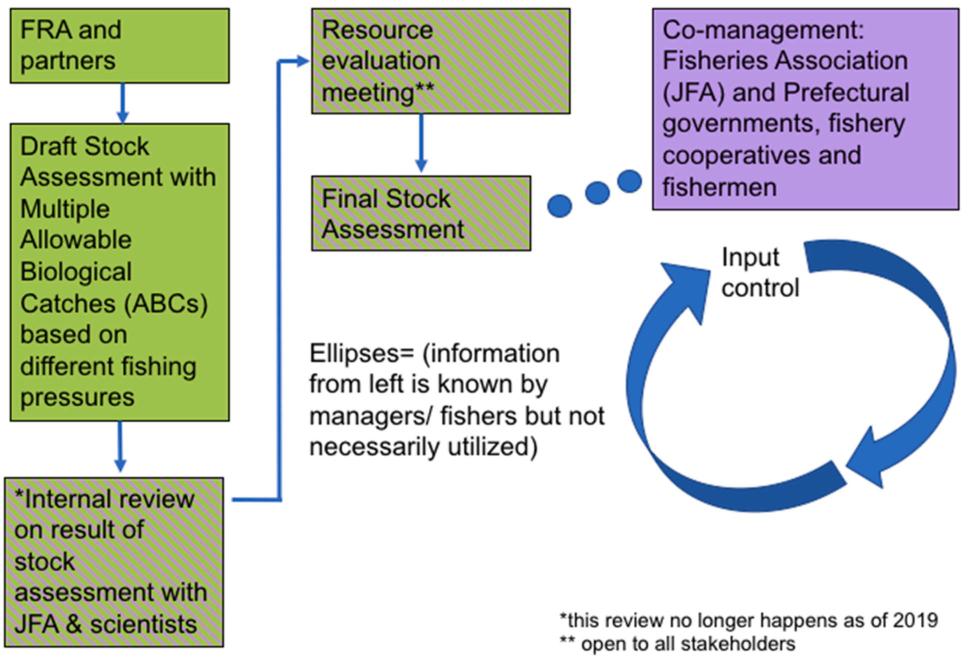


**Fig. 2.** Stock assessments for non-TAC stocks: For stocks not managed under the TAC system in Japan, stock assessments are conducted and then reviewed in a similar manner to TAC stocks, but the management of the stock is conducted by fisheries associations (industry led), prefectural governments, fishery cooperatives and fishermen. Instead of instituting catch limits, they often use input control measures such as controls on gear or effort.

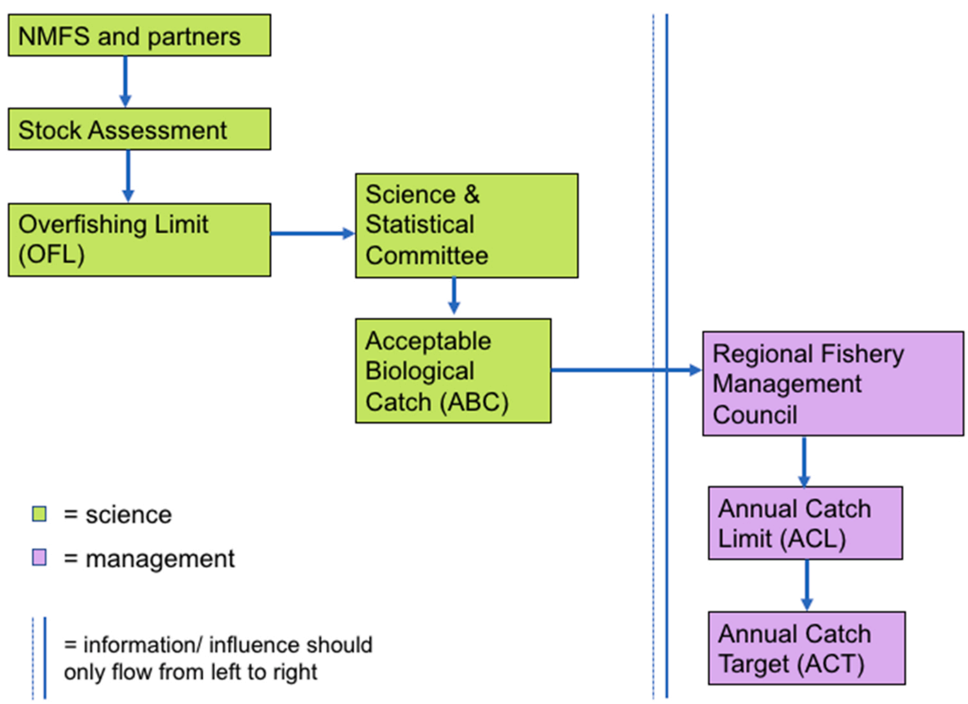


**Fig. 3.** How fishery catch limits are determined in the U.S. (with stock assessment): NMFS and partners conduct stock assessments and make a recommendation on an Overfishing Limit (OFL). The RFMC's SSC then takes the OFL, considers a scientific uncertainty buffer, and sets an ABC below the level of the OFL. This then moves into the management realm. The RFMC will set an ACL that cannot exceed the ABC, though can be equal to it. An even more conservative ACT can be set at a level below the ACL, but this is not required.

conservation for conservation's sake, not for the benefit of the fishermen [44,51].

## 3. How science is implemented in management

Using science-based decision-making has been put forth as one of the requirements for success in the sustainable management of natural resources [52–55]. This section follows the process of fisheries management in Japan and U.S., from stock assessments to setting catch limits, as outlined in Figs. 1–4. Key differences between the two countries' approaches include the independence and power given to the scientific estimates in the U.S., and the strength given to U.S. management through accountability measures (Table 1, with further details available in Appendix Table A.3). Neither of these is strong in the Japanese system. The scientific review process is another measure to help guarantee the independence of the science and ensures that the management decisions are based on the best available science. A comparison of the two countries investment in science, and a comparative timeline of when

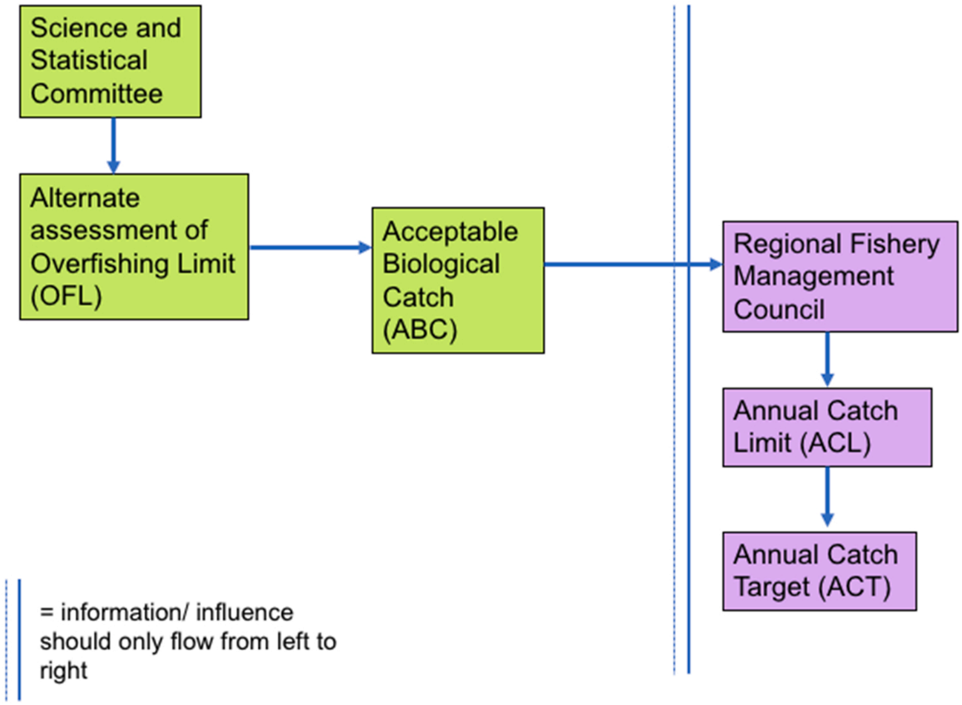


**Fig. 4.** How fishery catch limits are set in the U.S. (without stock assessment):.

stock assessments are conducted is provided in Appendix B with Appendix Figs. B.1 and B.2.

### 3.1. Japan

#### 3.1.1. Process

Stock assessments are conducted by staff from either FRA's central research institute in Kanagawa Prefecture or one of the 6 regional research institutes,[7] with input from prefectural fisheries staff and university scientists. Once the stock assessment is complete, they will make a recommendation for multiple reference points ABC based on different potential fishing pressures following Allowable Biological Catch (ABC) estimation rules [56]. (This process is explained in more detail in Appendix Table A.4.).

Scientists would then have an internal meeting[8] with managers at Japan Fisheries Agency (JFA) about their resource abundance estimate and their proposal for ABC. The status of the stock and the multiple reference point options are presented at a Stock Assessment Meeting which is attended by invited external experts (usually the same experts from year to year), managers from JFA, and fisheries representatives. After responding to comments from the invited researchers (or any managers or fishers present), the FRA and prefectural scientists will either accept or reject[9] the stock assessment. If the stock assessment is not accepted immediately, changes are usually made during the meeting and acceptance is obtained before the meeting ends (Fig. 1). Several different ABC models are presented and JFA would later choose one in the next step (often the one that yielded the highest catch) [57,58].

#### 3.1.2. Catch limits

Once the stock assessment has been accepted, the managers at JFA would then choose an ABC and set a draft TAC. Then the draft TAC is presented at a public stakeholder meeting and posted on the internet for a public comment period for up to one month. After the public comment period has closed, the draft TAC is brought to the Fishery Policy Council which is made up of fishermen, scientists, JFA managers, and the public. They discuss and make recommendations, and there may be several iterations of draft TACs created and debated upon before settling on a final Total Allowable Catch. After the Fishery Policy Council approves a TAC, it is transmitted to the JFA and it becomes final (Fig. 1 and Appendix Table A.5).

Prior to 2015, though TAC should be set at a level equal to or below ABC in order to ensure the sustainable use of the fishery stocks, exceptions were made for TAC of some stocks to be set at a level above ABC so as not to have an adverse socio-economic impact on fishermen. However, since 2015, JFA has complied with the principle that TAC should be set at a level equal to or below the maximum ABC proposed by JFA without exemption.

For stocks which are not allocated a TAC by the national government, the process starts out similarly. An assessment of the stock status based on biological information and landing data is conducted by either FRA scientists or prefectural science and technology centers. These results are presented at stock assessment meetings along with either multiple ABCs based on various potential fishing pressures, or if ABCs cannot be calculated due to lack of biological data, an estimate of how various fishing pressures may affect the population are presented. This information may be considered by the relevant fisheries associations and prefectural governments as they set their more localized input control measures, but there is no requirement to do so (Fig. 2).

#### 3.1.3. Scientific review

Scientific review of draft stock assessments occurs first during internal meetings with JFA managers, prefectural science centers, and

[7] Regional research institutes of FRA were reorganized into two research institutes, the Fisheries Resources Institute, and the Fisheries Technology Institute in July 2020.

[8] In the interest of transparency in the process and independence of the science, these internal meetings will no longer be held. Managers will receive the information on stock abundance level and ABC at the stakeholder meeting.

[9] Although not directly used for stock assessment, there are cases where the most recent stock recruitment data for the latest year is available as reference information. In cases where the observed recruitment information is clearly different from the expected recruitment, the stock assessment may be rejected and re-examined in old stock assessment scheme.

**Table 1**
Summary table of comparison of national-level fisheries management.

| | | Pre-fisheries-reform Japan | U.S. |
|---|---|---|---|
| 1 | Overall structure of fisheries management | Nested, bottom-up, system of fisheries management with some stocks managed at the national level, some at prefectural level and some at the local level. National government agencies set the fishing limits for centrally managed stocks (those with TAC) with input from scientists and fishing industry. | Commercially fished stocks are co-managed by Regional Fishery Management Councils, or states, or for stocks that cross the state or federal boundaries, by Interstate Fishery Commissions. |
| | Type of management tools used | Output control: Total Allowable Catch Limits. | Output control: Annual Catch Limits (ACL). |
| | Who performs the management | National government staff, informed by national and prefectural government scientists and stakeholders. | Regional Fishery Management Councils (government staff, scientists and stakeholders). |
| 2 | Objectives | Focus on food security and economic well-being of fishing communities | Conservation of fisheries for benefit of long-term health of fisheries industry. |
| | Specificity of fisheries laws in each country | The pre-reform fisheries law is quite broad, leaving room for managers to implement as they see fit. | Implementing regulations are very specific and very clear as to how fisheries management is conducted, and how fishing limits are set and by whom |
| 3 | Scientific data available | Overall- less than the U.S. Yearly stock assessments are conducted on nationally managed stocks, but mainly from catch data. Most scientific research is related to recruitment levels. | Overall, more than Japan, with a rotating schedule of stock assessments. |
| 3 | Independence of science in fisheries management | Managers participated in the scientific review and had the ability to influence setting of ABC. Multiple ABCs were presented by scientists, with managers selecting the one with the highest yield. | The MSA mandates (since 2007) that the ACL never exceed the scientifically calculated ABC, meaning that the scientific advice must be adhered to.<br><br>The MSA requires that management be based on the best scientific information available. NOAA uses a system of independent review for stock assessments. |
| | Catch limits | TAC is based on ABC information and since 2015 it is set equal to or below ABC. | Catch limits are set below or equal to allowable biological catch. |
| | Scientific review | Draft stock assessments are first reviewed during internal meetings with JFA managers, prefectural science centers, and select university researchers. | Novel or controversial assessments will be reviewed by the Center for Independent Experts. |
| | | After revisions a second draft is presented at public stock assessment meetings with review by scientists from FRA, representatives from the fishing industry (usually from a relevant fishery association), representatives from JFA, and 2 university professors | Simple updates using established methods of previous assessments are often reviewed only by the Scientific and Statistical Committee of the RFMC. |
| 4 | Approach to management uncertainty | There is no mandated approach to uncertainty. A buffer is calculated at 0.8 of the ABC limit by scientists to account for uncertainty. Also, managers reserve a portion of TAC to distribute later in the season considering uncertainties in fishing ground formation and migration pattern of a stock in a given year. | The MSA requires managers to account for uncertainty by requiring ACL to be less than or equal to ABC which must be less than or equal to OFL. RFMCs must also identify levels of acceptable risk of overfishing. |

select university researchers (Fig. 1). After revisions a second draft is presented at public stock assessment meetings[10] with review by scientists from FRA, representatives from the fishing industry (usually from a relevant fishery association), representatives from JFA, and 2 university professors. After the scientists present a stock assessment, the university

[10] 資源評価会議 (resource evaluation meetings; Japanese text provided for clarification for Japanese audience).

professors will provide comments which will most likely be incorporated into the following year's assessment; however, there is no regulation that they must be adhered to. After the question and comment period has closed, the scientists from FRA and prefectural science centers (experimental stations) will decide whether to approve the stock assessment. The professors and managers do not have input on whether the stock assessment is approved, though their opinions can influence the scientists.

### 3.2. U.S

Stock assessments for federally managed fisheries are conducted principally by the NOAA Fisheries Science Centers with varying amounts of support from state and academic partners. Six Science Centers are responsible for different geographic areas of the U.S. EEZ, and each has a partner Regional Office that handles the management concerns for those areas. But the Science Centers and Regional Offices are in a separate management chain, neither answering to the other, but both under the NOAA Fisheries headquarters office. This is the first level of separation of science and management, which protects the scientific advice from any potential influence from management or stakeholders [39].

#### 3.2.1. Process

Scientific advice is given greater authority by the fact that the RFMCs' SSCs set the ABC, and RFMCs cannot set an ACL above the ABC. This protects the science and empowers the role of the SSC [14,39]. That the ACL never exceed the ABC was set into law in 2007 [59].

As a first step, government stock assessment scientists work with regional scientists to gather relevant data on the stock or stock complex to be assessed. Some regions hold public data workshops where there is an opportunity for stakeholders to provide feedback on the inputs and the nature of the assessment. These workshops typically occur for new assessments or for complete review of existing assessments. Simple updates of existing assessments follow expedited protocols. (This process is explained in more detail in Appendix Table A.4).

Given the results of the workshop and the data available, government scientists project the abundance of a stock or stock complex and a sustainable fishing rate, and then make a recommendation on an Overfishing Limit (OFL) to the respective Regional Fishery Management Council's Science and Statistical Committee (SSC). The process by which the Science Centers and respective SSCs come to agreement on the best scientific information available is summarized in Lynch et al. [60]. The SSC then sets the Acceptable Biological Catch (ABC) with a buffer below the OFL to account for scientific uncertainty (Fig. 3). The protocols for this buffer are written in each RFMC's Fishery Management Plan (FMP) (Fig. 3 & 4).

As stated earlier, the MSA and National Standards are prescriptive in how science fits into the management process. The ABC, per National Standard 2, must be based on the best scientific information available, and is set to no greater than 50 % risk of overfishing.[11]

#### 3.2.2. Catch limits (science -> management)

Once the SSC has evaluated the stock assessment and selected an ABC, it is passed to the Regional Fishery Management Council.

The RFMC will hear from a variety of advisory bodies, including the SSC. This is the first time that the science is formally presented to managers, although the science review process by the SSC is an open process and representatives of many management and client groups may be present. Before the RFMC deliberates on a particular item, public comment is taken (either in person or written testimony). The RFMC will then, after deliberations and analyses, make a recommendation for the Annual Catch Limit, and possibly also a more conservative Annual Catch Target. (This process is described in more detail in Appendix Table A.5).

The recommended ACL is then submitted to the Secretary of Commerce to evaluate whether it conforms to the 10 National Standards of the Magnuson-Stevens Act. The Secretary of Commerce can only accept or reject recommendations. The Secretary of Commerce would only reject a recommendation if it did not conform to the 10 National Standards. Based on the recommendations, the draft, is published in the Federal Register and time is allowed for public comment. Then the final catch limits are implemented by NMFS [60].

The RFMC is also responsible for implementing any Accountability Measures (AMs) if an ACL is exceeded. These could be in-season AMs or post-season AMs [14].

#### 3.2.3. Scientific review

The MSA's National Standard 2 requires that fisheries management be based on the "best scientific information available". The RFMCs and the NMFS Science Centers work together to accomplish this by implementing a strong regional peer review program for all assessments [42]. At the national level, NMFS created the Center for Independent Experts (CIE), a program administered through an independent organization, to augment the externality of the regional reviews, especially for novel or controversial assessments [60], whereas simple updates using established methods of previous assessments are often reviewed only by the Scientific and Statistical Committee of the RFMC. When NMFS requires an independent review, they will contract with CIE to find qualified, independent experts in the relevant field. These experts may come from outside of the U.S., must have a proven academic track record in the topic being reviewed, and must demonstrate that they have no conflicts of interest [60].

## 4. Accounting for uncertainty

Uncertainty in fisheries management can be divided into scientific uncertainty (uncertainty about the data and results of the stock assessment) and management uncertainty (uncertainty about the management regime and its ability to stay within a fishing limit/ reach the target harvest level) [61].

### 4.1. Japan

In Japanese law there is no mandated approach to uncertainty, but there is a buffer calculated into any stock with an ABC estimate: the fishing mortality coefficient of the ABC limit is multiplied by 0.8 of the ABC target.

If stocks are exclusively managed within Japanese waters, management uncertainty is handled by JFA reserving a portion of TAC for additional distribution. For instance, when a pelagic stock spans the waters of several prefectures, JFA is faced with the difficulty of allocating the TAC for that stock between prefectures without knowing the exact migration pattern of the stock for the coming year. Under the allocation rule based on the past catch record, one prefecture may be left with unused TAC while another may hit their allocation too soon. Rather than having prefectures transfer allocations of TAC during the fishing season, JFA reserves a portion of the TAC and only allocates that portion once the fishing season has begun and it is clearer where the stock has migrated that season (per the Resource Management Basic Policy).

Lastly, in most cases, the TAC for year t is determined using the data for year t-2, based on the ABC calculated from the stock assessment conducted in the year t-1. ABC is calculated by predicting the next two years' worth of recruitments. If the observed recruitment level in year t-

[11] The definition of overfishing may be different for each Fishery Management Plan and is defined by the respective Regional Management Council. If there are no data available to estimate a stock abundance level, the Science and Statistical Committee makes an alternate assessment of the Overfishing Limit. (Fig. 4). Because Annual Catch Limits are expected to be set for all managed stocks, substantial effort has gone into development of methods for assessment of stocks in data-limited situations. This alternate assessment is usually based on catch history and/or CPUE.

**Table A.1**
Domestic commercial marine capture fisheries by volume and value.

| | Japan (2017) | | U.S. (2017) | | Japan (2017) | | U.S. (2017) | |
|---|---|---|---|---|---|---|---|---|
| | Species groups/ (fishery/fleet) | Volume (thousand pounds) | Species groups (fishery/fleet) | Volume (thousand pounds) | Species groups/ (fishery/fleet) | value in $ thousand dollars | Species groups/ (fishery/fleet) | Value in $ thousand dollars |
| 1 | Sardine (purse seine, set-net) | 768,556 | Pollock (Alaska) (mid-water trawl) | 3,388,620 | Tuna (longline, purse seine, pole and line) | 1,117,064 | Salmon (Purse seines, gillnets, and reef nets) | 687,770 |
| 2 | Mackerel (purse seine, set-net) | 517,602 | Menhaden (purse seine) | 1,413,104 | Shellfish (trawl net, coastal fisheries) | 822,045 | Crabs | 610,377 |
| 3 | Shellfish (trawl net, coastal fisheries) | 283,985 | Salmon (Purse seines, gillnets, and reef nets) | 1,008,198 | Skipjack tuna (purse seine, pole and line) | 627,891 | Lobsters | 593,874 |
| 4 | Skipjack tuna (purse seine, pole and line) | 226,865 | Hakes (mid-water trawl) | 774,762 | Sardine (purse seine, set-net) | 610,564 | Shrimp | 530,977 |
| 5 | Cod (trawl net) | 173,539 | Cod (bottom trawl, hook-and- line, pots) | 659,178 | Salmon (set-net) | 605,818 | Scallops | 511,945 |
| 6 | Tuna (purse seine, longline, pole and line) | 169,149 | Flatfish | 571,332 | Squid (angling, set-net, trawl net) | 597,845 | Pollock (Alaska) | 413,273 |
| 7 | Jack mackerel (purse seine, set-net) | 164,731 | Shrimp (trawl) | 283,272 | Mackerel (purse seine, set-net) | 409,155 | Flatfish | 267,013 |
| 8 | Yellowtail (set-net, purse seine) | 117,761 | Crabs | 274,578 | Yellowtail (set-net, purse seine) | 282,636 | Oysters | 236,418 |
| 9 | Squid | 103,414 | Squid | 207,409 | Jack mackerel (purse seine, set-net) | 280,900 | Clams | 210,755 |
| 10 | Pacific saury (saury stick-held dip net) | 83,803 | Sea herring | 179,920 | Flatfish (trawl net, gillnet) | 230,800 | Cod | 160,815 |

(MAFF and NOAA).
$1 USD = 110 yen.

**Table A.2**
Definitions of fisheries with catch.

| | Japan-2017 | U.S.-2017 |
|---|---|---|
| Coastal definition | Divided by type of fisheries, mainly include boat seine, set net, trawling line fishery, shellfish collecting and seaweed collecting, etc. | 0–3 nm from shore |
| Coastal landings | 892,807 tons (27 %) | 1,039,016 metric tons (22 %) |
| Offshore definition | Divided by type of fisheries, mainly include offshore trawl, small trawl, large and medium surrounding net, purse seine, saury stick-held dip net, etc. | 3–200 nm from shore |
| Offshore landings | 2,051,479 tons (63 %) | 3,445,876 metric tons (73 %) |
| High or far seas definition | Divided by type of fishery, mainly include distant water trawls, large trawl in East China sea, large and medium surrounding net (one-boat operation, skipjack and tuna, on distant water), skipjack pole-and line on distant water, squid angling on distant water etc. | > 200 nm from shore |
| High or Far seas landings | 313,734 tons (10 %) | 203,494 metric tons (4 %) |
| Total landings | 3,258,020 tons | 4,688,385 metric tons |
| Total value | 962,768,000,000 JPY (converted to 9,001,880,800 USD) | 5,694,312,000 USD |

[26,27].

**Table A.3**
Stock assessment characteristics in 2017.

| | Japan | U.S. |
|---|---|---|
| **Midterm or longterm goals for stock/ abundance assessments** | Increasing # assessed stocks, TAC stocks, stocks with resource amount estimate, improvement in the assessment accuracy | To improve timeliness and efficiency of assessments while maintaining their utility to fishery management, prioritizing work relative to available resources, expanding the scope of stock assessments to be more holistic and ecosystem-linked, and utilizing innovative modeling and data collection techniques |
| **Number of stocks that are assessed each year (define assessed)** | 84 stocks of 50 species, as limited by the budget | Average of 185 assessments per year (216 in 2017; 198 in 2018) |
| **Number of stocks with abundance estimates based on more than just catch** | 42 stocks have information on biomass or Spawning Stock Biomass (SSB) | 139 (of 216) in 2017 |
| **Method for estimating a stock's biomass or SSB** | Mainly Virtual Population Analysis, or direct estimation using ship survey data | Production models or structure models (e.g. statistical catch-at-age models) |
| **Are stock assessments subject to independent peer review?** | Not peer review, but comments are provided by independent reviewers intended to improve assessment | Yes |

[60].

1 is significantly different from the estimated recruitment level calculated in year t-2, such as the appearance of strong year class recruitment or significantly lower recruitment, TAC will be increased or decreased at that time (Appendix B, Fig. B.1).

### 4.2. U.S

In the U.S., accounting for uncertainty is required by the MSA. The MSA's National Standard 1 guidelines (as modified in 2009) specify that management actions should become more conservative as scientific and management uncertainty increase [41]. This results in a system where no limit in the next stage of the process can be greater than the step before: the ABC is less than or equal to the OFL, the ACL is less than or equal to the ABC, and the Annual Catch Target (ACT) is less than or equal to the ACL. Because the RFMCs are required to account for scientific uncertainty, any recommended ACL that equals an ABC that also

**Table A.4**
Setting ABC.

| | Japan | U.S. |
|---|---|---|
| **Type of data used for setting ABC** | Fish catch data (x-1 fishery season) and ship survey data collected by the assessment in year x, if available. | Standard model inputs: catch, abundance, and biology; where and when available, incorporate ecosystem and environmental factors. Fishery-dependent, and fishery-independent data used when available. (Fishery-independent surveys may be non-extractive/ camera systems etc.) |
| **Frequency and timing of consultation with management entities** | Before 2019, an internal review with JFA would occur prior to each stock assessment meeting | None. The SSC sets the ABC. |
| **Frequency and timing of discussions with fishers** | One formal stock assessment meeting and an informal ABC opinion exchange meeting can happen by request. | Informal discussions may occur during cooperative research, surveys on chartered fishing vessels, and formal discussions happen during pre-assessment workshops that occur in some regions. |
| **Frequency and timing of discussion with the public** | Stock assessment meeting, posting ABC on the internet and giving 2–3 weeks for public comment. | There is no mandated or regular discussion with the public, except for public comment periods during RFMC meetings and after Federal Register Notices. |

equals an OFL is assumed to not prevent overfishing, unless such a recommendation is accompanied by thorough and acceptable justifications [62].

The buffer created by reducing OFL to ABC accommodates scientific uncertainty about whether a catch level would prevent overfishing (e.g., uncertainty whether the specific ABC is below the true OFL). Each RFMC must identify an acceptable risk for overfishing for each stock or stock complex. Depending on the quality of data available, SSCs may engage in complex scientific estimations of this uncertainty, or they may account for uncertainty by setting ABC at a proportion of the Over Fishing Limit [61].

Reducing the fishing limit from ABC to ACL is designed to address management uncertainty regarding the ability to control catch levels [63]. The way RFMCs treat management uncertainty varies per fishery, with much of the variance explained by the frequency of data reporting [61]. Fisheries that are able to track and project total catch on a weekly basis, for example a fishery with electronic system to quickly track each catch report, have the greatest ability to implement in-season management adjustments. In contrast, a fishery that cannot assemble total catch reports until sometime after the end of the fishing season has more uncertainty regarding ability to hit the ACL [61].

In the U.S., there is expectation that the management system has accountability measures such that the annual catch will stay within the ACL [14,61]. Accountability measures could include establishing a more conservative ACT, closure of the fishery for remainder of the fishing year, changes in gear, or overage adjustments to reduce the ACL in the following fishing season [64]. There are not similar incentives in Japan.

## 5. Discussion

Japan's history, fishery targets, societal and governance structure all impact how its fisheries are managed and how changes to the management system can be implemented. The revisions to Japan's Fisheries Act are modeled on systems used in the U.S., and some of what is discussed in this paper may be implemented in Japan (and revisions have been

**Table A.5**
Setting catch limits.

| | Japan | U.S. |
|---|---|---|
| **How are catch limits determined?** | TAC are determined using the stock assessment at x year for x + 1 year's TACs. | ACLs set as informed by overfishing limit which is determined/affected by latest stock assessment input plus scientific uncertainty and management uncertainty. |
| **Who determines the catch limits?** | JFA and approved by the Fishery Council | Regional Fishery Management Councils recommends catch limits, and then approved by NMFS as long as in compliance with MSRA and then NMFS publishes in Federal Register |
| **Discussions with fishermen regarding catch limits** | TAC opinion exchange meeting, public comment | RFMC related meetings (minimum of 4); a minimum of 4 bodies that talk about ACLs: fishing advisory committee, fishery advisory panel, plan teams, SSC, full RFMC |
| **Opportunities for the public to comment** | TAC opinion exchange meetings, public comment | Public comment at RFMC meetings (where limits are set) and through federal register announcement of proposed catch limits; all RFMC advisory body meetings are public |
| **Who authorizes the catch limits** | Fishery Council | National Marine Fisheries Service, on behalf of the U.S. Secretary of Commerce |
| **Japan, What happens if the catch limit is reached?** | 1. Announcement of TAC limit<br>2. Request that fishers stop fishing<br>3. Order ships back to port | Closure of the fishery |
| **Penalties for exceeding catch limit** | If fishers do not return to port and continue fishing, penalties include possible imprisonment (<= 3 years) and/or fine (<= 2 M JPY). (No one has ever been imprisoned, and rarely fined) | The fishery may be reduced the following season by whatever amount exceeded the catch limit. If a fisher is caught fishing after the fishery is closed, they can be prosecuted criminally. |
| **How catch data are aggregated for the purpose of temporal closure of fisheries** | Prefectures and FCA's submit catch data to Japan Fisheries Information Service Center (JAFIC) on behalf of the JFA. | Fishermen report catch data to NOAA. The timing of this varies greatly by fishery. The timeliest reporting comes from ITQ fisheries with individual reporting, and large catch-processor fisheries with observers on board. For fisheries without capability of in-season monitoring, in theory there is an assessment at the end of the year and if limits were exceeded, the next season's limit may be taxed (i.e., lower by the amount of overage). |

implemented already).

Both Japan and the United States utilize co-management where stakeholders can participate in the management process, but the mechanism for stakeholder engagement is different between the two countries. This study did not delve deeply into the Fishery Cooperative Associations in Japan or the stocks they or prefectural governments manage, but there is a strong social pressure in these smaller communities to not violate the management measures that have been mutually decided upon. However, sometimes those management measures are not enough to maintain biological sustainability of a stock [35].

A global study found that fishery stocks that are more intensively managed are either improving or not declining [3], similarly in Japan, stocks managed both by TAC and non-TAC measures (usually input control measures) are less likely to be subject to overfishing [7]. Whether the combination of local co-management using a combination of input and output control measures can be as successful as setting clear fishing limits (TAC) could be a topic of further study.

### 5.1. Different objectives

Pre-reform fisheries management in Japan and fisheries management in the U.S. have been using different metrics of success. For Japan, success was the immediate well-being of fisheries communities, and for the U.S. it was the long-term health of fisheries communities, guaranteed by the biological well-being of the stock. In situations of abundance, there is no conflict between the well-being of the stock and the well-being of the fishing community. But in times of scarcity, the U.S. system is designed to protect the biological stock, at the expense of the fishing community. Japan's system was set to favor the opposite. This value system has led to several fishing limits set above levels known to be sustainable [35].

Fish are a more important source of food in the Japanese diet than the American diet, evidenced by the far greater consumption of fish per capita. That, combined with the relative lack of flat land for farming or ranching, and periods of food scarcity have created a focus on fishing as a solution to food security [65].

With the third highest GDP in the world, and a ranking of the top 20 for mean wealth per adult, Japan should not be suffering from a food security crisis [66]. However, this was not always the case, and in the years following World War II there were severe food shortages for several years [65]. The solution that both Japanese (pre-war) and Allied occupying forces (post-war) both arrived at was self-sufficiency, and that the way to accomplish food self-sufficiency for Japan, an island nation with little arable land, was to fish.[12] As the economy recovered, and then soared, food self-sufficiency remained a top policy [65,67]. The fact that Japan's consumption of seafood exceeds its production remains a political concern, which puts the objective of the pre-reform fisheries law into context, and sets the stage for the changes occurring now with the new fisheries law. The fisheries reform that Japan has now enacted could be considered one of the most difficult types of changes in governance as it involves competing values [68].

With the fisheries reform, Japan is beginning to shift its priorities to favor resource sustainability, linked to the goal of developing "fishery productivity, in view of the fact that fisheries have a mission to supply marine products to the citizens" [8]. If management practices follow suit, the reform should help reduce fishing pressure and increase the sustainability of fishery stocks. It would also be greatly beneficial if the fisheries insurance system could be modified so that management decisions do not qualify as a covered cause of loss of income. From a sustainability perspective, it is too early to know if Japan's fisheries reform will be effective in recovering stocks. But the fact that even the word "sustainable" is now in Article 1 bodes well. Much will depend on the how the new law is implemented as, like the pre-reform law, it is, relatively speaking, still broadly written [8].

Lessons from the evolution of the US fisheries management system are that the amended MSA remains focused on balance of resource sustainability and providing fishing opportunities, but now explicitly requires added conservation when information is uncertain. The law has been effective in achieving those goals (stocks are recovering and fewer stocks are overfished, resulting in continued availability of fish), but there are concerns that the pendulum has swung too far into the conservation realm [44,51,69], leaving fishing communities less supported. In particular, long periods with great reductions of catch were implemented in order to rebuild overfished stocks quickly, with little opportunity to balance the needs of the fishing community. Guidelines developed by NOAA Fisheries, but not yet implemented, suggest an expansion from assessing the biological stock status to a multi-objective approach that includes market assessment, fleet dynamics, value to individual fishermen, and the population dynamics and stock status of the fishery in question. Perhaps as Japan moves closer to the U.S. approach to fisheries management, the U.S. is moving slightly closer to Japan's, and a happy middle ground will be reached by both [44,46,51].

The U.S. has been successful in reducing the number of stocks subject to overfishing and rebuilding overfished stocks using a strict science-based management approach [60]. However, that approach is not a complete solution to all challenges facing fishery management. Two areas in which the U.S. is devoting substantial new emphasis are responding to the effects of climate change and dealing with cumulative effects and species interactions through an ecosystem-based management approach. Climate change is having two major effects on fisheries [70]: stock distributions are shifting across management boundaries and accustomed fishing and survey areas, and productivity of stocks is changing in ways that were not anticipated by standard fishery modeling approaches. In response to these challenges, NOAA has developed a climate science strategy to guide essential research and management changes [71]. The MSA has long recognized that fisheries are components of ecosystems, but a holistic ecosystem based management approach has been slower to develop than the approach used to provide single species advice. As overfishing has been brought under control, the need for a more holistic approach has come to the forefront. In 2016, NOAA developed an Ecosystem Based Fishery Management (EBFM) Policy and Roadmap to implement that policy [72]. In addition, NOAA has developed strategies to guide the stock assessments towards an EBFM approach [60]. Today, progress is being made toward bringing ecosystem and socio-economic information into the fishery management process [73]. As Japan moves forward with implementing reform, it should not lose sight of the socio-economic impacts on fishing communities.

### 5.2. Specificity

Japan's fisheries laws are broadly written, which provides flexibility to managers, but does not provide a strong legal defense for management decisions that may be unpopular with the fishing community, leaving them exposed to accusations of arbitrariness [74].

The less explicit nature of these laws is not unique to fisheries. In general, Japan utilizes a consensus-based, voluntary approach to environmental policies, valuing a lighter-hand when implementing regulations. Industry representatives are often part of the drafting of laws and, aided by the threat of the potential for heavy-handed regulations, the government is sometimes able to encourage industry to voluntarily adopt measures that would otherwise need to be controlled by more costly and time-intensive regulations. This has been effective in some areas such as noise-regulation, but less so in industries with large numbers of stakeholders, such as fisheries [75].

Prior to 2018, there was not a lot of detail in Japanese fisheries laws on how management ought to be conducted; they instead contained specifics on who holds responsibility to manage [48,76]. This focus on

[12] General McArthur also encouraged the resumption of the national whaling industry to address the food-security problems Japan was having [65].

the 'who' more than the 'what' is an example of the importance Japanese society places human relations [77]. Studies of Japanese political leadership stresses the importance of "harmony, trust, sincerity, relaxation of tension, and keeping in good contact with everyone" [29]. Along with a lack of specificity in laws and regulations, there often is a lack of specificity in institutional directions, relying instead on having the right people in the room who will figure out the best way to work with one another to accomplish the goal.

In contrast, MSA and the American style of doing business in general, is very prescriptive. A consequence of the litigious nature of the United States is that laws will most likely need to be defended in court. Therefore, effective laws tend to be clear and specific. For example, the MSA's National Standard Guidelines lay out quantitative definitions of status determination criteria (SDCs) such as overfished status, overfishing, and timelines that serve as triggers for making determinations [78].

The detailed level of MSA allows enforceable management. It is largely due to the specification that ACL may not exceed ABC and the establishment of recovery criteria in the accountability measures that has led to the number of stock recoveries.

One general legal structure is neither better nor worse than another; however, the combination of Japan's legislative flexibility has not succeeded in preventing overfishing. The fisheries reform passed in 2018 seeks to change that and increases the amount of specificity in its goals.

### 5.3. Who performs the management?

In Japan, for stocks managed at the ministerial level, the same, relatively small, office (Resource Management Promotion Office[13]) within the Japan Fisheries Agency is responsible for listening to the fishermen and balancing those requests with the need to sustainably manage resources. [14] This group of managers has a difficult time supporting reductions in TAC without strong legislation to back them up. Furthermore the industry representatives present in the resource evaluation meetings leveraged legislation that did not favor sustainable use of resources if a case could be made for temporary economic hardship. This created an often unwinnable situation for fisheries managers in Japan who were left approving unsustainable catch levels.

In the U.S. the development of management recommendations is delegated to the RFMCs (with some seats reserved for fishing community and other constituent groups); therefore, NOAA is not singularly responsible for setting catch limits. This plus the prescriptive language in the MSA serve to buffer NOAA from accusations of arbitrariness, although controversies over decisions still abound.

In both systems, both government employees and stakeholders have a role in managing fisheries. There will be competing values in the process of setting fishing limits, with industry leaning in one direction and conservation advocates (at least in the U.S.) leaning the other. This underscores the need for clearly-defined criteria for success (be it Maximum Sustainable Yield or another goal), the need for transparency, and the need for the best scientific data on which to base decisions.

### 5.4. Implementing science in management

In the fisheries governance literature, there are several overarching categories included in many comparative framework evaluation criteria: transparency and accountability, adaptability of management objectives, clarity of management objectives/simplicity of rules, science-based management decisions, precautionary approach (or risk management), incentives, and enforcement/compliance mechanisms [52, 79,80]. Most frameworks included scientific data or scientific advice as a criteria for successful (sustainable) fisheries management. The importance of scientific data in management is highlighted in numerous studies as a requirement of responsible fisheries management, and sometimes as one of the main reasons a management system is successful [3,14,52]. In their study on the evolution of a co-management arrangement in Japanese offshore fisheries, Tokunaga et al. note that the Ise-Mikawa Bay tiger puffer fishery suffered due to a lack of scientifically based harvest control rules [35].

When comparing differences between Japan and the U.S. in how science is implemented in management, two large differences emerge. One is the greater amount of scientific data available to U.S. managers.[15] This was not always the case but is due to a strong investment, especially since 2001, in stock assessment science. The second is the independence of the science.

### 5.5. Science investment and independence

As noted above, scientific data is an important component of success for fisheries management, but its mere presence may not be enough. In the tiger puffer fishery study mentioned earlier, formal stock assessments were conducted, but only used as a reference and not incorporated into the management decision-making process [35]. And while the access to scientific information about stock status is mentioned in multiple frameworks assessing the success of different forms of fisheries governance, very few evaluated how scientific data were incorporated into management decisions [52].

Much of the success of NOAA's current fisheries management system (recovering stocks, fewer overfished stocks, or stocks exposed to overfishing) has been due to successive revisions of the MSA,[16] resulting in a greater investment in stock assessment science, the requirement for management decisions to be based on the best scientific advice available, and perhaps most importantly, the requirement that managers cannot set ACL any higher than the ABC recommended by the SSC [39]. The power and independence this grants the science has been credited as one of the most important factors in the recovery of U.S. stocks [14]. These revisions took 3–5 years to implement in the U.S. [39]. While there are consultations between scientists and managers during data and assessment workshops in the U.S., there is a firm commitment to protecting the scientific results from any political or management concerns.

The pre-reform system in Japan did not protect the scientifically-derived ABC from influence of managers or industry. This, and short-term economic objectives, led to some TACs being set above the recommendations of a sustainable harvest level. Give what has been learned from the evolution of the US fisheries management system, this is likely the single most important change Japanese fisheries managers could make. They should ensure that the scientists' recommendation of ABC cannot be influenced nor exceeded. The fisheries reform in Japan grants more independence and power to the science, but while they are in the beginning stages of implementation and communicating the changes to stakeholders, it is important to emphasize the positive impact these actions had on fish stocks in the U.S.

Furthermore, access to data, ideally fisheries-independent data, will result in better stock estimates. Also, better data means that smaller buffers for uncertainty are needed. NOAA conducts a greater number of annual stock assessments and covers a greater number of stocks assessed overall. Part of this is due to the greater investment since 2001 of personnel, ship days, and funding, but NOAA also utilizes a formalized

[13] 資源管理推進室.

[14] The resource perspective, or rather, the science, is represented by Kanrika's sister Division at FAJ, Shigenka, which interprets the science conducted by FRA and prefectural science centers.

[15] While there are currently more scientific data available to US stock assessment scientists than to their Japanese counterparts due to investment in data collection, this is not to diminish the fact that there are many data-deficient stocks that the US is responsible for managing [46].

[16] Not to say that yet more progress can be made in the area of data-deficient stocks.

prioritization process so that not every stock needs to undergo a full assessment each year. Rather, there is a rotating schedule of stock assessments based on 14 factors in 5 themes: fishery importance, stock status, ecosystem importance, assessment information, and stock biology.

Included in Japan's fisheries reform bill is a greater amount of funding for stock assessment science in Japan. There is a stated goal of completing stock assessments for 200 species, so the amount of scientific data available for managers should increase in the coming years.

The U.S. has also made major investment in developing a rigorous system for independent scientific review. Having well-respected, unbiased reviewers evaluate the stock assessments on a regular basis has increased their transparency and quality. Currently in Japan, there are meetings with university scientists familiar with the fishery, but their recommendations are not binding. Instituting a system of rigorous, independent review will improve the quality, transparency, and trustworthiness of the stock assessments FRA produces.

## 6. Conclusions

It is important to acknowledge that this comparison is based on Japan's pre-reform (prior to 2020) fisheries management system. While the recent fisheries law was passed in 2018, implementation of the new regulations was still being debated during the time when observations and data were collected for this paper. Many of the recommendations discussed here are addressed in the new legislation, and our hope is that these findings help bolster fishery managers in their implementation of the new law.

The shift from a social definition of success (supporting fishing communities) towards the direction of biological definition of success (sustainability of stocks), places Japan a bit closer to the U.S. position in the tug-of-war between competing objectives. This is neither good nor bad, but a value choice Japan has made with regard to managing its fish stocks. Given that it is leaning more towards a biological definition of success, the following lessons can be derived from this comparison: a) the greater specificity in U.S. fisheries laws and regulations aid fisheries managers in implementing sustainable fishing limits, while Japan's more flexible regulations rely heavily on the individual managers to achieve the right balance of biological stock sustainability and economic well-being of fishing communities b) Japan's centrally managed fisheries stocks are at greater risk of being overfished by not having a clear division between science and management that can protect the scientific results from outside (non-scientific) influence, c) the U.S. elevation of the scientific assessment of ABC, so that fishing limits cannot exceed it, had a large impact on reducing the number of stocks that are overfished, and d) mandating an allowance for scientific and management uncertainty also allowed U.S. stocks to rebound.

As Japan continues to implement its 2018 fisheries law, the following recommendations can be made: a) limiting the review of scientific stock assessment to scientists until ABC has been set, b) ensuring that TAC cannot exceed the scientific assessment of ABC, c) making accommodation of scientific and management uncertainty a requirement in management processes d) investing more heavily in fishery-independent surveys of key stocks, and e) initiating a system of independent scientific review of stock assessments.

This study was limited, other than providing background information, to comparing the fisheries management at the national level. Fisheries management by prefectural governments or FCAs in Japan, or by States or interstate commissions in the US, use processes that vary too widely to be efficiently included in this paper but would be a very fruitful area to explore in future research.

## CRediT authorship contribution statement

**Siri Hakala:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing. **Shingo Watari:** Writing – review & editing, Validation. **Shinji Uehara:** Supervision, Project administration, Writing – review & editing. **Yujiro Akatsuka:** Writing – review & editing. **Richard Methot:** Writing – review & editing, Validation. **Yoshi Oozeki:** Supervision, Conceptualization.

## Declaration of Interest

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## Data Availability

No previously unpublished data was used for the research described in the article.

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## Appendix A

Tables A.1–A.5.

Both the U.S. and Japan have commercial fishery catch levels in the millions of tons, but the main targets differ. Japan‘s main targets are a mix of short-lived small pelagic fish, shellfish, and highly migratory species such as skipjack and other tunas. The U.S. main targets are a mix of groundfish, small pelagics, salmon, and shellfish, many with slightly longer lifespans [28]. This difference matters because small pelagic fish with short life-spans are more affected by climate-induced oceanic regime shifts than longer lived species, with population sizes fluctuating greatly depending on whether ocean conditions are favorable. Favorable regimes can last for several years, leading such fisheries to over-capitalize [6].

## Appendix B

*Investment in science*

*Data collection*

*Japan.* FRA had 8 research ships dedicated to fisheries science and approximately 717 days dedicated to these fisheries surveys in 2018. Also in 2018, approximately 366 FRA chartered ship days were dedicated to fishery surveys which include trawl surveys, egg/larval surveys, and acoustic surveys.

Fishery-independent data are collected during trawl surveys for select stocks of small pelagic and demersal fishes conducted by FRA and several prefectural governments. Biological measurements such as length, weight, sex, and age are collected.

*U.S..* In the U.S., fisheries-independent stock assessment surveys are conducted by the various Science Centers within the National Marine Fisheries Service and their partners (e.g., universities). NOAA Fisheries/NMFS had 9 research ships dedicated to fisheries science and approximately 1970 days (averaged from 2015 to 2017) dedicated to these fisheries surveys (excludes protected species and ecosystem surveys). Fisheries surveys collect information on abundance, biology, and ecosystems using a variety of methods including fishing and non-fishing methodology such as deep-water camera systems or acoustics.

Fishery-dependent data are gathered through a variety of means, depending on the requirements of the fishery management plans and feasibility: dockside monitors, at-sea observers, logbook data, electronic monitoring, reporting systems, telephone surveys, and vessel-monitoring systems.

*Timing of output controls and fishing season: a case study*

The timing of how these catch limits are set and implemented also illustrates a contrast in how long it takes to set management measures, and when and where the public can express their opinions into the process. The example of Alaskan/walleye pollock is given below. In the U.S., because of the importance of this fishery (and the life cycle of the fish), Alaskan pollock are assessed with new fishery-independent data each year. This is not the case for all fish stocks assessed in the U.S.

*Japan*

Using the Japan Sea stock of walleye (Alaskan) pollock as an example, Japan has a 2-year long process from data collection to setting catch limits. Surveys begin in January of year x with fish egg collection and end (for this stock assessment) in December with a survey for 1-year-old fish. Information is collected from fishermen in July of both year x and year x + 1. The analysis is completed in time for an internal meeting with both managers and FRA, prefectural and university scientists in August of year x + 1. At this point, the process shifts to the managers with the publication of the stock assessment on the JFA website. This is open to public comment for a period of x days, and the official notice is made of the stock assessment in October. In preparation for setting catch limits, managers set up a series of TAC briefing sessions with the affected fishery associations ("on the road") during December of year x + 1, with a final, public, TAC opinion exchange meeting held in January of year x + 2. The Fishery Policy Council meets in February and provides the final TAC determination. The fishing season then begins in April year x + 2. (Fig. B.1).

*U.S.*

For a similar stock of the same species, the U.S. has a 6-month process from data collection to setting catch limits. Surveys start in June of year x and wrap up by August the same year. Data are processed, and age-determinations are made on samples by the end of September. These are then used within the assessment which is drafted for review by mid-November (year x) and finalized by early-to-mid December in time for the North Pacific Fishery Management Council (NPFMC) meeting. The NPFMC meetings are typically 8 days in length, with the SSC meetings happening in the beginning of the week and the full RFMC meeting at the end. The ABC limits will be set during the SSC meeting, and the TAC set during the RFMC meeting. Fishing will begin on January 20 (year x + 1) for 45 % of the allotted TAC. In most cases, 45 % of the quota is reached by mid-April so the fishing season closes until June. Fishing will re-open on June 10th for the remainder of the quota and closes October 31st, but due to increased abundance of Chinook salmon taken as bycatch in October, most boats finish by late September or early October. (Ianelli, pers comm). (Fig. B.2).

Both prior to and after assessments, scientists will meet with fishermen to discuss data assumptions and results. These are informal meetings outside of the standard SSC and RFMC meetings.

It should be emphasized that this rapid timeline for walleye pollock does not reflect the timeline of all stock assessments in the U.S. Many take much longer.

Appendix Fig. B.1:

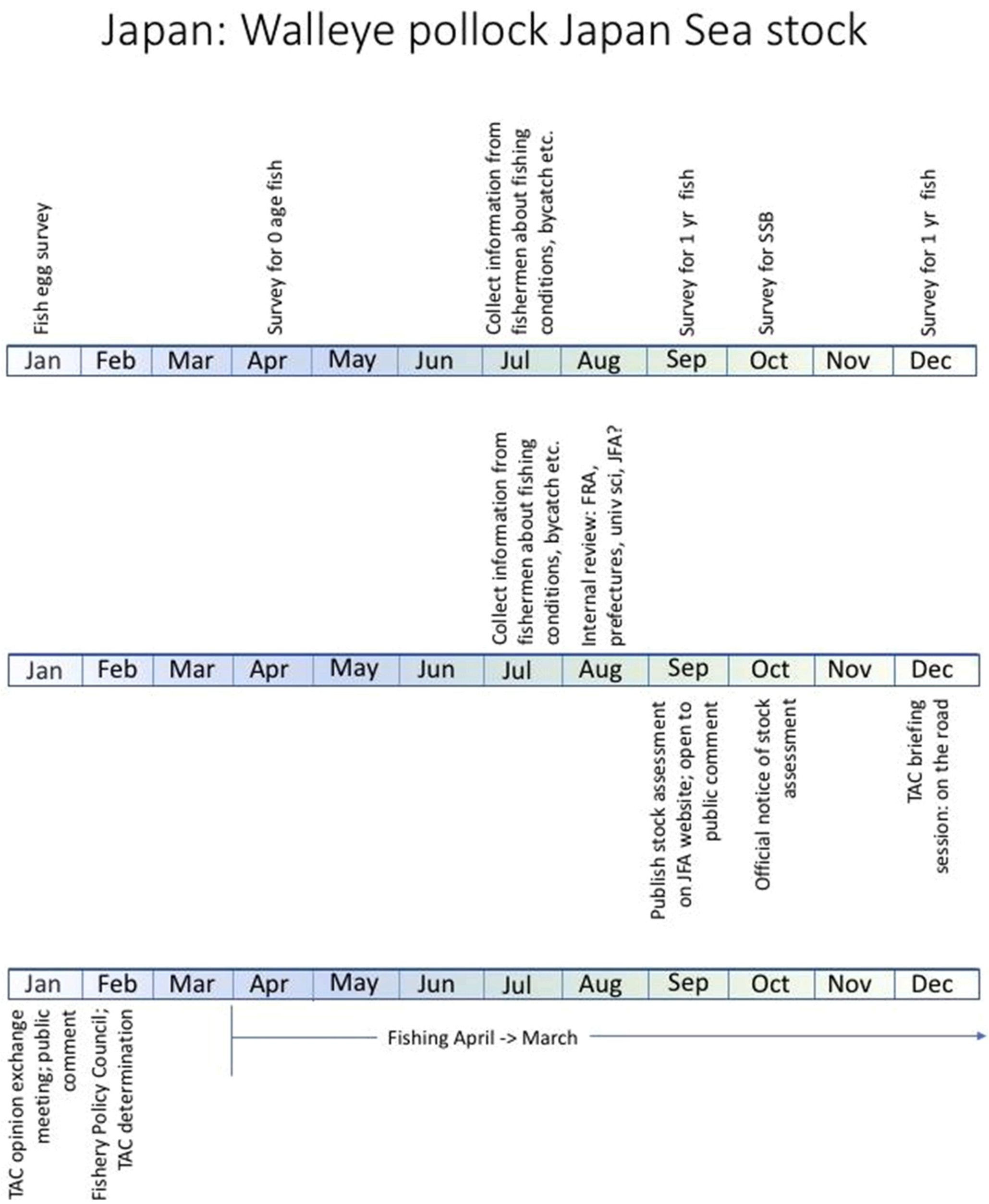
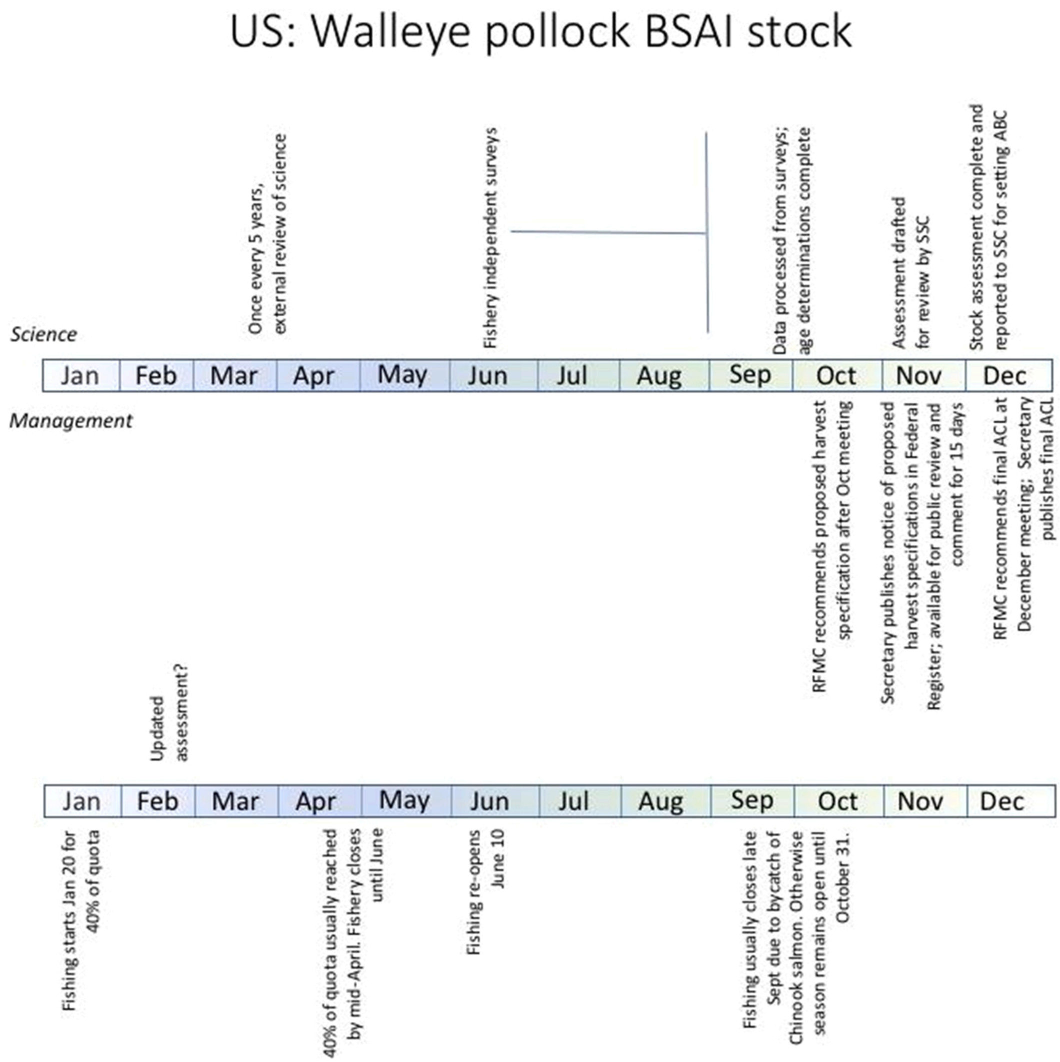



Image 1

A timeline of the data collection, assessment, and management decisions for one season of walleye pollock fishing. The science activities are written above the timeline and the management decisions below the timeline.

Appendix Fig. B.2:




## Appendix C. Data collection

Expert input provided by the following:
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