Shared Principles for Fishery Allocations Under Climate Change

Prepared for

Environmental Defense Fund

July 2022

Prepared by

Northern Economics

800 E Dimond Boulevard
Suite 3-300
Anchorage, Alaska 99515-2049
Phone: 907-274-5600
Fax: 907-290-2464
www.northerneconomics.com

PROFESSIONAL CONSULTING SERVICES IN APPLIED ECONOMICS AND SOCIAL SCIENCES

Principals:
Marcus L. Hartley, M.S. – President
Michael Fisher, MBA – Vice President
Diane Sauer – Office Manager

Consultants:
Raniyah Bakr, B.A.
Leah Cuyno, Ph.D.
Melissa Errend, M.S.
Don Schug, Ph.D.

Administrative Staff:
Terri McCoy, B.A. – Editor

800 E Dimond Blvd., Suite 3-300
Anchorage, Alaska 99515
Phone: 907.274.5600
Fax: 907.290.2464

Email: mail@norecon.com
www.northerneconomics.com

Preparers

Team Member	Organization	Project Role
Melissa Errend	Northern Economics, Inc.	Project Manager and Lead Author
Marcus Hartley	Northern Economics, Inc.	Advisor
Terri McCoy	Northern Economics, Inc.	Editor
Melissa Mahoney	Environmental Defense Fund	Contributing Author, EDF Project Manager
Katie Westfall	Environmental Defense Fund	Contributing Author, Contract Manager

Please cite as: Northern Economics, Inc. *Shared Principles for Fishery Allocations Under Climate Change*. Prepared for Environmental Defense Fund. July 2022.

Contents

Table **Page**

Figure **Page**

Abbreviations

ABC	Acceptable biological catch
BSAI	Bering Sea and Aleutian Islands
CMP	Coastal migratory pelagics
CP	Catcher processor
CPS	Coastal pelagic species
EDF	Environmental Defense Fund
FMP	Fishery management plan
GOA	Gulf of Alaska
ITQ	Individual tradeable quota
LE	Limited entry
MAFMC	Mid-Atlantic Fishery Management Council
MS	Mothership
MSA	Magnuson-Stevens Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NS	National Standards
NSG	National Standards Guidelines
OFL	Overfishing limit
POP	Pacific ocean perch
U&A	Usual and Accustomed

Executive Summary

Northern Economics, Inc. was contracted by the Environmental Defense Fund to work with stakeholders to develop a shared set of principles for allocating fisheries under climate change. This report summarizes work completed between September 2021 and July 2022 in support of that effort.

As a first phase of this project, Northern Economics worked to interview stakeholders and fishery experts in order to better understand allocation issues and identify potential participants for a convening. Through that process, 14 phone or teleconference interviews were conducted, while informal discussions were held with 6 others, and insights from 5 stakeholders were gathered using a web survey tool.

Fishery stakeholders across all regions communicated that they have perceived changes over time in ocean conditions and species distributions, and most attributed this to climate change. When asked about experiences from observing past allocation decisions, stakeholders shared mixed sentiments. Most people described how allocation decisions have generally resulted in winners and losers and have been politically fraught; but at the same time, many felt that the status quo procedures of allocating based on historical landings and participation were generally fair. Others in catch share programs felt the allocation process was fair, but that the costs associated with the program were a heavy burden. Some interviewees expressed concern about how limited entry has changed the ability for harvesters to be flexible in their operations. Several interviewees were lifelong fishermen who were able to make their start by experimenting across fisheries—an opportunity they felt was no longer available to incoming generations. Stakeholders were asked about factors that they thought should be considered, or were important to consider, when allocating fisheries under climate change. Most commonly, interviewees discussed a desire to have access to stocks that have shifted, either because they interact more with their target fisheries (such as sablefish in the Alaskan pollock fishery) or because they are desirable target species and there is a wish to allow vessels to "catch what's there" (such as summer flounder).

Based in part on results from interviews and discussions with fishery and allocation experts, combined with information from a literature review, we developed an indicator of allocation complexity which we applied to the majority of US federal fishery management plans (FMPs) as a way to visualize where allocation challenges may be more likely to arise under climate change, and then matched up our indicator with preexisting projections of range shifts and changes in habitat suitability for US species. For the complexity indicator, each FMP was scored along five dimensions which assess how many static allocations exist, if allocations for multiple species exist, how many management regions abut the species contained in the FMP, and whether or not the FMP is already under joint management. We find that on average across all FMPs, the West Coast and Alaska regions have the highest degree of allocation complexity, while those in the Caribbean and New England were the least complex, on average. We did not assess allocation complexity for Pacific Island FMPs, in part

due to the highly international nature of the fisheries there. Drivers of allocation complexity were different across regions, with complexity in the Southeast, Gulf of Mexico, and Mid-Atlantic regions primarily driven by a combination of a high number of abutting management regions as well as a combination of catch-share-managed fisheries, and fisheries with quota divisions between recreational and commercial sectors. In contrast, on the West Coast and in Alaska, complexity was largely driven by multilayered allocation schemes within and across catch share programs, which may allocate quota at the individual level, across sectors or stocks, spatially, or by other means.

When combining the complexity indicator with available projections under climate change, we find that FMPs in the Eastern Bering Sea may be particularly vulnerable to suitable thermal habitat changes, west coast groundfish stocks may experience large shifts northward, and stocks along the East Coast and Gulf of Mexico may experience a mix of increasing suitable thermal habitat and expansions in their spatial distribution. Implications for allocations, particularly in the Gulf of Mexico, are hard to interpret at the FMP level, especially without more information on the directionality of shifts or changes in suitable habitat. Overall, we find that more research would be helpful to more robustly identify challenges at the sub-regional level, but the current work is helpful to see the big picture of how complex allocation schemes are nationally, as well as the magnitude of changes that could occur over the next 80 years.

The convening was held in March of 2022 and brought together a group of fishing stakeholders across commercial, recreational, and tribal affiliations from around the US to discuss what they thought was important to consider when setting new, or revising, allocations under climate change. Through a collaborative process facilitated by Kim Howe at CoCreative Labs, the stakeholders arrived at a list of eight Principles representing shared ideas. After the convening, the Principles were refined and adjusted, if necessary, based on the review of each participant. The final list of Principles is as follows:

A climate resilient allocation system is one that…

1. *Considers all impacted communities and stakeholders*
2. *Promotes dynamic self-management*
3. *Addresses the equity issues associated with changing non-target species*
4. *Ensures sustainability of the resource and conservation of biodiversity of the ecological system*
5. *Incorporates adaptability in the regulatory structures*
6. *Recognizes historic and traditional dependence*
7. *Ensures transparent, inclusive, and meaningful co-management*
8. *Utilizes and integrates diverse knowledge sources*

After the convening, Northern Economics reviewed the Principles against existing management and policy guidance to evaluate if and where the Principles were similar, or the extent to which they provide a novel perspective. It was found that all of the Principles are consistent with current guidance and regulation, and several echo rooted concepts underlying the Magnuson-Stevens Act and other related laws and regulations, especially Principles 1, 3, 4, and 7. The other Principles were determined to be at least partially more novel, especially when viewed in the context of climate change.

Finally, we examined two recent fishery allocation actions through the lens of the Principles, to see if and how decisions align with the Principles. We looked first at an interstate allocation decision for summer flounder on the US East Coast, and second at an intersector allocation decision for select West Coast groundfish stocks. Overall, by looking at these two recent fishery management actions on the east and west coasts, it was easy to see places where the final list of Principles supports chosen management outcomes. In both actions, alternatives selected have components that would incorporate adaptability in regulatory structures (Principle 5) by making allocation decisions "frameworkable". Unsurprisingly, both actions also satisfy Principle 4 (Ensuring sustainability of the resource) since this is a core mandate under the Magnuson-Stevens Act, but in particular the West Coast intersector allocation amendment strikes a balance between this Principle and providing flexibility to sectors, which may become increasingly important under climate change. On the East Coast, changes to the summer flounder, scup, and black sea bass FMP goals and objectives make sure that Principles 6 and 3 will be considered in balance with one another by ensuring that both historical and traditional users' needs are balanced with other users' needs under changing conditions. However, some Principles were less evident or applicable in the reviewed management actions, specifically Principles 7 and 8, which address ensuring transparent and inclusive co-management and utilizing diverse knowledge sources. More discussion may be needed to think about how these Principles can, or should be, applied to management actions or FMP goals and objectives, or at higher levels in fishery management and policy under climate change.

Introduction

Why the Need for Shared Principles?

Allocation—who gets access to fishery resources—is already a sensitive matter and perhaps one of the most contentious issues in fishery management.

Climate change is causing stocks to shift and is altering their productivity and availability. This is already creating issues with access to stocks and the allocation of harvest opportunity to fishers. The problem will only worsen as climate change increasingly takes hold. The changing access to fishery resources creates problems at the social and economic level, such as issues of fairness and equity among fishermen. These problems feed back into management systems which are often already strained, and can adversely impact fishery participants, processors, and related communities.

The Magnuson-Stevens Act (MSA) provides some guidance concerning the allocation and acquisition of fishing opportunity, but largely speaks to situations where the environment is relatively stable. The key question, therefore, is how to maintain a desired balance of efficiency and equity as access to fishery resources is changing due to climate change. Rather than wait for more climate-related fishery conflicts to arrive, Environmental Defense Fund (EDF) is taking proactive steps to convene fishery stakeholders and allocation experts from around the country to co-create broad, nationally relevant stakeholder Principles to help US decision-makers make robust management and allocation decisions in the face of change.

Allocation decisions—complicated enough by data, politics, and historical precedence—may be even more difficult when considering:

- Uncertainty in direction, timing, and magnitude of changes
- Changes affecting multiple fisheries or ecosystems simultaneously
- Changes affecting multiple management jurisdictions
- Difficulty of using status quo allocation approaches (e.g., historical parameters)

The goal of this work is to develop shared Principles for allocation that complement established guidance within the MSA. The Principles should strive to be nationally applicable and relevant to the multiple fishery management jurisdictions that exist within the US.

Scope of Work

Northern Economics was hired by EDF in the fall of 2021 in support of this project. Work completed for this project had three main phases: data gathering, consensus building, and assessment. In the research phase, we gathered input via interviews with fishery participants and stakeholders to gain

insight into regional/current perspectives about climate change and fishery allocations. These informed the development of several scenarios, which were put forth during a convening of fishery stakeholders to develop a list of shared Principles for setting allocations under climate change. The supported Principles document was a the primary output of this project, which in addition to being included in this report, will be shared with Congressional leaders and staff, National Oceanic and Atmospheric Administration (NOAA) headquarters and regional staff, and other high-ranking decision-makers at both regional and national levels to educate them as to the broader fisheries community's thinking on roadblocks and opportunities to harness existing authorities under the MSA and fishery management tools to improve allocation decisions in light of climate change. Here, we also present results of the third phase, which examined allocation schemes across US fisheries and determined which fishery management plans (FMPs) may encounter challenges under climate change, as well as compared the Principles to recent fishery management actions that concerned fishery allocations.

Structure of this Report

This report has four primary sections. The first contains background information on fishery allocations, important definitions, and a review of important policy and related guidance for fishery allocation decisions. The second section summarizes interviews conducted and results of a survey administered to fishery stakeholders. The third section shares the results of an analysis to identify where allocation challenges might occur under climate change. And finally, the fourth section contains a summary of the convening, including the list of shared Principles, a discussion of how the Principles relate to current laws and regulations, and finally a discussion of how the Principles relate to recent fishery allocation decisions.

Background

Allocation decisions are well known to be contentious and high-profile in fishery management, but what exactly is an allocation? Here, we not only define allocations consistent with the laws and regulations applicable to US federal fisheries, but also review how allocations are structured as well as all relevant guidance and policy that directly relates to allocations. Defining such key terms and establishing the policy and regulatory context is critically important to any discussion about what allocations should look like under climate change.

What is a fishery allocation?

Allocations in US fisheries may refer to the privileges or access to certain fisheries granted to individuals or groups based on a set of criteria established by fishery managers (Lapointe, 2012). Allocation is defined by NOAA as "a direct and deliberate distribution of the opportunity to participate in a fishery among identifiable, discrete user groups or individuals" (50 CFR 600.325). While access to fisheries may be directly managed—through the direct distribution of fishing opportunities (e.g., permits) or quota, by setting rules and limits, or imposing costs on fisheries participation and catch—management also indirectly affects access, such as for new entrants or fisheries with incidental catch.

Allocations may occur at several different levels across fishery management including:

- Across sectors (e.g., recreational and commercial groups or different fleets within commercial fisheries)
- Across gear groups (e.g., to mobile gear or pot or trap fisheries)
- To different states or fishing communities (e.g., community development quota)
- To individuals or groups (individual tradeable quotas [ITQs] or cooperatives)
- Across space (to different fishery areas, such as inshore and offshore)
- Across time (e.g., to different seasons within a fishing year)

Allocation decisions are notoriously some of the most difficult in fisheries management for many reasons including changes to traditional views of access to fisheries, stakeholder perceptions of fairness, economic implications, and permanence of allocation decisions once made (Lapointe 2012).

How are fisheries allocated?

Lynham (2013) created a database that described the method used to allocate shares in nearly every major catch share fishery in the world and found that 54 percent of these fisheries allocated total catch solely based on historical landings, and a minority used auctions or equal sharing rules (3

percent and 6 percent, respectively). The remainder used a combination of methods, leading to an overall percentage of 91 percent of fisheries that have allocated at least some portion of rights based on historical catch.

Historical participation is also a predominant allocation approach in non-catch share fisheries. When moving from an open-access scheme to a limited entry, or restricted access, fishery, historical participation and catch is often used as the basis for allocating permits across both state and federally managed fisheries (Twomley, 2003), or for determining permit tiers (e.g., the Pacific sablefish permit stacking program).

For many fisheries, the quotas are also tied to different fishery management regions, such as state and federal boundaries; fishery sector, such as commercial and recreational; fishery seasons; or gear groups (fixed gear or mobile gear). Where these divides are relatively static and based on historical factors, changing conditions relative to the underlying baselines can contribute to conflicts.

This is the case for the summer flounder, or fluke fishery off the eastern coast of the United States. The fluke fishery has migrated north along the coast from its historical location, off the coast of North Carolina, to New Jersey. Commercial quotas, however, were allocated by state, with North Carolina getting the largest share at 28 percent, and fish were required to be landed in the state, resulting in fish being caught in New Jersey and landed back in North Carolina. Meanwhile, recreational anglers were increasingly landing fluke and exceeding their quotas, while quota in the southernmost states stays on the table. In 2019, the FMP was amended by revising the interstate allocations using a trigger point scheme, where if the total commercial quota was less than 9.55 million pounds (a seven year historical average), the allocation would remain at the status quo level, and when the total allocation would exceed that level, the additional amount of total quota would be distributed by equal shares, with the exception of Maine, New Hampshire and Delaware, which would split 1 percent of the additional quota. In addition, another proposed measure included adding "landings flexibility" to a list of "frameworkable" provisions in the FMP, so that adjustments could be made to the state landings requirement during the periodic specifications process; however, this measure was not ultimately selected (ASFMC, 2020).

According to a review of catch share programs in the United States, programmatic goals and objectives have varied, but have also had several common themes (Brinson and Thunberg 2016). The goals and objectives of management plans may directly relate to the design of the program, including how quota is allocated, and may therefore have implications for impacts under climate change. According to Brinson and Thunberg, all 16 programs had the goal of achieving biological objectives, such as rebuilding stocks and reducing discards, as well as reducing capacity (13 in total), and the majority sought to lengthen the fishing season and maintain diverse or small-scale fleets (10) and improve vessel safety and profitability (6 and 7). Fewer programs were designed with goals to minimize impacts to support sectors or communities (2 and 4, respectively), or minimize gear conflicts (2).

Review of Current Allocation Policy and Guidance

To assist with setting measures that ensure sustainable and responsible fishery management, NOAA Fisheries creates guidance to support the ten National Standards for managing fisheries outlined in the MSA. The secretary of commerce is charged with ensuring that FMPs, amendments, and regulations are consist with the National Standard Guidelines. National Standard 4 directly concerns fisheries allocations:

> *Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be (a) fair and equitable to all such fishermen; (b) reasonably calculated to promote conservation; and (c) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privilege. (16 US Code § 1851)*

As required under the MSA, NOAA Fisheries creates guidance to support the National Standards, most recently updated in 2016 (50 CFR 600.325). For National Standard four, this guidance outlines the definition of allocations, requirements for analysis of allocations, and factors in making allocations. Specifically, these requirements are that allocations should be "rationally connected to the achievement of OY [optimal yield] or with the furtherance of a legitimate FMP objective" since allocations inherently detriment one group while advantaging another, and so can do so justifiably if the FMP objectives are aligned with the allocation outcomes. In addition, hardships and disadvantages are permissible if such impacts are outweighed by benefits to another group or groups, or by maximizing net benefits and other factors (e.g., economic and social consequences, fishery dependence, transferability of effort and impacts on other fisheries, opportunities for new entrants, and recreational fishery opportunities).

> *Under the Magnuson-Stevens Fishery Conservation and Management Act (MSA), a fishery management plan (FMP) may restrict harvest below the level that would occur in the absence of active management. In such a case, the allocation or distribution of fishing privileges among identifiable, discrete user groups or individuals becomes an important consideration in plan development (50 CFR Ch. VI, §600.325(c)(1)). Allocation is at the heart of recent management actions such as the creation of catch shares (e.g., NOAA 2010), the imposition of restrictions on certain types of gear (e.g., GMFMC and NMFS 2009), and the consideration of how harvest should be distributed between different sectors of a fishery (e.g., NPFMC 2010). (Plummer, Morrison and Steiner 2012, page 1)*

In response to the increasing implications for climate change induced conflicts or mismatches under preexisting management arrangements, NOAA, fishery management councils, and interstate commissions have responded by conducting climate change scenario planning (New England/Mid-

Atlantic, West Coast), as well as by creating allocation working groups.[1] Recently, NOAA published a tech memo exploring the governance issues in cross-jurisdictional fisheries (Morrison 2021):

> *NMFS expects the management and governance challenges associated with fisheries that cross Council jurisdictions to increase in the near future for two main reasons. First, many important commercial and recreational fish stocks have shifted their distributions, and more are predicted to follow. The distribution of fish stocks is dynamic as the stocks shift, expand, or contract in response to environmental conditions, biological conditions (predators, prey, competitors, etc.), and condition of the stock (overfished, rebuilt). Conversely, the jurisdictions of the Councils are static as described under MSA section 302(a)(1). (Morrison 2021, page 14)*

More broadly, the Council Coordinating Committee Allocation Committee created national guidance for initiating allocation reviews in 2016, prompted in part because "demands for fishery allocation reviews have been increasing" while acknowledging that allocations are difficult to review and amend (National Marine Fisheries Service [NMFS] 2018a). In 2018, NOAA headquarters issued guidance on recommended practices and factors to consider when reviewing and making allocation decisions (NMFS 2018b) which stated that "Because fisheries management and the conditions surrounding fisheries are not static, allocation decisions need to be considered in the context of adaptive management." In previous years, much attention has been devoted to resolving allocation conflicts between recreational and commercial fishing sectors (see Holzer and McConnell 2014; Plummer, Morrison, and Steiner 2012), following highly contentious allocation issues in several fisheries including the Gulf of Mexico reef fish, or specifically the red snapper, fishery. No further guidance directly concerning the allocation of fishery resources under climate change has been produced since.

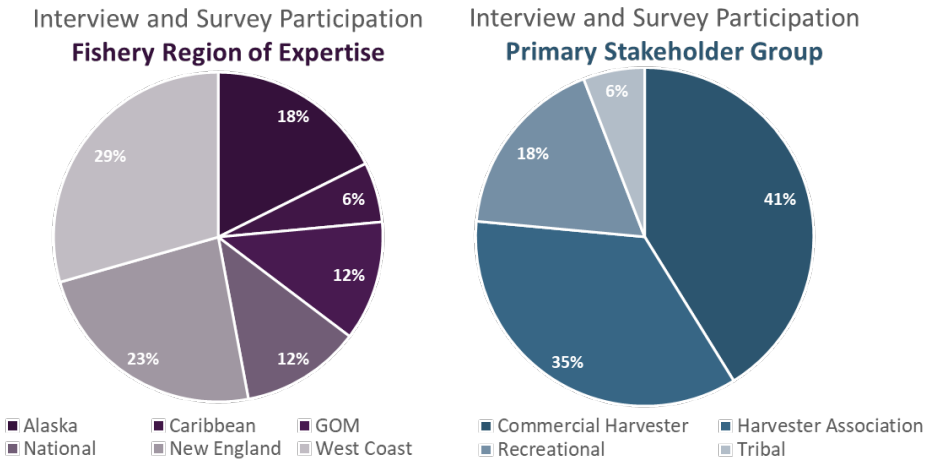
[1] For more details on this effort on the East Coast, see: http://www.asmfc.org/calendar/6/2021/Allocation-Work-Group/1741

Summary of Scoping Interviews

In the winter of 2021, we conducted a series of interviews with fishery stakeholders around the United States for multiple purposes: one, to assist with finding candidates for the convening, and secondly to compile insights from interviewees in order to develop scenarios for discussion at the convening.

In total, Discussions ranged from those with expertise in fisheries, such as academic researchers, to NGO representatives, to fishery stakeholders including harvesters, catcher-processors, fishery representatives, and community leaders. Most interviews (13) were with fishery stakeholders while informal discussions were held with experts on fisheries allocation. Stakeholders were largely representatives of commercial and recreational fishing associations, charter captains, and commercial fishermen. Stakeholder regions of expertise spanned New England, Gulf of Mexico, Caribbean, Alaska, and the West Coast as key regions, with additional insights spanning the South Atlantic and the Mid-Atlantic (Figure 1).

Figure 1. Interview and survey representation by fishery region of expertise and stakeholder group



Interviews were semi-structured and used a combination of prepared questions on perspectives of climate change, general allocation approaches in fisheries, and opinions of fairness, equity, and efficiency of allocations under changing ocean conditions. Individual interview responses were communicated as confidential and any quotes or paraphrasing in this document is done so without attribution.

Perspectives on Changing Conditions

Fishery stakeholders across all regions communicated that they have perceived changes over time in ocean conditions and species distributions, and most attributed this to climate change. These perspectives were more widely held by the Alaskan, East Coast, and Gulf of Mexico stakeholders. A couple West Coast stakeholders described either that they felt more unsure about what was natural, cyclical change, than human-induced climate change, while another felt they had not perceived any major changes in stocks or ocean conditions. While a few stakeholders did not feel like they were experiencing climate change impacts, the majority of interviewees and survey respondents described that they expected more impacts of climate change in the future.

> *"At this point, it's difficult to demonstrate cause and effect... changes are happening, but we don't have the ability to accurately tease apart climate drivers from other drivers (e.g., red snapper rebuilding has resulted in expansion of the stock into the eastern Gulf of Mexico)."*

Another common perspective from fishery stakeholders was that there are gaps in the scientific knowledge of what is driving change.

Fishery stakeholders in New England cited concerns about accountability in disentangling stock conditions as a result of overharvesting from environmental conditions. Stakeholders in Alaska discussed how change seemed more obvious over time, such as requiring less heating fuel while fishing and longer season lengths.

Despite change seeming imminent, the impacts on fishery operations are less clear to stakeholders—four out of five survey respondents answered that they felt uncertain whether change was a threat to fishery businesses. This sentiment was echoed during interviews, since from the perspective of harvesters, people generally felt that given the opportunity, fishermen would adapt their operations to changing conditions.

> *"It's only a threat if businesses can't adequately adapt in time. Change is constant and occurs at all scales."*

When asked about potential barriers to adaptation, the most commonly reported barrier was fishery regulations and the "slow wheels of government." Several interviewees discussed various aspects of fishery management as being limiting under change, from permit costs and costs of entry to the difficulty of having timely management responses. From a tribal perspective, a unique challenge is that some treaty tribes in Oregon and Washington have specified and fixed Usual and Accustomed (U&A) area boundaries in the ocean in which they can exercise their treaty rights, so unlike many

other fisheries, they lack geographic flexibility to fish. From an east coast recreational perspective, obstacles included representation, such being far away from the jurisdiction where fishery management measures are decided or where they are unable to serve on advisory panels, which was noted for species that cross boundaries between the Mid-Atlantic and New England regions. Other identified barriers included market conditions, knowledge of the fishery, and gear or vessel configurations.

Thoughts on Fishery Allocations: Past, Present, and Future under Change

Nearly all stakeholders reported that they had followed or been directly involved in past allocation decisions—typically the major rationalization programs, such as red snapper in the Gulf of Mexico, the New England multispecies sector program, the Pacific trawl catch share program, and the halibut and sablefish IFQ program. Non-rationalized fisheries that were also discussed included Pacific cod; Pacific salmon; Pacific Albacore; Dungeness crab; black sea bass, scup, and summer flounder; monkfish; Atlantic herring; Pacific squid; and spiny lobster, among others.

When asked about experiences from observing past allocation decisions, stakeholders shared mixed sentiments. Most people described how allocation decisions have generally resulted in winners and losers and have been politically fraught; but also, many felt that the status quo procedures of allocating based on historical landings and participation was generally fair. Others in catch share programs felt the allocation process was fair, but that the costs associated with the program were a heavy burden. Some interviewees expressed concern about how limited entry has changed the ability for harvesters to be flexible in their operations—several interviewees were lifelong fishermen who were able to make their start by experimenting across fisheries—an opportunity they felt was no longer available to incoming generations. One fisherman felt that the management system is biased towards those who are the loudest, biggest, and most able to attend fishery management council meetings. They felt they "lost" in past allocation decisions in part because they did not have the ability to engage in the process as much as others. Relatedly, others spoke about the increasing importance of fishing associations in the current state of fishery management, to ensure that all voices are heard.

Tribal treaty allocations, where they exist, are very different from other federal fishery allocations in part because they have an additional layer of legal interpretation based on treaty language that dictates how much, and where, treaty rights may be exercised. While the boundaries of access areas may be limiting under climate change, treaty tribes that have oceanic rights may exercise their rights over new stocks that shift into the boundaries of access areas through consultation with the federal government. This picture is more complicated for tribes that do not have granted ocean rights (such as the Klamath) or are not recognized federal entities. Typically, tribes that have dedicated access to federal stocks receive a set aside that comes off the top before any other subtractions are made. A complication for this is that then tribes must decide between themselves how to manage the set aside and U&As of tribes may overlap, leading to typical fishery management issues and conflicts including

fishing derbies. One representative we spoke to felt that a fairer system that tribes are pushing for is one of individual dedicated allocations for individual tribes.

How should fisheries be allocated under climate change?

Stakeholders were asked about factors that they thought should be considered, or were important to consider, when allocating fisheries under climate change. Most commonly, interviewees discussed a desire to have access to stocks that have shifted, either because they interact more with their target fisheries (such as sablefish in the Alaskan pollock fishery) or because they are desirable target species and there is a desire to allow vessels to "catch what's there" (such as summer flounder). Unsurprisingly, there are often barriers for use or entry, such as in the state-managed fisheries on the East and West Coasts, where individual states may receive allocations, or have unique permitting systems for stocks, or impose requirements for landing in the permitted state, such as in the summer flounder/fluke fishery. One stakeholder emphasized a need to get rid of unnecessary or antiquated regulations that make it more difficult to access or acquire fishing rights. This is the case in the NE groundfish fishery, where permits are tied to "endorsements" to a suite of different fisheries, like groundfish and monkfish, and cannot be sold independently.

> *"[The] management jurisdiction needs to align with the fishery's range. If a fishery shifts northward and new participants enter, those individuals need to be a part of the management process."*

Other factors were quite variable, from emphasizing the removal of barriers to economic efficiency to simply identifying social justice as the most important factor to consider for allocation decisions. Others felt business stability, access to financing, and the long-term goals of the fishery were the most important.

Stability was mentioned frequently during interviews, both in terms of how climate change is already destabilizing fisheries and the desire to create more stability for participants in the face of change. This included protecting participants from large changes in allocations when abundance changes dramatically, financial stability in terms of access to other fisheries when primary fisheries are limited, or even finding opportunities outside fishing for vessels and crew to earn income when fishing isn't possible.

One stakeholder expressed the opinion that before allocations can be determined, there is a need for better modeling, particularly ecosystem-level modeling, as it could help with finding more justifiable allocations (that the historical baseline is not reliable for setting future allocations). Another stakeholder described the need to move away from managing single stocks or species groups and manage at ecologically relevant levels. Several stakeholders discussed the need for more accountability, as to improve the science available generally, but also to better disentangle climate

change from human-induced changes, and avoid setting allocations based on levels of effort that led to overfishing.

From a recreational perspective, one stakeholder discussed the need for more limited entry in recreational fisheries, citing evidence from the benefits that sub-allocations for red snapper have had on the charter boat industry, and likely benefits for other recreational sectors under environmental change, such as stability and increased flexibility. Another stakeholder discussed the importance of having a universal federal recreational fishing permit that could better identify the universe of who is fishing and solve some of the data issues that currently exist in recreational fisheries management.

From a national perspective, some stakeholders were concerned about the transboundary governance aspects of allocative issues, such as if Councils had the necessary structure in place for consistently coordinating and communicating across their jurisdictions in contrast to coordinating only on an ad hoc basis. This structure might also be necessary for ensuring that everyone who needs to be at the table can get there. Ideas such as creating forums for cross-staff collaboration and discussion, attendance at other regions' meetings, or crash courses in other regions' fisheries and management might be warranted. In addition, there were concerns about supporting commercial harvesters and communities in regions such as the South Atlantic, that might be experiencing a net loss of stocks as species move northward but new fishing opportunities are not appearing as fast.

Discussions with those involved in permit banking efforts included a conversation about how permit banks can provide resilience to harvesters in times of change by providing low barriers for experimentation in other fisheries, but only if banks are allowed, or able, to acquire permits or quotas for given fisheries. It was noted that use caps may limit their ability to acquire quota for vessels, or that ownership by NGO entities may not be permissible under permitting requirements, or that it is simply not feasible to acquire permits for some fisheries, either due to cost or availability.

One stakeholder wondered if the goal of allocation decisions is to ensure fairness for those who used to fish, or if it is to build a platform for future fisheries. The stakeholder stated they believed the latter was more important. This is in contrast to the responses of most other interviewees, who largely felt that the status quo approach of allocating based on historical participation is a fair approach for allocating fisheries.

Representatives from all regions acknowledged the increasing costs of entry in limited entry fisheries, from permit prices to the costs of quota, but did not agree about whether this barrier should be removed in the face of climate change. Some stakeholders acknowledged that from the perspective of new entrants this is a cost, but for those who are in the fishery, permit value and quota values provide flexibility to harvesters since they know they can either use their assets as collateral for applying for loans, or particularly for the case of leasable quota, can obtain value via leasing even when not actively fishing, such as if they are unwilling or unable to transit great distances to prosecute their typical fisheries.

One stakeholder discussed the dangers of introducing 'flexibility' into management measures since it could mean slicing the pie into even more pieces that could put harvesters at the margin at risk of losing their businesses and pointed out that one of the reasons that systems like limited entry or tradable quota were introduced was to provide stability for participants, and flexibility could be destabilizing.

Takeaways

Key takeaways from all interviews can be summarized as follows:

- Create goals and objectives for the fishery that provide a vision for the future under change.
- Align management boundaries with biological distributions.
- Ensure good science and strong accountability.
- Consider impacts on resiliency (e.g., portfolio of options available) for affected fisheries.
- Consider known and unknown changes to the resource in the short, medium, and long term.
- Protect stability, create buffers against variable conditions.
- Outline triggers or circumstances for revisions or re-balancing of allocations.
- Create mechanisms for periodic redistribution of effort or latent effort, considering distribution to communities.
- Consider alternatives to historical baselines for stocks with known climate vulnerability.
- Consider impacts to communities and their climate vulnerability and dependence on fisheries.
- Find opportunities to compensate regions with net losses of stocks and fishing opportunities.
- Provide opportunities for entry, flexibility over time without jeopardizing stability.
- Policymaking/management directly involves individuals, businesses that may be more impacted in the future (e.g., from neighboring management regions).
- Make the management system more efficient, less time consuming, more adaptable under change ('frameworkable' changes vs FMP amendments).
- Reduce management costs by moving away from single-species management, fewer management plans that are biologically/ecologically relevant groups.
- Prioritize removing antiquated rules and permit structures that make it more difficult to buy and sell fishing rights.
- Ensure enforceability and accountability to support good data and conservation.
- Prioritize regional-level climate scenario planning, incorporate results into science and management.

Assessment of Potential Allocation Challenges Under Climate Change

Allocation battles are not expected to be a new challenge under climate change, rather more frequent and more complicated to solve due to a literally shifting landscape of changing user groups, species mixes, distributions, and uncertainty. Here, we develop an indicator of allocation complexity and apply it to 38 US FMPs as a way to visualize where allocation challenges may be more likely to arise under climate change. Then, we match publicly available projections of shifts in species distributions and changes in suitable habitat to species in each FMP to look at both allocation complexity and potential impacts due to climate change.

Methods

Based on discussions with stakeholders, a review of past and present allocation actions, and other related literature, we determined five suitable management components as indicators of allocation complexity to be combined into one aggregate indicator. The logic behind the selection of indicators is straightforward: the greater the number of static determinations, or divisions, on who can fish and how much they fish, the greater the need for management intervention under circumstances of changing supply or demand for quota due to changing ocean conditions. In addition, we expect that decisions might be further complicated or needed when multispecies quotas are present, when the number of abutting management regions is higher (due to the potential for interjurisdictional conflicts), and lower if joint management is present. We assume that under change, these factors may increase the difficulties of resolving challenges without management action, and even then, may be highly difficult to resolve due to perceptions of taking away established rights or direct or indirect economic consequences on one or more groups. This is apparent in contemporary allocation or re-allocation decisions such as for red snapper in the Gulf of Mexico. As discussed in the Background section, fishery allocations are generally based on historical catches (see Plummer, Morrison, and Steiner 2012) and therefore are vulnerable to changing conditions which deviate from the historical baseline. An example of this is the summer flounder, scup, and black sea bass fishery where allocations are divided across East Coast states, but the historical shares increasingly have not lined up with availability and catches as the stocks shift up the coastline. Northernmost states therefore have increased availability and demand for quota, while southernmost states must travel farther to prosecute the fishery, fish less, or acquire additional costly permits (Papaloannou et al. 2021). For summer flounder, in particular, shifting quotas has been met with high resistance:

> *North Carolina today gets the biggest slice of the East Coast fluke fishery, based on its 1980s history as the leader in summer flounder landings. It is eager to hold onto its summer flounder quota, even if that now means the commercial fleet motors to New Jersey and back to find fish. (Lavelle 2014)*

This analysis, therefore, picks up on the potential for allocation battles to occur once management intervention is needed as a result of changing ocean conditions. In addition to describing how static and complicated a given FMP's allocation measures are, the indicator also includes information about the number of adjacent fishery management regions, which is of particular importance for stocks with the potential to cross management boundaries. Choices of indicators were also informed by availability since the goal was to apply this at the FMP level across management regions. It should be noted that likely many other institutional and socioeconomic factors will influence the degree to which allocation issues may arise under climate change, but the analysis here is intended to be a broad indicator of challenges across regions and FMPs. More detailed analysis within regions and specific FMPs will be more likely to assess individual challenges and identify possible solutions.

To obtain information on each FMP, a variety of sources were utilized ranging from the Code of Federal Regulations,[2] individual FMPs, and NOAA's searchable database of fishery species.[3] To derive an overall measure of allocation complexity, each FMP was scored along the following dimensions:

1. **Limited entry (0-1).** Does the FMP limit how many permits or licenses are available? This means that there are a limited number of fishing permits available and generally no new permits may be issued. A score of 1 means the fishery or majority of the FMP species, sectors, or effort are managed using limited entry but there may still be an open access component of the fishery. Score of 0 means there is no limited entry, or most species or sectors are open access, 1 means it is mostly managed under limited entry.

2. **Number of static allocations (0–3).** For each level where a static allocation exists, examples include between commercial and recreational sectors, between commercial sectors, between individuals (even if shares are tradeable), or fixed divisions between areas or seasons. For this to count they must be perpetual measures, meaning not periodically updated through specifications or framework amendments. A score of 0 means there are no static quota divisions within the FMP, 1 means there is only 1 static quota division, 2 is two static divisions exist, and 3 means 3 or more static divisions exist.

3. **Presence of individual multispecies allocations (0–1).** In instances of catch share programs, is there a multispecies allocation framework where multiple individual quotas must be satisfied simultaneously? Includes target or bycatch quotas. Score of 0 means there is no multispecies allocation structure, 1 means there is a multispecies allocation structure.

4. **Number of abutting management regions.** Generally, this applies to all FMPs in a given region, but exceptions may be made for species like highly migratory species that may cross

[2] https://www.ecfr.gov/current/title-50/chapter-VI

[3] https://www.fisheries.noaa.gov/species-directory

into additional management jurisdictions. For Alaska and the Pacific coast regions, they were considered to be abutting regions though technically separated by international waters.

5. **Jointly managed with another council, interstate commission, or state (ameliorating factor**). If a stock is jointly managed, one point may be deducted. Joint management typically means the FMP is classified as being under the jurisdiction of multiple regions, per the CFR. Joint management here also may include where an interstate commission jointly manages a species.

In total, 38 FMPs were classified in terms of their complexity across the New England, Mid-Atlantic, South Atlantic, Caribbean, Gulf of Mexico, Pacific, and North Pacific fishery management regions. The Pacific Island region was not included in this assessment. Combined Allocation Complexity scores ranged from 0 to 6, with spiny dogfish receiving the lowest score and multispecies catch share programs generally receiving the highest scores. Spiny dogfish was the only FMP to receive a 0 because it is not limited entry, nor does it have any static allocation measures, but it is jointly managed by the New England and Mid-Atlantic fishery management councils. Overall, 23 FMPs were classified as a 3 or lower; 15 were classified as 4 or higher.

To gauge how susceptible individual FMPs might be to climate change, we compiled results from Morley et al. (2018) by FMP, and summarized information on average predicted shifts in distribution and changes in thermal habitat availability, as well as variance for FMPs with multiple species into the year 2100. Using their results, we obtain two sets of results, under a low future emissions scenario (RCP 2.6) and under a high emissions scenario (RCP 8.5), where the low emission scenario represents a "strong mitigation" pathway and the high scenario represents "business as usual" (See Morley et al. and Taylor et al. 2012 for more information about these scenarios).

While Morley et al. (2018) represents one of the most comprehensive studies on North American species, we were not able to match results to all species or for every FMP. Ultimately, we were able to match at least some species for 24 FMPs. In addition to summarizing results from their projections, we also summarize the level of uncertainty for projections for each FMP as the mean uncertainty score for each of the included species in the FMP. For single-species FMPs, the score is simply the level of uncertainty assigned to that projection directly from Morley et al.'s results. Uncertainty scores are on a scale of 1–3, where "1" is low uncertainty, indicating high agreement between model predictions, "2" is moderate uncertainty, and "3" is highly uncertain. We include results even for species with high uncertainty levels, especially for multispecies FMPs, but encourage caution when interpreting results for FMPs that have moderate to high average uncertainty scores.

For some species, particularly for species in the Gulf of Mexico and South Atlantic regions, projections were available for the same species in each region. Where that occurred, the projection from the FMP region was used. In these cases, the climate change impacts differ by the regional FMP, even if the FMP is technically jointly managed (one FMP). In other cases, the same species were present in multiple FMPs but only one projection was available (largely for West Coast and Alaskan groundfish

species). In these cases, the region, or nearest region for the current centroid of the distribution in the Morley et al. paper was used (e.g., if the centroid was Eastern Bering Sea, the species was put in the Bering Sea and Aleutian Island groundfish FMP). An exception was made for West Coast groundfish. Because few West Coast groundfish species have centroids attributable to the West Coast and are also in the Gulf of Alaska groundfish FMP, a majority of these species were linked to the West Coast groundfish FMP since projections for these stocks are that habitat and biomass will shift north.

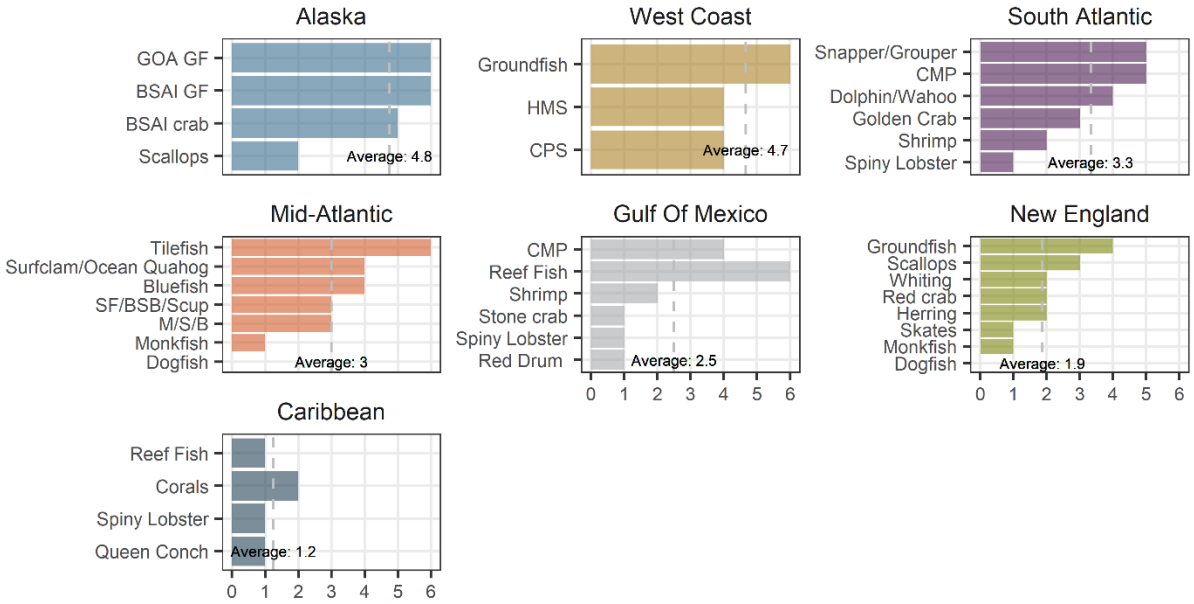
Findings

Allocation Complexity Scores

Across the 38 FMPs surveyed, we find that there are distinct drivers of allocation complexity across the different regions. On the Pacific Coast and in Alaska, the two regions with the highest average scores, complexity is driven by the number of multispecies catch share programs, with several levels of static allocations across sectors, communities, and individuals (Figure 2). In addition, the presence of tribal allocations is a unique factor in these regions that contribute to higher average scores. Alaska's four FMPs overall receive a score of 4.8, while the three Pacific FMPs examined receive an average score of 4.7. In the South Atlantic, Gulf of Mexico, and Mid-Atlantic, scores were driven by a combination of the presence of catch share programs, but also by allocations to commercial and recreational sectors, as well as spatially based allocations, such as in the case of king mackerel in the coastal migratory pelagics (CMP) FMP. Scores were also higher for these regions due to the number of adjoining fishery management regions, though species in these regions were also much more likely to already have joint management plans in place—such as the CMP FMP mentioned previously, or the spiny dogfish FMP in the Mid-Atlantic/New England area. The golden and blueline tilefish FMP received a high score of 6 because of the presence of a high number of adjoining regions and because of the presence of an IFQ program and recreational/commercial sector allocations. Mid-Atlantic FMPs generally received higher scores than other east coast regions because of the number of adjoining management regions and many managed species have a large spatial distribution.

The FMPs with the highest allocation complexity scores, each receiving a score of 6, were the West Coast groundfish FMP, Alaska's Bering Sea and Aleutian Islands (BSAI) and Gulf of Alaska (GOA) groundfish FMPs, the Mid-Atlantic golden and blueline tilefish FMP, and the Gulf of Mexico's reef fish FMP. Nearly all of the most complex FMPs contain at least one multispecies catch share program, the exception is the golden and blueline tilefish FMP. Again, it is important to note that this is only a high-level indicator. Within several of the most complex FMPs are several distinct management regimes, all of which may have unique features that may affect the nature and severity of allocation challenges. We further explore the nature and severity of these types of impacts by connecting our indicator with projections of changes in species distributions and suitable habitats.

Figure 2. Allocation Complexity Scores by FMP and Region.



Note: Acronyms are as follows: GOA GF- Gulf of Alaska Groundfish; BSAI GF- Bering Sea and Aleutian Islands Groundfish; CMP- Coastal Migratory Pelagics; CPS- Coastal Pelagic Species; SF/BSB/Scup- Summer Flounder, Black Sea Bass and Scup; M/S/B- Mackerel, Squid, and Butterfish; HMS- Highly Migratory Species.

Climate Change Vulnerability and Allocation Complexity

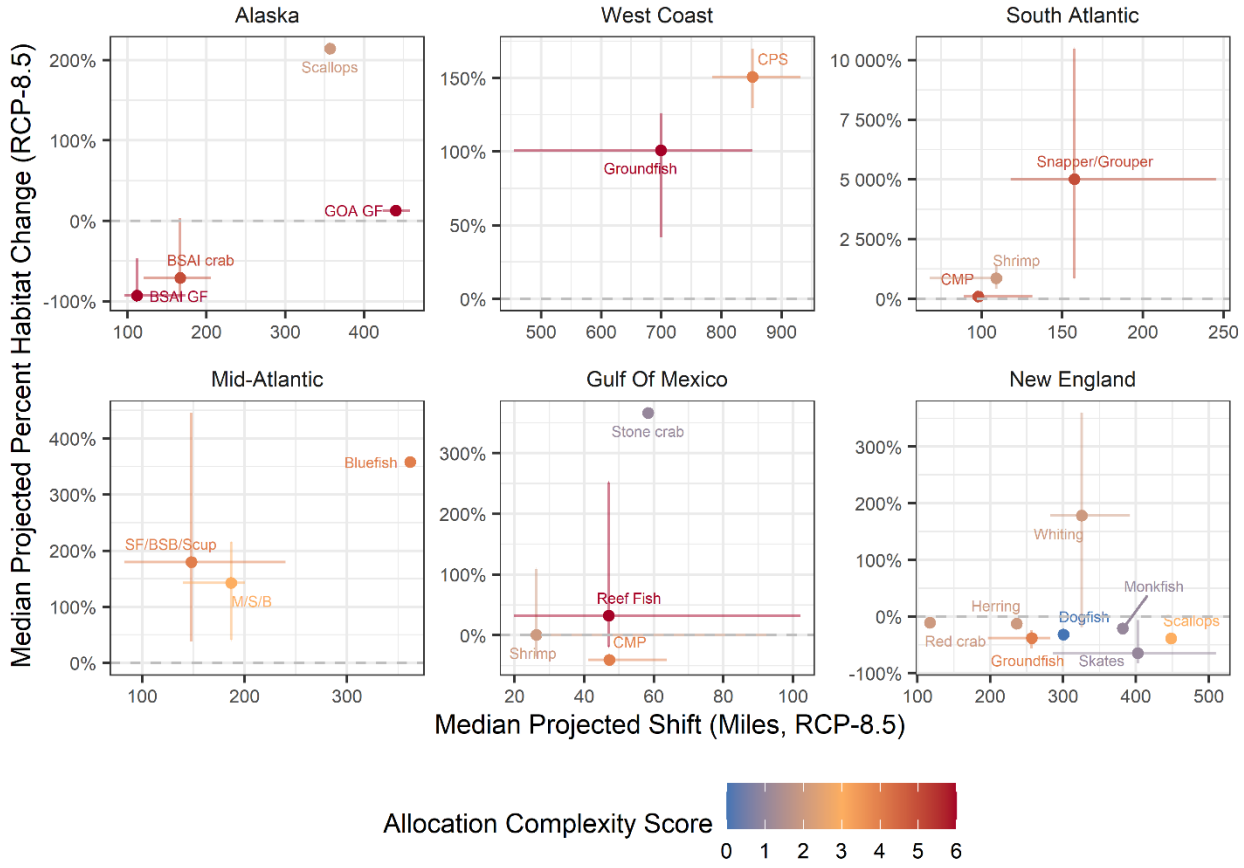
After matching species-level results to FMPs, we were able to match at least some species for 24 FMPs. Overall results for the high future emissions scenario are shown in Figure 3 while the low emission scenario is shown in Figure 4. Similar to the results for the allocation complexity scores we find that trends vary dramatically across regions.

In Alaska, the FMPs that received the highest allocation complexity scores may also be extremely vulnerable to climate change impacts, especially for species in the Eastern Bering Sea, where sharp declines in suitable thermal habitat could occur for both groundfish and crab species—median species changes were -71% and -93%, respectively (Table 2), in addition to shifts in their distribution on the order of 100–200 miles under the high future emissions scenario. By contrast, for the selected Gulf of Alaska groundfish species, median results indicate that species in this region are more likely to experience shifts in their distribution (nearly 450 miles) and slight increases in suitable habitat (12.5% increase). Additionally, average uncertainty for all species included in these FMPs was very low—1.3 and 1.5, respectively. Under the low emissions scenario, patterns across all FMPs were similar, but the order of magnitude of potential shifts and changes in suitable habitat were generally lower especially for the median species (Table 1). For BSAI crab species, the distribution of impacts was variable across the five species included, especially in terms of the potential habitat suitability, as indicated by the interquartile range, which shows potential changes for some species may decline by 25% or increase by nearly 48% (Table 2). If this changes the relative productivity of stocks or how

species overlap with other managed species, it may challenge static allocations, particularly where limited stocks constrain the harvest of other stocks. In addition, for many North Pacific fisheries, there are requirements for landing at shoreside processors as well as different permit designations for inshore and offshore fisheries. Shifts and changes in habitat may increase costs for vessels that must transit further offshore and still are required to deliver to an onshore plant and reduce the viability of such operations.

The most extreme shifts for any FMP were observed for both the West Coast Groundfish and coastal pelagic species (CPS) FMPs—for this region, there was also considerable variation for species within FMPs, but only in the direction of possible increases in suitable habitat and shifts in distributions ranging from 500 miles to 850 miles under the high emissions scenario (Table 2). Directionality of projected changes was not included in the analysis, due to data availability, but such a distance may be substantial if it is expected that most species will transit north and or offshore to deeper, cooler waters as a result of warming. The point-to-point distance from the northernmost point of Washington (Cape Flattery) to Point Loma in California is around 1,100 miles.

Figure 3. High Emission Scenario (RCP 8.5) Results by Region.

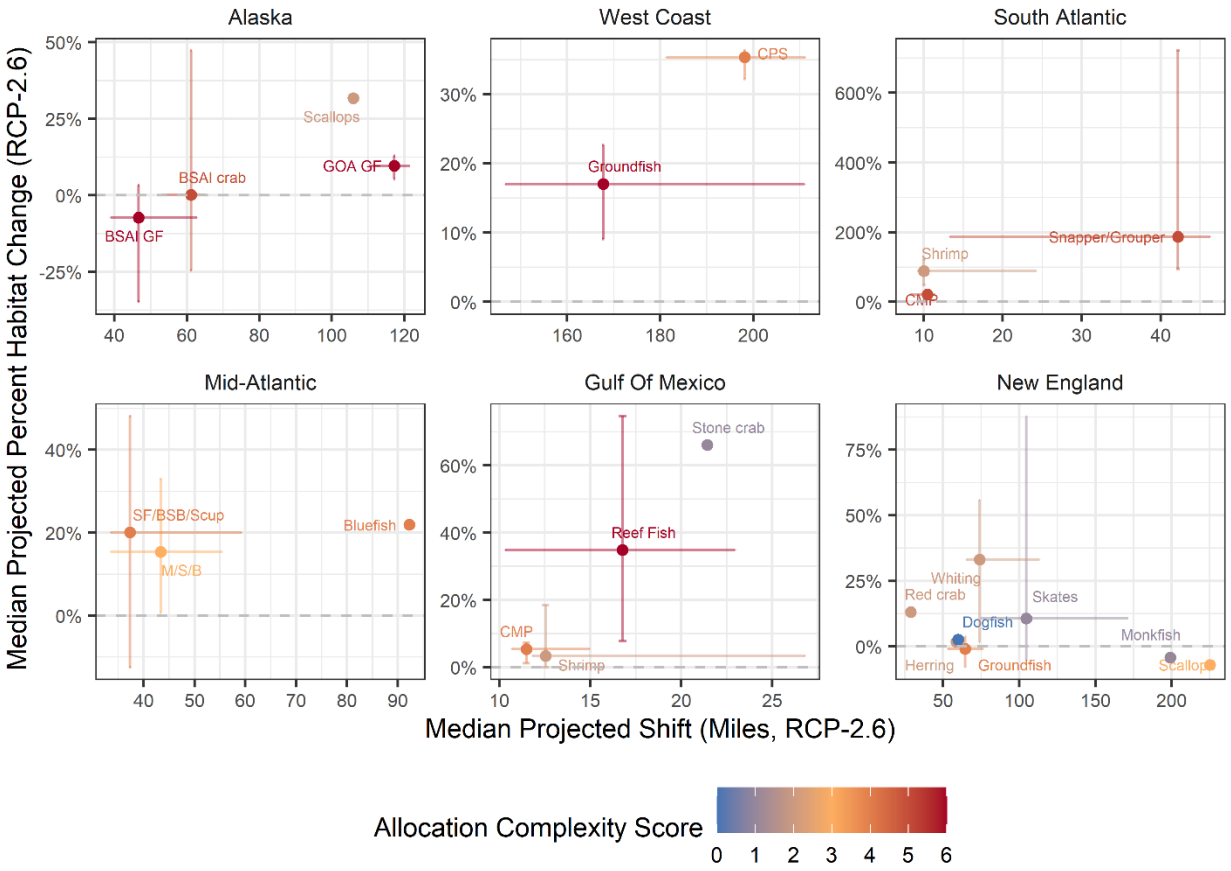


Note: Median shifts and changes for species within an FMP are shown, for multispecies FMP the interquartile range of both variables is depicted by error bars. Acronyms are as follows: GOA GF- Gulf of Alaska Groundfish; BSAI GF- Bering Sea and Aleutian Island Groundfish; CMP- Coastal Migratory Pelagics; CPS- Coastal Pelagic Species; SF/BSB/Scup- Summer Flounder, Black Sea Bass and Scup; M/S/B- Mackerel, Squid, and Butterfish; HMS- Highly Migratory Species.

For the South Atlantic and Gulf of Mexico, there was high correspondence between species included in multiple FMPs. Some of these fisheries are already under joint management, like the CMP FMP, but others, where apparent populations are present on both Atlantic and Gulf sides, like the reef fish and snapper/grouper FMPs, fisheries are managed separately. In both regions there are projected increases in thermal habitat availability for most FMPs; the Gulf of Mexico CMP FMP and shrimp FMPs are exceptions. For this FMP under the high emissions scenario, the average amount of suitable thermal habitat is projected to decrease by 40% while for the shrimp FMP, it stays relatively the same (0.7% change, Table 2). The FMPs with the highest allocation complexity scores are both the South Atlantic snapper/grouper FMP and the GOM reef fish FMP. These FMPs are also projected to have relatively high changes in terms of increases in suitable thermal habitat, especially for the South Atlantic where increases might be upwards of 5,000% and shifts may range between 118 and 245 miles (Figure 4). For the Gulf side, most species are estimated to shift between 20 and 102 miles

(Table 2). Especially due to a lack of directionality in results or a more fine-scale assessment of the exact shifts with respect to current distribution and management boundaries, it is more difficult to assess the types of allocation challenges that may occur as a result of shifts of this magnitude, especially considering the point-to-point distance from Tallahassee to Miami is roughly 400 miles. That said, multispecies catch share programs within these FMPs may pose challenges for catch balancing if quotas for some species become scarce due to displacement, or due to greater inshore opportunities or greater offshore opportunities the demand for quota across commercial and recreational sectors is altered.

Figure 4. Low Emission Scenario (RCP 2.6) Results by Region.



Note: Median shifts and changes for species within an FMP are shown, for multispecies FMP the interquartile range of both variables is depicted by error bars. Acronyms are as follows: GOA GF- Gulf of Alaska Groundfish; BSAI GF-Bering Sea and Aleutian Island Groundfish; CMP- Coastal Migratory Pelagics; CPS- Coastal Pelagic Species; SF/BSB/Scup- Summer Flounder, Black Sea Bass and Scup; M/S/B- Mackerel, Squid, and Butterfish; HMS- Highly Migratory Species.

For the Mid-Atlantic region, few FMPs that we could match to projections received high complexity scores, since we were unable to get projections for the golden or blueline tilefish species or ocean quahog and surfclam, each of which were scored as the most complex in the Mid-Atlantic region. Of those with projections, bluefish stands out as an FMP with the highest complexity (4) and highest potential shift (362 miles), followed by mackerel, squid, and butterfish fishery (M/S/B 187 miles),

and the summer flounder, black sea bass, and scup FMP (SF/BSB/Scup 148 miles) under the high emissions scenario (Table 2). Interestingly, there is less variability among the three M/S/B species than in the SF/BSB/Scup species, particularly in terms of the percentage change in thermal habitat availability.

For the New England region, groundfish and scallops stand out as the fisheries with the most complex allocation measures, but while scallops are projected to experience both losses in suitable thermal habitat and high shifts in distribution, the projections were determined to be highly uncertain for this species, as well as for a number of others including monkfish, and red crab in the low emissions scenario only. Therefore, we suggest caution with drawing conclusions about the potential vulnerability of these FMPs. For groundfish, which received an allocation complexity score of 4, predicted shifts for the 12 included species averaged around 257 miles, and ranged from 197 to 282 miles. Predictions for habitat changes typically ranged from a decline of 23.8% to 57%, indicating that stocks may become more restricted in their distribution, potentially at or beyond the border with Canada. For species moving into international waters, different types of allocation challenges may occur than is the primary focus of this work, but certainly the ability or inability to access stocks out of domestic waters will affect demand for quota for species that move less, more slowly, or for species that have become more abundant due to shifting from the Mid-Atlantic region.

Table 1. Low Emission Scenario (RCP 2.6) Results by Region and FMP

Region	FMP	Allocation complexity score	Mean uncertainty (1-3)	Number of species	Shift in Species Distribution (miles)			Percent Change in Thermal Habitat		
					Median shift	25th Percentile	75th Percentile	Median Change	25th Percentile	75th Percentile
Alaska	BSAI crab	5	1.3	3	61.2	53.1	65.2	0.1%	-24.6%	47.3%
	BSAI GF	6	1.5	8	46.7	38.9	62.7	-7.3%	-34.8%	3.3%
	GOA GF	6	1.3	3	117.3	110.4	121.7	9.7%	5.4%	12.9%
	Scallops	2	1.0	1	105.9	105.9	105.9	31.7%	31.7%	31.7%
Gulf of Mexico	CMP	4	2.0	3	11.5	10.7	15.0	5.4%	1.2%	7.4%
	Reef Fish	6	1.7	8	16.8	10.3	23.0	34.9%	7.9%	74.7%
	Shrimp	2	1.7	3	12.6	11.8	26.8	3.4%	0.0%	18.5%
	Stone crab	1	2.0	1	21.4	21.4	21.4	66.1%	66.1%	66.1%
Mid-Atlantic	Bluefish	4	1.0	1	92.3	92.3	92.3	21.9%	21.9%	21.9%
	M/S/B	3	1.3	3	43.3	33.5	55.5	15.4%	0.7%	33.0%
	SF/BSB/Scup	4	2.3	3	37.3	33.6	59.2	20.1%	-12.5%	48.2%
New England	Dogfish	0	1.0	1	59.9	59.9	59.9	2.6%	2.6%	2.6%
	Groundfish	4	1.3	12	64.6	53.2	76.3	-1.0%	-8.0%	3.9%
	Herring	2	1.0	1	58.6	58.6	58.6	1.7%	1.7%	1.7%
	Monkfish	1	3.0	1	199.0	199.0	199.0	-4.2%	-4.2%	-4.2%
	Red crab	2	3.0	1	28.7	28.7	28.7	13.1%	13.1%	13.1%
	Scallops	3	3.0	1	225.1	225.1	225.1	-7.1%	-7.1%	-7.1%
	Skates	1	2.0	6	104.7	74.7	171.4	10.6%	-5.6%	87.9%
	Whiting	2	1.5	3	74.0	65.1	113.5	33.2%	1.5%	55.9%
South Atlantic	CMP	5	1.0	3	10.4	8.3	11.5	21.8%	12.9%	25.5%
	Shrimp	2	1.0	3	10.0	9.2	24.3	88.6%	48.4%	122.5%
	Snapper/Grouper	5	2.3	7	42.2	13.3	46.3	187.3%	95.0%	721.3%
West Coast	CPS	4	1.0	4	198.2	181.3	211.2	35.4%	32.2%	36.3%
	Groundfish	6	1.4	12	167.7	146.7	211.1	17.1%	9.1%	22.6%

Table 2. High Emission Scenario Results by Region and FMP

Region	FMP	Allocation complexity score	Mean uncertainty (1-3)	Number of species	Shift in Species Distribution (miles)			Percent Change in Thermal Habitat		
					Median shift	25th Percentile	75th Percentile	Median Change	25th Percentile	75th Percentile
Alaska	BSAI crab	5	1.0	3	166.7	120.4	205.9	-71.0%	-97.0%	3.2%
	BSAI GF	6	1.3	8	111.8	95.5	173.3	-92.9%	-95.7%	-46.8%
	GOA GF	6	1.0	3	440.1	423.4	458.7	12.8%	9.9%	14.1%
	Scallops	2	1.0	1	356.7	356.7	356.7	214.1%	214.1%	214.1%
Gulf of Mexico	CMP	4	1.3	3	47.2	41.3	63.8	-40.3%	-45.7%	-33.8%
	Reef Fish	6	1.7	8	47.0	19.9	102.1	32.3%	-18.6%	251.8%
	Shrimp	2	1.3	3	26.3	23.5	93.8	0.7%	-35.2%	109.3%
	Stone crab	1	2.0	1	58.3	58.3	58.3	366.2%	366.2%	366.2%
Mid-Atlantic	Bluefish	4	1.0	1	361.6	361.6	361.6	358.0%	358.0%	358.0%
	M/S/B	3	1.8	3	186.9	139.5	200.5	142.5%	41.0%	215.4%
	SF/BSB/Scup	3	2.3	3	148.1	82.3	240.0	179.9%	38.5%	445.5%
New England	Dogfish	0	1.0	1	300.4	300.4	300.4	-31.6%	-31.6%	-31.6%
	Groundfish	4	1.9	12	256.9	196.8	282.4	-38.2%	-56.6%	-23.8%
	Herring	2	1.0	1	236.1	236.1	236.1	-12.6%	-12.6%	-12.6%
	Monkfish	1	3.0	1	381.9	381.9	381.9	-21.2%	-21.2%	-21.2%
	Red crab	2	2.0	1	117.0	117.0	117.0	-10.6%	-10.6%	-10.6%
	Scallops	3	3.0	1	448.4	448.4	448.4	-38.3%	-38.3%	-38.3%
	Skates	1	2.3	6	402.4	286.0	509.8	-64.4%	-82.1%	-6.3%
	Whiting	2	2.0	3	325.3	282.4	391.9	178.5%	-18.9%	359.6%
South Atlantic	CMP	5	2.0	3	97.9	88.9	131.5	91.8%	66.3%	106.3%
	Shrimp	2	1.7	3	109.1	67.9	113.1	867.1%	423.7%	1447.8%
	Snapper/Grouper	5	1.6	7	157.6	118.1	245.3	5011.0%	856.8%	10474.9%
West Coast	CPS	4	1.0	4	851.3	785.0	931.0	150.8%	129.3%	169.9%
	Groundfish	6	1.4	12	699.3	455.2	851.1	101.0%	41.7%	126.2%

Conclusion

This work classifies most US FMPs in terms of how static and complex their allocation measures are as an indicator of challenges that may arise under climate change. Additionally, we combine our indicator of complexity with publicly available projections for North American stocks under climate change to explore how distributions and habitat availability may change over the next 80 years. The chosen indicator of allocation complexity picks up on FMPs with static allocation divisions, limited entry, multispecies allocations, and a high number of abutting management regions as those that may face the greatest challenges under climate change since they might necessitate a complicated, political reallocation amendment to balance needs.

We find that many of the most highly regulated fisheries in the US fall into our classification as highest risk, and also are identified as being potentially impacted by a combination of shifting stocks and changes in suitable thermal habitat in the future, particularly those in Alaska. We also find that challenges will likely be unique from region to region, as predicted shifts are likely to be very large for West Coast species, but occur along large increases in suitable thermal habitat, as compared to Eastern Bering Sea and New England stocks, which generally are projected to experience declines in suitable habitat on top of experiencing shifts in distributions—potentially limiting productivity and becoming harder to access. For Mid-Atlantic, South Atlantic, and Gulf of Mexico regions, complexity stems from the fact that the regions are close together in space and share many species that are not jointly managed. Stocks that one region gains come from a loss from another, creating pressure to figure out if and how to limit movement of permits and effort while avoiding constraining fishermen.

Ultimately, however, where and how allocation challenges arise will depend on a myriad of social, economic, and ecological factors, many of which were not captured here. This analysis is intended to be a broad, comprehensive first look and subsequent work will be needed to accurately assess and anticipate challenges on the ground in each region.

The results of this work are not to suggest that the answer to climate change is less complexity in allocation structure or other management measures. Allocations have been used as a successful tool in countries around the world to create sustainable fisheries by supporting limits on who and how much people can fish and to empower those with fishing privileges to become better stewards of the resource. Rather, under the revolving door of impacts under climate change, managers need to plan ahead, coordinate with other regions, and introduce mechanisms for stakeholders and communities to adapt extant measures to changing conditions.

While this work looks at the number of static divisions or allocation measures that have already been put in place, it should be noted that it may also be challenging for managers to quickly and effectively put measures in place for less highly regulated species, while accounting for uncertainty and possible shifts into the future. Species and FMPs that are open access, or are less expensive or difficult to enter,

may face greater demand as fishing operations diversify or shift to other fisheries. This analysis can also be used to identify these FMPs, in order to plan ahead for possible changes in fishing effort under climate change.

Future work should focus on making the allocation complexity indicator used more robust to its assumptions and refining it for use in specific regions. This analysis uses very broad, generalized indicators of allocation complexity but there are many unique features that may be helpful or detrimental under change. Such features include quota allocations that are granted to processors, communities (such as community development quota), tribes, set-asides, or other quota allocations for flexibility (such as adaptive management quota). Incorporating social and economic metrics may also be helpful since species that are highly valued or that communities rely on may be more challenging to reallocate. It would be also helpful to assess, on a fishery-by-fishery basis, where inefficient or socially suboptimal outcomes may be likely to occur as a result of current allocation measures, such as if quota is likely to be stranded in some places or constraining in others. Similarly, looking across a region's FMPs to assess potential effort shifts would also be helpful, either where few options to diversify exist, or where many opportunities could exist, and therefore could be potential hotpots for entry. Finally, we rely on one set of available results of species projections and were not able to obtain robust results for all managed species nor were we able to quantify the directionality of impacts, which limits our ability to make robust conclusions about specific types of potential allocation challenges.

Shared Principles for Allocations Under Climate Change

Convening Summary and Final Shared Principles

On March 31, 2022, EDF convened a virtual meeting with 12 fishery stakeholders and several fisheries experts to collaboratively develop a set of shared Principles that will guide federal fishery allocation decisions in the face of climate change.

The methodology for the consensus was a layered approach where participants first worked with their own thoughts, then in smaller breakout groups to discuss and agree on a list of four to six concepts. Those same groups then tested their list against a hypothetical climate scenario to see if those concepts held up or needed to be modified in some way. Once each group had their final concepts, we worked with all concepts as a group to find common themes or patterns. We moved similarly themed cards into clusters and ultimately developed a short phrase to capture the theme of each cluster. These `top level` phrases became our draft Principles.

After the convening, EDF provided a survey to all participants to gauge individual and collective support for the draft Principles. Of the Principles that received lower levels of support, we looked at the feedback provided by respondents and made some refinements to increase clarity, strengthen the statement, or address a concern. This final list of Principles was then incorporated into a letter that will be shared with NOAA and Council leadership, signed by all stakeholders and participants willing to be listed as contributors.

The final set of Principles from the convening are as follows:

A climate resilient allocation system is one that…

1. *Considers all impacted communities and stakeholders*
2. *Promotes dynamic self-management*
3. *Addresses the equity issues associated with changing non-target species*
4. *Ensures sustainability of the resource and conservation of biodiversity of the ecological system*
5. *Incorporates adaptability in the regulatory structures*
6. *Recognizes historic and traditional dependence*
7. *Ensures transparent, inclusive, and meaningful co-management*
8. *Utilizes and integrates diverse knowledge sources*

Assessment of Principles to Current Guidance and Policy

While participants were informed that the scope of the work should be that the Principles ideally would build off of current policy guidance and principles of fishery management that already exist, many of the ideas and themes ultimately selected were very similar to the core principles at the heart of fisheries management in the US. In this section, we review the final list of Principles and discuss if and how current legal or policy requirements overlap with the Principles, and where opportunities for unique interpretation for climate change may exist, or where future work could expand upon themes.

In summary, Principles 2, 5, 6, and 8 appear to overlap the least with extant fishery management principles, or guidance directly related to allocations of federal fishery resources. Principles 1, 3, 4, and 7 are determined to be repetitive of specific requirements set out by law, or at least, may be too vague to differentiate from standard fishery management practices. It is recommended that language be modified to incorporate, or highlight specific ideas raised at the meeting which may be more novel or to add detail about how a given Principle is different in the context of allocations under climate change.

1. Considers All Impacted Communities and Stakeholders

This Principle could have some overlap with current policy guidance, but in this case, not with the National Standards (NS) or National Standards Guidelines (NSGs), but with the National Environmental Policy Act, E.O 12866, and Office of Management and Budget Circular A-4 requirements for social and economic impact assessment for fishery regulations. For these requirements, NOAA Fisheries produces a range of guidance on how to perform Social Impact Analyses (NMFS policy directive 01-111-02[4]) and economic reviews of NMFS actions (NMFS Policy directive 01-111-05[5]). In total, these require that social and economic impact analyses should be comprehensive enough to consider impacted entities and groups, including communities. In addition, the MSA itself requires that fishery impact statements similarly assess likely impacts to fishery participants, fishing communities, and participants in neighboring communities.

That said, this Principle could be more informative if details were added about how, or which, impacted communities and stakeholders might need greater consideration than has been typical in past management processes. Have representatives from all impacted communities weighed in on the management decision (e.g., through public comment, letter, or direct involvement in the management process)? Were qualitative or quantitative analyses constructed to specifically address potential impacts to a given community group?

[4] https://media.fisheries.noaa.gov/dam-migration/01-111-02.pdf

[5] https://media.fisheries.noaa.gov/dam-migration/01-111-05.pdf

2. Promotes Dynamic Self-Management

This Principle has potential to uniquely inform selection of management goals and objectives or to be a means by which to assess current allocation schemes since self-management, or bottom-up processes for resolving allocation and access issues are not explicitly described by the MSA or NSGs. Many of the concepts raised by stakeholders related to this Principle would be effective management goals or objectives since they range from "supports portfolio diversification" to "facilitates industry market resolution"—which speaks to the traditional ways that allocation schemes are set up, requiring top-down, regulatory involvement to adjust access over time, rather than using a more dynamic or market-based approach.

3. Considers the Equity Issues Associated with Changing Non-Target Species

This Principle was the trickiest for stakeholders at the convening to work through, in part because many of the ideas raised under it concerned what the definition of 'fair and equitable' was (per NS-4) and which user groups might be prioritized. These aspects of this Principle are not consistent with the NS because they explicitly state that allocation decisions must be determined to be fair and equitable across all fishery sectors—overarching guidance therefore could not pre-determine fairness in that way. In addition, taken on its face, the language in this Principle—"Considers the issues associated with non-target species"—also could relate to NS-9, which is to minimize bycatch. More detail about which issues specifically are important to consider with non-target species may be helpful here, since at a minimum non-target fishery catches would be considered as impacts to other fisheries per regulatory analyses requirements (similar to 1 above). One idea that was raised at the convening under this Principle was that allocation decisions should prioritize—and define—fairness and equity. While fairness and equity already must be prioritized per NS-4, the definition of what that means, ad-hoc, for a fishery management plan or allocation decision would be a step beyond what is necessary in NS-4 and would be helpful for evaluating fairness and equity outcomes.

4. Ensures Conservation and Sustainability of the Resource and Conservation of Biodiversity of the Ecological System

The fourth Principle, as written, likely has the most overlap with MSA and NS requirements. The entire act is designed to ensure conservation and sustainability and NS-1 explicitly defines how this is to be done by mandating that management measures be designed to prevent overfishing and achieve optimum yield, and when necessary, implement stock rebuilding plans. More detail is needed to refine what unique aspects of conservation and sustainability are important for climate-resilient fishery allocations. One such idea was raised at the convening, where it was suggested that accountability for conservation management regulations must be included. This could be important for allocation decisions since, while fisheries can implement "accountability measures" per NS-1 NSGs, this may be very different in concept than ensuring or promoting accountability to the fishery management measures, such as when rules may be easily circumvented or when the management system increases incentives for illegal behaviors.

5. Incorporates Adaptability in Regulatory Structures

Principle 5 suggests that regulatory and management structures themselves need to promote or support proactive adaptability. In interviews with stakeholders, it was often cited that the 'slow wheels of government' were one of the biggest barriers for adapting allocations to climate change. Emphasizing that allocation structures should be designed with proactive measures to ensure that measures can adapt to change with limited or no management intervention may be important in the future. This Principle, however, also overlaps to some extent with the current policy guidance on allocations. Policy directive 01-119-02, Recommended Practices and Factors to Consider when Reviewing and Making Allocation Decisions, also recommends that Councils "plan for future conditions" and recommends FMP or FMP amendment mechanisms for implementing actions in an expedited manner, such as "If/Then" allocations (NMFS 2018b, p. 4).

6. Recognizes Historic and Traditional Dependence

This Principle may overlap somewhat with current requirements but is nuanced enough that it may still add value since it broadens terms used in the MSA, policy guidance, and Social Impact Analysis guidance which typically focus on measures of dependence, engagement, importance, etc., framed in the current landscape of the fishery, and less so with the lens of what the historical conditions for a given fishery were as well.

Specifically, NS-8 requires that "[c]onservation and management measures shall, consistent with the conservation requirements of this Act…, take into account the importance of fishery resources to fishing communities…in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities"

7. Ensures Transparent, Inclusive, and Meaningful Co-Management

It may be argued that the federal fishery management process inherently ensures transparent and inclusive co-management by having open, regular, and public meetings to discuss management issues and where anyone is allowed to give public comment on management matters, and therefore the process itself may meet the standard outlined in this Principle. This Principle may be more helpful if adjustments or unique aspects of transparency and inclusivity are discussed, or areas where the current system is lacking.

8. Utilizes and Integrates Diverse Knowledge Sources

There are no current requirements for the types of knowledge or information sources as used in management, just in NS-2, which requires the 'best' scientific information available. There may be room to define what creative, collaborative, and diverse knowledge sources are, and how they should be considered alongside typical scientific information sources used in fishery management, especially where qualitative.

Comparison of Principles to Recent Allocation Actions

The previous sections present the outcomes of interviews and a convening with fishery stakeholders and allocation experts to develop a set of shared Principles for fishery allocations under climate change. In this section, we examine two different recent allocation decisions on the East and West Coasts and evaluate if, and how the Principles align, or contrast, with selected alternatives or decisions.

Summer Flounder State Reallocation

The commercial summer flounder fishery illustrates the difficulty of making reallocation decisions. Between 2016 and 2019, managers faced the question of whether state allocations should be changed to reflect the northern shift of the stock into New England state waters, and between 2019 and 2021 they debated how to adjust allocations between the commercial and recreational sectors, to better reflect the current understanding of the historic proportions of catch and landings from the commercial and recreational sectors. The Atlantic States Marine Fisheries Commission (the Board) and Council developed this amendment in response to recent changes in how recreational catch is estimated by the Marine Recreational Information Program, which resulted in a revised time series of recreational data going back to the 1980s. This analysis focuses on the former analysis since it was more directly informed by changing ocean conditions and the challenges that may be experienced across regions in the future.

Summer flounder are managed by the Mid-Atlantic Fishery Management Council (MAFMC), which represents states between New York and North Carolina. In 2019, the Board and the Council jointly approved the Summer Flounder Commercial Issues Amendment. The 21st Amendment to the FMP revises the management program's goals and objectives specific to summer flounder and implements new state-specific commercial allocations. The revised management program's goals and objectives focus on ensuring biological sustainability of the resource, supporting and enhancing development of effective management measures, and optimizing social and economic benefits from the resource. These revisions were made to reflect current priorities in sustainably managing the resource.

As with many fisheries around the country, state commercial allocations for summer flounder were first set in the early days of the FMP, back in 1993 and were based on landings data from 1980 through 1989 (MAMFC, 2021). Since then, the distribution, biomass, and fishing effort have all changed, which led stakeholders to contend that the initial allocations were either inequitable or based on flawed data (Witek, 2016). As a result of this, the Council and the Board initiated Amendment 21 to revise state allocations and also update the original FMP objectives, which had not been changed since 1993.

Here, we examine the outcomes of Amendment 21, to see if and how they align with the Principles set out in our work, as well as examine the revised FMP goals and objectives.

Assessment of the Outcomes of Amendment 21 to the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan

Amendment 21 proposed several changes to the FMP. Ultimately selected were revised state commercial allocations, based on a 9.55-million-pound trigger point. When the annual coastwide commercial quota is at or below 9.55 million pounds, the formula for allocating the quota to the states will remain status quo (i.e., the same state-specific percentages that have been in effect since 1993). When the annual coastwide quota exceeds 9.55 million pounds, additional quota above 9.55 million pounds is distributed as follows: 0.333% to the states of Maine, New Hampshire, and Delaware and 12.375% to the remaining states. As a result, state allocations vary over time based on overall stock status and the resulting coastwide commercial quotas.

Other alternatives considered included revisions to the requalification criteria for federal summer flounder (Alternative 1), and the adding the ability to make changes to landings flexibility in future framework adjustments, rather than going through a full amendment process (Alternative 3).

Alternative 1: Federal Moratorium Permit Requalification

Ultimately, the Council did not change the eligibility qualification criteria for federal summer flounder commercial moratorium permits under this alternative (No Action). If the other proposed alternative had been selected, it would have imposed requalification on commercial federal permits, including permits not currently affiliated with a vessel (also called those in Confirmation of Permit History). This alternative was not designed to, nor would have it directly allowed for new entrants, however. Rather, it would have eliminated permit eligibilities if they did not reach a landings threshold over a certain time period. Seven sub-alternatives were considered with different combinations of landings thresholds and time periods. Under each of these sub-alternatives between 25% to 55% of all permit eligibilities would have been canceled—up to 516 eligibilities (i.e., MRIs, see page 195 MAFMC 2021).

In the impacts analysis of this alternative, it was determined that the cancellation of permit eligibilities would not affect overall effort, but rather would affect how fishery effort would be distributed among participants, by reducing the pool of vessels able to prosecute the fishery. The impacts of keeping the historical number of eligibilities were determined to depend on the extent that latent effort could re-enter the fishery in the future, where higher levels of entry (due to higher state allocations, or other conditions) may mean spreading the quota among more individuals.

As viewed through the lens of the Principles, this alternative and outcome appears to most directly concern Principles 1 and 2, as well as Principles 4 and 5. While not discussed in the impacts of the alternative, reducing the number of available permits may increase revenue to participants remaining but also increase the value of permits when sold. This is a positive impact for current permit holders, but potentially a negative impact for prospective entrants, such as those in states who may have increasing opportunities to participate under climate change. By keeping the number of eligibilities higher, it may satisfy Principle 1 (Considers all impacted communities and

stakeholders) by maximizing opportunities especially for future users. In some sense, it also supports Principle 2 (Promote dynamic self-management) by allowing for a greater number of potential permits to be bought and sold in the future. As noted by the impacts analysis, however, by allowing for latent effort to enter the fishery, this alternative may come at a tradeoff with Principle 4 (Ensures conservation and sustainability of the resource) by allowing for the maximum number of participants. However, if effort is successfully managed by catch limits within each state's allocation, this tradeoff may be avoided. Similar to Principle 2, under Principle 5 (Incorporates adaptability in the regulatory structures) by keeping the number of eligibilities higher, until there is a need to reduce them, there is more regulatory flexibility in this alternative as compared to a scenario where the number of eligibilities was reduced and as a result created higher barriers for entry or movement.

Alternative 2: Commercial Quota Allocation

As mentioned previously, the main alternative of this action was the revision of the commercial state-based allocations in order to reflect changes in the distribution of the stock and changes in fishing effort. In addition to No Action (status quo), three other alternatives were considered. The first was based on the recent biomass distribution, the second was based on a trigger point, and the third would allocate quota seasonally, as is the case for the scup fishery. Under the first option, the impact analysis discusses how allocations in Northern states (New York and north) would increase (by 19% or 40.1%, depending on the option) while allocations for southern states would decrease (by 9.1% or 19.2%, depending on option). Because prices for summer flounder are typically higher in northern states even at higher quantities, total fishery revenue was estimated to be maximized under the option to increase northern state quotas the most. Ultimately, the analysis concluded that positive benefits would accrue to northern states whose allocations would increase while southern states would be negatively impacted. Northern states that already have directed fisheries established were determined to have the highest positive impacts, and also larger allocation increases, compared to Maine and New Hampshire, which would see very low allocation increases (less than .07%). Under existing regulations, states are also able to transfer or combine portions of their commercial quotas (under Amendment 4 MAFMC 2021).

The chosen alternative, which utilizes a trigger structure, only allocates higher-than-historical amounts of quota to northern states in times of higher-than-average commercial quotas (based on a recent average (roughly a 7.5-year average). The analysis of this option found that in 21 of the last 26 years the quotas would have exceeded this trigger. In years where quotas exceed the trigger, every state except Delaware, New Hampshire, and Maine would split 12.375% of the excess quota, while the other states would evenly split 1% of the total additional quota. According to the affected environment of the amendment, the center of biomass for summer flounder has shifted northward concurrent with an increase in abundance. The centroid for summer flounder was estimated to be approximately 40.75 degrees north latitude (OceanAdapt portal, https://oceanadapt.rutgers.edu/), just off the tip of Long Island. It is also noted that while observations of summer flounder north of Cape Cod have historically been rare, young of the year observations have been recorded in southern

Maine, as early as in 2012 (Rudnicky et al. 2016). Morley et al. (2018) predictions of changes in summer flounder distribution and thermal habitat suitability are considered to be highly uncertain but could indicate that further shifts and an expansion of thermal habitat may continue under climate change. Given this, it appears that the model selected by the Council has distinctly dynamic elements (consistent with Principle 5, adaptability in regulatory structures) which allow quotas in times of low abundance to be more accessible to historically engaged or highly reliant communities, especially those in the south (consistent with Principle 6, traditional and historic dependence), and given the context of further increases in abundance in the future due to further shifting, the gains will be equitably spread across most states. The caveat here is that although the amendment cites several studies that had been completed at the time that cite the rapid expansion and shift of the stock, nowhere does it appear that the allocation formula has the ability to further adapt under changing conditions, especially for states like New Hampshire and Maine. While Principle 5 (Incorporates adaptability in the regulatory structures) is at least partially satisfied by this trigger structure, because it leaves out states and communities that might be more directly affected under continued change (also limiting to Principle 1, considers all impacted communities and stakeholders), it seems that further management intervention would be required, unless southern states agree to transfer their quota. Compared to the alternative which would base allocations on the distribution of biomass, impacts on quota allocations would be similar, or lower, due to low current allocations (.0475% to ME, .00046% to NH), since even that alternative was based on current distribution, not expected or potential distribution. Nye et al. (2009) observed a .029 degrees latitude shift per year for summer flounder. In addition, because this allocation restructuring lacks the ability for quota to move across individuals without states transferring quota explicitly, it also can be argued that none of the alternatives considered would promote dynamic self-management, unless viewed from the perspective of states.

Alternative 3: Landings Flexibility Framework Provisions

The third alternative considered in Amendment 21 concerned whether to add "landings flexibility" policies to a list of issues in the Council's FMP that can be modified through a framework action, as opposed to an amendment. Framework adjustments take less time than amendments and are viewed as generally being more efficient than a full amendment for an issue or two.

Landings flexibility would allow commercial vessels to land or possess summer flounder in states where they are not permitted at the state level. This alternative was purely administrative and would only allow the Council to consider adding this flexibility under a future framework action.

Ultimately, this alternative was not selected by the Council. When looking at our Principles, however, this alternative would have been consistent with Principle 5—Incorporates adaptability in the regulatory structures. Frameworkable provisions may allow for Councils to respond to issues caused by climate change more quickly and efficiently and need not be permanent changes to fishery regulations but rather one-year or two-year provisions in order to respond to unforeseen or

unprecedented changes in fishery conditions. If initial public comment or analysis under a framework suggests that an amendment process is needed, that can still occur.

The amendment notes that the Council did consider an alternative to add a landings flexibility policy, but ultimately decided not to pursue this so that individual states could design their own landings flexibility agreements, which could be more flexible and customizable (page 98, MAFMC 2021).

Assessment of the Revised Goals and Objectives under Amendment 21

The revised FMP goals and objectives for summer flounder include three goal statements, each with one or more associated management objectives.

- Goal 1: Ensure the biological sustainability of the summer flounder resource in order to maintain a sustainable summer flounder fishery
    - Objective 1.1: Prevent overfishing, and achieve and maintain sustainable spawning stock biomass levels that promote optimum yield in the fishery
- Goal 2: Support and enhance the development and implementation of effective management measures
    - Objective 2.1: Maintain and enhance effective partnership and coordination among the Council, Commission, federal partners, and member states
    - Objective 2.2: Promote understanding, compliance, and the effective enforcement of regulations
    - Objective 2.3: Promote monitoring, data collection, and the development of ecosystem-based science that support and enhance effective management of the summer flounder resource
- Goal 3: Optimize economic and social benefits from the utilization of the summer flounder resource, balancing the needs and priorities of different user groups to achieve the greatest overall benefit to the nation
    - Objective 3.1: Provide reasonable access to the fishery throughout the management unit. Fishery allocations and other management measures should balance responsiveness to changing social, economic, and ecological conditions with historic and current importance to various user groups and communities.

Revised Goal 1 directly relates to Principle 4, while Goal 2 less directly relates to any of the Principles but could apply to Principle 1 (Considers all impacted communities and stakeholders) and Principle 7 (Ensures transparent, inclusive, and meaningful co-management), since it prioritizes coordination and communication of all the related governance entities under its first objective. Goal 3 is the most relevant to our Principles since it directly addresses changing conditions under its objective and the

need to balance responsiveness to the cultural and historical importance, which clearly reflects Principle 3 (Addresses equity issues associated with changing non-target species) and Principle 6 (Recognizes historic and traditional dependence). Calling for balance here, that both elements should be equally considered, is significant since it does not prioritize historical users over the need to be responsive to those impacted by changing conditions. The objective also directly states that this balance should be found in allocation measures.

West Coast Groundfish Catch Share Program Intersector Allocations

For the West Coast (or Pacific) Groundfish fishery, allocations exist along many different dimensions, including within and across sectors as well as individuals. Amendments 20 and 21 to the FMP established a rationalization program which created cooperatives for the at-sea whiting fishery mothership (MS) and catcher processor (CP) sector as well as an individual tradeable quota (ITQ) program for the shorebased trawl sector (whiting and non-whiting). When the Council designed the catch share program it created bycatch caps for four overfished species taken incidentally by the MS and CP sectors—darkblotched, canary, and widow rockfish as well as Pacific ocean perch. It was intended that the cooperatives in these sectors would be responsible for ensuring that their members did not exceed these caps; however, how the bycatch caps were set differed across the species. For the three species other than canary rockfish, the cap amounts were set by the FMP, while for canary the amount was set biennially through the specification setting process. The allocation formulas for these three fisheries were as follows (PFMC, 2019):

- Darkblotched Rockfish: Allocate 9% or 25 mt, whichever is greater, of the total LE [limited entry] trawl allocation of darkblotched rockfish to the whiting fisheries (at-sea and shorebased combined).
- Pacific Ocean Perch: Allocate 17% or 30 mt, whichever is greater, of the total LE trawl allocation of Pacific ocean perch to the whiting fisheries (at-sea and shorebased combined).
- Widow Rockfish: Initially allocate 52% of the total LE trawl allocation of widow rockfish to the whiting sectors if the stock is under rebuilding or 10 percent of the total LE trawl allocation or 500 mt of the trawl allocation to the whiting sectors, whichever is greater, if the stock is rebuilt. If the stock is overfished when the initial [quota share] allocation is implemented, the latter allocation scheme automatically kicks in when it is declared rebuilt.

After applying these formulas, the amounts available for the whiting fishery were divided among the shorebased, MS, and CP sectors in proportion to the whiting allocation to each sector (42 percent to the shorebased sector, 24 percent to the MS sector, and 34 percent to the CP sector).

Under the bycatch caps for the at-sea sectors, sectors were required to stop fishing immediately if their allocation for any species was reached or exceeded. While there was some flexibility for NMFS

to transfer allocations between sectors, or inseason actions, to allow fishing to resume, due to a series of overages, it was determined that this system was constraining to the at-sea fishery and the Council began to take action to change the bycatch caps to set-asides in 2016. Set-asides are managed annually, which means they are not subject to inseason management adjustments and generally provide a sector with more flexibility as long as all fisheries and sectors are below target or maximum harvest levels (Allowable Biological Catch [ABCs] and Overfishing Limits [OFLs]). The Council approved this change for darkblotched rockfish and Pacific ocean perch in Amendment 21-3 in 2017 but remaining were bycatch caps for widow and canary rockfish, as well as the allocation formulas, which were still set in the FMP.

Here we review the analysis and outcomes of Amendment 21-4, which eliminated the allocation formulas for darkblotched rockfish, widow rockfish, and Pacific ocean perch (POP), and changed bycatch caps to set-asides for widow and canary rockfish, and compare them to the Principles outlined in this work.

Assessment of the Outcomes of Amendment 21-4 to the Pacific Groundfish Fishery Management Plan

One of the main purposes of Amendment 21-4 was to allow the at-sea whiting fishery to harvest its allocation more fully and efficiently to the benefit of industry, communities, and consumers by increasing the flexibility of sectors to continue fishing when its incidental bycatch of certain species exceeds initial allocations (PFMC, 2019). It achieved this by changing bycatch caps to set asides and by removing fixed allocation formulas from the FMP, so that allocations could be set biannually during the specifications process. Both of these changes were intended to first, allow fleets to continue fishing even if caps are exceeded as long as it did not jeopardize the sustainability of the stock, as well as allow for the Council to make efficient and timely adjustments to allocations during the specifications setting process.

At-Sea Set-Aside Alternatives

Under No Action (Alternative 1), POP and darkblotched rockfish are managed as set asides and the amounts are determined by the FMP and widow and canary rockfish are managed as bycatch caps with allocation amounts set in the FMP. The preferred alternative, Alternative 4, creates set-aside management for all four species and removes allocation formulas from the FMP. Alternatives 2 and 3 either only removed darkblotched and POP allocation formulas, or only created set-aside management for all four species, respectively.

The analysis of the alternatives notes that the primary mechanisms stemming from the removal of bycatch caps occurs through two mechanisms: first, changes to fishermen's incentive structures for bycatch avoidance, and secondly, through changes in the management system's ability to prevent fishing mortality in excess of total OFLs and ABCs, both of which result in a suite of biological, physical, and socioeconomic impacts, and well as governance. For the removal of a fixed allocation formula, the primary impact mechanism is the need to create divisions across sectors every two years, which takes time and effort, compared to a system that is fixed and certain.

Ultimately, the analysis concludes that while the preferred alternative reduces incentives to avoid bycatch, it does not eliminate them and that managers will still have the ability to ensure that OFLs and ABCs are not exceeded. For removing allocation formulas, the analysis outlines that this will increase management costs and also increase the potential for inter-sector conflicts in times when multiple sectors seek increased allocations. The Council's rationale discusses that by setting the default allocation as the previous FMP allocation, that the Council will gain flexibility to respond to changing stock abundances and projected attainments in non-whiting fisheries, while at the same time preserving an element of predictability by maintaining the existing formulas as defaults.

When viewed from the lens of the Principles, these changes largely speak to Principle 3, Considers the equity issues associated with changing non-target species. One reason that the at-sea fleet increasingly found the bycatch caps constraining was due to rebuilding of certain groundfish species (PFMC and NMFS, 2017), which made them more difficult and costly to avoid, limiting utilization of whiting. Under climate change, species that may have been more typical to catch as bycatch may similarly become more constraining and it may be essential to revise rules to create flexibility for the fleet. It should be noted that while this change could be seen as relaxing important measures for conservation, the west coast fishery operates under a management regime with a high level of accountability, ensured through a system of comprehensive at-sea and shoreside monitoring that enables a high degree of in-season catch monitoring that is not possible in many other fisheries. Therefore, satisfaction of Principle 3 does not come at the risk of compromising on Principle 4, Ensure sustainability of the resource. Because this Principle removes the fixed nature of the allocation structure in the FMP and allows for adjustment through the specifications setting process this change also fits in with Principle 5, Incorporates adaptability in regulatory structures. One Principle that this change does not in itself satisfy, is Principle 2, Promotes dynamic self-management. Ultimately, allocations for each sector still must be set by the Council and may still use the fixed allocation formula original to the FMP. None of the alternatives considered would have changed this, but for it to satisfy this particular Principle there would need to be more direct abilities for sectors to pool, buy, sell, or transfer quota between sectors.

Conclusion

Overall, by looking at two recent fishery management actions on the East and West Coasts, it is easy to see places where the final list of Principles support chosen management outcomes. In both actions, alternatives selected have components that would incorporate adaptability in regulatory structures (Principle 5) by making allocation decisions "frameworkable". Unsurprisingly, both actions also satisfy Principle 4 (Ensuring sustainability of the resource) since this is a core mandate under the MSA, but especially the West Coast intersector allocation amendment strikes a balance with this Principle and providing flexibility to sectors, which may become increasingly important under climate change. On the East Coast, changes to the summer flounder, scup, and black sea bass FMP goals and objectives make sure that Principles 6 and 3 will be considered in balance with one

another—by ensuring that both historical and traditional users' needs are balanced with other users' needs under changing conditions. However, some Principles were less evident or applicable in the reviewed management actions, specifically Principles 7 and 8, which address ensuring transparent and inclusive co-management and utilizing diverse knowledge sources. More discussion may be needed to think about how these Principles can, or should be applied to management actions, FMP goals and objectives, or at higher levels in fishery management and policy under climate change.

Acknowledgements

This work was supported by the Walton Family Foundation, granted to Environmental Defense Fund and in contract with Northern Economics. This work would not have been possible if not for all of the fishery stakeholders, fishery experts, and EDF staff who were interviewed and consulted with throughout the project. In total, 31 fishery experts or stakeholders were interviewed, consulted, or participated in the survey or convening on this project. Specifically, the following people spent many hours collaborating with the report authors on the design of the convening and participated in its execution:

- Alice Thomas-Smyth, EDF
- Jacqui Vogel, EDF
- Rod Fujita, EDF
- Julia Mason, EDF
- Khadija Boussen, EDF
- Kim Howe, CoCreative Labs

Sources

ASFMC (Atlantic States Marine Fisheries Commission). 2020. Amendment 21 to the interstate fishery management plan for summer flounder, scup, and black sea bass. Summer flounder commercial issues and FMP Goals and Objectives. Approved by the Atlantic States Marine Fisheries Commission in March 2019 and NOAA Fisheries in December 2020.

Brinson, A., and E. Thunberg. 2016. Performance of federally managed catch share fisheries in the United States. Fisheries Research. July 2016. 179. 213-223.

Carter, David W., Juan J. Agar, and James R. Waters. 2008. Economic framework for fishery allocation decisions with an application to Gulf of Mexico red grouper. NOAA Technical Memorandum NMFS-SEFSC-576 (September). National Oceanic and Atmospheric Administration, Miami.

Holzer, Jorge, and Kenneth McConnell. 2014. "Harvest Allocation without Property Rights." Journal of the Association of Environmental and Resource Economists 1: 209-232

Lapointe, George. 2012. Marine Fishery Allocation Issues: Findings, Discussion, and Options. Prepared for the National Marine Fisheries Service. December 2012.

Lavalle, Marianne. 2014. Summer Flounder Stirs North-South Climate Change Battle. The Daily Climate. June 9, 2014. Accessed at: https://m.jacksonfreepress.com/news/2014/jun/09/summer-flounder-stirs-north-south-climate-change-b/

Lynham, J. How have catch shares been allocated? Working paper No.2013-8. January 2013

Nye et al. 2009. Changing spatial distribution of fish stocks in relation to climate and population size on the Northeast United States continental shelf. Marine Ecology Progress Series 393: 111-129

Mid Atlantic Fishery Management Council (MAFMC). 2021. Amendment 21 to the Summer Flounder, Scup, and Black Sea Bass FMP. Accessed at: http://www.asmfc.org/uploads/file/615efa50SummerFlounder_Amnemdment21_CommercialIssues_2019.pdf

Morley et al. 2018. Projecting shifts in thermal habitat for 686 species on the North American continental shelf. PlosOne 13(5): e0196127.

Morrison, Wendy. 2021. Governance Case Studies on Marine Fisheries that Cross Jurisdictional Boundaries in the United States. NOAA Technical Memorandum NMFS-OSF-10. September 2021

NMFS (National Marine Fisheries Service) 2018a. Criteria for Initiating Fisheries Allocation Reviews Council Coordinating Committee Allocation Workgroup Guidance Document. NMFS Procedure 01-119-02. Effective July 27, 2016. Renewal October 2018.

NMFS 2018b. Recommended Practices and Factors to Consider When Reviewing and Making Allocation Decisions. NMFS Procedure 01-119-01. Effective July 27, 2016. Renewal, October 2018

OPB (Oregon Public Broadcasting). 2021. Oregon Public Radio. Oregon's own squid game: Crab still tops state's commercial fishing, but squid is gaining. November 11, 2021. Available at: https://www.opb.org/article/2021/11/11/oregon-squid-commercial-fishery-abundance-demand/

PFMC (Pacific Fishery Management Council) and NMFS, 2017. West Coast Groundfish Trawl Catch Share Program: Five-year review. Approved by the Pacific Fishery Management Council November 16th, 2017, Costa Mesa, CA.

PFMC. 2019. Amendment 21-4 to the Pacific Groundfish Fishery Management Plan. Accessed at: https://www.pcouncil.org/actions/groundfish-fmp-amendment-21-and-related-amendments-allocation-of-harvest-opportunity-for-trawl-and-other-sectors-of-the-pacific-coast-groundfish-fishery/

Plummer, Mark L., Wendy Morrison, and Erin Steiner. 2012. Allocation of fishery harvest under the Magnuson-Stevens Fishery Conservation and Management Act: Principles and practice. NOAA Technical Memorandum NMFS-NMFSC-15 (February). National Oceanic and Atmospheric Administration, Miami.

Rudnicky, B.M., and J.A. Sulikowski. 2016. First Observation of YOY *Paralichthys dentatus* (summer flounder) in a Southern Maine estuary. Northeastern Naturalist 23(1):N1-N3.

Taylor KE, Stouffer RJ, Meehl GA. 2012. An overview of CMIP5 and the experimental design. Amer Meteor. Soc.485-498.

Twomley, Brue. 2003. License Limitation in Alaska's Commercial Fisheries. Commercial Fisheries Entry Commission. July 2003.

Witek, Charles. 2016. Who gets the fish. Marine Fish Conservation Network. September 27, 2016. Accessed at: https://conservefish.org/2016/09/27/who-gets-the-fish/