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Multi-stakeholder engagement around territorial bottomfish stock assessment: perspectives from Hawai‘i and Guam

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Executive Summary

Fishing communities, Western Pacific Regional Fisheries Management Council staff, and territorial and federal agency scientists and managers are separated by geography, language, historical conflict and mistrust, institutional cultures, and the specialized knowledge that each stakeholder group wields. Yet, these stakeholders' roles are highly interdependent in their contribution to territorial bottomfish fisheries and their stock assessment. This project represents a first step in bridging these gaps to build relationships and shared understanding through a multi-stakeholder engagement process.

We collected data through unstructured interviews and participant observation at public meetings from September 2020 to July 2021. Interviewees were selected either for their participation in the 2015–2016 Hawai'i bottomfish commercial fishery data workshops or their knowledge of, contribution to, or direct participation in Guam's bottomfish fisheries, fishery operations and data collection, stock assessment science, and management. We interviewed 42 stakeholders, representing fishers and fish vendors, the NMFS Pacific Islands Regional Office and Pacific Islands Fisheries Science Center, the Guam Division of Aquatic and Wildlife Resources, and Council staff and committee members.

Factors that may pose challenges during multi-stakeholder engagement include cultural and institutional forces unique to each stakeholder group; which, in some cases, inhibit their engagement with other stakeholders. Stakeholders' behavior is also guided by a combination of priorities and engagement incentives. Understanding where these converge and diverge across stakeholder groups allows us to leverage them for collective efforts and benefits. Data accuracy, for example, was a priority shared across all stakeholder groups. Some engagement incentives are shared across stakeholder groups, but few align through time for all stakeholders. Although the last territorial bottomfish stock assessments heightened tensions between stakeholders and highlighted the criticality of science and management decisions, it also served as a unique catalyst, synchronizing stakeholders' diverse engagement interests and timelines.

Stakeholders' now synchronized investment in engagement provides an opportunity for multi-stakeholder engagement. But, there are critical communication issues and the sociopolitical contexts that require attention. The cases we present demonstrate stakeholders' variable interpretations of "good science," discussions around gear efficiency and catch per unit effort (CPUE), and the Catch-It-Log-It application. They illustrate the ways in which stakeholders make vastly different associations with shared subject matter and language, from the technical aspects of stock assessment to poor relationships between the federal government and the territories, or threats to culture and ways of life. If ignored, these different interpretations of shared discussion will inhibit effective communication and may unnecessarily escalate conflict. We suggest that these underlying challenges be used to tailor communication and engagement that is inclusive of multiple values and perspectives, rather than attempting to separate them from their topical discussions. Additionally, coordinating efforts between institutions and stakeholders requires great investment, but in avoiding redundant initiatives, conflicting narratives, and further degraded trust between stakeholders, provides benefits to efficiency.

Interviewees highlighted value in different strategies to help achieve engagement outcomes. Meeting stakeholders where they are geographically, both in settings where they are comfortable and in terms of their perspectives and values, was noted to facilitate participation and input. Preparing for multi-stakeholder engagement by meeting in smaller groups can help to circumvent social hierarchies and inter-group conflict, encouraging the sharing of more diverse perspectives. Directed questions, documented decision-making, and balancing validation with maintaining discussants' focus on shared, clearly communicated goals can benefit group productivity and preserve group time and energy. Although the specific goals of engagement will likely determine who is included, care should be taken not to exclude perspectives prematurely. Part of the work that may precede engagement is identifying missing voices to diversify the conversation as much as is appropriate, while respecting the time and efficiency of meetings and their attendees. Interviewees noted that capacity for stakeholder mediation and culturally sensitive facilitation is key in the Pacific Islands Region, particularly in American Samoa.

Although stakeholders valued engagement outcomes like relationship-building and improved legitimacy of fisheries science and management, these alone may not provide sufficient incentives for engagement. Sharing information, improving fisheries science and management processes, and building stakeholder capacity were among the more tangible outcomes valued and hoped for by stakeholders. Upcoming data workshops on stock assessment, for example, may benefit from stakeholder input that informs modified data treatment to better represent the fishery. If stakeholder input cannot be integrated into stock assessment in the short-term, it may identify data gaps and inform future research.

Interviewees described a lack of understanding and coordination in the ways that their roles connect to others'. PIFSC stakeholders deliver survey-sampling designs to territorial agencies, with little awareness of how they are implemented and produce best science available based on data for which they lack context. Territorial agencies are asked to implement survey designs for an expansion algorithm executed by the Western Pacific Fisheries Information Network (WPacFIN), and neither of these stakeholders feel they have ownership or understanding of the expansion algorithm. Fishing stakeholders are asked to submit data to agencies they do not trust, for use in scientific and management processes for which they lack context. In their silos, stakeholders are left to a) fulfill their roles based on priorities and values shaped by their communities, leadership, and federal mandates; and b) make assumptions about the intentions and activities of other stakeholders, perpetuating mistrust and defensive or offensive posturing. We suggest multi-stakeholder engagement for a systemic assessment that seeks shared understanding of the following processes: fishery operations, data generation, data treatment, stock assessment, and management systems.

Finally, institutional frameworks are not conducive to proactive stakeholder engagement. In this system, individuals comprising the stakeholder groups we have identified must go above and beyond their institutional roles—propelled by their individual values—to improve communication, multi-stakeholder collaboration and, ultimately, territorial stock assessments. This not only places a burden on individuals but also makes the system vulnerable upon individuals' departure. We therefore highlight the need for systemic, institutional support to incentivize engagement and build capacity within these stakeholder groups to engage more effectively.

Future work may evaluate the use of participatory modeling tools to minimize translation issues and maximize accessibility for all stakeholder groups. For example, Fuzzy Cognitive Mapping (FCM) is a qualitative participatory modeling tool that can help to communicate information about complex systems in a way that is accessible to diverse audiences. FCM accommodates diverse ways of knowing in its simple representation of variables and their directional impacts on one another, fosters collaboration and trust-building through transparent discussion, and can bring attention to individuals' roles and agency in the system. We suggest that participatory modeling or simple cognitive maps be explored as a tool for upcoming multi-stakeholder engagement endeavors, whether they seek to make stock assessment models and their assumptions accessible to diverse stakeholders, or establish collective understanding of the bottomfish fishery and stock assessment system.

Introduction

Given the large geographic scope of the Pacific Islands region, federal managers and scientists are often removed from the fishing communities they serve and local agencies with whom they collaborate. These stakeholders have limited opportunities to build familiarity and exchange knowledge in ways that could benefit fisheries, science, and management. Further, the specialized knowledge and activities of fishers, scientists, and managers leaves them ill-equipped to communicate with one another or commit resources to engagement efforts. These challenges have been highlighted by recent territorial bottomfish stock assessments and the contention that resulted with their dissemination to fishing communities. These challenges are not, however, unique. In instances across the nation, stock assessment model complexity and scientists' ownership of the stock assessment process have led to fishing communities' distrust of stock assessment inputs and outputs, especially when results do not corroborate their own experiences (Wendt and Starr 2009). Federal and territorial scientists, managers, and fishing communities are thus separated by challenges related to geography, interpersonal communication, each group's specialized fisheries knowledge, and interpretation of stock assessment results. This project represents an effort to bridge these gaps through a collaborative approach grounded in social science.

In August 2019, the Pacific Islands Fisheries Science Center (PIFSC) released a report presenting stock assessment results for American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI) (Langseth et al. 2019). In the report, the territories' bottomfish stocks were determined to be overfished and experiencing overfishing (American Samoa), overfished and not experiencing overfishing (Guam), and neither overfished nor experiencing overfishing (CNMI). In early 2020, PIFSC staff participated in public meetings in the territories to share basic stock assessment output information. Fisher comments revealed issues of mistrust, poor data availability, perceptions of scientists as outsiders, and a lack of processes to include fisher perspectives.

Fisher knowledge has benefitted bottomfish stock assessment in the Pacific Islands region. In 2015–2016, PIFSC conducted a series of data workshops with the bottomfish fishery community in the main Hawaiian Islands to improve the treatment of data for stock assessment purposes (Yau 2018). The results of these workshops were incorporated into updated catch and CPUE analyses for the assessment. However, the breadth and contention raised in discussions around territorial fisheries, data, and stock assessment highlight a need to first build foundations in shared understanding, stakeholder communication, and relationships. Given these topics' complexity, the distribution of relevant expertise across stakeholder groups, institutions, and geographies, and the complexity of relationships between those stakeholders, a process must be carefully developed to achieve these foundations.

Participatory approaches applied to natural resource issues can produce both process- and outcome-based benefits to its participants and their understanding of natural resource system dynamics (Reed 2008). These include improved equity, access to new information (Beierle 2002), scientific efficiency and accuracy (Mackinson and Nøttestad 1998), perceived management legitimacy (Hønneland 1999), and fisher compliance (Cinner et al. 2012). Collaborative processes that foster mutual understanding, familiarity, and trust between fishers and scientists may in fact produce such benefits independently of their more tangible outcomes

(Loucks 2006; Young et al. 2016). Additionally, fisher knowledge can contribute new scientific information related to stock distinctiveness, fish size and morphology differences, long-term and annual changes in fishery efficiency, patterns in CPUE (Neis et al. 1999), and population dynamics (Golden et al. 2014). This kind of fisher knowledge is particularly valuable in monitored fisheries with long-term participants like those in the Pacific Island region. Where fisher knowledge may not be directly incorporated into scientific assessments, discrepancies between the two may identify critical data gaps (Carruthers & Neis 2011) or inform the development of collaborative research to address such gaps (Wendt and Starr 2009). The success of engagement endeavors, however, hinges on processes that prioritize equity, trust, transparent goals, learning in pursuit of indeterminate outcomes, and quality facilitation (Reed 2008).

This project is situated within a broader context, which seeks ultimately to improve territorial stock assessments. There are ongoing efforts to evaluate and improve territorial data streams, alternative stock assessment approaches, and management frameworks, operating at various scales and timelines. Social science has a critical and parallel contribution to offer that may enable the success of these efforts, including an examination of the different ways stakeholders might define improvements to stock assessment. Therefore, this project's enabling objectives are to evaluate challenges and opportunities in collaborative, multi-stakeholder approaches to improving territorial stock assessments. We hope our focus on collaborative engagement processes that meet Reed's (2008) criteria will also allow us to build relationships and trust between stakeholders invested in bottomfish fisheries, their research, and management, from the fishing community, territorial agencies, Council, and the National Marine Fisheries Service (NMFS). If these enabling objectives are not pursued, progress toward improved territorial stock assessment may suffer avoidable inefficiencies and increased stakeholder conflict.

We intended originally to design, pilot, and document the successes and failures of an engagement process that would foster mutual understanding and trust between multiple stakeholders. The COVID-19 pandemic, however, limited travel and postponed in-person engagement from March 2020 through much of 2021. We therefore invested, during the 2021 year, in virtual data collection to prepare for upcoming multi-stakeholder engagement. Stock assessment scientists have been preparing for the upcoming bottomfish stock assessments, which are scheduled for American Samoa, Guam, and CNMI in 2023, 2024, and 2025, respectively. The American Samoa data workshops assessments were held in February of 2022, necessarily in a virtual format. Guam and CNMI workshops are slated for 2023 and 2024. The data we present here will inform multi-stakeholder engagement processes around territorial bottomfish stock assessment, such as the data workshops.

American Samoa's last bottomfish stock assessment yielded the least favorable outcomes for its bottomfish fisheries, and its stock assessment is scheduled first for early 2023. However, given the centrality of stakeholder relationships to this work, we selected Guam as the pilot territorial community given the lead author's networking and research experience there.

Although this report primarily focuses on Guam's stock assessment, we hope it will provide a framework to elicit engagement insights in American Samoa and the CNMI in future studies. Insights presented in this report may also directly inform PIFSC engagement practices in American Samoa and the CNMI, guiding agency efforts in science communication, multi-stakeholder collaboration, and relationship-building more broadly. Still, key differences between

the cultural protocols and local social, political, and economic contexts of fishing and PIFSC's work in Guam, American Samoa, and the CNMI warrant in-depth explorations of stakeholder dynamics in each of these communities.

Research questions

1. What can stakeholder perspectives tell us about engagement challenges?
2. What kinds of engagement process(es) might facilitate forward progress toward stakeholder goals?
3. What benefits can we derive from stakeholder engagement

Methods

We collected data primarily through virtual unstructured interviews from September 2020 to July 2021. Interviewees were selected for either A) their participation in the 2015–2016 Hawai‘i bottomfish commercial fishery data workshops, or B) their knowledge of, contribution to, or direct participation in Guam’s bottomfish fisheries, fishery operations and data collection, stock assessment science, and subsequent management. Participants were identified through the 2015–2016 workshop attendee list (Yau 2018) and the lead author’s points of contact within the National Marine Fisheries Service (NMFS), the Western Pacific Regional Fishery Management Council (WPRFMC, hereafter referred to as “the Council”), the Guam Division of Aquatics and Wildlife Resources (DAWR), and Guam and Hawai‘i fishing communities. Additional participants were identified through participant referral. We interviewed 42 stakeholders in total. Sixteen of these met criteria A, and 30 of these met criteria B, with several interviewees meeting both criteria. Interviewees provided representation from fishers and fish vendors (15, nearly equally split between Hawai‘i and Guam), the NMFS Pacific Islands Regional Office (PIRO) or Pacific Islands Fisheries Science Center (PIFSC) and its contractors (15), the Guam DAWR (5), and the Council, its contractors, and committee members (7).

Interviews were conducted via WebEx, which enabled audio recording when interviewees provided consent. Interviews typically lasted 30 to 90 min. Interviews focused on the interviewee’s relationship to bottomfish fisheries, their stock assessment, and management; experience with multi-stakeholder engagement around bottomfish fisheries; valuable engagement outcomes and goals; preferred engagement processes and venues; and expected challenges. An interview guide provided a general framework with which to conduct unstructured interviews, but interviewees were encouraged to introduce and elaborate on topics relevant to their expertise or perspective. Questions were also modified or omitted as needed to maintain relevance to the interviewee.

We also attended meetings hosted by the Council and its territorial Advisory Panels in which the territorial bottomfish fisheries, their stock assessment, and/or management were discussed by multiple stakeholder groups. Participant observation provided insights into how stakeholders with membership in fishing, research, and management communities across federal and territorial institutions perceive and communicate around such issues. As these discussions focused on American Samoa’s bottomfish fisheries and their stock assessment given their earlier stock assessment timeline, we take the opportunity to document relevant insights from American Samoa intermittently throughout this report.

Field notes were written up as soon as possible, following each data collection event. Audio recordings from interviews primarily served as documentation to supplement field notes. In some cases, audio was transcribed for access to direct quotes, which are used to illustrate themes in this report. Both field notes and transcribed interview data were imported to NVivo (version 12, QSR International, Inc.) for coding.

We followed best practices outlined in the Declaration of Helsinki for work with human subjects. The project has exempt status for Human Subjects Research from the University of Hawai‘i Committee on Human Studies under the exempt project 6105142, Socioeconomics of Western Pacific Fisheries.

Data analysis

Data collected through interviews and participant observation were documented both using field notes created by the lead author and complete interview transcripts, when available. Content analysis was conducted on these records. Data were coded to capture and organize themes relevant to multi-stakeholder engagement processes and the relationship between bottomfish fisheries, science, and management.

In some studies, thematic results of content analysis are reported along with a number indicating the frequency of its occurrence in the data. However, because of the differential completeness of field notes and interview transcripts, themes' occurrence frequency is not an accurate metric of their prominence in interviews and meetings. We therefore limit our use of such numbers to represent these data and focus instead on the themes themselves. Where numbers are presented to indicate the number of interviews or meetings in which themes occurred, we provide the following caveat: Our goal was to capture emerging, unique perspectives from diverse stakeholders. Redundant themes mentioned consistently throughout the data collection process may therefore be subject to slight underrepresentation in these numbers. These numbers should be interpreted as approximate, relative metrics of themes' prominence in the data.

Guam's bottomfish fishery

The Guam bottomfish fishery targets both shallow and deep-water species. Shallow bottomfish include reef-associated snappers, groupers, jacks of genera *Lutjanus*, *Lethrinus*, *Aprion*, *Epinephelus*, *Variola*, *Cephalopholis* and *Caranx*, typically found at 100–500 ft (Allen and Bartram 2008). Deep bottomfish include snappers and groupers of the genera *Pristipomoides*, *Etelis*, *Aphareus*, *Epinephelus*, and *Cephalopholis*, generally associated with a 500–700-ft depth range. Allen and Bartram (2008) describe the deep-water component of the bottomfish fishery as comprising a smaller fraction of the fishery than the shallow-water component, and developing later in time due its relative distance from shore and higher costs associated with entry into the fishery. An economic boom in the 1980s increased access to offshore fishing, prior to which the cost of vessels and gear were prohibitive. Historically, bottomfishing has been concentrated in the summer months when weather conditions are more favorable, especially for access to offshore banks. Trolling and bottomfishing on the same fishing trip is not uncommon (Rubinstein 2001). However, trolling appears to dominate boat-based fishing activity and catch in Guam, with bottomfishing accounting for 10–15% of recorded boat-based catch (Allen and Bartram 2008). Success in deep bottomfishing has been described by participants as skill-dependent. The attribution of peaks in commercial bottomfish landings to highliners corroborates this description (Allen and Bartram 2008). The bottomfish market is small, primarily coordinated between fishers and individual business owners and restaurateurs. The bottomfish fishery is predominately a small-boat fishery characterized by vessels less than 30-ft in length, with some recent participation from kayak fishers. Allen and Bartram describe gear configurations as follows:

Deep bottomfishing gear consists of a long vertical line with a bag of chum (chopped fish), a series of baited (often with pieces of skipjack tuna) hooks, and a weight at the end. When the hooks reach the appropriate depth, the line is jerked to release the chum (Amesbury and Myers, 1982). Spin-casting reels are often used for catching the species occurring in the shallower

waters, and electric reels, which may have multiple hooks per line, are used to catch deeper-dwelling fish (Myers, 1993).

Stakeholder categories

Many stakeholders and institutions play a role in Guam's bottomfish fisheries and their stock assessment through their participation in fisheries, research, and management. We report on most of our results themes according to the following four stakeholder categories: 1) fishers and fish vendors, 2) territorial agencies, 3) Council staff, contractors, and committees, and 4) NMFS staff and contractors. We introduce them here, along with their key subgroups. Importantly, this list may not represent a complete inventory of stakeholders and sub-groups. Instead, these descriptions summarize the major functional roles of different stakeholders as they are relevant to bottomfish fisheries and their stock assessment.

Fishing stakeholders

This category is made up of bottomfishers and vendors, unless they are employed by territorial agencies, the Council, or PIFSC. For example, we categorize fishers and fish vendors that serve on the Council or its committees as fishing stakeholders, whereas fishers employed by the Council are included in the "Council stakeholder" group.

Institutions in Guam that comprise the fishing stakeholder group include the Guam Fishermen's Cooperative Association (GFCA), recreational fishing groups like the Marianas Underwater Fishing Federation (MUFF), and the Guam Advisory Panel (AP), which is convened by the Council but made up of Guam community members.

Territorial agency stakeholders

Territorial agencies are responsible for boat- and shore-based creel surveys and commercial receipt book data. These are collected in cooperation with territorial fishers and vendors, respectively. The Guam Bureau of Statistics and Plans (BSP) currently collects commercial receipt book data and enters it into a database managed by the PIFSC's Western Pacific Fisheries Information Network (WPacFIN) group. The Guam Division of Aquatics and Wildlife Resources (DAWR) is housed by the Department of Agriculture (DoAg). The DAWR staff implement creel surveys based on a sampling design provided by PIFSC, quality control creel survey data, and enter the data into a WPacFIN-managed database.

In American Samoa, the Department of Marine and Wildlife Resources' (DMWR) bottomfish stock assessment-relevant duties include the collection of creel survey and commercial invoice data and the development of a territorial bottomfish management plan.

Council stakeholders

In this group, we include the Council, its staff, contractors, and various committees. Council staff plan and facilitate meetings to convene Council members and staff, territorial agencies, fishing community members, scientists in academia, and scientists and managers from local and federal agencies to participate in various plan teams, committees, and workshops. Some of their stock assessment relevant workshops serve to consider socioeconomic and more typical quantitative metrics in the recommendation of subsequent management measures like Annual Catch Limits (ACLs). The Council also works with stakeholders to organize meetings. For example, they are

coordinating with territorial agencies to conduct Bottomfish Management Unit Species (BMUS) list revision workshops.

The Council has one staff member that coordinates stakeholders and activities in each of the territories. The Council also partners with contractors in Guam and Hawai'i-based Pacific Islands Fisheries Group (PIFG) to assist with pilot projects like the electronic self-reporting Catch-It-Log-It initiative. These contractors conduct outreach and trainings around the Catch-It-Log-It application to encourage fisher and vendor participation in Guam.

NMFS stakeholders: PIRO and PIFSC

In the NMFS stakeholder group, we include the Pacific Islands regional staff, federal and contracted, of both PIRO and PIFSC. PIRO roles relevant to bottomfish stock assessment include implementing Council recommendations by translating them into rules and regulations. These include ACLs, Fishery Ecosystem Plan amendments, and interim actions for the territorial bottomfish fisheries pending ACLs. In this process, PIRO staff ensure consistency with the MSA. PIRO staff also work in a supportive role with territorial agencies to develop Fishery Management Plans. Both PIRO and PIFSC have staff in the territories to help coordinate activities locally.

Many of the PIFSC stakeholder subgroups we describe here belong to the Fisheries Research and Monitoring Division (FRMD). The FRMD programs that play key roles in the bottomfish fishery's stock assessment are WPacFIN, the Life History Program (LHP), and Stock Assessment Program (SAP). Broadly, FRMD also provides access to grant funding to collaborators at PIFSC and in the territories, and recommendations and training opportunities to territorial agency staff. The latter could focus on, for example, species identification or modifications to sampling design to reduce uncertainty in data.

WPacFIN houses, receives, and manages data streams from the territorial agencies. Their support includes management of applications that house shared data, collaborative quality control, and data cleaning for territorial data streams (e.g., shore- and boat-based creel surveys, commercial receipts, potentially Catch-It-Log-It data). WPacFIN also fulfills data requests for the territorial agencies and executes the algorithm that expands territorial data to produce total catch estimates.

The LHP generates biological and ecological information for the SAP and direct management measures. Along with other published studies, the LHP provide estimates of fish life history parameters like individual fish growth and length-at-age, size or age at reproductive maturity, maximum lifespan, and length vs. weight relationships for use in stock assessments. The LHP biosampling program may also provide fish size information that the SAP can use in stock assessment models. The LHP's primary focus is the BMUS, but it also collects life history data for pelagic species. Until recently, the LHP also collected reef species' biosampling data in the territories. This effort dissolved in 2018, when the Council reclassified a large number of Coral Reef Ecosystem Management Unit Species (CREMUS) as Ecosystem Component Species (ECS) no longer requiring stock assessment or associated management (WPRFMC 2019). This shifted focus and required reorientation of territorial biosampling programs toward BMUS. In American Samoa, this required the LHP to establish a new program through engagement with territorial agencies and fishers. In the Marianas, this required reorganization of biosampling contracts.

For the last decade or so, PIFSC staff in Guam managed the commercial biosampling program in partnership with a contracted vendor. These data included species identification, length and weight, catch and trip information, and biological samples from reef and bottomfish species as needed. The recent shift of biosampling effort toward BMUS triggered a transition to a new contracting agreement, which began in 2020, in which an independent local contractor inherited the biosampling program. Biosampling data is now collected through the contractor's direct engagement with Guam bottomfishers.

The SAP analyzes data from the territorial agencies, WPacFIN, the LHP, and scientific publications to perform bottomfish stock assessments. Estimates of annual catch derived from reported landings are a primary requirement of most stock assessment models. The SAP works with WPacFIN to produce catch estimates and quantify uncertainty around estimated annual catches. The SAP interprets and may modify the algorithm used by WPacFIN to expand these data to represent territorial fisheries. The SAP also uses fisheries data collected by the territorial agencies to estimate CPUE (e.g., lb caught per hour fishing) and produce fish size (length or weight) information. Fish size information and life history parameters are also taken from the LHP and other published studies. Although biosampling data from the territories and LHP are not useful in a complex assessment production model, it can be applied in data-poor, species-specific Length-Based Spawning Potential (LBSP) or age structure models.

Currently, the SAP is evaluating available data streams from American Samoa to explore alternative stock assessment models for its bottomfish fisheries. The SAP is also hosting data workshops in the territories. American Samoa's data workshops were held virtually in February 2022. Guam's data stream evaluation will be completed in time for in-person data workshops in January 2023 given the staggered Western Pacific Stock Assessment Review (WPSAR) schedule that determines which fish stocks SAP will assess and when the final assessment must be delivered to the Fishery Management Council. American Samoa's bottomfish stock assessment is scheduled to be completed and delivered to the Council in February 2023, Guam's for 2024, and the Commonwealth of the Northern Mariana Islands (CNMI) in 2025.

The final PIFSC stakeholder group we introduce here is the Social-Ecological and Economic Systems (SEES) group, of which this report's authors are members. SEES' human dimensions group seeks to examine perspectives from diverse stakeholders and share them in a way that encourages collaborative solutions, understanding, and thoughtful navigation of cultural and institutional differences. Our research depends on engagement and collaboration in perpetuity, and values diverse types and forms of knowledge. Reflexivity is a key part of this process, and the reason we include ourselves here. We hope to serve as a pseudo-neutral party, but recognize that our membership within PIFSC and within the social science community comes with its own biases.

Results

In this section, we report on key themes that inform multi-stakeholder engagement processes. These include engagement challenges, the procedural elements of engagement that may help us to overcome such challenges, and engagement outcomes and informational foci that stakeholders identified as valuable. These data draw on insights primarily from Hawai'i and Guam, but also

from American Samoa, given stakeholders' cross-regional work and its prominence in Council-facilitated discussions.

RQ1: What can stakeholder perspectives tell us about engagement challenges?

Institutional challenges

Interviewees identified constraints that reduce stakeholders' capacity to deliver on key roles. Common constraints across stakeholder groups include the COVID-19 pandemic and geographical separation. Historical management decisions and stakeholder interactions have in some cases led to mistrust and conflict, which persist even as new personnel enter this system. These historical conflicts can then create barriers to collaboration. In other cases, multiple roles critical to system function may fall to a few key individuals—for example, maintaining institutional knowledge and good relationships that bridge otherwise disconnected stakeholder groups. If capacity for these roles is not distributed across personnel, the system is made vulnerable to these individuals' departure. Finally, because stakeholders' roles are interconnected, each stakeholder's ability to execute their individual role effectively depends at least in part on other stakeholders. In this section, however, we focus first on within-group dynamics that affect stakeholders' roles.

Fishing stakeholders

One of the most broadly accessible and important inputs that fishing stakeholders provide for stock assessment science is fisheries data, through creel surveys and commercial receipt books. Some of the factors affecting the flow of fishing stakeholders' data include mistrust of data collection agencies, high engagement costs, and cultural norms (e.g., the behaviors that are socially acceptable within a group).

Fishing stakeholders have cited their experiences with science and management agencies producing largely unfavorable outcomes for territorial fisheries. This has resulted in some fishing stakeholders' mistrust of those collecting data (e.g., territorial agencies or Council- and PIFSC-affiliated contractors). Fishing stakeholders described fishers intentionally avoiding data collectors. Some described fishers refusing to submit data to the Guam DAWR in protest of the lack of FADs available to the fishery: "Some captains say, you asking us for our data? Put the buoys back!" In discussions of data reporting, fishing stakeholders also expressed concern that their community is prone to exaggerating catch estimates.

Regarding both quantitative (e.g., creel surveys, voluntary reporting via Catch-It-Log-It) and qualitative data (e.g., public meetings), fishing stakeholders cited the high costs of engagement discouraging their participation. For example, participation would take away from time to fish, do other work, or spend time with family.

In public or group meetings convening multiple fishing stakeholders, interviewees described a deference to dominant or respected individuals that could impede direct input from all participants in both American Samoa and Guam. In American Samoa, for example, the culture of respect toward titled men might inhibit contributions from untitled men in shared discussions. In Guam, fishing stakeholders described a reluctance to express views that differed from elders,

mentors, or the dominant culture to avoid mamahlao¹ or “because they don’t wanna offend someone or be a target.” Fishing stakeholders described the potential for this dynamic to subdue voices that could be more receptive to fisher-agency collaboration, data submission, and management.

Territorial agency stakeholders

Territorial agency stakeholders are responsible for collecting the fisheries data. Some factors affecting their ability to collect data include multiple and diverse data collection requirements and difficult field logistics.

Several stakeholders highlighted the challenges inherent in working in territorial government systems. One interviewee noted, “I have never seen [a territorial agency leader] that cares as much as [this leader] does, but working in a government agency it’s hard for [this leader] to get things through too. [This leader is] pulling teeth.”

All of the DAWR fisheries staff are required to conduct creel surveys, but it is one of the many tasks assigned to them. The breadth of the DAWR staff’s responsibilities include turtle research, fish surveys, monitoring marine preserves, fisheries development projects, and generating data reports for the Council, local government, Guam users, and funding sources such as the Sportfish Foundation. As one PIFSC stakeholder noted, “They seem to have so much already on their plate... they’re doing ungulate research, some of the same people that do creel surveys are also involved in some of the other work going on in terrestrial arenas or back and forth.”

In addition to the breadth of DAWR’s responsibilities, interviewees described various challenges that survey technicians might encounter in the field. These included a high volume of boats overwhelming technicians, challenging commutes between survey sites, decision-making in a funding-limited environment, and a voluntary reporting system, which provides little incentive for technicians to confront fishers that are unwilling to participate.

Council stakeholders

One of the factors complicating Council stakeholders’ roles is their variable perceptions of the intersection between stakeholder engagement, science, and management. For example, one interviewee described a recurring dialogue among the Council’s Science and Statistical Committee (SSC) in which some more statistically-oriented participants withdraw from the discussion completely, citing decision-making as a role reserved for the Council rather than the SSC. This is followed by other participants’ assertion that SSC discussion is appropriate, necessary, and distinct from decision-making, given that the Magnuson Stevens Act (MSA) requires the SSC to advise the Council on the potential impacts of management options to fisheries and fishing communities. Council stakeholders also noted difficulty balancing statistical scientific information with qualitative information about the fishery presented during meetings, and scientific objectivity with fishery impact considerations. We elaborate further on the intersection between science, stakeholder engagement, and management in a Results section called ““Good science’ is...”.

¹ An interviewee used the word to describe a culture in which juniors (e.g., in age or experience) might feel ashamed and disrespectful by departing from the way things have been done historically.

NMFS stakeholders: PIRO and PIFSC

Several factors affect PIFSC stakeholders’ roles. One factor is that their work is dictated by federal frameworks and timelines. For example, if the SAP does not deliver stock assessments according to the WPSAR schedule, they are in violation of the law and must enter an elaborate justification process through NOAA headquarters. This violation also puts them at risk for losing funding, given the specificity of their role at NMFS.

NMFS stakeholders also noted a lack of dedicated, formal, institutional support for engagement activities. This means that engagement is largely prioritized based on the individual interests of personnel rather than the institution’s framework itself. NMFS stakeholders expressed interest in being involved in improved stakeholder engagement and recognized the need to build on their own stakeholder communication and engagement skills. However, the availability of staff time and program budgets provide little support for engagement capacity building.

Stakeholder priorities and engagement incentives

Interviewees discussed various stakeholder priorities and incentives that guide their work, behavior, and engagement with one another. The themes we report on here represent both self-reported perceptions and perceptions held by other stakeholders. In Table 1 we present stakeholders’ priorities, ordered from most to least common across all four stakeholder groups. Table 2 presents the motives and incentives that guide stakeholders’ engagement with one another, also ordered from most to least common across stakeholder groups. Note that the presence of a stakeholder priority or engagement incentive in a stakeholder category means that it emerged at least once in interviews with or discussions around the stakeholders in question, not that the value or motive is shared by all members of said stakeholder category. Equally important, the absence of a priority or incentive in a stakeholder category reflects its absence in the sources of data that we describe in our Methods, not necessarily the absence of its value for that stakeholder group. Because we collected data from fewer than three PIRO stakeholders, we narrow our NMFS stakeholder group here to focus on PIFSC stakeholders’ perspectives in this section.

Table 1. Stakeholder priorities.

| Priority | Description | Fishers/ vendors | Territorial agencies | Council | PIFSC |
|----------------|---|---------------------|-------------------------|---------|-------|
| Data accuracy | Generating data that is accurate and/or representative of the fishery. Includes references to both data quality and quantity. | X | X | X | X |
| Cultural value | Accounting for the cultural aspects of fishing and community in engagement or fisheries science and management. | X | X | X | X |
| Community | Considering the needs of or impacts to fishing communities in engagement and decision-making. | X | X | X | |
| Fishing | Maintaining current or future | X | X | X | |

| Priority | Description | Fishers/ vendors | Territorial agencies | Council | PIFSC |
|---------------------------------------|---|---------------------|-------------------------|---------|-------|
| | access to fishing opportunities. | | | | |
| Resource stewardship + Healthy stocks | Ensuring the sustainability of fishing. | X | | | X |
| Scientific integrity | Includes references to science that is representative of the “real world,” or maintains independence from external biases. Differs according to stakeholder (see “‘Good science’ is...” section). | X | | | X |
| Livelihood | Maintaining livelihoods; capacity to support oneself and one’s family. | X | | | X |
| Defending science + personnel | Producing defensible science, or defending (often subordinate) personnel in public settings, as in a leadership role. | | | | X |
| Longer-term goals | Driving decision-making based on more systematic, long-term goal horizons. | | | | X |
| Information guarding | Guarding information, sometimes as a defense mechanism, but more often to protect proprietary fishing strategies. | X | | | |

Two priorities were held across all four stakeholder groups: data accuracy and cultural value. However, the ways in which stakeholders expressed these priorities differed. For example, some fisher and Council stakeholders expressed their valuing data accuracy through explicit concerns around the accuracy of creel survey data according to its sampling design and execution, the accuracy of self-reported data, and assumptions used to draw conclusions about the fishery from these data. PIFSC and territorial agency stakeholders identified their roles in data collection and quality control as priorities: “[It’s important] that we’re getting as accurate data as possible and as complete data as possible. So, good coverage of bottomfishing activity [as far as] the amount of activity... species and sizes and weights being collected as well.” One PIFSC stakeholder highlighted the benefits of fisher-scientist collaboration to data collection efforts: “We trust the quality of the information because we’re part of the collection, participants making part of their living. Win-win.” As this example illustrates, information about stakeholders’ priorities can be leveraged for collective efforts and benefits, even if they differ from one another. Here, fishers’ livelihoods and scientists’ investment in accurate data converge to produce mutually beneficial outcomes.

Commentary on the value of cultural sensitivity and fishing culture was also expressed differently by different people. Interviewees talked about perceived threats to fishing activity triggering fishers because, for many, fishing can represent a way of life and tradition:

When [stock] assessment comes in play it's like, "So, I pretty much can't fish then." "Oh, you're telling me that I'm being restricted from my own right to provide."... It hurts the fishermen because it's like, "Man, I've been doing this my whole life!" It becomes a very, very soft subject.... It gets really serious.

Scientists affiliated with both PIFSC and the Council described processes that could help to acknowledge species' cultural value in science and management. A PIFSC stakeholder noted, "We're working on hierarchical cluster analyses... we're looking at commercial data top catches. What is culturally and commercially significant or important. And then how do we align that with what is found in federal waters." In other cases, the inclusion of cultural considerations in science was desired and aspirational:

I know science is numbers, but I think that there needs to be some sensitivity to the cultural side, too. And in that sense it will ease tensions and improve communication, I trust, within the science side and the fishing community.

Community and fishing were described as priorities held by fishing, territorial agency, and Council stakeholders. Fishing stakeholders were described explicitly as "caring about their community," but also expressed their orientation toward community needs indirectly. Territorial agency and Council stakeholders demonstrated their community values as they called for more attention to orienting work and engagement, for example, around immediate impacts to the community:

[The AS DMWR is] sitting there with an interim ACL... a rebuilding plan... we're not on the same time scale of, it's going to take 6, 7, 8 years to fix it. They're, "No, we can only catch 1700 lb of fish starting next year." And that is the focus.

One of PIFSC stakeholders' priorities, longer-term goals, provides a helpful example of tension between stakeholder priorities that creates opportunity for thoughtful engagement instead of conflict:

My bias is I'm constantly looking at the long-term or the future. I'm thinking [how do we] improve MUS lists to better align with the MSA [and] federal waters versus territorial waters? How do we work with the territorial agencies to develop an FMP? ...They're sitting there with an interim ACL... a rebuilding plan... We're on different time scales.

The interviewee noted that this kind of awareness allows for acknowledging biases and validating the priorities of other stakeholders, instead of asserting their priorities in a way that may appear dismissive to others.

Priorities around fishing itself were separated thematically from those around healthy stocks and resource stewardship, though they were often discussed together. Unsurprisingly, fishing activity was identified as a priority for fishers:

Fishermen, they just want to fish. They want to do what they've been doing all their life... Their concern is not so much the statistics or the data collection, their concern is: Are they able to catch fish when they go fishing?... At the end of the day, it's all about tradition. It's all about personal love for certain things in life.

In addition, fishing activity was also identified as a priority for vendors:

I mean if we have to be restricted 'cause we are overfished, I'm all for it.... We want to work with the scientists to make sure we do have fish. The Council really just wants us to have a future in fisheries. And to have fish for our kids and grandkids, and for fish to still be around.

The importance of fishing was also expressed by territorial agencies and Council stakeholders. A key example of maintaining fishing opportunity and access is a bottomfish community development plan being spearheaded by American Samoa's DMWR, which also prioritizes cultural fishing values.

Scientific integrity was discussed as a priority for fishing and PIFSC stakeholders. In many cases, the definition of scientific integrity differed according to stakeholder (we will elaborate upon this in a later section, "'Good science' is..."). However, the examples we present here from the fishing and PIFSC communities highlight shared interests in "representing the real world" in scientific endeavors. A PIFSC stakeholder noted:

I'm not out to find an overfished fishery. I want to do the best science we can, using the most data we can.... Accurately representing the real world with math, we want to do as good a job of that as we possibly can.

Livelihoods were also discussed by both fishing and PIFSC stakeholders, but in different ways. Some fishers noted livelihood dependence on fishing being the impetus for their participation in fisheries science and management. In contrast, scientists' participation is primarily a function of their work. As one fisher put it, "It's more a job for [scientists], maybe not personal. With fishermen it's strictly personal."

A priority described only for PIFSC was defending science and scientific personnel. In some cases, this manifested as researchers described the importance of scientific integrity, including in its definition science that is defensible. As one scientist put it, "Part of science is open debate. It's important to document what was done, why it was done. Reason-giving is critical." More often, this theme manifested as PIFSC stakeholders sought to protect or defend their science and/or scientific personnel in multi-stakeholder discussions: "I [have] personnel that I oversee and I have to make sure that they are comfortable and that they feel that their work is valued and respected." Some interviewees noted that this kind of response may unintentionally create tensions with other stakeholders. Observations and interviews highlighted that defensive responses or engagement structures may be perceived by others as a form of censorship.

The final priority, information guarding, was identified by various fishing stakeholders. They described guarding information about fishing spots, techniques, and catch in order to protect their fishing opportunities. This may affect the way fishers submit data or the conditions under they are willing to cooperate with scientists. One fisher commented on his conditional willingness to get scientists out on the water: "I'm willing to take you out for free as long as my spots are kept secret."

Table 2. Stakeholder incentives for engagement.

| Engagement incentive | Description | Fishers/ vendors | Territorial agencies | Council | PIFSC |
|----------------------|--|------------------|----------------------|---------|-------|
| Data access | Stakeholder engagement facilitates data collection and sharing (e.g., survey technicians engage with fishers to collect data; fishers may engage with scientists to access novel or summarized information about their fishery). | X | X | X | X |
| Financial + Material | Financial and material incentives may directly incentivize community engagement, and financial support facilitates the allocation of agency time and personnel to engagement endeavors. | X | X | | X |
| “Until it hurts” | Stakeholders are spurred to engage when negative impacts to the fishery are imminent or occurring. | X | | X | X |
| “Make a difference” | An internal desire to facilitate some change in the fishery, its science, or management. | X | | | |
| Leadership support | Leadership support may dictate whether or not engagement is prioritized, within communities and institutions. | | | | X |
| Rejected science | Scientists are spurred to engage when formalized processes reject their products. | | | | X |
| Incentives lacking | Where institutional or external incentives for engagement are lacking, engagement requires intrinsic motivations. | | | | X |

The only incentive all four stakeholder groups identified as motivating engagement endeavors was data access, but in different ways. Interviewees noted that a centralized resource for fishers to access information about their fisheries might be useful and incentivize engagement with the scientific community. One fisher commented:

[PIFSC] put a presentation together, and made it open to us so we could review it.... By doing it virtually, most of us were able to log on and learn something... Surprisingly there was a super large onaga caught, 34 lb, on Kauai, during the cooperative research. Largest ever caught in Hawai‘i. And it turned out not to be the oldest caught in Hawai‘i. So, those are the kinds of things that interest us. How old is the fish? Wow, that fish is 45 years old! To grow to 30 lb? 27 years to grow to 34 lb? You know, it’s hard to comprehend. Where were these fish all these years that never got caught! Yeah? So, that’s the benefit we get from the process.

For territorial agencies, Council, and PIFSC stakeholders, stakeholder engagement was described as a necessary mechanism to acquire fisheries data, both directly and indirectly through the building of relationships and trust.

Examples of financial and material incentives for engagement also differed across stakeholder groups. Financial and material incentives for fishing stakeholders’ engagement included raffle prizes for the Catch-It-Log-It pilot project, which were distributed to those that submitted data. Financial support could also serve as a factor that enables fishing stakeholders’ participation in engagement by offsetting some engagement costs. Interviewees cited examples of scientists

buying fishers' catch for biosampling, or fishers' travel being paid for to enable their attendance at distant meetings. Territorial agency and PIFSC stakeholders could also be incentivized to engage through financial mechanisms, as they are beholden to their funding sources. Along with funding, interviewees identified leadership support as an enabling factor for scientists' level of engagement. Commenting on the 2015–2016 Hawai'i bottomfish data workshops, one fisher noted:

I put my heart and soul into this thing and I know they did too, the scientists. Look how much money they spent.... Obviously you got the higher ups to believe, because the grants are so big! This is not one fishery that is like longline, or the salmon, or like in Alaska, man, everybody got these licenses, costs million dollars to have.... How you write a grant is one of the key things.

Given its requirement for concerted effort across stakeholder groups, multi-stakeholder engagement serves to benefit from aligned leadership support across institutions. This is especially critical for institutions like NMFS, which provides poor institutional incentives for engagement. This means that the extent to which engagement is prioritized varies depending on personnel in roles of leadership or with access to engagement-related funding. A PIFSC stakeholder noted, "In [National Standard] 1, what [we] follow to do the assessments, there is zero incentives for data workshops... I have to ask [for] money."

Some fishing stakeholders noted a more intrinsic engagement motivation to contribute their perspectives and make positive changes in fisheries science and management: "It's kinda disheartening a little bit [because] I like to join stuff to make a difference, to make impact... It's a lotta time, a lotta meetings, a lotta energy." As this quote illustrates, engagement costs are high for fishing stakeholders who take time away from fishing, family, work, or leisure to attend meetings while other stakeholders engage as part of their work or during work time. Given the high investments required for engagement, one fisher described many of his peers' general passivity: "Most fishermen are passive. They don't get involved in an issue until it hurts."

Council and PIFSC stakeholders were also described to have more incentive to engage when "it hurts," meaning that there are clear negative impacts to the fishery. An unfavorable stock assessment outcome and subsequent negative impacts to the fishery were described as stimuli that force alignment between stakeholders' otherwise dissonant engagement incentives and timelines. These outcomes were also described to stimulate engagement indirectly by increasing access to funding.

Stakeholders noted another important trigger for PIFSC's investment in engagement in Hawai'i: rejection of its stock assessment after independent review. One PIFSC stakeholder said of the 2015–2016 Hawai'i bottomfish data workshops:

The contention around that assessment [raised] interest for attending these meetings.... If there's not a driver or if there is a general view that, "Oh, I don't need to spend my time, this isn't really going to change anything. Or it's not going to be used to address something," I would worry that attendance would not be as large, or the outcomes viewed as important.... And if [a purpose and outcome] aren't articulated or if it's not apparent to everyone, then you'll get varying levels of interest and involvement.

These incentives and negative stimuli that trigger engagement are key enabling factors for multi-stakeholder engagement. Yet, they represent just one facet of the enabling context for engagement. One interviewee noted that the 2015–2016 Hawai‘i bottomfish data workshops were a product of decades of management framework changes, discussions of bottomfish fishery data inadequacies, and outreach in the main Hawaiian Islands to bottomfish communities.

Unsurprisingly, when “it hurts,” the urgency of resolution and tensions between stakeholders are also elevated. A territorial agency stakeholder called for a less reactive, more strategic diagnosis of the problem not necessarily centered on the outcome of the assessment but on improving data streams, if needed:

I think it might be wise to think if either Council or Science Center go through the whole process as to why we come up with these numbers because we cannot always be questioning the results of data when the result is a bad one. If... the data collection is not adequate, I think that that needs to be enumerated. And I think if something needs to be done to improve the data, the collection effort, it needs to be done.... I mean, not just to say that, you know, we need to collect better data, but I guess to identify what the problem is... when the results are not what you want.

Although there are some incentives shared by most or all stakeholders, the mechanisms by which incentives trigger stakeholders’ investments in engagement are specific to the stakeholder in question and don’t necessarily align across institutions or time. One interviewee pointed out that the last round of territorial stock assessments forced temporal and institutional alignment between engagement incentives, delivering a unique collaborative opportunity that at once forces stakeholders together and increases the opportunity for conflict. In the next section, we discuss some expected engagement challenges.

Challenges in communication

Lack of communication between stakeholders was a recurring theme in our data. Common among these discussions was the idea that increased communication would provide resolution to many issues by facilitating information flow between stakeholders. For example, communication might eliminate duplicate efforts between stakeholders:

We didn’t know anything about the Catch-It-Log-It web app until it was practically done. And actually [we were] tasked with creating something similar to what Catch-It-Log-It does... I want people to get more together so that we know what’s going on with the other group. We can always help each other.

Or, communication might help to explain patterns in the data using fisher knowledge:

[Scientists] said, ‘I’m looking at the data. For some unknown reason, every month [tātaga‘ and hangon] disappear. Gone. Nobody can find them.... Three or four days, gone.’ I said, ‘Well, that’s because it’s full moon.... When it’s not full moon... they’re holed up or they’re sleeping, and fishermen can catch them.’ They didn’t disappear. They’re just wide awake! So [scientists and fishermen] have to have that dialogue. Because the fishermen can answer those questions and fill in those gaps. That doesn’t happen for Guam and the Territories. In Hawai‘i, they have the workshops and the fishermen are sitting at the table and can interact, ask those questions and answer them. On Guam, if the scientists have a question, lucky if you’ll get a phone call like I did to answer those questions. But we can’t hear what they’re talking about, so we don’t know what questions to answer. And, a lot of those holes can be filled with a simple exchange.

However, creating opportunities to communicate may not resolve all communication issues. One fisher noted:

I get frustrated [because I feel] I'm not saying it in the way that they can understand.... 'Cause [this scientist] and I, eventually we realized... We're coming from similar grounds. It's the arrogance that's irritating me... 'cause [this scientist will] just shut you down.... And it was my insistence that was irritating [the scientist]. So, it was a personal problem, not an informational problem. It was a communication problem. Most problems are communication problems anyway. Very few things are yes and no.

Interviewees also highlighted inefficiencies in communication styles used between stakeholder groups. For example, interviewees noted the inefficacy of messages communicated through the presentation of statistical data—a perspective shared by members of the fishing community as well as interviewees with scientific expertise outside the statistical realm:

Who's delivering it is really important too, because you can be a really, really smart scientist and not be able to communicate to a layperson what you're doing. You just listen, passing each other in the dark. What we can pick up, we can comment. The rest of the stuff, your eyes glaze over and you let the two scientists talk to each other and go through the process.

One interviewee noted the importance of individuals serving as “a bridge between both sides”:

Sometimes I heard some things that the scientists were saying that didn't really sound too accurate.... [This fisher] sometimes doesn't necessarily articulate a really important perspective in a way that's digestible if you're not on the water. And so I remember reiterating [this fisher's] point once, and a couple other perspectives. Just so they were really clearly identified.

These communication issues likely contribute to a phenomenon in which participants share a discussion, but walk away with different interpretations of that experience: “I find that we're often talking past each other... We have meetings and we feel that everyone is on the same page. Then we realize that everyone just walked away with completely different understandings of what was just said.”

To help illustrate these challenges in communication, we provide concrete examples that emerged from interviews and public meetings in the following subsections.

Language

Interviews and public meetings highlighted several examples of language that is used or interpreted differently by different stakeholders. As a simple example, one interviewee suggested that scientists might use local common species names instead of scientific names, and units of measurement like inches and fathoms instead of metric system units to make information more accessible to fishing communities. Another noted:

Too often we assume that fishermen [aren't gonna] understand the concepts behind science, but that's pretty faulty thinking. We can explain our science to them.... I think if we just make a minor effort to translate some of our technical jargon, they'd quickly understand. And they'd wanna understand.

One interviewee found certain words to elicit negative reactions during engagement with fishers. The interviewee noted that some fishers immediately associate phrases like “deep bottom,” “stock,” or “stock assessment” with potential regulation or negative judgements on their fishing activity:

When I say “stock assessments” they’re like, “Ugh. This guy’s not going to let me fish.” And I come back and say, “We’re just using it for statistical purposes... numbers.” Then... it’s like, “Ok, I thought this guy was going to tell me I can’t fish. Now he’s telling me he’s going to need a few numbers.”... Whenever I say, “Deep water, stock,”... the normal thinking is, “Oh, he’s telling us it’s bad to fish... we shouldn’t fish that.”

This association between fear of restriction and fisheries science and management is not specific to stock assessment. The interviewee added, “If I talk about... ‘Oh, I work for the fisheries,’ they’re like, ‘Oh, you’re one of those.’ Like I’m a bad guy.” The reactions these kinds of words elicit in different stakeholder groups can inform how they are used, or build capacity among stakeholders to engage with more sensitivity. Another interviewee with a role in fisher engagement noted:

I had to really sort out in my own mind the big picture and how I would respond to fishermen who brought up different issues that might be obstacles to participation. I had to think that through, including the wording. I have [technicians that] engage the fishermen as well.... Slowly I kind of warm [them] up to why a fisherman may react the way that they do and why they may ask questions that they do.... Because they only have a shallow understanding of the context, it’s so easy for them to make mistakes.... So, it’s an educational process that I’ve been going through with them continuously. Continuously.... You can’t approach [fishers] with your biases all over your sleeve and stuff. They’ll just turn around and laugh at you. You’ll never see them again, and they’ll start spreading the word: ‘These guys are a joke. These guys are not respectful, they’re part of the group that’s trying to regulate and tell us we can’t fish to make money for our families.’ It can go sideways real fast if you use the wrong approach.

The importance of listening to understand the other stakeholders’ perspectives, maintain open dialogue, and potential for collaboration was a common theme in interviews and public meetings.

Technical jargon may also lead to diverse interpretations of the same language. For example, while “data-limited” might be interpreted as a lack of data, it has a very specific definition in stock assessment science. One PIFSC stakeholder noted, “Some say [the bottomfish fishery is] data-limited but actually it doesn’t even meet the definition of data-limited. You have a time series with removals and CPUE... For this particular species it’s not data-limited.”

“Standardization” was another word that was interpreted differently by different people. A PIFSC scientist described CPUE standardization as “a major part of any assessment that includes all drivers that can impact CPUE.” The scientist noted that “fishers need to be involved in the data workshops and in getting insight in helping us [see] through standardization.” For one fisher, discussions around “standardization” trigger a very different response connected to the word’s conventional meaning and usage in federal policy:

I notice... from a science point of view the need to streamline or ‘standardize’ I think is the word... but the territories, we are not standard. We’re not a state. We don’t have the power of

lobbying, of getting information through Congress, through the states. I mean, our hands are tied. We have very limited power.... Can't vote for President and yet you can join the military and die for the country.... And we don't fit the National Standard... One or two. We need the un-national standard, or territory standard....

[You're trying to] make something fit the tool instead of using the right tool for the job.... Why can't it be just for the Territories?... Everyone involved mostly is in Honolulu somewhere. Yet you're trying to use those ideas that work with the resources and the structure you have there in the territories, which are unstructured and don't have that information. Because we truly eat all the fish. The fish doesn't get exported. It's all to feed the people of the islands. We don't have big commercial fisheries, there's no auction.

These examples demonstrate the starkly different responses stakeholders may have to shared language. The latter example also shows that word choice represents just one facet of effective communication, given that stakeholder interpretations can be derived from contexts spanning technical science to sociopolitical inequity.

Stakeholder disconnect

In this section, we describe some of the more complex dynamics that impede effective communication. These exemplary cases are rooted in stakeholder disconnect, which we use to refer to the different ways stakeholders either interpret shared discussions or experiences, or create distinct interpretations given a lack of shared experiences. In each of the examples below, disconnect between stakeholders is illustrated through their conflicting narratives around the same titular theme. In presenting these examples, we hope to shed light on the factors that enable this disconnect, including diverse stakeholder values, institutional cultures, and constraints; and in so doing, identify opportunities for improved multi-stakeholder engagement.

First, a simple example: One interviewee noted that boundaries between PIFSC programs may be more easily understood by PIFSC and Council stakeholders than others. Fishing stakeholders external to PIFSC may neither perceive distinctions between PIFSC programs, nor view them as relevant to their concerns. The interviewee noted that scientists' communication might be more effective if they accommodate fishing stakeholders' perspectives by responding to their root concerns, rather than elaborating upon the differences between PIFSC programs, projects, and budgets.

“Good science” is...

Stakeholders highlighted different criteria that qualify “good science.”

Scientific integrity was a common term used by PIFSC stakeholders during public meetings to describe their science and the work of their personnel. In some cases, PIFSC stakeholders associated scientific integrity with some level of independence from external influences, including the biases of scientific peers, leadership, and other stakeholder groups. For this reason, the relationship between stakeholder engagement and scientific integrity held tension for some scientists. One Council stakeholder pointed out that in cases where engagement is not a key part of the scientific process itself, communicating with fishing communities and managers remains a valuable step in scientists' work given its impacts to them:

I understand the whole scientific independence, but that doesn't negate engaging the stakeholders as well as the fishery managers in terms of, “How are we gonna move forward with this?” You

can maintain the scientific integrity, but [having] early coordination and engagement with the fishery managers could go a long way in terms of preparing the community on the impacts of the assessment outcome.

For other stakeholders, engagement and “good science” went hand in hand. Participants from the 2015–2016 Hawai‘i bottomfish data workshops noted that stock assessment science benefitted from engagement, with improved outcomes for the assessment’s perceived legitimacy by stakeholders and its independent review. One fisher said:

They were looking at it just from the viewpoint of being scientists, and they were missing a lot of the “whys.” We were able to bring all of that to them so that they were able to understand the numbers that they were crunching. They had the data, but they were not knowledgeable enough to be able to analyze the data properly. That’s what we were able to do. That was the goal, and I feel that that goal was accomplished. And their next assessment was peer review approved. So that was great. It was the reason why we were brought in and I think it was successful.

Diverse interviewees—including fishers, Council stakeholders, and PIFSC stakeholders—echoed this sentiment that a key part of innovative science, and the science they seek to provide, is validating models with stakeholders’ experiences of the fishery. One fisher noted:

When you look at the science and mathematics that go into it, we kinda glaze over. Because we’re not familiar, we don’t live in that world. We live in actuality, you know?... So, what was missing in the equation was the empirical science. The science of actually talking to those fishermen that were in the business, in the industry, living it day to day.

A Council stakeholder reinforced this idea, commenting on the need for validation from the community to ensure alignment between data collection and inferences modelers make from the data:

There has to be a validation. But as modelers we always assume that the data are correct.... We model it and we say, “statistically we say that this model fits the data the best.” We hide behind, “this is the best fit.”

For this reason, many stakeholders expressed reservations about the last territorial stock assessments based on a lack of engagement prior to data analysis. Engagement might have affected, for example, the decision to include in the model’s quantification of fishing effort all fishing trips with bottomfishing gear onboard, including those with zero catch and potentially zero dedicated bottomfishing time. While pending data workshops in the territories may help to facilitate engagement between stock assessors and fishers, one interviewee also pointed to the value of learning from creel survey technicians: “If modelers go out and observe sampling with the surveyors, they’ll catch so much. You can ask questions and gain so much information [and] great insights for their modeling.” This consultation between multiple stakeholders in the system—including but not limited to fishers, survey technicians, and stock assessors—is especially critical because of the extent to which these stakeholders’ roles are interdependent, but functionally disconnected. As outlined in the “Stakeholder roles” section, creel survey sampling design, survey implementation, data management and review, and data analysis are scattered across various institutions, including the fishing community, territorial agencies, survey technicians, and multiple PIFSC programs within FRMD.

Other PIFSC stakeholders focused more on their objectives to produce defensible, scientifically accurate science, which acknowledges data gaps and scientific uncertainty, and communicates outcomes in terms of probability. One opportunity that PIFSC stakeholders identified to make progress toward these objectives was splitting the BMUS complex into individual species units for stock assessment.

The relationship that stakeholders drew between “good science” and “good data” also varied. Some fishers expressed appreciation for stock assessors’ work, making a distinction between their science and the quality of the potentially “flawed” data with which they are provided. For many stakeholders, however, the separation of quality data and science was a point of frustration. As one Council stakeholder asserted at a public meeting, “When is the data too poor, and a stock assessment not appropriate for management?” A fishing stakeholder commented on data quality issues and the dramatic jumps made between rebuilding timelines in the territories, which further fractured trust in the process:

It’s never gonna be perfect, but it’ll be way more accurate. I’m tired of hearing, “This the best information possible that we got.” Yeah it’s the best but it’s very inaccurate. And we need to think about fixing that. And I’m not saying the scientists’ work is not accurate, but something like that happens, that’s a big mistake! [Rebuilding plan from 8 years to] 19 years? How do you make that big of a mistake? I don’t really understand it.

Mechanisms to integrate data quality and treatment considerations into the fisheries science and management decision-making process appear to be limited. Commenting on the role of the SSC, one interviewee noted that the fisheries system within which we work is not well equipped to prioritize reflections on engagement, data validation, or treatment before applying science to management:

Our task is... to first declare whether it’s BSIA [Best Scientific Information Available] or not. And the national guidance on that doesn't mean it has to be perfect. It just has to be the best available. And if the best available is pretty bad, everybody says, “Ok, I’m gonna compromise, it's the best available.” Then the system is set up to run with it.

One example of an institutionalized mechanism to integrate discussions of data and its treatment into decision-making is a framework adopted exclusively by the Southeast Fisheries Science Center (SEFSC), in which a panel of stakeholders including representatives from the fishing industry sign off on what data is used and how it is used in the stock assessment. Thereafter, stock assessors run their models based on these agreed-upon terms. A PIFSC stakeholder noted that adopting the SEFSC’s framework is preferable and the “right thing to do,” as it would create a systemic requirement for engagement that would persist regardless of the “strategies or values” of those in leadership positions. However, this interviewee noted that such a process would require increased capacity and personnel to execute properly; resources that PIFSC currently lacks compared to the SEFSC.

Identity and power: Gear type and CPUE

In multi-stakeholder discussions, we observed stakeholders “talking past each other.” While the subject matter appears to be shared, variable stakeholder interpretations can impede communication and escalate emotions as a result of threatened stakeholder identities and values.

We describe one such example with subject matter centering on fishing gear and CPUE, and weave in insights from interviews to illustrate underlying context for these discussions.

In Council meetings, fishers from across the Pacific Islands region and its territorial agencies highlight the territories' relatively small, more non-commercial fisheries compared to Hawai'i. These stakeholders often call attention to differences in equipment, noting that American Samoa's deep bottomfish fishery uses handlines instead of electric reels. One fisher noted, "[It] would be so nice to go out with the electric reels and show the scientists that there's so much fish out there, it's so abundant." Another said of Hawai'i and American Samoa, "You're comparing apples and oranges if you're comparing CPUE." PIFSC stakeholders have responded to these comments with an emphasis on the technical aspects of science, noting that, "If you're starting to use electric reels, that actually would increase your CPUE, so it would falsely suggest you have a healthier stock."

On their own, these statements appear to be related to the relationship between gear type and CPUE. Their underlying contexts, however, point to very different issues. One centers on stock assessment science and presumes that improving other stakeholders' scientific literacy may resolve this discussion. This idea that improving understanding of science and scientific processes is a key part of the solution was shared by multiple stakeholders, including scientists and fishers. In this case, however, a technical scientific response may not be well suited to address territorial stakeholders' concerns.

These concerns represent a more fundamental opposition to the conclusions of territorial stock assessment based on territorial stakeholders' experience of their fisheries: "That's the last thing the fishermen want to hear—they're out on the water every weekend, every day sometimes, and somebody sitting at a desk in Hawai'i is telling them what they're seeing is not what's going on." Several Guam fishers, for example, described their bottomfish fishery as having few skilled participants, with low overall extractive capabilities given the complexity of the fishery and the recency of its adoption in Guam, and low overall productivity given the limited market demand on island. Some territorial stakeholders described these factors as irreconcilable with the idea that Guam's bottomfish fisheries could possibly be overfished; an idea that was more prominent even for American Samoa: "[It's] almost impossible to be overfished. We're hearing all these pleas from guys that are there just trying to feed their families." Guam fishers also distinguished their fishery from Hawai'i beyond the fishery operations themselves:

[I] feel like we're being treated the same as Hawai'i but we're not the same at all.... We don't have the manpower out here to do the creel surveys correctly. The big problem that we're reaching over and over again, is we're not saying that the scientists are doing a bad job. We're not saying that at all. We're going back to the creel surveys. If you don't have the manpower to go out and collect the correct information and the right times....

This interviewee referenced two other common themes in our data: a need for increased capacity in creel survey implementation, and the defensive dynamic between stakeholders that can impede productive discussions.

Interviews also indicated that territorial stakeholders' references to their relatively small bottomfish fisheries are contextualized within their broader relationship with the U.S. federal government. Below, two interviewees describe this relationship as one primarily of

marginalization, in which “outsider” federal power is asserted through regulation, loss of fishery access, and military imposition, without proportional political power or federal support:

Guam is technically a possession of the U.S., without the ability to vote for President.... Guam is small. We get most things dictated to us. So, a lot of people are resentful about that political relationship, and it transcends just politics. And it colors things like, you know, resource management. Enforcement. Regulatory enforcement and regulatory burdens and everything else.

The military build-up. It's too much.... We've got three firing ranges that run from the southern to the northern coastline of Guam on the west side. And they average about, anywhere from about 10 to 15 square miles of ocean, bottomfish area, that's closed off. And then they have the Essential Fish Habitat issue coming on the table. And most of the corals are located on the western side of the island.... At the end of the day, all the marinas and boat launches are all on the western side of the island. So, you're closing off the entire western side of the island for coastal fishery, basically. And those issues are near and dear to me because our fishing community is already fragile as it is.

Various territorial stakeholders also noted that federal frameworks do not accommodate their communities. A territorial agency stakeholder noted, “The science doesn't fit our situation. And neither do the proposed management outcomes.” Two fishers juxtaposed the blanket application of federal science and management frameworks against the selective allocation of federal funds:

Every year, every meeting, it's the same thing. The Science Center says the same thing: “Funding, funding, can't do this.” From the federal perspective, you see Hawai'i whose fishery is not in peril, not being overfished or experiencing overfishing. They had seven cruise surveys for bottomfish. They had so many hundreds of thousands of dollars for fisheries surveys, independent surveys. All of this funding and then, “Oh, for the territories, we're just going to try to increase the resolution of creel surveys.”... Throw that money and that funding to the areas that are overfished, are experiencing overfishing.

The [NOAA] ships come by, yet they're more interested in whales and turtles and volcanoes and corals, but the human factor of living people who pay taxes. [They're] not trying to help our situation with fishing.... Where is the human element of all of it? I just feel a lot of it is being put on the islanders to count the catch ourselves and let the scientists use that as opposed to scientists coming in and doing their scientific review so they know what they need and they can use what works for them in assessing it.

This final quote also touches upon the high engagement costs to fishers and community members participating in these discussions. Key stakeholders from the territories expressed frustration with the often “disheartening” outcomes of the time and energy they invest in such efforts as multi-stakeholder processes facilitated by the Council and cooperative research. Calls for collaboration and collective action in recent meetings have felt for some fishers like, “A slap in the face.... It's kinda like, ‘Oh we weren't working together to begin with?’ It's kinda just like a top down... they just weren't hearing some of the points that the fishermen were making.” This fisher noted that the inclusion of fishers at some meetings, like the WPSAR, has felt like a formality rather than a meaningful mechanism for fisher input.

Catch-It-Log-It

The Catch-It-Log-It (CILI) application is the focus of a Council pilot project intended to address gaps in territorial data streams used in NMFS' science. CILI was intended as a proactive, technological tool for fishers' (and vendors', via the Sell-It-Log-It application) to address both fisher and agency needs identified in Council meetings past. Through observation and interview we discovered various narratives around the CILI initiative that illuminate data collection challenges, and opportunities to improve stakeholder communication and collaboration.

Council stakeholders have described CILI as an opportunity to "record the catch so that we can get out from underneath this overfished status and provide quality data." Discussions at Council meetings have revealed inconsistencies between CILI messaging being delivered by Council stakeholders and stakeholders at PIFSC and PIRO. NMFS stakeholders, for example, have expressed confusion with the apparent perception that CILI "was the panacea that was going to cure everything." Even as an addition to existing data streams, several conditions make the use of CILI data in stock assessment unlikely in the near future. Representatives from PIFSC and PIRO recently outlined these conditions in a presentation to the SSC and Council. They include mandatory licenses and reporting for commercial fisheries in the territories, and submission over a period such that a time series can be compared and linked to existing data streams.

These conditions for CILI data's use in stock assessment require action from multiple institutions. In Guam, creel survey and commercial receipt book data are collected and managed by the DAWR and the Bureau of Statistics and Planning (BSP), respectively. Mandatory licenses and reporting from commercial fishers would require new legislation from the territorial government. Additional data management and linkage with existing data streams may fall to FRMD's WPacFIN. All of these processes are interdependent. On moving forward with CILI and creel survey reevaluation, a territorial agency stakeholder commented:

That honestly isn't completely dependent on us. I mean, in order to change any of those processes requires collaboration with the Science Center and I feel that in conversations that I've had... I sort of push or express that we're eager to make changes to this process, but it's difficult to do that quickly because we need this continuity in the process in order to ensure that the data that we're collecting will remain valid and reliable. So it's, I think, harder to put a timeframe on it with those sort of parameters or requirements.

Despite the need for interagency coordination, a PIFSC stakeholder noted their surprise at the CILI application's development:

We didn't know anything about the CILI until it was practically done. [WPacFIN was] supposed to do something similar to that... Now we have to find a way to maybe merge the two. Merge the commercial CILI web app with the catch and the creel data. If we're not gonna have any commercial side in the creel because everybody is reporting in the CILI for the commercial side, then we have to find a way to merge the two data sets.... Because if I was a fisherman, I wouldn't report two places. It would be double work for them."

As this interviewee alluded, there is also some potential for CILI data submissions to displace reporting through established mechanisms. This seems plausible given that reporting can be cumbersome. Council meeting discussions also revealed that some stakeholders hoped the CILI data stream would replace the creel surveys. PIFSC stakeholders commented that this is not

feasible because the creel surveys are designed to capture data from non-commercial and commercial sectors, while mandatory reporting from CILI would capture primarily commercial fishing activity. A PIFSC stakeholder noted, “80–90% of the data is noncommercial and there’s no way [we can expand from] commercially-based self-reporting.”

These inconsistencies in messaging and differential timing of key stakeholders’ inclusion in the CILI initiative has led to confusion and frustration among fishing stakeholders, whose relationships with science and management institutions were already uncertain: “Now we’re being told [PIFSC is] not even going to use that data... If it’s not gonna matter why are fishermen even gonna submit their data?” Another fisher commented:

You know it can be realized when other places do it—all along the Eastern Shores, they use electronic reporting via apps... These fishermen that are using this app, they feel like they are part of the process. But, they work with the scientists on what information they can use. Out here in the Western Pacific, our scientists say: “We don’t like it. We can’t use it. We’re not going to use it.” Instead of working with the app developers, working with the managers saying: “This is what we have, but this is how to make it better. Let’s do it. Let’s move forward.” But that’s not the attitude. The attitude is—not going to happen, never going to happen.

The phenomenon of stakeholders investing in data collection to produce data that was not or could not be used in NMFS’ science was described in more than one case in the data. Although in these examples, stakeholders often assign blame or take defensive postures, they highlight opportunities to improve coordination between stakeholders and institutions. This will improve the likelihood that all stakeholders’ time, energy, and resources are invested efficiently, result in shared understanding of expected outcomes, and achieve said outcomes.

Independent of these issues, CILI’s uptake by territorial fishers has been slow, in part due to its dissemination during the pandemic when in-person training and outreach were limited. Fishing stakeholders also identified several concerns about its uptake in the community independent of the pandemic. These include the accuracy of self-reported data, some usability challenges which may be more pronounced for those that are less tech savvy:

No criticism on the CILI, but we have fishermen that are not interested in doing that, and you have fishermen that are not technologically advanced to get involved in that. A lot of our fishermen are over 60, and they can barely answer their text messages because their vision is so bad. And then you get on the phone and you try to put all this data in on a little screen unless you have a computer at home, which hardly anybody has, as far as I know. Kids are using it mostly... [And, I had] meetings with fishermen and their concern is actually the accuracy of the information. If the fishermen puts/says... I caught 50 lb of bottomfish, was it actually 50 lb, or was it 25 lb?

Others noted user-friendliness issues unrelated to age: “It’s nice, but it’s not a real app ‘cause you still have to log into a website and go into a different browser... That small thing for me is what determines whether or not I’m gonna do it, especially ‘cause I could be doing this while I’m on the water.” Uptake may simply be slow for some for its novelty. One fisher described recording their catch diligently as a part of their fishing practice for decades, but not having updated their CILI records for months at a time.

Following data submission and management, there are unanswered questions about how CILI may impact management. A Council stakeholder noted, “We’re trying to keep the data collection part separate from the management part... so it doesn’t turn into, ‘Oh you used our data against us.’” But the connection between data, science, and management is undeniable. Fishing stakeholders have shared the conflict they feel between reporting and encouraging their peers to record, and concerns about how increased reporting might deliver the community to the new bottomfish ACL more quickly, resulting in closure of federal waters:

I’m trying to make an accurate count on my part, but I don’t know if everybody’s doing that. I think if it was accurate it would go way over 31,000 lb. And I think that’s the part that we’re having a hard time with, is, they want everyone to turn in their catch but if we go over the 31,000 lb we’re gonna be restricted. But if we go under it they’re gonna be like, “Oh they don’t really have that much fish.” So we don’t really understand out here in Guam what they really want from us.

RQ2: What kinds of engagement process(es) might facilitate progress toward stakeholder goals?

In this section we report on engagement processes that interviewees identified as helpful for navigating the issues we described above. This includes discussions of engagement venues, structures, and participants.

Interviewees talked about the importance of setting, which could determine attendance or participants’ comfort contributing to discussions. Interviewees suggested that communities be engaged at meetings held in various parts of the island, not only in formal settings like city center hotels. Interviewees also identified various opportunities to utilize existing engagement structures and community networks, including the Council’s AP meetings, fishing clubs, Guam village fiestas organized by local mayors, or that of the GFCA. Other elements that interviewees described as making engagement more accessible: spatial layouts that encourage mingling, presenting information not in verbally and visually accessible formats (e.g., avoiding PowerPoints with lots of text and statistical data), and sharing food or drink. One PIFSC stakeholder suggested:

The best thing to do, often, is say, “Hey, I want to have a small group, I want to get an idea of everyone’s perspective, I’m buying two rounds,” or, “I’ll meet you at the harbor, I’ll bring some pupus and some cold beer, do you mind just hanging out for 20 minutes?”

Several interviewees also highlighted the value of scientists going out on the water with fishers to learn about their experience firsthand. They both suggested that Guam fishers have the opportunity to show scientists their bottomfish fishery: “Do the research, come to our island, we’ll show you,” and expressed appreciation for scientists’ doing so in Hawai’i: “[The scientist] was real open minded too. [The fisher] took her on several trips to show her actually what we were talking about.”

Given the challenges of a pandemic, interviewees discussed the pros and cons of virtual meetings. Virtual meetings enable attendance and participation from a wider audience, without spatial or geographical limitations. Among its challenges, interviewees included technological difficulties and the benefits of in-person engagement for relationship building:

If this was a virtual setting, I think it would be much more challenging to have that rapport built up that you get when you're in-person, meeting when you're away from your house or away from the PIFSC office. Kind of a neutral setting.

Interviewees also noted that within-group meetings might be helpful to prepare for multi-stakeholder engagement. Prompted for strategies to navigate inter-stakeholder conflict, one interviewee suggested, "Separate meetings... When we meet with fishermen and we have meetings or presentations we'll have one for fishermen and one for the different agencies." Meetings between two stakeholder groups may follow to allow for discussion and conflict resolution in a less public setting, reducing the likelihood of assigning blame and defensive posturing.

Adjusting group structure might also help to address the issue of dominant group voices subduing perspective sharing; a dynamic we first introduced in the "Fishing stakeholders" section. Interviewees noted breakout groups can help to divide larger stakeholder groups in a way that encourages "the more softer spoken, the really important perspectives to add in and enrich the conversation," and mingling between stakeholder groups to build relationships and familiarity. Group size in general is also an important consideration. One interviewee described the benefit of:

Enough people where the conversation gets going and you get participation. But it's also not so many people that you don't get anything accomplished.... On that note also I think it's important to go in with an agenda and be well organized. And, it's ok for some conversations to get sparked and allow time for some of that, but also to make sure you regroup and tell people, "Hey, we really need to accomplish this. And maybe we can make note to go back to that discussion because you guys seem really passionate about that. But we really wanted to accomplish this today." And, also set realistic agendas.... It could be really an important discussion that people just aren't engaging in because they're tired, right? So, you want to be cognizant of that.

This quote also touches on several other multi-stakeholder engagement recommendations shared by interviewees, central to which is quality facilitation that balances stakeholder inclusion and input while also respecting participants' shared time and energy. Interviewees suggested such strategies as establishing ground rules and clear, attainable engagement goals up front, and communicating them early and often. Specific, directed questions and respectful recognition of topics tangential to the group's shared goals were also described as helpful to structure discussions:

I found that the scientists that asked questions... provided the best input and output. Especially the ones that could hold you to the question. And they would be able to politely say, "Thanks", and then I would know, ok, they heard enough, I answered their question (*laughs*). Rather than just sit there and let me ramble on and on.... Specific questions. They would say something like, "You got this spot, wind's nice, current's nice, you see something. You drop your line, nothing happens, what do you think? Is that the fish that's not biting, you saw that before? Or is it something that brought the fish there, that's why last time the fish were biting, fish were there?" ... I found that very useful, 'cause it made me think about it too.

The fisher added, complimenting the facilitator's efforts to keep the group on task: "[If] I strayed too much the hammer would come down. It wasn't only with me. It was with scientists and other people too." Additionally, interviewees found the reorientation of comments toward solutions to

be helpful: “Letting guys vent when they needed to vent, and then coming back and saying, ‘Ok, so how are we gonna fix that? If you’re gonna grumble, come throw out a possible solution.’”

Given that disputes are expected within and across stakeholder groups, validating stakeholders’ perspectives and documenting the group’s final decision-making process is critical. Also critical is preparation for and expectation of conflict. A key lesson from stakeholders who participated in the Hawai‘i bottomfish fishery’s stakeholder engagement endeavors: that “conflict is endemic.” In these situations, conflict can provide an opportunity not to defend or explain, which can escalate conflict, but to listen and understand the perspective of others:

In the beginning [this scientist] was kinda like a punching bag for a lotta mad fishermen, and [the scientist] took it really well and still remained constructive.... [They were] frustrations that I'm sure she could understand. It definitely wasn't [the scientist's] fault, everybody knew that, but tensions run high in that kinda environment.

Hawai‘i stakeholders’ experience also taught them that achieving stakeholder cooperation and shared understanding is a process that takes years of consistent work, and that prioritizes relationship- and credibility-building.

Importantly, the success of many engagement strategies provided by interviewees hinges on shared commitment from all participants. One fisher commented:

When you guys have these meetings, you tell ‘em, “Ok, look... You can't just come and go as you please. When you start the day, you end the day here. You gotta be constructive.” ‘Cause you don’t want those guys that are just there to drop some bombs and disrupt things, and then walk out, and then come back later and disrupt again. You want the guys [that are there] to make a difference.... Unless it’s an emergency or something, this is a commitment that you’re gonna take seriously. And hopefully you’ll weed out the guys that shouldn’t be there.

Given the complexity of the communication and relational issues that underlie multi-stakeholder engagement in fisheries science and management, facilitation and mediation skills are also crucial. The personnel in these roles could benefit from some familiarity but also separation from participating stakeholders, “Working with fishermen and the agencies before [and] not being a part of any of the groups you’re contacting, that would benefit you, just because you have no affiliation with anybody locally.” However, interviewees also emphasized the importance of familiarity with local cultures and protocol. Local facilitators and mediators might therefore be explored. Skills helpful for mediation might not necessarily be held exclusively by those in facilitative roles. Participants may also help to bridge communication barriers and differential perspectives between stakeholder groups.

Interviewee recommendations around who to include in multi-stakeholder engagement also included key individuals that can facilitate access to their broader communities, and different sectors of the fishery that may not typically be represented in fisheries science and management discussions. While some argued for the inclusion of all fishing stakeholders that might have interest in bottomfish fisheries (from commercial fishers to non-commercial fishers to fish consumers), others recommended more selective inclusion based on the extent to which stakeholders would be impacted by potential management measures or fishers’ level of experience: “I think [include] the ones that are consistently doing it. Because those are the ones that are gonna impact the fishery the most, and those are the ones that any ACLs are going to

impact the most.” The specific goal of engagement endeavors will likely dictate criteria for inclusion. However, Guam stakeholders did express support for hearing from more diverse voices. Two examples are provided below:

I think you should cast a wider net.... Those [that are most vocal] are important, of course, but then there are those others that are quiet that are practicing the same thing and probably catch the same amount of fish, deep bottomfish... Perhaps it would be nice to hear their position and opinion on these things, or participate in the process.

I don’t want to see it that it’s always the same people at the AP, you know, the same people that are dealing with our same faces. I’d like to see new fishermen on there. Their input is valuable [and] I don’t really want to shut them out and exclude them. But as long as they understand that... this is what we want to talk about and they’re interested... then please join in.

Finally, it is important that multiple stakeholders from the fishery, local agencies, NMFS, and Council are present. This equips the group with different experiential and institutional perspectives and enables transparent, systems-level discussions. Interviewees also noted stakeholders’ presence demonstrates their shared commitment to the process, with benefits for stakeholder relationships and trust: “It was really good [to have statisticians and modelers] engaged in that process as well. So... industry folks didn’t feel like, ‘Oh well they’re too smart for us and they don’t want to be involved.’ It was more like, we’re all involved, we’re all gonna figure this out together.”

In Table 3, we compile key engagement insights derived from this study’s methodology, and Research Questions 1 and 2.

Table 3. Key engagement tips derived from data collection.

| Timing | Engagement tip |
|------------------------|--|
| Ongoing | Invest in building engagement capacity for PIFSC staff. |
| | Explore opportunities to systemically embed and incentivize engagement practices in fisheries science and/or management processes where appropriate. |
| | Communicate with fishing communities and managers as a way to acknowledge the impact of scientists’ work on others , even when engagement is not a part of the scientific process itself. |
| | Explore opportunities to collaborate with other stakeholders for the benefit of more robust science (e.g., to co-create methods and data, interpret or ground-truth results, etc.). |
| | Practice awareness of your position. E.g., How does the power of a U.S. federal scientist (and the historical role of the U.S. government) relate to that of a Guam fisher or a Guam agency employee? How might a PIFSC scientist’s work realistically impact other stakeholders, positively or negatively? |
| Engagement preparation | Begin by identifying the diverse stakeholders that participate in the fisheries, research, or management of the issue in question. Understand their functional roles in the fisheries operations, research, and management system and how they relate to one another. |
| | Start with empathy and curiosity. Build awareness of across- and within-group conflicts and institutional barriers for engagement to enable: |

| Timing | Engagement tip |
|-------------------|--|
| | <ul style="list-style-type: none"> • Sensitivity of historical and/or relational issues between groups, contextualizing issues that may arise later (e.g., Why do stakeholders behave the way they do? What values guide their decision-making? How do different stakeholders interpret the same discussion?). • Development of engagement processes that capitalize on shared stakeholder priorities like accurate data (Table 1) and accommodate their barriers to and incentives for participation (Table 2). <p>Engage early with other stakeholders when developing projects that require cooperation and/or uptake from other stakeholders to succeed in perpetuity. This helps to align messaging, reduce confusion, and maximizes efficient use of time/resources/energy.</p> <p>Consult existing engagement structures and community networks as appropriate, including the Council’s AP meetings, fishing clubs, Guam village fiestas, or that of the GFCA.</p> <p>If possible, host within-group discussions first to prepare for more complex multi-stakeholder engagement.</p> <p>“Conflict is endemic”: Prepare to listen and seek understanding, not internalize others’ frustrations. Expect to resolve conflict over a period of years, not a few meetings! These are complex issues.</p> |
| Engagement design | <p>Prioritize attendee accessibility when selecting meeting venues and format:</p> <ul style="list-style-type: none"> • Consider geographical location and settings that prioritize the comfort of target stakeholders. • Communicate in verbally and visually accessible formats (e.g., avoiding PowerPoints with lots of jargon and statistical data in community meetings). • Offer food or drink as a gesture of goodwill and respect. • Consider the accessibility costs and benefits of virtual meetings. <p>Establish and communicate ground rules and clear, attainable engagement goals early.</p> <p>Be intentional about who you include (and therefore who you may be excluding) in engagement processes and how those decisions serve your goals. Are the appropriate stakeholders properly represented?</p> <p>Encourage informal discussions (e.g., over lunch or refreshments) and networking in the spatial design and agenda of meetings.</p> <p>Design breakout groups or adjust group structure to enable participants’ input regardless of social status.</p> <p>Provide structure to group discussions using specific, directed questions.</p> <p>Ensure quality documentation and facilitation of engagement processes (e.g., respectful of individuals but adhering to meeting structure and intent). Consider local facilitators and mediators for such roles.</p> |
| During engagement | <p>Address layered communication issues by:</p> <ul style="list-style-type: none"> • Creating opportunities for stakeholders with interdependent roles to share information with one another. • Including people who can act as a “bridge between both sides.” • Communicating in language and formats that are accessible to your audience and sensitive to the different ways your audience may respond to terms (e.g., “standardization”). <p>When encountering another stakeholder’s concern, make an effort to understand the root of that concern and its emotional core (see section on 'Identity and power: Gear type and CPUE') rather than responding first with a technical/logical explanation.</p> |

RQ3: What benefits can we derive from stakeholder engagement?

Interviewees cited various goals and benefits that make stakeholder engagement valuable. We present direct quotes that illustrate the five most cited goals and benefits of engagement in Table 4. The most prominent goals and benefits of engagement were building shared understanding and facilitating information flow between stakeholders and improved fisheries science and management processes. Information sharing could occur uni-directionally, as one stakeholder shares information with another, or by facilitating information exchange between multiple stakeholders. Information of interest included various topics and their interconnectivity, from fishery operations to data to stock assessment to management. We outline these types of information in more detail in the next subsection, “Sharing information for shared understanding.” Benefits of stakeholder engagement to various fisheries science and management processes included facilitating stakeholder input to improve fisheries science and management, improved data submission and collection, and improved data treatment and stock assessment modeling.

Table 4. Interviewee commentary on engagement goals and benefits.

| Theme (# of interviews/ meetings in which theme was cited) | Illustrative quotes |
|---|---|
| Shared understanding + information (43) | <p>“It’s hard to get the whole group to understand it benefits everybody if the science is done really well, yeah? And it doesn’t favor any user group. So the best information and all the information presented would be the ideal.”</p> <p>“I just want the facts on the table, I want the truth laid out, and I want a solution to every exercise.... But it has to be discussed and it cannot be one size fits all, and it cannot be definite one side fits all. You know, stakeholders have to be involved, other organizations have to be involved so we find the truth.”</p> <p>“I feel like that could be informative for people top to bottom.... To know their whole process.... It sort of reminds me of the Karl Marx things about workers being disengaged from the fruits of their labor. If you’re working in a shoe factory, if you just tie one part of the shoe together versus being a shoe maker and you make the whole shoe and you see the whole thing and you understand why it’s important for the sole to be made this way and attached this way. And I think there’s always a lot of value in that for everybody.”</p> |
| Improved processes (43) | <p>“I was hoping that [the 2015–2016 Hawai‘i bottomfish] workshop would be a good opportunity to get everyone in the same room and help improve the science by involving people that spend way more time on the water with these species of concern. I was also expecting a lot of controversy and maybe animosity and lack of communication because everybody speaks such different languages whether it’s from the science side or the fishermen’s side. So I was hoping for improved management and assessment overall.”</p> <p>“I’m very grateful because there’s a lot more data coming from all of this... not only from our meetings and setting stock assessment, but it expanded to life history programs.... And it hasn’t stopped yet. We still send all of our onaga gonads.”</p> <p>“There was sort of the ongoing criticism about the data and that there wasn’t engagement early on with the fishing community. So the Stock Assessment group and FRMD I think is really making an effort to change that pathway by having some of these deep data workshops....</p> |

| Theme (# of interviews/ meetings in which theme was cited) | Illustrative quotes |
|---|---|
| | Hopefully they'll be able to get out of them the information they need [and] we're able to translate into actionable ways of dealing with the data." |
| Relationship building (20) | <p>"So, a lot of our work was to... build a mutual trust. Trust of the scientists by the fishermen that we were working in the best interest for them and future generations, and trust between the scientists and the fishermen that the fishermen were perfectly capable of collecting scientifically valid data following established protocols."</p> <p>"But everybody's input directed the fishery to where it is today. And it did not happen overnight. It took us years. Probably over 5 years? And working with all the scientists, working with all the managers, getting to know these people on a personal basis, and knowing that we can kinda work with each other to get to where we need to be to satisfy the management side and satisfy the fishing side."</p> <p>"A lot of the time [fishers] just don't want to talk when they're at the dock, but maybe meet for beers or lunch or dinner or coffee. That's the kind of... in my mind that's kind of where it really happens. Not only is there an exchange of information but that's also where the trust and the relationship building really occurs."</p> |
| Capacity building (15) | <p>"Hopefully the data workshops are not just for the fishers and the AP, but the territory agency biologists, too, or even the surveyors themselves.... So the surveyors understand how that information is being used so they can make sure that they're filling in all the areas that are needed and how it's often used and how if they don't do certain aspects how it could potentially underestimate or overestimate removals or CPUE."</p> <p>"One of the things that we really need in the territories are like homegrown people that are going to get Bachelor's degrees in science and then stay there and work there, because having the data manager change every two to three years for a lot of these surveys, and the surveys techs change every couple of years- It would be so much better if they could have a little bit more continuity."</p> |
| Improved legitimacy (14) | <p>"The model didn't get all these accolades just because it was something that we did... This is something <i>real</i>. Like real, not just beyond one desk using mathematical figures to figure out [a] quota.... I mean if we got just anybody to try to do it? These people put their heart and soul into it, I know that for a fact. They said they had some long nights figuring this thing out... I tip my hat off to these scientists because they had open minds."</p> |

Interviewees also noted the benefits of stakeholder engagement for relationship building between stakeholders, capacity building, and improving the legitimacy of fisheries science and management. Discussions around capacity building included references to building local capacity for fisheries science and management roles, improving stakeholders' engagement, emotional awareness, and communication skills, and enabling stakeholders to recognize and execute their role within a larger system. For example, by training those who report and collect data in species identification and the utility of key pieces of data for science and management; equipping fishers with technological training for electronic reporting; or, building capacity within the scientific community to meaningfully incorporate stakeholder input into scientific processes. Discussions around the improved legitimacy of fisheries science and management mostly focused on the perceptions of fishing stakeholders. However, this PIFSC stakeholder's commentary on the BFISH survey development process highlights opportunities to work together to produce science seen as more legitimate by multiple stakeholders:

We [communicated] with the fishermen that for a valid experimental design for the survey, we needed a standard sampling method... it was up to the fishermen to decide amongst themselves what that methodology would be... that's all their expertise, not ours. So, we worked with them for a couple years to develop a standard fishing method.... [That] generated a sense of engagement and value for the project for the fishermen. And then also made it much less likely for the fishing community to question the methods because they had developed them, they had a real intimate understanding of them. Many of the reasons for questioning a particular scientific method is due to lack of understanding, so that took care of that, and also can be due to lack of expertise in some of the research community about particular fishing practices and methods.... Bringing both of our strengths to the table, I feel we were able to come up with something that was quite robust that the fishermen could understand, could agree to, and that really resulted in the best methods.

Sharing information for shared understanding

The most prominently cited engagement benefit was shared understanding and information between stakeholders. Stakeholders requested certain types of information be shared better between stakeholder groups, expressing interest both as information sharers and recipients. Because information may provide opportunities to ground otherwise nebulous engagement practices in focused, collectively beneficial discussions, we summarize three key informational areas identified as important by stakeholders here: bottomfish fisheries, the data to stock assessment pathway, and fisheries management. Numbers in parenthesis denote the number of interviews or meetings in which each informational topic appeared.

Overall, stakeholders' discussions about information sharing were driven by these underlying themes: stakeholders need to understand their own role better in the context of the system, from fishery operations to management. Improved understanding of the roles and activities of other stakeholders may also help to stimulate more consistent engagement efforts that aren't dependent only on negative management outcomes. One interviewee noted, "A lotta people are quick to complain about the outcome, but not really wanna be a part of the process and figure out a way to make things better."

Bottomfish fisheries (n = 41)

Bottomfish fisheries were the most prominent topic discussed by stakeholders in the context of improving information flow between stakeholders. PIFSC stakeholders expressed a desire to learn from fishing stakeholders in the context of territorial assessments:

We need information from them. We need to know what's really going on there. But another huge benefit would be to add legitimacy to the stock assessment.... For the most part the data is going to speak for itself. But you don't know what you don't know.... The time for us to find out any surprises is definitely not after the assessment's been finished and approved for management. So, if there is any other interesting things, kind of lurking in how the data's collected or who's getting interviewed or even something simple like, "If the winds are blowing from the northwest, no one fishes." Just a statement like that, if true, would modify how we handle the data.

And, in the context of data workshops in Hawai'i:

Understanding [CPUE] needed a lot of input from fishermen.... Probably the biggest uncertainties are what's happening on the boats, from setting your gear, how your gear is configured, how you fish, what you're targeting, what can you target.... I think fishermen were

fairly communicative about it. Without forcing them to give up their secret spots or their secret techniques. We just generally needed to know more about how fishing is conducted.

Fishing stakeholders also expressed a desire to share information with PIFSC stakeholders, often expressing a lack of interest to receive on the scientific community's part: "There has to be more effort by the statisticians to look at... moon phase... weather conditions.... I love science. But at the end of the day, I wish that the scientists would love science, too."

The size distribution of catch and observations of spawning aggregations and egg-bearing fish were identified as desirable pieces of information by PIFSC stakeholders.

Factors affecting CPUE were of interest across stakeholder groups. These included fishery operations from beginning to end. How fishers decide to fish based on factors like weather and bait availability could provide relevant insights: "As a fisherman, tide is no good, bait is no good, ocean is rough we can't go fishing, there are reasons we don't catch fish. Sharks catch fish. But scientists only go by catch." Some factors that affect fishers' decisions to fish are inherently linked to the likelihood of catch success, including the season, tide and moon phase, depth, and currents. Fish behavior and depredation were also described as factors that could affect catchability.

A recurring theme across Hawai'i and Guam data collection was the importance of considering fishery participation and fisher skill level in stock assessment. One fishing stakeholder noted that the proportion of Guam's bottomfish fishery composed of highliners vs. more casual fishers changes through time, and includes time periods in Guam's fishing history when highliners were absent. Interviewees explained gaps in fishing skill with a lack of knowledge transfer from highliners to mentees, and the high skill level required to achieve high bottomfishing productivity. The interviewee also described one highliner's departure from the fishery, which likely led to a drop in catch documented by commercial receipt books: "It took 10 years for the next highliner to be equal to him. Ok? So, within that 10 years, there wasn't a decline in fish stocks. There was just no one able or who had that skill level to do it."

Stakeholders also noted the importance of fishing materials. For example, vessel size may dictate in what weather, with what kind of gear, and at what distances fishing activity occurs. Vessel type may also dictate whether fishers are subject to creel surveys, given that kayaks and small vessels may not return at marinas where sampling efforts are focused. Also of importance, fishers' decisions about what to target, whether or not to switch between methods, and the types of gear and technology acquired through time. This example illustrates the interconnectedness of these factors:

In the beginning it was bottomfishing only when the weather permits.... It was just too heavy to bring both trolling and bottomfishing gear. So, what you kind of end up doing is you end up waiting for good weather.... With technology, electric reels, spectra line, thinner line means you don't have to have heavier weights. Everything is streamlined. Nowadays you can bring both gear on the boat and be feasible. So I would say in the past you had to choose, whereas the past 8 years, you could actually bring both gear. Yeah, the technology has changed, and the price! The price has gone down. Before 10 years ago, you could get decent electric reels out of Japan, but they were a couple grand a piece.... [Now] everyone's making electric reels and you can get a

decent one in the \$500 range. So, the price of gear, the technology of the gear, and the downsizing of the gear has really made it feasible to bottomfish.

These kinds of changes through time are critical because, as one PIFSC stakeholder noted, “in order to impact an assessment, you have to have a change over time.”

Stakeholders’ desire for improved sharing of bottomfish fisheries information was largely in the direction of fishing stakeholders to PIFSC stakeholders. However, some fishing stakeholders expressed interest in receiving information about their fisheries. Topographical maps, information about fish behavior and distribution (including sharks, for avoidance purposes), fish life history, and oceanographic information like temperature and currents could be helpful resources for the fishing community. Some fishers noted that this information is available online for the United States, but often not available with specificity to the territories.

Data to stock assessment pathway (n = 35)

Stakeholders expressed interest in learning and sharing more information about the pathway that connects fisheries data to stock assessment, from fishery data generation to data management, to data expansion, and stock assessment. Critical to this endeavor is multi-stakeholder engagement, which could bring to the table representatives from territorial agencies, PIFSC, Council, and the fishing community. The presence of multiple stakeholders facilitates efficient access to their various decision-making roles and expertise:

“We’ll have to get that information back to you,” is never really a good answer.... As long as there is someone there that can directly respond to how it’s done and what’s being done and take valuable feedback as opposed to [Council staff] sitting in... and jumping in and answering it. I think that would be the best [if] we can see the person actually doing it.

Accessing multiple stakeholders’ experiential and institutional knowledge is key because of the inherent connectivity of stakeholder roles. For example, fisheries data is co-created between fishers’ experiences and local agencies’ data collection and management processes, both of which change through time via mechanisms that may not be well documented in the data itself. Together, fishers and territorial agencies’ institutional and experiential knowledge may elicit new understanding of how statistical data should be interpreted by stock assessors to represent fisheries. Stakeholders noted the value of the following:

Being able to talk to the fishermen about some of the problems with the fishery dependent data stream in terms of how it’s incorporated into the Stock Assessment model and data filtering... And then working with the fishermen to come up with the best mitigation metrics and methods to improve the way [that data] is treated in the Stock Assessment. I know that those discussions were very fruitful. I know that the Stock Assessment scientists found them very valuable.

One thing that I think would be really important would be actually going over the intercept or interview questions.... How does the intercept and interview, and the actual questions asked, and then the participation survey, how does it all come together in the expansion? ... Adding stock assessors and fishers at the same time, reviewing all that—that’s not something I’ve ever seen at the SSC or at the Council to that level.

Beyond bottomfish fishery operations themselves, PIFSC stakeholders described other types of information they might seek from fishing stakeholders for stock assessment: “There [are] more

obscure things on the ground that fishermen and local agencies—the ones that actually do the sampling—can tell us... They could help us interpret some of these patterns.” As one example, this interviewee expressed interest in the different types of fish preferences vendors might have that could create or negate sampling bias. PIFSC stakeholders also described challenges related to fish identification that may or may not be integrable to data treatment processes. One challenge is changing species identifications through time, which might occur as survey technicians are trained in new species identification protocols, or as new species identified (as is the case with a new ehu). Another challenge: local common names and scientific species names do not have a one-to-one relationship (e.g., three opakapaka species, 10–15 mafuti species in Guam). They may be reported differentially by fishers. Understanding these disconnects between data generation through time and data treatment will be increasingly important as stakeholders explore opportunities to split the BMUS complex into smaller groups, potentially individual species, for stock assessment.

Another PIFSC stakeholder noted the need to set expectations about how stock assessments can be modified to accommodate new information:

The goal is always to improve our products. And I would like for the stakeholders to understand that although we might agree that the SA has issues, we [don't] necessarily need or have to discredit it completely. It's important for us to understand and try to find ways to minimize potential misinformation, but they will exist, and there's nothing we will do about it. We just have to find the best way we can to accommodate the limitations. But no stock assessment is perfect.

For this reason, it may be helpful to build stakeholders' shared understanding of scientific processes underlying stock assessment. One fisher noted:

Somehow the model is set up to make those unknowns, knowns. And that's a hard part for fishermen to grasp. That a model can make that happen. So that's something that the fishermen were able to learn from the scientists. And that the scientists don't have just one model, but that they try to fit the best model to the situation.

PIFSC stakeholders may also help to clarify how fishers' and data collectors' reported data is used, with details about how information should be provided to accurately represent fishing activity, and implications for science and management. One Hawai'i fisher noted the potential for these types of information to improve reporting by clarifying misunderstandings:

The greatest disconnect was this: The general philosophy among fishermen was, if we don't report what we catch, the presumption was there's more fish in the ocean to be caught. That's 180 degrees out of context because if there are more fish in the ocean, you ought to be able to catch more. If there are fewer fish in the ocean, you're gonna catch less. And that was probably the “aha” moment for myself and couple of my friends. To this day, it is still not an “aha” moment for many of my peers.

There is value also in explaining and examining together more complex processes, such as the algorithm that expands creel survey data to represent territorial bottomfish fisheries. Both fishing and territorial agency stakeholders expressed interest in learning about the expansion algorithm from PIFSC stakeholders to help identify key first steps toward improving stock assessment:

The mathematics of when we do surveys, how do we expand that to the rest of the day and how do we expand that to other ports... I'm kind of wondering if maybe it's time to reevaluate these expansion systems... If we need to increase the number of survey days, I would like to hear that from Science Center. Because you don't just want to increase surveys and it's not going to improve anything... I think maybe relatively soon I need to kind of engage with them and kind of rediscuss some of the mathematics that we have that maybe needs to be tweaked a little bit more to [make] at the end of the day, the numbers at least more accurate.

Sharing information about the data generation and treatment with fishing stakeholders provides them opportunity to understand and comment on the connections made between their experience of the fishery and its statistical representation with available data. One interviewee suggested that after data has been collected, scientists, "Create a story with the data and ask back. These are the samples that we got from. Do you think this represents the fishing effort and catch? Is there anything that we are missing?" In addition to the potential to modify data treatment practices, sharing this information between fishing, PIFSC, and territorial agencies stakeholders provides opportunity for transparency and improved legitimacy:

I would find it interesting and helpful... an entire presentation [about] how the data is collected and how it's used to develop opinions. Opinions. About the condition of different stocks. The whole treatment. You know, not a dissertation, but something that shows how the data is used. Because fishermen will be able to spot where the weaknesses are.... [If] they can't spot any data weaknesses, it may build the credibility of the conclusions.... If they don't know, they'll just assume the worst most of the time.

Interviewees also noted that in the absence of transparent, explicit discussions around scientific decisions and processes, stakeholders are left to ponder the kinds of political factors that might have affected outcomes.

Fisheries management process (n = 16)

In addition to sharing information about fisheries, data, and stock assessment science, stakeholders described value in sharing information about fisheries management processes. Interviewees recommended different variations of "Fisheries Management 101" to help stakeholders understand how management works through a low resolution, big picture lens. This might cover such topics as: what management tools are available, how they are implemented across territorial and federal waters, and by whom. One fisher with previous involvement in Council meetings and committees noted the steep learning curve experienced as he was newly exposed to federal management frameworks and mandates. Given the system's complexity, the fisher noted that many things "sank in after the fact," years later.

Interviewees described potential for stakeholders' understanding of fisheries management to help stimulate their willingness to engage; for example, by helping them grasp the gravity of negative management outcomes. However, keeping stakeholders updated, regardless of the urgency of management actions, can also be valuable for building and maintaining relationships: "Just tell them the facts, and what's coming down the pipe." Interviewees noted fishing stakeholders' requests not to be "regulated before they are educated."

Awareness of management processes and implications can also be improved for the scientific community, as this interviewee noted:

Having that dialogue between the Science Center, that placed the Stock Assessment Program, you know, they became immersed to the fishing community instead of doing their work in a black box. In a bubble, independent of what's going on in terms of management issues and what's really happening in the water.

Life history (n = 6)

Fishing stakeholders expressed general interest in both receiving from and providing life history information to scientists. There was general interest from fishing stakeholders to learn about fish life history and the connections between biosampling data and stock assessment, especially in situations where they helped to collect or submit samples to scientists. Fishing stakeholders also described a desire for PIFSC to better receive and use life history information they collect:

We've collected maybe over 60 samples of otoliths of onaga species. So, at the end of the day, we're very excited about collecting data. The problem is, like when we did the non-commercial survey, nobody wanted from the Science Center to help us out in compiling data.... all the fish that we have received from our fishermen have shown reproduction year-round.

Discussion

Fishing communities, Council stakeholders, and territorial and federal agency scientists and managers are separated by geography, language, historical conflict and mistrust, institutional cultures, and the specialized knowledge wielded by each stakeholder group. These shape different and often conflicting views of concepts as fundamental as what makes science good, and how science should intersect with stakeholder engagement or management. Yet, these stakeholders' roles are highly interconnected and interdependent in their contribution to territorial bottomfish fisheries and their stock assessment. This project represents a first step in bridging these gaps to build relationships and shared understanding through a multi-stakeholder engagement process.

Through interviews and participant observation, we identified various challenges. Forces unique to each stakeholder group shape and constrain their role fulfillment. Fishing stakeholders face cultural norms and high costs of engagement. Territorial agencies and survey technicians juggle a wide variety of responsibilities, limited funding, and practical challenges in the field. Council stakeholders' diversity requires them to navigate varied interpretations of how different types of information should inform their recommendations and how science and management should interact. These manifest in both interpersonal differences and internal conflict. PIFSC stakeholders are beholden to federal frameworks and timelines, with little institutional support for stakeholder engagement.

Stakeholders' behavior is also guided by a combination of priorities and engagement incentives. Understanding where these converge and diverge across stakeholder groups allows us to leverage them for collective efforts and benefits. Shared priorities like improving data accuracy may represent the lowest hanging fruit. However, divergent stakeholder priorities provide opportunities to acknowledge and validate those differences and seek creative solutions that appeal to each stakeholder's values. For example, understanding stakeholder-specific engagement incentives may allow us to improve stakeholder participation through mechanisms that are meaningful and accessible to them (e.g., by facilitating their access to data or offsetting engagement costs; Ayers et al. 2017). The last territorial bottomfish stock assessments escalated tensions between stakeholders and highlighted the criticality of science and management decisions. However, it also served as a unique catalyst, synchronizing stakeholders' diverse engagement interests and timelines. We are thus presented with a great challenge and opportunity.

Upon these within-group forces that inform stakeholders' behavior, we layer communication issues and the sociopolitical contexts that underlie their engagement with one another. The cases we present demonstrate stakeholders' variable interpretations of "good science," discussions around gear efficiency and CPUE, and the CILI application. They teach us that few institutionalized mechanisms exist to hold "good science" and management accountable to "good data." They illustrate the ways in which stakeholders make vastly different associations with shared subject matter and language, from the technical aspects of stock assessment to poor relationships between the federal government and the territories, or threats to culture and ways of life. These different interpretations then direct us to different solutions components, including: increasing education around scientific processes, standardizing the notation of fishing effort in data collection efforts, or validating power differentials and the distinctness of territorial fisheries

from those in the states. If ignored, these different interpretations of shared discussion may inhibit effective communication and unnecessarily escalate conflict. Further, they may be assumed to contradict one another instead of illuminating different facets of a shared problem and, in turn, more robust multi-pronged solutions. We suggest that these underlying challenges be used to tailor communication and engagement that is inclusive of multiple values and perspectives, rather than attempting to separate them from their topical discussions. This respectful navigation of “other” values, beliefs, and identities is critical for effective navigation of conflict (Madden 2015).

From these examples of communication and sociopolitical disconnects between stakeholders, we find the following may be helpful: Prior to engagement and data workshops, PIFSC stakeholders might clarify the extent to which territorial agency and fishing stakeholders’ input may be integrated into stock assessment science to improve its validity without compromising scientific integrity. NMFS stakeholders might work to structure engagement and messages around solution-finding, and in concert with other participating stakeholders, refrain from offensive or defensive posturing. Agency guidance recognizes the importance of both managing expectations around NMFS-external stakeholders’ level of influence on agency action and accounting for all stakeholders’ partial understanding of systemic issues through an inclusive process that seeks “complete information” (NOAA OCM 2015). Coordinating such efforts will require great collective investment. But, given the systemic connections between stakeholders and institutions, coordination is necessary to achieve change and critical to avoid redundant initiatives, conflicting narratives, and further degraded trust between stakeholders (Madden 2015). Some of these practical remedies to communication issues are highlighted in the compiled list of engagement insights derived from data collection (Table 3). We elaborate upon Table 3 below.

Interviewees also highlighted value in different engagement strategies to help achieve engagement outcomes. Meeting stakeholders where they are geographically and in terms of their perspectives and values were noted to encourage participation. Meeting stakeholders in settings comfortable for them, whether virtual or in-person, formal or informal, may also encourage participation and facilitate input. Preparing for multi-stakeholder engagement by first meeting in smaller groups can help to circumvent social hierarchies and inter-stakeholder conflict, and encourage the sharing of perspectives that are more diverse. Directed questions, documented decision-making, and balancing validation with maintaining discussants’ focus on shared, clearly communicated goals can benefit group productivity and preserve group time and energy. Although the specific goals of engagement will likely determine who is included, care should be taken not to exclude perspectives prematurely. Part of the work that may precede engagement is identifying missing voices to diversify the conversation as much as is appropriate, while respecting the time and efficiency of meetings and their attendees. Capacity for stakeholder mediation and culturally sensitive facilitation is also key.

The process-focused elements of engagement we outline above align with a body of work across disciplines that identifies early and collaborative goal-setting, inclusivity, committed staff in facilitative roles, and transparent decision-making as critical engagement processes and to achieve project outcomes with maximum utility to multiple stakeholders (Mease et al. 2018; Reed 2008; Vaughan & Caldwell 2015; Beierle & Cayford 2002). A process that prioritizes mutual learning and dialogue-based communication (as opposed to persuasive communication) may result in mutual respect and collective support for decision-making, even when topical

disagreements are not resolved (Leong et al. 2007). We hope that these strategies will help to facilitate not only topical discussions around fishery operations, data collection, and stock assessment, but build relationships between stakeholders that persist upon workshops' conclusions (Hartley & Robertson 2006).

Although stakeholders valued engagement outcomes like relationship-building and improved legitimacy of fisheries science and management, these may not be powerful enough incentives to overcome the high costs of engagement. Sharing information to promote collective understanding of the system, improving fisheries science and management processes, and improving stakeholders' capacity to better fulfill their roles were among the more tangible outcomes that stakeholders valued and hoped for. Engagement may therefore benefit from a tangible goal like sharing information more effectively between stakeholders, while mobilizing process-focused engagement strategies that are sensitive to underlying sociopolitical contexts.

Upcoming stock assessment data workshops, for example, may facilitate information exchange that informs modified data treatment to better reflect realities of the fishery. Or, if stakeholder input is not integrable into stock assessment models in the short-term, it may help to identify data gaps (Carruthers & Neis 2011) or inform new collaborative research efforts to address such gaps (Wendt and Starr 2009).

Interviewees described a lack understanding and coordination in the ways that their roles connect to others'. PIFSC stakeholders deliver survey sampling designs to territorial agencies with little awareness of how they are implemented, and produce best science available based on data for which they lack context. Territorial agencies are asked to implement survey designs for an expansion algorithm executed by WPacFIN, and neither of these stakeholders feel they have ownership or understanding of the expansion algorithm. Fishing stakeholders are asked to submit data to agencies they do not trust, for use in scientific and management processes for which they lack context. In their silos, stakeholders are left to conceptualize "good" role fulfillment based on priorities and values shaped by their communities, leadership, and federal mandates. Without effective communication, stakeholders are also left to make assumptions about the intentions and activities of other stakeholders, perpetuating mistrust and defensive or offensive posturing. We therefore must negotiate stakeholders' diverse and incomplete perceptions of a problem in our diagnosis of problems and pursuit of efficient solution pathways (Adams et al. 2003; Bond and Morrison-Saunders 2011; Watkin et al. 2012).

We suggest that multi-stakeholder engagement be applied to a systemic assessment in which stakeholders build shared understanding of the following processes: fishery operations, data generation, data treatment, stock assessment, and management systems. Stakeholders identified several processes that require demystification that could ground such an effort. They are captured by the following questions: How is the creel survey implemented and how does this differ from its sampling design? What assumptions are made by stock assessment models and the expansion algorithm? Do these assumptions align with, as much as possible, fishers', survey technicians', and data managers' experiences and interpretations of data they co-create?

In an effort to expand beyond unidirectional info-sharing toward building relationships and collaborating with the community (International Association for Public Participation 2018), our engagement process may employ strategies such as workshops, focus groups, interviews, and

public meetings (Walsh et al. 2017). These methods may be used to execute a targeted engagement process and evaluate its impact: documenting changes in relationships, understanding of the stock assessment process, or perceptions around providing input into stock assessment, for example. If possible, such meetings will be held in person in Guam to encourage participant familiarity and effective collaboration (Ansell and Gash 2007), but the criticality of consistent engagement and the stock assessment timeline necessitates engagement, whether virtual or in-person.

Finally, institutional frameworks are not conducive to proactive stakeholder engagement (Yaffee and Wondolleck 2003; Leong et al. 2011). In this system, individuals comprising the stakeholder groups we have identified must go above and beyond their institutional roles as scientists, managers, or fishers—propelled by their individual values—to acquire and commit resources to improving communication, multi-stakeholder collaboration and, ultimately, territorial stock assessments. This not only places a burden on individuals but makes the system vulnerable upon individuals' departure. Personnel turnover and all stakeholders' withdrawal due to engagement fatigue threatens losses in engagement continuity, institutional knowledge, and key relationships dependent on such individuals. We therefore highlight the need for NMFS' systemic, institutional support to incentivize engagement and build sustained capacity amongst its staff to engage more effectively (Nguyen et al. 2019).

Future work

As information is shared during multi-stakeholder engagement, effort should be made to minimize translation issues and maximize accessibility for all stakeholder groups. Participatory modeling is an engagement approach that synthesizes the perspectives of stakeholders and represents them in a shared model. Many types of participatory modeling tools require different levels of technical expertise and integrate different proportions of qualitative vs. quantitative data (Voinov et al. 2018). These may be explored and tested in future studies.

Fuzzy Cognitive Mapping (FCM) is one qualitative participatory modeling tool that can help to communicate information about complex systems in a way that is accessible to diverse audiences. Inherent in FCM is the assumption that there are different theories around a phenomenon or system. FCM thus accommodates diverse ways of knowing in its simple representation of variables and their directional impacts on one another (Andersson and Silver 2019). FCM also fosters collaboration and trust-building through transparent discussion (Dion et al. 2018). When stakeholders are included as variables themselves, FCM can help to identify exogenous (e.g. climate change) and endogenous (e.g. fire users behavior) variables that help individuals realize agency in their various stakeholder roles (Devisscher et al. 2016). For these reasons, we suggest participatory modeling or simple cognitive maps as a tool for upcoming multi-stakeholder engagement endeavors, whether they seek to make stock assessment models and their assumptions accessible to diverse stakeholders, or establish collective understanding of the bottomfish fishery and stock assessment system.

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Literature Cited

- Adams W, Brockington D, Dyson J, Vira B. 2003. Managing tragedies: Understanding conflict over common pool resources. *Science*. 302(5652), 1915–1916.
<https://doi.org/10.1126/science.1087771>
- Allen S, Bartram P. 2008. Guam as a Fishing Community. Pacific Islands Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-08-01, 61 p.
- Amesbury SS, Myers RF. 1982. Guide to the Coastal Resources of Guam, Vol 1. Fishes. University of Guam Press.
- Andersson N, Silver H. 2019. Fuzzy cognitive mapping: An old tool with new uses in nursing research. *J Adv Nurs*. 75. 3823-3830. doi:10.1111/jan.14192
- Ansell C, Gash A. 2007. Collaborative governance in theory and practice. *J Public Adm Res Theory*. 18, 543-571. doi:10.1093/jopart/mum032
- Ayers AL, Leong KL. 2020. Examining the seascape of compliance in U.S. Pacific island fisheries. *Mar Pol*. 115, 1–13. doi:10.1016/j.marpol.2020.103820
- Beierle TC. 2002. The quality of stakeholder-based decisions. *Risk Anal*. 22(4). 739-749.
- Beierle TC, Cayford J. 2002. Democracy in practice: Public participation in environmental decisions. Taylor & Francis Group. Retrieved from ProQuest Ebook Central, <https://ebookcentral.proquest.com/lib/uhm/detail.action?docID=592521>
- Bond AJ, Morrison-Saunders A. 2011. Re-evaluating sustainability assessment: Aligning the vision and practice. *Environ Impact Assess Rev*. 31 (1), 1–7.
<https://doi.org/10.1016/j.eiar.2010.01.007>.
- Carruthers EH, Neis B. 2011. Bycatch mitigation in context: Using qualitative interview data to improve assessment and mitigation in a data-rich fishery. *Biol Conserv*. 144. 2289-2299. doi:10.1016/j.biocon.2011.06.007
- Cinner JE, McClanahan TR, MacNeil MA, Graham NAJ, Daw TM, Mukminin A, ... Kuange J. 2012. Comanagement of coral reef social-ecological systems. *PNAS*. 109(14), 5219-5222. doi:10.1073/pnas.1121215109
- Devisscher T, Boyd E, Malhi Y. 2016. Anticipating future risk in social-ecological systems using fuzzy cognitive mapping: the case of wildfire in the Chiquitania, Bolivia. *Ecol Soc*. 21:4. doi:10.5751/ES-08599-210418
- Dion A, Joseph L, Jimenez V, Gutierrez AC, Ameer AB, Robert E, Andersson N. 2018. Grounding evidence in experience to support people-centered health services. *Int J Public Health* 64:5. 797-802. doi:10.1007/s000038-018-1180-9

- Golden AS, Naisilsisili W, Ligairi I, Drew JA. 2014. Combining natural history collections with fisher knowledge for community-based conservation in Fiji. *PLoS ONE*. 9(6). e98036. doi:10.1371/journal.pone.0098036
- Hartley TW, Robertson RA. 2006. Stakeholder engagement, cooperative fisheries research and democratic science: The case of the Northeast Consortium. *Hum Ecol Rev*. 13(2). 161-171. Retrieved from <http://www.jstor.com/stable/24707588>
- Hønneland G. 1999. Co-management and communities in the Barents Sea fisheries. *Hum Organ*. 58(4). 397-404.
- International Association for Public Participation. 2018. IAP2 spectrum of public participation [Table]. *Spectrum*. Retrieved from <https://www.iap2.org.au/resources/spectrum/>
- Langseth B, Syslo J, Yau A, Carvalho F. 2019. Stock assessments of the bottomfish management unit species of Guam, the Commonwealth of the Northern Mariana Islands, and American Samoa, 2019. NOAA Tech Memo. NMFS-PIFSC-86. 177p. (+supplement, 165 p.). doi:10.25923/bz8b-ng72
- Leong KM, McComas KA, Decker DJ. 2007. Matching the forum to the fuss: Using coorientation contexts to address the paradox of public participation in natural resource management. *Environ Pract*. 9. 195-205. doi:10.1017/S1466046607070330
- Leong KM, Emmerson DP, Byron R. 2011. The new governance era: Implications for collaborative conservation and adaptive management in Department of Interior agencies. *Hum Dimens Wildl*. 16. 236-243. doi:10.1080/10871209.2011.585436
- Loucks L. 2007. Patterns of fisheries institutional failure and success: Experience from the Southern Gulf of St. Lawrence snow crab fishery, in Nova Scotia, Canada. *Mar Pol*. 31. 320-326. doi:10.1016/j.marpol.2006.09.005
- Mackinson S, Nøttestad L. 1998. Combining local and scientific knowledge. *Rev Fish Biol Fish*. 8. 481-490.
- Madden F. 2015. People and Wolves in Washington: Stakeholder Conflict Assessment and Recommendations for Conflict Transformation. For the Washington Department of Fish and Wildlife. Retrieved from <https://wdfw.wa.gov/publications/01719>
- Mease LA, Erickson A, Hicks C. 2018. Engagement takes a (fishing) village to manage a resource: Principles and practice of effective stakeholder management. *J Environ Manage*. 212, 248-257. doi:10.1016/j.jenvman.2018.02.015
- Myers R. 1993. Guam's small-boat-based fisheries. *Mar Fish Rev*. 55(2):117–128.
- Neis B, Schneider DC, Felt L, Haedrich RL, Fischer J, Hutchings JA. 1999. Fisheries assessment: what can be learned from interviewing resource users? *Can J Fish Aquat*. 56(10). 1949–1963. doi:10.1139/cjfas-56-10-1949

- Nguyen VM, Young N, Brownscombe JW, Cooke SJ. 2019. Collaboration and engagement produce more actionable science: quantitatively analyzing uptake of fish tracking studies. *Ecol Appl.* 29(6). 1316-1330. doi:[10.1002/eap.1943](https://doi.org/10.1002/eap.1943)
- NOAA Office for Coastal Management. 2015. Introduction to stakeholder participation. 15 p. Retrieved from <https://coast.noaa.gov/data/digitalcoast/pdf/stakeholder-participation.pdf>
- Reed MS. 2008. Stakeholder participation for environmental management: A literature review. *Biol Conserv.* 141. 2417-2431. doi:10.1016/j.biocon.2008.07.014
- Rubinstein D. 2001. A Sociocultural Study of Pelagic Fishing Activities in Guam. Final progress report available from University of Hawai'i Joint Institute for Marine and Atmospheric Research, Pelagic Fisheries Research Program. Also available at: <http://www.soest.hawaii.edu/PFRP/pdf/rubinstein01.pdf>
- Vaughan MB, Caldwell MR. 2015. Hana pa'a: Challenges and lessons for early phases of comanagement. *Mar Pol.* 62. 51-62.
- Voinov A, Jenni K, Gray S, Kolagani N, Glynn PD, Bommel P, ... Smajgl A. 2018. Tools and methods in participatory modeling: selecting the right tool for the job. *Environ Model Softw.* 109. 232-255. doi:10.1016/j.envsoft.2018.08.028
- Walsh EA, Becker WJ, Judelsohn A, Hall E. 2017. Civic infrastructure and sustainable regional planning: Insights from the sustainable communities initiative regional planning grantees. *Cityscape.* 19(3). 63-92.
- Watkin LJ, Kemp PS, Williams ID, Harwood IA. 2012. Managing sustainable development conflicts: The impact of stakeholders in small-scale hydropower schemes. *Environ Manage.* 49. 1208–1223. <https://doi.org/10.1016/j.eiar.2010.01.007>
- Wendt DE, Starr RM. 2009. Collaborative research: An effective way to collect data for stock assessments and evaluate marine protected areas in California. *Mar Coast Fish: Dynamics, Management, and Ecosystem Science.* 1. 315-324. doi:10.1577/C08-054.1
- Western Pacific Regional Fishery Management Council. 2019. Annual Stock Assessment and Fishery Evaluation Report: Mariana Archipelago Fishery Ecosystem Plan. Retrieved from <https://www.wpcouncil.org/wp-content/uploads/2020/07/Marianas-FEP-SAFE-Report-2019-Final-v4.pdf>
- Yaffee SL, Wondolleck J.M. (2003). Collaborative ecosystem planning processes in the United States: evolution and challenges. *Environments.* 31(2), 59 p. *Gale Academic OneFile*, link.gale.com/apps/doc/A111855599/AONE?u=anon~702210dc&sid=googleScholar&xid=a4abf156. Accessed 24 Sept. 2021.
- Yau A. 2018. Report from Hawai'i bottomfish commercial fishery data workshops, 2015-2016. NOAA Tech Memo. NMFS-PIFSC-68. 105p. doi:10.7289/V5/TM-PIFSC-68

Young N, Corriveau M, Nguyen VM, Cooke SJ, Hinch SG. 2016. How do potential knowledge users evaluate new claims about a contested resource? Problems of power and politics in knowledge exchange and mobilization. *J Environ Manage.* 184. 380–388.
doi:10.1016/j.jenvman.2016.10.006