



Engaging formal and informal institutions for stewardship of rockfish fisheries in the Gulf of Alaska

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ABSTRACT

Examining relationships between formal and informal institutions for governing small-scale fisheries may reveal pathways for effectively engaging resource users in management. This study explored formal and informal institutions for management of rockfish (*Sebastes* spp.) fisheries in the Gulf of Alaska. Forty-three experts (fishers and agency staff) were interviewed about their engagement with rockfish management. We analyzed interactions and gaps between formal and informal management institutions using the Inter-Institutional Gap (IIG) framework. Participation in the State of Alaska Board of Fisheries (BOF) process, a formal management institution, was viewed by some experts as more effective for enacting regulatory change, compared to informal institutions. However, fishers who were deterred from engaging with the BOF by complex bureaucratic processes tended to favor informal interactions with the Alaska Department of Fish and Game (ADF&G) through visits to local offices and communication with port samplers. Formal institutional gaps identified by experts included transparency issues regarding regulatory decisions and/or interpretation, underrepresentation of recreational and subsistence harvesters in the BOF process, complexity of regulations, and bureaucratic barriers to coordination between the Sport and Commercial divisions of ADF&G. Informal institutions of self-governance, such as stewardship actions taken by fishers to reduce bycatch and minimize harm to incidentally caught fish, were identified by fishers and agency staff as important to rockfish fishery sustainability. Communication gaps in rockfish management may also be addressed by strengthening informal institutions that build trust and relationships between fishers and agency staff, such as collaborative research to coproduce knowledge about rockfish ecology.

1. Introduction

Natural resource management challenges have emerged as a result of failures in governance [1], sometimes arising from institutional rigidity (“command and control” management; [34]). Solutions may stem from the design of effective governance structures that are participatory, responsive, clearly defined, and locally relevant [48], while recognizing that there is not a single, universally successful approach to management of common-pool resources [1]. Management systems composed of formal and informal institutions that interact can improve the outcomes of governance [49,50]. Formal institutions operate around an organized set of rules and bureaucratic governance, whereas informal institutions function under a system of more flexible rules based upon customs, traditions, and norms of conduct [45]. While institutions are set up to

address problems and conflict in a system, the source of conflict may emerge within the institutions themselves [38].

Examining the interactions between formal and informal institutions governing small-scale fisheries may help to identify pathways for improved public participation in fishery management. Engagement of community members in environmental decision-making can improve the quality and relevance of outcomes for participants [21,60]. For example, advisory groups can be an effective strategy for engaging expertise in fishing communities to help communicate community concerns and facilitate joint problem-solving between the public and formal management institutions [42]. However, gaps between formal and informal institutions, or the absence of rule-based interactions [50], can create barriers to effective public engagement. Gaps can arise from a range of mechanisms, including low social capital to bridge formal and

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informal institutions, lack of communication and information flow between government officials and community members, and cultural mismatches between local customs and formal rules [50]. In fisheries, such gaps have led to unequal power dynamics, weak inclusion of fishers in decision-making, fishery access challenges, and limited knowledge sharing among institutions [29,35].

Here, we examined how formal and informal institutions interact in the management of commercial and recreational (sport) fisheries for nearshore rockfishes (*Sebastes* spp.) in the Gulf of Alaska. Rockfishes in this region have experienced increased fishing pressure from commercial and sport sectors and declining biomass for some species since the 1970s, raising concerns about long-term fishery viability [31]. Since 2016, a series of increasing restrictions has been imposed on fisheries in Alaska state waters (within 3 nmi from shore), including reduced bag limits for sport fisheries [36] and fishery closures or bans on directed harvest of most non-pelagic and demersal shelf rockfishes for sport, personal use, and commercial fisheries in Southeast Alaska [4,5]. While rockfish issues have not been elevated to the same level of management concern as other prominent state-managed fisheries in Alaska (e.g., Cook Inlet salmon, [33]; Sitka herring, [14,58]), emerging conservation challenges and increasing restrictions have focused more attention on rockfish monitoring and management since the mid-2010s [19,36].

The primary formal institutions managing rockfish fisheries in state waters are the Board of Fisheries (BOF) and Alaska Department of Fish and Game (ADF&G), both established in 1959 by the state legislature (Alaska Stat. § 16.05.010, Alaska Stat. § 16.05.221). The BOF makes regulatory decisions about fishing seasons, allocations, spatial management, and gear restrictions for commercial, sport, subsistence, and personal use fisheries (Alaska Stat. § 16.05.251). ADF&G is tasked with enforcing regulations set by the BOF, permitting, and conducting fisheries and biological surveys to monitor stock status [6]. The North Pacific Fishery Management Council (NPFMC) is the formal institution governing fisheries in the U.S. Exclusive Economic Zone (3–200 nmi) off Alaska, including federally managed rockfish fisheries in the Gulf of Alaska [46]. State and federal management is coordinated between the BOF and NPFMC for several stocks, including yelloweye rockfish within the demersal shelf rockfish assemblage [7].

Alaska's fisheries management institutions provide platforms for the public to participate in management processes. The BOF accepts regulatory proposals for consideration from any group or member of the public. There are four to six BOF meetings each year, with specific geographic regions of the state slated for review of proposals on a three-year cycle [12]. The public may submit written comments on proposals prior to meetings or deliver oral public testimony during meetings [8]. In addition, ADF&G Advisory Committees (ACs) are local groups of fishers, industry, and community members that provide forums for input on state fishery management and conservation issues [3]. There are 84 geographically based ACs throughout the state, each composed of up to 15 members who are selected to represent multiple communities and user groups [3]. ACs develop regulatory proposals and provide input on other proposals submitted to the BOF; they may also set emergency closures when delegated by the Commissioner [13], though this privilege is rarely used in practice. Fishers may serve as AC members in their community of residence and/or attend any regional AC meeting as a member of the general public. ADF&G staff attend AC meetings to answer questions and provide interpretation of submitted proposals from an agency perspective. Parallel opportunities for engagement exist at the federal governance level [47].

The goal of this study was to identify the interactions and gaps within and among formal and informal institutions for state-managed rockfish fisheries in the Gulf of Alaska during a time of rapid regulatory and environmental change. Using data gathered from semi-structured interviews with fishers and agency staff, we addressed the following questions: (1) What roles do formal and informal institutions play in rockfish management?; (2) What is the relative value that fishers and agency staff place on formal versus informal institutions in a rockfish

management context?; and (3) What barriers to participation exist in formal and informal institutions and how do they differ among rockfish fishery sectors? We focused on Sitka and Kodiak, communities in the eastern and central Gulf of Alaska where rockfish issues have been an emerging management concern [31]. In Sitka, the guided sport (charter) fishery has grown dramatically in recent years, with rockfishes more frequently targeted over the last decade [19]. Kodiak is home to a growing black rockfish jig fishery and has also experienced increases in rockfish harvest by the charter fleet [31]. Through our analysis, we identified existing pathways for public participation in rockfish management at the state level, and present possible solutions to address inter-institutional gaps based on fishers' and agency staff expertise.

1.1. Inter-Institutional Gap framework

We used the Inter-Institutional Gap (IIG) framework [50] to assess the interplay between formal and informal institutions and between rule levels in a natural resource management setting (i.e., state-managed rockfish fisheries). While institutional arrangements can take varied forms [45], formal institutions are often characterized by official governmental rulemaking bodies and law enforcement, whereas informal institutions can include community-based organizations or more loosely formed communities of practice that generate locally accepted rules, codes of conduct, and social customs [50]. Ostrom [48] defined three hierarchical rule levels within institutions: constitutional choice, collective choice, and operational choice rules. Constitutional choice rules determine the structure for rule-making at lower levels, including who is eligible to participate and the process by which collective choice rules are created ([48,50]; e.g., fisheries laws and governance structures). Collective choice and operational choice rules operate within the bounds of constitutional choice rules. Collective choice rules determine the policies for rule-making and enforcement, and operational choice rules involve regular day-to-day decision making about monitoring, enforcement, and resource use ([48,50]; e.g., decision-making on the fishing grounds). In the IIG framework, collective choice and operational choice rule levels are combined into "non-constitutional" rules because they are often difficult to separate in practice [50]. By explicitly categorizing institution types (formal, informal) and rule-levels (constitutional, non-constitutional), the IIG framework provides a means of conceptualizing interactions and gaps among institutions and rules governing actions [50].

2. Methods

2.1. Study communities

Sitka (8458; [61]) is located on the west coast of Baranof Island in Southeast Alaska, on the ancestral and contemporary lands of the Tlingit people [57]. The City and Borough of Kodiak (population 13,101; [61]) is located along the northeast coast of Kodiak Island in the central Gulf of Alaska, on the ancestral and contemporary lands of the Alutiiq/Sugpiaq people [15]. These regions are shaped by Indigenous stewardship and knowledge of the land and sea since time immemorial. Commercial fishing supports livelihoods and economies of these communities. State and federally regulated fisheries for groundfish (including rockfishes), Pacific salmon, and shellfish take place in both regions. Rockfishes are also caught for customary and traditional use in both regions but are a relatively minor component of subsistence harvest [59].

2.2. Semi-structured interviews

We conducted semi-structured interviews with ADF&G staff and fishers with long-term experience (~10 or more years) fishing for rockfishes under commercial and sport regulations. Research participants were initially recruited through preexisting contacts developed from long-term research connections by two authors (AHB, CC) and

Table 1

Summary of formal and informal institutions and their roles in Alaska state fishery management. Specific examples are provided for informal institutions, from a case study of nearshore rockfish fisheries in the Gulf of Alaska.

Institution type and rule level	Institution	Description	Role in fishery management	Examples
Formal, constitutional	Board of Fisheries (BOF)	Board composed of 7 governor-appointed members to oversee conservation and development of Alaska's fishery resources ¹	Makes regulatory decisions regarding fishing seasons, harvest levels, allocations, allowable gear, spatial management; Reviews regulatory proposals and considers public testimony in decision-making ^{1,5}	
Formal, non-constitutional	Alaska Department of Fish and Game (ADF&G)	Agency that provides opportunity for the use, development, and conservation of the state's aquatic and terrestrial resources ²	Enforces regulations; Collects, manages, and analyzes fishery, habitat, and biological data to inform management; Develops regulatory proposals to BOF ^{2,4}	
Formal intermediary, multiple rule levels	Advisory Committee (AC)	Advisory bodies (84 statewide) that provide forum for local input to fish management and conservation issues ³	Consults with fishers, organizations, and ADF&G; Develops regulatory proposals to BOF; evaluates and provides recommendations on proposals to the BOF; Sets emergency closures when delegated by commissioner ²	
Informal, constitutional	Fishing associations [†]	Community-based, fisher-led organizations that engage with political advocacy, research, and maintaining fishing opportunities for their respective user groups	Writes proposals and testifies at BOF; Generates own rules and norms for managing fishery	Alaska Longline Fishermen's Association's participatory bathymetry database; Southeast Alaska Guides Organization (SEAGO) members voluntarily use deepwater release mechanisms prior to mandate
Informal, non-constitutional	Unmediated interactions between ADF&G and fishers Individual stewardship actions	Fishers interact with managers and scientists through informal in-person or phone conversations Fishers make choices about gear type, retention, fishing locations, and so forth that are independent of ADF&G regulations	Fishers obtain clarity on regulations, share ideas, and express concerns; Informal relationship building establishes trust between fishers and managers Actions promote sustainability of fishery	Fishers visit the ADF&G office to ask staff questions; Fishers converse with port samplers while being surveyed Avoid fishing in certain areas, reduce waste, release vulnerable species (e.g., yelloweye rockfish)

¹[12]²Alaska Stat. § 16.05.010, Alaska Stat. § 16.06.221³[13]⁴Alaska Stat. § 16.06.251⁵[3]

[†]primarily informal constitutional rule-level institutions, though the structure and purpose of fishing associations varies substantially and their rule-levels can span from constitutional to non-constitutional.

community outreach conducted by the research team in Sitka and Kodiak. We also sought recommendations from our professional networks at ADF&G, University of Alaska Fairbanks, Alaska Sea Grant, and fishing associations. The Sitka Tribe of Alaska and Sun'aq Tribe of Kodiak were invited to participate in this work; however, a focus on rockfish was not a priority of the tribes at the time of this study. Snowball sampling (i.e., chain referral) was used to recruit additional participants with relevant expertise [22]. We conducted as many interviews as possible during research trips in 2019 and confirmed that we had reached an adequate number of interviews based on data saturation, in which no new codes or themes were generated from additional interviews [32]. Research participants' experience spanned multiple sectors, gear types, years of experience, and species targeted.

Research participants were asked open-ended questions about their engagement within rockfish management institutions and stewardship-driven fishing practices and values (Appendix A). The interview guide (Appendix A) was developed and piloted with feedback from 14 individuals with experience in state and federal management, tribal governance, research, and fishing. Interviews were conducted by two authors (JYG, AHB), with a lead interviewer primarily asking questions and a supporting interviewer adding clarifying questions and taking handwritten notes as a backup in case the recording failed. Interviews ranged from 30 to 90 min and were recorded with permission of the participants and transcribed for thematic analysis.

2.3. Thematic analysis

We performed thematic analysis, a qualitative analytical method used to detect, analyze, and describe patterns, or recurring themes in interview data [18,25]. Coding was performed collaboratively by the research team using NVivo 12 software (QSR International, Burlington, U.S.A). The lead coder (JYG) initially coded transcripts using inductive and deductive approaches [22]. Codes about changes in rockfish populations, participation in formal and informal management processes, and stewardship were generated deductively, as these themes were grounded in the interview questions (Appendix B). Codes about various strengths and challenges of participants' engagement in management were generated inductively, since these topics emerged from the examination of the transcribed interviews. Codes were summarized as organizing themes (e.g., interactions between fishers and agency staff, stewardship, knowledge generation, attitudes towards regulations) and broader global themes (e.g., relative value of formal and informal institutions, institutional gaps, barriers to effective engagement). A thematic map of the data [25] and the codebook were developed and iteratively refined through discussion with other authors during initial coding stages. All transcripts were then coded again by the lead coder and separately by a second coder (EMS) using the refined codebook. The two researchers calibrated their codes for all transcripts by discussing and sometimes resolving dissonance in the coders' interpretations of the interviews. Additionally, the second coder provided input on the clarity and comprehensiveness of the codebook, which resulted in several minor changes to codes and codebook structure.

3. Results

We interviewed a total of 43 individuals, 25 in Sitka and 18 in Kodiak. The majority of research participants (n = 39) self-identified as white and two self-identified as Alaska Native; other racial identities are not disclosed to avoid identifying individual participants. Thirty-four participants identified their gender as male (79%) and nine (21%) as female. Participants' ages ranged from 20 to 81 years, with a median age of 51. Interviewees associated their rockfish fishery experience with one of the following categories: commercial fishing (13 interviewees in Sitka, 8 in Kodiak); charter operation (5 in Sitka, 2 in Kodiak); unguided sport, personal use, or subsistence fishing (3 in Sitka, 3 in Kodiak); and employment by ADF&G as a manager or biologist (4 in Sitka, 5 in Kodiak). Most fishers had participated in multiple fisheries during their career, and several agency staff also had fishing experience. Commercial fishers targeted rockfishes in directed jig fisheries, longline fisheries, and trawl fisheries and caught rockfishes as bycatch in Pacific halibut (*Hippoglossus stenolepis*) and sablefish (*Anoplopoma fimbria*) longline fisheries and Pacific salmon troll fisheries. Some fishers participated in both state and federal commercial groundfish fisheries.

3.1. The IIG framework for rockfish fisheries management

We use the IIG framework to identify the institutions and rule-levels for state-managed rockfish fisheries and their interconnections (Table 1). For rockfish management, the BOF is the formal constitutional rule-level institution and the ADF&G is the formal non-constitutional rule-level institution (Fig. 1). ACs are formal bodies with constitutional and non-constitutional rule-level attributes (Fig. 1). Fishing associations are primarily informal constitutional rule-level institutions that operate outside of Alaska's formal governing bodies of ADF&G and BOF (Fig. 1), though the structure and purpose of fishing associations varies substantially and their rule-levels could span from constitutional to non-constitutional. Fishers' individual fishing decisions and unmediated interactions with ADF&G are informal, non-constitutional rule-level institutions (Fig. 1). In the following sections, we discuss how fishers and agency staff participate in these formal and informal processes for rockfish management and how these engagement pathways

are perceived and valued by fishers and agency staff. Finally, we discuss gaps in connectivity among institutional components and rules governing actions within the context of rockfish management.

3.2. Formal institutions, rules governing actions, and interactions with informal institutions

Interviewees were asked about their degree of participation in formal institutions for rockfish management. Agency staff generally participated in formal institutions as a part of their job, while fishers participated as members of the public. Sixty-four percent of Sitka-based participants (13 fishers, 3 agency staff) and 33% percent of Kodiak-based participants (5 fishers, 1 agency staff) stated that they regularly attended BOF meetings, and 16% of Sitka-based participants (4 fishers) and 11% of Kodiak-based participants (1 fisher, 1 agency staff) said that they had infrequently attended BOF meetings. Forty-eight percent of Sitka-based participants (10 fishers, 2 agency staff) and 28% of Kodiak-based participants (4 fishers, 1 agency staff) said that they have written BOF proposals. Both fishers and agency staff described the role of ADF&G staff in assisting fishers with writing proposals. A Kodiak commercial fisher with over 35 years of experience, who had received support from ADF&G to prepare BOF proposals, explained how ADF&G staff act in an advisory capacity:

They're very careful in taking a professional stance. To keep that neutral...they're like,

“Well, you can do whatever you want, however, I would advise that the Board of Fisheries may see this as a reallocation or something, but yeah, you do whatever you want.” So you kinda read between the lines as to what—they can't tell you what their view is. And I think they handle it very professionally (Interview #5, May 2019).

An ADF&G staff member in Sitka described their role in assisting fishers with BOF proposals, explaining, “I'm sort of the liaison between the public and the board. If you want to change something, a lot of times you'd start with me and I will get you kind of pointed in the right direction” (Interview #19, September 2019). ADF&G staff who discussed their role in this way did not provide assistance with BOF proposals as a

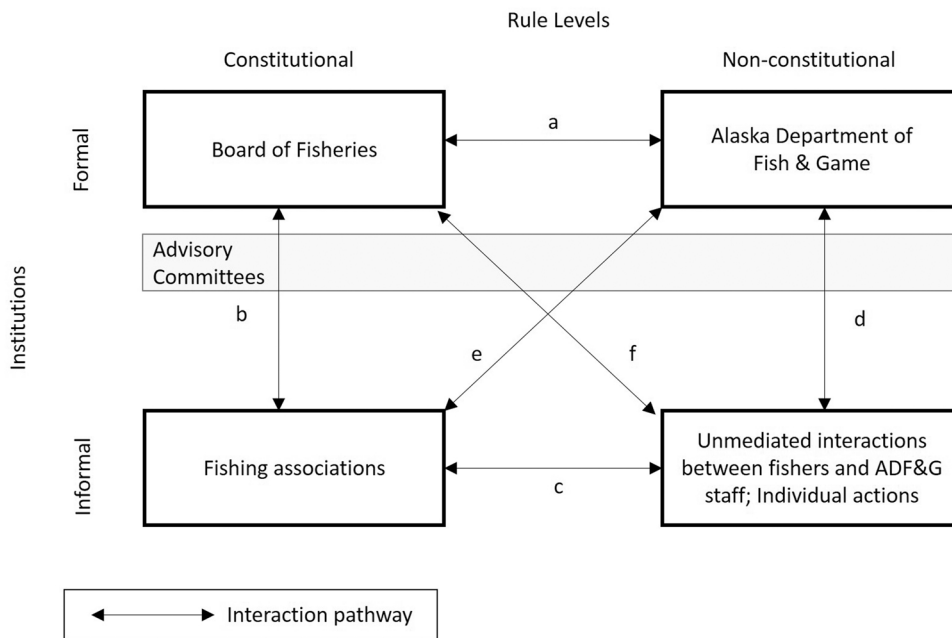


Fig. 1. Interactions between the formal and informal management institutions and rule levels (adapted from [50]) for fishery management in Alaska, based on a case study of near-shore rockfish fisheries in the Gulf of Alaska. Formal institutions include the Board of Fisheries (BOF), Alaska Department of Fish and Game (ADF&G), and Advisory Committees (AC) to the BOF, which serve in an intermediary role among institution types and rule levels (gray box). Informal institutions include fishing associations that establish local rules and norms and individual stewardship actions taken by fishers. Interaction pathways include, but are not limited to: submission of regulatory proposals to the BOF by ADF&G or an AC (a, b); enforcement of regulations set by the BOF by ADF&G (a); submission of regulatory proposals to the BOF by fishing associations (b); public testimony provided at BOF meetings by associations and individuals (b, e); individual fishers and fishing associations networking informally with BOF and ADF&G staff (b, d, e, f); fishers' individual actions adopted into collective norms within fishing associations (c); fishing associations creating voluntary rules that individuals choose to follow (c); fishing associations and individuals interacting with ADF&G at AC meetings (d, f).

mandated job duty, but rather as a professional service. They explained that they offer guidance on language or framing that might be best understood by the BOF, while maintaining neutrality about the outcome.

Some fishers and agency staff discussed active involvement in their local ACs. More participation was reported in Sitka (36% of interviewees; 6 fishers, 3 agency staff) compared to Kodiak (17% of interviewees; 1 fisher, 2 agency staff). Fishers participated as AC members, attended meetings as non-voting members, and provided comments at meetings. Agency staff had attended AC meetings to answer questions and provide information on relevant fishery issues and BOF proposals. Participants in Sitka described the AC as very active in their community and an accessible platform for fishers to engage with the decision-making process. As explained by a commercial fisher in Sitka with over 35 years of experience:

The Fish and Game advisory committee process is fabulous... the people on it work really hard to get information, you know, fairly balance the decision-making process. I mean, it depends on the Board [of Fisheries], how well they listen to those advisory committees, and I think anything that's done to help people who represent an advisory committee be heard in the process is really important... I think the Board process feels much more manageable than the federal process to most people. And they're in the communities more. You have the local advisory committee to go talk to (Interview #26, September 2019).

Fishers also discussed more generally the importance of understanding fisheries management institutions and the ability to voice their knowledge and concerns within these bodies.

Though this study focuses on rockfish management at the state level, 44% of Sitka-based participants (10 fishers, 1 agency staff) and 56% of Kodiak-based participants (9 fishers, 1 agency staff) referenced their involvement in federal management to frame their perceptions of state management. As reflected in the previous quote, some fishers and agency staff described the BOF and AC processes as more accessible and representative than the NPFMC processes, especially for small boat fishers. Participants attributed this, in part, to the siting of ADF&G offices and BOF meetings within rural fishing communities throughout the state. They perceived federal agencies to be more geographically distant bureaucracies.

3.3. Informal institutions, rules governing actions, and interactions with formal institutions

Fishers demonstrated a strong sense of agency over their fisheries through informal interactions with ADF&G staff, involvement with fishing associations, and individual actions to promote stewardship of rockfish fisheries. In-person or phone conversations with ADF&G staff were identified as the primary modes of informal interaction, as noted by 72% of Sitka-based participants (15 fishers, 3 agency staff) and 67% of Kodiak-based participants (7 fishers, 5 agency staff). Informal conversations were identified by fishers and agency staff as an accessible and effective way to ask questions about regulations, offer ideas, and express concerns. Some fishers said that the only time they visited the ADF&G office in their community was to submit logbooks. Fishers who operate vessels in the black rockfish commercial jig fishery are required to submit logbooks to a representative at the Kodiak ADF&G office or to a dockside sampler after each trip [24].

Participants in Sitka (52% of interviewees; 10 fishers, 3 agency staff) and Kodiak (28% of interviewees; 3 fishers, 2 agency staff) talked about the value of living in a small, close-knit community for building meaningful and personal relationships with one another. This dynamic facilitated more active engagement from fishers in both formal and informal management institutions. Multiple fishers also spoke highly of the role of port samplers who conduct dockside surveys in their community as an approachable and knowledgeable "face" of the agency at

the waterfront. Agency staff felt that port samplers served as liaisons between the agency and the community, having the opportunity to build relationships with fishers and answer questions about the biology and management of various species. Overall, both fishers and agency staff emphasized the importance of individual relationships; many fishers mentioned a specific person who served as their primary contact at ADF&G.

Participants in Sitka (40% of interviewees; 10 fishers) and Kodiak (33% of interviewees; 6 fishers) noted their membership in various sport and commercial fishing associations that were generally described by interviewees as community-based, fisher-led organizations that strive to maintain healthy fisheries and fishing opportunities for their respective user groups. Participants discussed the varied roles of these fishing associations, which included political advocacy, research, and establishing voluntary rules for their fisheries that members can choose to follow. Fishing associations also submit proposals to the BOF and may collaborate with ADF&G on research and monitoring projects. An example provided by multiple Sitka participants is the participatory mapping database developed by Alaska Longline Fishermen's Association (ALFA) to improve target species catch while avoiding bycatch [11]. Members of ALFA's Fishery Conservation Network collect seafloor bathymetry data, which are merged into a database and incorporated into interactive electronic maps that are returned to participating fishers. The Fishery Conservation Network also documents rockfish bycatch rates in longline fisheries, which are added to the maps to help fishers become familiar with rockfish habitat and reduce bycatch. State and federal agencies have been given access to the ALFA bathymetric data to assist with rockfish survey and stock assessment efforts [11]. This example demonstrates fishers' proactive stewardship efforts and willingness to engage in cross-institutional knowledge sharing.

At the individual level, fishers shared that they exhibit stewardship over their fisheries through fishing decisions that are independent of state regulations. Sixty-four percent of Sitka-based participants (15 fishers, 1 agency staff) and 39% of Kodiak-based participants (7 fishers) said that they use certain types of gear and handling practices to promote survival of rockfish upon release. For example, deep water release mechanisms (DRMs) were frequently mentioned as a means to promote ethical fishing and increase survival of released rockfish. DRMs assist fishers in releasing rockfish at depth to reduce barotrauma-related mortality and are currently required on all sport vessels statewide [9]. The fishing association Southeast Alaska Guides Organization sponsored the 2013 mandate for DRMs on charter vessels in Southeast Alaska [9]. A charter captain in Sitka with nearly 30 years of experience commented that charter guides were using DRMs before they were mandated and described their voluntary use as "just the right thing to do" (Interview #23, September 2019). While DRMs are not required on commercial vessels, two commercial jig fishermen in Kodiak also mentioned that they voluntarily use the devices to improve the chance of rockfish survival, despite the added time and loss of fishing opportunity when using the devices. A Kodiak commercial fisherman with over 35 years of experience, who uses a DRM while jigging, recalled other methods for safely releasing rockfishes:

I do everything I can to prevent barotrauma. And a lot of times what I'll do — it's as simple as you just shake the fish overboard and it's just starting to barotrauma and you push its head down really quickly with the flat side of a deck brush to startle the fish into swimming downwards. And a lot of times that'll do it (Interview #5, May 2019).

Additional practices that fishers mentioned in response to open-ended questions included: avoiding long-lived rockfish species (52% of Sitka interviewees, 39% of Kodiak interviewees), reducing waste of all fish species (40% of Sitka interviewees, 28% of Kodiak interviewees), size-selective fishing to avoid older fish (28% of Sitka interviewees, 33% of Kodiak interviewees), and fishing in specific locations to avoid sensitive habitat for rockfishes (40% of Sitka interviewees, 11% of Kodiak

interviewees).

A majority of participants identified specific concerns about the sustainability of rockfish fisheries for future generations (60% of Sitka interviewees: 13 fishers, 2 agency staff; 56% of Kodiak interviewees: 10 fishers, 0 agency staff). Sport and commercial fishers expressed concern about declining abundance of some species and bycatch by non-selective gears [31], but also discussed proactive measures they have taken to ensure that future generations have access to a healthy fishery. Many of these individuals made an effort to educate their crew to promote sustainability of the fisheries. A Sitka commercial fisher with 25 years of experience said that they choose to fish in a way that preserves the fisheries for future generations, explaining:

I want to make sure that my actions aren't affecting future generations. That it affects them positively. Passing on the same opportunities. I don't even have kids but I feel like it doesn't matter. I just think it's irresponsible to do anything but that (Interview #24, September 2019).

3.4. Perceived value of formal and informal institutions

A subset of participants ($n = 26$) discussed their perceptions of the relative value of informal and formal institutions in facilitating meaningful and effective participation in management. Approximately 27% of interviewees found engagement with formal institutions to be of greater value in affecting change, 31% of interviewees identified informal modes of engagement as more valuable, and 42% described formal and informal pathways as equally important. Participants discussed that informal processes are important for establishing relationships and trust, but do not lead to concrete changes in management without the BOF. Taken together, their perspectives suggest that to be effective in formal processes, informal networking and relationship-building must also take place.

Some fishers who placed more value on informal processes noted the power relationships within formal institutions as a deterrent to engagement. An unguided sport fisher in Sitka with 10 years of experience described BOF as "politicized" and valued informal engagement because "you're building trust, you're building relationships and you know ... that goes a longer way of influencing people and things like that. And trusting the information you're getting" (Interview #29, September 2019). Others expressed that they prefer the formality and structured accountability associated with decision making at the BOF level, but acknowledged the importance of engaging with the local ADF&G staff within their communities. As explained by a commercial fisher in Kodiak with over 35 years of experience:

Well, I mean obviously the actual board meetings—Board of Fisheries meetings where the actual decisions get made—[are] where the rubber meets the road. And I mean the local guys [ADF&G staff] ... they can change some of their practices but they can't change actual rules, so I mean it's good to engage them as allies, and I always do (Interview #5, May 2019).

An agency staff person in Sitka with 10 years of experience described the value of formal and informal engagement in rockfish management and the importance of reciprocity in information sharing between fishers and agency staff:

I think they are both extremely important. The informal, like I said, maintaining a solid communication with them goes a long way. We rely on them for fishery data for in-season management. If I am hoping to get an immediate response from them, they probably feel the same way about me if they ask me a question about fish tickets or a regulation question... So, I try to be super timely in my responses and provide as much information as I can to them (Interview #20, September 2019).

Fishers described the high degree of preparation and commitment

necessary for an individual to effect change at the formal constitutional rule level. Conversations with agency staff outside of formal management meetings were viewed as an important part of the process of building an effective case on a specific issue. While the BOF has decision-making power, agency staff at ADF&G are tasked with the interpretation and enforcement of regulations. Therefore, interactions with ADF&G were thought to be less influential but still important in building allyships.

3.5. Institutional gaps

Fishers and agency staff identified factors that impede engagement within and across formal and informal institutions, including political motivations, lack of representation by some fishery sectors in formal institutions, lack of transparency from agency staff about management decisions, complexity of regulations and monitoring, and barriers to communication within formal institutions.

The politics of formal management institutions at the state and federal levels was viewed as a deterrent to participation by 48% of Sitka interviewees (11 fishers, 1 agency staff) and 39% of Kodiak interviewees (6 fishers, 1 agency staff; Fig. 1f). This was especially true for groups that have been historically or are currently underrepresented in BOF and AC membership, namely sport and subsistence fishers (Fig. 1b,f). Some participants noted that the management system is inherently set up to exclude subsistence harvesters. A subsistence fisher with 50 years of experience shared that the BOF seems to view subsistence harvesters' knowledge and harvest records as untrustworthy or inaccurate. Because of the lack of regard for subsistence harvesters' knowledge, they felt discouraged from attending and providing testimony at BOF meetings, noting that it was a waste of time. As described by the same fisher:

One thing I've learned early on is if going into an issue you don't know your vote then you're probably not gonna get it... they say trust the system, you know, and go in and testify... that's how they teach people to engage. ... To me that makes no sense, you know, just like you show up and spend three minutes or two if there's a lot of people testifying... When a lot of people are coming in public discussion, by the time they're at their end of their tenth, let alone the one-hundred and fiftieth, person giving two minutes of testimony it's just a bit of a blur you know... It's hard to rationally think that that's just gonna work perfect and everything's fair (Interview #27, September 2019).

Some charter operators also felt that there were inequities within the BOF process due to the greater representation of commercial interests on the Board (e.g., [28]).

Five Sitka-based fishers (20% of Sitka interviewees) and one Kodiak-based fisher (6% of Kodiak interviewees) expressed that a lack of transparency regarding use of fishery data for decision-making impeded trust between fishers and agency staff (Fig. 1d,e). For example, some fishers discussed a concern that spatial harvest information will be used to drive more restrictive regulations. A commercial fisher in Sitka noted, "I'm really sensitive to rockfish being a big driver of closing other fisheries" (Interview #24, September 2019), and explained that in the past, spatial closures for trawl fisheries had led to restrictions for other fisheries. They explained that better communication from ADF&G regarding the justification for closing certain areas would improve trust from fishers and encourage them to contribute ideas and knowledge about their fisheries to ADF&G.

Another issue raised by participants in Sitka (24% of interviewees; 5 fishers, 1 agency staff) and Kodiak (28% of interviewees; 2 fishers, 3 agency staff) is that certain regulations and management structures were complicated and difficult to accurately follow (Fig. 1d, f). An issue frequently noted as challenging was adhering to bycatch regulations when commercial fishers are not experienced with rockfish species identification. A few participants noted that the commercial black rockfish jig fishery in Kodiak was challenging to navigate due to its complex management structure. While logbooks are not required in all

fisheries, black rockfish jig fishers must complete detailed logbooks with the location, date, number of hooks and lines deployed, fishing depth, number and duration of drifts, and number of fish caught [24]. One Kodiak ADF&G staff person summarized it concisely: “We ask a lot of them in their logbook” (Interview #1, May 2019). Fishers must also check into a specific management district with a set guideline harvest level (quota) prior to fishing. Adding to these issues, some participants noted that complex regulations are sometimes interpreted differently by ADF&G area management biologists and enforcement officers, with consequences for fishers in the form of citations or fines.

Participants also identified intra-institutional gaps, and this may be of particular concern for rockfishes and other species where regional overlap exists between sport and commercial fisheries. Sixteen percent of Sitka-based participants (1 fisher, 3 agency staff) and 22% of Kodiak-based participants (4 agency staff) noted barriers in communication between sport and commercial divisions of ADF&G. A former ADF&G staff member explained that “even within Fish and Game, the Sport Fish Division and Commercial Fish Division, they might as well be two different departments” (Interview #23, September 2019). They noted that while staff in both divisions care about viability of the collective resource, they seemed to be operating independently to support their respective fisheries. A commercial fisher in Sitka with 20 years of experience also remarked on the apparent separation between the two divisions:

When you say Fish and Game though, I’m sure you’re well aware of the sport side and the commercial side... In terms of chain of command, they don’t share a common person ‘til all the way up the Commissioner... it’s certainly not unique to rockfish (Interview #30, September 2019).

For rockfish fisheries, participants noted that lack of communication between divisions has resulted in disparate data sources, conflict over allocation between sectors, and an overall lack of awareness of research and management efforts from the other division. This divided infrastructure has been noticed by fishers and agency staff alike.

4. Discussion

4.1. Summary of key findings, strengths, and limitations

Using the IIG framework, we explored perspectives of fishers and agency staff on the roles of formal and informal institutions and their interplay in management of rockfish fisheries in Alaska. Research participants highlighted the value of multiple pathways of engagement in rockfish management. The majority of interviewees had participated in the BOF process and some were active in their local AC, particularly in Sitka. Fishers who were deterred by the politics of the BOF tended to favor informal interactions with ADF&G staff. Communication among fishers and agency staff through in-person office visits, interaction with port samplers, and phone conversations was viewed as important for building trust and a foundation for effective engagement with formal institutions. Informal institutions of stewardship by fishers include conservation leadership by fishing associations and actions taken by individuals to reduce harm to incidentally caught rockfish, driven by a strong desire to maintain opportunities for future generations. Application of the IIG framework also helped to reveal barriers to participation and institutional gaps that have broader relevance beyond rockfish fisheries. The most prominent gaps identified by participants were between formal and informal institutions, arising from inaccessibility of the BOF process, underrepresentation of some user groups in formal decision-making, and transparency issues regarding regulatory decisions and/or interpretation. An important intra-institutional gap identified by participants is the existence of bureaucratic barriers to coordination between the sport and commercial divisions of ADF&G.

A strength of our approach is that closely examining institutional relationships and gaps through a rockfish fishery lens allows an entry

point for examination of broader issues in the state management system affecting multiple fisheries and fishery participants. However, a limitation is that applying the IIG framework to a single case study may mask other inter-institutional relationships and gaps that are more prominent in non-rockfish fisheries. To generate a more complete assessment of the interplay between formal and informal institutions in Alaska fisheries management, we recommend applying this framework to multiple fisheries that include different user groups, species, and cultural and political dynamics.

4.2. Barriers to participation and inequities in formal institutions

The primary gaps highlight a need to make the BOF process more accessible to actors within informal institutions, especially for small-scale commercial and non-commercial rockfish fishers, who comprised the majority of fisher-participants in this study. Participants discussed power dynamics and issues of representation that are not unique to rockfish fisheries. Other studies have also documented barriers to access to the BOF process, particularly for rural and majority Indigenous communities, such as travel costs for meeting attendance, language and cultural barriers, and access to funding [39]. In a study of Bristol Bay salmon fisheries, Reedy-Maschner [53] found that Indigenous and rural resident fishers were at a disadvantage when engaging with the BOF compared to non-resident fishers who were able to leverage their wealth to gain access to scientific and political resources to maintain their fishing opportunity. Particularly for subsistence harvesters, contemporary barriers to participation stem from broader structural inequities that arose through commercialization of fisheries beginning in the 19th century and the legacy of assimilative colonialism that persists within Western management institutions today [17,23,27,44,58].

Inter-institutional gaps can widen when local and traditional knowledge is delegitimized, or not adequately considered, within formal institutions [51]. Participants discussed the dismissal of particular forms of knowledge, particularly Indigenous Knowledge, at the BOF. Currently, at the federal fishery management level in Alaska, there are steps being taken to include multiple knowledge systems and identify onramps for local, traditional, and Indigenous knowledge in Bering Sea commercial fishery management [43,52]. Similar efforts at the state level could support greater inclusion of fishers’ knowledge in rockfish fisheries assessment and management. However, Jentoff (2004, p. 142) cautioned that, “...knowledge will not always do the trick when it comes to changing institutional structures or behaviour. Sometimes it also works the other way round: power is knowledge because those who are in a powerful position can define the knowledge that is valid and relevant in the decision-making process. Fisheries managers and scientists frequently occupy this position, while those who fish do not.” Furthermore, different user groups may have differing capabilities of collecting, accessing, and using the data that is deemed legitimate for management [41]. Data generated through positivist frameworks of western science can be viewed as a “unique technology of power” ([41], p. 1587), in that access to such knowledge, or lack thereof, can exacerbate other existing inequities among user groups. Therefore, equitable inclusion of diverse forms of knowledge in decision-making requires recognizing multiple ontologies and epistemologies, addressing substantial power imbalances, particularly between Indigenous Knowledge and western scientific knowledge [62], and paradigm shifts within formal institutions.

4.3. Opening pathways for communication among agency staff and fishers

Each of the institutional gaps identified within this case study are interconnected, and bridging one gap has the potential to bridge others. For example, political literacy among fishermen may be facilitated by access to agency staff support, translating into more effective engagement with formal, constitutional rule-level institutions. Krupa et al. [40] found that regulatory proposals submitted by ADF&G had a higher

success rate than non-ADF&G proposals; however, the authors did not have the data to evaluate the extent to which ADF&G proposals are co-produced with fishers and responsive to fishers' interests. Participants in our study perceived the professional service that some ADF&G staff provide in preparing regulatory proposals as a means of improving the potential success of proposals at the BOF. The ACs also facilitate interactions between fishers and formal fishery management institutions, and Krupa et al. [40] found that regulatory proposals submitted by ACs had the highest approval rates among non-governmental groups. Participants noted that there is high variability across communities in the degree to which ACs are active, possibly leading to inequities in representation among regions and user groups. At a recent BOF meeting, the Sitka AC was praised by Board members for providing a model of leadership and engagement in the management process [2]. In contrast, many other communities in Southeast Alaska have not established an AC [10]. The valued role of advisory groups is not unique to Alaska; in a study of public engagement by fishery and ocean management agencies in Canada, Australia, and the U.S., advisory groups were cited most often by interview respondents as tools for collaborative problem-solving, engaging underrepresented groups, and building trust [42]. Some commercial and sport fishers in this study also participated in well-organized fishing associations, which can be a mechanism for increasing the capital, knowledge, authority, social identity, social relations, and technology that mediate access to formal institutions [54].

Participants noted the historical lack of coordinated data sharing across divisions of ADF&G, and limited data for rockfish in general [31], as challenges to rockfish management. An ongoing effort to address intra-institutional gaps at ADF&G is the Statewide Rockfish Initiative (SRI), a working group that was formed in 2016 to bring together ADF&G staff from sport and commercial divisions to coordinate data management, research, and assessment for the yelloweye rockfish and black rockfish fisheries [37]. The SRI has expanded rockfish-specific outreach, including presentations to ACs, public meetings, a rockfish card deck with information on species identification and life history, and educational materials online [55]. When interviewed for this project, multiple agency staff spoke of the pivotal nature of the SRI for addressing the intra-institutional gaps, noting that opportunities to directly collaborate with staff from the other division were rare or non-existent for other fisheries. Participants also reported existing efforts to improve education about rockfishes in their communities, such as signage about DRMs and barotrauma, and workshops to educate fishers about rockfish species identification. ADF&G also provides free DRMs to anglers who request them.

In future work, the SRI could increase engagement with fishers to serve as a mechanism for inclusion of fishers' knowledge within formal institutions. Fishers' place-based, long-term knowledge of rockfish populations along the U.S. West Coast has allowed them to recognize and respond quickly to changes in rockfish stocks and take personal action to promote rockfish stewardship [20,31,56]. In Puget Sound, Washington, fishers with long-term knowledge about rockfish biology and fisheries were also more likely to support agency-driven conservation measures [56]. Similarly, fishers in this study reported avoiding certain vulnerable species or habitats, reducing waste, and reducing mortality through at-depth release of rockfishes. They also showcased proactive care for their fisheries to ensure the health of fish populations for future generations.

4.4. Conclusions

Public processes that facilitate trustworthiness, representation, and local relevance are important to effectively include the diverse knowledge and leadership of multiple actors in natural resource management [30,60]. Pathways to facilitate open channels of communication among resource users and management institutions already exist in Alaskan rockfish fisheries, but are currently limited in their capacity to mitigate barriers to participation and broaden representation of different user

groups in these public processes. Some changes are possible within existing agency structures to better include fishers in the process of rockfish research and management. For instance, when hosting public meetings and workshops, facilitators can proactively address barriers for different groups and identify ways that certain individuals may be more privileged in these processes [26]. Additionally, communication and outreach about rockfish regulations could be expanded to improve knowledge sharing and relationship building between fishers and agency staff. Finally, collaborative research between agencies and fishers may be key to assessing data-limited rockfish stocks. In Puget Sound, coproduction of knowledge about rockfishes through collaborative research by anglers and state and federal agency staff resulted in the first delisting of a marine fish under the U.S. Endangered Species Act [16]. Maintaining and strengthening diverse interaction pathways across formal and informal institutions can better facilitate trust and knowledge sharing in support of sustainable rockfish fisheries.

CRediT authorship contribution statement

JYG: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **AHB:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration, Funding acquisition. **EMS:** Methodology, Formal analysis, Investigation, Writing – review & editing. **CC:** Methodology, Writing – review & editing.

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Appendix A

Interview Guide

This interview protocol is a guide for the interviewer, who will conduct verbal, in-person interviews with participants in a semi-structured format. Participants will not have to provide written answers to questions.

Reminders for interviewer: Summarize the participant information

sheet for them, and allow time to look it over (includes project overview, confidentiality information, and tells them about how long the interview should take). Allow time for questions. Ask them for oral consent. Ask for consent to audio record. If yes, start audio recorder and state date and interview #.

Part 1. Background and experience

We're interested in your experience fishing for rockfish in the coastal waters of the Gulf of Alaska. [Ask about all relevant experience including years in each fishery, regions, seasons, gear types, and target species (and bycatch, if relevant).].

Commercial (Permit codes listed at the end of the survey).

- Black rockfish mechanical jig
- Black rockfish dinglebar troll
- Black rockfish hand troll
- Salmon- hand troll
- Salmon- power troll
- Demersal Shelf Rockfish (DSR)- hand troll
- Demersal Shelf Rockfish (DSR)- dinglebar troll
- Demersal Shelf Rockfish (DSR)- mechanical jig
- Demersal Shelf Rockfish (DSR)- longline vessel under 60'
- Demersal Shelf Rockfish (DSR)- longline vessel over 60'
- Other:

Sport.

- Guided (charter) as a:
 - Guide
 - Client
- Unguided

Subsistence.

- State
- Federal

Fisheries biology and/or management.

Other (please specify).

Part 2. Management and regulations

Rockfish harvest in some sectors has recently increased in the Gulf of Alaska. Because of this, Alaska Department of Fish & Game (ADF&G) is looking at revising regulations for rockfish harvest. The following questions are aimed to understand your views of current rockfish

Table B.1

Codes generated deductively from interview questions. Interview questions are shown in abbreviated form; refer to the interview guide in [Appendix A](#) for full text.

Code Name	Code Description	Interview Questions
Rockfish fishery concerns	Factors that contribute to decline of rockfish populations and/or fisheries	What are your concerns (if any) about the health of rockfish populations? (Appendix A : Part 2, Question 2)
Stewardship	Ways that fishers are independently (without agency guidance) taking personal and/or collective actions to steward / conserve / sustain the resource	Do you have any particular rules on your boat that are more conservative than state regulations? (Appendix A : Part 2, Question 3)
Attitudes towards regulations	Perceived effectiveness and fairness of rockfish regulations and management system	How are rockfish regulations affecting you (if at all)? (Appendix A : Part 2, Question 4)
Stakeholder interactions with management	Communication pathways, formal and informal modes of engagement, and knowledge generation and transfer among fishers and agency	What should ADF&G do to most effectively manage rockfish populations? (Appendix A : Part 2, Question 5) What should ADF&G do to most effectively include fishers' and community members' ideas and concerns in rockfish management? (Appendix A : Part 2, Question 6) Do you communicate your questions, ideas, and concerns to managers? If so, how? [ask about relative value of formal vs. informal communication, including views of their effectiveness; for agency staff, ask how fishers communicate with agency] (Appendix A : Part 2, Question 7)

management, your ideas about how management could be improved, and concerns for the future of rockfish management. [For fishers, ask all questions. For agency staff, ask questions 2, 5–7.].

1. What are your reasons for harvesting rockfish? What factors influence how many rockfish you decide to catch on a trip?
2. Do you have concerns about the health of rockfish populations? If so, what are they?
3. Do you have any particular rules on your boat that are different from state regulations? [e.g., more conservative rules or other stewardship approaches]
4. How are rockfish [sport, commercial] regulations affecting you (if at all)?
5. What should ADF&G do to most effectively manage rockfish populations? [follow up questions to understand whether / how ADF&G is currently doing these things]
6. What should ADF&G do to most effectively include fishers' and community members' ideas and concerns in rockfish management? [follow up questions to understand whether / how ADF&G is currently doing these things]
7. Do you communicate your questions, ideas, and concerns to managers? If so, how? [ask about relative value of formal vs. informal communication, including interviewees' views of effectiveness of each mode; for agency staff, ask about how fishers communicate their questions, ideas, concerns]

Part 3. Demographic information

Interviewee may write responses to this section.

1. In what city or town do you live?
2. What year were you born?
3. What is your gender?
4. What is your race, ethnicity, or cultural background? Mark one or more boxes.
 - American Indian or Alaska Native – Name of principal tribe:
 - Asian
 - Black or African American
 - Hispanic or Latino
 - Native Hawaiian or other Pacific Islander
 - White
 - Other, please specify:
 - Do not wish to provide

Appendix B

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