



# When a Shark Is More Than a Shark: A Sociopolitical Problem-Solving Approach to Fisher-Shark Interactions

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Fisheries are often conceptualized through a biophysical lens resulting in management approaches that fail to account for stakeholder conflicts and sociopolitical inequities. Using a fisher engagement approach, this case study examines the sociopolitical dimensions of fisher-shark interactions in pursuit of more complete problem definitions and effective solutions. Through interviews with Hawai'i small boat fishers and observations of a community-based shark-tagging project, we examined fisher perspective, socioeconomic landscapes, stakeholder relationships, and power dynamics. We interpreted these data using an adapted framework that mobilizes concepts from conflict theory and problem definition. We discovered that economic cost, sharks as fishing competitors, and factors of fishers' on-the-water decisions define the fisher-shark interaction problem at the dispute level. Deeper conflicts include fishers' poor perceptions of management legitimacy, degraded relationships with researchers and managers, threatened fisher identities, and poor enforcement capacity. Together, dispute and deeper conflicts limit the effectiveness of singular approaches (e.g., regulation) to mitigate fisher-shark interactions and necessitate multi-pronged solutions with substance-, process-, and relationships-based components. This case study documented one such multi-pronged strategy employing fisher-researcher knowledge exchange, collaborative research, and means of more transparent communication. This strategy has the potential to affect both dispute- and deeper-level outcomes by advancing collective understanding of sharks and shark-handling tools, fisher behavior, and reducing shark mortality. Thus, a sociopolitical approach to problem-solving may yield greater collective benefits to fisheries stakeholders and sharks, with broader implications for the systemic management of complex human and biophysical ecosystem components.

**Keywords:** human-wildlife conflict, problem definition, sharks, stakeholder engagement, Hawai'i

## INTRODUCTION

Natural resource management often employs partial problem framings that favor biophysical, “scientifically objective” information (Young N. et al., 2016; Stephenson et al., 2017). Given stakeholders’ diverse perceptions of the problem (Bardwell, 1991; Adams et al., 2003; Ebbin, 2011), deciding whose narratives to include makes the problem definition process inherently political (Weiss, 1989). Moreover, problem framings are often inattentive to the sociopolitical, conflict-laden landscapes within which natural resource management problems manifest and evolve (Nie, 2001). Failed problem-solving endeavors ignoring social, cultural, and political contexts have been documented in conflict resolution (Ginges et al., 2007; May, 2013) and conservation management (Dickman, 2010; Clark and Slocombe, 2011). Even as socioeconomic and biophysical data are integrated to improve management outcomes (Stephenson et al., 2017), using simplified models for decision-making can lead to overly simple solutions (Scott, 1998). It is essential in problem-solving endeavors to embrace the full range of systems-level complexity of natural resource management problems (Ostrom, 2007; Palsson et al., 2013; Aswani et al., 2018).

Sociopolitical analyses have begun to shed light on the systemic complexity of human-wildlife conflict and management. For example, an emerging body of literature describes terrestrial management efforts aimed at biological and tangible problems of human-wildlife interaction that instead exacerbated conflicts. In some cases, management regimes generated symbolic meanings for large terrestrial wildlife among stakeholders who then viewed wildlife as negative representations of state governance (Nie, 2001; Naughton-Treves and Treves, 2005) or the interests of distant, privileged environmental groups (Skogen et al., 2008). Where these symbolic meanings around human-wildlife conflict are ignored, animosity toward wildlife may persist even after negative human-wildlife interactions have been resolved (Dickman, 2010). Other cases point to implementation breakdowns due to failure to account for power dynamics between managers and stakeholders (Webber et al., 2007; Clark and Slocombe, 2011). Strategies that instead engage stakeholders to take stock of and improve relationships among stakeholders and between humans and wildlife may be better positioned to resolve human-wildlife conflict (Marchini et al., 2019). Madden and McQuinn (2014) present two success stories in human-wildlife conflict management where problem-solving processes account for politics and stakeholder relationships. Together, these studies caution against narrow problem framings of human-wildlife conflict and highlight the benefit of considering sociopolitical contexts and engaging stakeholders as we strive toward human-wildlife coexistence.

Sharks (subclass: Elasmobranchii; superorder Selachii) present an opportunity to diversify the human-wildlife conflict literature. Research around human-shark interaction has focused primarily on public (Friedrich et al., 2014; Garla et al., 2015; O’Byrhim and Parsons, 2015; Acuña-Marrero et al., 2018) and fisher (McClellan Press et al., 2016; Drymon and Scyphers, 2017; Shiffman et al., 2017; French et al., 2019) attitudes toward shark conservation, fisheries interaction patterns and their

economic and ecological implications (Stevens et al., 2000; Glaus et al., 2019; Mason et al., 2019), and efforts to mitigate shark depredation and bycatch (Carruthers and Neis, 2011; Gilman et al., 2015; Oliver et al., 2015; Kumar et al., 2016; Mitchell et al., 2018). Researchers have also focused on characterizing the global shark seafood trade (Clarke et al., 2006; Shea and To, 2017), shifting livelihoods of shark fishers (Jaiteh et al., 2017), and emerging opportunities and challenges in shark tourism (Techera, 2012; Vianna et al., 2012). This body of work exemplifies the diverse positions from which researchers and managers understand sharks and people (Molony and Thomson, 2020) including public safety, shark conservation, and fisheries impacts. Collins et al. (2020) explore the more intricate relationships between shark management measures’ efficacy and diverse fisher economies, adaptive capacities, social norms, and perceptions of management. However, a need for research and policy mechanisms to account for behavioral (Fulton et al., 2011) and socioeconomic factors affecting the feasibility of shark management and bycatch mitigation measures persists (Campbell and Cornwell, 2008; Booth et al., 2019). The sociopolitical lens, with its attention to stakeholder relationships, diverse problem definitions, histories, and power, has received limited attention in human-shark conflict and shark management to date.

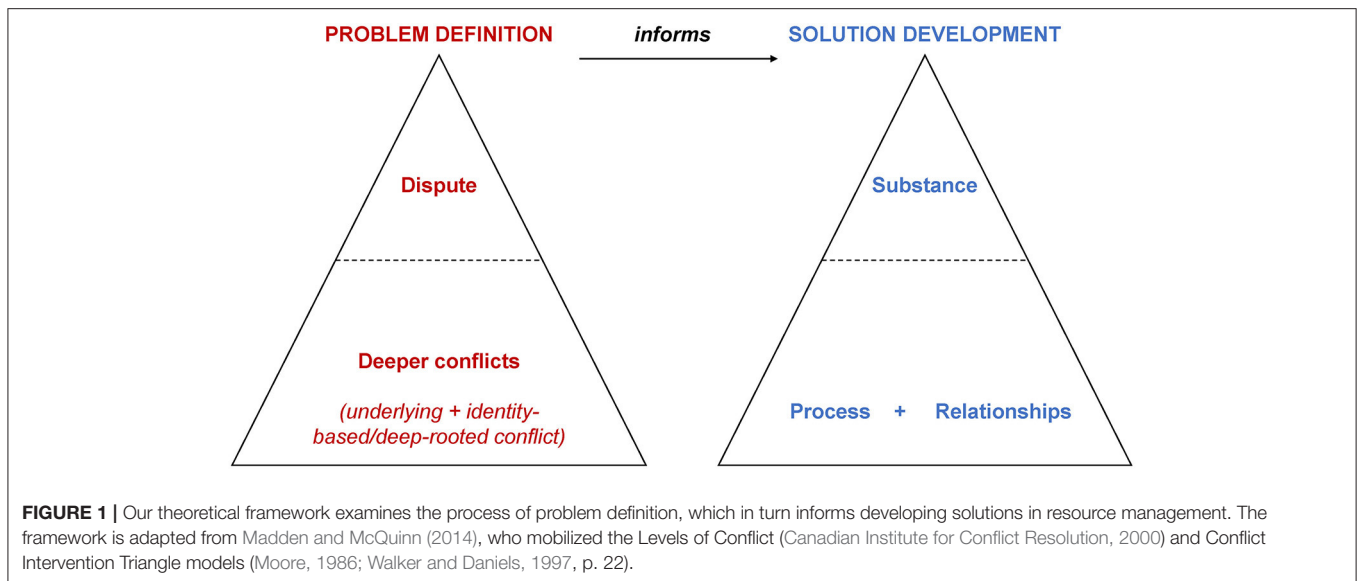
This research contributes to the existing body of literature by delivering a localized sociopolitical analysis of fisher-shark interactions. In this West Hawai’i case study we engaged small boat fishers to expand upon biophysical, conservation-driven problem framings around fisher-shark interactions and account for stakeholder conflicts and power dynamics. An adapted theoretical framework connects concepts of problem definition and layered conflict, providing structure to examine complex problems and comment on the equity and effectiveness of potential solutions. Coupled with its stakeholder interview and observation methods, this research examines the relevance of stakeholder conflict, power, history, and identity to fisher-shark interactions and the importance of process and relationships in reconciling them.

We explore problem-solving in fisheries through two overarching research questions: (1) What layered conflicts are embedded in fishers’ definitions of the fisher-shark interaction “problem”? and (2) How might solutions address both dispute and deeper conflicts for the benefit of stakeholders and sharks?

## METHODS

### Theoretical Framework

This study adapts Madden and McQuinn (2014) conflict framework to examine problem-solving in fisheries. Madden and McQuinn draw from two conflict models. The first identifies three Levels of Conflict (Canadian Institute for Conflict Resolution, 2000), in descending order: dispute, underlying conflict, and identity-based conflict. Dispute encompasses the presenting, often tangible conflict, such as the contested boundaries of a marine protected area. Underlying conflict provides relational and historical context for the dispute and



is often reflective of actors' past interactions and unresolved conflicts that may or may not be related to the dispute at-hand. How actors navigate the dispute at-hand can be deeply affected by underlying conflict. An example of underlying conflict is persisting mistrust between actors based on past management decisions. Identity-based, or deep-rooted conflicts, derive from perceived threats to actor values, culture, and identity. Identity-based conflict might arise, for example, as resource users perceive management as a threat to their autonomy.

In Madden and McQuinn's (2014) Conflict Intervention Triangle—adapted from Moore (1986) and Walker and Daniels (1997)—substance comprises the triangle's apex, and process and relationships sit at its basal corners. Process is defined as, “decision-making design, equity and authority, and how (and by whom) these are exercised” (Madden and McQuinn, 2014, p. 102). Relationships refer to those between individual actors or stakeholder groups and the levels of trust and respect entwined in them. While substance, process, and relationships are all connected and integral to conflict resolution, substantive interventions are considered better suited for dispute, and relationship- and process-based interventions better suited for underlying and deep-rooted conflicts.

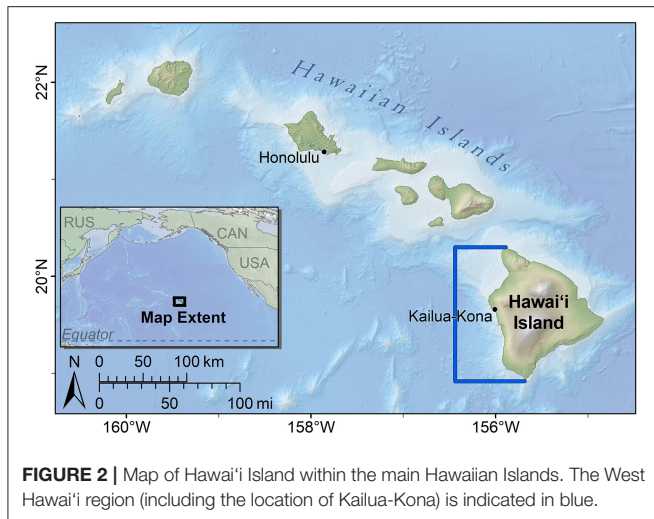
Researchers have applied Madden and McQuinn's framework to examine the social conflicts that underlie human-wildlife conflicts, highlighting their relevance to management (Dorresteijn et al., 2016; Hill, 2017; Crespin and Simonetti, 2019). Our study adapts the Madden and McQuinn framework to investigate stakeholder perceptions of how problems are defined and solutions are developed. We adapt their conflict models to interpret these two critical processes in fisheries management (**Figure 1**). Madden and McQuinn (2014) framework depicts three levels of conflict (dispute, underlying, and identity-based) and corresponding conflict resolution approaches (settlement, resolution, and reconciliation). Zimmermann et al. (2020) build on this framework and provide additional guidance, including specific approaches to identify and address each level

of conflict. However, underlying and identity-based conflicts are often intertwined, and both derive potential benefits from reconciliatory solutions (Lederach, 1997; Lundy and McGovern, 2008). Within our study context, separating underlying and identity-based conflicts provides little benefit to our problem-solution analysis. We therefore interpret underlying and deep-rooted conflict together as facets of “deeper conflict” rather than as distinct tiers of a conflict hierarchy that benefit from distinct solutions. Further, we demonstrate interactions between dispute and deeper conflicts, which necessitate solutions incorporating dimensions of process, relationships, and power.

## Case Study Site and Problem

In December 2016, the National Marine Fisheries Service (NMFS) proposed a rule to list the oceanic whitetip shark (*Carcharhinus longimanus*) under the Endangered Species Act (ESA), citing significant declines in abundance throughout its habitat range due to overexploitation (Young C. N. et al., 2016). Subsequent management measures would likely focus on pelagic high-seas fisheries that inflict high shark bycatch and mortality rates (Bonfil, 1994; Gilman et al., 2008). However, the ESA listing's undetermined status and managers' and researchers' growing interest in oceanic whitetip sharks provided an opportunity to explore fisher-shark interactions in Hawai'i more broadly. We took this opportunity to conduct a sociopolitical examination of the West Hawai'i small boat fleet and its interactions with pelagic sharks, including, but not limited to the oceanic whitetip shark.

Information around pelagic shark interactions within the West Hawai'i small boat fleet is largely undocumented. Shark species, interaction frequencies, outcomes, and determining factors for fisher and shark behavior were among the unknowns. Prior to this study, anecdotal evidence indicated that fisher-shark interactions within this fishery could produce negative outcomes for both fishers and sharks; namely, loss of fisher catch and gear, and shark injury. Fishers also expressed a desire to reduce



these interactions, which they described as largely incidental and undesirable. Thus, shark conservation, research, and fishery impacts perspectives provided rich context to examine the implications of problem definition for developing solutions.

West Hawai'i refers to the leeward, western coast of Hawai'i Island (Figure 2). Its calm waters and proximity to pelagic species allow fishers to accumulate a relatively large number of fishing days per year with good visibility for pelagic shark observations. The West Hawai'i small boat fishing community represents diverse fishing methods, experience levels, and ethnicities. It includes perspectives from local, outer island, and continental U.S. fishing cultures, and membership from the recreational, part- and full-time commercial, and charter fisheries.

West Hawai'i fishers' exposure to fisheries management and research also lends itself well to a sociopolitical analysis. The West Hawai'i Regional Fishery Management Area (WHRFMA) encompasses four Marine Life Conservation Districts and seven Fisheries Management Areas, with bans on SCUBA spearfishing and the take of reef sharks and rays (State of Hawai'i Division of Aquatic Resources, 2019). Aquarium fishing has been suspended since 2017, with a recent environmental impact statement requesting limited permits rejected by the Board of Land and Natural Resources (BLNR votes 7-0 against environmental impact statement for aquarium fishing permits in West Hawaii, 2020). Several local and international non-governmental organizations (NGOs) operate there in lobbying and research support capacities (Tissot et al., 2009). West Hawai'i is also a focus area for the National Oceanic and Atmospheric Administration's (NOAA) Habitat Blueprint and Pacific Islands Ocean Observing System (PacIOOS) Hawaiian Islands Sentinel Site Cooperative. All of these inform the West Hawai'i fishing community's perspectives on local science and management.

In months following the oceanic whitetip shark's proposed ESA listing, a team of University of Hawai'i and NMFS-affiliated shark researchers expanded its pelagic shark-tagging efforts to include West Hawai'i small boat fishers. The team hoped that fisher participation would enhance understanding of

sharks' movements and alternatives to shark-handling practices that could result in mortality. The team trained fishers in shark-tagging protocols and shared information about shark life history, vulnerability to fishing activity, and management measures. Financial incentives were awarded to fishers who deployed electronic and identification tags on oceanic whitetip, silky (*Carcharhinus falciformis*), and bigeye thresher (*Alopias superciliosus*) sharks. The tagging program prioritized these species given their listing in the Convention on International Trade in Endangered Species' (CITES) Appendix II, and the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species as "Critically Endangered" and "Vulnerable." The early growth of this collaborative program, now termed the Hawai'i Community Tagging Program (HCTP), provided a valuable opportunity to observe evolving fisher-researcher relationships with a substantive focus on fisher-shark interactions.

## Data Collection

Across disciplines, stakeholder perspectives have revealed new technical problem framings (Leong et al., 2007) and clarified the relevance of politics, stakeholder values, and culture to solution design (Watkin et al., 2012; Madden and McQuinn, 2014). Participatory processes have also been enlisted to challenge the biophysical constraints of fisheries problem-solving (Mikalsen and Jentoft, 2001; Beierle, 2002; Ebbin, 2011; Sayce et al., 2013). We combined semi-structured interviews with participant observation to explore problem definition and potential solutions through fisher perspective and fisher-researcher relationships. We sought to generate new understanding from the data rather than interpreting data through pre-established hypotheses using a qualitative, inductive approach. IRB clearance was obtained through NOAA's Pacific Islands Fisheries Science Center (PIFSC) under Joint Institute of Marine and Atmospheric Research (JIMAR) exempt project 19449, Socioeconomics of Western Pacific Fisheries.

Data were collected primarily through semi-structured interviews. Preliminary meetings with members of local fisher-oriented NGOs, HCTP, fishers, and fisheries social scientists informed development of an interview guide, solicited guidance around best practices for fisher engagement, and identified contacts within the West Hawai'i fishing community. Public workshops were co-hosted by the lead author and HCTP given their shared target audience. Participation was also advertised through flyers distributed in tackle shops and harbors, and announcements in the local Hawai'i Fishing News magazine. These printed materials were unsuccessful in connecting the lead author to new research participants. Additional interviewees were identified through the snowball sampling method, which relies on established participants' referrals to identify new contacts and user groups in their community (Atkinson and Flint, 2001).

In addition to serving as a subject of this case study's observations, the HCTP and its public workshops provided a venue for the lead author to promote participation in and share results from this case study. These shared venues for the lead author and HCTP to recruit participants and communicate

results may have produced some bias among interviewees who also participated in the HCTP. However, data collected for this project are distinct from that of the HCTP and fewer than half of this study's interviewees were HCTP participants.

The fisher engagement strategies used in this case study and the HCTP had some similarities. Both initiatives sought to accommodate fishers while operating within the study scope and budget. Outreach efforts and public workshops were centered around Kailua-Kona, where many participants either lived or worked. Workshops were scheduled after consultation with research participants in an effort to make them more accessible to the local fishing community. For individual and small group meetings, HCTP PI and the lead author for this case study met with fishers in settings of their choice and made travel arrangements to accommodate fishers' schedules as much as possible. Case study interviews were conducted in family homes, at the Honokōhau Harbor, and at local restaurants. Informal, fisher-led HCTP gatherings also promoted participation in the tagging program. For example, one fisher hosted a gathering in his home. Previously the HCTP had difficulty connecting with commercial fishers given their unpredictable and demanding fishing schedules.

Case study interviews were conducted in-person from September 2017 to June 2018, and typically lasted 1–3 h. We asked participants about their relationship to fishing and fishing history; information sharing in Hawai'i Island fisheries; shark interactions and handling practices; and local fisheries management and science (see Appendix in **Supplementary Material** for detailed interview guide). Interviews continued until data became saturated—meaning that new interviews repeated themes and ideas captured in former interviews (Saunders et al., 2018)—resulting in a total of 29 interviewees. Interviews were audio recorded and detailed notes were written up as soon after the interview as possible. Interviews were transcribed and interviewees were given a copy of their interview transcripts for voluntary review and revision.

Observations supplemented interview data on fishing practices and fisher-researcher interactions. The lead author conducted participant observation on three occasions with the HCTP research team. These included a chartered shark-tagging trip on a commercial fishing vessel out of Kailua-Kona and two public shark-tagging workshops held in October 2017 and 2018. At both workshops, the HCTP team trained fishers in tagging protocol, distributed shark-tagging gear, and reported on the progress of their research.

## Data Analysis

Data analysis followed an inductive process typical of grounded theory (Glaser and Strauss, 1967). Data were collected and primary analyses completed before selecting a theoretical framework. This approach enabled pursuit of themes important to interviewees and elicited connections between relevant biological, social, economic, and political components. The lead author coded all interview transcripts using NVivo software (NVivo, RRID:SCR\_014802, version 11 Plus). Preliminary codes followed the interview guide's broad themes: fisher identity, sharks, information-sharing, and management. Additional codes

**TABLE 1** | Interviewee demographics.

Characteristic		<i>n</i>
Age, years	18–35	4
	36–50	7
	51–65	12
	66–80	6
Ethnicity	Caucasian	11
	Asian <sup>b</sup>	11
	Hawaiian	3
	Hawaiian-mixed	4
Origin	Hawai'i Island	14
	Neighbor islands	7
	Continental US	8
Type of fishing	Commercial only <sup>a</sup>	12
	Charter and commercial	5
	Charter only	4
	Recreational/retired	8
Years fished in Hawai'i	5–15	3
	16–30	10
	31–45	10
	46–60	6

<sup>a</sup>3 of 12 commercial only participants identified as full-time commercial fishers.

<sup>b</sup>8 of 11 Asian participants were Japanese.

were created liberally to capture all relevant information, including descriptions of West Hawai'i fishing practices and cultures through time, economic context, fishing motivations, human well-being, power, and knowledge. A transcript excerpt could be coded for multiple themes, overlapping or separate across the text. Two rounds of coding ensured that all relevant data were represented in the codebook and that codes were organized to reflect thematic relationships and consolidate coding redundancies.

In February 2019, the lead author returned to the study site to present preliminary results to research participants at a public HCTP meeting and solicit feedback. Twelve of ~30 attendees were interviewees. Although interviewees did not volunteer feedback in front of the group, the few who later corresponded with the lead investigator shared positive comments about the way their input was represented and volunteered their support for future collaborative research endeavors.

## Research Participants

The 29 male interviewees represented diverse demographic and fishing identities (**Table 1**). Interviewees averaged 30 years of fishing experience in West Hawai'i per fisher; a conservative estimate, excluding shoreline fishing that predates boat fishing ventures or formal fishing careers, and rich fishing experiences inherited from generations past. Independent of their charter, commercial, and recreational identities, a total of 16 interviewees described non-fishing occupations that either supplement their fishing income or serve as their full-time position. On average, interviewees described fishing for over 160 days per year in the peak of their careers. Interviewees' participation in collaborative

research and management-related fisher engagement also varied, with most having limited experiences in either.

Although participants' repertoire of fishing methods was extensive, those described most frequently by interviewees were handlining ( $n = 23$ ), trolling ( $n = 21$ ), and fishing with live bait ( $n = 18$ ). Interviews covered a diverse range of target species, the most popular of which were deep bottomfish (primarily snappers and a grouper), 'ahi (either bigeye or yellowfin, *Thunnus obesus* and *T. albacares*, respectively), marlin, and 'ōpelu (mackerel scad, *Decapterus macarellus*). Other target species cited in interviewees' primary fisheries, past and present, included pelagics like mahimahi (*Coryphaena hippurus*), aku (skipjack tuna, *Katsuwonus pelamis*), and ono (wahoo, *Acanthocybium solandri*), reef fish both for consumption and sale in the tropical fish trade, Kona crab (*Ranina ranina*), and black coral.

## RESULTS

Interview and observational data revealed dispute and deeper conflicts framing the fisher-shark interaction problem, along with several substantive, process-, and relationship-based solutions.

### Problem Definition

We found that fisher-shark interaction problem framings are both disputative and steeped in deeper levels of conflict related to fisheries science and management. We expand on both of these below.

#### Dispute

Shark attributes described by interviewees were coded as negative, positive, or neutral depending on their overall cost or benefit to fishing activity. Negative descriptors were the most prominent (49% of all references). Most commonly, interviewees described sharks as competitors (26% of all references), generally and through two specific mechanisms. They described sharks as either depredating—removing hooked fish or bait from fishing gear (Gilman et al., 2008)—or deterring target fish from interacting with their gear. Competition for fish, in turn, translated to competition for fisher income and a threat to fisher livelihoods.

Sharks' competitive impact on fishing was greater for those who rely more on landing fish for income—full-time commercial fishers, for example, as opposed to part-time commercial, charter, or recreational fishers. Despite occupational differences, interviewees described these consistencies across the West Hawai'i small boat fleet: increasing costs of fishing material, uncertain landings, and a fishing community that has grown rapidly in recent years. These conditions increase competition for fishing spots and a decent price at which to sell catch. More than two-thirds of interviewees described fishing as a "lifestyle" associated with financial insecurity.

Interviewees described sharks differently according to species. We selected three species that illustrate this diversity: tiger (*Galeocerdo cuvier*), oceanic whitetip, and thresher sharks (*Alopias* spp.) (Figure 3). Some descriptors were linked to interviewees' shark interaction frequencies and handling practices. Shark aggression and depredation (Figures 3A,B)

were often talked about together and associated in some cases with shark mortality for its burden to fishing activity. "An aggressive, hungry shark is probably gonna die," said one fisher. Sharks' role as fish indicators (Figures 3B,C) may increase interaction frequency because, "If there's sharks around, then you know there's fish around, why leave?" However, sharks as fish indicators were categorized positively because, as one fisher noted, "It's a good sign too. When you're getting the interactions with the oceanic whitetips there's more fish around normally." In contrast, the danger (Figure 3A) or hassle (Figure 3C) that a shark imposes on a fisher might diminish fisher willingness to interact with certain species. Importantly, the relationship between shark descriptor and fisher behavior is not always the same. For example, tiger and thresher sharks were both described as economically valuable. However, tiger sharks' economic value was attributed to the benefit of their sensationalized image to the tourism industry, while thresher sharks' derived from their market value. Landed thresher sharks thus provide fishers opportunity for direct financial compensation, while tiger sharks' economic value is relatively inconsequential for fishers.

Interviewees noted a number of factors related to shark attributes, landing opportunity, social pressure, physical capacity, and investments in time and finances that affect their decisions during a shark interaction (Table 2). Any number of these can play a role in fisher behavior during a shark encounter, but the cost-benefit calculus varied by individual. For example, considering how many sharks vs. target species are in the area, one fisher commented:

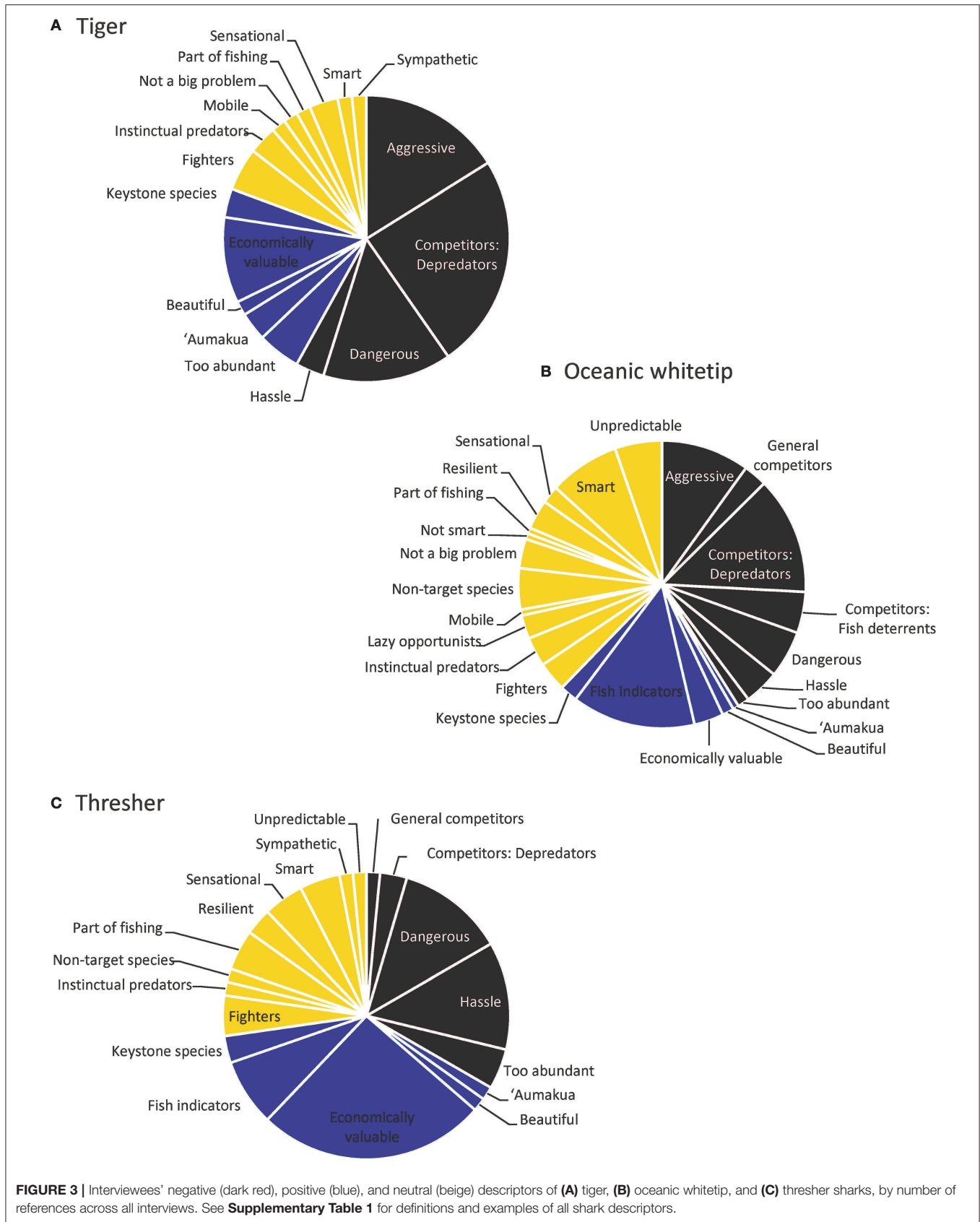
[If] it's just nothing but sharks... [that's] time to quit, because not only are we going in the hole with our gas and our ice and our bait, they're taking our tackle, destroying our stuff... We got a thousand dollars in the hole, we just have to let the conditions change out there until those damn sharks move out of here.

Another fisher said, "If there's a lot of tuna and a lot of sharks, you find different ways to kind of get around the sharks." At the intersection of shark species and financial considerations lies the market value of mako (*Isurus* spp.) and thresher sharks. One fisher commented: "It's really bycatch. You're going for 'ahi and all of a sudden a thresher bites, and then you look at this thing, you don't have anything in your box, you go, 'Oh I can make money killing this shark.'" Some fishers noted social factors affecting their behavior: "You don't know who's in the other boat too, so you [don't want to] just shoot [the sharks]."

Despite sharks' competitive impacts and the physical, financial, and time investment risks they pose to fishers, many interviewees described not devoting much thought to sharks prior to engaging in this case study or the HCTP. Many interviewees ( $n = 17$ ) described sharks as incidental, non-target species. Fishers thus dedicated relatively little observational attention to sharks and discussed them with others in the fishing community only peripherally to their main fishing activity.

### Deeper Conflicts

Deeper conflicts derive from threats to identity, culture, and values, or unresolved conflicts between actors. The



**TABLE 2** | Decision-making factors during a shark interaction.

Factor category	Factor (# of interviewees citing each)	Effect on fisher behavior; Illustrative quote(s)
Shark attributes	Shark accessibility (20+)	The degree of physical access a fisher has to a shark determines his/her behavioral options. Namely, whether or not the shark is hooked or at the surface.
	Shark persistence (19)	Shark persistence despite fisher handling increases the readiness of fishers to apply more severe handling practices. Tiger, blue ( <i>Prionace glauca</i> ), and oceanic whitetip sharks were among those described as persistent.
	Number of sharks (16)	Coupled with shark persistence and aggression, a high number of sharks may result in fishers leaving an area.
	Survivorship (12)	Some fishers described their shark-handling preferences based on the perception that they do not result in shark mortality or significantly impact shark populations.
Landing opportunity	Shark market value (15)	The market value of mako and thresher sharks offers fishers the added opportunity to land them for sale.
	Target species' presence (15)	If target species are present, a fisher is less likely to leave and more likely to attempt to fish around or handle a shark.
	Fish on the line (6)	If a fish is on the line, fishers may be more receptive to short-term strategies that are otherwise unattractive (e.g., shark feeding, juggling).
	Time of day (5)	Small windows of opportunity for fish bites make fisher decisions more critical and reduce behavioral options.
Social pressure		The increased likelihood of being observed in daylight may also restrict fishers' handling options if they may be perceived as socially undesirable. <i>If [the sharks] come and get you at prime time, you're done.... Dusk or dawn, yeah. You see the first crack of gray.... Our movements, the way we chum, the way we check our baits, becomes ten times as critical.</i>
	Other boats (10)	Presence of other boats in an area may discourage fishers from using certain shark-handling practices, redistribute shark impacts among fishers, or inhibit a fisher's ability to move given already occupied fishing spots. <i>When there's a lot of charter boats out there live baiting... Then there's less shark predation on my side.</i>
Physical capacity	Safety (14)	Shark-handling is a physically demanding activity. Tools can reduce its physical stresses, but also pose additional bodily risks. Safety considerations' impact to each fisher's behavior varies according to personal preference, physical ability, age, and gear/vessel configuration.
	Gear (10)	Fishers' typical gear configurations are limited in the access to sharks and handling practices they enable. <i>When we go out for fishing, we're just rigged for fishing.... So you kind of use what you got, and what you got to work with.</i>
	Crew (6)	More hands on deck make physically challenging handling practices more accessible to some fishers. It may also discourage the use of certain tools (e.g., guns) for safety reasons.
	Vessel size (4)	Fishers with larger vessels have access to more behavioral options and are able to handle larger sharks.
Time/financial investment	Distance traveled (2)	Fishers may be disinclined to travel to distant fishing grounds if they know there are sharks in the area. Fishers may also consider a wider range of behavioral options if they are already fishing a distant area.

*Direct quotes in italics.*

deeper conflicts that emerged from interviews drew from broader discussions of local fisheries management and fishers' experiences with researchers and managers. Interviewees noted several problems in local fisheries management and science (**Table 3**). The most commonly cited were disconnect in fisher-manager or -researcher logic, experience, and power; misplaced management focus on small boat fishers; lack of enforcement; politicized decision-making; questionable data validity; and a lack of transparency around science and management. Each of these issues degraded fishers' perceptions of the legitimacy of fisheries management and science (noted with

asterisks in **Table 3**). Interviewees referenced, for example, the scapegoating of fishers for less visible or manageable issues: "Most of these laws are people bored and they wanna blame fisheries for the depletion of fish, or hunters for depletion of animals in the forest, even though they don't see the real issue."

Often, deeper conflicts came to light as fishers described engaging with researchers and managers. Three problem themes emerged in direct connection with these experiences: fishers' voice, apprehension around engagement, and resignation from engagement processes (**Table 4**). Although interviewees



**TABLE 3** | Problems in fisheries management and science described by interviewees.

<b>Problem theme (# of interviewees citing each)</b>	<b>Included perceptions of...</b>	<b>Illustrative quote(s)</b>
Stakeholder disconnect* (17)	Disconnect between fishers and managers/scientists, often between fishers' on-the-water experiences and manager/scientist logic. Also, a lack of consideration or empathy for how management and research decisions affect fishers.	<i>Go to the fishermen that are in the water and actually interact with the animals every day. Ask them, first. Before you go to Land Board, all those other people that think they know what they're doing. If people that generally made laws could do that, I think it would open their eyes a lot more as to what actually goes on. Instead of just reading what is on the piece of paper... and signing it off.</i>
Relative impact* (14)	Misplaced focus of research or management. Often related to perceptions of other fishing groups having greater resource impacts and/or lesser regulatory oversight.	<i>Sportfishing and the local commercial fishermen are minute compared to the big corporation or big fishing companies in the state of Hawai'i. The longline fleet takes top priority... And they get away with a lot more than anybody else could, and if the smaller fishermen came in there to voice what they thought about the tuna... they just went in one ear out the other ear.</i>
Lack of enforcement* (14)	A lack of enforcement in terms of capacity as well as practice.	<i>They have enough [state enforcement] people on this island to do one 8-h shift 5 days a week. For the whole island, from the top of the mountain to 3 miles offshore.</i>
Politicized decision-making* (13)	Management and regulations based on public sentiment and special interests rather than science and rationality. Also, science used to support political decisions.	<i>Unfortunately a lot of regulations are made not by science but by emotion. Just like every scientist I know [does], they only take the information that proves [their] fact.... Every single scientist.</i>
Data validity* (11)	Questionable validity of data collected for fisheries management, its use in decision-making, and the ways that might be improved.	<i>I'm all for proper management if I can see the results. Show us where those numbers came from. The fishermen are out there all the time. They're out there in fact more than the scientists I think, in numbers. So they can be an asset.</i>
Transparency* (8)	A lack of transparency or clarity with regard to managers' or scientists' motives and goals.	<i>All we know is that you guys just want us to try and tag [sharks]. And that they may be on the endangered species list.... What more are you looking for? What's your objective? What's your goal? I stood up, I said, "How did you get that blue line since it's not reported?" And [scientist] says, "We have our ways."</i>
Lack of compromise (8)	Management discourse and processes being biased and unwilling to compromise or consider other perspectives.	<i>You've got the total left that just want regulation... and then you've got the other side that is just all or nothing. There's nothing in the middle.... There's no management. A lotta time the decision is already made and they just have these public hearings and all these things... It's so one-sided that it just [always goes] one way already.</i>
Permanence (7)	Management measures as permanent and non-adaptive.	<i>They had that 10-year ban in Ka'ūpūlehu, that thing is never gonna open.... It's never gonna have a review after 5 years. It's because the state [doesn't have] any money. If you make it a law that you cannot kill this... now you're going to get a million sharks around you, you can't even fish. There's gotta be a balance.... Because in the future you might not be able to retract that law.</i>
Inequity* (5)	Inconsistencies in management decision-making, which affords benefits to certain groups and targets others disproportionately for regulation.	<i>It really seems like they pick and choose... What rules they want to push, what rules they want to enforce, to kind of pick on a specific group of people.</i>

Direct quotes in italics. \*Issues that degrade fishers' perceptions of the legitimacy of fisheries management and science.

expressed interest in sharing their voice and perspectives with researchers and managers, opportunities to do so were often described as limited or superficial. Several interviewees described past experiences that resulted in mistrust of managers and

researchers, fear of losing fishing access, or a withdrawal from fisher engagement processes altogether. In some cases fishers expressed these concerns, facilitating transparent fisher-researcher discussions that helped to overcome them:

**TABLE 4** | Interviewee perceptions around fisher engagement.

Engagement theme (# of interviewees citing each)	Included perceptions of...	Illustrative quote(s)
Fishers' voice (19)	A need for fishers' voices to be heard by fisheries management actors and to affect meaningful change. Often this was a fisher goal that went unmet during engagement.	<i>We have no voice. The fishermen have no voice. You guys are probably gonna be fisheries managers or advising fisheries managers and stuff, and at least you listen.</i>
Apprehension (6)	Fishers' concerns for or fears related to fisher engagement motives and outcomes.	<i>That's where everybody shuts up... 'cause [things] end up out of our control. And then next thing you know it's a law, and we can't go near them, or we can't fish these areas.</i>
Resignation (5)	Fishers giving up on engagement opportunities given their past experiences.	<i>I told him, "No dude, I'm done with that kinda deal."... At the end, I felt like it was so much effort coming from our side, with no end result. Or meaningless time that we spent there... No matter what we say or do, there's gonna be no results.  I go off and on, but not taking interest like I used to because it doesn't matter. That's the sad part... Why have people go over there and have issues where somebody really cares about something, voices their opinion, and [it doesn't] matter?</i>

*Direct quotes in italics.*

I had to ask about your goals and intent because... I go to meetings now, I know what they're trying to do to Kona. They're trying to make this an aquarium... They have to also think about the culture. And the local people here.

In discussions of fisheries management and engagement, interviewees perceived certain actors and knowledge types to wield greater power than others. Often, interviewees described themselves or their communities as adversely affected by these power dynamics: "They make these decisions for this stuff without really knowing the impact... it has on our life." Interviewees described financial capital and formal, academic, and scientific knowledge to facilitate access to management decision-making and leverage over its outcomes. One fisher advised, "To fix all the problems, you have to get your degree... and find [a] route to the money." Fishers, who offered experiential knowledge through communication styles often considered informal, felt disadvantaged by this dynamic. Interviewees perceived managers to assert their power through uninformed decision-making, evading answers when fishers' knowledge challenged their own, and hosting public meetings with limited outreach or accessibility. Interviewees perceived researchers' power through their representation of fisheries and delivery of fisher data to managers, and a lack of transparency around their science or goals. Interviewees felt both researchers and managers influence decisions with relatively little impact to themselves compared to fishers who experience direct impact. Some research participants expressed concerns that this case study and the HCTP intended to create new fishing regulations and inquired about funding sources. These examples of power embedded in deeper conflict cut across various problem themes from **Tables 3, 4**. Financial capital and influence on

public perception also emerged from interviews as forms of power wielded by the tourism industry, high seas fisheries, environmentalists, the wealthy, and NGOs.

Many of these deeper conflicts denied or threatened key elements of fisher identity. Interviewees most commonly discussed their identities as self-reliant, stewards, local, multi-generational fishers, and scientifically curious. These emphasized fisher agency, practices of self-management to sustain fisheries, and commitment to place and local fishing culture. Interviewees also took pride in their acuity for on-the-water observation and experimentation and expressed interest in novel scientific data collection methods and projects, including shark-tagging data.

## Solution Development

This case study documented several solutions rooted in substance, relationships, and process. These were either discussed by interviewees or exemplified in the engagement strategies employed by the lead author or HCTP.

## Substance

The substantive solutions that emerged from interviews and observations included shark-handling alternatives, regulation, information provision, and financial incentives. **Table 5** provides fisher perspectives and exemplary quotes for each of these solution types. Fishers were amenable to shark-handling alternatives that would preserve factors like their landing opportunity and safety (**Table 2**). For example, "jugging" consists of rigging a jug or floated object to a baited hook. This contraption is often deployed unattached to the vessel. Once taken by a shark, it maintains the shark's surface position and deters it from the fishing area or target species. Research participants raised such ideas as biodegradable jugs or more

**TABLE 5** | Substantive solutions.

<b>Solution element (# of interviewees citing each)</b>	<b>This study documented...</b>	<b>Illustrative quote(s)</b>
Shark-handling alternatives (28)	Firearms, releasing hooked animals, jugging, and shark avoidance strategies were among the most commonly discussed shark-handling alternatives. Preferred strategies varied by individual, but were often viewed as the most efficient, safest, or only available options to protect fishing opportunity. Fishers were receptive to the idea of novel shark-handling alternatives.	<i>A lot of times as a fisherman it was hard because if you could wave the magic wand, please go away, you would. I don't know what else could be done... That's the only thing I would listen to, if you had a deterrent. Other than that I wouldn't go to listen to anything else.</i>
Regulation (26)	Discussion of various regulatory tools, including area closures, shark finning bans, fishing licenses, and catch limits. Interviewees linked poor enforcement with perceptions of management as ineffective and illegitimate.	<i>A law with no enforcement is merely a suggestion... Over here, there's zero enforcement. In Hawai'i, it's all about who you know, not what you know. In Alaska, it doesn't matter. The rules [are] the rules.</i>
Information provision (24)	New information about sharks' cultural significance or biology having limited potential to change fisher behavior and reduce shark mortality.	<i>The Hawaiians said release all the sharks that you catch because it was their cultural practice or something. So, I just... let them go.</i>
Financial incentives (15)	The opportunity for financial incentives to address the costliness of shark interactions. By offsetting costs and acknowledging fishers' livelihood insecurities, financial compensation may legitimize and increase fisher access to a broader number of behavioral and shark-handling options.	<i>You get the grant, and there has to be some type of reward... "Cause if not, everything comes down to the end of the month. You pay your mortgage, you pay your college loan.... You give me x amount of dollars to go tag every single shark that comes by the boat, they'll live. I'll spend all day tagging sharks.</i>

*Direct quotes in italics.*

readily eroding jugging rigs, and provided anecdotal evidence of shark-tagging as an effective shark deterrent. Interviewees also discussed various regulatory measures, but often in tandem with a lack of enforcement or legitimacy that cripples their effectiveness. Some fishers requested informational tools, like shark identification guides with species' protected statuses. On rare occasions, fishers described modifying their shark-handling practices as they acquired new information. One fisher said after learning of thresher sharks' vulnerability: "Now I will not shoot a thresher shark that I catch. Because [HCTP PI] informed me.... And we have a deep respect for the ocean." But, as one fisher put it, "Where there's sharks there's fish." Challenges inherent in fishing like sharks and financial cost limit fishers' capacity to modify their behavior. By directly offsetting cost, financial incentives may provide fishers access to alternative shark-handling practices like tagging: "You give me x amount of dollars to go tag every single shark that comes by the boat, they'll live. I'll spend all day tagging sharks."

We found that the impact of any substantive solution on fisher perspective and behavior depends on a number of variables including livelihood dependence on fishing and fishing method. A fisher using live bait, for example, has more behavior change flexibility than a handline fisher. Upon encountering a shark, one live bait fisher described his options to continue moving through the area or reduce the likelihood of shark interactions by switching to an artificial lure. Handline fishers, in contrast, are committed to a fishing spot and their chances of landing a fish depend on consistent chumming. This increases the likelihood of shark interactions and makes avoidance maneuvers challenging. Other variables related to fishers' capacity for behavior change are less tangible.

Some interviewees, for example, described their receptivity to modify shark-handling practices as a function of their age or experience level.

### Process and Relationships

Drawing upon our adapted theoretical framework, we posit that process- and relationship-based solutions may be better equipped to address deeper conflicts. In their discussions of fisheries management, science, and fisher engagement, interviewees described several solution elements attentive to process and relationships (Table 6). Interviewees highlighted the importance and inseparability of trust-building and transparent fisher-researcher and -manager communication, connecting these processes to tangible benefits for data collection and scientific knowledge. Fishers also noted that convenience can help to facilitate fisher participation given fishers' demanding schedules and geographic spread. One participant said, "Fishing advocate[s]... They're kinda retired and they have time to make a difference." Finally, several interviewees highlighted the fishery's diversity and the need to account for it in our engagement processes:

People have all kinds of different perspectives.... I know people that have a high paying job, they fish on weekends, they only catch for recreation.... You gotta get everybody's opinion.... Not only one side of the story. Please capture everybody.

### Cross-Cutting Strategies

This case study documented two strategies that cross-cut multiple substantive and deeper-level solutions: collaborative research and knowledge exchange.

**TABLE 6** | Process- and relationships-based solution elements.

Solution element (# of interviewees citing each)	This study documented...	Illustrative quote(s)
Communication (23) + Trust-building (16)	The value of two-way communication in building trust and relationships between fishers and researchers or managers; often described together. Interviewees noted the role of key actors and non-threatening approaches in communication and trust-building, and the potential for improved communication to benefit fisher participation and buy-in (e.g., sharing research results with fishers may benefit collaborative data collection).	<p><i>That's the reason why nobody [submits data], you know what I mean? But it's a detriment to the research, because if they had ... just a short thing they can send to the fishing public, so that they know that all this reporting was not done in vain. But right now, it's a bottomless pit.... You don't know where that information is going.</i></p> <p><i>Starting a conversation... [don't] just say, "Hey, I'm here, I'm a scientist... where'd you get that and how was the current?" Like, "Hey brah, how'd you do today?" and just feel them out... Not come from the top and nīele<sup>a</sup> and just sneak up on them.</i></p>
Convenience (12)	Issues of convenience and accessibility related to fisher engagement. Fishers noted the investment in time and money required to attend meetings and share their perspectives (e.g., paying their way to outer islands or rearranging fishing/livelihood schedules to meet researchers' and managers' needs). Also, challenges engaging with geographically dispersed communities like that of West Hawai'i.	<p><i>It's hard to get those guys.... [They're] so spread out, they don't wanna come to meetings. ... You get fishermen from way south, and you're going to hold one meeting up here.... If people [are] right here they're going to go right here. But people far away, they're not going to attend one meeting.</i></p>
Inclusion (8)	Diverse fisher perspectives varying according to age, experience level, occupation, fishing method, and geographic origin. These require researcher and manager efforts to account for diversity. Fishers also noted differences across the island chain.	<p><i>Get the old-time fishermen, the new fishermans, and they probably all got different opinions.</i></p> <p><i>People have all kinds of different perspectives too. 'Cause I know people that have a high paying job, they fish on weekends, they only catch for recreation.... You gotta get everybody's opinion, please.... Make sure now! Not only one side of the story. Please capture everybody.</i></p> <p><i>You should ask probably commercial fishermen in O'ahu. And Maui, who have more interaction with sharks than we do on [Hawai'i] Island.</i></p>

<sup>a</sup>To keep asking questions... often used in pejorative sense, as of a busybody asking things that do not concern him" (Nīele, 2020). Direct quotes in italics.

### Collaborative Research

This case study and HCTP took collaborative research approaches to enlist fishers in data collection. Researchers employed various strategies to increase fisher participation, from engagement processes (see Methods) to financial rewards for tag deployment. Mutually beneficial outcomes like improved data collection or shark deterrents also incentivized fisher engagement. Fishers described being motivated to participate by their interest in the development of a shark deterrent or handling alternative, and shark behavior and habitat use: "That kind of information might be useful. Then certain times of the year maybe [they're] not around, and the fish are biting, that's when you go... That's another tool in our tool bag when we go fishing." One fisher also contacted the HCTP PI offering to tag sharks for free if funds were scarce, and thanked her for including fishers in HCTP's collection of "real true data."

Key actors, respected and in communication with others, were instrumental in bolstering fisher participation in collaborative research efforts. Interviewees highlighted researchers' and managers' opportunities to use social structures within the community to build trust and share information. One fisher noted key actors' roles in gaining community support: "If you can somehow get the support of the iconic guys... Then they'll

spread the word, ah?... Rather than the scientists coming over telling, 'You guys should be doing this'... It's good to garner some support in-house." Several fishers also noted that their decision to participate resulted from friends' encouragement rather than, for example, learning of these projects through printed materials: "I had actually heard about it through the flyers at Pacific Rim, and saw it at the bulletin board and stuff. I just wasn't necessarily gonna go until I heard that other guys were going."

Growth in HCTP participation was observable through attendance at its public tagging workshops. HCTP's first workshop in 2017 was attended by 6 ocean users, most of them fishers. Thirty people attended its second tagging workshop a year later. Afterward, one fisher reached out to congratulate the HCTP team, commenting, "It's typically hard to get that many fishermen to meet for anything. One of the things I got from what you said last Saturday was that getting this kind of participation was a main point of your interest. If that's true, you succeeded." When the lead author returned to Kailua-Kona in February 2019 to share interview results with research participants at a public HCTP workshop, about 30 ocean users attended, including 12 interviewees.

Two-way communication during interviews and HCTP public workshops facilitated trust-building between fishers and

researchers. During these events, fishers asked questions and voiced concerns about researchers' motives and goals, allowing researchers to recognize and respond to them explicitly. This process built trust with participating fishers and encouraged their continued support in data collection and interviewee referral. Interviewees also noted both situational and more general shifts in their own shark-handling practices, including the release of certain shark species, following case study interviews and conversations with the HCTP PI. One fisher, for example, described his friend's remarks upon encountering an oceanic whitetip shark: "[He] told me, 'Ho, I'd kill him but then I thought about [lead author]. I thought, ah, no.'" Importantly, the lead author took care during interviews not to convey judgment or make arguments against fishers' handling practices. Thus, fisher-researcher communication and relationship-building may also play an inadvertent role in shaping fisher perspectives and behaviors.

In addition to building relationships, trust, and encouraging participation, the HCTP's collaborative research efforts enabled the collection of valuable data that might not otherwise be available. The HCTP trained and equipped fishers for opportunistic shark-tagging. In the 2 years after its first public workshop in 2017, participating fishers deployed 37 tags on oceanic whitetip, thresher, blue, and silky sharks. Prior to this, HCTP researchers independently deployed 15 tags in a comparable 2-year period beginning in 2015, at greater expense in time and finances to the program. Fishers shared their shark-handling practices with the research team in an effort to brainstorm and develop non-lethal shark-handling practices. Some participants were also given special tags to monitor sharks' survival following interaction and, in some cases, jugging. These data expand HCTP researchers' understanding of the impact of small boat fishers' handling practices to sharks.

### *Knowledge Exchange*

Fisher-researcher knowledge exchange was facilitated by collaborative approaches to research, but represents a distinct process in its validation of multiple types and sources of knowledge. Collaborative research and knowledge exchange can, but do not necessarily co-occur. In our case study and the HCTP, researchers and fishers engaged in on-the-water fieldwork and workshop discussions that allowed them to share their perspectives, and demonstrated a willingness to learn from one another. This resulted in shifts of fisher and researcher perspective and, in some cases, behavior. One participant said:

For once someone's actually going out there with commercial fishermen. Not just one... with multiple. You guys are kinda seeing everyone's point of view. And at the same time, getting everyone to change a little bit toward what you guys see.

One fisher noted the potential collective benefits of fisher, researcher, and manager exchange:

I think if you create an opportunity that's non-threatening that has nothing to do with taking away their rights, the science and the managers are gonna get a lot of valuable information that they

might not otherwise hear, and the fishermen that come... their knowledge and understanding of these species that are important are gonna be dramatically increased.

In the HCTP, both fishers and researchers benefitted from the exchange of knowledge, whether acquired through decades of fishing experience or scientific research. One fisher provided examples from his conversations with the HCTP PI, in which he contextualized tagged sharks' movement data using his knowledge of buoy locations, enlightening her to some sharks' repeated visits to a specific offshore buoy. He noted, "It was really neat though, sharing your knowledge. Like I pointed out to [HCTP PI] about the buoy thing, and she pointed out to me about all the things that I wasn't aware of." This fisher also highlighted an important difference between the ways researchers and fishers like himself perceive the fisher-shark interaction problem:

Most of the scientists feel that we... don't like the sharks "cause" they eat [our] fish. I can count the number of times on one hand that a shark's actually attacked my fish. The problem is when they're in the area, we can't catch fish. They create a barrier.

Knowledge exchange was not a primary goal of the HCTP. But, as a result of participants' respect for both experiential and scientific knowledge, it improved fishers' and researchers' understanding of shark interactions.

## DISCUSSION

This case study took advantage of managers' and researchers' growing interest in the oceanic whitetip shark to explore the poorly documented fisher-shark interactions of Hawai'i. Stepping back from the dominant shark conservation narrative, we engaged West Hawai'i small boat fishers to understand from their perspective what problems frame fisher-shark interactions. This early investment in problem diagnosis is critical to develop solutions that are not only effective, but avoid intensifying any existing conflicts (Zimmermann et al., 2020). We used our adapted framework (**Figure 1**) to examine the layered conflicts defining this "problem" beyond threats to pelagic sharks, and reflect on potential solutions better oriented to coexistence. Prominent among dispute-level problems was decreased fishing efficiency. We documented some applications for substantive solutions like information provision, financial incentives, and the development of shark-handling alternatives. However, diversity among fishers and the various factors interviewees described guiding their behavior on the water necessitate integrated, multi-pronged solutions that also account for deeper conflicts. Deeper conflicts revealed in this case study were contextualized by relationships, power dynamics, and identity-based conflicts.

Interviewee definitions of the fisher-shark interaction problem were dominated by dispute, referencing sharks as fishing competitors, financial costs of an interaction, and fishers' decision-making factors during shark encounters. However, our findings reinforce that the meaning fishers ascribe to sharks (**Figure 3**) varies according to species and context (Molony and Thomson, 2020), with emotional, cultural, safety, and

economic considerations (Glaus et al., 2019). Upon encountering a shark, fishers included situational shark attributes, landing opportunity, physical capacity, time and finances invested, and social pressures among their decision-making variables (**Table 2**). These represent a number of individual capacity, economic, and social norms variables that drive fisher behavior and merit further investigation (St. John et al., 2010). To the extent that these variables predict fisher behavior, interventions may enable alternative decision-making pathways (Fulton et al., 2011); for example, by mitigating fishers' financial costs.

Interviewees offered some substantive solutions that address these goals, including providing information, compensating fishers, and developing shark-handling alternatives. Some interviewees described shifts in their perspective or behavior after building relationships with researchers or learning about sharks' biology or threatened status. However, the diversity of West Hawai'i fishers' demographics, values, attitudes, and capacity for behavior change around sharks necessitates more than social influence and information provision (Stern, 2000; Campbell and Cornwell, 2008; Reddy et al., 2017). Other solutions may help to address this diversity. Our results suggest that financial incentives may promote fisher engagement and increase fisher access to a broader suite of behavioral and shark-handling options, including shark-tagging. Financial incentives may benefit fisheries management goals and cost-effectiveness (Innes et al., 2015), but their success is conditional (Bladon et al., 2016). Fisheries bycatch mitigation may benefit from the application of financial incentives with multi-pronged approaches that also prioritize, for example, collaborative research or efforts to support community leadership and stewardship capacities (Lent and Squires, 2017; Milner-Gulland et al., 2018). Interviewees also expressed interest in a shark-handling alternative or deterrent, making suggestions for non-lethal handling strategies that might preserve fishing opportunity. This illustrates the collaborative space that exists for fishers, researchers, and managers to pursue solutions with collective benefits for fishers, sharks, and those invested in shark conservation.

Although we documented success in applying substantive solutions to disputes, we also recognize that solutions may cross-cut levels of our framework. The interpretation that levels of conflict require solutions at equal and potentially shallower levels (Zimmermann et al., 2020) may obscure innovative problem-solving. For example, fishers' perception of sharks as threats to fishing opportunity has been connected to their diminished support for shark conservation (Drymon and Scyphers, 2017). However, fishers' participation in this study and the HCTP highlights opportunities to dissociate the two. Firstly, like U.S. recreational fishers who expressed a lack of concern for "nuisance" sharks frequently caught as bycatch (McClellan Press et al., 2016), interviewees devoted little attention to sharks historically, characterizing them as incidental, non-target species. Secondly, interviewees described their increasing attention to sharks—and in certain cases, adopting less harmful handling practices following fisher-researcher engagement—over the course of this study. Along with the role of social pressure in determining fishers' behavior, these examples underline the potential for social norms (Nyborg et al., 2016), influential

actors (St. John et al., 2010), and fisher-researcher relationships (Campbell and Cornwell, 2008) to affect fishers' participation and on-the-water behavior. If researchers and managers seek only substantive solutions to disputes, they may miss opportunities to change fisher attitudes and behaviors through process- and relationships-based approaches.

Substantive solutions may also generate deeper conflicts instead of resolving disputes as intended. Given the deeper conflicts described by interviewees and the region's absence of enforcement (Tissot et al., 2009), regulation may not only fail to achieve its goals but critically impede other fisheries management efforts. Following regulation, fishers may assign additional negative meaning to sharks, further complicating sustainable resolution of fisher-shark interactions as has been seen with other species (Nie, 2001; Naughton-Treves and Treves, 2005). Inappropriate substantive solutions may also exacerbate stakeholder conflict (Redpath et al., 2013) and diminish fishers' perceived legitimacy of management and science. Degraded legitimacy is of concern given the benefits of legitimacy for compliance (Levi et al., 2009), particularly when enforcement is lacking (McClanahan et al., 2006) as in the case in West Hawai'i. Deeper conflicts like these may then obstruct parallel and future efforts to mitigate fisheries management problems involving the same actor groups, whether or not the dispute is focused on sharks. In this case study, for example, researchers encountered and addressed feelings of apprehension from past fisher-researcher interactions (**Table 4**) to build trust and improve collaborative research efforts. Thus, degraded relationships, mistrust, and unresolved conflict at once challenge problem-solving endeavors (Schuckman, 2001; Ansell and Gash, 2007) and highlight opportunities for creative, collaborative solutions.

Awareness of deeper conflicts is therefore critical to effective problem-solving. This study illuminated issues of power, historical relationships, and identity in fishers' problem definitions that necessitate relationships- and process-based solutions (Webber et al., 2007; Campbell and Cornwell, 2008; Penney et al., 2017; Shiffman et al., 2017; Crespin and Simonetti, 2019). Interviewees described concerns about fisheries management and science that degraded fishers' perceptions of their legitimacy (**Table 3**). Among them, disconnect between fishers' and researchers' or managers' knowledge and vulnerability to fisheries management, politicized science and decision-making, poor enforcement, data validity, and transparency. Interviewees also perceived certain actors, such as fishing industry or environmental groups, to have greater organizational capacity, financial capital, and access to management decisions—forms of power that play important roles in conservation contexts (Schuckman, 2001; Chapin, 2004). When regulations were perceived to be inequitable or politically motivated, interviewees doubted management logic and efficacy. Despite fisheries scientists' and managers' growing recognition of the value of stakeholder knowledge (Neis et al., 1999; Reed et al., 2007; Wendt and Starr, 2009), interviewees also noted power differentials resulting from fishers' lack of formalized knowledge or specific language through which input is typically valued. Designing engagement to increase access and participation for groups that possess alternative forms of knowledge, capital,

or language can help to address these imbalances. Fishers also perceived management to deny their agency, connection to place, and stewardship. Solutions that ignore issues of identity may fail to resolve conflicts as intended (Hicks, 2001; Rothman and Olson, 2011; Doucey, 2011). Finally, interviewees expressed concerns about being misrepresented or contributing to a process that would result in fishing closures or restrictions (Silver and Campbell, 2005; St. Martin and Hall-Arber, 2008; Carruthers and Neis, 2011). To improve outcomes, fisheries solutions might deliberately consider fisher identities, cultures, and physical and financial risks (Faasen and Watts, 2007; Coulthard et al., 2011; Rivera et al., 2017).

To address layered problems and avoid generating new, deeper conflicts through singular approaches, robust fisheries management solutions should consider integrated, multi-pronged approaches (Madden and McQuinn, 2014; Ayers and Leong, 2020; Booth et al., 2020). To this end, our work demonstrates potential for collaborative research and knowledge exchange to incorporate substance-, process-, and relationships-based elements. Through regular communication, researchers shared information about shark biology and management statuses, outcomes of collaborative research, and responded to fishers' concerns about researchers' motives and goals. Engagement included early disclosure of possible risks and outcomes of engagement, which helped to establish fisher-researcher trust and reciprocity. Key actors and face-to-face interactions encouraged information sharing and certain behaviors (Abrahamse and Steg, 2013; Mbaru and Barnes, 2017), including shark release. Key actors were also instrumental in recruiting participants and gathering data. As engagement exerts high, prohibitive transaction costs on its participants, requiring investments in time, energy, and money (Ayers et al., 2017), researchers made efforts to minimize these costs to better include diverse fisher perspectives. Other key process-based engagement elements include foundations in trust, equity, and learning, explicit goals (Reed, 2008), facilitative capacity, and transparent decision-making (Reed, 2008; Vaughan and Caldwell, 2015; Mease et al., 2018).

Collaborative research efforts documented in this case study improved fishers' and researchers' understanding of fisher-shark interactions and enabled the collection of otherwise inaccessible shark interaction data through interviews and tagging. A collaborative approach may improve the cost-efficiency of data collection (Mackinson and Nøttestad, 1998). Just as local, participatory processes may improve the perceived justness and legitimacy of regulations (McClanahan et al., 2006), collaborative research may improve the credibility of resulting data for both researchers and fishers (Hartley and Robertson, 2006; Wendt and Starr, 2009).

Collaborative research and knowledge exchange also forged a shared space to pursue novel on-the-water strategies to mitigate fisher-shark interactions. As fishers and researchers exchanged knowledge, both groups acquired new understanding of the problem by recognizing the value in both experiential and scientific knowledge (Hartley and Robertson, 2006). This learning process is crucial to bridging stakeholder disconnect and facilitating productive discourse (Adams et al., 2003).

Engagement processes that facilitate the sharing and adaptation of conflicting values and interests are likely to benefit outcomes' legitimacy and durability (Søreng, 2006; Redpath et al., 2013).

## CONCLUSION

Complex fisheries problems are often identified and managed based on biophysical, dispute-level problem definitions. This study delivers a foundational inventory of localized sociopolitical context relevant to pelagic sharks and their interactions with West Hawai'i small boat fishers. By identifying factors that shape fishers' diverse perceptions and behavior around sharks, researchers, and managers, we take a crucial first step toward strategies that are more cost-effective, equitable, and prepared to achieve their goals (Booth et al., 2019). While others have applied Madden and McQuinn (2014) framework to examine conflict in various contexts, including human-wildlife conflict, we adapted it to uncover hidden problems and solutions. This allows framework users to question monolithic problem definitions, account for stakeholder politics and histories in problem-solving which may appear unrelated to the dispute, and identify potentially harmful management pathways.

The fisher-researcher exchanges integral to this study and the Hawai'i Community Tagging Program improved fisher access to management discourse, fisher-researcher relationships, and both groups' understanding of sharks and their interactions with Hawai'i small boat fisheries. These outcomes indicate that collaborative solution-finding efforts could reduce costs and negative outcomes and produce novel benefits to local fishers, sharks, and the research and management communities invested in them.

Pelagic sharks represent an international policy concern given their mobility and global distribution. This case study illustrates that the sociopolitical contexts for pelagic shark management not only require diagnosis at local scales, but reveal process- and relationship-based solutions that international policy may not be able to provide. This framework can be applied locally to illuminate deeper conflicts and innovative solutions wherever humans and wildlife might coexist. Furthermore, the framework has utility wherever we seek solutions amidst dissonant problem definitions, threatened identities, fractured relationships, and power inequities.

## DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available due to confidentiality considerations, data can only be shared anonymously, in aggregate. Requests to access the datasets should be directed to Mía A. Iwane, mia.iwane@noaa.gov.

## ETHICS STATEMENT

This study was reviewed and approved by University of Hawai'i Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

MI collected and analyzed data, adapted the theoretical framework to synthesize results, and wrote the manuscript under the guidance of her thesis committee members KO, KL, and MV. KO served as the committee chair, providing oversight along with KL throughout the project. All authors provided critical feedback to shape the manuscript.

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## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fcsc.2021.669105/full#supplementary-material>



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**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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