Nature United

FISHING FOR SOLUTIONS

Harvester perceptions of climate change vulnerability in Canada's Pacific fisheries

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Nature United publication

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Additional partner organizations: First Nations Fisheries Council of British Columbia; United Fishermen & Allied Workers' Union – UFAWU-Unifor

University of Victoria · First Nations Fisheries Council of British Columbia · BC Seafood Alliance · University of Washington · BC Commercial Fishing Caucus · native fishing association · UFAWU | UNIFOR United Fishermen & Allied Workers' Union

EXECUTIVE SUMMARY

The changing climate is impacting fish populations and the ecosystems that sustain them with potentially profound consequences for the fisheries and communities that they support. To enhance the resilience of fisheries and fishing communities to climate change and the responsiveness of fisheries management, in-depth knowledge of both the ecological and social components of fisheries systems is needed.

As front-line workers for the fisheries sector, harvesters' perspectives and input are crucial to identifying priority areas for responding to the most urgent concerns related to climate change and fisheries. They are also valuable for developing effective strategies for bolstering resilience and the ability to respond to multiple challenges and emerging opportunities. As such, Nature United teamed up with a group of collaborators[1] to investigate the human dimensions of fisheries and climate change in British Columbia (BC) by exploring the perspectives and perceptions of commercial fish harvesters.

This report summarizes the findings of an online survey to which 105 commercial fish harvesters from Canada's Pacific region responded in 2020. The survey elicited harvester perceptions of climate change impacts and the harvesters' ability to adapt. Key perceptions from the fish harvesters who participated in the survey include the following:

- Climate change is happening and will impact future generations.
- Salmon fisheries are experiencing strong negative impacts from climate change.
- Albacore tuna and hake, as they move northward, will result in positive B.C. fisheries impacts.
- Fishing is strongly tied to harvesters' well-being, identity, and connections.
- Changes in fisheries are stressful and affect harvester well-being.
- Current capacity for harvesters and management to adapt to fishery changes is low.
- Calculated vulnerability was higher for herring and salmon fisheries; it was lower for crab, halibut and rockfish fisheries.
- Harvesters have strong concerns about fishery management, access, and habitat loss.
- Participatory processes could help build more flexible, responsive management.

These insights, generated from the survey, only representing a portion of fish harvesters in B.C. However, they provide a snapshot of some of the pressing concerns that commercial fish harvesters have with respect to the impact of climate change on fisheries in Canada's Pacific region. Some of these insights are not entirely new but reinforce what has been articulated by fish harvesters in other forums, and with increased emphasis considering climate change. As Canada moves forward in its planning for and response to climate change impacts on fisheries, understanding the human dimension is critical to creating strategies that work for nature and for people.

1 BC Commercial Fishing Caucus; BC Seafood Alliance; United Fishermen & Allied Workers' Union –UFAWU-Unifor; The First Nations Fisheries Council of British Columbia; Native Fishing Association; Fisheries and Oceans Canada (DFO) climate adaptation researchers; University of Victoria; University of Washington; and The Nature Conservancy.

PACIFIC FISHERIES FACE CHALLENGES DUE TO CLIMATE CHANGE

The changing climate is impacting fish populations and the ecosystems that sustain them with potentially profound consequences for the fisheries and communities that they support (Bell et al., 2020; Cheung et al., 2015; Savo et al., 2017). While information on the projected impacts of climate change on Canada's Pacific region fisheries is accumulating, for example shifting species ranges, changes in species abundance (decrease/increase), shifts in predator-prey dynamics and marine food webs, and changes in fisheries catches (Cheung et al., 2015; Cheung & Frölicher, 2020; Crozier et al., 2019; Grant et al., 2019; Okey et al., 2014; Talloni-Álvarez et al., 2019; Weatherdon et al., 2016), much less is known about the human dimension of climate impacts on fisheries. However, fisheries have long been integral to Pacific coast economies and cultures, and continue to be a key component of the lives and livelihoods of coastal communities and peoples (Mathews & Turner, 2017; Newell, 1997). To Indigenous peoples along the Pacific coast of Canada, as elsewhere around the world, fish and fisheries are central to identity and cultural continuity (Gauvreau et al., 2017). Fisheries are important to the fishing families and businesses, who, through multiple generations, have shaped coastal economies and industries. Climate change is poised to amplify existing threats (and distributions of costs and benefits) in unpredictable and/or compounding ways. There is a clear need to better understand these challenges and begin thinking of ways that fisheries management, industry, and harvesters can adapt.

SEEKING SOLUTIONS FROM THE FISHERIES FRONT LINES

To enhance the resilience of fisheries and fishing communities to climate change and the responsiveness of fisheries management, in-depth knowledge of both the ecological and social components of fisheries systems is needed. With priorities and legislative agendas being heavily influenced by public perceptions (Slovic, 1997), understanding how those most connected to fisheries perceive the risks associated with climate change is critical to developing effective responses. As front-line workers for the fisheries sector, harvesters'

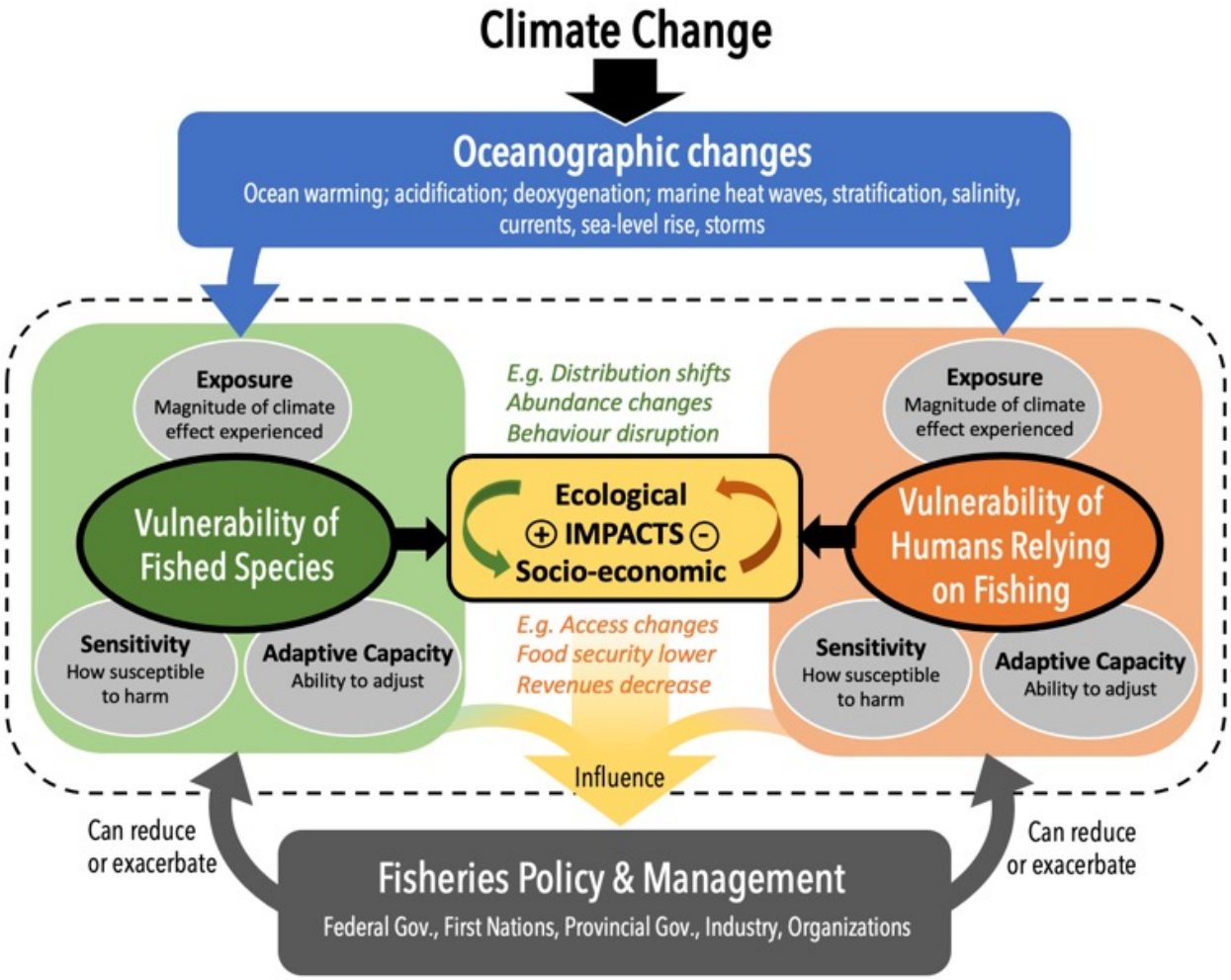


Figure 1. *Diagram showing the impact of climate change on fisheries as a social-ecological system with the various components of vulnerability and their relationship to one another and to broader processes.*

perspectives and input are crucial to identifying priority areas for responding to the most urgent concerns related to climate change and fisheries. They are also valuable for developing effective strategies for bolstering resilience and the ability to respond to the multiple challenges threatening fish, fisheries, and fishing communities in the Pacific region of Canada, and taking advantage of emerging opportunities. As such, Nature United teamed up with a group of collaborators to investigate the human dimensions of fisheries and climate change in B.C. by exploring the perspectives and perceptions of commercial fish harvesters. This was done through an online survey to access and understand fish harvester perceptions of risk (due to both fishery exposure and harvester sensitivity) and adaptive capacity (harvester ability to anticipate, adjust and respond to change, and to take advantage of new opportunities), which together can help provide an understanding of the social vulnerability to climate change (Orange box - Figure 1). Vulnerability in the context of this study refers to social vulnerability, which is associated with the loss of resilience and/or lack of adaptive capacity of people or human communities to cope and adjust to stresses caused by social, economic, political, and environmental changes (Nayak et al, 2021). The goal of this study was to investigate variability in perceived vulnerability of fisheries to climate change, while also identifying other concerns and perspectives of fish harvesters, to advance climate resilient fisheries and enhance the responsiveness of management.

Research Question – What we wanted to know:

- What are the perceptions of B.C. commercial fish harvesters regarding the vulnerability of themselves, coastal fisheries, and fishing communities to climate change and their capacity to adapt?

Research Goals – What we hope to achieve:

- To understand and communicate key concerns of fish harvesters regarding social, ecological, economic, and institutional dimensions of fisheries in the context of climate change
- To use this information to help build a foundation for dialogue and action to advance climate resilient fisheries and responsive fisheries management.

ENGAGING PARTNERS IN THIS WORK

We elicited B.C. harvesters' perspectives and perceptions about climate change vulnerability through an online survey that took place between March and September 2020. Nature United worked with many partners to make this possible. The survey was originally designed and piloted by researchers at the University of Washington and The Nature Conservancy to survey fishers in Washington, Oregon and California. We then adapted the survey to the Canadian Pacific region fisheries context by seeking feedback from the BC Commercial Fishing Caucus, the BC Seafood Alliance, United Fishermen & Allied Workers' Union – UFAWU-Unifor, The First Nations Fisheries Council of British Columbia, the Native Fishing Association, and Fisheries and Oceans Canada (DFO) climate adaptation researchers. These same organizations also played a key role in helping distribute the survey and providing feedback on the results.

B.C. FISH HARVESTER SURVEY - DESIGN AND IMPLEMENTATION

The survey focused on questions that related to perceptions of climate change impacts on fisheries, exposure to climate impacts, the sensitivity of community and individual well-being to changes in fisheries resulting from climate change; and harvester perceptions of their ability (and that of their communities) to adapt to these changes. Details of the survey design and implementation are outlined below. Analysis methods and how vulnerability was calculated based on the survey questions can be found in Appendix A.

The sampling frame for the survey was commercial fish harvesters in B.C. targeted through the commercial licence registry. The fishery-specific survey questions focused on 26 commercial fisheries (species-gear combinations), which target the dominant commercially fished species in B.C. The survey aimed to capture a representative sample of fish harvesters, by age, gender, and Indigenous identity. Survey participants provided information on demographic and other characteristics including age, port of call, fishing experience, and species targeted. They also answered questions regarding observations of environmental change, and whether they felt their ability to catch fish had been impacted by climate change. To understand relative concern for various climate change related impacts and other challenges harvesters face with respect to social, economic, and operational dimensions of fisheries, participants were asked a series of questions, where they ranked their level of concern for these as "very", "somewhat," or "none".

To assess vulnerability, we asked fish harvesters about the degree of EXPOSURE of different fisheries to climate change (e.g., what, if any, effect do you believe ocean warming is having on X commercial fishery?). When asking about perceived fishery-specific impacts of climate change, we asked respondents to select from a five-point scale from negative to positive, in addition to offering the selection of "I don't know." This was done to enable separating the scaled responses (people who feel they have knowledge about species impacts) from the responses that reflect either lack of climate-impact knowledge or less familiarity or knowledge about a given fishery. We display the results as proportions of the scaled responses only, along with the sample size of fish harvesters' respondents that this reflects. We also asked an associated question about their level of confidence in their responses. Note that here we focused on ocean warming, which is just one dimension of exposure to climate change.

We also asked participants about the degree to which

individual and community well-being is sensitive to changes in the health of fisheries and the environment fishery (SENSITIVITY). We did this using questions pertaining to several dimensions of well-being as outlined by Breslow et al. (2016; see Appendix A for details). Well-being is considered here as "a state of being with others and the environment, which arises when human needs are met, when individuals and communities can act meaningfully to pursue their goals, and when individuals and communities enjoy a satisfactory quality of life" (Breslow et al., 2016, p.2).

Lastly, we asked questions about adaptive capacity—how easily individuals and communities can anticipate, respond to and recover from changes in fisheries species composition, distribution, or abundance, and their ability to take advantage of emerging opportunities (Barnes et al., 2020). The adaptive capacity of individuals and communities is dependent on assets (i.e., social and human capital), flexibility, learning, social organization and trust in institutions, socio-cognitive constructs and agency, and thus the survey questions focus on these themes (Cinner & Barnes, 2019). We included in the survey several open-ended questions and opportunities for survey participants to include context and commentary. Overall, there were 44 questions included in the survey (see survey and questions).

The study and survey were reviewed and approved by the University of Washington Human Subjects Division, including approval to expand the sample population to include B.C. fishers. The adapted version for the B.C. context was approved by the University of Victoria Ethics office (RAIS Application # 20-0462).

The survey was administered, and responses collected by a professional survey firm—Pacific Market Research Ltd. Fish harvesters were invited to complete the survey online or via the phone. Methods for eliciting B.C. fish harvester participation included mail invitations sent to a random sample of B.C. commercial licence holders, and email invitations sent out to fish harvester associations and industry partners.

FINDINGS

Survey responses from harvesters covered a wide range of fisheries and regions

The online survey was completed by 105 individuals who participated in one or several commercial fisheries along the B.C. coast in 2020. There are an estimated 2,377 unique-licence holders (Standing Committee on Fisheries and Oceans, 2019) from the approximately 4,866 commercial marine fisheries licences in the Pacific region, so the survey represents approximately 2% to 4% of the commercial licence holder population in B.C. The survey was initially mailed out to approximately 1,200 unique addresses, but in a follow-up communication, the online survey link was shared more widely so it could have had a slightly broader reach. Based on the initial mail out, the response rate to the survey was about 9%.

The fish harvesters surveyed reported participation in a range of Pacific region fisheries, with 68% participating in salmon, 43% in other pelagic, 44% in groundfish and 31% in invertebrate fisheries (graph of specific fishery breakdown in Appendix B). Participants indicated "regular fishing grounds" in all major regions of the B.C. coast: North Coast (57%), the Strait of Georgia (43%), Northern Vancouver Island (42%), Haida Gwaii, including Hecate Strait (42%), and the Central Coast (40%).

Survey participants were highly experienced, but Indigenous harvesters, female harvesters, and younger harvesters were under-represented

Eighty-two percent of harvesters surveyed reported they have been fishing for over 25 years, while 72% reported having lived in their current community for over 25 years. Only 23% of survey participants were under 50 years old, 6% were women, and 10% identified as Ingidenous.

HOW DO HARVESTERS FEEL ABOUT CLIMATE CHANGE?

Climate change is happening and will impact future generations

Most survey participants (77%) agreed with the statement, ***I believe that climate change is occurring*** and 72% agreed that ***Climate change will harm future generations*** (Figure 2). Many expressed that climate change was just one among many challenges that threaten their fisheries. However, while expressing that climate change might not be the most pressing challenge, some cited impacts that could be related to or amplified by climate change, whether the participants made this connection or not. For example, when asked to explain how climate change is impacting participants' ability to fish, one survey participant indicated, "poorer weather, longer trips, more expenses" (Harvester #68). While more than half (57%) of harvesters suggested they themselves would not leave fishing if they had a choice, 60% indicated that they would not encourage their children to be fishermen (Figure 4). As one fish harvester expressed, "Nobody I know in the industry with children wants their kids to be fisher people" (Harvester #5). Many themes emerged from responses to the open-ended questions related to how fishing will be impacted, other species impacts, range shifts and changes in the timing of fishing (Table 1).

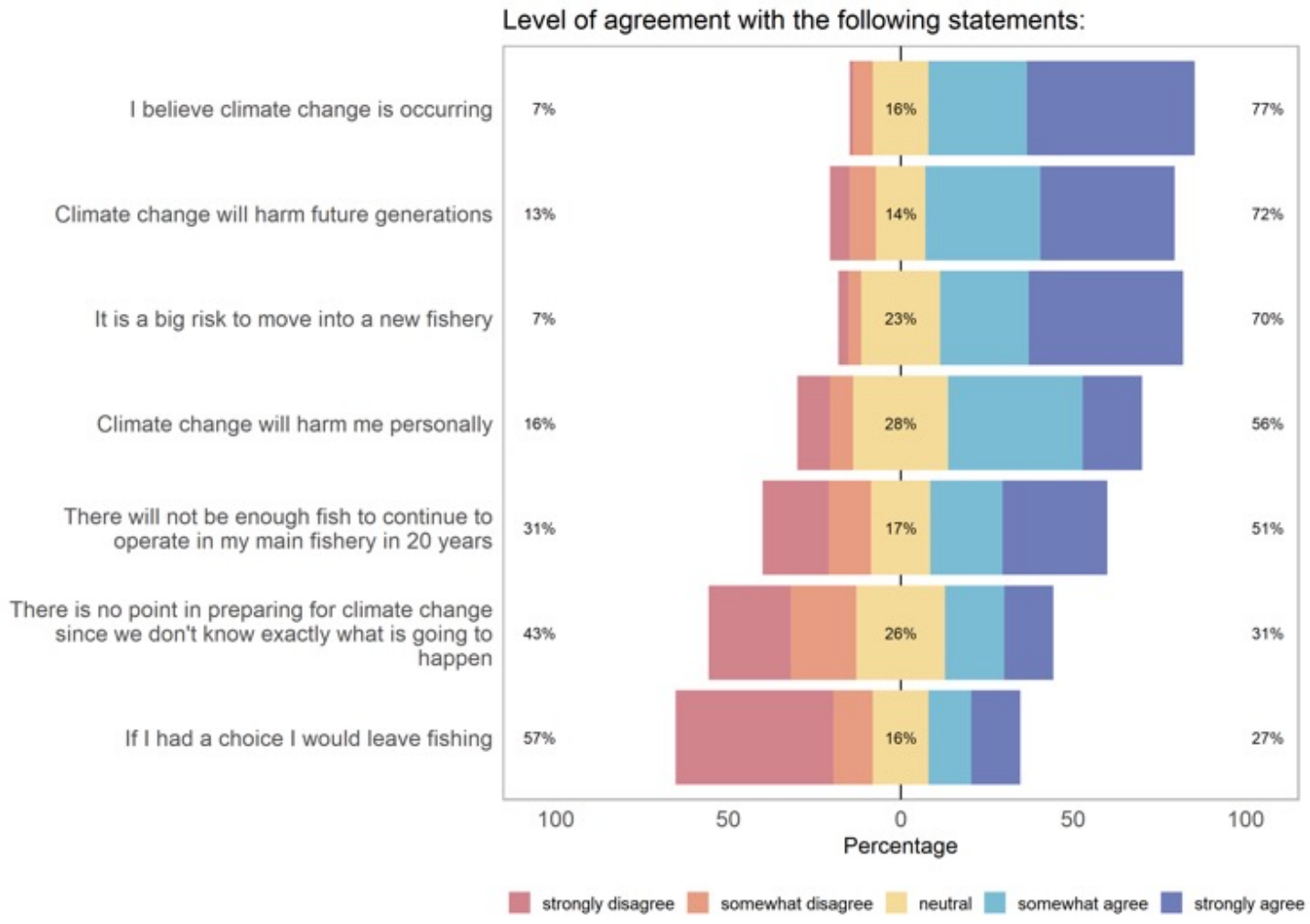


Figure 2. *Responses of survey participants showing level of agreement to statements that relate to the belief in and sensitivity to climate change.*

Table 1. *Summary table of open-ended questions related to how harvesters think their fishing activities will be (or are being) affected by climate change, key themes that emerged from the responses, and select quotes from harvesters.*

SURVEY QUESTION	KEY THEMES	SELECT QUOTES
How has your ability to catch fish been affected by climate change?	Reduced runs sizes; decreased abundance; rougher weather; fish moving deeper; increased predation	"Less returning adult salmon due to significantly reduced ocean survival. A series of dry summers in northern B.C. have resulted in difficult salmon passage to spawning grounds. The overall population and the allowable catch has been significantly reduced because of climate change." (Harvester #41)
How are your primary fisheries being affected by changes in other species?	Competition from marine mammals; predators interfering with gear; reduced prey available for fished species; sea lice from fish farms affecting wild salmon	"There seems to be a direct correlation between higher ocean temperatures and decreased food supply for salmon as they migrate to the open ocean. There also appears to be greater outbreaks of sea lice in the salmon farms on the years with warmer water and thus higher infestation of the wild salmon on their outward migration." (Harvester #50) "The increase of fish farms, seals, and sea lions is having a huge negative impact on salmon." (Harvester #39) "It is much harder to target salmon in areas of high predators without damaging gear and losing catch." (Harvester #41)
How has the range of your primary target species changed?	Species moving northward; into deeper waters	"Fish are consistently deeper than 25 years ago." (Harvester #7) "Rockfish are found deeper." (Harvester #70) "The fish aren't moving through the Strait of Juan de Fuca and they are now going further north through the Johnstone Strait." (Harvester #5) "More tuna in Canada." (Harvester #62) "There is less fish in certain areas, way spottier deeper water fishing." (Harvester #103)
How has the time of year you fish shifted?	Later in season; shorter openings; to calmer weather months	"We went from fishing all summer to fishing a number of weeks." (Harvester #25) "It's shifted to later in the year." (Harvester #27) "We fished many more days per year in the past." (Harvester #29) "Fishing seasons are much shorter now and are generally later than 30 years ago." (Harvester #34) "Fishing more in summer months due to weather." (Harvester #68)

TO WHAT DEGREE IS CLIMATE CHANGE IMPACTING COMMERCIAL FISHERIES? (EXPOSURE)

Salmon fisheries perceived to have strong negative impacts from ocean warming

Salmon fisheries were perceived as the most vulnerable to the impacts of ocean warming, with 71% of the participants who responded to the direction and scale of change suggesting a "strong" or "slight" negative effect from ocean warming (Figure 3a). Sockeye were perceived to be the most negatively impacted Pacific salmon fishery (78% of participants who provided a categorical response for sockeye indicated either "strong" or "slight" negative effect; Figure 3a), but there was also good agreement from >85% of survey respondents that chum, coho, pink, and chinook salmon were also negatively impacted (Figure 3a). In the open-ended questions, salmon were the most frequently referred to as being negatively affected. One harvester expressed this in saying, "the salmon will eventually disappear" (Harvester #101). Some harvesters included which species of salmon or life stage will be most impacted: "I think that salmon would have a harder time spawning in this quickly changing environment." (Harvester #12); "Fraser sockeye stocks continue to decrease, shorter fishing seasons, increased costs, management of resource of great concern" (Harvester #100). Others indicated some of the compounding stressors, such as stream habitat being devastated by drought, runoff, and extreme weather conditions (Harvester #13). Almost half (49%) of participants indicated a high level of confidence in their response to perceived effect of ocean warming on salmon (Figure 3b).

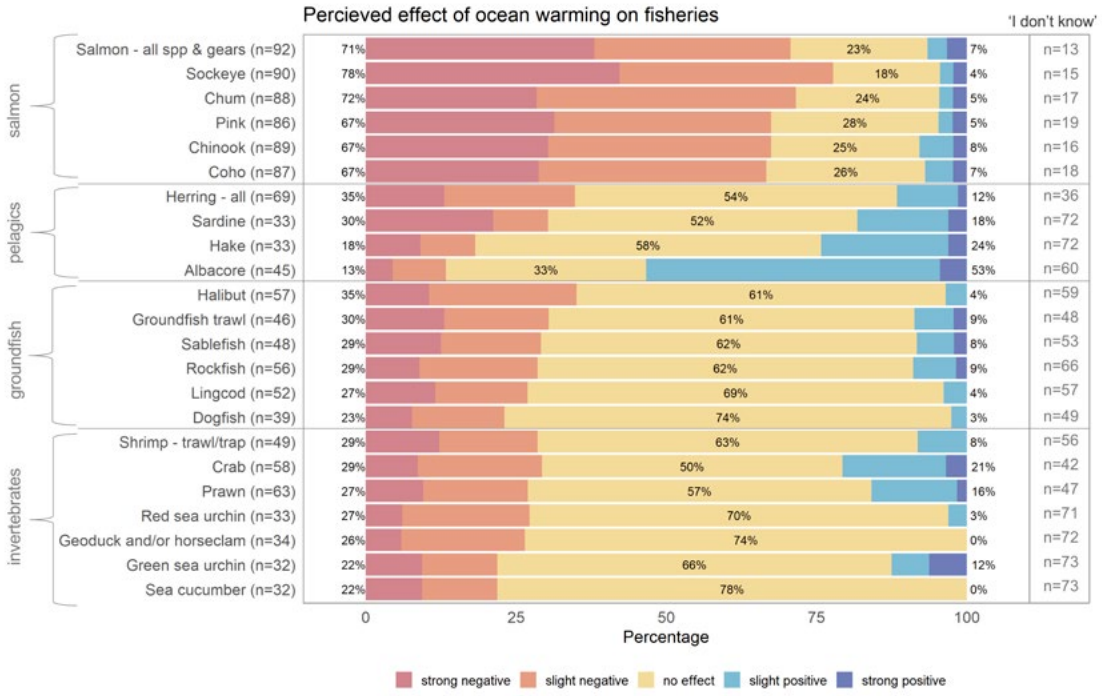


Figure 3a. *Perceived effect of ocean warming on Pacific region commercial fisheries. For each fishery the number of participants (n = x; out of the 105 total number of survey participants) who responded with a categorical rating is included in brackets beside each fishery and the number of survey participants who responded 'I don't know' in the far-right column. Percentages listed on the y-axis along the left-hand represent negative responses (strong negative + slight negative), while the ones of the right-hand side represent positive (strong slight positive + strong positive) responses.*

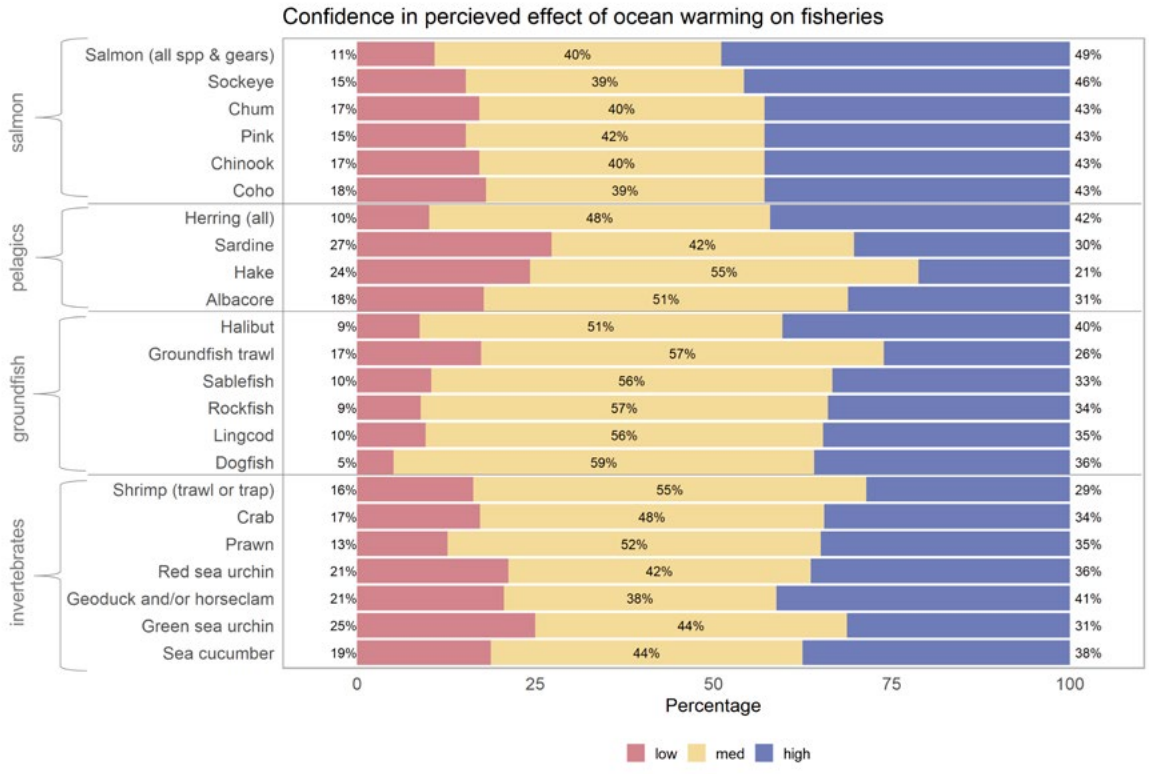


Figure 3b. *Confidence (low, medium, high) associated with perceived effect of ocean warming on Pacific region commercial fisheries.*

Other fisheries perceived as having both "negative" and "no effects" from ocean warming, but uncertainty is generally high and confidence in the ability to predict effects is "low"-to-"medium"

Apart from albacore tuna, hake, dogfish, urchin, and sea cucumber fisheries, at least 25% of harvesters who provided a categorical response for fishery-specific impacts of ocean warming felt that most non-salmon fisheries would be negatively affected (Figure 3a). In the open-ended questions, crab, halibut, herring, krill, and shellfish were highlighted as having the potential for negative impacts. When asked ***which species will be negatively impacted*** a common response was "most other [non-salmon] species to some degree" (Harvester #15).

A considerable percentage of survey participants who responded to the direction and scale of change indicated that they thought ocean warming would not have any effect on certain fisheries. The largest were dogfish (74%), geoduck (74%), and sea cucumber (78%; Figure 3a). For all fisheries except salmon and albacore tuna, over half of those who responded indicated "no effect." However, only about a third of the total number of survey participants indicated the impact they thought warming would have on these fisheries. The remaining two-thirds indicated that they did not know (Figure 3a).

Overall, there was greater uncertainty about the effects of warming on non-salmon fisheries. For most non-salmon fisheries, close to half or more than half of the harvesters selected 'I don't know'. Of those who did provide a categorical response, a This uncertainty is also reflected in the large proportion (ranging from 51% to 79% depending on the fishery) indicated a "low" or "medium" level of confidence in their perception of the effects of ocean warming.

Several fisheries perceived to be positively influenced by ocean warming

Over half of the participants who responded to fishery-specific impacts of ocean warming (53%; Figure 3a) indicated albacore tuna would experience a positive impact, further supported by responses to the open-ended question regarding species that could be positively impacted. However, this estimate is based on a limited number of fish harvester responses, suggesting uncertainty across the survey population as to the impact of ocean warming on the albacore fishery. After albacore tuna, the hake fishery had the second highest percentage of responses indicating a positive impact (24% of survey participants who provided a categorical response for this fishery). Prawns were frequently mentioned in response to the open-ended question on which species would be positively impacted; however, as shown in Figure 3a, only 16% of survey participants indicated a positive impact on this fishery. Jellyfish and squid were mentioned as being positively impacted, although there are currently no fisheries for jellyfish or squid in B.C. Participants indicated that crab are currently doing well and that they will likely continue to do so. The survey highlighted a lot of fish harvester uncertainty regarding the direction and scale of impacts from ocean warming, with approximately half of the harvester responses to the open-ended question on which species would be positively impacted, as "I don't know" or "none."

HOW CONNECTED ARE COMMUNITY AND INDIVIDUAL WELL-BEING TO CHANGES IN THE ENVIRONMENT AND FISHERIES? (SENSITIVITY)

Fishing is strongly tied to harvesters' well-being, identity, and connections

Most harvesters surveyed feel strongly that fishing is tied to their well-being, as it is important to their identity and core connections. In response to the statement, ***I feel a connection to my environment***, 89% of survey participants agreed or strongly agreed, and 86% of participants either agreed or strongly agreed with the statement, ***fishing is important to my identity*** (Figure 4). In terms of sense of community, 77% of participants agreed or strongly agreed with the statement, ***I feel a connection to my community***. While these show a strong affiliation to fisheries and communities, in response to the statement, ***I would encourage my children to be fishermen***, 60% of participants disagreed or strongly disagreed.

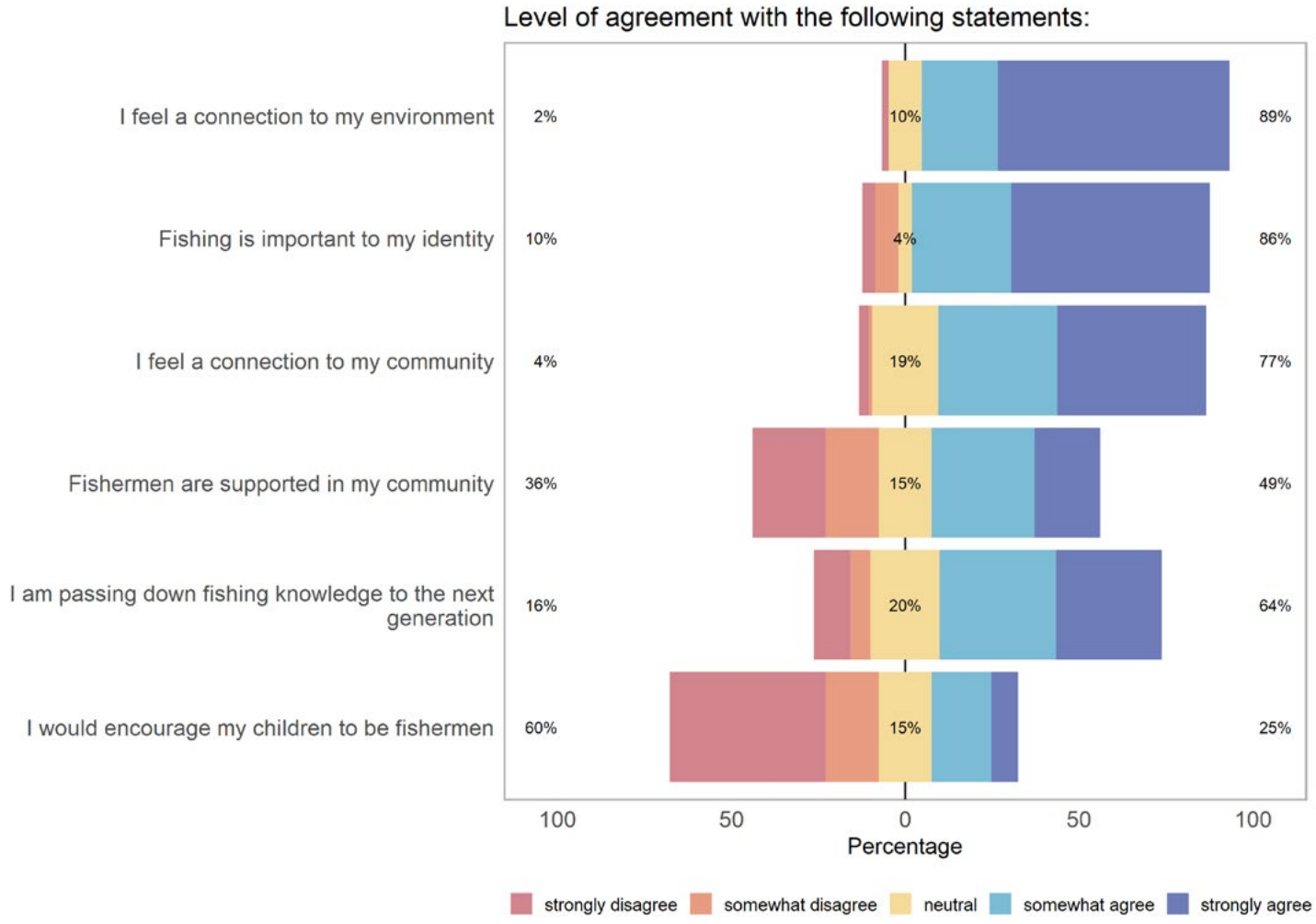


Figure 4. *Survey responses showing level of agreement to statements that relate to the connection between fisheries and well-being.*

Changes in fisheries are stressful and affect harvester well-being

Changes in fisheries were connected to higher levels of stress and negative impacts on the well-being of fish harvesters, with 73% of harvesters surveyed agreeing with the statement, ***changes in fisheries have raised my stress levels*** and 72% agreeing with the statement, ***changes in fisheries have negatively impacted my overall well-being*** (Figure 5). Responses to other statements regarding different aspects of well-being were more evenly distributed between those who agreed and disagreed with the statements (Figure 5).

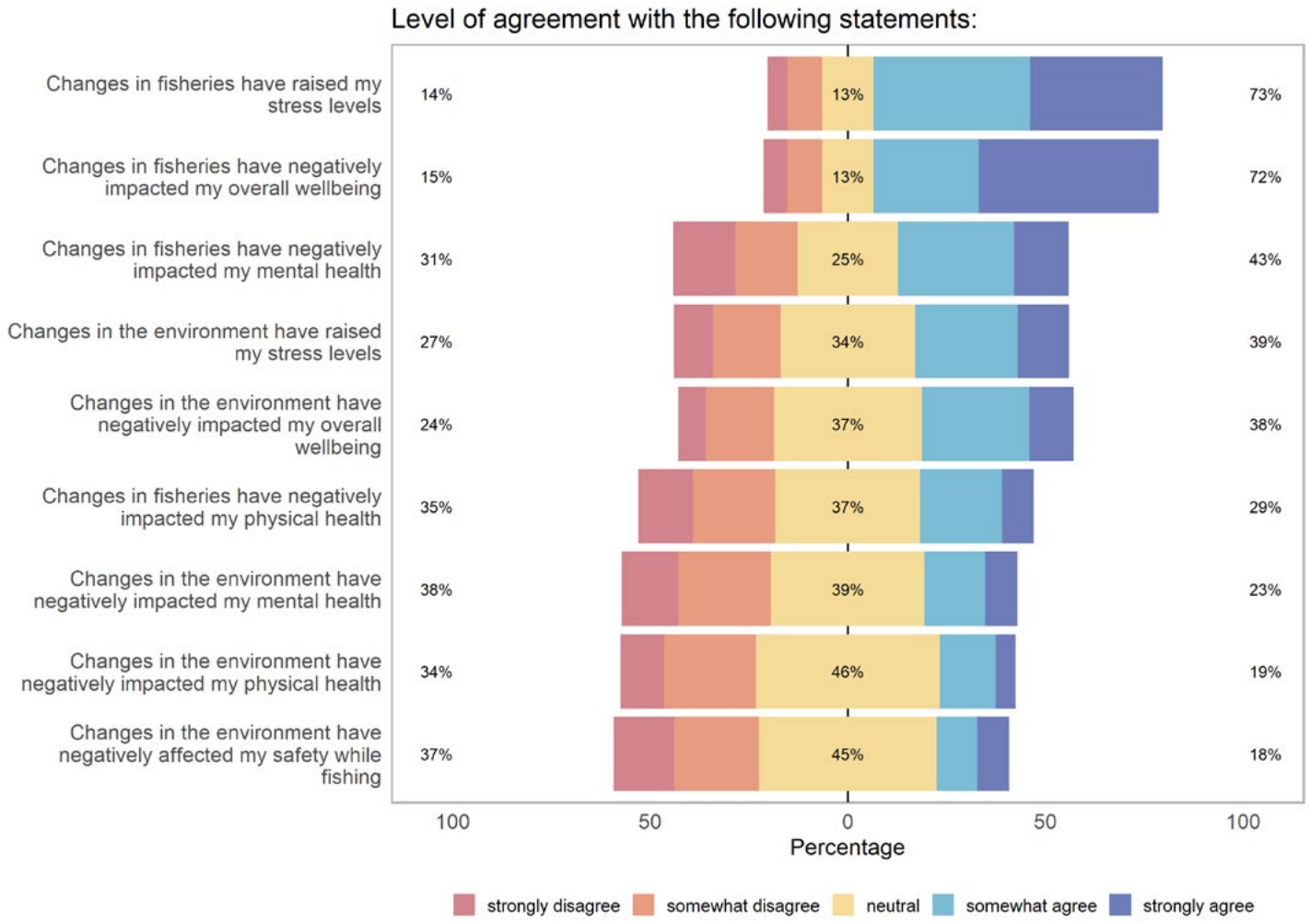


Figure 5. *Survey responses showing level of agreement to statements that relate to perceptions of well-being in relation to changes in fisheries and the environment.*

HOW EASILY CAN HARVESTERS ADAPT TO CHANGES IN FISHERIES? (ADAPTIVE CAPACITY)

Capacity for management and harvesters to adapt to fishery changes is perceived as low

Most participants (72%) indicated a lack of confidence in the ability of fisheries management to adapt and respond quickly to changing environmental conditions (Figure 6). Regarding harvester perceptions of their own adaptive capacity, 60% agreed with the statement ***I feel constrained in my ability to adapt easily because of regulations***, most participants (71%) felt they could not easily move into a new fishery, and 66% expressed a lack of confidence in finding alternate work in another natural resource industry. The fish harvesters surveyed, indicated some confidence (45% of participants) in their ability to travel further to fish if needed, however, it is worth noting that many fish harvesters already travel long distances to their fishing grounds.

In the open-ended comments, one fish harvester explained, "I think there will be winners and losers on a species-by-species level. Fishermen will need to be diversified" (Harvester #84). Another participant expressed a similar sentiment, "You have to be extremely adaptable in commercial fishing now. You have to move region to region in season, month to month almost week to week. This is hard for the fishing community to do, but it is necessary" (Harvester #5).

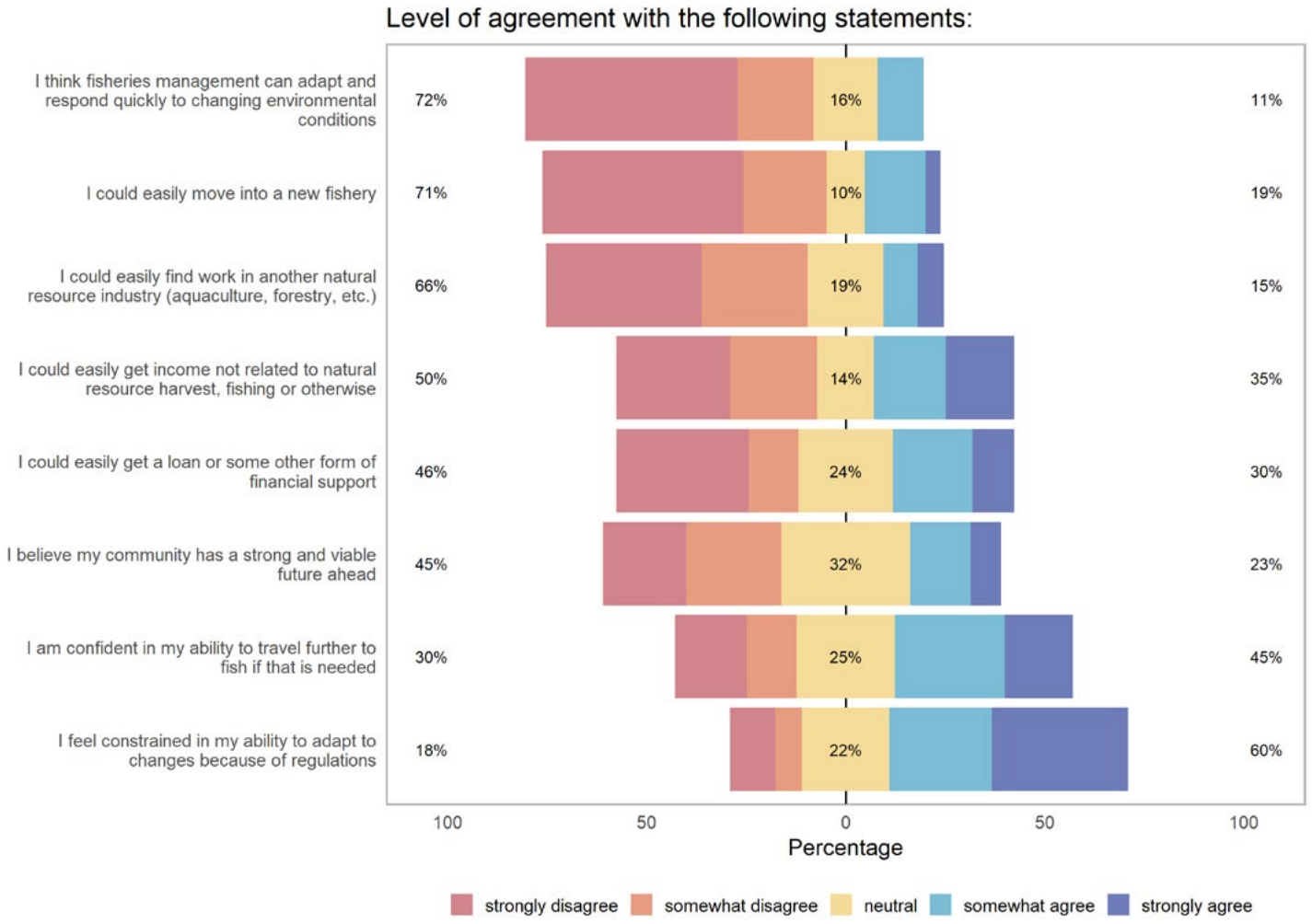


Figure 6. *Survey responses showing the level of agreement with statements related to adaptive capacity of fish harvesters.*

WHAT IS THE ESTIMATED VULNERABILITY OF B.C. HARVESTERS TO CLIMATE CHANGE?

Harvesters in herring and salmon fisheries perceived as more vulnerable; crab, halibut and rockfish harvesters less vulnerable

Fish harvester perceptions of exposure, sensitivity, and adaptive capacity were used to calculate an overall score for harvester vulnerability. Individuals' perceptions of exposure and sensitivity were first combined to calculate risk, then grouped by fishery and an average risk calculated. Average risk was combined with average adaptive capacity to give an overall estimate of harvester vulnerability by fishery (see equation 1 in detailed survey analysis – Appendix A). Note that average perceived fishery exposure as presented in Figure 3 (what all survey participants thought the impact of a warming ocean would be on each fishery) differs from what is presented below in Figure 7—calculated overall harvester vulnerability—where we took *only* the perceptions of those who participated in that fishery. For this reason, we present only those fisheries where at least five of the harvesters surveyed participated in, thus excluding hake, sardine, and shrimp trawl fisheries. We also combined sablefish trap and sablefish longline scores into one category.

The calculated vulnerability scores reveal that across fisheries, B.C. harvesters were overall perceived to be moderately vulnerable (i.e., moderate risk and moderate adaptive capacity), in that they are situated somewhat in the middle of the total possible 'vulnerability space' (Figure 7—inset panel, bottom right). Looking at relative harvester vulnerability by fishery, there were higher vulnerability scores for individuals participating in the herring roe on kelp, salmon seine, groundfish trawl and herring roe fisheries, and lower harvester vulnerability scores for individuals in the crab, halibut longline and rockfish fisheries (Figure 7 & 8; Table 2).

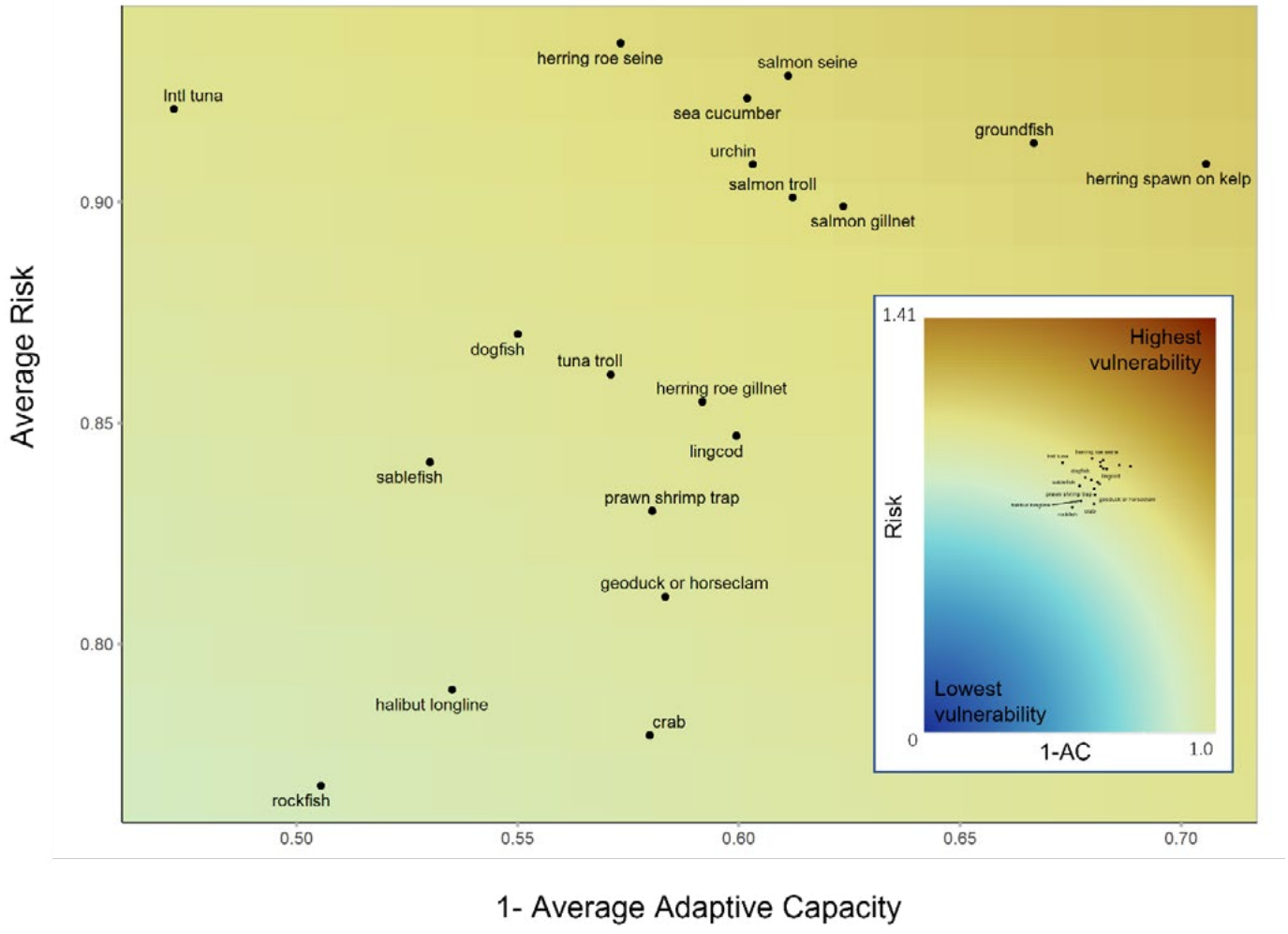


Figure 7. *Calculated harvester vulnerability by fishery, with risk (exposure x sensitivity) on the y-axis and the inverse of adaptive capacity on the x-axis (i.e., from left to right is decreasing adaptive capacity, thus increasing vulnerability). The main plot area is scaled to the minimum and maximum average risk and adaptive capacity values for individuals within particular fisheries, and the inset plot (bottom right) shows points relative to the minimum and maximum possible values.*

It is also illuminating to examine the relative values for how harvesters in different fisheries perceived their exposure, sensitivity, and adaptive capacity, which collectively determine the calculated vulnerability (Figure 8). For example, fishers in groundfish and herring spawn on kelp showed high vulnerability (darkest red) because the harvesters in both fisheries perceived their adaptive capacity to be very low, whereas groundfish harvesters perceived very high exposure, and herring spawn on kelp harvesters perceived high sensitivity. While this fishery specific data is useful, some of these scores are calculated from small harvester sample sizes (Table 2) and future analyses would benefit from calculations based on more harvesters within each fishery.

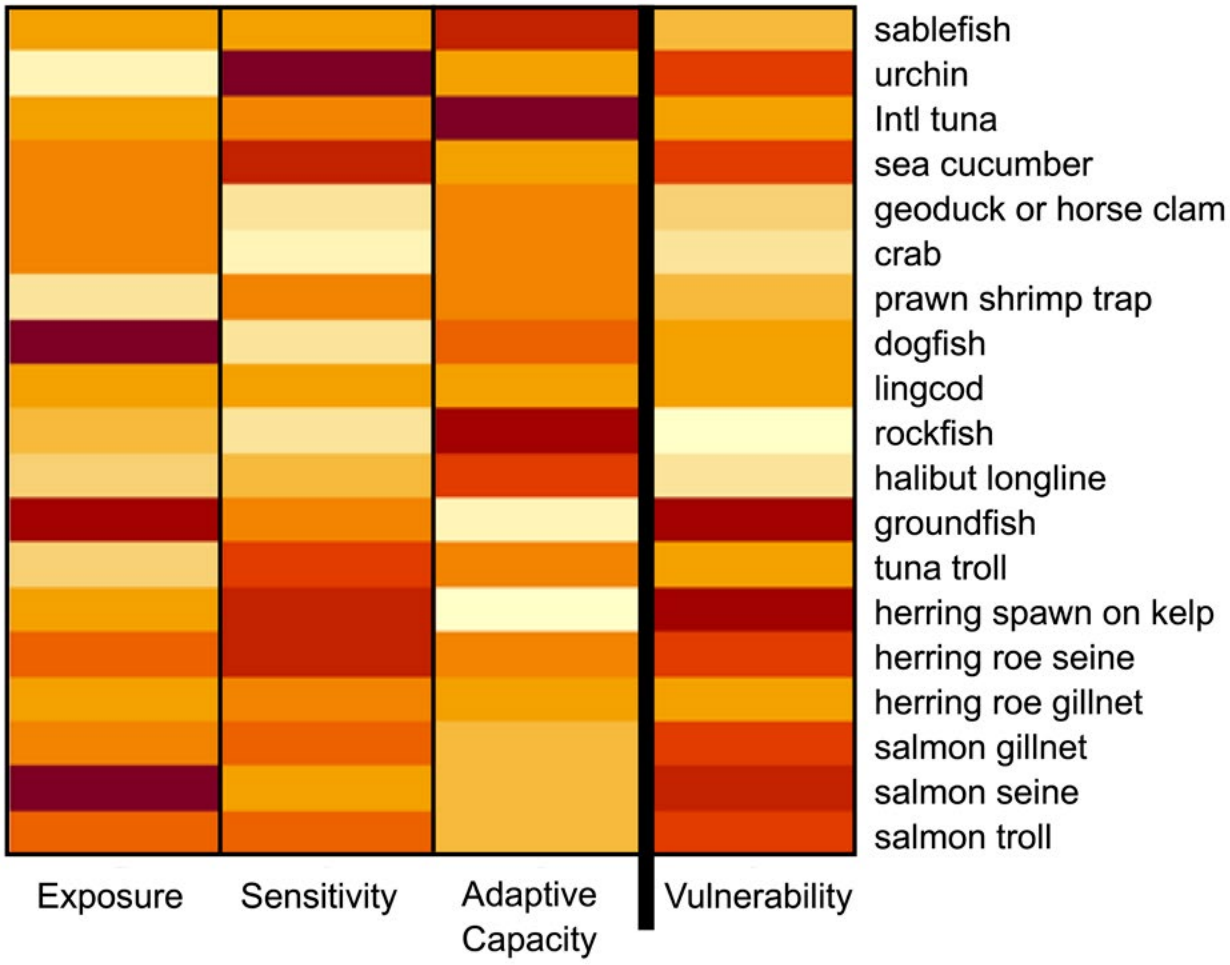


Figure 8. *Heat map showing exposure, sensitivity and adaptive capacity based on individual responses along with the calculated harvester vulnerability, grouped by fishery. Values are represented as colors with darker colours indicating a higher value and lighter colors, lower values. Note: darker/higher exposure and sensitivity scores contribute to darker/higher vulnerability whereas darker/higher adaptive capacity contributes to lighter/lower vulnerability. The color spectrum is relative within each column (i.e., dark red in exposure not necessarily same value as dark red in vulnerability).*

FISHERY	SAMPLE SIZE (N)	AVERAGE VULNERABILITY (V)	STANDARD DEVIATION	AVERAGE EXPOSURE	AVERAGE SENSITIVITY	AVERAGE ADAPTIVE CAPACITY
herring spawn on kelp	5	1.16	0.09	0.61	0.66	0.29
groundfish trawl	6	1.15	0.27	0.71	0.56	0.33
salmon seine	13	1.12	0.12	0.72	0.55	0.39
herring roe seine	11	1.11	0.13	0.65	0.64	0.43
sea cucumber	6	1.10	0.13	0.62	0.67	0.40
salmon gillnet	38	1.10	0.21	0.64	0.59	0.38
urchin	11	1.10	0.12	0.54	0.71	0.40
salmon troll	27	1.10	0.27	0.65	0.58	0.39
herring roe gillnet	20	1.05	0.23	0.61	0.57	0.41
tuna (U.S. & intl)	7	1.05	0.24	0.62	0.56	0.53
lingcod	19	1.04	0.26	0.62	0.54	0.40
tuna troll	18	1.04	0.20	0.58	0.62	0.43
dogfish	5	1.03	0.25	0.73	0.44	0.45
prawn shrimp trap	19	1.02	0.14	0.56	0.57	0.42
sablefish	14	1.01	0.23	0.61	0.55	0.50
geoduck	5	1.00	0.09	0.63	0.45	0.42
crab	8	0.97	0.21	0.62	0.41	0.42
halibut longline	30	0.97	0.20	0.57	0.52	0.46
rockfish	15	0.93	0.21	0.59	0.46	0.49

Table 2. *Average vulnerability scores and associated standard deviation calculated based on individual perceptions of exposure, sensitivity, and adaptive capacity, grouped by fishery that the harvesters surveyed participate in. Sample size (n) refers to the number of harvesters surveyed that participate in a particular fishery. The range of possible values for the vulnerability score is from zero to 1.41, whereas average exposure and sensitivity range from zero to 1.*

THE FUTURE OF FISHING IS CHALLENGED BY MORE THAN JUST CLIMATE CHANGE

Harvesters have strong concerns about fishery management, access, and habitat loss

When presented with a list of issues that may affect fishing success, individual well-being or the well-being of the harvester's community, harvesters were most concerned about stock assessments, operational costs, habitat loss, fish populations, and regulations with around two thirds or more of the participants being "very" concerned about these aspects of fisheries (Figure 9). Harvesters mentioned the need for better data for more robust stock assessments, and funding for habitat improvements, monitoring spawning grounds, and watershed assessments.

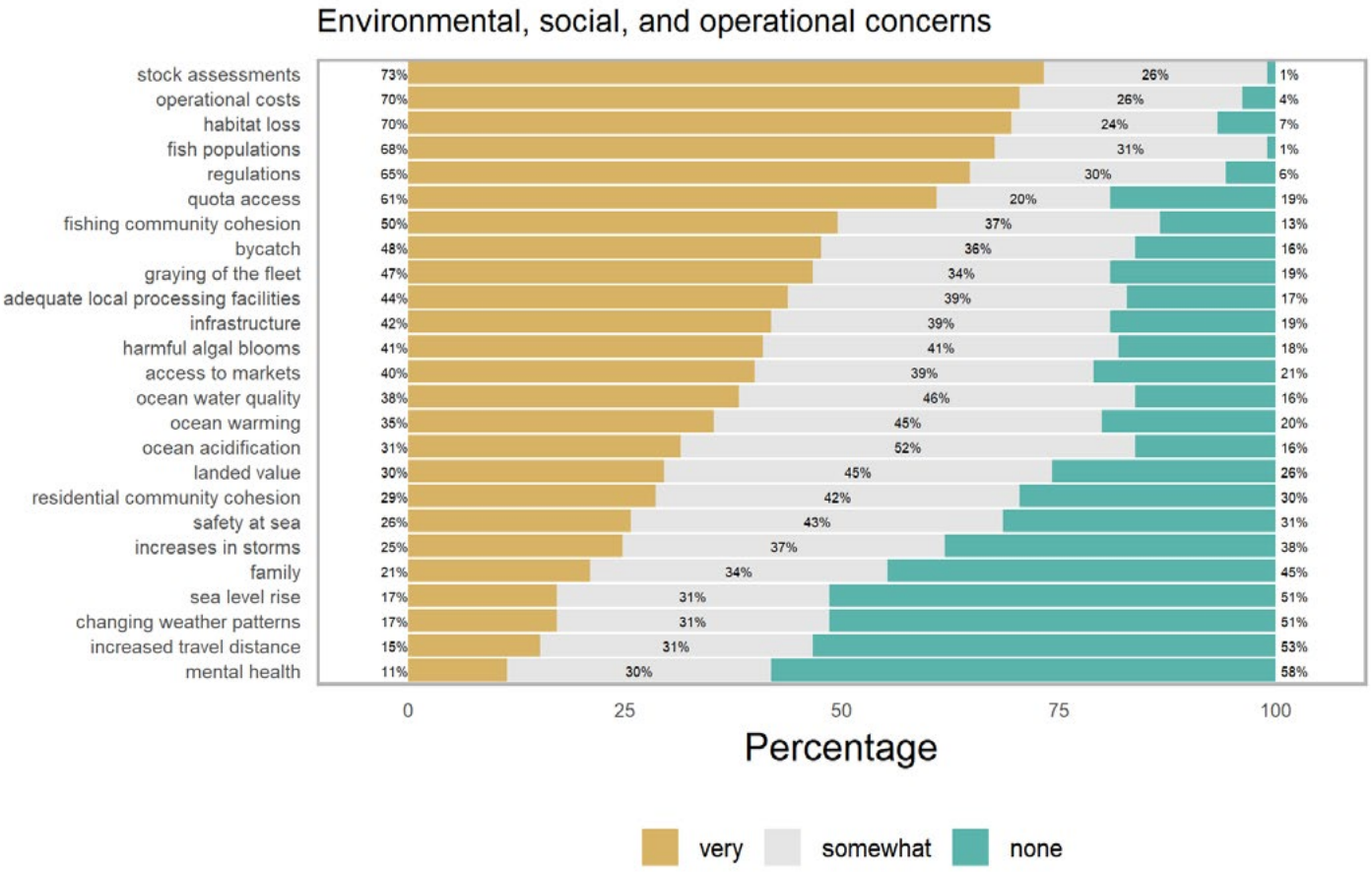


Figure 9. *Level of concern expressed by harvesters for various environmental, social and operation dimensions of fisheries.*

Of relatively lower concern were sea level rise and mental health, increased travel distance and changing weather patterns (Figure 9), with approximately half of participants indicating 'none' as the level of concern for these issues. One participant contextualized their concerns over climate change relative to other concerns in the following open-ended response:

> "Global warming is definitely having an impact but at the same time, for the same species, so might regulations, markets, costs... etc." (Harvester # 48).

In response to an open-ended question regarding future concerns, fish harvesters cited various concerns, with climate as just one among many. Concerns that came up frequently included sea lion predation, the impacts of fish farms on wild capture fisheries, the spread of misinformation through social media creating conflict between groups, challenges in accessing quota, especially for young harvesters, and overall access and allocation concerns. Some of these concerns are articulated in the following responses by survey participants:

> "Salmon aquaculture (in its current form) continues to be a very serious issue. it will one day be known as the second-hand smoke of fisheries—particularly for wild salmon stocks." (Harvester #54)

> "My concerns about the next generation of young fishermen. Most will have a hard time finding financing for the exorbitant prices. To buy a boat and quotas and earn an honest living." (Harvester #101)

In terms of concerns related to habitat loss, one harvester surveyed indicated, "Fish habitat restoration and real action on climate change are mandatory to secure the future of fishing and fishing communities." (Harvester #34)

When asked about future concerns, one participant responded, "hope we have a future" (Harvester #83). While another participant stated, "there is no future the way it is being managed presently" (Harvester #103).

EXPLORING POSSIBLE SOLUTIONS

Participatory processes involving all fisheries stakeholders are needed to respond to the social and ecological impacts associated with climate change

In response to the open-ended question, ***what sorts of changes could quicken response time and make fisheries management more flexible as it responds to future challenges?*** one-third of harvesters surveyed called for more participatory processes, including more input from fishers and representation across groups to address the broad range of interests and considerations related to climate change impacts on fishers and fishing communities (Table 3). Others identified the proven value of such processes and why they should be supported from a government perspective.

THEMES	KEY THEMES and SELECT QUOTES	NUMBER OF HARVESTERS
Encourage participatory processes	"Fisherman and communities need to start working together to get their voice heard rather than being in competition with each other. Young fishermen need to have a stronger voice and access to licences and quota as it is their future and they are the future of the industry." (Harvester #40) "Improve upon Gov/Industry collaborative processes which develop co-managed responses to the changes often required for both ecological and socio-economic improvements for fisheries." (Harvester #91) "Open and transparent dialogue with all users. All users need to be adequately represented." (Harvester # 70) "Fisherman led processes of the last couple of decades have proven to be extremely valuable. Governments should respect and encourage more processes like this rather than just develop policy in Ottawa designed for the east coast only. Pacific Coast should have more autonomy and DFO leadership." (Harvester #91) "In fisheries where management and stakeholders co-manage to a great extent – i.e., halibut, geoduck, those fisheries are prime examples of successful and sustainable fisheries." (Harvester #22)	32
Engage fish harvester knowledge	"Listen more to the knowledgeable commercial fishers." (Harvester #20) "Fishermen should be more involved in decisions made about fish stocks." (Harvester #43)	23
Devolve decision-making; more local and regional authority	"More autonomy for the Pacific region rather than having to go through Ottawa" (Harvester #67)	16
Enhance communication	"Better communication from DFO federal... Better opportunities for DFO to celebrate and communicate their successes as this would add more confidence and trust in the department from the general public resulting possibly in better funding from politicians." (Harvester #13) "Better communication with fishers who are actually on the frontline who also have valuable information and knowledge of the industry." (Harvester #72)	12

Table 3. *Themes that emerged from the open-ended survey questions, sample quotes and the number of participants who gave responses related to each theme.*

Harvesters' "on the water" knowledge is valuable and could be better incorporated into fishery management

Several survey participants emphasized the need to involve harvesters' knowledge in management and decision-making, for more responsive and effective outcomes (Table 3).

Having management and decision-making at a more local level could make fisheries management more responsive

Many harvesters suggested that fisheries should be managed at the local level, devolved from central decision-making that currently takes place in Ottawa, away from the coasts (Table 3). Some also indicated the need for better coordination across jurisdictions and government authorities and departments.

Communication on all levels is critical for effective and responsive management

Responses that call for better communication ranged from communication within and across government departments, regions, stakeholders, and community groups (Table 3).

DISCUSSION AND IMPLICATIONS OF THIS STUDY

Most of the fish harvesters who participated in the survey (77%), believe that climate change is occurring, which is just below the national average of 83% of Canada's general public who believe climate change is occurring (Mildenberger et al., 2016). Fish harvesters spend a great deal of time on the water observing the interactions between the environment and marine species, so this finding suggests they are attributing at least some of the changes they observe to climate change. This is important in the context of fishery management, because if harvesters, fisheries scientists, and fisheries managers can all agree that climate change is happening, this is an essential first step towards exploring options for responding and adapting. Similarly, public perceptions influence public policy (Slovic, 1997), therefore alignment between policy-makers and those impacted by climate related changes are key to developing effective responses to these changes.

Fish harvesters perceived salmon species to be the most vulnerable to negative impacts associated with climate change, which is not surprising. Species or fishery specific concerns highlighted the perceived negative impact of climate change on salmon fisheries, providing further support for the mounting evidence that salmon, particularly in southern parts of British Columbia, are not only threatened but are already facing climate-related impacts at every stage of their life-cycle (Grant et al., 2019), with substantial impacts on commercial salmon fisheries that are already considered to be in crisis (UFAWU-Unifor, 2021). Aside from salmon, no other single fishery showed overwhelming agreement on negative impacts from ocean warming, although between 22% and 35% of harvesters who responded categorically to the fishery-specific impacts perceived negative impacts of ocean warming for every listed fishery (except albacore tuna and hake). While this reflects a legitimate climate concern for many species out there, it also suggests that harvester perceptions are variable. For example, 29% of those who responded perceive negative climate impacts for crab, while 23% perceive positive impacts and 50% suggest there will be no effect. While many harvesters are acutely aware of the potential negative impacts that ocean acidification could have on crab (J. McIsaac, personal observation, 2021), this question focused on ocean warming. For most fished species, over 50% of those who responded categorically indicated, 'no effect', however there were a high number of survey participants who responded, "I don't know", which highlights fish harvester uncertainty over the direction and scale of impacts from ocean warming. "I don't know" responses might also be selected by harvesters if it was a fishery they don't participate in or know less about. When harvesters did select a scale and direction of impact, harvester confidence in the perceived fishery effect was, for the most part, low-to-medium. While these responses reflect harvester knowledge gained through lived experience, they are also likely a reflection of the overall state of knowledge on the impacts of climate change on B.C. fisheries (i.e., variable and uncertain), and how well existing knowledge and information has been shared with or communicated to fish harvesters.

A variety of spatial modeling and Delphi[2] processes have been used to assess vulnerability to climate change of select commercial fisheries for various regions in North America, focusing mainly on exposure and sensitivity of species based on physical-oceanographic, biological and ecological characteristics (Grant et al., 2019; Hare et al., 2016; Hunter et al., 2020; Spencer et al., 2019; Stortini et al., 2015). For the Pacific region of Canada, a recent study assessed 15 non-salmon fisheries and found the highest level of climate change vulnerability was for Pacific herring (Hunter et al., 2020). In the United States, Spencer et al. (2019) assessed the impact of climate change on 36 fish and invertebrate stocks in the eastern Bering Sea, taking into account and combining numerous attributes of exposure and sensitivity. Hare et al. (2016) assess vulnerability by combining the exposure of each species to a stressor (climate change and decadal variability) and the sensitivity of that species to the stressor for 82 fish and invertebrate species in the Northeast U.S. Shelf. In Atlantic Canada's Scotian Shelf, Stortini et al. (2015), conducted a vulnerability assessment (combining exposure and sensitivity but focusing more narrowly on ocean warming) for 33 fish and invertebrate species. While these studies used slightly different approaches to frame and assess vulnerability to climate change, the key difference to the work presented here is that we have captured perceptions of risk, sensitivity, and adaptive capacity. For sensitivity, we used the sensitivity of the harvester to climate change impacts on fisheries, and, unlike the other studies, we include adaptive capacity in our conceptualization of overall calculated harvester vulnerability, whereas vulnerability in the other studies mentioned include only exposure and sensitivity and focuses on species vulnerability (Füssel & Klein, 2006). Nevertheless, looking across different studies to combine and compare results can be helpful in bringing together different ways of knowing—modeled understanding with on-the-water observations—for a more robust inquiry into and insights on the impacts of climate change on fisheries.

2 A Delphi process is an expert-based approach to support decision-making that can be used in situations where models are unavailable or compromised by lack of appropriate data. The method aims to develop consensus between experts over several rounds of deliberation based on the assumption that combining the expertise of several individuals will provide more reliable results than consulting one or two individuals (MacMillan & Marshall, 2006).

It is widely recognized that the social-ecological nature of marine systems and fisheries requires consideration of social vulnerability in climate change vulnerability assessments (Cinner et al., 2013), and work to bring these dimensions together for the Pacific region is ongoing (Hunter et al., 2020). While direct comparisons between perceptions and modelled vulnerability is cautioned due to differing inputs into these calculations, a comparison of similar elements, e.g., fishers' perceptions of exposure (question about impact of ocean warming on fisheries) and the modelled ocean temperature exposure (Hunter et al., 2020) linked to the physiological limit to temperature of the fished species across fishing grounds, could be illuminating. Where there is alignment, this could further prioritize science and management resources towards those fisheries, and where there are discrepancies, this could flag where a better understanding of what is driving these discrepancies is needed and where there might be a need for alternative strategies, for example, increased engagement and communication between fishers, managers, and scientists.

Estimated overall vulnerability, based on harvesters' responses to questions relating to exposure, sensitivity, and adaptive capacity, suggest that harvesters in herring spawn on kelp, groundfish trawl, and salmon seine fisheries are most vulnerable, while harvesters in crab, halibut longline, and rockfish fisheries scored the lowest in terms of perceived vulnerability of the assessed fisheries. However, these findings should be interpreted cautiously, as some of the sample sizes were low, meaning that more weight was given to any one harvester's perceptions of exposure, sensitivity, and adaptive capacity. While the method of assessing the various dimensions and calculating vulnerability is sound and has been used previously, the results presented here would be more robust with a larger sample size. Despite this limitation, the existing survey and results are supported by studies and literature, especially on salmon and herring, that describe the risk of these species to a variety of stressors, including climate change, and the limitations of current assessment and management approaches to respond to these and ability to adapt (Gauvreau et al., 2017; Salomon et al., 2019).

While concern for climate change impacts on fisheries was clearly reflected in the survey findings, there were many other concerns that fish harvesters have that relate to broader social, ecological, economic, and institutional considerations, that have been described previously. For example, concerns over access to licences and quota, especially for independent and young harvesters, are in line with concerns that have been raised in recent years (Bennett et al., 2020a; Bennett et al., 2021; Standing Committee on Fisheries and Oceans, 2019), which may be further compounded by climate change, increasing management challenges, especially for transboundary species such as salmon, halibut and tuna, which are jointly managed (Koubrak & VanderZwaag, 2020). Harvester support for ecosystem-based management has also been noted inside integrated processes like the Pacific North Coast Integrated Management Area Plan (PNCIMA) and the Marine Plan Partnership (MaPP), where harvesters have

been working to build a common understanding with other stakeholders and governments to co-exist with our marine ecosystems (J. McIsaac, personal observation, 2021).

Challenges faced by young fishers were raised by many of the participants in the survey. While these challenges may not have been directly related to climate change, they highlight ongoing challenges that will become even more pronounced as an already greying fleet retires. Changes in stock abundance and distribution associated with climate change (both positive and negative) will affect future fisheries. A recent industry report on the future of the B.C. salmon industry suggest that for young fishermen to succeed, they need better access to low interest loans and funding for vessel modifications, in addition to training opportunities, supported through government programming (UFAWU-Unifor, 2021). These identified challenges for young fishers constitute the assets dimension of adaptive capacity as outlined by Barnes et al. (2020), and thus represent an obstacle to climate responsive and resilient fisheries.

Insights that were elicited through this survey regarding how fisheries could be made more flexible and responsive to climate change pointed to broader, overarching concerns that fish harvesters have related to the management of fisheries. These include a perceived urgency in responding to the impacts of increased marine mammal predation on fisheries, to mitigate negative ecosystem impacts of fish farms, interactions with wild capture fisheries, and to act on addressing concerns, articulated previously, over access and allocation challenges and conflicts. The combined impacts of increased predation and climate change are a perfect storm for salmon fisheries, requiring urgent and immediate attention. The government of Canada announced Pacific salmon fishery closures for the 2021 season as part of a strategy towards longer-term reductions in fishing pressure to help combat the multiple stressors faced by declining and threatened salmon populations (Government of Canada, 2021). Both the decline of salmon and management responses to these have widespread social, cultural, and economic impacts for fishers and fishing communities along the B.C. coast. Therefore, soliciting harvesters' in-depth, on-the-water knowledge about climate change is key to tightening the feedback loops and responsiveness of fishery managers, in addition to increased legitimacy and trust that are associated with participatory approaches to management engaging those most involved in and dependent on the resource.

Other suggestions that harvesters brought up with respect to improving management flexibility were the need for better communication across departments, levels of government, jurisdictions, and stakeholder groups. These findings reinforce the importance of departmental communication strategies with dedicated roles and responsibilities for ensuring information that is critical for rapid response to change and for building trust and support for management processes gets communicated widely and presented in an easily accessible and digestible format. This is in line with recent emphasis on and approaches for science communication and ocean literacy (Kelly et al., 2021). Effective communication is identified as key to engaging stakeholders in the collective problem solving necessary to navigating threats to fisheries sustainability (Mackinson et al., 2011).

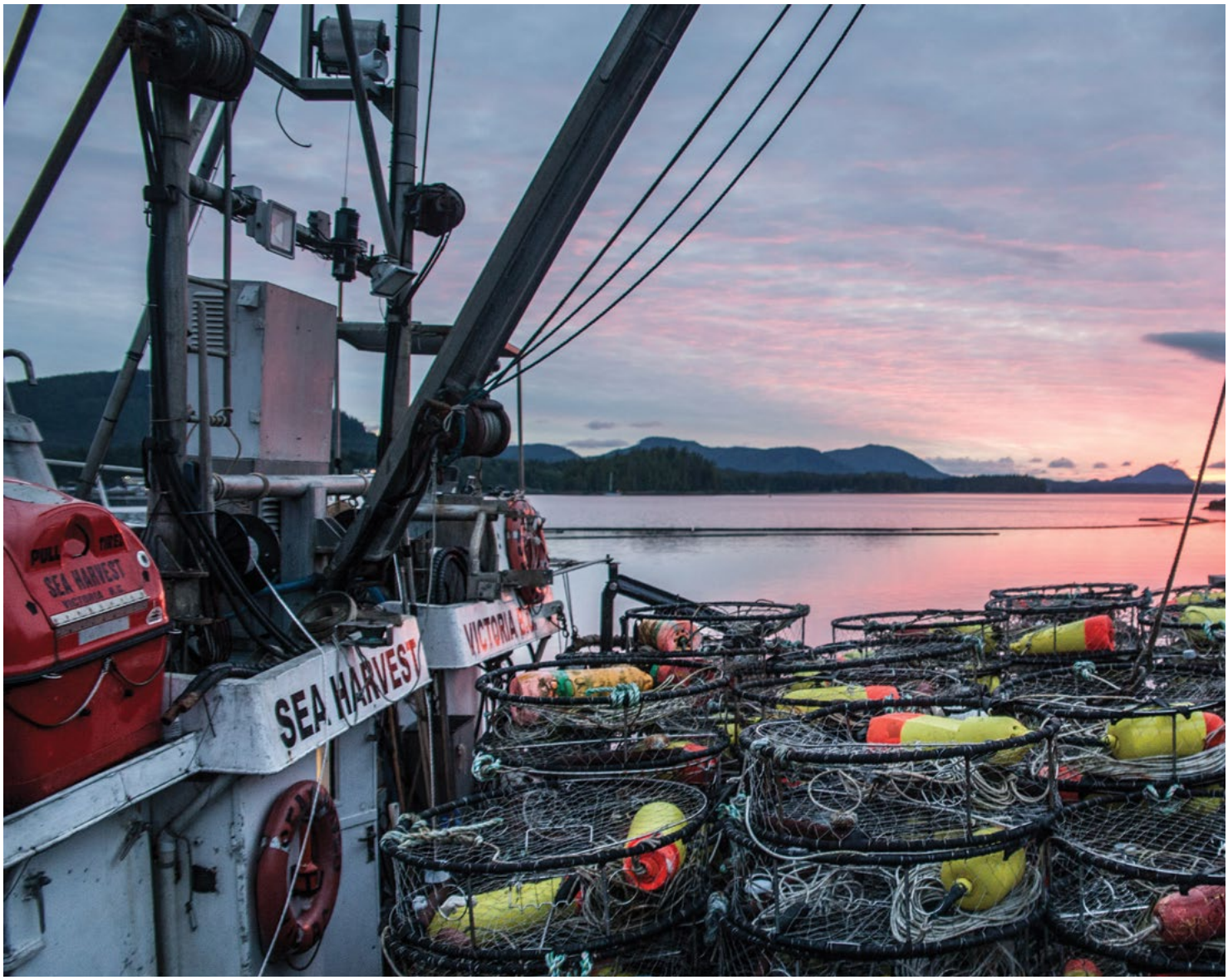
This survey was designed to collect demographic data to investigate and better understand how identity might influence perceptions of vulnerability; however, the sample was not large enough to accurately reflect the composition of fish harvesters in the industry across the range of identities that exist in the sector (e.g., age, gender, Indigenous identity, etc.). For example, according to the 2016 Census, approximately 17% of fishermen and skippers in B.C. were women, so this survey (6% female survey participants) is not representative based on gender. Additionally, while special efforts were made to engage Indigenous commercial fishers, several barriers to the participation by Indigenous fish harvesters may have been present, and responses from harvesters identifying as Indigenous was low (10% of survey participants). Moreover, the questions were not specifically designed to capture the unique relationship that Indigenous peoples have to the lands and waters and worldviews that shape this, while also not specifically attending to the historical and ongoing mistreatment and marginalization of Indigenous peoples in Canada, that impacts all aspects of their lives and livelihoods. To understand the complexities of climate change impacts on Indigenous peoples in the context of fisheries, there is recent and ongoing work being led by and done in collaboration with Indigenous communities, which provide a starting point for understanding some of the same challenges and concerns explored in this survey from an Indigenous-perspective (Northwest Indian Fisheries Commission, 2016; Thompson et al., 2020; Whitney et al., 2020). Broadly, work is needed to expand and decolonize understandings of vulnerability, methods for assessing it and approaches for responding to it (Johnson et al., 2021).

It is important to note that this survey coincided with the onset of the COVID-19 pandemic in March of 2020. While it is difficult to know how the pandemic may have influenced the results, we feel the expressed perspectives and findings remain representative and relevant. Many of the challenges and concerns faced by fish harvesters existed pre-pandemic (Archibald & Rangeley, 2019; Robertson et al., 2015; Standing Committee on Fisheries and Oceans, 2019), although they may have been expressed differently during the pandemic or been more pronounced due to it. The pandemic and policy responses to it disrupted markets and exposed fishers and processors to additional health risks and overall amplified conditions for already marginalized groups of fish harvesters (Bassett et al., 2021; Bennett et al., 2020b). The immediacy of the concerns that arose from the pandemic may have increased or decreased climate change concerns and influenced perceptions. While the impact of the timing of this survey coinciding with a global pandemic cannot be fully known, this timing also made clear some of the underlying vulnerabilities that exist in the fisheries sector (Sowman et al., 2021). And while understanding vulnerability and adaptation to climate change may look different to that of a pandemic,

there is much to be learned about the ability of a country, community, or individuals to respond during times of crises. Therefore, the current moment presents an opportunity for deep reflection and learning, which could motivate actions and changes to increase people's ability to respond in future.

Overall, these findings provide valuable information for fishing communities, industry, fisheries scientists, managers, and policy-makers who are grappling with understanding the impacts of climate change on fisheries as social-ecological systems, identifying, and balancing the trade-offs associated with various courses of action that could be taken to develop more resilient fisheries and responsive management considering climate change. This study can be seen as a starting place and a foundation upon which dialogue and knowledge can be expanded. These findings could also inform future scenario planning efforts, which have become much more widespread, with examples of ongoing initiatives and collaborations between governmental and non-governmental organizations, in other jurisdictions (Bell et al., 2020; Teh et al., 2017).

The complexity of climate-related challenges, added to pre-existing threats to fisheries, make fisheries management no easy task. While fisheries management in Canada considers a broader range of environmental variables in fisheries assessments and associated management advice, more is needed to understand the human impacts associated with climate driven changes to fisheries and the ability of fish harvesters, fishing communities and the institutions involved in supporting these systems to respond. What was very clearly articulated in responses to this survey of B.C. commercial fish harvesters is deep concern for a range of fisheries-related threats that are likely to be amplified under a changing climate. This is coupled with a strong desire for more inclusive processes, so harvesters can participate in developing appropriate and effective responses to the many challenges faced by fisheries and all those involved in Canada's Pacific Region.



APPENDIX A - DETAILS ON SURVEY DESIGN AND ANALYSIS

Statements related to sensitivity, defined here as sensitivity of fish harvesters' individual wellbeing on changes in fisheries, where survey participants had to indicate their level of agreement with these statements, were designed using the concept of well-being defined by Breslow et al (2016), which identifies four sub-categories of well-being (Figure A1).

CATEGORY OF WELL-BEING	DEFINITION	SURVEY QUESTION(S)
Conditions	Circumstances in which "human needs are met," and include the tangible qualities of environment, economy, safety, and human health.	"Changes in fisheries have negatively impacted to overall well-being" "Changes in fisheries have raised my stress levels"
Connections	"Being with others and the environment," and including the tangible and intangible interrelationships with other people and with nature, and our cultural values and identities.	"Fishing is important to my identity" "Fishermen are supported in my community"
Capabilities	The factors directly enabling individuals and communities to "act meaningfully to pursue their goals," including activities, knowledge systems, political participation, and governance.	"I make enough money to support my family" "I have a voice in fisheries management"
Cross-cutting domains	Includes themes of equity and justice, security, resilience, and sustainability that relate to a state of caring for oneself, other people and living things, and sustaining our collective "satisfactory quality of life".	"The fisheries I participate in are managed in an equitable way" "There are opportunities for people who are not currently fishing to enter into west coast fisheries"

Figure A1. *Categories of wellbeing as described by Breslow et al. (2016), including definition and sample question from the survey.*

Analysis of the survey was done using a mixed methods approach. All categorical questions (where participants responded to various statements regarding their level of agreement or disagreement) were analysed using R statistical software (R Core Team, 2021), while open-ended questions were analyzed using NVivo software (QSR International, 2020).

Specific questions related to exposure, sensitivity and adaptive capacity were then used to calculate vulnerability and presented as a scatter plot, grouped by fishery. There are many methods used to calculate vulnerability; here we used the Euclidean distance method (Samhouri and Levin, 2012) (Eq 1).

Eq 1. $$v = \sqrt{e^2 + s^2 + (1 - ac)^2} v = \sqrt{e^2 + s^2 + (1 - ac)^2}$$

Individual exposure (e) reflects fish harvester's perceptions of the impacts of ocean warming on fish species (survey question 20). Higher scores equate to a higher exposure. Individual sensitivity (s), captures fish harvester perceptions of how changes in fisheries and the environment are affecting their health, well-being, and stress levels (survey question 38). Higher scores equal higher sensitivity. Adaptive capacity (ac) is the harvester's perceived ability to respond to or cope with changes in fisheries (survey question 42). Higher scores equate to higher adaptive capacity. Finally, taking Euclidian distance (distance points on a graph) of the sum of these three variables results in an estimate of individual vulnerability (v), which translates into a vulnerability score.

Open-ended questions were coded using predefined codes using themes from the literature, research objectives, and survey questions (e.g., climate change impacts on species, management flexibility), and codes/themes that emerged from participants

responses. Responses to the open-ended questions provided additional context and more depth in support of, and in some cases in contrast to, the categorical (five-point Lickert scale) questions. The final two questions of the survey invited perspectives and insights on how management can be more flexible and what fisher's think about the future of fishing. These questions were also coded with certain emergent themes that are broadly relevant to fisheries management, with some more related to climate change than others.

Preliminary results and analysis of the survey findings were presented to industry partners, government collaborators, and stakeholder groups to invite feedback and insights to assist in the interpretation and validation of the results. Feedback and insights elicited through this process were incorporated into the study, adjusting interpretations where necessary.

Appendix B - Survey participants

Harvesters who responded to the survey participated in a wide range of fisheries (Figure B1). Approximately two-thirds of participants indicated they participated in more than one fishery, with only 32.3% indicating participation in a single fishery.

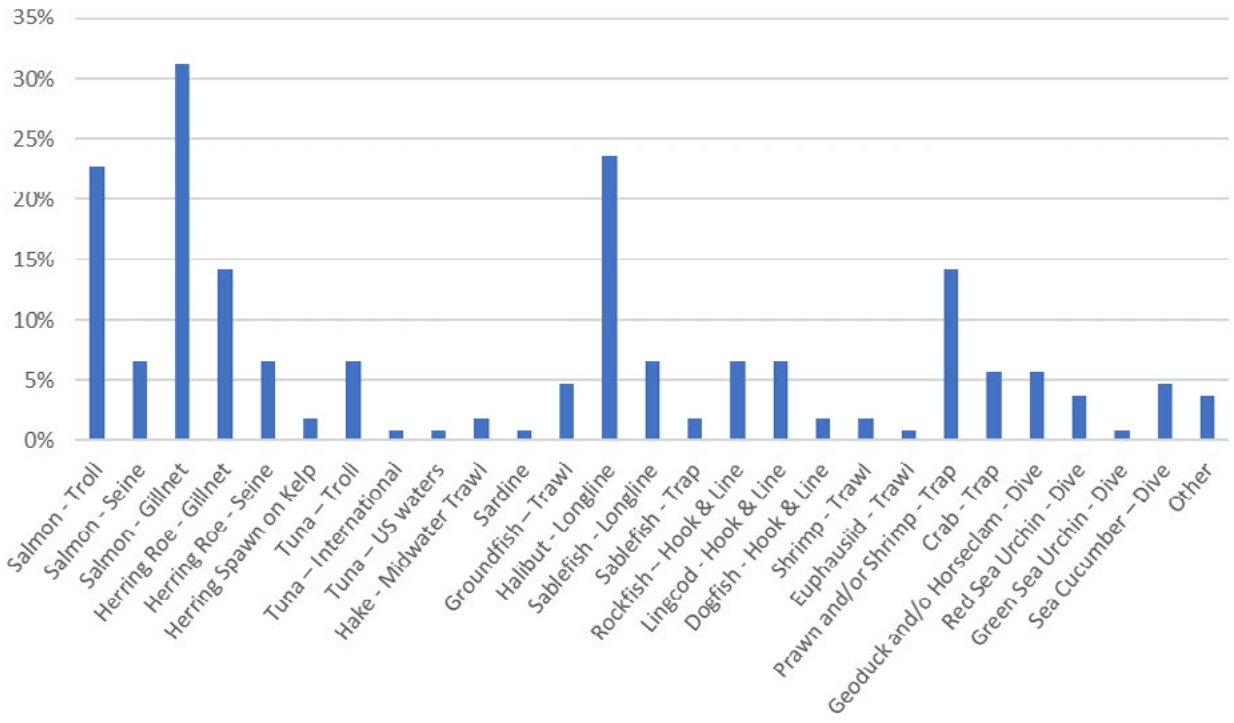


Figure B1. *Proportion of harvesters surveyed that participate in Pacific region commercial fisheries. Other included Pacific oyster, manila clam and octopus.*

While there is no comprehensive data source for the number of fishers by fishery, to get an approximate gauge of survey responses relative to participation in the fishery we used the licences by fishery as a proxy for number of harvesters by fishery. In some cases this may underestimate participation in a fishery where several crew are involved in fishing one licence. In other cases it might overestimate participation, where licences are stacked and fished by the same individual or crew. However, this gives an approximation of how representative this survey was across different fisheries (Table B1).

Fishery	No. of survey participants	No. of total licences by fishery	Approx. % representation
Halibut	25	341	7%
Salmon – gillnet & troll	57	1,007	6%
Herring roe – Gillnet	15	743	2%
Herring roe – Seine	7	196	4%
Prawn & Shrimp Trap	15	185	8%
Sablefish	9	41	22%
Crab Trap	6	189	3%
Sea Cucumber	5	84	6%
Sea Urchin	4	128	3%
Geoduck	6	50	12%

Table B1. *Survey participation by fishery relative to the number of licences as an approximate estimate of the representativeness of the survey results for a given fishery. Note that these fishery groupings differ slightly from the more expansive list used for the survey; however, this is how they are aggregated for DFO licence reporting purposes.*

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