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Sustaining an Alaska Coastal Community: Integrating Place Based Well-Being Indicators and Fisheries Participation

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ABSTRACT

The incorporation of human dimensions into ecosystem-based fisheries management has largely focused on metrics of economic welfare. Yet researchers have demonstrated the variety of well-being that is derived from fisheries as well as the need for localized and collaborative scientific efforts that result in appropriately contextualized metrics. This article presents the results of a project intended to address these needs and inform the North Pacific fisheries management process with a set of indicators that are related to multiple dimensions of human well-being and links to fisheries participation. The article showcases a mechanism of applying a well-being framework and participatory methods to develop locally relevant quantitative indicators for one of the most highly engaged fishing communities in Alaska - Sitka. These indicators can be used to track how fishery shocks may reverberate through social systems and affect fishing communities. Furthermore, the discussion of the multifaceted well-being indicators presents information on local values and complex dynamics between community well-being and fisheries that are difficult to conceptualize and integrate into management decisions. Ultimately, this work can facilitate a more comprehensive incorporation of human dimensions into ecosystem-based frameworks in fisheries management, contextualizing that expansion within locally relevant narratives that engage stakeholders in resource management.

KEYWORDS

Alaska; fisheries management; fishing community; indicators; well-being

Introduction

Ecosystem-based management (EBM) reflects the increasing understanding that resource management regimes need to not only move beyond a single-species orientation but to include various aspects of ecosystem integrity (Breslow et al. 2016; Millennium Ecosystem Assessment 2005). This wider approach is intended to balance multiple objectives, incorporating temporal, spatial, and sectoral tradeoffs while managing for overall sustainability (Link and Browman 2014; Marasco et al. 2007). Integrated ecosystem assessments (IEAs) are an internationally utilized framework for supporting the implementation of EBM in marine ecosystems (International Council for the Exploration of the Sea [ICES] 2017;

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Levin et al. 2009). IEAs engage scientists, stakeholders, and managers using various knowledge systems to evaluate ecosystem status with respect to multiple objectives (Mascia et al. 2014).

A key component of IEAs and EBM more broadly is the integration of humans and their well-being into a systems framework. Herein we apply the definition of human well-being conceptualized by Breslow et al. (2016) as a state of being when needs are met and individuals and communities can pursue their goals and enjoy a good quality of life. With evidence that humans have now in some way affected every ecosystem on Earth (Aswani et al. 2018; Crutzen 2006) comes an increasing understanding that natural resources need to be managed with a holistic perspective that blends multiple disciplines and integrates humans into a coupled social-ecological system (Liu et al. 2007). Many early efforts in this arena were the result of coalitions of social scientists and ecologists building an understanding of how economic and institutional theory can be applied to examine common property problems (Dietz, Ostrom, and Stern 2003; Ostrom 1990). However, researchers are increasingly finding the need to utilize social indicators beyond economic outcomes to conceptualize different types of ecosystem impacts, dimensions of human well-being, and resiliency in social-ecological systems, especially in the context of fisheries management wherein this effort is increasingly gaining momentum (Anderson et al. 2015).

The development of human well-being indicators that cut across various social and economic dimensions is a growing effort within NOAA's IEA work and is increasingly being integrated with metrics of natural resource use and ecosystem health (Colburn et al. 2016; Levin et al. 2016; Poe, Donatuto, and Satterfield 2016). While objectively identified metrics that can be applied across multiple spatial and temporal scales may provide efficiency and consistency, researchers have demonstrated the subjectivity of well-being definitions and priorities (Biedenweg 2017; Smith and Clay 2010). Thus, NOAA researchers are increasingly implementing localized research efforts as part of IEAs to help identify contextualized well-being linkages to ecosystem uses and to create a degree of local relevance and political support that is not readily replicated with more diffused methodologies (Ingram, Oleson, and Gove 2018; Leong et al. 2019; Donkersloot et al. 2020).

This article presents the results of a project intended to inform the federal fisheries management process in the North Pacific with a set of indicators that are related to multiple dimensions of human well-being and how those are derived from a community's participation in fisheries. The project is built upon over 10 years of efforts to advance EBM in Alaska and is one of a number of efforts in the region to integrate well-being into EBM and to understand the multiple dimensions of human resilience to ecosystem change in the context of fisheries management (Fissel et al. 2018; Holsman et al. 2019; Zador, Holsman, et al). As part of the Gulf of Alaska IEA, a team of social science researchers conducted a targeted effort aimed at understanding the linkages between fisheries and community well-being for Sitka, the most active commercial fishing community in Southeast Alaska in terms of commercial fishing vessels and federal and state fishing permits (Fey et al. 2016). This study examines the results of that effort, showcasing a methodology of applying the well-being framework to develop locally relevant quantitative indicators that can be used to track how fishery shocks may

reverberate through social systems and affect fishing communities. The discourse about the top indicators identified by study participants demonstrates information on local values and complex dynamics between community well-being and fisheries uses that have been heretofore difficult to conceptualize and integrate into management decisions. Thus, the study informs how EBM may be shaped into a more integrated process of identifying human well-being indicators tied to fisheries uses beyond conventional reliance on economic welfare metrics alone and contextualizes those indicators within locally relevant narratives that engage stakeholders in resource management.

Methods

We applied the conceptual framework of human well-being to organize information from stakeholder engagement regarding the types of values they derive from local fisheries (Biedenweg, Stiles, and Wellman 2016; Breslow et al. 2016) in a process detailed in Applying the well-being framework to a fishing community section We then describe our methodology in Participatory focus groups within the community section, which was a combination of a literature review, participatory focus groups, and semi-structured interviews to identify locally relevant well-being components derived from fisheries and to identify, refine, and rank indicators of these components (Biedenweg, Stiles, and Wellman 2016; Biedenweg 2017). Identifying the components of well-being derived from fisheries use section explores the terminology on the values derived from local fisheries that was used during the focus groups and links that to well-being components based on approximations in the literature (Breslow et al. 2016; Rosellon-Druker et al. 2019). Indicator development section describes the process for identifying indicators that were presented to community stakeholders for discussion and ranking. Finally, Data for indicators section describe how the highly ranked indicators were developed and presented to stakeholders for ground truthing localized relevance to fisheries participation, and prioritizing a final list of indicators.

Applying the well-being framework to a fishing community

The Gulf of Alaska IEA was initiated with a place-based framework that focuses on a single fishing community in Southeast Alaska, Sitka (Rosellon-Druker et al. 2019). Located on the west coast of Baranof Island, Sitka was chosen based on its geographic representativeness of the eastern Gulf of Alaska subregion with respect to biophysical properties and reliance on commercial, subsistence, and recreational fishing (Fey et al. 2016; Rosellon-Druker et al. 2019). The Sitka IEA focuses on developing and examining models that represent the linkages between ecosystem and human dimensions components for four highly economically and culturally relevant focal species (Rosellon-Druker et al. 2019).

Creating a place-based IEA focusing on a geographic community necessitates understanding the diversified and complex linkages between fisheries uses and fishing participants, and the community as a whole, analogous to mapping the socioecological region in other natural resource contexts (Leslie et al. 2015). This provides a basis for moving research beyond the conventional US federal fisheries management approach which

Table 1. Expertise represented, average age, gender distribution, and overlap with previous focus groups across the three sessions in Sitka.

	First focus group	Second focus group	Interviews
Expertise represented	Commercial fisheries participants and managers (3); subsistence fisheries participants and managers (4); community health/food (2); community environmental NGOs (2); Sitka Tribe resource management (2); marine science (2)	Commercial fisheries participants and managers (4); subsistence fisheries participants and managers (1); community health/food (2); community environmental NGOs (1); marine science (3)	Commercial fisheries participants and managers (4); subsistence fisheries participants and managers (1); community health/food (3); marine science (1); community government (1)
Average age	45	41	45
Gender distribution	9 women; 3 men	6 women; 3 men	7 women; 2 men
Participated in previous focus groups	N/A	4	6

tends to emphasize economic dependence over any other form of dependence, and moreover economic dependence based narrowly on commercial fisheries participation. Rather, this work offers a conceptualization of numerous dimensions of community well-being derived from fisheries that have been utilized in other marine ecosystem management realms (Biedenweg et al. 2016; Biedenweg 2017; Bernard 2017).

Participatory focus groups within the community

Two participatory focus groups and a series of semi-structured interviews were utilized to gather place-based knowledge on social and economic connections of Sitka community residents to their local fisheries. Focus groups are increasingly utilized to elicit information about the linkages between human well-being and uses of natural resources and are helpful when group interactions may produce insights beyond what can be expected with individual interactions alone (Kidd and Parshall 2000; Poe, Donatuto, and Satterfield 2016; Bisack and Clay 2020). Focus groups and interviews were held in the community and open to the public. Participation was voluntary and based on principles of informed consent (Homan 1991). Each of the focus groups lasted 3 h, while the interviews ranged from 60 to 90 min in length.

We used a purposive sampling design of individuals representing domain-specific knowledge, with respect to the community's interaction with its local fisheries (Creswell and Poth 2018), who were identified with the help of collaborative partners in the community (Krueger and Casey 2014). Specifically, we targeted several key groups including subsistence and commercial harvesters, harvester representatives and fishery managers for each of the study focal species, as well as community health and well-being educators and leaders (Rosellon-Druker et al. 2019). Participants were contacted by phone and via e-mail by a researcher to describe the project, why their specific input was being sought, and to invite their participation.

Table 1 shows the distribution of expertise, age, and gender across the focus groups and semi-structured interviews in the community, as well as the number of overlapping participants. Overall, there were 19 unique participants in this research effort, 14 of

whom were women and 5 of whom were men, with an average age of 43 and a range of 25–65. Participants had expertise in commercial and subsistence fisheries participation and management, community health and food issues, environmental non-governmental organizations, Sitka Tribe resource management, marine science, and community government. The sample size is considered sufficient in purposive sampling design (Guest, Bunce, and Johnson 2006) especially given the attainment of theoretical data saturation (Strauss and Corbin 1990) which we detail below (Rosellon-Druker et al. 2019).

Several data and information gathering techniques were utilized throughout the process, including handouts for participants to respond to specific topics and write general notes, major themes summarized on flip charts for immediate participant feedback (focus groups only), note taking by researchers, and voice recording for further review (Krueger and Casey 2014).We developed an interview guide that consisted of nondirective questioning with open-ended topic areas to elicit spontaneous and multilayered responses (Kidd and Parshall 2000), which has been utilized in other contexts to understand local values associated with ecosystem usage (Gould et al. 2015; Poe, Donatuto, and Satterfield 2016). Following the sessions, researchers held debriefings to discuss the major themes that had emerged (Kidd and Parshall 2000), which were summarized in a document and relayed to participants for further feedback within 2 weeks of the sessions themselves. This feedback loop was intended to serve as an opportunity for participants to challenge any interpretations by the researchers and to provide further explanations.

Identifying the components of well-being derived from fisheries use

In order to integrate and track human well-being associated with fisheries in Sitka, researchers had to first understand the dimensions of well-being associated with fisheries uses, as defined by people in the community. Therefore, during the first focus group, participants identified the components of well-being that are derived from local fisheries uses and the drivers of fisheries participation that may in turn affect well-being (Rosellon-Druker et al. 2019). The well-being components identified by Sitka residents were adapted from Breslow et al. (2016), based on the congruence of the phrases used by focus group participants to describe the values they derive from fisheries uses and the attribute definitions used in Breslow et al. This process is further discussed in detail in Rosellon-Druker et al. (2019).

Indicator development

The first step toward deriving a list of indicators associated with fishing community well-being for Sitka was to search a database of 2,308 well-being indicators associated with ecosystem use developed by a team of social scientists working on the California Current IEA (Breslow et al. 2016). The list of indicators provided in this database was narrowed to those related to fisheries uses. The well-being components that were identified as associated with the indicator by Breslow et al. were then revised, to the extent necessary, to reflect knowledge specific to the community of Sitka.

With this list condensed to fisheries uses, a set of indicators was determined that was associated with each of the well-being components linked to fisheries previously

identified by Sitka residents. We started by ranking the indicators on the basis of how many components in total they measured and then added indicators that uniquely identified components otherwise not measured (e.g., spirituality). To further condense the list, we applied a set of criteria that have been utilized in previous efforts for evaluating human dimensions indicators relevant to ecosystem services (Loomis and Paterson 2014a, 2014b; Loomis et al. 2014): (1) pragmatism, utility, and practicality for managers and decision makers; (2) the availability of secondary data; (3) a focus on noneconomic indicators (since economic indicators are more established in evaluating fisheries management within NMFS) ; and (4) consideration of resilience, vulnerability, and sustainability as overarching constructs. We further considered the uniqueness of the indicators, with respect to other indicators in the set and to information that is already regularly presented to fisheries managers as part of various reporting mechanisms (for example, within the Economic Stock Assessment and Fishery Evaluation Report and Ecosystem Status Reports regularly published by the NMFS, see https://www.npfmc.org/safe-stock-assessment-and-fishery-evaluation-reports/). This final list included 25 indicators.

A second participatory focus group was held in the community to review the 25 indicators, intended to identify those most relevant. Participants were given the list of indicators and the well-being components that had previously been identified by community members as related to fisheries use and were asked to (a) identify which (if any) components each indicator measured, and (b) rank the relevance of each indicator as high, medium, or low in terms of how well that indicator reflects Sitka resident well-being. This was conducted as an exercise by individual participants on a handout that was collected by the researchers at the end of the meeting (see Supporting Information for handout), and followed by a group discussion with the researchers asking participants to identify indicators of high, medium, and low (or no) relevance, and new indicators that they thought were relevant but not included in the exercise. Each of these four categories was identified on its own flip chart sheet at the front of the room, allowing for a fluid discussion between these categories and related indicators.

The two elements of the individual exercise were intended to provide participants with a cognitive feedback mechanism (van Merriënboer and Kirschner 2012). Identifying the components measured by the indicator allowed participants to contextualize its relevance while the relevance ranking allowed them to reflect on the validity of the indicator at measuring components of well-being. Coupling an individual exercise with a group discussion was also intended to limit the effects of group bias and power dynamics on indicator ranking (Carey 2016), while providing for a nuanced discussion that informed researchers of possible linkages between fisheries participation, the indicators, and the well-being of Sitka residents. Besides the original 25 indicators they were asked to review, participants identified an additional 29 indicators that they thought were relevant, some of which were essentially permutations of the original set of indicators (e.g., per capita versus total) or were associated with the preceding discussion on well-being components (e.g., barter networks).

Following the second focus group, researchers utilized the indicator well-being component identification and ranking exercise, coupled with the group discussion, and a set of criteria to identify a set of indicators to present to community residents as time-series data. Responses to the individual exercise were quantified such that for each indicator:

$$\text{Score}_j = \sum_{j}^{J} x_j \; + [1(h_i) + 0.5(m_i) - 0.5(l_i)]$$

For each component j, where $J = 25$ components, x is the number of participants who identified the component j as relevant to indicator i. Where h, m, and l are the number of participants that identified the indicator as ranking high, medium, and low relevance, respectively.

These summary values were considered together with the discourse during the group discussion about the relative importance of the indicators to the community and considerations of potential social dynamics that may have elevated some indicators. Researchers further considered measurability and data availability for the indicators, which (as described in more detail in the Results) were key limitations to advancing many indicators. The 29 indicators that emerged from this process were intended to provide information on the varied dimensions of human well-being tied to fisheries for the community that would be consistently measurable over time and unique to each other and within the management process. This process is presented in detail in the Results.

The final step in determining a set of indicators for Sitka was to present time-series data for the 29 indicators identified in the previous step in a series of semi-structured interviews with stakeholders (Wengraf 2001). Specifically, participants were asked to respond to: "what story, if any, is this indicator telling about Sitka community well-being? And, how is this tied to fisheries?" Participants discussed the relevance of the indicators and, given the congruence of viewpoints, that discussion determined the choice of the set of indicators that advanced to the next step.

Data for indicators

A wide variety of data sources were used to create the indicators presented to community members during the semi-structured interviews. For brevity and context, this section focuses on the data sources used to create the final set of indicators that are discussed in detail in Tying fisheries participation to indicators of community well-being section. All of the data for this set of indicators were presented as a time series at the community level for Sitka. Inconsistencies in the years included across the indicators are related to data availability issues. All cost and revenue data were adjusted for inflation by setting all revenues to 2017 (USD) (U.S. Bureau of Labor Statistics [US BLS] 2018). Table 2 presents the data sources and indicators that are presented in Tying fisheries participation to indicators of community well-being section. Additional details on these sources as well as those used for the whole suite of final indicators are presented in the Supporting Information.

Fisheries data in Alaska generally does not include gender information; therefore, we applied a gender prediction methodology to incorporate this attribute for Sitka commercial fisheries participation using the name and birth date of the permit holder (Szymkowiak 2020). The method applies stepwise gender prediction based on accuracy estimates of the multiple gender prediction packages in R ("Gender" and "genderizeR") that utilize different name databases (ibid.).

Table 2. Data sources used for the final set of well-being indicators for Sitka that is presented in "Tying fisheries participation to indicators of community well-being" section.

Data source	Indicators	References
Alaska Department of Fish and Game (ADF&G)	Crew licenses (1993 to 2017); fisheries permit holder name, residency, and age (1993 to 2017) used for gender and age demographic indicators; Subsistence Halibut Registration Certificate (SHARC) card holder harvests (2003 to 2017)	https://www.adfg.alaska.gov/
Alaska Commercial Fisheries Entry Commission (CFEC)	Active permits (1993 to 2017); active vessels (1993 to 2017); fisheries revenues (1993 to 2017); personal use fish taken during commercial fishing trips (2003 to 2017)	https://www.cfec.state.ak.us/
Alaska Permanent Fund Dividends (PFD)	Total full-time residents based on annual PFD payouts for Sitka (1993 to 2017)	https://pfd.alaska.gov/
Alaska Department of Labor	Age demographics of the community (1985 to 2017)	http://live.laborstats.alaska.gov/pop/
University of Alaska Fairbanks Cooperative Extension	Food costs based on Alaska Food Cost Survey and comparisons with Portland, Oregon and Anchorage, Alaska (1997 to 2018)	https://www.uaf.edu/ces/foodhealth/fcs/

We applied both linear fit and locally weighted scatterplot smoothing (LOWESS) regression to evaluate trends in women's participation rates and revenues for men and women (addressed in more detail below). LOWESS fits a locally weighted polynomial to the data and is useful for examining trends when a preconceived relationship (linear, quadratic, etc.) is unknown or inappropriate (Cleveland and Devlin 1988). This technique allows for examining trends over the whole time frame as well as whether those trends change relative to the last few years of data, with a bandwidth of 0.4 indicating that the LOWESS smoother has a span equal to 40% of the data.

We calculated the Herfindahl-Hirschman Index (HHI) for fisheries revenues for Sitka resident-owned vessels. The HHI is calculated as the sum of the squares of the percentages of gross annual revenues derived from groups of jointly targeted or managed species. The mean of these individual vessel scores is then calculated to determine the annual average HHI for the community. This metric is coupled with a figure that explores total vessel revenues in the community by species grouping, examining how key target species may be changing over time.

Results and discussion

The section below illuminates the results of the iterative process of developing locally relevant well-being indicators tied to fisheries use for Sitka. The following sections detail how the indicators were developed, the limitations that were realized in that development, and the links between community well-being and fisheries that were identified during the prioritization process.

Sitka well-being derived from fisheries use

Over the course of the two focus groups, Sitka participants identified the linkages between specific components of well-being and subsistence and commercial fisheries use, which are presented in Table 3 and described in more detail in Rosellon-Druker

Table 3. Components of well-being associated with commercial and subsistence uses of local fisheries for the community of Sitka, identified and defined by focus group participants.

Commercial	Commercial and subsistence		Subsistence
Income Security *Evidence of stability & ability to plan into the future*	**Identity** *Sense of self & community identity*	**Stewardship** *Sustainable practices & conservation efforts*	**Local Food Security** *Ensured access to safe, nutritious, and culturally appropriate food*
Livelihood *Employment & income*	**Sense of Place** *Meaning & identity connected to a place*	**Family Heritage** *Generational connections to uses*	**Spirituality** *Sacredness, deep meaning & values*
Physical Safety *Protection from exposure to threats*	**Sense of Community** *Social relationships within community*	**Food/Nutrition** *Food that meets dietary needs & personal preferences*	
National Food Security *Ensured access to safe, nutritious, and culturally appropriate food*	**Family Connection** *Intra-family relationships & bonding*	**Mental Health** *Perception of quality of life & emotional well-being*	
	Education and Information *Possession & transmission of knowledge & skills, access to information, science communication*	**Physical Health** *Well-being of the body*	
		Political Participation *Voice in advocacy & political process*	
	Personal Development *Building human capital*	**Self Determination** *Independence & agency*	
	Sense of Enjoyment & Fulfillment *Experience of pleasure & achievement of goals*	**Social Justice and Equity** *Equitable distribution and allocation of resources; access and tenure*	
	Cultural Values & Traditions *Transfer of customs, practices, values between people*	**Local Economy** *Production and trading of goods & services, barter and sharing networks*	
	Connection to the Water and Ecosystem *Physical & psychological association with water & the broader ecosystem that affects it*	**Governance and Management** *Effective and efficient management that is readily accessible to the public*	

et al. (2019). These well-being components and definitions were further reviewed by focus group participants. Because the well-being components identified by participants were aligned with components identified in previous research on human well-being derived from marine ecosystems (Biedenweg 2017; Gould et al. 2015; Poe, Donatuto, and Satterfield 2016) and because no additional components were noted in follow-up reviews of major focus group themes, researchers were confident that both conceptual validity and data saturation points had been achieved (Guest, Bunce, and Johnson 2006; Rosellon-Druker et al. 2019; Strauss and Corbin 1990).

However, two major groups were generally not represented at the focus groups, including participants in the charter sector, who are paid by anglers to take them on fishing trips, and representatives from Sitka Tribe. Both of these groups were targeted with specific efforts to elicit their participation in the research but were not able or willing to participate. Natural resource managers from Sitka Tribe did participate in the first focus group, but not in follow-up efforts. The exclusion of these groups from our study unfortunately limits our findings, which is addressed in more detail in the initial discourse on locally relevant indicators section below. Continued research efforts in the

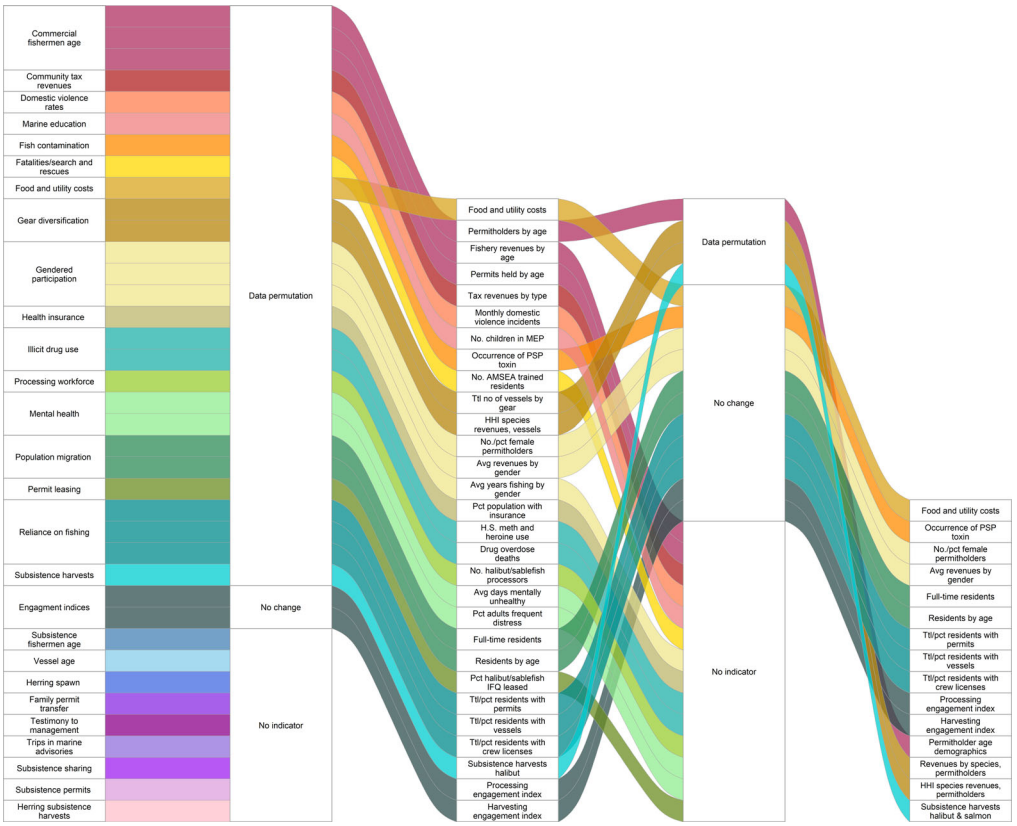

Figure 1. Alluvial diagram of community well-being indicator development and prioritization process for Sitka.

community will necessitate more efforts at soliciting input from these stakeholders including their reflections on the chosen indicators.

Initial discourse on locally relevant indicators

The second focus group in Sitka focused on developing locally relevant indicators of well-being tied to fisheries, reflecting the well-being components identified by participants during the first focus group. Figure 1 represents the indicator development and prioritization process that researchers undertook over the course of the second focus group and follow-up semi-structured interviews in the community – a process that is described in more detail for each indicator in Table S1 in the Supporting Information 4. (The Supporting Information also includes Table S2 that details indicators proposed by study participants that were not pursued by researchers and the reasons for omission). The first column represents the indicators that were presented to (and those that were identified by) participants during the second focus group. The second column identifies the next development stage for these indicators, with the vast majority undergoing some data permutation (e.g., identifying appropriate sources, level of aggregation, categorizations) and some not resulting in further pursuit (no indicator). The individual exercises and discourse during the second focus group determined the indicators that

researchers pursued in follow-up efforts in the community, subject to representativeness, measurability and data limitations that resulted in some indicators not being developed (no indicator). The third column in Figure 1 represents the outcome of the process from the second column and the indicators that were presented to study participants for the semi-structured interviews. These latter indicators underwent a prioritization process informed by the discourse over their relevance, in terms of their ties to fisheries and community well-being, as well as data limitations. This resulted in numerous indicators that were effectively eliminated from further development and in the identification of priority indicators that are discussed in detail in Tying fisheries participation to indicators of community well-being section.

From the initial list in column one of Figure 1, researchers generally developed the indicators that received the highest scores and/or were highly ranked during the group discussion. Indicators with "low" scores were considered to be those below the 50th percentile of scores. However, researchers eliminated two indicators that focused on the herring fisheries despite high scores because of the lack of representation from Sitka Tribe members, who are particularly reliant on that resource. Researchers also pursued indicators of gendered fisheries participation, despite overall low scores, because some participants raised concerns about the masked effects of gender dynamics in the fishing fleet. The harvesting and processing engagement indices were also developed by researchers despite relatively low rankings and not meeting the uniqueness qualifications (they are regularly presented in documents to the North Pacific Fisheries Management Council [NPFMC]) because they provide context for Sitka's fisheries engagement relative to other Alaska communities. The commercial crew license indicator and the age demographics of commercial permit holders were also developed despite their low ranking because the discourse during the focus group revealed their overall prioritization among participants.

The most prevalent impediments to pursuing indicators were measurability and data availability, as demonstrated in column two of Figure 1. Some suggested indicators could not be readily defined and therefore measured. For example, a participant suggested two variations of active participation indicators that could not be readily translated into metrics ("how many vessels are owner operated permits?" and "owner operated fleet"), as the determination of "owner-operator" has been an ongoing conversation in the research community and within management bodies (Szymkowiak and Himes-Cornell 2015, 2017). An indicator for the prevalence of barter or sharing networks was also not developed due to both differentiated perspectives from participants on how that could be measured (including number of times per year trading took place, number of people traded with, quantity and diversity of traded goods) and lack of data on sharing networks in general. Participants were also interested in developing an indicator of public participation in the fishery management process. However, despite a high ranking by most participants for the proposed indicator of "number of residents providing public comments/testimony to fishery management bodies," there was concern that relying on available data sources for creating such an indicator (e.g., number of written or oral public comments submitted to fisheries bodies) could engender a misperception about the directionality and dynamics of the relationship between community well-being and public engagement. Increased public participation could in fact

indicate conflicts over dwindling resources and therefore decreased community well-being; furthermore, participation is often highly reliant on access to capital to attend meetings and flexibility in employment to take time off.

The lack of robust, community-level data linked to the fisheries occupation hampered the development of critical indicators related to physical safety and mental and physical health that participants noted were key to the well-being of commercial fishermen in the community and could provide information on how they are responding to changing fisheries conditions. Despite multiple iterations of developing an indicator for physical safety between researchers and study participants (see columns one through three in Figure 1), confounding variables and the lack of uniformly applicable metrics (column four) across the community's fleet prevented a final safety indicator. Yet risk-taking behavior was noted by participants as likely to increase in response to any revenue squeezes (*inter alia* Chinook stock declines, lower sablefish dockside prices, and increasing lease fees for halibut and sablefish IFQs) as has been documented in the literature (Emery et al. 2014). Study participants also discussed the importance of health insurance coverage and healthcare access for fishermen in preventing injuries and chronic conditions that can impede fisheries participation and for women to sustain participation during pregnancy and after having children. Although the American Community Survey provides information on both public and private health insurance coverage in the community, the lack of an occupational breakdown in that data prevented the development of a health insurance indicator specific to the fishing fleet (see columns three and four in Figure 1).

Finally, the potential predisposition of fishermen to risk-taking behavior including drug use (Pollnac, Poggie, and VanDusen 1995) coupled with focus group participants' discussions of drug-related fishing accidents and drug abuse in crewmembers all informed the necessity of developing an illicit drug use indicator (columns one through three in Figure 1). However, illicit drug use rates for the community are generally based on surveys that, due to large non-response rates, have wide confidence intervals or are not available due to confidentiality issues; similarly, hospitalization or mortality records due to illicit drug use are also subject to confidentiality constraints at the community level. And none of this data would provide information specific to fisheries participants.

Tying fisheries participation to indicators of community well-being

Following the second focus group in Sitka, researchers developed 29 indicators using time-series data (column three in Figure 1). Researchers returned to the community to discuss with study participants how each indicator informed community well-being and its tie to fisheries participation to identify the most relevant indicators. In general, the descriptions below are intended to provide a context for discussing the tie between fisheries participation and the community well-being indicators chosen by study participants as most relevant. In other words, how would changes in community well-being manifest as trends in the indicator and/or what are the community well-being implications of changes in the indicator? However, in some cases participants discussed specific trends evident in the indicators as those changes were the underlying impetus for developing the metric. For the indicators for which specific trends were discussed, we present

the actual data to facilitate the discussion of the results. The most relevant indicators as determined by this process were

- Number of full-time residents
- Food costs
- Energy costs
- Occurrence of paralytic shellfish causing toxins
- Crew licenses (# and % of residents)
- Vessel owners (# and % of residents)
- Number and percent of permit holders who are women
- Percent of population by age
- Percent of permit holders by age
- Halibut and salmon harvested for personal consumption
- Commercial harvesting and processing engagement indices
- Permit holders (# and % of residents)
- Revenue diversification (totals by species/species groups; HHI)
- Average revenues for women and men

Community dynamics in response to changing demographics and rising costs of living

One of the prominent trends affecting Sitka community well-being is the population decline coupled with an aging demographic (Figure 2). Since 1993 the population has declined from just over 8,000 to 6,800 in 2018 (AK DOL 2019). While the reasons for the overall population decline were not evident in the discussions, the potential implications of these coupled trends were of particular concern to residents. As the population continues to decrease and age, the tax base is eroded concurrent with decreasing revenues from the State; the result of which is leaving fewer residents to bear the costs of maintaining city revenues. Participants described this in terms of squeezing the remaining population with increasing taxes, which is having a particularly detrimental effect on young families. Increasing tax burdens are synergized with declining school funding from the State due to decreasing enrollment. At the same time, community priorities are shifting toward services for the aging population and away from those for children and families. These dynamics may further push young families out of the community, according to study participants, as they realize fewer personally beneficial community services despite increasing taxes. Figure 2 also demonstrates the aging demographic of community permit holders, reflecting not only general population trends but also a trend documented by researchers as related to increasingly restricted fisheries access (Coleman et al. 2019; Donkersloot and Carothers 2016; Ringer et al. 2018).

Study participants discussed how these demographic dynamics in the community along with increasing food and energy costs may also affect subsistence and commercial fisheries participation. Participants noted a direct relationship between food prices and reliance on subsistence, reflecting not only caloric needs but that protein tends to be the most expensive source of calories (Figures 3 and 4). There was an expectation among participants that the continued out-migration of young people would manifest itself as decreasing participation in commercial fisheries for the community, which in turn could affect the capacity of the community to utilize subsistence resources. Participants noted that a substantial portion of the community's subsistence harvests are generated from the commercial fleet retaining personal use fish during commercial fishing trips known as "home-pack," a common practice throughout Alaska (Fall et al. 2017; Sill, Halas, and Koster 2019). In addition, an aging population may be less able to participate in subsistence fishing due to the physical demands of harvesting and having

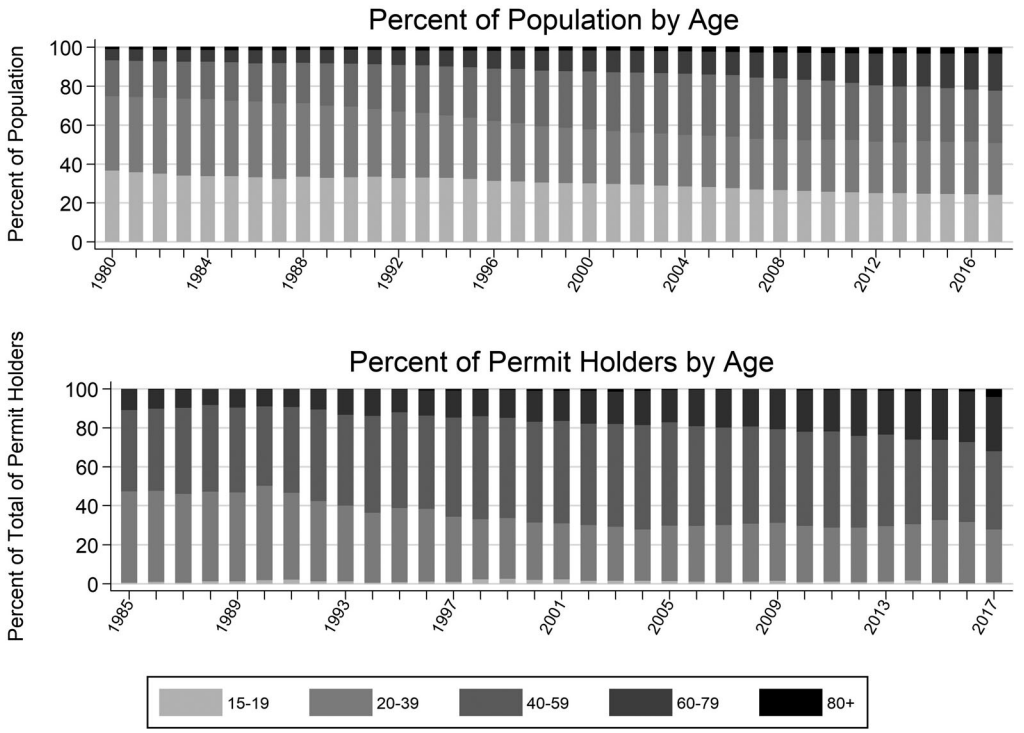

Figure 2. Age demographics of Sitka residents and commercial fishing permit holders.

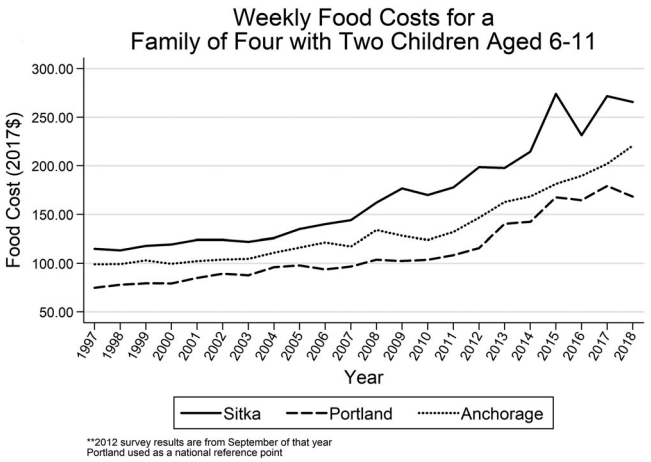

Figure 3. Food costs in Sitka relative to Anchorage and Portland, Oregon.

less disposable income for vessel maintenance, fuel, bait, gear, and so forth. Together, an aging population and fewer commercial fisheries participants were expected to stress subsistence sharing networks in the community due to increasingly mismatched supply and demand. Ultimately participants noted that the growing need for subsistence resources due to rising food prices may not be realized in an upward trend of subsistence harvests due to these broader social dynamics in the community, although other

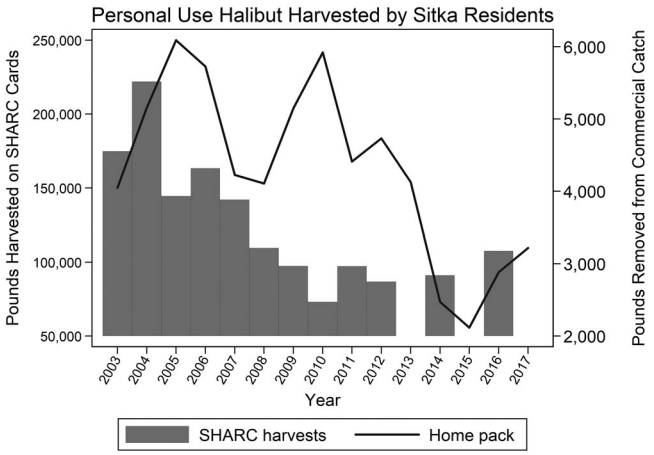

Figure 4. Personal use halibut harvested by Sitka residents.

important variables including resource availability and underreporting[1] would affect these trends as well.

Another important dynamic that emerged from this discussion was how the concurrence of an aging demographic and rising costs of living would increase reliance on locally accessible subsistence resources such as shellfish, which are easier to harvest than fish and do not require access to a boat. Therefore, a food safety indicator was added, measured as the occurrence of paralytic shellfish causing toxin at a locally accessible beach. Shellfish are susceptible to paralytic shellfish poisoning that can cause severe illness and even death in humans, which are caused by harmful algal blooms that are expected to increase with warming waters and other environmental effects resulting from climate change effects (Etheridge 2010; Paerl and Huisman 2008). The continued occurrence or increase of these events could imply a food security issue for some Sitka residents.

Commercial fisheries participation – engagement, resilience, and sustainability

Participation in Alaska's fisheries has substantially consolidated since the early 1990s in response to a number of factors including management, price, and resource abundance changes (Carothers 2013; Knapp 2013). Nevertheless, Sitka remains one of the top five highly engaged fishing communities in Alaska in both the harvesting and processing sectors (Fissel et al. 2018) in terms of vessels, landings, and revenues. That participation really frames how study participants discussed the importance of commercial fisheries to the broader community. Participants noted the need to decouple multiple facets of the harvesting sector as separate indicators (crew, permit holders, and vessel owners) (Figures 5–7), because they convey different levels of participation and empowerment, as well as information about upward mobility, issues that are being explored throughout Alaska (Donkersloot and Carothers 2016; Ringer et al. 2018). Whereas the data reveals an overall decrease in participation relative to the early 1990s, the trend reversed in the mid-2000s toward increased participation. Study participants associated that reversal with increasing dockside salmon prices as the market has bifurcated farmed and wild salmon, as well as a resurgence of pride in the community's fishing identity, which has

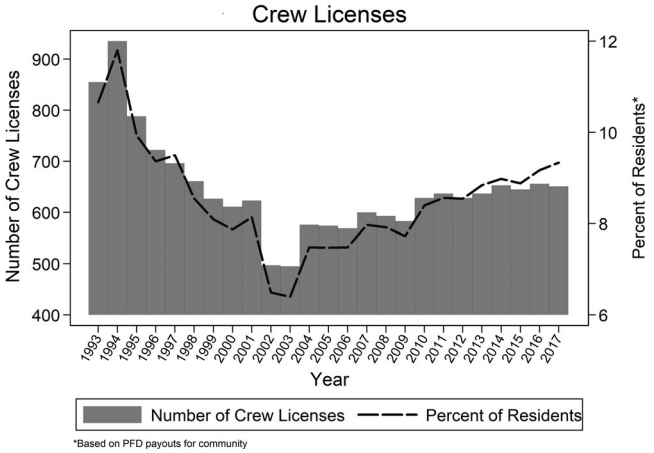

Figure 5. Total commercial fishing crew licenses held by Sitka residents and percent of residents with crew licenses.

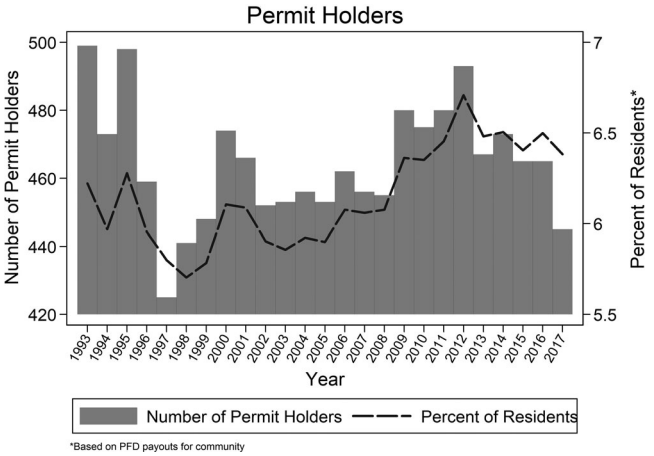

Figure 6. Total commercial fishing permit holders in Sitka and percent of residents who are permit holders.

incentivized young people to enter fishing. Coupled with Sitka's overall decreasing population, these trends manifest as increasing per capita participation above that of the early 1990s.

However, some nuances in this data limit interpretability with respect to actual participation trends. The permit holder and vessel ownership data are associated with participants who are known to be actively fishing, but changes in the permitting structure over time (with some fishing permits regrouped under fewer categories) would affect consistency in this data as well. The crew license data captures the number of licenses sold to Sitka residents rather than the number of license holders in the community because of inconsistencies in the data that prevent accurate determinations of unique individuals (Tide 2008). Furthermore, the crew license data may be capturing changes in the licensing system itself as between 2005 and 2015 fishermen could purchase a

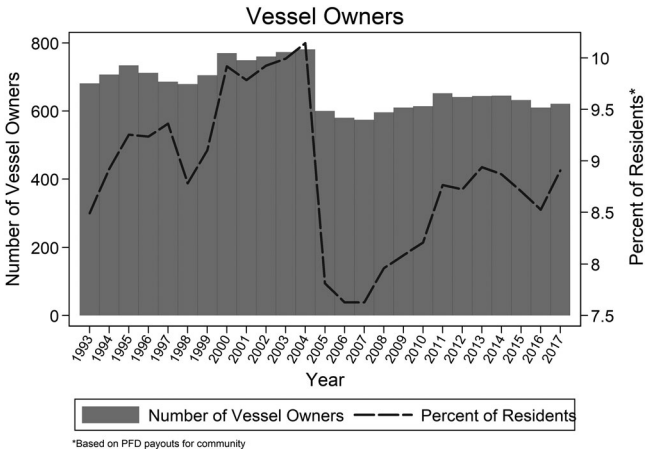

Figure 7. Total commercial fishing vessels owners in Sitka and percent of residents who are vessel owners.

seven-day license repeatedly throughout the season (in addition to an annual license), but the option for multiple seven-day licenses was revoked in 2015.[2]

Because the institution of limited entry and catch share programs over the last several decades resulted in many harvesting privileges becoming quite valuable, fishing participants have become constrained in their ability to readily move across fisheries and diversify their portfolios (Holland et al. 2017). Specialization, although it can provide for some efficiency gains (Ward et al. 2018), may also have negative implications for economic resilience as fishermen are less able to buffer against revenue losses from one fishery by increasing their participation in another (Kasperski and Holland 2013; Sethi, Reimer, and Knapp 2014). Despite some indication of a resurgence of fisheries participation in Sitka, the diversification of the fleet has decreased over time as manifested in the HHI and the emergence of key species for revenue generation (Figure 8),[3] which could in turn adversely affect their resilience in the face of changing conditions. With fewer diversification opportunities, rising uncertainty about the long-term health of fisheries due to climate change, and decreasing revenues for key species from stock declines or lower dockside prices, study participants noted increasing mental stress amongst fishermen with rising concerns about illicit drug use and other risk-taking behavior.

Equity in fisheries access and participation – gendered dynamics

Perhaps the most contentious discussion of community well-being indicators was associated with gender in fisheries. Some study participants stressed that focusing on the gender dimension of local fisheries participation was irrelevant for Sitka because women have equitable access to fisheries and are highly represented in the fleet due to families fishing together. However, others noted that women's role on board family fishing boats is usually as crewmembers, which is subordinate in the context of fisheries hierarchies. Because the skipper or permit holder is the one that interacts with the processor over payment, there is an inherent power dynamic that may leave women feeling like their roles and contributions are not recognized and that they are generally *invisible*, a

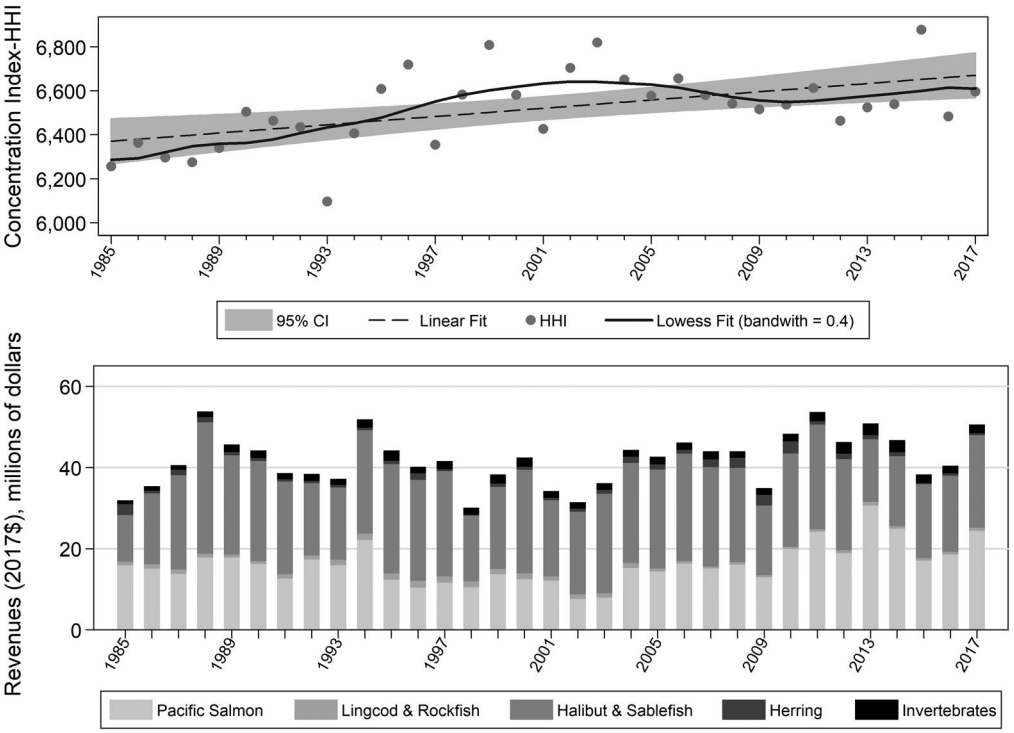

Figure 8. Herfindahl-Hirschman Index (HHI) of revenue concentration and species revenue distributions for Sitka resident-owned vessels.

dynamic that is manifest throughout global fisheries (Frangoudes and Gerrard 2019; Szymkowiak and Rhodes-Reese 2020).

Some study participants felt that because fisheries access is now largely determined by one's ability to buy into them, the playing field has been leveled for women and men. Yet others believed that limited entry and catch share programs institutionalized the gender distribution of fishing privileges that existed at the time of implementation, which were heavily skewed toward men. Furthermore, there is an increased necessity to gain capital and experience in fisheries to qualify for loans to purchase fishing privileges, which may further marginalize women due to differences in how men and women participate in fisheries. According to some study participants, women's capacity to build that meet these requirements of capital and experience is disproportionately constrained due to a number of factors that tend to affect women differently than men, including gender stereotypes, superstitions and norms; fear of harassment and violence; and lack of health insurance coverage – gendered impediments that are commonplace throughout global fisheries (Frangoudes and Gerrard 2019; Szymkowiak and Rhodes-Reese 2020) despite the important roles they may play in maintaining fisheries (Szymkowiak 2020; Szymkowiak and Rhodes-Reese 2020). For example, women's participation in Alaska fisheries continues to be constrained due to a mix of stereotypes about their physical abilities, superstitions about them as bad luck on fishing boats, norms about fishing as a male occupation, and a shift toward gender traditionalism in parenthood with women as the primary child caregiver (Szymkowiak 2020). Participants also

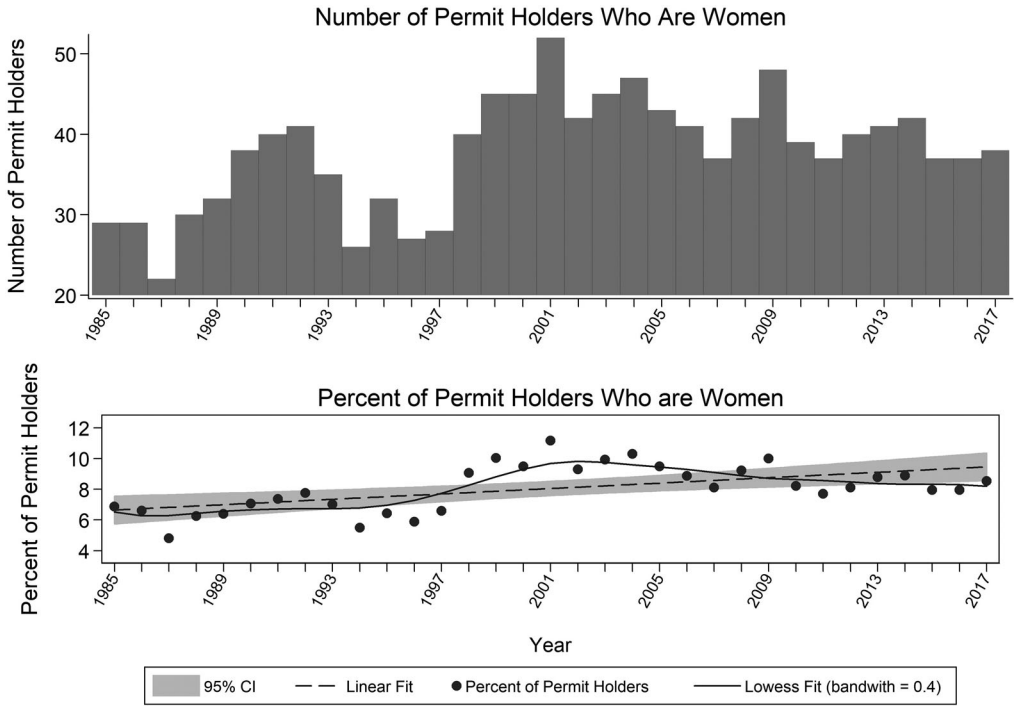

Figure 9. Number and percent of Sitka resident commercial fishing permit holders who are women.

discussed how concerns about gendered harassment and violence also make women more discriminating about crew jobs, which limits their ability to readily gain requisite skills and capital for upward mobility (Szymkowiak 2020). Finally, because women tend to utilize more health care and spend more money on it throughout their lives (Owens 2008), participants noted that an occupation that does not have health insurance coverage is inherently self-limiting for women.

Researchers presented indicators of gendered fisheries participation to study participants including the gender distribution of fishing permits, as well as women's and men's average revenues. Women's participation in fisheries has increased in Sitka over the last several decades (Figures 9 and 10); however, much of the increase may be attributed to the decline in total participants as the absolute numbers amount to only a handful of women. Nevertheless, according to some study participants despite the proportional increase in women's participation, the gender distribution of permit holders in the community demonstrates continued inequities in access. Similarly gendered differences in average revenues were associated with fishing being a fundamentally different type of job for men and women, with the latter's revenues amounting to about half of the former's over time – an earning difference that was largely related to women fishing part-time during the summer in fisheries where children can be on board (Szymkowiak 2020).

Conclusions

Fisheries managers are increasingly interested in conceptualizing fisheries from an ecosystem perspective that integrates humans as highly dependent resource users. This

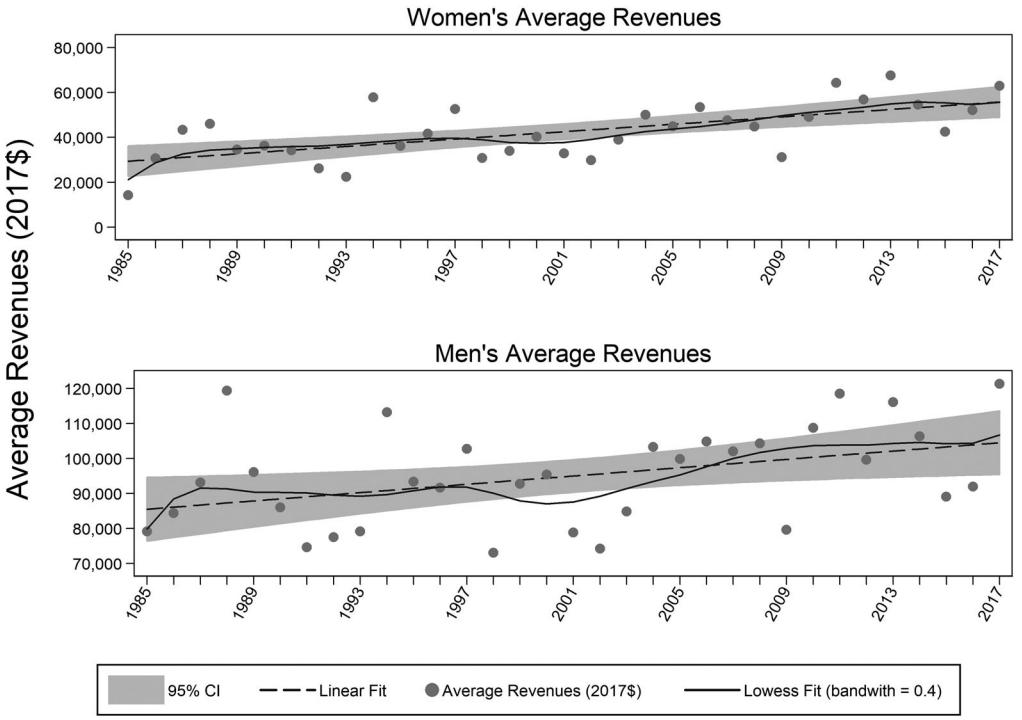

Figure 10. Women's and men's average revenues for Sitka resident commercial fishing permit holders.

study demonstrates a process of identifying locally relevant human well-being indicators tied to fisheries uses that can be utilized in ecosystem-based management frameworks across various regions. This process prioritizes localized value systems, incentivizes stakeholder engagement in resource management, and produces a suite of tractable metrics of well-being, outside of the traditionally used economic indicators, that can be used to map ecosystem shocks. This framework can be applied in other regions to determine indicators that can be applied by managers to understand when shifts in marine systems are taking place, which can facilitate more responsive and targeted policymaking. In doing so, fisheries management can move beyond detecting ecosystems shifts largely with the use of biological indicators to understanding the human dimensions of those shifts and how they too can serve as flags of change.

The prioritization of indicators and how that process reflects local objectives for fisheries management should be considered temporally and spatially dynamic. The indicators identified through this process are necessarily reflective of the structure of local fisheries participation, community norms, and issues that may be both spatially and temporally bounded in relevance. For example, age demographics may be less relevant for other communities, which may be, for example, more concerned with transportation costs or access to medical care. The importance of age dynamics in the community of Sitka may also change over time and be replaced by other issues. Thus, whereas this process identifies indicators that may be highly relevant for a single community, the capacity to scale up these indicators to apply to more communities or at an ecosystem

level may be constrained and need to be tested for localized relevance. Furthermore, the methodology applied herein would benefit from repeated measurements over time to test for confounding variables and the temporal robustness of the indicators.

One of the primary impediments to developing various well-being indicators evidenced by this study is a lack of primary data that leads to reliance on secondary data sources, which may themselves be limited by overall availability, confidentiality, applicability of the data to fisheries participants, the level of the data, and its temporal and spatial coverage. There is an inherent tradeoff between relying on secondary data sources, which may be more readily accessible and consistent across communities, and collecting primary data, which can be costly and time-consuming but can also produce layers of information otherwise not available. Primary data gathering may be necessary especially for key well-being components relevant for fishing communities that cannot be readily informed by secondary data sources, such as physical health and safety which may differentiate fisheries from other occupations. Equity and social justice are also not readily captured without primary data collections and have been highlighted by social scientists as cross-cutting across multiple well-being dimensions (Donkersloot et al. 2020).

As EBM evolves, a holistic understanding of how human well-being is derived from various uses is going to have to encapsulate knowledge about how social systems and adaptation strategies may modulate human interactions with ecosystems and mediate ecological impacts including on human communities. Due to the geographic remoteness of Alaska's communities, adaptation strategies throughout the State are likely to be highly localized, influenced by *inter alia* cultural values and traditions, the demographics of the resident population, well-being priorities, the presence and influence of non-fishing industries, access to technology and capital, and institutions and governance systems. Thus, future research should focus on the nexus between these dynamics and adaptation strategies, and how it affects community resiliency.

Notes

1. Study participants noted that the estimates of personal use halibut retained on commercial fishing trips presented for this indicator were likely grossly underrepresenting the magnitude of this practice in the community, due to disincentives from the processor in terms of recording home-pack.
2. This was in response to evidence that some fishermen were purchasing multiple seven-day licenses rather than an annual license because the former was a cheaper option even for someone fishing for a whole season.
3. The HHI shows a similar upward trend over time when applied at the individual level but calculated with respect to the revenues by permit code. The actual values of the concentration index are higher for the HHI calculated for permits, however, due to intense reliance of the fleet on the salmon fisheries, which can be generally harvested using the same permit (provided there is no gear switching or moving to waters outside of Southeast Alaska).

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