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The incorporation of traditional knowledge into Alaska federal fisheries management

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ABSTRACT

Fisheries policy and management processes for federal waters off western Alaska currently lack consistent and considered integration of traditional knowledge (TK), TK holders, social science of TK, and subsistence information. The incorporation of these into fisheries work can lead to more informed, equitable and effective policy and management practices. This paper includes information and recommendations derived from previous work by the authors as well as from two community workshops with indigenous TK holders and fisheries experts. Discussions of TK and related concepts, TK research in the Bering Strait and Yukon River regions, and Alaska federal fisheries management-related institutions and processes as pertains to TK are presented. Substantive recommendations are provided for improving processes, increasing tribal representation, capacity building, effective communication, outreach and relationship-building, the incorporation of indigenous concerns and values, and regarding the development of a Fisheries Ecosystem Plan for the Bering Sea.

1. Introduction

Management of fisheries in federal waters off the coast of western Alaska (3–200 nautical miles offshore) is often a complicated and fraught process with multiple stakeholders and agencies involved. The primary body responsible for developing management strategies, policies and regulations related to Alaska federal fisheries is the North Pacific Fishery Management Council (NPFMC, or the Council) [78]. The NPFMC is one of 8 regional councils created by the Magnuson-Stevens Fishery Conservation and Management Act (MSA) [58]. The regional councils are overseen by the Department of the Commerce's National Marine Fisheries Service (NMFS), which is a part of the National Oceanic and Atmospheric Administration (NOAA; NMFS is often referred to as "NOAA Fisheries"). The councils are not part of NMFS or any other federal agency, but rather are an independent body which works with NOAA/NMFS. The councils develop management plans and regulations which can be (and almost always are) adopted by NMFS who then implements them and provides enforcement. This paper pertains to all the key institutions involved in western Alaska federal fisheries management (including those noted above, as well as other related institutions such as the North Pacific Research Board [NPRB]). As the NPFMC plays the key role in developing management plans and regulations, considerations of its role are, however, the focal point of this paper.

As discussed further below, traditional knowledge (TK), TK holders, and the social science of TK have by and large not been incorporated by the NPFMC into their science, policy, and management initiatives, positions and actions for western Alaska federal fisheries, with the potential emerging exception of the development of a Bering Sea Fisheries Ecosystem Plan (FEP). Western Alaska tribes and others have expressed concern over this lack of integration, which has also been of particular concern given the seemingly high level of involvement of commercial fishing industry interests throughout the NPFMC decision-making process (see e.g. [25,86]). It is timely to consider what role TK and social science of TK can play in fisheries management processes, in particular with regard to the NPFMC as it continues its work on issues of critical concern to tribes and expands their work into other areas like the creation of a Bering Sea FEP.

In this paper, the authors provide a definition of TK, discuss TK and subsistence fishing (as well as social science relating to it) in western Alaska, evaluate key aspects of the historical and current state of affairs regarding TK and fisheries management in western Alaska, and finally provide a discussion of the value of integrating TK into Alaska federal

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Fig. 1. Study area.

fisheries management accompanied by recommendations for this integration (Figs. 1 and 2).

This paper focuses heavily on data drawn from work with Bering Strait and Yukon River indigenous communities. These western Alaska communities are a major point of impact from Alaska federal fisheries activities and management, and are also within the areas of expertise of the authors. The recommendations in this paper, as well as the tribal perspectives presented within it, have been formulated based on over a decade of social science research conducted by the authors in and with Alaska Native fishing communities in western Alaska. Additionally, two workshops were held by the authors (one in Golovin and one in Russian Mission) specifically to solicit comments and input on this paper and its recommendations. Each workshop was convened with a group of experts chosen by the tribal governments of the two communities. Workshop participants reviewed drafts of this paper, had extensive conversations with the authors, and provided detailed feedback on manuscript content, including the recommendations section. While this paper reflects the thoughts and ideas gleaned from previous work with many western Alaska tribes, it was most intensively reviewed and commented on by fisheries experts in these communities.

2. Traditional knowledge and subsistence

2.1. Overview of traditional knowledge

Building upon the work of Raymond-Yakoubian and Raymond-Yakoubian [96], the authors will forward and utilize the following definition of TK for this paper:

> Traditional Knowledge (TK) is a living body of knowledge which pertains to explaining and understanding the universe, and living and acting within it. It is acquired and utilized by indigenous communities and individuals in and through long-term socioculturral, spiritual and environmental engagement. TK is an integral part of the broader knowledge system of indigenous communities, is transmitted intergenerationally, is practically and widely applicable, and integrates personal experience with oral traditions. It provides perspectives applicable to an array of human and non-human phenomena. It is deeply rooted in history, time, and place, while also being rich, adaptable, and dynamic, all of which keep it relevant and useful in contemporary life. This knowledge is part of, and used in, everyday life, and is inextricably intertwined with peoples' identity, cosmology, values, and way of life. Tradition – and TK – does not preclude change, nor does it equal only 'the past'; in fact, it inherently entails change.

As Berkes and Folke note, "[t]he word *traditional* is used to refer to historical and cultural continuity" ([12]: 5); change, growth, and loss may occur within a body of TK, and this itself is part of a constant process of contemplation, discussion and negotiation within indigenous societies (*ibid.*, [96]: 8).

The authors posit that, as bodies of TK contain systematic interconnections between sociocultural, environmental, spiritual, and other phenomena, TK pertains necessarily to, among other things, the environment, and has an ecological or ecosystematic perspective. The literature discussing and documenting the environmental, ecological, and ecosystematic aspects of TK, and the interconnections between the environmental and other aspects of TK, is vast (e.g. [10,62,41,11]).

This paper will also stress, in addition to the importance of TK itself, the importance of indigenous voices regardless of their, or their knowledge's, connection to 'tradition' – that is, the authors recognize the importance of the crucial epistemic (as well as policy and management) contributions to marine policy processes that indigenous people in general can make.

How to interface TK and western science, policy and management is a complex, unresolved, and contentious issue. The same can be said of how best to characterize and compare TK and science in relationship to each other (see e.g. [13,14,10,19,40,61,110]). TK has many fundamental parallel and similar qualities and characteristics to science, albeit sometimes with different foci and contexts, in addition to having contrasting and dissimilar characteristics and qualities (e.g. *ibid.*, and [42]: 27). Likewise, as with its potential interfacing with western policy and management (see e.g. [41]), various aspects of TK can be more or less compatible or, alternately, incompatible with western science. This paper will not take a position as to whether and how much TK should be viewed as scientific, but rather will stress that TK should be considered equal to science from epistemic, policy, and management perspectives.

2.2. Overview of subsistence and traditional knowledge in the Bering Strait and Yukon River regions

By the term "subsistence," the authors employ the senses commonly used by indigenous residents of this region (as opposed to, for example, the State of Alaska's understanding). The indigenous perspective encompasses hunting and gathering related activities which have a deep connection to history, culture, and tradition, and which are primarily understood to be separate from commercial activities.

Indigenous communities along the Bering Sea coast and the Yukon River are very diverse culturally (being primarily Aleut, Yup'ik, St. Lawrence Island Yupik, Inupiaq, and Athabascan). Also diverse are the various ecosystems within which these communities are located. The Bering Sea area extends from the Aleutian Islands north to the Bering Strait, and the Yukon River extends 2200 river miles inland. Because of the extent of these areas, it is impossible to give one description of the seasonal round of subsistence activities carried out by Bering Sea and Yukon River residents. The communities located here all have residents that conduct subsistence activities.

The exact timing of subsistence harvests varies by area within this large region, as do the particular species harvested by each community. Some of the major foods harvested by these communities include: all 5 species of salmon, halibut, herring, various other non-salmon fish, caribou, muskox, moose, bowhead whales, beluga whales, ice seals, walruses, bears, birds, berries, and other plants. Harvests of subsistence foods largely follow the seasonal migrations of different species,

or the growing seasons of different plants, and also have variability (e.g. changing according to yearly variations in weather and ice conditions). Increasingly, with climate change, the timing of various animal movements has changed (or can be unpredictable from year to year), which poses challenges to harvesters (see e.g. [102]: 123 regarding the impact of changes in ice conditions on the ability to harvest whitefish).

The harvest of subsistence foods for cultural, nutritional, spiritual and other reasons is extremely important to the indigenous residents of the Bering Sea coast and Yukon River. In some communities, subsistence foods comprise over half of the food consumed by households each year. In the Bering Strait region, the most recent information indicates that over 4.5 million pounds of subsistence foods are harvested by just 12 communities in the region, with salmon consisting of over 470,000 pounds of that total ([2]: 289). In some Bering Strait communities that could amount to over 150 pounds of salmon per year, per person (*ibid.*: 55–60). Salmon is a staple for indigenous people on the Yukon River, constituting a majority of the subsistence harvest of fish annually. Declines in salmon stocks – and associated regulations accompanying those declines – have created great stressors on indigenous communities in both Bering Strait and Yukon River regions (e.g. [52,117,15,27,44,96]).

Indigenous communities in the Bering Strait region have always valued salmon as a subsistence food, either through direct harvest and/or through trade. Early visitors to, and those knowledgeable about, the region have long noted that salmon has been used by, and is important to, the residents of the area (e.g. [120,75,87,94]). Subsistence foods, including salmon, are used in combination with western foods obtained at local village stores or by other means. Communities have a combination of subsistence and cash economies (e.g. [116,119,56]). Researchers have documented salmon harvest declines in the region over the past two decades (e.g. [55,118,57,52]). These reduced harvests of subsistence-caught salmon are due to a variety of factors, including the reduced numbers of salmon available for harvest (e.g. [53,54,2,118]: 372). Bering Strait region research and documentation of TK about salmon and related topics has increased in recent years. The most recent work was conducted by two of the authors [98] and was specifically focused on TK of salmon in the region in collaboration with 8 communities. Other related work in the region, and in areas adjacent, includes Magdanz et al. [54], Brown et al. [16], Georgette and Shiedt [38], Jones [45], Magdanz et al. [56], Raymond-Yakoubian [100], Ray et al. [95], Myers et al. [71], Andersen et al. [7], Raymond-Yakoubian [102], Carothers et al. [20], J. Raymond-Yakoubian et al. [103], and B. Raymond-Yakoubian et al. [99]. These works each examine TK about subsistence resources in western Alaska communities, including climate and environmental observations.

TK holders in the Yukon River region have detailed and expansive knowledge of salmon and other aspects of their environment. This has been well documented over the past decades including the lower Yukon [28–32,67,8], the middle river [107,112–115,88,89], the Koyukuk River [60,76,77], and the upper Yukon River [109,24,3,34]. Additionally, work by one of the authors of this paper documented TK specific to salmon in the lower and middle river [67,69,70]. Yukon River TK is holistic, and TK experts make observations of connections between the environment and the interactions between fish, animals, birds, plants, wind, and weather [49,5,66,70]. Non-salmon fish have also been a focus of TK studies [17,4,48,6]. These studies have documented the rich TK of non-salmon fish regarding their habits, seasonal movements, and their Native taxonomy. Some concerns of TK holders have also been documented for the Yukon River [15,17,48,70], including changes in Chinook salmon size and abundance, increased parasitism, more extreme and generally warmer weather, changing hydrologic conditions, increased beaver dams (in the upper Yukon), warmer winter air temperatures, and an increase in sandbars.

Individuals and communities use TK to inform subsistence fishing in a number of ways. For example, it has been demonstrated that TK holds important observations about connections between plants, animals, water, and the weather. Yukon River fishers have relied on tested observations, or "indicators," of aspects of the environment to know when and in what condition the salmon will arrive [65,66,70]. As with Yukon River communities, villages in the Bering Strait region rely on their TK to inform their subsistence fishing activities (see e.g. [102,96]). For example, TK about salmon migration patterns, short-term weather patterns, and long-term climate changes help inform people about whether or not to fish, where and in what form to set nets, and how much they should harvest for particular species. TK also provides valuable insights for knowledge-holders about appropriate behavior in the environment, which helps, for example, in understanding proper human-animal and other human-environment relationships (e.g. providing models of respect and for local management), in providing rules for ensuring safety while practicing subsistence, and in providing a means for understanding and adapting to changes in the environment (see e.g. [46,47,85,96]).

3. Traditional knowledge and Alaskan fisheries management: A discussion of the current situation

Below is a discussion of some aspects of TK and Alaskan fisheries management which are germane to this paper.

3.1. Traditional knowledge, subsistence, and the North Pacific fishery management council

The NPFMC has by and large not integrated TK, TK holders, and the social science of TK into their science, policy, and management initiatives, positions and actions, with the emerging exception of the development of a Bering Sea FEP. The NPFMC does not have a definition of TK which it employs, and there is a lack of clarity on the part of the public and Alaska Native tribes about the role which TK, indigenous subsistence concerns, and social science relating to TK play in NPFMC decision-making. Subsistence use information consisting in large part of harvest survey reports for communities has been utilized by the Council in previous work. Use of this information has proven problematic; for example, in a recent Draft Environmental Impact Statement, the subsistence economy was characterized as being "underground" ([83]: 331; [84]: 568), which was perceived by many as portraying the subsistence economy as not legitimate. While the Council has struggled to address TK and even subsistence use data in their work in the past, they have recently moved towards greater consideration of TK.

As has been noted, the NPFMC is currently in the process of drafting a Bering Sea FEP. The groundwork for this began in 2013, and the most recent substantial developments include a discussion paper [80], Council motions initiating development of the FEP [81], and subsequent work in 2016 by NPFMC staff on developing the FEP [82]. The FEP is meant to inform and guide the NPFMC in their fishery management actions for the entire Bering Sea (see e.g. [80]). The FEP can serve as a framework for informing the NPFMC in the use of "ecosystem-based fisheries management" (EBFM), a type of fisheries management which is contrasted with single species based management and which takes the broader ecosystem into account in decision-making (*ibid.*). It should also be noted that in February of 2014, the NPFMC adopted an "Ecosystem Approach" as a policy; among other things, the policy acknowledges the importance of fisheries in the NPFMC region to subsistence, and also notes that implementation of the policy in fishery management will involve incorporating the best available science which includes local and traditional knowledge [79]. The NMFS has an EBFM policy and associated roadmap in place [73,74]. Notably, one of the guiding principles in the NMFS EBFM policy and roadmap, that which pertains to ecosystem-level planning, notes that FEPs are a way to implement this type of planning, including facilitating tribal participation in the EBFM process (*ibid*).

During this process, the NPFMC has received substantial public input, much of which parallels recommendations in this paper, advocating for a Bering Sea FEP to be developed, to include TK, and to act as a springboard to initiate greater future inclusion of TK and subsistence interests in Council processes. There are many reasons why the FEP seems a suitable mechanism for beginning meaningful and significant recognition and inclusion of TK and subsistence and tribal concerns into NPFMC processes. Language used in the FEP development includes some of the most substantive Council discourse, historically speaking, indicating a desire to incorporate this knowledge and these areas of concern. The FEP, and its EBFM philosophy, also fit well with certain key aspects of TK and indigenous subsistence concerns (e.g. the need to understand the impacts and importance of fisheries and fisheries-related activities on indigenous people, ecosystematic perspectives, the important role of humans in ecosystems, etc.). The FEP also offers an opportunity to introduce overt discussions into management about contrasting value systems related to fisheries, as well as integrating more deeply considerations of climate change, which are a great concern to indigenous communities. Other potentially promising aspects of FEP development include improving NPFMC processes related to outreach and public participation, transparency and openness, developing protocols for using subsistence information, and including a diverse range of experts and stakeholders into the process. There are causes for concern related to the consideration of TK in this process; this will be discussed further below in Section 4.2.6.

The authors argue that, in the Magnuson-Stevens Fishery Conservation and Management Act (MSA) [59] and associated National Standards, there is a substantial groundwork laid justifying the necessity of including TK in federal fishery management.

For example, the MSA has as one of its core purposes the establishment and implementation of fishery management plans (FMPs) which, "in accordance with national standards [...] will achieve and maintain, on a continuing basis, the optimum yield from each fishery" ([58], [111]: 16 U.S.C. § 1801 (b)(4)). National Standard 1 holds that "[c]onservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry" ([111]: 16 U.S.C. § 1851 (a)(1), [22]: 50 C.F.R. § 600.310 (a)). Optimum yield is "prescribed on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor" ([111]: 16 U.S.C. § 1802 (33), [22]: 50C.F.R. § 600.310 (e)(3)(i)(A)). The MSA requires that FMPs "assess and specify the present and probable future condition of, and the maximum sustainable yield and optimum yield from, the fishery, and include a summary of the information utilized in making such specification" ([22]: 16 U.S.C. § 1853 (a)(3)). National Standard 1, noting how the assessment of optimum yield includes consideration of these factors noted above ([111]: 50 C.F.R. § 600.310(e)(3)(iii)), mentions several examples with obvious connections to subsistence and TK (e.g. "the cultural place of subsistence fishing" and "economic contribution to fishing communities" [[111]: 50 C.F.R. § 600.310(e)(3)(iii)(B)(1,2)]). The authors would posit that the information provided by TK and subsistence information provide vital information about such factors and as such are necessary to be incorporated into any decision-making regarding achieving optimum yield.

The integration of TK and social science of TK into federal fishery management also fits with the MSA-mandated National Standard 2 ([22]: 16 U.S.C. § 1851 (a)(2), [111]: 50 C.F.R. § 600.315) and National Standard 8 ([22]: 16 U.S.C. § 1851 (a)(8), [111]: 50 C.F.R. § 600.345).

National Standard 2 states that "[c]onservation and management measures shall be based upon the best scientific information available," and calls for the use of economic and sociological information ([111]: 50 C.F.R. § 600.315(a) and (a)(1)). Including TK and social science of TK fits well within language describing the criteria for evaluating the best scientific information available (e.g. relevance, inclusiveness, etc.). For example, the "inclusiveness" criteria for evaluating such information calls for information from relevant disciplines, attention to alternative scientific views, and the inclusion of relevant local and traditional knowledge when evaluating the best scientific information available ([111]: 50 C.F.R. § 600.315(a)(6)(ii)). The Standard calls for peer reviewers to reflect a "balance in perspectives" with "sufficiently broad and diverse expertise" to the relevant range of perspectives to be considered ([111]: 50 C.F.R. § 600.315(b)(2)(i)). The Scientific and Statistical Committees of the Councils must report on the "social and economic impacts of management measures," and use the best scientific information available for making advice and recommendations, including information about the social and economic conditions of fishing communities in Stock Assessment and Fishery Evaluation reports ([111]: 50 C.F.R. § 600.315(c), (d)). Fishery management plans (FMPs) must identify and take into account the best scientific information available per this Standard ([111]: 50 C.F.R. § 600.315(e)). Among other reasons, the authors would argue that the inclusion of TK as well as the social science of TK should be included within NPFMC federal fishery management per the various aspects of this Standard just noted (i.e. those calling for the inclusion of local and traditional knowledge when evaluating the best scientific information available, the use of the best scientific information available, the appropriate range of disciplines and viewpoints, and the need for social and economic information). Ounanian et al. [90], for example, have argued that while National Standard 2 has often been taken to support physical, biological, and chemical scientific inquiries, it should rightly include the social sciences as well. Additionally, the authors would argue that the inclusion of TK holders and social scientists with TK expertise should also be included in Council-related processes to fulfill elements of this Standard's guidance (e.g. in the peer review process).

National Standard 8 can also be seen as laying groundwork for the inclusion of TK in federal fishery management (see e.g. [23,1], Ounanian et al. [90] and [51] for related arguments, including with regard to sociocultural data in general). Lyons et al. [51] have noted, for example, the relevance of the development of the 1996 Sustainable Fisheries Act and National Standard 8 to the inclusion of sociocultural data in management and the participation of fisheries-dependent communities through the use of the best scientific information available. The Pacific Fishery Management Council has also noted that "National Standard 8 represents a substantial opening for the role of social science in fisheries management" [91]. The authors of the current paper feel that the integral inclusion in NPFMC processes of TK and TK holders, as well as social science of TK and social scientists with TK expertise, is justified by the following elements of the Standard. The Standard calls for conservation and management measures to, while remaining consistent with MSA conservation requirements, "take into account the importance of fishery resources to fishing communities by utilizing economic and social data that are based upon the best scientific information available" to provide for these communities' "sustained participation" and to minimize adverse economic impacts on these communities "[t]o the extent practicable" ([111]: 50 C.F.R. § 600.345(a) and (a)(1,2)). The Standard notes that "FMPs must examine the social and economic importance of fisheries to communities potentially affected by management measures" ([111]: 50 C.F.R. § 600.345(c)(1)). The Standard notes that fishery impact statements may use both quantitative and qualitative data, including information from fishermen (CFR: 50 C.F.R. § 600.345(c)(2)). FMPs should consider the "[i]mpacts of both consumptive and non-consumptive uses of fishery resources" ([111]: 50 C.F.R. § 600.345(c)(4)), and "[t]he best available data on the history, extent, and type of participation of [...] fishing communities in the fishery should be incorporated into the social and economic information presented in" an FMP ([111]: 50 C.F.R. § 600.345(c)(3)). Additionally, consideration of social and economic impacts should include identification of

alternatives which minimize adverse impacts to fishing communities (within the bounds of other relevant constraints) ([111]: 50 C.F.R. § 600.345(c)(5)).

3.2. Successful incorporation of TK and subsistence concerns into Alaska fisheries management

The authors would like to discuss here some examples from the Yukon River of the successful incorporation of TK into Alaskan fisheries management.

The non-profit Yukon River Drainage Fisheries Association (YRDFA) hosts in-season fisheries management teleconferences with the mission of exchanging information throughout the drainage on run timing, abundance, escapement data, and management strategies. The teleconferences facilitate dialogue between users of salmon resources along the river and managers (from the Alaska Department of Fish and Game and the US Fish and Wildlife Service). The teleconferences are a unique method of co-management [68]. They are an opportunity for managers to hear local observations about current and past conditions on the river, share management strategies, and receive immediate feedback and buy-in from knowledgeable fishers. They are an opportunity for the local fishers to share their knowledge and influence management decisions. For example, during the teleconferences, fishers have discussed several factors (e.g. natural indicators) locally used to understand or predict salmon behavior during the run and over time, and some managers have begun to incorporate these tools into their management decisions (e.g. timing fishery openings with favorable winds) [26,64]. After years of evolving, today there is a give-and-take process, as opposed to earlier when management informed fishers of decisions made without their input. With today's approach, fishers have an opportunity to have a voice in Yukon River in-season management, and managers listen to fishers and attempt to provide a fishery that meets their needs with the understanding that fishers need to be on board with management actions in order for them to be successful. Teleconference participants have the opportunity to voice their concerns, ask questions, and request explanations behind decision-making and management strategies. Managers also have the opportunity to propose management actions and hear feedback prior to implementing changes. Often these discussions lead to group decision-making regarding the best strategy.

Additionally, YRDFA has been bringing together fishers representing each tribe along the Yukon River with state and federal managers to discuss the upcoming fishing season at the Yukon River Pre-Season Summer Preparedness Planning Meetings since 2010. The goal of this annual meeting is to share potential management actions, with a focus on Canadian origin Chinook salmon, and to receive feedback from fishers who represent their communities. At these meetings, management and researchers discuss upcoming salmon run expectations as well as proposals for potential management actions under various scenarios, and fishers discuss their concerns, ideas, and opinions. These meetings were designed with the goal of giving Yukon River fishers a voice in management. The comments and actions proposed by the fishers are incorporated into the management plan for the summer whenever possible. One extraordinary result from these meetings occurred in 2015, when fishers, facing a second year in a row of closed Chinook salmon subsistence fishing, proposed one upriver fishing district be allowed to fish for Chinook salmon on the early part of the run prior to the closure to ensure they would receive some fish, as their river location precluded them from receiving any of the alternative species – the abundant summer chum salmon – which does not migrate through their part of the river. Managers develop their final plans for the season after these meetings, so they have the opportunity to include fisher input. This collaboration, something that had not always occurred for the Yukon River, currently benefits from managers who are very interested in working *with* the fishermen to ensure the management of the fishery meets their needs as best they can with current conditions.

4. Discussion and recommendations

4.1. Discussion

The authors propose that TK can be of great utility for fisheries management, including in the particular case of Alaska Native TK and the western Alaska federal fisheries management processes related to the NPFMC, NMFS, and NOAA.

TK can be of use to fisheries management in comparative, complimentary, and supplemental fashions. TK and TK research have made substantial contributions to understanding marine environments and particularly resource management (see e.g. [43,110,90]). As a body of knowledge, TK contains explanatory data, models, and structures which have value in understanding entire ecosystems as well as component parts (e.g. fish behavior, biology, harvest, policy and management, sociocultural importance, human impacts, environmental change, etc.) (e.g. [35,36,96]). TK holder knowledge is broad in extent, relevance, and applicability, including beyond the local (while at the same time, such knowledge is often developed based on intensive and rich placed-based, *in situ* observations and relationships). TK also introduces different values into understanding ecosystems, and contains valuable and often unique datasets as well as systems, models, guidance, and rules constituting or resulting in forms of natural resource management (e.g. [43,35,36]). In addition to having many parallel qualities with western fisheries science, TK also offers what can be particularly unique benefits in comparison to western fisheries science, including knowledge derived from long-term, practical, *in situ* observations and engagement with the environment. TK offers perspectives which western science and management are often only beginning to grapple with, including ecosystematic perspectives, understanding interconnections between fisheries resources and environmental change, providing long-term and historical data, and suggesting alternative means of conceptualizing human-environment relationships. Further, working with TK holders can assist in understanding how humans fit within ecosystems, and how people are impacted by activities within ecosystems including subsistence harvests, commercial harvests, and management actions. In addition to the above, and the MSA-related requirements noted earlier, TK can fit well into key goals of NPFMC processes in other ways, including minimizing impacts of management to subsistence communities, creating open and transparent processes, and improving ecosystem-based fisheries management frameworks (see e.g. [21] regarding how incorporating ecological knowledge of fishers can accomplish this).

TK and social science of TK are different, but it is important that both are included in fisheries management. As natural resource management is becoming more clearly recognized as primarily entailing the management of human behavior (e.g. [9], Heck et al. 2015, Mundy in Ronson [104]), bringing social data into these processes (e.g. TK itself as well as the social science of TK) is, as Heck et al. [39] observe, only logical. Lyons et al. [51] have noted a more recent move towards the incorporation of social concerns in fisheries management (albeit one that has encountered difficulties). There is a greater need for, among other things, putting social science on equal terms with the natural sciences in these management arenas, and for integrating the two domains (Heck et al. [39]). Ramírez-Monsalve et al. [93] have, for example, illustrated a version of a model for an ecosystem approach to fisheries management regarding the European Union which, at its simplest, has policymakers, natural and social scientists, and stakeholders interacting on equal footing in a co-creative process. It would be reasonable to argue that the development of an ecosystem-based approach (such as that in the NPFMC's Bering Sea FEP) offers a way to change previous dynamics towards a one that gives greater attention to other forms of knowledge (i.e. TK) and analysis (i.e. social science of TK

related to fisheries). The authors would further argue that a development such as the Bering Sea FEP should not only reflect a divergence from single-species considerations, but also from single-disciplinary as well as single-epistemological approaches as well. Involving more sources of social data in fisheries management than have been previously heavily utilized – e.g. by involving TK holders – is similarly apropos, and could be done in a way which increases the 'social breadth' of fisheries management. Truly genuine, equitable, properly-intentioned and designed, and respectful interactions with TK and TK holders can also have the possibility, the authors would suggest, for mitigating some of the well-known problems associated with the integration of TK into management processes (see e.g. [72,105]).

4.2. Recommendations

Here the authors provide recommendations about how TK – and by extension, TK holders, tribal concerns, indigenous communities, subsistence concerns, and social science – can be better incorporated into western Alaska federal fisheries management. The recommendations are based in large part on the authors' work with Bering Strait and Yukon River indigenous communities (see e.g. [63,64,65,67,70,101,102,96]). This also includes recent work explicitly conducted in the development of this paper entailing workshops on this manuscript's topic with two communities (Golovin and Russian Mission) highly engaged in fisheries matters.

4.2.1. Developing a process to include TK, TK holders, indigenous subsistence communities, and social science of TK

It is recommended that a rigorous, specific, and formal process be developed for the inclusion of TK, TK holders, indigenous subsistence communities, and social science of TK in all NPFMC-related processes.

This recommendation involves, among other things, the development of procedures and policies for, and the institutionalization of, meaningful tribal consultation through NMFS which would then be extensively, rigorously, and consistently implemented into NPFMC-related policy, management, and science initiatives [101]. This would include early, frequent, and ongoing consultation with tribes, as well as better coordination between the NMFS and NPFMC with regard to tribal consultation. Not only is meaningful consultation needed, so is its direct integration into research and decision-making processes with the potential for making substantive contributions and impacts on these processes. TK, TK holders, and tribes should be involved in all stages of NPFMC scientific, policy, and management processes. Additionally, it is recommended that the unique and sometimes 'special' (e.g. legal) status of indigenous people and their TK should be recognized in NPFMC processes.

Additionally, a key aspect of this recommendation is the need for the development of a theoretical, methodological, and institutional framework for the interfacing of TK with western fisheries science, policy, and management. One facet within this, for example, would include developing guidance and tools related to interfacing, evaluating, comparing, contrasting, and integrating TK and social science of TK with other forms of data and into management [33,39,51]. Additionally, developing processes for collaboration, co-production of knowledge and policy, and co-management [110,42] would be relevant here.

An aspect of this overall recommendation is for the NPFMC to see TK and social science of TK as necessary to integrate fully into their processes in order to meet MSA and associated National Standards requirements. Another aspect of this recommendation is for institutional steps to be taken to enshrine a principle of TK being seen on equal grounds with western science. Examples of this include equalizing seats, time, funding, and staff related to TK as compared to western science, and equalizing the incorporation of TK-related voices into decision-making compared to western science as well. Sullivan et al. [108] have argued that TK falls within the realm of the best available science and should be used in decision-making. Placing the social and natural sciences on an equal footing is also recommended, as well as crafting the means by which to interface TK and social science data with other sources of data (see e.g. [39,51]). This is especially true for the non-economic social sciences, which have been particularly under-utilized in NPFMC processes to-date.

As part of the process associated with these suggestions, social scientists will need to work to provide data to the NPFMC in ways which can be most effectively utilized; on the other hand, the NPFMC should develop the capacity and processes to evaluate and incorporate different types of data than what they are accustomed to, including social science data (see e.g. [51]). As Ounanian et al. [90] have demonstrated, the incorporation of social science research into fisheries management has been a long-standing challenge.

This recommendation would also entail NPFMC and related entities (e.g. the North Pacific Research Board [NPRB] and the Alaska Fisheries Science Center [AFSC]) promoting the conduct of TK research for its science and policy initiatives. There is a need for more TK research related to fisheries to go along with the greater incorporation of TK-related social science and social scientists into Council processes (see e.g. [51]). As Lyons et al. (*ibid.*) have noted, increasing social science data collection activities helps to increase the knowledge base as well as develop relationships between fisheries managers and communities. Furthermore, there is also a greater need for the inclusion of knowledge from TK holders and subsistence practitioners into non-social science research. For example, scientific reports to the Council could include knowledge from indigenous communities (e.g. regarding health changes being seen with stocks). An attention – through research and management – to areas of concern identified by TK holders, and taking the concerns and perspectives of TK holders seriously, is also important. The authors would also call for a greater involvement of communities in all aspects and stages of research [37,92,97,98].

The relevant scientific and management processes need to be changed to include the requirements necessary for incorporating TK and TK-related work (e.g. from consultation, social science, etc.). This includes changes at multiple levels, many of which have been detailed above. Some other changes include changes to timelines and research priorities, as well as the institution of funding and consultation-siting mechanisms which account for the economic disparities faced by TK holders relating to participation in fisheries management processes. As Brzezinski et al. [18] has noted, for example, representation in fishery management council processes is strongly influenced by the financial resources available to potential participants in those processes.

4.2.2. Tribal representation and power

It is recommended that there be equitable (and thus increased from the present) representation of tribal and TK holder concerns at all levels of the NPFMC process. This would include equalizing seats on the Council, Advisory Panel, committees, and teams for tribal voices, TK holders, indigenous subsistence practitioners, and scientific TK experts (e.g. anthropologists). There is a strong desire amongst these groups to have a greater say in fisheries management, and to be a part of decision-making. ICC Alaska has identified indigenous power over decision-making and management as a crucial dimension of food security for Inuit people (with a lack thereof contributing to food insecurity) [42].

4.2.3. Capacity

Developing capacities related to TK in NPFMC-related bodies will be crucial to integrating TK into Alaska federal fisheries management (see e.g. [101]). Additionally, developing and recognizing local (including collaborative) capacities and institutions will also be valuable for this goal.

Some general recommendations can be made with regard to increasing the Alaska federal fisheries management-related entities' capacity to facilitate the integration of TK into fisheries management.

An increased understanding of TK, indigenous communities, and subsistence amongst the staff and members of the Council would be valuable. Increased awareness and education, as well as visiting and communicating with TK holders and communities, could all be ways in which such an increased understanding could be fostered. Additionally, the authors recommend staffing capacities be increased in all of the Alaska federal fisheries science and management bodies and institutions in order to increase expertise related to TK and social science (particularly of TK). For example, the NPFMC should take steps to expand its own internal capacity for understanding, evaluating, and integrating TK and social science of TK into the Council's work, which could be aided by the addition of a social scientist with expertise in these areas. Expertise related to TK, indigenous subsistence, and TK-related social science is currently virtually non-existent at the NPFMC and the AFSC (the NMFS institution devoted to Alaskan fisheries science). The value of increases in non-economic social science staffing and expertise, for example, is known as being both highly valuable as well as being a recognized gap and area for growth (see e.g. [23,1,50]). Additionally, increasing the staffing capacity for tribal liaison capabilities would also be a positive step for integrating TK into Council processes [101]. Increasing social science expertise amongst management bodies, such as through the hiring of social scientists, has been identified as one potential avenue for addressing problems of a lack of integration of social and natural science in fisheries management [39,51]. Additionally, increasing expertise in appropriate fields has been argued to be a way to increase the likelihood of adequate integration of the values of fishers and communities into fisheries management [106].

Some possibilities for capacity-building also reach across to both management bodies and communities. For example, the creation of more collaborations between the NPFMC and other organizations, such as tribes, Alaska Native organizations, and community organizations, could be very helpful for all groups. Additionally, increases in funding at all levels for science and research related to TK, and the taking of steps to increase integration of TK and TK holders into management and policy (e.g. to ensure adequate participation of TK holders and subsistence practitioners in NPFMC processes), would help to increase capacity for multiple groups.

Indigenous communities have long-standing systems associated with fisheries stewardship which deserve recognition, and can be learned from. Thornton and Scheer have noted nurturing traditional and collaborative stewardship systems to conserve marine ecosystems as a step in enhancing adaptation and resilience whilst integrating local and traditional knowledge and marine science and management [110]. Developing local capacities for funneling the knowledge of TK holders and subsistence practitioners into science and policy documents and decisions in an ongoing fashion would be of great value to the fisheries managers and communities. Additionally, hiring local fishers for involvement in fisheries-related research would also be valuable on a number of levels to fisheries managers and scientists as well as community members (e.g. in terms of sharing knowledge, providing local income, and so on).

4.2.4. Communication, outreach, and relationship-building

Relationship-building between management bodies and communities in general is needed and would be beneficial to Alaska federal fisheries management [101].

In addition to the points made earlier about tribal consultation, the following is recommended. It would be beneficial to NPFMC members and staff to travel to communities to gain a better understanding of TK and subsistence activities. Improved outreach to and communication with communities about all aspects of federal fisheries science, management and policy would also be well-received by communities. However, it is worth noting that outreach and regular communication are not the same as tribal consultation, and are also not the same as TK documentation. Federal fisheries managers promoting the creation of processes and fora related to dialogue between managers and subsistence users would be beneficial; some examples of such fora were noted earlier with regard to the Yukon River, and give-and-take approaches have a history of success [63,64,67]. Approaches grounded in respect, understanding, and trust are encouraged [110,67].

4.2.5. Recognition and incorporation of indigenous concerns and values

The authors recommend Alaska federal fisheries science, management and policy have a greater recognition, incorporation, and prioritization of indigenous subsistence concerns into their processes. Subsistence is a – if not *the* – primary concern of Alaskan indigenous communities, and fisheries play a significant role in this. Subsistence activities and foods are understood to be integral to the cultural, spiritual, and nutritional well-being of Alaska Native people. TK is often intricately interconnected with subsistence. The appropriate recognition of TK, as well as the prioritization of protecting subsistence and the ways of life of Alaska Native communities (e.g. from the impacts of commercial fisheries, fisheries management actions, etc.), would be an enormous step for Alaska federal fisheries management.

Adjusting the imbalance subsistence communities currently have now in Alaska federal fisheries management processes, wherein they and their knowledge are extremely marginally accounted for, especially as compared to other interests, values and epistemologies, would be a great stride. Incorporating values and practices underlying indigenous subsistence traditions into Alaska federal fisheries management would also serve as a strong basis for fisheries management. Some examples include principles of not wasting; respecting fish, animals, and the environment; fishing 'cleanly' (e.g. without bycatch or taking of prohibited species); and not taking more than is needed (see e.g. [96]).

Recognizing and acting on TK-holder identified concerns would be beneficial to integrating TK into management as well (e.g., see [96] for extensive discussion of such concerns in the Bering Strait region). Thornton and Scheer [110] note that acknowledging threats and stresses to marine local and traditional knowledge and livelihoods is a step in enhancing adaptation and resilience while integrating local and traditional knowledge and marine science and management. Additionally, it is notable that TK holders are particularly well-equipped to provide insights of value to science and management on these issues, such as in the interconnections between environmental change and fisheries (see e.g. [96]). Finally, a broad concern of note that could be integrated into Alaska federal fisheries management would be to take steps to ensure that management actions do not shift the burden of conservation to subsistence users and away from the true causes of fisheries problems; there is a strong sense amongst subsistence communities that regulatory measures in fisheries management are unequally distributed whereby the burden on subsistence communities is far greater than what is on the large-scale commercial fishing fleet.

4.2.6. Recommendations specific to the Bering Sea FEP and ecosystematic approaches

Given the authors' view that the Bering Sea FEP potentially constitutes an excellent opportunity for the more general goal of increasing the inclusion of TK and indigenous subsistence concerns in western Alaska federal fisheries management, the authors recommend that the above-noted considerations and recommendations throughout this paper be considered in the development of the FEP. Additionally, the authors have specific recommendations related to the Bering Sea FEP process moving forward, some of which speak to areas of concern relating to problems in how the process has evolved to-date.

The authors recommend that the Bering Sea FEP (as well as other NPFMC processes and documents) evince a richer, more complete, rigorous, and systematic understanding of TK, its values, and the ways it can and should be incorporated into fisheries science and management than NPFMC processes (including early Bering Sea FEP development) have shown to-date. Appropriate considerations of TK in-

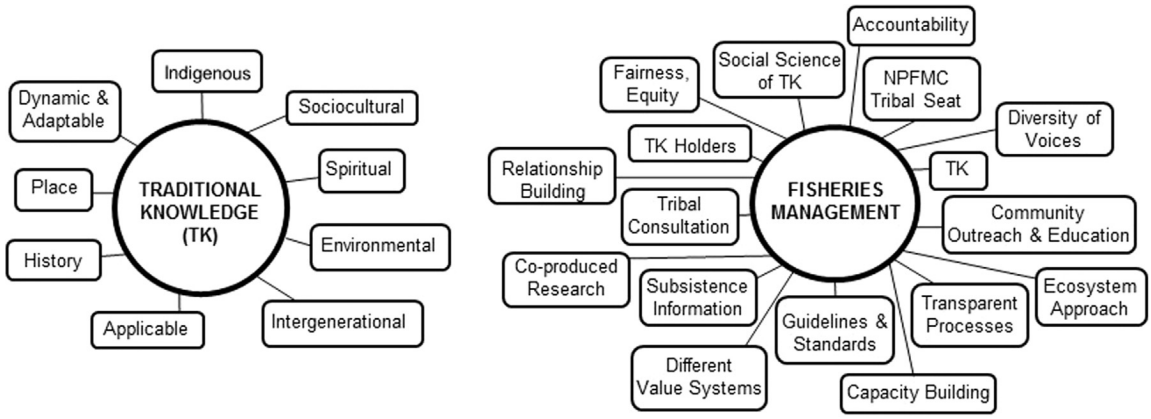

Fig. 2. Left: Key aspects of Traditional Knowledge (TK); Right: Some elements needed in Alaska federal fisheries management processes for them to be successful and inclusive (from TK, social science, and subsistence perspectives).

clude, among other things, turning away from approaches which view TK as being simply supplemental and validatory to western science, and as highly limited in scope (e.g. restricted to small-scale observations, or to understanding the impacts of commercial processes on subsistence resources), especially compared to its western counterparts. The broad scope, utility, and applicability of TK should be properly recognized, as should the ecosystematic nature of TK. TK should also not be confused with other concepts and issues, however related they may be – such as local knowledge, subsistence data, and so on. Gathering and involving TK and TK holders should also extend beyond simply outreach and public participation processes, and include the rigorous integration of TK and TK holders into scientific and decision-making processes. Furthermore, interactions with tribal and TK voices should live up to the standards and expectations discussed in this paper, as well as those used in other federal decision-making processes such as in standards for government-to-government tribal consultation. TK and TK holders should be included in all sections of the FEP and all elements of the FEP process. Membership of FEP-related bodies should also more adequately represent TK, such as through TK expert, tribal, and social science seats. The authors recommend a TK action module be incorporated into the FEP process. The authors also recommend that the NPFMC recognize that information from TK holders and indigenous subsistence communities should be expected to have wide-ranging, rather than limited, impacts on management decisions. Additionally, the authors recommend the NFPMC take steps to expand its own internal capacity for understanding, evaluating, and integrating TK and social science of TK into their work.

The human dynamic in ecosystems is an important aspect for management based on ecosystematic principles. Understanding humans as points of impact, as forces, as sources of various epistemologies, and as having differing values, are important considerations. Ecosystem-based approaches can lead to smarter management when communities are engaged and their knowledge incorporated into management. Such approaches can improve upon limited previous approaches using only western biological/ecological knowledge. This is especially true now that it is becoming more widely recognized that management focuses on human behavior. Additionally, the authors posit that an ecosystem-based approach to management should not only be a move away from single species management, but should also be oriented away from single-disciplinary approaches as well as single-culture and single-epistemological views which have characterized so much of western science, policy, and management.

An ecosystem-based approach should also take steps to integrate ocean and river management, and to improve federal and state interaction on fisheries science and management matters. Fish stocks, harvest activities, and management activities extend and/or have impacts across these divides, frequently to the unequal detriment of subsistence communities. The authors posit that, if done correctly, this integration and improved interaction could vastly improve the health and understanding of fisheries, and also the well-being of indigenous subsistence communities as pertains to fisheries.

5. Conclusion

In conclusion, the authors argue that TK can and should be used in NPFMC processes. TK can offer important information and perspectives for fisheries science, management, and policy. Use of TK in NPFMC processes could reduce the impact of management decisions on subsistence communities, increase equity and fairness in management processes, and increase the understanding of marine ecosystems and the role of humans in them. Integrating TK and social science of it would also help the NPFMC meet mandates detailed in the MSA and associated National Standards. The authors highly recommend a rigorous, meaningful, specific, and extensive process be developed, implemented, and supported for inclusion of TK, TK holders, subsistence concerns, and social science in all NPFMC activities; the authors have provided a number of recommendations in this vein which are gleaned from extensive work with Alaska Native TK holders and subsistence communities. The development of a Bering Sea FEP which attends to these considerations could provide an excellent opportunity for Council success with greater involvement of TK and subsistence communities in Alaska federal fisheries management.

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