Journal of Environmental Planning and Management

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/cjep20

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To cite this article: Diana Garavito-Bermúdez & Wiebren J. Boonstra (2023) Knowing through fishing: exploring the connection between fishers' ecological knowledge and fishing styles, Journal of Environmental Planning and Management, 66:9, 1841-1860, DOI: 10.1080/09640568.2022.2043257

To link to this article: https://doi.org/10.1080/09640568.2022.2043257

Journal of Environmental Planning and Management, 2023
Vol. 66, No. 9, 1841–1860, https://doi.org/10.1080/09640568.2022.2043257

Knowing through fishing: exploring the connection between fishers' ecological knowledge and fishing styles

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(*Received 27 April 2021; revised 26 January 2022; final version received 7 February 2022*)

That fishers' ecological knowledge (FEK) can contribute to the sustainability and legitimacy of environmental planning and management is widely accepted. Nevertheless, despite this broad consensus about its importance, there is uncertainty about the ways in which FEK can be captured methodologically. Here, we present the results of a methodological inquiry aimed to connect FEK to the diversity of work practices within fisheries. Using a sample from a qualitative study of Swedish small-scale fishers, we test to what extent a new combination of concept and method – Fishing Style analysis and the Structure-Dynamic-Function framework – can produce insights into the partiality and diversity of FEK, as well as its embodied and tacit aspects. Results demonstrate how different work practices generate a variety of FEKs. We use this finding to discuss the implications of our work for future study of FEK, and how attention to FEK can inform environmental planning and management.

Keywords: fishers' ecological knowledge (FEK); traditional ecological knowledge (TEK); local ecological knowledge (LEK); fishing styles; methodology

1. Introduction

The value and significance of fishers' ecological knowledge (FEK) for environmental planning and management is, by now, well established (e.g. Löfgren 1972; Poizat and Baran 1997; Neis *et al*. 1999; Stanley and Rice 2001; Silvano and Begossi 2002, 2012; Davis *et al*. 2004; Silvano and Valbo-Jørgensen 2008; Zukowski, Curtis, and Watts 2011; Le Fur, Guilavogui, and Teitelbaum 2011; Pálsson 1998; Hind 2012; Carr and Heyman 2012; Bevilacqua *et al*. 2016; Machado *et al*. 2016; Garavito-Bermúdez and Lundholm 2017; Björkvik, Boonstra, and Hentati Sundberg 2020. Ribeiro, Damasio, and Silvano 2021). This vast body of scientific research builds on the assumption that people who directly depend on local ecosystems to maintain their livelihoods, develop rich and nuanced understandings of these ecosystems. It is argued that appreciation and application of this knowledge in environmental planning and management can improve its effectiveness, sustainability and legitimacy (Berkes, Folke, and Colding 1998; Björkvik, Boonstra, and Telemo 2021).

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Yet, a number of studies (e.g. Briggs 2013) are critical of the assumption that local resource users hold a readily available repository of knowledge about local ecosystems, to use for sustainable management of natural environments. Davis and Ruddle (2010), for example, subscribe to the view that local resource users have ecological knowledge derived from their intimate relationship with ecosystems, but point out that this knowledge can be partial and inaccurate (see also: Johannes 2003; Huntington 2011), and that the quantity and quality of ecological knowledge differs between local users. Other studies highlight that FEK is typically contextual, tacit and embodied and therefore difficult to directly observe and apply in environmental planning and management (Mellegård and Boonstra 2020; Björkvik, Boonstra, and Telemo 2021). This critique points out the need to assess FEK in more depth to better understand its potential to contribute to the legitimacy and effectiveness of environmental planning and management.

This paper documents our work on the development of a methodology for the study of FEK that can consider FEK in its intricate connection with the biographies, working practices, social and ecological contexts of fishers. The study we performed is based on the assumption that closer attention to the people, practices and contexts through which knowledge is generated can help to reveal and appreciate the partiality and diversity of FEK and its embodied and tacit nature.

Our work should certainly be considered as a pilot study (Denscombe 2017), or "pre-study" (Swedberg 2014, 25–28), because it is based on a limited amount of data, without having the pretension, at this stage, of producing insights that can represent a population of cases. The aim of the study outlined here is, instead, to generate new ideas, theoretically and methodologically, which can contribute to further study of FEK and related types of knowledge, such as Traditional Ecological Knowledge (TEK), Local Ecological Knowledge (LEK), and Indigenous Ecological Knowledge (IEK).

Our study first concerns the theorization of FEK as ways of knowing rather than repositories of knowledge. Second, building on this theorization we present two analytical tools – Fishing Style Analysis (FSA) and the Structure-Dynamic-Function (SDF) framework – that are used in tandem to test what their combination reveals about the partiality, diversity, embodied and tacit aspects of FEK. Third, we discuss the implications of these results for environmental planning and management.

2. Fishers' knowledge

A good start for theorizing fishers' knowledge is to consider how this term relates to others that are also frequently used to indicate the types of knowledge that communities of local resource users hold, such as 'local ecological knowledge', 'traditional ecological knowledge' and 'indigenous knowledge'. As will become clear from the following citations and references, no clear boundaries exist between these forms of knowledge, despite each having its own distinct quality. We present a number of definitions to explore the qualities of these types of knowledge and how they relate to FEK.

Local ecological knowledge is, for example, defined by Bettina, Winkel, and Primmer (2018, 521) as "people's site-specific ecological knowledge that can be practically applied". They continue by stating that local ecological knowledge can include "knowledge held and used by traditionally living indigenous people with a historical

Figure 1. Relations between Local Ecological Knowledge, Traditional Ecological Knowledge, Indigenous Ecological Knowledge, and Fishers Ecological Knowledge (areas A and B).

continuity of resource use, as well as by non-indigenous natural resource users". The quote usefully highlights that local ecological knowledge can (sometimes, but not always) include what has been called traditional and indigenous knowledge. Likewise, the Convention on Biological Diversity (2021) defines traditional ecological knowledge as "knowledge, innovations and practice of indigenous and local communities around the world […] developed from experience gained over the centuries and adapted to the local culture and environment". Here too we see that aspects of all three types of knowledge are related. Finally, an often-cited definition of indigenous knowledge comes from Berkes (2012, 7): "a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission regarding the relationship of living beings, including humans, about one another and their environment".

The definitions make clear that the relationship between these types of knowledge is one of "family resemblance" (Wittgenstein 2006 [1953]), a family in which members share some traits but no-one is exactly the same.

FEK has been defined and described using all of these three types of knowledge (Hind 2015, 57–60). Using the definitions introduced earlier we define FEK as knowledge that fishers hold about the interrelationships between themselves, others, and their local environments. This knowledge is social in the sense that it is shared with a group (which can be a community, tribe, association, etc.) and that it is learned from others. In our definition, LEK is thus always traditional because LEK is handed down from one generation to another (it is 'inherited'). It is also always local because LEK concerns knowledge about local environments (Area A in Figure 1). But LEK is not always indigenous: only when the relevant social group and cultural context in which LEK is generated and reproduced can be qualified as such (Area B in Figure 1) (Reid *et al*. 2021).

Although this definition of FEK and its relationship to traditional, local, and indigenous knowledge is fairly clear, a number of problems remain. First, the term does not disclose how this knowledge is diverse and partial. That FEK is, in other words, plural ('knowledges') rather than a single uniform body of knowledge (Reid *et al.* 2021). Garavito-Bermúdez, Lundholm, and Crona (2016), for example, point out how fishers' dependence on target species influences what they know about ecosystem structure and dynamics, and highlight qualitative differences in fishers' ecological knowledge based on the use of different types of fishing gear. The second problem with the term FEK is that it can easily be interpreted as a repository of knowledge related to aquatic ecologies only. Research demonstrates that fishers do not separate ecological knowledge from other knowledge that is just as essential for fishing, such as knowing how to operate gear. Lauer and Aswani (2009, 323), for example, conclude that fishers: "tend not to analytically separate knowledge about marine environment from changing contexts of [their] everyday […] activities such as navigating and fishing. Instead, knowledge is based in the sensitivities, orientations, and skills that have developed over one's lifetime through actual engagements in and performance of practical activities". Some scholars, for this reason, argue that FEK needs to be considered in relation to knowledge of social contexts, as well as practical knowledge of how to fish (e.g. Hind 2015).

To address these concerns about the diversity and the practical nature of FEK, we theorize it in this paper as ways of knowing aquatic ecosystems which seamlessly infuse with the skills and habits that are used in processes of work (see also: Lauer and Aswani 2009; Neis 1992; Stanley and Rice 2001; Pálsson 1998; Hind 2012; Genz 2014). Indeed, FEK is an "integral part of the everyday practice of production" (Briggs 2013, 238; see also Ignatow 2007; Ingold 2011; Sennett 2008). Yet, FEK does not only exist in working practices, tacit knowledge, skills and habits; it also manifests itself discursively and in connection to learning from others in institutions of formal (e.g. schools) and informal education (e.g. apprenticeship), as well as communication with relevant others, such as fisheries managers and scientists (through e.g. the reading of reports or direct dialogue), and technology-generated knowledge (Garavito-Bermúdez, Lundholm, and Crona 2016; Garavito-Bermúdez 2020a). These different ways of knowing – discursive and practical – are so closely linked that it seems not only impossible, but also a mistake, to reduce FEK to just one of them. In this study, FEK is therefore considered as a mutually reinforcing duality of different ways of knowing (Garavito-Bermúdez, Lundholm, and Crona 2016); part of fishers' knowledge is conscious, lending itself to scientific objectification and translation, but much of it is tacit and locked up in working practices and skills. In the next section we explore the methodological challenge that the theorization of FEK presented here evokes.

3. Research design and methods

Pálsson (1998, 56) offers an instructive example of the difficulties involved with the study of the intimate connection between fishers' knowledge, work, and context, when he quoted an interviewed Icelandic fisher: "It's so strange, when I get there it's as if everything becomes clear. I may not be able to tell you exactly the location but once I'm there it's as if everything opens up." This often-cited quote sums up the methodological difficulty that comes with the theorization of FEK as knowledge rooted in practices of everyday work. Capturing fishers' tacit and embodied knowledge regarding marine environments "offline" (Wilson 2002) i.e. when fishers are not fishing, is challenging, because it is difficult for fishers to verbalize their tacit knowledge (Mellegård and Boonstra 2020).

To overcome this difficulty, many scholars of LEK therefore perform research using ethnographic methods that include, besides interviewing, participant observation of fishing trips (Lauer and Aswani 2009; Pálsson 1998; Hind 2012; Genz 2014). To gain full access to tacit knowledge and practical consciousness – or "online" knowledge (Wilson 2002) – requires methods that can capture the fisher *in situ*.

The aim with our pre-study was to test whether it is possible to capture the diversity, partiality, as well as the embodied and tacit aspects of FEK *offline*, i.e. when we meet fishers not at work. This is a useful approach because fisheries scientists or managers are not always able, or have the opportunity, to engage in participant observation at sea. If this is the case, what methods, other than participant observation, can be used to capture the richness and complexity of FEK? For our test we combined two different methods and their output: the SDF framework and FSA.

The first author applied the SDF framework in a study of knowledge and learning in Swedish fisheries (Garavito-Bermúdez, Lundholm, and Crona 2016). The SDF framework is based on a systemic approach to studying people's understanding of natural environments (Hmelo, Holton, and Kolodner 2000), and is applied to fishers' knowledge with regard to three aspects of ecosystem complexity (Garavito-Bermúdez, Lundholm, and Crona 2016): (i) *Structure* – the identification of biotic components and feeding interactions by fishers; (ii) *Dynamic* – the recognition of ecosystem changes over time, whereby fishers identify drivers of change and their causal effects on fish stocks; and (iii) *Function* – the identification of services provided by ecosystems to fishers as well as to the local community, in terms of material (e.g. fresh water and food) and non-material (e.g. cultural, spiritual and recreational) benefits.

The second author developed and applied FSA in a general study of the Swedish Baltic Sea fishery (Garavito-Bermúdez, Lundholm, and Crona 2016). FSA has since then also been used in other contexts (e.g. O'Farrell *et al*. 2019; Schadeberg, Kraan, and Hamon 2021). FSA is a relatively new methodological tool that can be used to typify fishers, instead of the more conventional classification of fishing practices according to fleet, fishery, and métier (ICES 2003). Fishing styles are defined as "collectively shared and enacted, durable, habitual patterns of systematic and coherent actions, which aim to create congruence between normative notions about how fishing should be practiced, and fishers' dependence on different social and ecological contexts." (Boonstra and Hentati-Sundberg 2016, 82). A distinctive feature of FSA is its ambition to integrate attention to fishing practices (how fishers fish) with attention to the values, norms, habits, and motivations that underlie diverse fishing practices (why fishers fish). For their study of the Swedish Baltic Sea fishery, Boonstra and Hentati-Sundberg (2016) performed a multi-method approach whereby quantitative and qualitative methods are integrated to classify the diversity of the Swedish Baltic Sea fishery using three different fishing styles: (a) Archipelago fishing, (b) Coastal fishing, and (c) Offshore fishing.

The idea that prompted the combination of the SDF framework and FSA was the assumption that it would prove possible to classify the fishers involved in the first author's study of LEK into the styles of fishing that the second author had developed. The classification, in turn, would allow comparison between the LEK of different styles of fishing in order to explore connections between the fishers' different working

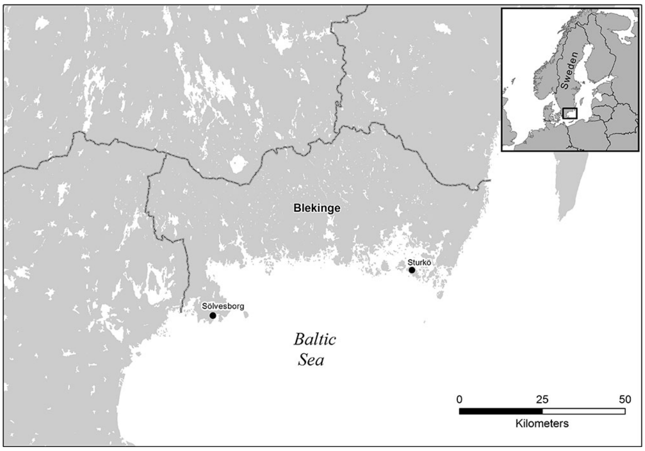

Figure 2. Geographic location of the study. Right: Archipelago of Blekinge with the localities of Sölvesborg and Sturkö. Left: Sweden.

practices and their ecological knowledge. The comparison might provide a way to describe the partiality and diversity of FEK, and explore ways of studying its embodied and tacit character *ex situ*, i.e. when fishers are not working at sea.

It should be emphasized here that the purpose of this study is to pilot the combination of these methods and to assess their potential contribution for better understanding FEK. The study will not produce general insights about Swedish small-scale fishers or about FEK. Our study should, therefore, be understood as an attempt to develop methods that can capture FEK *ex situ* as ways of knowing aquatic ecosystems in everyday processes of work (see Section 2).

We applied our multi-method approach to interviews with six small-scale fishers living and working in Sölvesborg and Sturkö, county of Blekinge (Sweden) (Figure 2). These interviews were performed by the first author for, and included in, a larger research project on ecological knowledge and sustainable resource management in Swedish small-scale fisheries (Garavito-Bermúdez, Lundholm, and Crona 2016). The interviews were completed in 2011 and based on a biographical approach (Robertson 2002) that combined semi-structured interviews, participant observations at the shore, and family picture analysis. The interviews were recorded and transcribed, and included the following themes: (1) fishers' sociocultural background; (2) the use of fishing gear and equipment in everyday work; (3) knowledge about biological and ecological characteristics of target species and fishing grounds; (4) views of ecosystem management and fisheries policies; and (5) feelings or emotions related to fishing as a profession and the marine environment (see Appendix A for information about the interview questions). Observations were recorded through notetaking and photographs.

We used the six interviews from Blekinge conducted by the first author (see Garavito-Bermúdez, Lundholm, and Crona 2016) for this specific pre-study because these fishers all qualify as Swedish Baltic Sea fishers and therefore fall within the population covered by the fishing style typology proposed by Boonstra and Hentati-Sundberg (2016). Coastal Blekinge also has a rich cultural heritage of fishery (see Stenholm 1986), and the archipelago is home to a rich diversity of marine species; factors which led to Blekinge archipelago being designated as a Biosphere Reserve by UNESCO in 2011. We, therefore, assumed that the knowledge these fishers have could

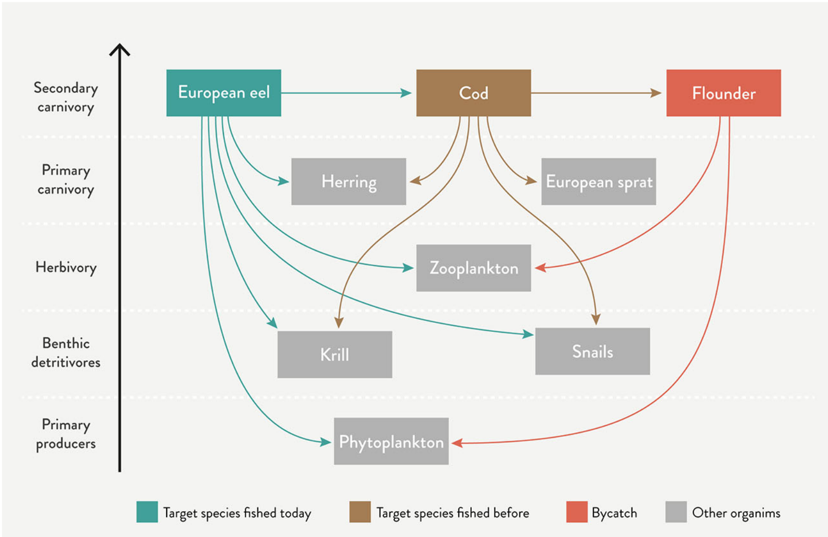

Figure 3. Baltic marine food web described by AF4 (age 69).

refer to a wide number of species and species interactions and would include knowledge that they inherited from their predecessors. In other words, that their FEK could be identified as both local and traditional ecological knowledge (see Section 2).

For our approach the first author analyzed these interviews for excerpts that dealt with ecosystem *structure, dynamics* and *functions*, and coded these excerpts for first and second-order categories using a thematic analysis (Braun and Clarke 2006). Based on this categorization, the first author drew two types of diagrams to conceptualize, illustrate, and compare fishers' ways of knowing the Baltic marine ecosystem. The first type of diagram visualizes ecosystem structure as food webs, including various trophic levels (i.e. primary producers, benthic detritivores, herbivores, primary carnivores, and secondary carnivores) to capture the feeding interactions between fishers' target species and other groups of organisms (Figures 3–5). The analysis includes target species being fished today (represented with green rectangles) and fished previously (brown rectangles), other organisms (grey rectangles), baitfish (red rectangles), and the feeding interactions among them (arrows). The second type of diagram visualizes ecological changes that fishers identified. These diagrams (Figures 6 and 7) show the drivers of environmental changes (e.g. cormorant and seal populations, overfishing, eutrophication) and the ways in which they influence Baltic fish stock populations, according to the fishers.

The interviews were also analyzed in parallel by the second author to assess whether the fishers could be classified as archipelago, coastal or offshore Baltic fishers (a description of these styles features in Section 4). For this purpose, the second author coded interviews with the qualitative codebook of the FSA in NVivo © qualitative software through a deductive approach (Benaquisto 2008).

Through using FSA and the SDF framework in tandem for data analysis, it was possible to consider how fishing styles might be linked to the diversity of FEK. The next two sections present the results from this combined data analysis. To keep the identities of the fishers anonymous a notation was used consisting of capitals and

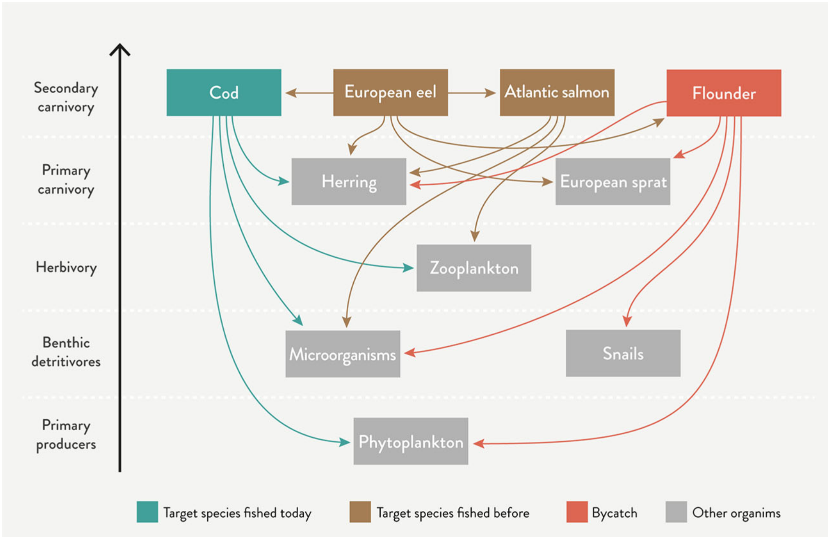

Figure 4. Baltic marine food web described by CF1 (age 39).

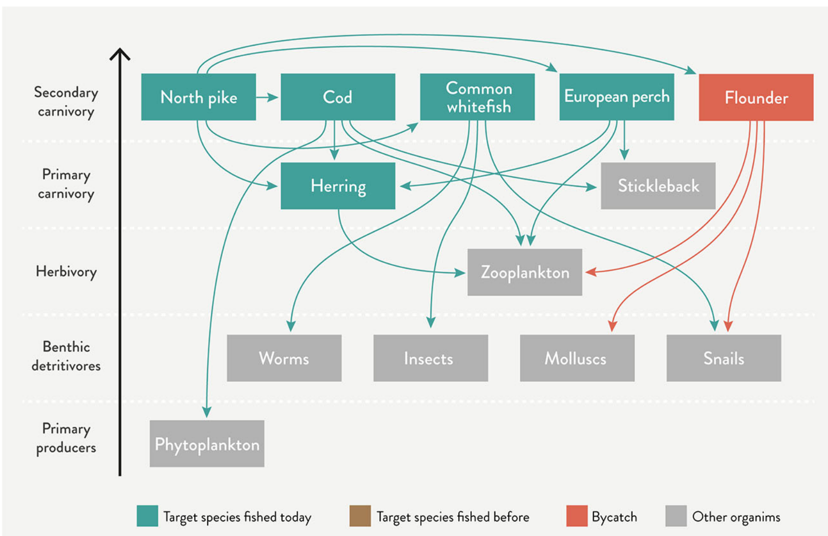

Figure 5. Baltic marine food web described by ACF5 (age 42).

numbers. AF stands for archipelago fisher, and CF stands for coastal fisher. The number refers to the chronological order in which the fishers were interviewed. In the quotations used below the letter 'I' refers to the interviewer.

4. Connections between FEK and fishing styles

The results focus on the connection between FEK and fishing styles. It includes interview excerpts and diagrams of food webs and ecological dynamics. Using FSA, it

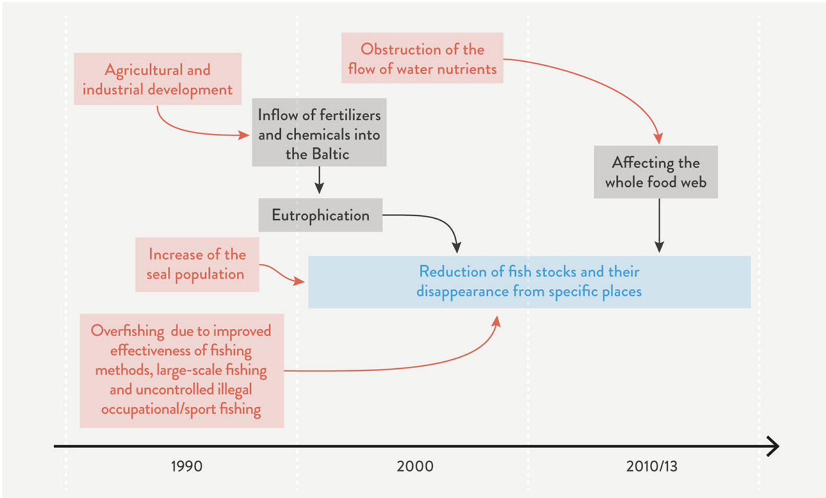

Figure 6. Ecosystem dynamics described by CF1 (age 39).

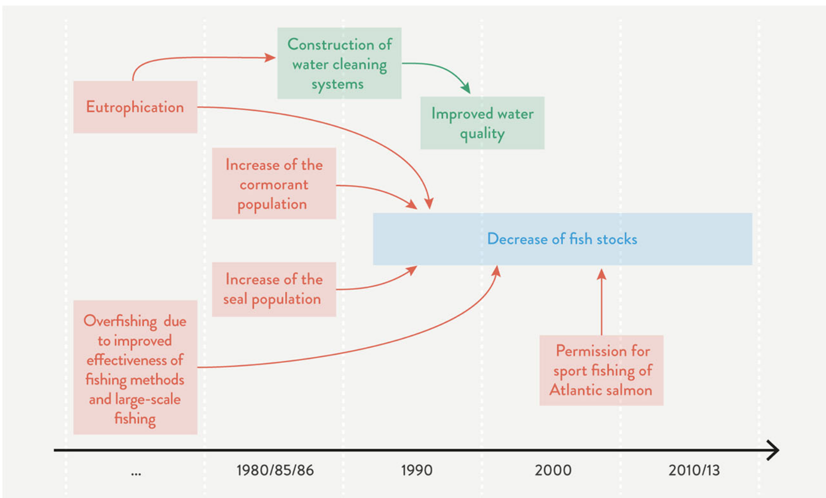

Figure 7. Ecosystem dynamics described by AF4 (age 69).

proved possible to classify respondents as archipelago fishers (AF2 and AF4) and coastal fishers (CF1, CF3 and CF6). Archipelago and coastal fishers operate boats that are relatively small, between 6 and 12 meters. They share a normative ideal of being independent and self-reliant, as illustrated in the following quote from one of the respondents in this study:

> AF2: […] the challenge is to create your income by yourself. If I am lazy, I won't get anything. You need driving force and willpower. Apparently, I had that inside me, because we [his fishers' colleagues] survived. That's the driving force, completely. It's power to push yourself forward […]. It's something [fishing] not something for all people. With fishing you have to make decisions by yourself all the time […]. You can never run into a slump, unfortunately; it can never go down.

The aspiration of these fishers to safeguard their autonomy and to maintain control over their working life is also observed when they discuss their interactions with organizations and agencies, such as governments or trade corporations. The next quote highlights the cautiousness with which one of the interviewed archipelago fishers handled opportunities to borrow money to invest in a bigger boat:

> AF4: For 10 or 15 years ago, the Swedish Board of Fisheries granted big loans to fishers to keep their [fishing] going. I also applied for just a small loan 20,000 [Swedish Crowns] to repair my boat by myself, and the money was to buy the material. It wasn't a big loan, but I felt it was. The County Administrative Board of Blekinge said 'sure' and approved the loan. They forwarded the decision to the Swedish Board of Fisheries, where they said no. They said that I could not get a loan for 20,000, but I could get one for 300,000 to buy a new boat. But I replied that I didn't want a big boat. I persisted. I could have gotten 300,000, but 20,000 that was impossible. But this is what happened to other fishers. They were handing out millions to get big boats, and to make sure they didn't go bankrupt fishers were forced to fish harder. That's how it goes.

These fishers also distinguish themselves consciously from other fishing styles that are more capital- and technology intensive, such as offshore trawling. In the following quote, an archipelago fisher illustrates this difference by referencing to the different ways of operation, as well as the idea that different styles of fishing generate different knowledge:

> AF4: So, small-scale […] those boats are disappearing. And this knowledge is disappearing with them. I believe the idea that one needs to have a good understanding of ecosystems when you operate different types of fisheries, and that operating small boats requires more skill because you need to be able to operate the gear, know where to put it in. You need also to know the lifecycles of the different species that you fish. Now, if you think of large-scale fishing, they work with a method that is not selective; a method that catches everything.

As the previous quote highlights, a particular style of fishing generates ecological knowledge. But the causal interrelationship also works in reverse: particular (ecological) knowledge is required to perform certain fishing styles. Moreover, as our respondents highlighted, learning this knowledge requires frequent and long-term involvement in fishing:

> I: I would like to ask you about your own knowledge. Which knowledge is important for managing your fishery?

> AF4: That would be knowledge of, e.g., the seafloor. That's simply environmental thinking. Disturbing as little as possible to get as much fish as possible, to gauge the size of the fish well and to cull the small from the big fish. That's clearly good and important knowledge to sustain fish species and everything. And because we fish with gillnets and longlines, we have great opportunities to do this well. With hooks you only get the fish that is hungry. For example, when we fish perch, I don't have to weigh them. I can put hundred perch in a tray and know that they weigh thirty kilo something. […] I don't have to weigh them. I know it for sure because I only take them of one particular size.

I: But do your colleagues also have this knowledge?

AF4: Not all have it [in the same way]. They don't get so good catches compared to the ones with the knowledge. For example, there have been some fishers here who come from other places, or those who have worked some time on land. When they come back, they cannot keep up. They don't have the information. They are simply not at the right place at the right time. […]. [Fishers] who did not get the knowledge from previous generations. Fishing is not so easy […]. Take for example when we go out fishing during the night. We always ask among ourselves […] We are five men aboard." Where shall we go tonight?" One can say 'there'! Another one say 'there'! I say 'I believe we should go there'. That's where the herring is tonight. OK let's try it then they say. Most of the times it's me with one or two who say the same. Nine out of ten times we are right when we get to the place. Then you just have a little […] we all have been in the area the night before. So, we have experienced the movement that gives you the feeling for it. An awful lot is about feeling.

The interviews and diagrams produced with the SDF framework reveal that the major difference between archipelago and coastal fishing styles in terms of knowledge stems from the species that fishers target, which relates to the gear they use, and the locations they fish. These differences can be seen through a comparison between the diagrams that depict the feeding interactions identified by fishers between their target species and other marine organisms, such as snails and/or zooplankton.

Archipelago fishers in the Swedish Baltic usually catch a mixture of fresh and salt-water species, including European eel (*Anguilla anguilla*), cod (*Gadus morhua*), herring (*Clupea harengus*), pikeperch (*Sander lucioperca*), whitefish (*Coregonus* spp.), northern pike (*Esox lucius*), perch (*Perca fluviatilis*), European flounder (*Platichthys flesus*) and salmon (*Salmo salar*), using mostly bottom and drift nets (Boonstra and Hentati-Sundberg 2016). Yet, for many of these fishers, eel is the most important species because it is most profitable (Björkvik, Boonstra, and Hentati Sundberg 2020). When archipelago fishers specialize in catching eel, they often rely on so-called pound nets. Especially in Blekinge, relatively many archipelago fishers hold licenses that enable them to catch eel. Figure 3 depicts the feeding interactions identified by an archipelago fisher who specializes in catching eel.

Coastal fishers, on the other hand, operate further from shore than archipelago fishers, and also target fewer species. Their main catch consists of cod, which they often combine with catches of European flounder, turbot (*Scophthalmus maximus*) or salmon. Some coastal fishers operate longlines to catch cod and salmon, but most operate gillnets. Figure 4 shows the feeding interactions identified by a coastal fisher.

Interestingly, one fisher who was interviewed (ACF5) combined both archipelago and coastal fishing styles. A first difference between this fisher and his colleagues who specialize in either catching eel (Figure 3) or cod (Figure 4) concerns the number of species that he targets (Figure 5). The comparison between the diagrams depicting feeding interactions highlights how much more complex the food web described by ACF5 is. The following interview excerpt illustrates how ACF5 conceptualizes feeding interactions between his target species and other organisms:

ACF5: Herring eats plankton […]. Turbot eats the slugs, clams, snails […]

I: And what does cod eat?

ACF5: It eats the herring and other fish species. North pike eats other fish species, eats themselves, or their own offspring. A North pike of 10 kilos eat up to 3½ kilos. […] Perch eats fish and shrimp.

I: Do they eat the same food during different life stages?

ACF5: Yes, the very first time when they are small, but later when they get bigger, they can hold of their prey so they eat other fish. A North pike starts with sticklebacks and might eat prawns and stuff. And then it eats whatever it finds […] Whitefish eats little shells and such, some gastropods especially, or any kind of worms on the bottom. When you open their stomachs [of whitefish] for clearing, you find often little shells and small shrimps.

In addition to questions about feeding interactions, these fishers were also asked about the changes they had noticed over the years in the marine environment, and their understanding of the ecosystem services that these environments provided for society in general. Both these aspects will be discussed in turn.

No major differences between archipelago and coastal fishers could be identified in how these fishers understand marine ecological dynamics. All of them identified eutrophication, overfishing, and the growth of the seal and cormorant populations as important drivers of change in Baltic fish stocks, affecting feeding interactions and energy flows in the Baltic ecosystem (cf. Figures 6 and 7). The next quotes illustrate how fishers explain these causal relations:

CF1: I think that the decrease of cod stocks is due to various different factors, for instance an enlarged seal population. They eat a lot of fish, seven kg fish per day, 365 days. Seals eat small cod juveniles this affects negatively cod reproduction. I think that seals and overfishing from industrial boats, and in some extent changes in the sea related to climate change, for example when the wind blows from the wrong direction preventing oxygenated water from flowing into the Baltic. And, in some extent eutrophication from agricultural runoff that flows into the water.

CF2: They [fishers trawling offshore] can say what they want. I have been harbourmaster 29 years and talking to all the fishers in the area. We talk about the fact that salmon fishing goes down in the Baltic, and that trawl fishing is responsible for this. Trawl boats sweep the sea […] it's clear that salmon eats small herring [juveniles], isn't it? It may be the dumbest to figure that out […] And they [trawlers] fish with a bag that is so dense [i.e., has small mesh size] that nothing goes through. They take all the herring and leave nothing for the salmon to eat.

CF3: Definitely, the trawlers are responsible for it all. I can get maybe 10 kg cod every day, 38 cm large that is the minimal size permitted. If they are smaller, I drop them into the water, and they swim down. But a trawl, it's just like a bag that goes after them [fish] with four knots in maybe 10 hours. Fishes press on and press on and press on [in the net], so those [trawl fishers] get up to 5 tons of fish that are too small [than the minimal size permitted]. All these fish are dead. Thrown out back to the sea. Five tons!!

I: Do you mean that the problem lies in the number of trawl boats that fish?

CF6: Yes, I think the problem is that when large trawls boats come in here and fish, they fish large quantities of cod, so prices go down. Danish vessels fish as quickly as possible, and then go to the North Sea for fishing sand lances or flatfish. They are here one, two or three times so they fish their quotas. But I think that fishing time should be longer than three or four months. Fishery should be deployed sustainably, in the way we can continue to have a living industry for the future […] Actually, big boats are needed. The problem is that you don't know if it's [fisheries] managed properly, if quotas are too large and if trawlers fish too much.

In relation to ecosystem services, fishers also thought similarly about the material and non-material benefits that they felt the Baltic marine ecosystem provided. They highlighted material benefits from provision of food and work, but also immaterial values sustained through recreation and fishing activities. Interestingly, some fishers discussed archipelago and coastal fishing styles as cultural ecosystem services, and how these are currently marginalized due to lack of recruitment. They identified, for example, eel fisheries as an old tradition representing cultural value (see Svensson 2020), but also one that was bound to disappear altogether, together with the knowledge of the fishers, who are without successors:

CF2: [The knowledge about eel and how to fish it] comes from my ancestors. My grandfather … my father learnt from him, and my grandfather learnt from his father. All these fishers had been in the same place since the 1600s. Every generation learned little new, but now it goes to the grave […]. It feels sad seeing nobody going out in his boat and fish, and when everything [equipment, boats, gears] stands on land. I don't want to see it. The profession I have it can't revive, after which everything is gone […]

CF3: When I was a child I followed with my grandfather and my dad, especially during summer […] I fished eel with traps and trout with nets as a hobby. I used to do that also with my oldest kid during summertime [he has two boys], when he was 3 to 5 years. We fished salmon with nets, and we could get one or two. It was very nice for him. But today, we can't do that anymore. He can't follow with me for put in nets or traps like before.

I: So, you can't teach and experience fishing with your boys as you did as a kid, like a profession that goes from a generation to another.

CF3: I would like, but isn't possible. I'm the last fisher in my family. It's sad. I wish I could teach the profession to my kid or someone else. My kids like to fish, but I can't encourage them to be fishers. Because I know they couldn't survive or live from fishing.

In the next section, we explore the relationship between FEK and fishing styles, and our methodological approach in relation to previous research. The section concludes with a discussion of the implications of these findings for environmental planning and management.

5. Discussion

This study uses FSA to differentiate fishers' working practices into various styles, as introduced in Boonstra and Hentati-Sundberg (2016). In addition, the SDF framework, operationalized by Garavito-Bermúdez, Lundholm, and Crona (2016), describes fishers' knowledge of the ecological structures, functions and dynamics of marine environments.

The results demonstrate that the combination of FSA and the SDF framework helps to concretize the diversity of FEK. The use of the SDF framework reveals that the number of target species constitutes a key aspect of fishing styles that directly affects FEK. The fishers who target relatively many species (e.g. 5–10 species) also report more drivers of change related to ecosystem dynamics and the reduction of fish stocks. It is instructive here to compare the fisher who combines coastal and archipelago fishing styles (ACF5) with the fishers who work according to one style (e.g. CF1 and AF4). ACF5 focuses on the largest number of target species (i.e. north pike, common whitefish, cod, European perch, herring and turbot), and he also identifies a large number of feeding interactions between these and other organisms (Figure 5). These results lend support to the hypothesis that the variety of working practices might be related to diversity in FEK (Begossi *et al*. 2008, 2011, 2016; Ruddle 2000). More research based on a representative and extended sample is needed to corroborate this hypothesis.

When it comes to changes affecting the Baltic marine ecosystem, fishers across styles identify similar drivers, such as eutrophication, overfishing and the growth of seal and cormorant populations. These results illustrate how the diagrams of ecosystem dynamics might help to indicate the partiality of FEK. It has been pointed out in previous research that fishers can exaggerate the influence of social or political actors or conditions, compared to the impact of fishing practices on the marine environment (Maurstad, Dale, and Bjørn 2007; Machado *et al*. 2016; Boonstra, Birnbaum, and Björkvik 2017). It is therefore interesting to notice that the fishers in the interviews point out overfishing as a driver of ecosystem change. Although some specifically blamed offshore trawlers for overfishing as a driver of ecosystem change, others point to the mechanization of fisheries resulting in higher fishing pressure. These findings highlight the value of systematically comparing fishers' viewpoints with other sources of knowledge to identify the main drivers of ecological change in marine environments (see, e.g. Acheson and Steneck 1997).

The FSA and the SDF framework together help to demonstrate that different fishing practices generate different knowledge of marine environments. As such, we find that the FSA and the SDF framework can be used to draw attention to the diversity as well as the partiality of FEK, and therefore fit with the theorization of FEK as processes and practices (see Section 2). The results also demonstrate that the methodology needs to expand to include the embodied and tacit aspects of FEK. To capture these aspects, additional methods that are less dependent on verbal expression, such as participant observation, various types of visual methods such as photo elicitation (Mellegård and Boonstra 2020), or biographical approaches to understand the context of knowledge generation and reproduction (Garavito-Bermúdez 2020b), can usefully complement the methodology we introduced and tested in this paper.

6. Conclusion

Time and again scholars of FEK are confronted with forms of knowledge that resist expression in words. We have already re-quoted the Icelandic fisher in Pálsson (1998, 56); here we offer a quote from a coastal fisher, whose interview we considered for this paper, that carries the same message:

> My grandfather was a fisher his whole life. So, you can almost say that it came with him automatically. All the edges and all the depth contours and rocky bottoms; all this kind of things had my granddad in his head. He used to say: 'have a mark on that island [a reference point in the landscape], follow its coastline, and then there you have rocky bottom, and there you have a bottom with seaweed, and there you have stone bottom'. He had all that built in. And then one just inherits it. I can use that now. I continue to have this in my head, so to say. Perhaps not quite when I am sitting here, but when I get to the place. Definitely.

This paper describes how we try out a methodology that is sensitive to the tacit aspects of FEK, as well as its diversity, partiality and embodied character. Due to these qualities the scientific study of FEK, as well as LEK, TEK and IEK, is challenging, because these are types of knowledge that are often difficult to verbally articulate. This major methodological challenge was something we wanted to highlight and address in this study.

The results generated by our methodology lend support to the assumption that there is a relationship between the nature of FEK and the diversity of working practices that fishers employ. Due to the small sample of six fishers that this study is built on, the findings do not speak to the characteristics of FEK for Swedish Baltic Sea fishers, but concern the methodological possibilities for capturing the tacit nature of FEK *ex situ*.

The findings also have some implications for understanding of fishers' knowledge and its potential to contribute to environmental planning and management. First, our findings imply that scientists, planners and managers can consider, understand and thus assess the diversity and partiality of FEK, as long as there is an understanding of the practices through which local users work. The focus on practices of work also helps to avoid the idea of FEK as knowledge repositories, readily available to make management and planning of natural environments more sustainable or legitimate. Second, our study suggests that to understand and include the tacit and embodied nature of FEK in environmental planning and management requires methods that link knowledge to the socio-cultural context in which it is generated by local users (Garavito-Bermúdez 2020b).

As a final reflection, we want to raise awareness that with the disappearance or marginalization of certain fishing styles, livelihoods and work, certain types of FEK also cease to exist because they are no longer reproduced in practices of work and taught to new generations. With the depopulation of coastal communities, the retirement of fishers, and the various regulatory barriers that prevent recruitment and engagement in small-scale fisheries, knowledge connected to these styles of fishing is bound to disappear (Björkvik, Boonstra, and Hentati Sundberg 2020). If FEK is considered significant for the preservation, use and sustainable management of natural environments, as many scholars suggest (e.g. Löfgren 1972; Poizat and Baran 1997; Neis *et al*. 1999; Stanley and Rice 2001; Silvano and Begossi 2002, 2012; Davis *et al*. 2004; Silvano and Valbo-Jørgensen 2008; Zukowski, Curtis, and Watts 2011; Le Fur, Guilavogui, and Teitelbaum 2011; Pálsson 1998; Hind 2012; Carr and Heyman 2012; Bevilacqua *et al*. 2016; Machado *et al*. 2016; Garavito-Bermúdez, Lundholm, and Crona 2016; Björkvik, Boonstra, and Hentati Sundberg 2020; Ribeiro, Damasio, and Silvano 2021), more attention needs to be paid not only to the collection of FEK but also to its reproduction in practices of work.

For environmental planning and management this would mean to be aware of the (development of) diversity in local resource use and the knowledge that is both the cause and result of this diversity. If deemed valuable or desirable from a sustainability or legitimacy perspective, environmental planning and management would do well to create circumstances that can offer opportunities for the development and innovation of livelihood diversity and associated forms of knowledge and skill.

Acknowledgements

We would like to thank all six fishers who participated voluntarily in this study for their invaluable contributions, opening the doors to their homes, answering our questions, and sharing their feelings and memories. We thank Cecilia Lundholm for her academic support and comments, Beatrice Crona for her valuable advice, and Jens Bengtsson for putting us in contact with the fishers in Blekinge. Finally, we thank Lars Lundahl from the County Administrative Board in Blekinge for providing information and assistance, Emma Björvik for transcribing the interviews, Erik Smedberg for supplying us with the Blekinge map, Jerker Lokrantz for help with the diagrams, and Janet Ahlberg for a language check.

Disclosure statement

None of the authors has any competing interest in the manuscript.

Funding

This study is part of the project ‘Ecological knowledge and sustainable resource management: The role of knowledge acquisition in enhancing the adaptive capacity of co-management arrangements’, which is funded by the Swedish Research Council for Sustainable Development, and supported by FORMAS Project Grant (No. 2013-1293) ‘Working knowledge in Swedish coastal fishery – Making cultural capital visible for sustainable use of coastal sea- and landscapes’ and the Research Council of Norway-funded project ‘Localizing the 2030 Agenda for Sustainable Development for the Barents Sea-Lofoten. Cultural heritage and environment in a changing climate’ (LoVeSe-SDG).

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Appendix A

Interview questions included the following five themes:

1. Fishers' socio-cultural background and life story (How long have you been an occupational fisher? How did you start fishing as an occupation?)
2. The use of fishing gears and equipment (Which kind of gears do you use? How selective are they? When and where do you fish?)
3. Knowledge about biological and ecological characteristics of target species and fishing grounds (What target species do you fish? Where and when do you find these target

species? Where and when do target species breed in the Baltic Sea? Who eats what/whom?), local ecological changes (How have the stocks changed? Do you have any idea why such changes have occurred? How have these changes affected fishing species?), and ecosystems services (Why is the ecosystem in the Baltic Sea important? Which are the services provided by this ecosystem to people? Which services are important for you?)

4. Views of ecosystem management and fisheries policies (Are you participating in fisheries management in this area? Do you underwrite the goals of fisheries management? Is it important to manage fishing in a sustainable way? What solutions do you propose for a sustainable fishing?)
5. Feelings or emotions for the fishing profession and the marine environment (Can you describe what you feel when you are fishing out at sea? How and why did you become a professional fisher? Is fishing challenging? What is important to you when you fish?)