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Bridging the Gap Between Experience-Based Knowledge and the Scientific Knowledge

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Abstract

The context for this study was to document fishers' experience-based knowledge is reliable and can be included in citizen science as supplementary information to scientific research. Fishers' experience-based knowledge contributes to important understanding of the environment and the marine ecosystem. Hence, fishers' knowledge over time is not always regarded as supplementary knowledge. There is a lack of information on how fishers have acquired reliable knowledge when they have not had formal scientific education and in what way fishers' knowledge can be used as empirical data. In this study, a survey was conducted by scientific educator within the fishing community of Mausund in Norway. The survey was limited to specifically targeting fishers' knowledge of the migration pattern of the edible crab (*Cancer pagurus*) in Sulfjorden, Mausund and Frohavet. This study performs in-depth interviews with five fishers at Mausund. The experience-based knowledge acquired by these fishers is first and foremost learnt through intergenerational learning from fathers, grandfathers, and uncles to sons. The study supports existing research on fishers' experience-based knowledge, which is professional and very precise. Experience-based and local knowledge can be understood as a knowledge contribution of value to the research field of environment monitoring.

Keywords: *Cancer pagurus*, toxic elements, environment, experience-based knowledge, citizen science

1. Introduction

Within science education, the educator contributes to both research and teaching in science, and the research in this context depends on the educator's subject area. In the process of the scientific research work, citizen science can contribute with supplementary information to the research field. Citizen science have different approaches to the construction of knowledge, and cover a wide range of scientific research (Haklay et al., 2021). There are many citizen science practices not even known, e.g. fishers who contribute to construction of knowledge, but there is still skepticism to further growth, and acceptance of citizen science, in many academic practices (Schade et al., 2021). In Education for Sustainability (EfS), there are many social scientific issues (SSIs), that are relevant within science education, such as environmental pollutants in marine species. Challenges related to environmental issues are compound and complex (Öhman, 2008). Toxic elements in brown meat in edible crab (*Cancer pagurus*) is a current topic and Averina et al. (2022) raised questions about what could be the sources of toxic elements the edible crabs ingest, based on the fact that there is concern about increasing values for several toxic elements , and that high values of toxic elements have been detected in patients. Fishers are a professional group that contributes with citizen science. There has been research interest in mapping out how fishers acquired knowledge, in terms of ascertaining how reliable the information the fishers provide is about aspects like the seasonal migrations and patterns of the edible crab. The fishers have experience-based knowledge and information that can contribute to increased understanding, but the fishers' knowledge is not always accepted and seen as supplementary information.

For many years students and researchers have been to Mausund to carry out environmental monitoring of edible crab, and they have collaborated with a local fisher. Mausund, in Frøya municipality in Central-Norway, is an active fishing community, and crab fishing is an important industry. The fisher has helped catch edible crab and has provided invaluable information about the areas the edible crab lives in. In dialogue and communication with the professional fisher during the fieldwork, the students and researchers have obtained information about the state of the ocean, the ecosystem of different species, changes in where the species live, pollution by marine litter, and many other aspects. The knowledge, or experience-based knowledge, that fishers in the Mausund community have, provides valuable additional information in research work, not least when there is focus on finding possible explanations for environmental impacts in the ocean, as increased levels of toxic elements in brown meat in edible crab at the coast of Central Norway (Ervik et al., 2018; Ervik et al., 2020).

In Norway, dense populations of edible crab can be found all along the coast north of the border between Nordland, and Troms and Finnmark counties. They also live between Hammerfest, 70º N (Troms and Finnmark County in Norway) in the north and Canary Island in the south, 28ºN (Woll & van der Meeren, 1997). Most edible crab prefer shallower waters (40 meters or less). They live on different substrates but settle and mature in kelp forests outside exposed coastlines. Male and juvenile crabs are less mobile than females. Both males and females prefer deeper waters in the winter, and edible crabs are observed at depths of more than 400 m (Bakke, Buhl-Mortensen & Buhl-Mortensen, 2019). Woll (2005), and Woll, Bakke and van der Meeren (2021) describe what characterizes the edible crab in Norway. The females have a very complex seasonal nomadic movement and pattern, due to their reproduction cycle and their ability to find enough food in different stages of their cycle. Large female crabs can migrate several miles. This results in the movement pattern seeming to be quite unpredictable. The quality of the female crab, in terms of edibility, may thus vary from year to year, even when caught in the same place (Woll, 2005).

Previously in Norway, fishing for edible crab took place from August to November (Woll & van der Meeren, 1997), but nowadays fishing takes place from summer June to October.

After the winter, the crab migrates up from the depths. In the period from spawning to hatching, female crabs stay at depths of 20-25 meters in areas with a sandy bottom, in combination with stones and overhang, and some dig into the sand (Woll, 2005). The life cycle of the crab is divided in a short pelagic stage, where spawned eggs and larvae drift with the ocean currents. The larvae molts seven times, and in the final juvenile stage they take on a crab-like form and settle to the sea floor in the intertidal zone until they reach a carapace of 60-70 mm and then migrate to deeper water. Most juvenile crabs prefer kelp forests as they are rich in food and provide good shelter.

There is research that substantiates that fishers' knowledge is credible, and claims that argue against this. Johnson (2010) states that fishers' knowledge must be verified by a process of translation before it becomes scientific knowledge. Fishers` experience-based knowledge can become a supplement to scientific knowledge and can be used as empirical data. Stephenson et al. (2016) point out that it is necessary to define the concept of knowledge when talking about fishers' knowledge research (FKR) and thereby being critical of incorporating FKR into all experience-based knowledge. Despite this, they emphasize that management and scientists value and integrate fishers' knowledge which is in one way described as spanning the boundary, because fishers contribute with knowledge such as gear design, deployment, and vessel operation. They also contribute with knowledge about bottom types, currents, and depths, and give information to scientists as to where and when to catch fish and about fish movement and behavior patterns, and thus in this way, fishers build their ecological knowledge. Scientists learn the complexities that fishers deal with, and the fishers learn about biology and fish biology in this two-way cooperation (Johnson, 2010). Johannes & Neis (2007) also describe fishers' knowledge as how habitat, season, weather, phases of the moon, and other factors affect sea life in different ways from year to year. Brattland (2013) describes fishers' experience-based knowledge as ancient knowledge that has developed in interaction with the environment, and that this knowledge is scientifically credible. Nevertheless, this credibility is questioned.

The highest motivation for fishers to accumulate knowledge is what helps their fishery activities (Sulamain, 2018). The fishers' knowledge is also called into question because they may have an underlying reason and use knowledge building to their own advantage in the fishing field (Brattland, 2013). The fishers' expertise is explained by Johnson (2011) as nonscientific knowledge.

Johnsen, Hersoug & Solås (2014) point out that after the 1990s, local ecological knowledge (LEK) has only been applied to a limited extent in Western fisheries and resource management. One of the reasons for this is that LEK does not fit into the models currently in use. They argue that LEK can become a central element in fisheries and coastal management in Norway, but then only when it is presented to fit into the frames of reference used in coastal management.

A research study conducted in the US showed that fishers have detailed knowledge of the spatial and temporal distribution of cod spawning in their local environment at Georges Bank and Nantucket Shoals, and have identified spawning grounds that were previously unreported in the scientific literature (De Celles et al. 2017). The fishers` knowledge was also used in a study of the southeastern Brazilian coast. In that study, the fishers´ knowledge was applied to investigate temporal changes in the amount (biomass) and composition (major ecological categories) of fishing resources (Lima et al. 2016).

Ames (2017) reported that fishers have spent much of their lives accumulating intimate, fine scale, ecological information that is not otherwise available. Fishers' understanding of biodiversity and fish ecology is important for management plans and scientific knowledge (Medeiros et al., 2018).

Quist (2018) followed fishers´ movement in the sea environment in coastal and offshore areas in Tabasco, in the Gulf of Mexico. One reason was to understand the fishers` embodiedness of their seafaring way of life, which cannot be articulated in words. The fishers have a movement-bound knowledge, in this case about how increased seismic activity and pollution associated with oil spill displace and kill marine life. The oil industry does not agree, and the environmental legislation only regards the oil industry`s knowledge as valid, and the fishers` local knowledge is excluded.

Anbleyth-Evans & Lacy (2019), argue that there is a need to overcome the general negative perception of the accuracy of non-scientist knowledge. They mean that fishers` LEK in England has developed through interaction with research. They conducted sixty interviews to understand fishers` LEK of biodiversity. Their paper involved interviews and participant observation of fishers in government workshops. They found that fishers` LEK is increasingly compatible with research.

Fishers` experience-based knowledge helps to detect if there are gradual changes in the environment, and it is important to take the fishers' concerns seriously. Lack of overview of species-related adaptations can lead to misjudgments of how the ocean climate changes, for example, *Cancer pagurus* is poorly equipped to compensate for change (Whiteley et al. 2018). Fishers' knowledge has proved to be an important additional tool in the monitoring of catches (Martins et al. 2018). Pollution associated with marine litter is, seen in context with climate changes, a threat of biological diversity, as the stress factors caused by climate change are added to the consequences of marine litter (Ford et al., 2022; Lincoln et al., 2022). Marine plastic debris are sources of emerging contaminants, (ECs) (da Costa et al., 2023; Scott et al., 2021), and furthermore environmental pollutants as toxic elements, adsorb on the surface of the marine plastic waste (Bradney et al., 2019; Liu et al., 2016).

In this study the researchers, who also are science teachers, will build knowledge that is necessary in science education, when working with subject as environmental pollutants in marine species, within EfS. It includes documenting of fishers` experience-based knowledge, which can contribute with reliable information within citizen science. There is still a knowledge gap as to what affects the crab throughout the annual cycle, and which factors affect the crab when it migrates to the depths in winter. In this work, fishers' experience-based knowledge is an important contribution.

The aim of our study was to map how fishers acquire experience-based reliable knowledge of the environment that can be used as supplementary documentation and empirical data in scientific research.

Our study was based on interviews with five fishers from Mausund in Central Norway. The survey was limited to specifically targeting the fishers' knowledge of the migration pattern of the edible crab (*Cancer pagurus*) at Mausund.

2. Method

This study was a qualitative study, where the focus of interest was to examine and understand how Norwegian fishers at Mausund acquire the experience-based reliable knowledge they use in their daily life as fishers. We focused on how the local fishers created their knowledge.

As empirical material, five in-depth interviews with experienced fishers were conducted. These represent a professional group that scientists contact for practical reasons, because the fishers know the coastal area well. We were interested in obtaining in-depth understanding, which can support similar research.

All the informants were male, and they are, or have been, active and experienced professional fishers.

The focus in the interviews was on the knowledge the fishers have of the migration pattern of edible crab *Cancer pagurus* during the year, and how they have acquired this knowledge. The knowledge of migration patterns represents experience-based knowledge, obvious in a way for the fishers, and tacit more than spoken.

The questions were based on curiosity about whether the fishers need to have special knowledge to fish and use the technological equipment and machines they have on board the fishing boats. It was also of great interest to ask them to talk about where they had obtained their experience-based knowledge. In this article, a particular focus is on the fishers' knowledge about edible crabs. In addition, they were asked questions about the environment in the ocean and about marine plastic pollution.

Open and selective coding of the transcribed material was carried out. The codes were sorted into categories, and these were further processed into a story, and furthermore to summaries and direct quotes from the interviews.

3. Results and Discussion

The focus in the interviews was on the knowledge the fishers have of the migration pattern of edible crab *Cancer pagurus*, and how they have acquired this knowledge.

Analysis of the transcribed interviews was through coding into three categories.

The categories were 1) experience-based knowledge, 2) The edible crab migration patterns, and 3) Additional information - Marine litter.

3.1 Experience-based knowledge

The information that emerged through the category experience-based knowledge, was first summarized into one story.

> **The story**
>
> For children born in coastal Norway between 1935-1960 it was common to participate in work from the age of 10. The children did not attend school every day. Therefore, they had to contribute to the daily work in their homes. The boys were with grandfathers, uncles, or fathers out fishing. They had to help to prepare before they went fishing, assisting during the fishing and the finishing work after fishing. This also applied to crab fishing. In this way, they gained experience. It is *experience* which older fishers set as a criterion for whether a child or youth is ready for fishing. According to the fishers, these practical experiences are not necessarily understood as knowledge. Children and adolescents notice how the older fishers oriented themselves on the ocean. They learn to locate the *med* (Note 1) by performing a cross-view and remembering the place to catch fish and edible crab next time they go fishing. They brought these experiences with them into adulthood when they began fishing themselves. This is acquired, experience-based knowledge. With technological development came chart plotters, GPS, and sonars. These are used partly or fully in fishing today. Communication between fishers entails exchanging experience and information flow in the fishing of both fish and edible crab. The fishers have, like other professional groups, their own context and common terms when communicating. The fishers' professional vocabulary, developed and transferred across generations, are concepts like *med*, *depth, shallow, fishing gear, seasons and temperature*. The fishers have these concepts and the concept meanings under their skin and are confident with them. This strengthens the fishers' reliability of experience-based knowledge.

The story describes how the fishers create experience-based knowledge about the edible crab's migration pattern at Mausund. They record the *meds*, the different positions during the season, and they can map the migration pattern in an area. Todal (2018) also use the term *med* in his book *Havlandet (The Sea Land).* Among older fishers *med* were, and still are, common for navigating. If there was fog, they could use the speed of the boat and measure the time to navigate to the right position.

One of the informants commented that performing a cross-view and remembering the place as a *med,* is not something you learn at school. There is concern that such knowledge gets lost, for young people who are growing now and want to work as fishers, rely on technology only to orient themselves on the ocean. Every fisher with experience, who knows about *meds* in the ocean, also knows the depth of the sea in this area, and they automatically register this in an old unit, but quickly convert it to meters when asked about it. A part of the fishers' job is to keep focused on the daily weather forecast. They also follow the temperature in the ocean, and they know where different species usually are at different times of the year. The prerequisite for fishing is knowing the fishing spots and knowing about the sediment conditions on the seabed and the depth of the sea.

When asked about what they should have experience of, an informant answered that they had to work with the line, handle the cheat machine and know how to handle the fish. He described this as practical skill.

When asked where he had learned what he could do, the informant replied that it was from his grandfather and uncle. He could be far out on the ocean with his grandfather and yet the grandfather could see viewpoints in the landscape and be able to tell where they were. In adulthood, the informant still wondered how the old men could find the fishing spots without echo sounder and chart-plotter. As he said, "I do not understand it." When asked whether he could read nature in the same way as his grandfather and his uncles, he replied affirmatively. This is a good example of how knowledge is transferred between generations. But it is also a good example of the fact that the fishers do not emphasize what they themselves have in terms of knowledge, or experience, as this fisher calls it himself. They were also asked if the positions were written down somewhere, but he replied that they had to remember those. Some wrote it down, others talked about the *med* to their sons or other friends, but it was each fisherman's secret business.

3.2 The Edible Crab Migration Patterns

According to the informants, edible crabs have seasonal migrations to a deep-water region with a depth of 100 – 400 meters. One of the informants had caught edible crab in halibut nets set at a depth of 400 meters in late autumn before Christmas. He told that, earlier, it was unusual to catch edible crab in fishing nets, but now it is more common. In summer, he catches edible crab in shallow water, and the catch is stable during the season. What is most interesting in this study is that the fishers can name where they know the edible crab have been living during different seasons around Mausund, and that they can confirm having caught crab at 400 meters depths in that area. This verifies what fishers have observed when the edible crabs emerge from great depths. In their study, Bakke et al. (2019) have, with an underwater camera, documented edible crab at depths of over 400 meters.

An informant said that edible crabs were marked by researchers in a place called Kya (63º N, 8º E). The marked crabs were later caught after a long walk, in Kvennværet or Froan (63º N, 9 E), and most of the crab that walked far away were female. He also said that before 1965 there were no crab in Røst and Lofoten (67º N, 12º E), but now the fishers also catch edible crab in this area. One reason why crab go further north, according to the informant, is because of the change to a higher temperature in the ocean. Woll et al. (2019) state that there has been a significant increase in sea temperature since 1980, which has led to the edible crab expanding their habitat to the north of Norway, and edible crab today are considered common west of Kvaløya in Troms (69°N, 18°Ø). Another informant said that a diver had observed edible crab digging down into the sandy bottom. Only their feelers were protruding from the seabed. The knowledge the local fishers have about the seasonal migration pattern of the crabs may assist in understanding the causes of the levels of toxic elements in brown meat of the edible crab, which exceed regulatory guidelines (Rosa et al. 2014). There are documented high levels of toxic elements in brown meat in edible crab (*Cancer pagurus)* in the area of Mausund (Ervik et al., 2018; Ervik et al., 2020).

3.3 Additional Information - Marine Litter

Both marine litter and climate change threaten biological diversity, and seen in context, greater damage is caused to biological diversity as the consequences of marine litter are added to the stress factors caused by climate change (Ford et al., 2022; Lincoln et al., 2022). More extreme weather and floods associated with climate change, will exacerbate the spread of plastic in the natural environment. Both issues occur throughout the marine environment, and ecosystems and species can be particularly vulnerable to both.

All the informants said they don't see huge amount of marine litter in the oceans, they sometimes get it in their fishing gears, but it is only when marine litter is washed ashore in the archipelago, that they realize there is an awful huge amount, and they said it is awful.

One of the informants also participated for a while as a coastal renovator in a company that carries out professional cleanup of marine litter throughout the year.

He said: “No, I'd say I've seen that there's been quite a bit of marine litter, but when I was involved in the daily cleanup in Froan archipelago, it really opened my eyes. I never dreamed of how large the quantities were, and I have no doubt that it will affect both the fishery and many other things, if there is not increased attention and action around this issue".

Another informant said: “The fish eat what floats [marine plastic debris] in the water masses, and other marine species eat what has settled [marine plastic debris] on the seabed”.

Thus far, there has been disagreement between researchers about whether the fishers' experience-based knowledge is reliable to be used as empirical material in assisting scientific research. In this study, the results show that fishers acquire experience-based knowledge about the migration patterns of the crab *Cancer pagurus* through interacting with older fishers in a community of practice. It is characteristic that this knowledge is so obvious and embodied to the fishers that they do not even think of it as knowledge. They call it experience.

The fishers’ expertise in bottom types, shallows, depths, *meds*, seasons, weather, phases of the moon, habitats, and how other factors affect the sea life in different ways from year to year, should be defined as reliable knowledge, and thus based on that, be defined as FKR.

Many studies have pointed out and argued that fishers' experience-based knowledge must be taken seriously into consideration and indicate that fishers' experience-based knowledge can become supplementary results to scientific knowledge, and fishers' knowledge can be used as empirical data. However, previous research also argues that fishers’ knowledge must be verified by a process of translation before it can become scientific knowledge (Johnson, 2010).

Today, fishers use technological equipment to determine a location. Young fishers can very precisely document different positions when using technological equipment, but do not learn to read nature in the way their fathers and grandfathers did. As one of the informants replied in the interview: “If the technology fails, then they (the young fishers) have to stay on land". Much of the experience that young people who choose to become fishers acquire will come from collaboration with older fishers: where to go to fish, and from the observations they naturally make when they are out fishing. Although they make greater use of technological equipment for navigating and mapping an area, the information the older fishers provide about different species in an ecosystem will be reliable information. The informants in this study have not left Mausund to go to high school and into higher education but have worked for many years as fishers at Mausund and can therefore provide information on how the composition of species has changed in a long-term perspective.

The fishers are worried about experience-based knowledge getting lost in themselves compared to their own forbears, and in new generations, mainly due to new technology. That this worry is justified, is supported by existing research such as Cristancho & Vining (2009) and White (2015).

Common to the informants was that they answered with very few words. The fact that they spoke so laconically reflects the fact that they are not used to explaining their professional knowledge. Their fishing skills are just something they know from experience, and they do not elaborate on it anymore. The fishers themselves call their knowledge experience. However, it should be called experience-based knowledge, and this is a kind of local, very precise knowledge that the fishers deeply embody. This is a notion also in other surveys. Medeiros et al. (2018) argue that for management plans and scientific knowledge, fishers' understanding of biodiversity and fish ecology is important. This is also supported by Ames (2017), who reported that fishers have spent much of their lives accumulating intimate, fine-scale ecological information that is not otherwise available. Johnson (2010) mentions that fishers` knowledge must be validated and translated into scientific knowledge, even if scientists themselves state that they learn a lot from fishers to understand the complexities of the marine ecosystem. Hence, Johnson writes, we must consider that fishers have an overview of the marine ecosystem which characterizes their knowledge, and further on that this knowledge should be incorporated as FKR (fishers' knowledge research), as Stephenson et al. (2016) described it.

The fishers have in common that they have a unique knowledge of nature. They have special knowledge about the rhythm of ebb and flow, about the phases of the moon, and the moon`s influence on fish and edible crab migration patterns. They know where the falls in the ocean are, and where the fishing grounds are. The fishers` knowledge has been transferred between generations from grandfathers, uncles, fathers, and by experienced older fishers. Some write it up in book form, but more commonly remember the places where it is common to catch fish and crab. The landmarks have been necessary for the fishers to be able to orient themselves on the ocean before chart plotters were taken into use. When asked where fish are caught, they state exactly the location, based on the characteristics of nature.

In our time, it is common to use chart plotters, where accurate position is registered. It is increasingly being used, and the older fishers' experience-based knowledge is in danger of disappearing. As Christanco & Vining (2009) describe, experience-based learning is replaced in the young generation by conceptual learning in school. This does not necessarily mean that younger fishers are becoming less reliable in documenting observations. They will orient themselves on the ocean by using technology, and their documentation of positions where species are observed will be precise. A part of a fishers` life in the future will still be to share information with other fishers, and share experiences in communities of practice where a social dimension is strongly present. Moreover, in the future, fishers will have to be precisely focused, and then they are dependent on fellow fishers.

As Johnsen et al. (2014) state, one challenge is that LEK (local ecological knowledge) does not fit into the models or the governance instrumentation for ecosystem management. One way to improve this situation is, as Knol (2013) points out, to develop a framework which can be a governance instrumentation.

Several studies (Ames, 2017; Anbleyth-Evans & Lacy, 2019; DeCelles et al., 2017; Lima et al, 2016; Martins et al., 2018; Medeiros et al., 2018; Quist, 2018, and Whiteley et al., 2018) share common arguments stating that fishers have very exact local knowledge that must be taken more into consideration than before. This study supports those arguments and existing research on fishers' experience-based research, also mentioned as non-scientist knowledge. As Öhman (2008) describe, environmental issues are compound and complex. It is therefore necessary to use several sources when collecting data to gain a good understanding of the environment. The fishers` experience-based knowledge will support and strengthen scientific knowledge.

In this study, we have had special focus on how fishers acquire knowledge about the edible crab`s migration patterns, using landmarks and current technology, and acquiring unique and reliable knowledge about the marine ecosystem.

4. Conclusion

The empirical material consisting of interviews with five fishers from Mausund in Central Norway, were analyzed with a qualitative method. The experience-based knowledge acquired by the fishers in this study was first and foremost learnt through intergenerational learning from fathers, grandfathers and uncles and passed on to sons. The knowledge was learned through interacting with older fishers in a community of practice, doing what the older fishers did, together with them. In this intergenerational community and experience-based learning, a professional vocabulary was developed: *med, depth, shallow, fishing-gear, seasons,* and *temperature* These are examples of concepts that are much more than simply words. Instead, these concepts are part of the fishers' skills and knowledge, with great and precise details.

The fishers did not present their knowledge in a rigid system such as tables and graphs, but combined the information they provided within a concept, a summary of one or more days they have been out in the field to fish, which also described what they did in their work when they recorded the data and stored it in their memories. It seems that fishers are to a greater extent consulted when fishing and coastal management are to be discussed. Fishers' knowledge must be formalized to be used as empirical data. When scientific researchers through conversations with fishers receive relevant and useful information, the researchers should make it visible and use the fishers' summaries and stories as raw material and systematize the fishers' findings and data, so that the data the fishers contribute, can be recorded in a scientific way under method, results and/ or during discussion, when reporting scientific articles. In this way, fishers can contribute with experience-based reliable knowledge as empirical evidence in scientific research.

This study supports what previous research shows, which is that the professional group of fishers contributes with invaluable knowledge of the environment in the ocean, and of changes they register in the ocean over a long period of time. For science education, this is also valuable information. When working with compound and complex issues such as environmental challenges in the ocean, as a theme in EfS, the additional information from the fishers will contribute to an overall picture, which only data from results on toxic element in edible crabs cannot provide.

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Note

Note 1. looking at landmarks and the place of the cross-view point is called med in Norwegian.