Food security and safety in fisheries governance

A case study on Baltic herring

Pihlajamäki, Mia; Sarkki, Simo; Haapasaari, Päivi Elisabet

Published in:
Marine Policy

DOI (link to publication from Publisher):
10.1016/j.marpol.2018.06.003

Publication date:
2018

Document Version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
Pihlajamäki, M., Sarkki, S., & Haapasaari, P. E. (2018). Food security and safety in fisheries governance: A case study on Baltic herring. *Marine Policy*, *97*, 211-219. https://doi.org/10.1016/j.marpol.2018.06.003

Marine Policy 97 (2018) 211–219

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Food security and safety in fisheries governance – A case study on Baltic herring

Mia Pihlajamäki[a,b,c,*], Simo Sarkki[d], Päivi Haapasaari[b,e]

[a] Water Resources and Environmental Engineering Research Group, University of Oulu, P.O. Box 4300, FI-90014 Oulu, Finland
[b] Ecosystems and Environment Research Programme, Faculty of Biological and Environmental Sciences, University of Helsinki, P.O. Box 65, FI-00014 Helsinki, Finland
[c] Faculty of Management, University of Tampere, FI-33014 Tampere, Finland
[d] Cultural Anthropology, Faculty of Humanities, University of Oulu, P.O. BOX 1000, FI-90014 Oulu, Finland
[e] Innovative Fisheries Management (IFM), Department of Planning, Aalborg University, Rendsburggade 14, DK-9000 Aalborg, Denmark

ARTICLE INFO

Keywords:
Participatory backcasting
Catch use governance
Paradigm shift
Forage fish
Dioxins

ABSTRACT

One of the objectives of the EU Common Fisheries Policy (CFP) is to increase the contribution of fisheries to fish food availability and self-sufficiency. Still, the use of catch is often a secondary concern in fisheries governance and management – or not a concern at all – while the focus is on harvesting. This paper examines how the use of forage fish for human consumption can be increased within the limits of sustainability, using Baltic herring as a case study. Baltic herring contains high levels of dioxins and the human consumption is very low: the catches are mostly used for industrial purposes. The paper uses a participatory backcasting exercise to define a desirable future vision for the use of Baltic herring catch and to develop pathways of actor-specific governance actions to increase the use of the fish as a safe-to-eat food. The results reveal that increasing the contribution of forage fish, such as Baltic herring, to food security entails a paradigm shift in fisheries governance that involves 1) inclusion of well-defined objectives for catch use in the EU CFP and the related regional multiannual plans, 2) broadening the scope of the MSY-driven governance and management to one that addresses catch use, and 3) proactive catch use governance.

1. Introduction

The recently reformed EU Common Fisheries Policy (CFP) calls for increased contribution to food security while “paying full regard” to food and feed safety to decrease the dependence of the EU fish and seafood market on imported products [14]. The growing demand for fish in the EU [19] has been met mainly by importing fish from non-EU countries, including developing countries, and increasing aquaculture production [17,44,65]. These are of concern, because the former may weaken food security in the poorer regions of the world [2], and the latter has adverse effects on the marine environment [27,61]. In addition, many fisheries around the world have been exploited at intensities that have driven fish stocks far below the maximum sustainable yield (MSY) levels [3]. At the same time, small pelagic species, the largest group in capture fisheries, have been used primarily for industrial purposes [20,62], despite the repeated call by the UN to prioritize the resource for human consumption [21,24,25].

The reformed EU CFP raises food security as a new issue to address and to aim at in fisheries governance. However, it identifies aquaculture as the only strategy to increase food security, while the contribution potential of small pelagic forage fish that have been underutilised from the perspective of food security is not mentioned. Instead, the European Parliament and Council have emphasized that “all fishery products landed, including those that do not comply with common marketing standards, may be used for purposes other than direct human consumption” [15]. This indicates that currently there is no interest to govern the use of the catch at the EU level and that the trend of reducing wild captured fish into feed is likely to continue unless the issue is more explicitly addressed.

At least two explanations can be identified for the apparent limited interest in governing the use of the catch. First, fisheries governance has evolved from the need to control the use of common-pool resources in an ecologically sustainable manner [28,41,43]. The MSY principle, which aims to restore and maintain fish abundance above the levels that can produce the largest yield [14], has been the main tool to govern harvesting [18,39]. Owing to the over-riding aim of fisheries governance to maximise the harvest in an ecologically sustainable way (see e.g. UN Law of the Sea, EU CFP, UN Sustainable Development

* Corresponding author at: Faculty of Management, University of Tampere, FI-33014 Tampere, Finland
E-mail addresses: mia.pihlajamaki@uta.fi (M. Pihlajamäki), simo.sarkki@oulu.fi (S. Sarkki), paivi.haapasaari@helsinki.fi (P. Haapasaari).

https://doi.org/10.1016/j.marpol.2018.06.003
Received 29 September 2017; Received in revised form 7 June 2018; Accepted 8 June 2018
Available online 17 July 2018
0308-597X/

Goals) and the narrow definition behind the MSY principle, many other issues and objectives, such as food security, are not explicitly addressed by the fisheries governance [52]. Second, commercial fishing has been treated as business activity that is largely driven by economic objectives [56] and therefore fisheries governance has tended to rely on market-based mechanisms and self-organising fishers to maximise economic growth [6]. Although the use of the catch can be affected by governance mechanisms that are imposed on the fisheries sector, such as food safety requirements, trade policies [64], and sustainability certifications [47], catch use is ultimately determined by market conditions, i.e. demand, costs and revenue [56], which Stephenson et al. [59] have considered largely uncontrollable by fisheries governance and management.

The aim of this paper is to examine how food security and safety issues could be integrated in fisheries governance. The paper defines food security as "physical availability of food, economic and physical access to food, food utilisation, and stability of the three dimensions over time" [23]. Food safety refers to the quality of the product, namely that the fish is safe to eat [16,25]. The paper uses the governance of Baltic herring (*Clupea harengus*) fisheries as a case study to explore how the contribution of forage fish to food security could be increased. Baltic herring has been regarded as an abundant and sustainable resource [33,34], but as the majority of the catch is used for industrial purposes, the species has a great contribution potential to food security. After the collapse of the Baltic cod stock in the late 1980s, Baltic herring and sprat have been the main commercial catch species in terms of volume in the Baltic Sea [73]. However, the relative importance of Baltic herring varies between the nine Baltic Sea riparian countries: while all nine countries have a herring fishery, the largest annual herring quotas have been allocated to Finland and Sweden, circa 40% and 20% respectively [33,34].

The paper is structured as follows. First, a background of the use of Baltic herring catch and food security and safety in fisheries governance is provided. The methods section describes a participatory backcasting method that was applied to define a desirable future state for the use of Baltic herring catch and to create pathways of actor-specific governance actions towards concrete acknowledgement of food security and safety in fisheries governance [54]. This is followed by a discussion on how to increase the contribution of Baltic herring to food security within the limits of sustainability from the perspectives of the abovementioned obstacles for catch use governance, namely the aquaculture-driven food security policy, the MSY-driven fisheries governance and management, and the market-driven catch use governance.

2. Background

2.1. The use of the catch

Baltic herring has been a traditional source of food in many Baltic Sea countries, but over the past few decades the demand for it as food has decreased to an all-time low [26,42] and instead, the majority of the catch has been fed to fur animals or reduced to fishmeal and oil [33,38]. In Finland, for example, around two thirds of the catch have been used to feed fur animals since the 1980s [57,58]. One plausible explanation for the decreased demand for Baltic herring as food is related to the simultaneously increased demand for and supply of farmed salmon and rainbow trout, and canned tuna [26,40,42]. In addition, Baltic herring is consumed mainly by elderly people [26,40], which implies that in the future the demand is likely to decrease further unless the demand for herring products amongst younger people begins to increase. The use of the catch is also affected by the conventional and largely-accepted focus of the Baltic herring fleets on targeting herring primarily for industrial purposes [38]. This decreases the availability of Baltic herring suitable for human consumption.

From the food safety perspective, the potential to use Baltic herring for human consumption is restricted due to high concentration levels of dioxins, which often exceed the maximum allowable level established by the European Commission for food and feed [10]. Dioxins are persistent organic pollutants (POPs) that accumulate in the fatty tissue of herring and are known to have adverse impacts on ecosystems and human health [1,30]. The dioxin concentrations have been decreasing from their peak in the 1970s, but the problem still remains in many parts of the sea [71]. Currently, herring from the southern and western parts of the Baltic Sea is considered to be compliant with the regulation, while large herring[1] from the northern and eastern parts, is likely to exceed the maximum allowable dioxin level [9].

As a result of the dioxin regulation [10], the EU Member States are not allowed to place fish that exceeds the maximum allowable level of dioxins on the EU food market. However, Finland, Sweden, and most recently Latvia, have been granted an exemption to place such fish on their national markets, providing that they inform consumers of the related health risks [13]. The main arguments behind the exemption request in Finland and Sweden include cultural importance of Baltic herring, health benefits related to fish consumption and the need to protect fishermen's livelihoods [1]. The exemption is particularly crucial from the Finnish perspective, because the nation's most important commercial fishery operates mainly in the Gulf of Bothnia [46], where the dioxin concentrations are the highest, but also since the traditional Finnish herring dishes are made exclusively of large herring.

The other Baltic Sea countries, which could also apply for the exemption, but have chosen not to, have implemented alternative strategies. For example, in Estonia, where the majority of the catch is used for direct human consumption, the strategy is to target small, safe-to-eat Baltic herring to gain access to the EU market [7]. Whereas in Denmark, the majority of the Baltic herring catch is used for industrial purposes [8]. Russia, the only non-EU member state in the Baltic Sea region and therefore the only country unaffected by the dioxin regulation, has been a significant buyer of Baltic herring intended for direct human consumption. In mid-2014, the exports to Russia came to halt as a result of the sanctions between the EU and Russia related to the crisis in Ukraine. This share of the catch has been since used mainly for industrial purposes [46]. The fish fed to fur animals is not limited by the regulation, but the feed used in aquaculture is. However, over the past decade the removal of dioxins from the fishmeal and oil during the production process has become cost-efficient, and therefore, the use of Baltic herring as feed in aquaculture has been increasing [58].

2.2. Food security and safety in fisheries governance

Baltic herring fisheries are governed in a multi-level setting. Within the formal governance system, decisions on fisheries management and regulations are made at the EU level and their implementation is carried out at the national level. In addition, there are two regional bodies: the Baltic Sea Fisheries Forum (BALTFISH), which is a platform for cooperation between the EU Member States in the Baltic Sea region on fisheries management, and the Baltic Sea Advisory Council (BSAC), which is a stakeholder forum.

The management of Baltic herring fisheries is realised via the EU CFP and the related multiannual plan for the stocks of Baltic cod, herring and sprat [13]. These policies do not address the use of the herring catch explicitly. This has not always been the case: between 1977 and 1998, the direct fishing and landing of herring for purposes other than human consumption was prohibited in the EU on the basis of overexploitation and declining herring stocks [11,12]. Thus, if there is political will, the EU enforcement power could be harnessed also to enhance the contribution of Baltic herring to food security.

In the absence of formal top-down arrangements, bottom-up initiatives have emerged to enhance the use of fish as food in a sustainable way. The Marine Stewardship Council (MSC) is an international

[1] For ICES subdivision 28.1 the limit for large herring is 21 cm, for other subdivisions it is 17 cm.

non-profit organisation, which works together with fisheries, scientists, and seafood producers and brands to certify sustainable fisheries. In the Baltic Sea, the Western Baltic spring spawning herring fishery has been certified to the MSC standard in 2015, while the Finnish herring fishery was entered into the assessment in early 2017. Similar certification, provided by the Aquaculture Stewardship Council (ASC), is available for farmed fish, such as Rainbow Trout, and it entails that the fish used as feed is MSC certified. Other examples include: the John Nurminen Foundation's Local fish project, which combines nutrient recycling and increased fish food availability and self-sufficiency by bringing domestic cyprinid fish to plates; the WWF sustainable fish guides, which help consumers to make responsible choices when purchasing seafood products; and the work of the Finnish Pro Fish Association, which aims to increase public awareness of domestic fish products.

3. Material and methods

A participatory backcasting method [48,54,55] was used to develop concrete suggestions to increase the use of Baltic herring as food. The backcasting exercise was arranged as part of a two-day expert workshop on the dioxin problem of Baltic herring organised in Copenhagen, Denmark, in February 2016. Eleven fisheries and dioxin experts, representing fishermen, producer organisations (both food and feed), researchers, administration, and non-governmental organizations,[2] were engaged to produce recommendations and paths to achieve a desirable future point [36,49,54,55].

Backcasting is a normative scenario method that can be useful to study transformations to a more sustainable world [55,69]. The rationale behind the method is to work backwards from a desirable future state to the present, in order to identify actions needed to reach the desired state, and to assess its feasibility and implications [53,54]. Backcasting scenarios can be policy-relevant when they connect long-term objectives to short-term decisions and actions [32]. Thus, they can facilitate achieving policy objectives by determining concrete stakeholder-specific actions and steps for that. Stakeholders and scientists are often engaged in the backcasting exercise to co-produce the normative scenarios and recommendations [5,55,72]. Therefore, a heterogeneous group of experts was invited to the workshop [31,63] to identify 1) governance actions to increase the use of Baltic herring for food, and 2) actors capable of executing the actions by moving beyond current state and "business-as-usual" trajectories [70]. The focus of both the workshop and its analysis was on "who should do what" rather than "who said what", in order to identify a diverse set of actions and actors to address the question, also beyond the stakeholder groups involved in the workshop.

The backcasting exercise comprised three main steps. First, the experts were asked to define future visions for the use of the Baltic herring catch and the dioxin problem of herring. The suggestions were deliberated, and it was agreed that the main vision to be used in the exercise was to increase the use of Baltic herring for human consumption significantly by 2040. This particular end-point was considered suitable for this purpose as it was close enough to the present time for the issue to remain relevant, and far enough to allow changes to take place. The research team further divided the vision into three more specific sub-targets for the backcasting exercise based on the suggestions and deliberations: 1) 35% of the total Baltic herring catch is used for human food in Baltic Sea countries, 2) 40% of the total Baltic herring catch is exported and consumed as human food, and 3) dioxin level in Baltic herring used for human food decreases to a safe level. Second, the experts were divided into three parallel working groups to develop paths and milestones to reach each target, respectively. This was followed by the third step, which was to identify stakeholder-specific governance actions that are needed to reach the milestones and the ultimate target. The discussions were supported and structured by backcasting tables into which the actions, and the actors needed to support their execution, were recorded. The discussions were also tape-recorded and transcribed after the workshop to ensure that material not included in the tables was also part of the analysis.

For the purpose of this paper, the collected material was analysed from the perspectives of 1) ensuring that the dioxin problem is under control (food safety), 2) increasing the use of Baltic herring for human consumption (food security), and 3) division of responsibilities between actors. In order to enhance the credibility of the results, the empirical material was triangulated [63] with secondary material, including empirical material from the other sessions of the workshop,[3] literature, policy documents and statistical databases. The results are presented in the next section.

4. Results

4.1. Pathways to get the dioxin problem under control

> "Dioxin is a killing factor. (…) Dioxin is the bottleneck for further development of markets." Representative of a fishermen's organisation, Sweden

The experts considered getting the dioxin problem under control as a prerequisite for increasing the contribution of Baltic herring for the food security objective. Although exports outside the EU are not restricted by the dioxin regulation, exporting fish that does not meet the EU's own safety criteria was considered an unsustainable and unethical strategy in the long-term as awareness and social responsibility grow. Therefore, a set of pathways relating to how to get the dioxin problem under control were created. These are presented in Fig. 1 and the key actions include: 1) using small, safe-to-eat herring for human consumption, 2) developing fisheries management strategies to decrease the dioxin levels in Baltic herring, 3) dealing with dioxin sources, 4) changing dioxin risk management and 5) reducing the overall dioxin exposure by reducing the dioxin risk of other foods. These are complementary to each other and provide a way to deal with the dioxin problem at different timeframes ranging from immediate to long-term (2040).

In the short term, the key action identified by the experts to get the dioxin problem under control was to sort the catch and use small, safe-to-eat Baltic herring for direct human consumption. It was stressed that this action could increase the contribution of Baltic herring to food security significantly, owing to the large abundance of small under 17 cm herring in the catch (see e.g. [7,51]). To increase this share further, it was suggested that fisheries could employ size-selective fishing to target explicitly smaller fish by using certain mesh sizes and fishing closer to the sea surface (see also e.g. [51]). However, employment of size-selective fishing on a larger scale was noted to require further development of methods and practices.

> "This is what we do in Estonia, we sort out 10% and the rest complies with the regulation. This means that 90% we can use for human consumption. (…) This is one of the most efficient ways to do it (to increase the supply of compliant herring on the market)." Representative of food safety authority, Estonia

Increasing the use of large, non-compliant Baltic herring as food was also seen as possible within safe limits. The rationale for this was twofold. First, it was noted that the Finnish and Swedish dioxin risk

[2] The experts were from Finland, Sweden, Denmark and Estonia, because the workshop was carried out as part of the BONUS GOHERR research project, which focused on these four case study countries.

[3] In addition to the backcasting exercise, roundtable discussions were organised on four main topics: 1) the implications of dioxins to herring fishing sector, 2) global prospects for Baltic herring fishery, 3) dioxins as a public health problem, and 4) consumers' fish-eating habits.

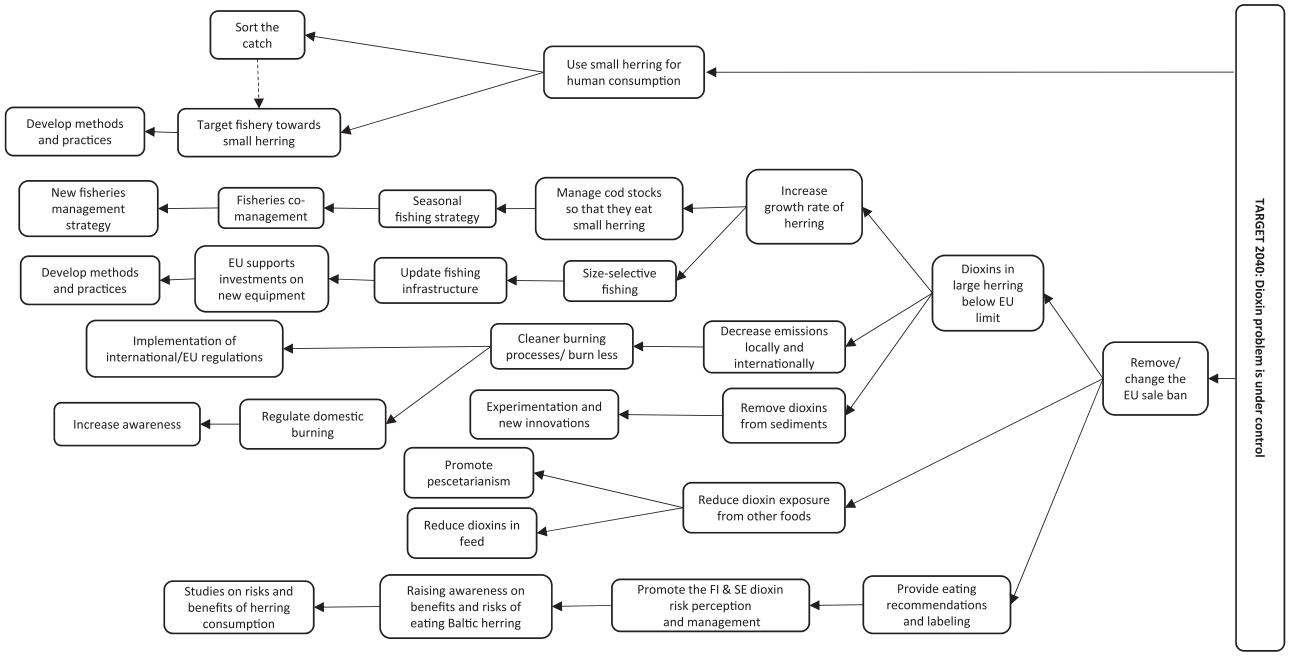

Fig. 1. Pathways developed by the experts to get the dioxin problem under control by 2040.

perception and management, which allows the consumption of large Baltic herring based on public dietary recommendations, could also be adopted by the other EU countries [25,67]. This was considered plausible, since the risks relating to dioxin exposure are subject to great uncertainties and the maximum levels for dioxins in Baltic fish are ultimately set through political decision-making processes, which as Assmuth and Jalonen [1] have pointed out involve "value judgement, conventions and pragmatism". Such change in dioxin risk management could open access for all Baltic herring products to the EU market and therefore lead to increased consumption. Second, it was argued that in Finland and Sweden, where the exemption is applied, and people consume mainly large Baltic herring, the consumption in general is so far below the recommended maximum intake that it could be increased manifold within safe limits. According to Tommila et al. [66], such an increase could replace circa 10% of the imported fish in Finland.

> "There should be information (in stores and restaurants) about the advice and if people see that once a week is ok for large part of the population, then I would believe that they'd eat more. So there is already potential to increase the consumption now within the current dioxin problem." Representative of food safety authority, Sweden

In the long term, the key actions identified by the experts were to change and ultimately remove the EU sale restriction. Three sets of pathways relating to this were created. First, it was stressed that the dioxin sources need to be addressed in order to decrease the dioxin levels in Baltic herring to a safe level. Reducing long-distance and local emissions was considered the most important action but exploring the feasibility of removing dioxins from the Baltic Sea sediments was also suggested (see also [71]).

Second, the experts suggested that the Baltic Sea fish stocks could be managed in a way that reduces dioxin levels in Baltic herring. The rationale behind this was that the faster the herring grows the less the dioxins accumulate (see also [45]). Thus, the growth rate of herring could be increased by removing small herring extensively and thereby allowing the juveniles to grow faster (ibid. [46]). It was suggested that this could be done by 1) managing Baltic cod fishery to increase predation on small herring, or 2) size-selective fishing. The former was noted to entail stricter regulation on the Baltic cod fishery in order to allow the stocks to grow, but this was expected to be an unpopular action due to the implications to the cod fishery. The latter option was therefore considered more suitable as it is a more technical issue and regards the Baltic herring fisheries alone, although the technical feasibility of the action was contested (see also [74]).

Third, it was suggested that the dioxin risk related to Baltic herring could be reduced by reducing the human exposure to dioxins caused by other food stuffs. The experts pointed out that this could be done either by promoting low-meat and low-dairy diets or by reducing dioxins in animal feed.

> "Intake of dioxins of a vegetarian, let's say lacto-ovo-vegetarian, is much, much, lower than regular consumer's. If you eat fruits and vegetables you decrease consumption of animal products and that will have a good effect on dioxin intake. Everyone should be vegetarian and dioxin would then not be a problem." Representative of food safety authority, Sweden

4.2. Pathways to increase the use of Baltic herring as food

The pathways to increase the contribution of Baltic herring to food security are presented in Fig. 2. They include actions to increase the use of Baltic herring as food and fish feed, and also actions to establish the production of fishmeal and oil for direct human consumption. Regarding the first one, the pathways culminate in accessing the fish food markets, which was not considered to be affected only by the dioxin problem, but also by limited supply of Baltic herring suitable for human consumption and low demand in the Baltic Sea region.

Increasing the supply was believed to necessitate structural changes within the fishing industry. More precisely, the experts called for a shift from feed to food-directed fishing, which was acknowledged to require investments in on-board freezing equipment in large vessels or increased use of small vessels that land their catches locally and regularly, thereby guaranteeing a continuous supply of Baltic herring suitable for human consumption.

> "Because the Finnish vessels fish where they do, there's no point for the big vessels to go out for one day and come in and freeze for human consumption. They stay out for a week. This means that the first, second and third trawl are for fishmeal and the last trawl for

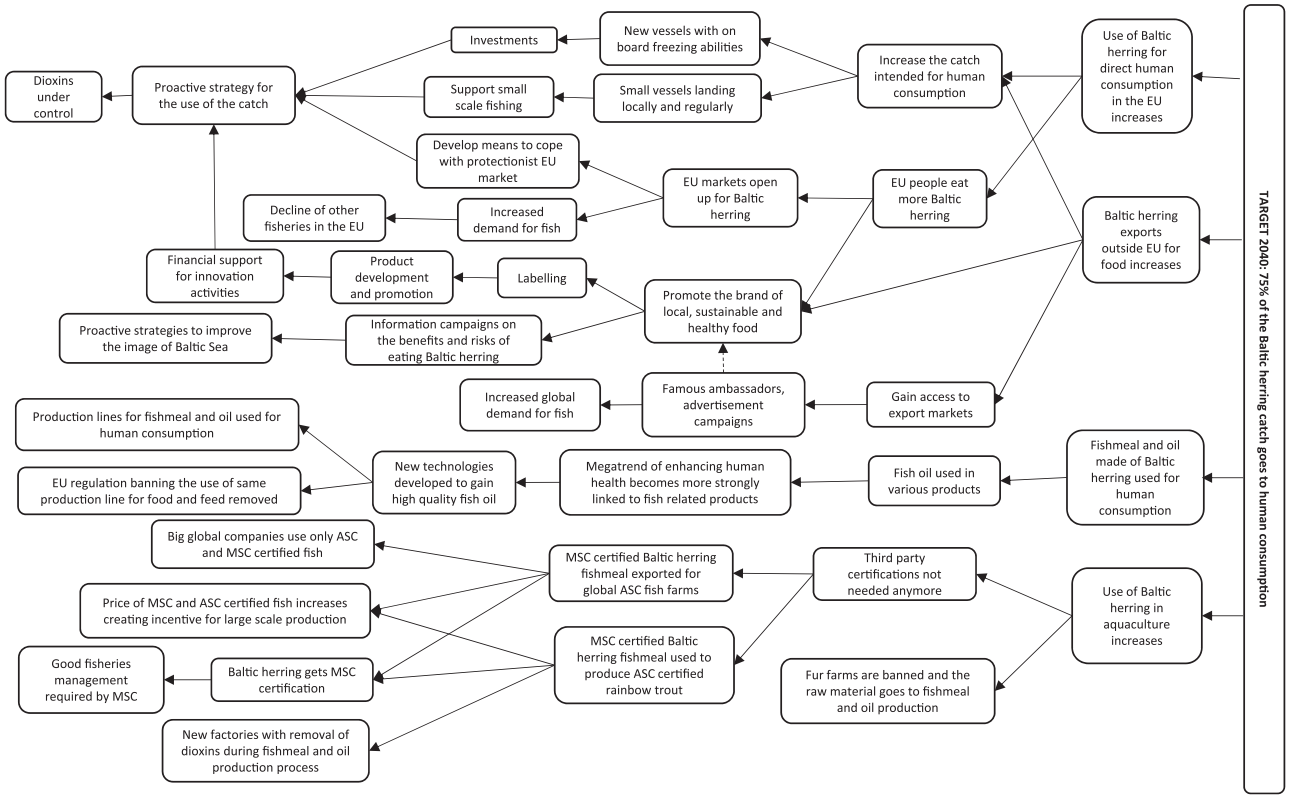

Fig. 2. Pathways developed by the experts to increase the contribution of Baltic herring to food security by 2040.

human consumption." Representative of a fishermen's organisation, Estonia

"Then we have a problem with the structure of the industry. They (vessels) tend to be very large ones and landing bulks in Skagen (Western Danish coast). We need small vessels landing locally and regularly." Representative of a fishermen's organisation, Sweden

Implementation of such structural changes, although necessary to meet the target, was considered risky as long as the market for Baltic herring food products is underdeveloped and there are uncertainties relating to the demand. However, the experts were optimistic that the demand could be increased through the following actions: 1) investing in the development and promotion of new and traditional products made of both small and large Baltic herring, 2) using certifications and other labelling as marketing tools to brand and promote local, sustainable and healthy Baltic herring products, and 3) creating strategies and information campaigns to improve the image of Baltic herring as well as the Baltic Sea, which was noted to suffer from a poor image as a sea with many environmental problems.

In addition, creating and developing markets for Baltic herring in and outside the EU were called for. The European fish market was viewed as very competitive and protective of the existing market shares, and therefore carefully planned strategy was suggested to open the market for Baltic herring. The fish markets outside the EU were noted to provide a huge potential for increasing the use of Baltic herring as food due to increased demand for fish and the current poor state of many wild captured fish stocks. For example, the Estonian fisheries representative noted that the demand in China is already "so huge that we must combine from all the Baltic to satisfy", but he continued that gaining access to large export markets, such as the Chinese market, can be a slow and bureaucratic process.

"If you want to export you have to be approved by different authorities so it takes a lot of time (to create an access on the Chinese market), two years." Representative of a fishermen's organisation, Estonia

Owing to the dioxin problem, reducing Baltic herring to dioxin-free fishmeal and oil was considered an important way, especially in the short term, to increase the contribution of Baltic herring to food security. The identified actions to develop domestic and export markets included new factories that are able to remove dioxins from the product and the use of certifications that indicate the environmental and social responsibility of seafood production. The growth potential of fish feed made out of Baltic herring was thought to be restricted by the high and steady demand from the fur industry. In contrast, the experts stressed that there are synergies between direct human consumption and aquaculture production if the by-products from food processing (e.g. the waste that remains after filleting) are used in feed production (see also e.g. [20]).

"My vision is that the whole catch goes to human consumption and only the filleting waste goes to meal and oil industry." Representative of a fishermen's organisation, Finland

Finally, actions to create a market for Baltic herring fishmeal and oil for human consumption were identified. These included responding to the growing demand for healthy fish products, and investing in new production lines or, alternatively, revising regulations to allow the production of fishmeal and oil for human consumption in the same production line as for feed.

"The Danish factories don't produce fishmeal and oil for human consumption, because of the legal regulation. They are not allowed to use it. Because they are considered by-products. Completely same factories in Peru can produce for human consumption, but not in Denmark. But they are trying to change it. It should be the products, the quality of the products that decides whether it can be used or not." Representative of fishmeal and oil industry, Denmark

Table 1
Actor-specific governance actions developed by the experts to get the dioxin problem under control and to increase the contribution of the Baltic herring fisheries to food security by 2040.

	Governance Actions	Policy	Markets	Civil society	Science
Actions to get the dioxin problem under control	**Use small herring for human consumption**	Sorting to be made mandatory.	Campaigns to promote the consumption of healthy fish.	Campaigns to promote the consumption of healthy fish.	Assessment of area-specific percentages that need sorting out.
	Manage the Baltic Sea fish stocks to decrease the dioxin levels in Baltic herring	Make herring grow faster by increasing quota for herring or reducing quota for cod.	Decision to target small herring (size-selective fishing).		Technical feasibility, and socio-economic and environmental impacts of size-selective fishing, increased fishing pressure and increased predation.
	Deal with dioxin sources to decrease input to the Baltic Sea	Political decisions and investments. Implementation of existing regulations and control. Public campaigns on raising awareness.	Development and implementation more efficient dioxin removal processes.	NGO campaigns to raise awareness, public pressure to act or not to act.	Scientific evidence on the role of different sources and how they could be reduced.
	Change dioxin risk perceptions	Adoption of Finnish and Swedish dioxin risk perceptions and management in other EU countries.	Promote new dioxin risk perception and management.		Dioxin risk and benefit analysis.
	Reduce dioxin risk by reducing dioxin exposure from other food	Policy integration to promote healthier diets and climate mitigation (more vegetables and fish, less dairy and meat).	Promotion of healthy food choices.	Campaigning based on science.	Research on health, climate and other impacts of different foods.
Actions to increase the contribution of Baltic herring fisheries to food security	**Increase the amount of herring used for human consumption in EU**	Financial support from the EU and states to develop new products and promote the brand. System guaranteeing that the products entering the market are safe to eat.	Development and marketing of new products, promotion of traditional products. Investments and innovations from market actors (mainly food industry).	Developing image of local, healthy and sustainable products. Fisheries related voluntary organisations disseminating and advertising the products. MSC certification.	Involved in developing new products. Health studies. Develop methods to reduce oxidating (aging) of the product.
	Increase the amount of herring exported outside of EU for food	Good international relations with other countries.	Creating new trendy products and active marketing.	Ecolabels and certifications important competitive advantage, promoting the image and brand of Baltic herring. Ambassadors to promote the products.	Market studies to scan opportunities. Health studies to communicate potential risks and benefits. Socio-cultural value studies to find consumption patterns.
	Certification (MSC/ASC) of herring products	Implementation of multi-species management plan, support fisheries to adopt certificates and science to assess and develop standards.	Decision to apply for and use certifications. Financial investments.	Power of consumers to choose products, open and inclusive certification processes.	Certification assessments, audits and development of standards.
	Use fishmeal and oil made of Baltic herring for human consumption	Removal of by-product restrictions. New EU rules and regulations.	Developing the market.	MSC certification.	Studies relating to quality, monitoring and health.
	Increase the use of Baltic herring in aquaculture	Good management required by the MSC certification.	Use certifications to increase use of herring in aquaculture production.		

4.3. Actor-specific governance actions

The actor-specific governance actions identified by the experts are summarised in Table 1. As demonstrated by this summary, several actors can play a meaningful role in the implementation of the identified actions needed to reach the targets. The responsibilities of the formal fisheries governance system would include revising policies (e.g. making sorting compulsory) and providing financial support to actions implemented by the other actors. However, the identified actions cannot be implemented only by the fisheries governance system. For example, actions from the health sector would be needed to revise the food safety regulations. Similarly, to deal with the dioxin sources, actions from the environmental sector, in collaboration with the polluters, would be needed.

The actions relevant for market actors, such as the fishing and food industry, would be mostly related to the investments needed for product development and marketing, although their role as lobbyists was also acknowledged. Civil society's role in implementing the identified actions would be first and foremost related to improving the image of Baltic herring and providing certifications. Science would be needed to increase understanding on the risks and benefits relating to fish consumption, and also to explore the potential socio-economic and environmental impacts of the suggested actions such as size-selective fishing.

5. Discussion

The results of the paper show that there are multiple ways to increase the use of Baltic herring as safe-to-eat food. The developed pathways comprise direct and indirect ways to contribute to food security in the EU and globally, both in the short and long-term. This implies that the use of the catch is not as uncontrollable as perhaps previously thought [59]. Based on the results, the paper identifies three main shifts needed to support the integration of food security and safety in fisheries governance: 1) from an aquaculture-driven food security policy to one that also defines targets and measures for forage fish that have been underutilised from the perspective of food security, 2) from the narrow MSY-driven fisheries management and governance to a broader perspective that addresses what happens to the catch after landing, and 3) from a market-driven approach to proactive catch use governance to increase demand and supply within the limits of sustainability.

First, the trend of reducing wild captured fish to feed is likely to continue as long as the EU CFP defines aquaculture as the only strategy to increase fisheries' contribution to food security. Such a narrow strategy ignores the well-established need for both wild captured fisheries and aquaculture to meet the growing demand for fish as a source of food [20,65]. The results of this paper support the idea that from the food security perspective there are synergies rather than trade-offs between the use of the catch as food and in aquaculture [18]. More to the point, the results demonstrate that defining shared future visions and targets for the use of the Baltic herring catch among different stakeholder groups and jointly identifying pathways towards them, can be useful for maximising the contribution of the fishery to the food security objective. In practice, the implementation of the co-produced targets and actions entails that they are mandated and formally collected to the policy system or that similar deliberations are arranged within the system. According to the Green Paper [4] related to the EU CFP reform, poorly-defined management objectives had hampered the implementation of the previous EU CFP and achieving its targets. Therefore, this paper argues that owing to the universal food security principles [14,25], objectives and measures to increase the use of forage fish as food should also be defined in the EU CFP and especially in the related regional multiannual plans.

Second, broadening the scope of fisheries governance towards a system that considers food security, and thereby also food safety aspects more explicitly, would be needed to support the implementation of a catch use related food security objective. A wider perspective on fisheries governance could also have positive implications for achieving the other fisheries management objectives. For example, the use of the catch does not affect the ecological sustainability of the stock as long as harvesting is considered to be sustainable. Instead, prior studies have found that the inclusion of ethical issues such as food security in fisheries governance can enhance ecologically sustainable harvesting [22,37]. Moreover, increasing the use of Baltic herring for human consumption can have positive impacts on employment and income as it could create more processing jobs in the fishing sector and as the fish sold for human consumption has been of higher economic value than that sold for industrial use [42]. Increasing the competition between the different uses of forage fish might also improve the profitability of fishing [62].

However, breaking the path dependency relating to feed-directed fishing might be particularly difficult, not only because of the many obstacles to increasing the use of Baltic herring as food, but also due to the recently increased opportunity to use Baltic herring as dioxin-free feed in aquaculture. The latter alone has increased the contribution of Baltic herring to food security indirectly and improved the viability of the herring fishing industry [58]. The willingness of the fishing industry to invest in structural changes and product development could also be decreased by the narrowing monetary gap between fish sold to industrial use versus food [42], and the fewer restrictions concerning feed production. In this scenario, the dioxin problem could be accepted as it is, without further efforts to manage or solve it. This tendency to remain on the current governance path is supported by previous research, which has shown that diversion from it is one key challenge in the implementation of cross-sectoral, ecosystem-based management in the Baltic Sea region [29].

Third, proactive catch use governance would be needed to increase the supply of safe-to-eat fish on the food market in a sustainable manner and to create demand for species that have been less valued as food. The presented study demonstrates that collaboration and deliberation between fisheries, public health and environmental authorities and experts on the inclusion of food security and safety issues in fisheries governance is likely to yield practical solutions for dealing with the dioxin problem of Baltic herring and increasing its use as food. This finding is somewhat contrary to a previous study that has demonstrated less successful inter-sectoral collaboration between fisheries and environmental sectors owing to conflicting rationalities [60]. One possible explanation for this difference is that regarding the use of Baltic herring catch, there appears to be a shared interest across policy sectors to increase its use as food and to facilitate this, to develop different ways to enhance its safety.

The results do not support the idea of strict top-down regulation of catch use, but instead, they suggest possible actions and decisions that could be taken by the formal governance system at the EU and national levels as well as by the fishing industry, science and the civil society to support their implementation. Fundamentally, these actions are related to increasing the supply of Baltic herring suitable for human consumption and creating demand for it. Their implementation involves financial risks and therefore, as long as the demand remains low, there might be little incentive to increase the supply. However, changes in demand have previously reflected changes in the marine ecosystem and thereby food availability [35]. This implies, given the growing demand for fish and seafood [18] that increasing the availability of safe-to-eat Baltic herring products on the fish food market could also increase the demand.

Examining the results from the perspective of multi-level governance, it was surprising that the experts did not address the potential role of the regional policy and governance level in the implementation of the identified actions. This might be because, on the one hand, food security and safety related issues have been traditionally dealt with at the EU and national levels, and on the other hand, because the role of the two institutions, the BALTFISH and BSAC, between the EU and national level governance system has been perceived as ambiguous and lacking in authority in fisheries governance [50,68]. Yet, the implementation of the EU CFP calls for nested governance systems that are able to deal with regional specificities and support collaboration between the Baltic Sea countries and policy sectors on fisheries management and to engage stakeholders in fisheries governance [29,50,60]. Indeed, collaboration between the Baltic Sea countries might also be useful from the food security perspective, for example, when dealing with the bureaucracy relating to accessing large export markets and ensuring that there is sufficient supply of safe-to-eat products. The latter is of special importance, owing to the spatial heterogeneity of the dioxin problem and varying national quotas and fishing areas. Therefore, in order to maximise the supply of safe-to-eat Baltic herring on the EU fish food market, it might be useful to consider catch use governance at the regional level. However, further work is required to explore how to reorganise the governance system to support the inclusion of food security in fisheries governance.

Some limitations regarding the feasibility of the results remain. Mainly, owing to time limitations at the workshop, the side-effects of implementing the identified actions were not discussed explicitly, although many of the related challenges and benefits were mentioned during the discussions. Therefore, for example the potential negative environmental side-effects of size-selective fishing [74] were not discussed and further studies are needed to determine the feasibility of the

action. However, since the majority of the Baltic herring catch currently comprises small herring, there is already potential to increase the availability of herring suitable for human consumption by sorting the catch. Finally, increasing the use of Baltic herring as food could have implications to fur industry, but these were not discussed. From the food security perspective, using imported fish as feed to fur animals, instead of Baltic herring, might not be a sustainable and ethical solution. Thus, the integration of food security and safety aspects in fisheries governance entails holistic planning.

6. Conclusions

This paper has studied the integration of food security and safety issues in fisheries governance to increase the contribution of fisheries to the food security objective in a sustainable manner. The paper argues that owing to the increasing demand for fish as food and the universal ethical principles encouraging the prioritisation of the use of wild captured fish for human consumption, there is need for a paradigm shift in fisheries governance. This involves defining the EU CFP food security objective more explicitly also in relation to forage fish that has been underutilised as food, as well as widening the scope of fisheries governance to address the use of the catch. The shift also implies confronting the traditional, reactive approaches to fisheries catch use governance and management. Using Baltic herring as a case study, the paper has demonstrated that even a fishery with multiple problems, such as the dioxin problem, low demand, and limited supply of fish suitable for human consumption, could increase the contribution of the resource to food security, both in the short and long term. However, owing to the multi-sectoral nature of food security and safety issues, collaboration between different stakeholders, policy sectors and across different policy levels are needed to facilitate the inclusion of food security and safety issues in fisheries governance.

Acknowledgements

This paper is a contribution from the BONUS GOHERR project (Integrated governance of Baltic herring and salmon stocks involving stakeholders), and it has received funding from BONUS (Art 185), funded jointly by the EU and the Academy of Finland. The authors wish to thank all the stakeholders who participated in the workshop as well as the peer-reviewers for their constructive comments.

Note

The empirical findings of this paper were first presented at the 2016 EurSafe Conference on Food futures – ethics, science and culture, in Porto, Portugal 29.09 2016, and published as extended abstract in the conference proceedings, https://doi.org/10.3920/978-90-8686-834-6_36.

References

[1] T. Assmuth, P. Jalonen, Risks and management of dioxin-like compounds in Baltic Sea fish: an integrated assessment, TemaNord 2005 (2005) 568.
[2] J. Atta-Mills, J. Alder, U.R. Sumaila, The decline of a regional fishing nation: the case of Ghana and West Africa, Nat. Resour. Forum 28 (2004) (2004) 12–21.
[3] T.A. Branch, O.P. Jensen, D. Ricard, Y. Ye, R. Hilborn, Contrasting global trends in marine fishery status obtained from catches and from stock assessments, Conserv. Biol. 25 (4) (2011) 777–786, https://doi.org/10.1111/j.1523-1739.2011.01687.x.
[4] Commission of the European Communities (CEC), Green Paper. Reform of the Common Fisheries Policy. Brussels, 22.4.2009. COM (2009)163 final, 2009.
[5] K.H. Dreborg, Essence of backcasting, Futures 28 (9) (1996) 813–828.
[6] S. Engelkamp, D. Fuchs. Performing 'green Europe'? A narrative analysis of European fisheries policy. Sustainable Governance Discussion Paper 01/2016, Münster, 2016. Available at: 〈https://www.uni-muenster.de/imperia/md/content/fuchs/publikationen/sgpaper/sg_discussion_paper_fisheries_narratives.pdf〉 (last accessed 27 April 2018).
[7] European Commission, Final report of an audit carried out in Estonia from 10 to 20 June 2014 in order to evaluate the food safety control systems in place governing the production and placing on the market of fishery products. DG(SANCO2014-7132 – MR FINAL, 2014.
[8] European Commission, Final report of an audit carried out in Denmark from 26 to 30 November 2012 in order to evaluate the monitoring and control of dioxins, furans and PCBs in fish from the Baltic region. DG(SANCO) 2012–6521, 2012.
[9] European Commission, Commission Recommendation (EU) 2016/688 of 2 May 2016 on the monitoring and management of the presence of dioxins and PCBs in fish and fishery products from the Baltic Sea region. Official Journal of the European Union, 4.5.2016, L 188/16-23, 2016, http://data.europa.eu/eli/reco/2016/688/oj.
[10] European Commission, Commission Regulation (EU) No 1259/2011 of 2 December 2011 amending Regulation (EC) No 1881/2006 as regards maximum levels for dioxins, dioxin-like PCBs and non dioxin-like PCBs in foodstuffs. Official Journal of the European Union, L 320/18-23, 2011. http://data.europa.eu/eli/reg/2011/1259/oj.
[11] European Council, Council Regulation (EEC) No 2115/77 of 27 September 1977 prohibiting the direct fishing and landing of herring for industrial purposes other than human consumption. Official Journal of the European Communities, 28.9. 1977, No L 247/2, 1977.
[12] European Council, Council Regulation (EC) No 1434/98 of 29 June 1998 specifying conditions under which herring may be landed for industrial purposes other than direct human consumption. Official Journal of the European Communities, 7.7. 1998, L 191/10-12, 1998, http://data.europa.eu/eli/reg/1998/1434/oj.
[13] European Parliament and Council, Regulation (EU) 2016/1139 of the European Parliament and of the Council of 6 July 2016 establishing a multiannual plan for the stocks of cod, herring and sprat in the Baltic Sea and the fisheries exploiting those stocks, amending Council Regulation (EC) No 2187/2005 and repealing Council Regulation (EC) No 1098/2007. Official Journal of the European Union, 15.7.2016, L 191/1-15. 2016, http://data.europa.eu/eli/reg/2016/1139/oj.
[14] European Parliament and Council, Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulation (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) 639/2004 and Council Decision 2004/585/EC. Official Journal of the European Union, 28.12.213, L 354/22-61. 2013a, http://data.europa.eu/eli/reg/2013/1380/oj.
[15] European Parliament and Council, Regulation (EU) No 1379/2013 of the European Parliament and of the Council of 11 December 2013 on the common organization of the markets in fishery and aquaculture products, amending Council Regulations (EC) No 1184/2006 and (EC) No 1224/2009 and repealing Council Regulation (EC) No 104/2000. Official Journal of the European Union, 28.12.2013, L 354/1-21. 2013b, http://data.europa.eu/eli/reg/2013/1379/oj.
[16] European Parliament and Council, Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Official Journal of the European Union, 25.6.2008, L 164/19-40. 2008, http://data.europa.eu/eli/dir/2008/56/oj.
[17] EUMOFA, The EU fish market 2017 edition. European Market Observatory for Fisheries and Aquaculture Products. Directorate-General for Maritime Affairs and Fisheries of the European Commission, 2017.
[18] FAO, The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Rome. 200 pp, 2016.
[19] FAO. FAOSTAT. Statistics division, 2015. Available at: 〈http://faostat3.fao.org/home/E〉. (Accessed 20 May 2016).
[20] FAO, The State of World Fisheries and Aquaculture. Opportunities and challenges. Rome, 2014, 2014.
[21] FAO, Aquaculture Development. 5. Use of Wild Fish as Feed in Aquaculture. FAO Technical Guidelines for Responsible Fisheries 5, (2011), p. 5.
[22] FAO, Ethical Issues in Fisheries, FAO Ethics series, Rome, 2005, p. 4.
[23] FAO. An introduction to the basic concepts of food security. Food security information for action. Practical guides. Available at: 〈http://www.fao.org/docrep/013/al936e/al936e00.pdf〉.
[24] FAO, Technical Guidelines on Responsible Fishing no 7, Responsible Fish Utilization, FAO, Rome, Italy, 1998 〈http://www.fao.org/docrep/003/w9634e/W9634e04.htm#TopOfPage〉.
[25] FAO, Code of Conduct for Responsible Fisheries, FAO, Rome, 1995. Available at: 〈http://www.fao.org/3/a-v9878e.pdf〉.
[26] A. Glynn, S. Sand, W. Becker, Risk and Benefit Assessment of Herring and Salmonid Fish From the Baltic Sea Area, National Food Agency, Sweden, 2013 (Report no 21-2013).
[27] S.J. Hall, A. Delaporte, M.J. Phillips, M. Beveridge, M. O'Keefe, Blue Frontiers: Managing the Environmental Costs of Aquaculture, The WorldFish Center, Penang, Malaysia, 2011.
[28] G. Hardin, The tragedy of the commons, Science 162 (3859) (1968) 1243–1248.
[29] B. Hassler, M. Boström, S. Grönholm, Towards an ecosystem approach to management in regional marine governance? The Baltic Sea context, J. Environ. Policy Plan. 15 (2) (2013) 225–245.
[30] HELCOM. Hazardous substance in the Baltic Sea – An integrated thematic assessment of hazardous substances in the Baltic Sea. Balt. Sea Environ. Proc.s No. 120B. 〈http://www.helcom.fi/lists/publications/bsep120b.pdf〉, (last accessed 6 September 2017).
[31] M. Hennink, I. Hutter, A. Bailey, Qualitative Research Methods, Sage publications, London, 2011.
[32] N. Hughes, Towards improving the relevance of scenarios for public policy questions: a proposed methodological framework for policy relevant low carbon scenarios, Technol. Forecast. Soc. Change 80 (2013) 687–698, https://doi.org/10.1016/j.techfore.2012.07.009.
[33] ICES, Report of the Baltic Sea Fisheries Assessment Working Group (WGBFAS). 14-

21 April 2015, headquarters, Copenhagen, Denmark. ICES CM 2015/ACOM:10, 2015.
[34] ICES, Report of the Herring Assessment Working Group for the Area South of 62°N (HAWG). 10-19 March 2015, ICES HQ, Copenhagen, Denmark. ICES CM 2015/ACOM:06, 2015.
[35] J.L. Jacquet, D. Pauly, The rise of seafood awareness campaigns in an era of collapsing fisheries, Mar. Policy (2007) 308–313, https://doi.org/10.1016/j.marpol.2006.09.003.
[36] Y. Kishita, B.C. McLellan, D. Giurco, K. Aoki, G. Yoshizawa, I.C. Handoh, Designing backcasting scenarios for resilient energy futures, Technol. Forecast. Soc. Change 124 (2017) 114–125, https://doi.org/10.1016/j.techfore.2017.02.001.
[37] M.E. Lam, T.J. Pitcher, The ethical dimensions of fisheries, Curr. Opin. Environ.l Sustain. 4 (2014) 364–372 (2012).
[38] H. Lassen, Industrial Fisheries in the Baltic Sea. European Parliament Directorate General for internal policies. Policy Department B: structural and cohesion policies. Fisheries. Brussels, March 2011, 2011.
[39] P.M. Mace, A new role for MSY in single-species and ecosystem approaches to fisheries stock assessment and management, Fish Fish. 2 (2001) 2–32.
[40] R. Mononen, N. Urala, Kuluttajien suhtautuminen silakkaan (consumer perceptions on Baltic herring). Research report 26.11.2010. Kuulas Research Agency Oy, 2010.
[41] National Research Council, The Drama of the Commons. Committee on the Human Dimensions of Global Change, in: E. Ostrom, T. Dietz, N. Dolsˇak, P.C. Stern, S. Stovich, E.U. Weber (Eds.), Division of Behavioral and Social Sciences and Education, National Academy Press, Washington, DC, 2002.
[42] Natural Resources Institute Finland. Statistics database, 2016. Available at: ⟨http://stat.luke.fi/⟩. (Last accessed 1 March 2018).
[43] E. Ostrom, Governing the Commons. The Evolution of Institutions for Collective Action, Cambridge University Press, New York, 1990.
[44] D. Pauly, R. Watson, J. Alder, Global trends in world fisheries: impacts on marine ecosystems and food security, Philos. Trans. R. Soc. B 360 (2005) 5–12.
[45] H. Peltonen, M. Kiljunen, H. Kiviranta, P.J. Vuorinen, M. Verta, J. Karjalainen, Predicting Effects of Exploitation Rate on Weight-at-Age, Population Dynamics, and Bioaccumulation of PCDD/Fs and PCBs in Herring (*Clupea harengus* L.) in the Northern Baltic Sea, Environ. Sci. Technol. 41 (2007) 1849–1855.
[46] H. Pokki, J. Setälä, J. Virtanen, Kalatalouden toimialakatsaus 2015 (*Fisheries overview 2015*). Luonnonvara- ja biotalouden tutkimus 61/2015. Luonnonvarakeskus, Helsinki 2015. ⟨https://jukuri.luke.fi/bitstream/handle/10024/519982/luke-luobio_61_2015.pdf?Sequence=1⟩, (last accessed 6 September 2017).
[47] S. Ponte, The marine Stewardship Council (MSC) and the making of a market for 'sustainable fish', J. Agrar. Change 12 (2–3) (2012).
[48] J. Quist, P. Vergragt, Part and future of backcasting: the shift to stakeholder participation and a proposal for a methodological framework, Futures 38 (2006) 1027–1045, https://doi.org/10.1016/j.futures.2006.02.010.
[49] J. Quist, W. Thissen, P.J. Vergragt, The impact and spin-off of participatory backcasting: from vision to niche, Technol. Forecast. Soc. Change 78 (2011) 883–897.
[50] J. Raakjaer, J. van Leeuwen, J. van Tatenhove, M. Hadjimichael, Ecosystem-based marine management in European regional seas calls for nested governance structures and coordination – A policy brief, Mar. Policy 50 (2014) 373–381.
[51] J. Raitaniemi, K. Manninen (Eds.). Kalakantojen tila vuonna 2015 sekä ennuste vuosille 2016 ja 2017. Silakka, kilohaili, turska, lohi, siika, kuha ja ahven. Luonnonvara- ja biotalouden tutkimus 57/2016. Luonnonvarakeskus, Helsinki, 2016. Available at: ⟨http://jukuri.luke.fi/bitstream/handle/10024/537489/luke-luobio_57_2016.pdf?Sequence=1&isAllowed=y⟩. (Last accessed 14 September 2017).
[52] A. Rindorf, C.M. Dichmont, P.S. Levin, P. Mace, S. Pascoes, R. Prellezo, A.E. Punt, D.G. Reid, R. Stephenson, C. Ulrich, M. Vinther, L. Worsoe Clausen, Food for thought: pretty good multispecies yield, ICES J. Mar. Sci. 74 (2017) 475–486, https://doi.org/10.1093/icesjms/fsw071.
[53] J.B. Robinson, Energy backcasting. A proposed method of policy analysis, Energy Policy 10 (1982) 337–344.
[54] J. Robinson, Future subjunctive: backcasting as social learning, Futures 35 (2003) 839–856.
[55] J. Robinson, S. Burch, S. Talwar, M. O'Shea, M. Walsh, Envisioning sustainability: recent progress in the use of participatory backcasting approaches for sustainability research, Technol. Forecast. Soc. Change 78 (2011) 756–768, https://doi.org/10.1016/j.techfore.2010.12.006.
[56] S.A. Sethi, T.A. Branch, R. Watson, Global fishery development patterns are driven by profit but not trophic level, Proc. Natl. Acad. Sci. USA 107 (27) (2010) 12163–12167.
[57] J. Setälä, The Economic Significance of Fodder Fishing, Finnish Game and Fisheries Research Institute, 1996, p. 1996.
[58] J. Setälä, M. Kankainen, J. Vielma, J. Niukko, A. Pitkämäki, M. Saario, S. Ahvenharju, A. Hillgren, P. Tommila. Itämerirehua kotimaisista kalavirroista. Loppuraportti. (*Baltic Sea fish feed from domestic resources. Final report.*) Luonnonvara- ja biotalouden tutkimus 28/2016, 2016. Available at: ⟨https://jukuri.luke.fi/bitstream/handle/10024/535286/luke-luobio_28_2016.pdf?Sequence=4⟩, (last accessed 6 September 2017).
[59] R. Stephenson, H. Peltonen, S. Kuikka, J. Pönni, M. Rahikainen, E. Aro, J. Setälä, Linking biological and industrial aspects of the Finnish commercial herring fishery in the northern Baltic Sea, in: F. Funk, J. Blackburn, D. Hay, A.J. Paul, R. Stephenson, R. Toresen, D. Witherell (Eds.), Herring: Expectations for a New Millennium, University of Alaska Sea Grant, Fairbanks, 2001, pp. 741–760 (AK-SG-01-04).
[60] C. Stöhr, I. Chabay, Science and participation in governance of the Baltic Sea Fisheries, Environ. Policy Gov. 20 (2010) 350–363, https://doi.org/10.1002/eet.552.
[61] R.U. Sumaila, C. Bellmann, A. Tipping, Fishing for the future: an overview of challenges and opportunities, Mar. Policy 69 (2016) 173–180, https://doi.org/10.1016/j.marpol.2016.01.003.
[62] A.G.J. Tacon, M. Metian, Fishing for feed or fishing for food: increasing global competition for small pelagic forage fish, Ambio 38 (6) (2009) 2009.
[63] S.J. Taylor, R. Bogdan, M.L. DeVault, Introduction to Qualitative Research Methods: A Guidebook and Resource, 4th ed., Wiley, Hoboken, 2016.
[64] A. Thorpe, S. Williams, J. van Zyl, The post-harvest chain, in: J. Kooiman, M. Bavinck, S. Jentoft, R. Pullin (Eds.), Fish for Life. Interactive Governance for Fisheries. MARE Publication Series, Amsterdam University Press, Amsterdam, 2005(No. 3).
[65] R.H. Thurstan, C.M. Roberts, The past and future of fish consumption: can supplies meet healthy eating recommendations? Mar. Pollut. Bull. 89 (1–2) (2014) 5–11 (15).
[66] P. Tommila, L. Hakala, L. Oja, T. Pursula, S. Vilhunen. Itämeren alueen kalavarojen riittävyys alueen asukkaille (*Sufficiency of Baltic Sea fish resources for regional consumption*). Report by Gaia Consulting Oy and WWF Finland, 2012. Available at: ⟨https://wwf.fi/mediabank/2622.pdf⟩, (last accessed 6 September 2017).
[67] J.T. Tuomisto, M. Niittynen, A. Turunen, S. Ung-Lanki, H. Kiviranta, H. Harjunpää, P.J. Vuorinen, M. Rokka, T. Ritvanen, A. Hallikainen, Baltic herring as nutrition – Risk-benefit analysis. Finnish Food Safety Authority Evira. Evira Research Reports 1/2015, 2015.
[68] L. van Hoof, Fisheries management, the ecosystem approach, regionalization and the elephants in the room, Mar. Policy 60 (2015) 20–26.
[69] P.J. Vergragt, J. Quist, Backcasting for sustainability: introduction to the specific issue, Technol. Forecast. Soc. Change 78 (2011) 747–755.
[70] J. Wangel, Exploring social structures and agency in backcasting studies for sustainable development, Technol. Forecast. Soc. Change 78 (5) (2011) 872–882.
[71] K. Wiberg, A.T. Assefa, K.L. Sundqvist, I.T. Cousins, J. Johansson, M.S. McLachlan, A. Sobek, G. Cornelissen, A. Miller, J. Hedman, A. Bignert, H. Peltonen, M. Kiljunen, V. Shatalov, I. Cato, BalticPOPs: Managing the Dioxin Problem in the Baltic Region with Focus on Sources to Air and Fish, The Swedish Environmental Protection Agency, 2013.
[72] M. Zimmermann, I.-L. Darkow, H.A. von der Gracht, Integrating Deplhi and participatory backcasting in pursuit of trustworthiness – the case of electric mobility in Germany, Technol. Forecast. Soc. Change 79 (2012) 1605–1621.
[73] H. Österblom, S. Hansson, U. Larsson, O. Hjerne, F. Wulff, R. Elmgren, C. Folke, Human induced trophic cascades and ecological regime shifts in the Baltic Sea, Ecosystems 10 (2007) 877–889, https://doi.org/10.1007/s10021-007-9069-0.
[74] S. Zhou, A.D.M. Smith, A.E. Punt, A.J. Richardson, M. Gibbs, E.A. Fulton, A. Pascoe, C. Bulman, P. Bayliss, K. Sainsbury, Ecosystem-based fisheries management requires a change to the selective fishing philosophy, Proc. Natl. Acad. Sci. USA 107 (21) (2010), https://doi.org/10.1073/pnas.0912771107.