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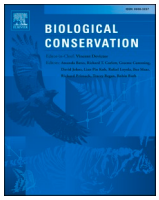

Stakeholder workshops on western Baltic cod fisheries–conflict and consensus in the face of a highly dynamic ecosystem

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ABSTRACT

A shift in ecological systems often produces or exacerbates conflicts among different stakeholders within the corresponding socio-ecological system. One approach to resolution is to involve the various parties in participatory processes (e.g., in a workshop setting) and work towards co-design of management recommendations. Using the western Baltic cod (*Gadus morhua*) fishery as case study, this research documents a series of stakeholder workshops which happened to take place during the rapid deterioration of the stock. This overlap shed light on challenges for established fisheries management and conservation systems when confronted with rapid, unforeseen changes of the corresponding ecosystems and stakeholder involvement in such situations. The aspiration of the workshops including participatory cognitive mapping was to understand stakeholder perceptions and work towards mutually agreed management recommendations - a goal that became more elusive as the stock collapsed and the fishery was closed during the process. Such situations may become more common in the context of ever-increasing anthropogenic pressures on aquatic ecosystems, including climate change, habitat degradation, and overfishing. The workshops engaged four different stakeholder groups: commercial fishers, recreational fishers, environmental non-governmental organizations, and fisheries authorities. Conflicts were identified with regard to human-wildlife interactions, the role of scientific contributions and competition between commercial and recreational fisheries. Consensus was reached regarding the impact of external factors, particularly eutrophication, and the need for fisheries management and specific management measures. This study documents the workshop results and experiences, reports lessons learnt and translates these into possible steps forward.

1. Introduction

Marine social-ecological systems (Ostrom, 2009) are under continued anthropogenic stress (e.g., eutrophication, overfishing, climate warming), making them susceptible to sudden and unintentional changes in structure and function. Such changes occur when one or several critical characteristics/properties of these dynamically stable systems passed their respective thresholds for self-stabilisation and, when sufficiently impactful, are often termed/labelled 'regime shifts' (Scheffer et al., 2001; van Ginkel et al., 2020; Cheung et al., 2021). Although the concept of discrete thresholds in ecological systems and in particular our ability to foresee them is controversial (Hillebrand et al., 2020), the terminology is useful to describe the reality of ecological systems that behave fundamentally different from what humans have become accustomed to (e.g., productivity (Szuwalski et al., 2015).

Such rapid ecological changes typically have significant consequences for the dependent social and economic systems (Möllmann et al., 2009; Milkoreit et al., 2018), resulting in, for example, the emergence of new and intensification of existing stakeholder conflicts (White and Ward, 2010; Koubi, 2019). Conflicts, common in fisheries systems, arise due to diversity of interests, values, priorities, and manners of exploitation among resource users such as commercial and recreational fisheries (Arlinghaus, 2005; Arbo and Pham, 2016; Arlinghaus et al., 2023) who target the same common property resource (Hanna and Smith, 1993; Spijkers et al., 2021). Allocation conflicts occur in particular when commercial fishers are confronted with declining target fish

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stocks and quota cuts, political and social instabilities, and financial challenges (Boucquey, 2017; Payne et al., 2021), or emerge from recovery measures such as quota cuts or implementation of no-take zones. These conflicts are further intensified when the reasons for the underlying stock declines are unknown or highly uncertain/contentious and when management responses for practical reasons focus on curtailing fishing mortality, even though in reality other anthropogenic pressures are equally or even more strongly affecting stock dynamics (e.g., warming, anoxic zones caused by eutrophication, etc.). Conflicts between fisheries and other sectors, including agriculture, conservation and coastal infrastructural development (Charles, 1992; Jentoft, 2017; Dahlet et al., 2021) as well as conflicts related to fisheries governance are also common, the latter arising if fishers criticise management decisions as being political rather than based on the state of the resource as perceived by them (Bower et al., 2014). In recent decades conflicts between conservation and fisheries interests in the Baltic Sea are also becoming more intense (Salomon et al., 2011; Grip and Blomqvist, 2020; Arias-Schreiber and Gillette, 2023). These conflicts are particularly pronounced in the case of imbalances in decision making power (Boucquey, 2017; Jentoft, 2017), create tensions between stakeholders and pose major challenges to management and policy in ensuring the sustainable use of marine and coastal environments (Charles, 1992; Jentoft and Chuenpagdee, 2009; Erkkilä-Välimäki et al., 2022).

To address stakeholder conflicts proactively, some form of stakeholder involvement beyond the scientific community and fisheries managers is preferable over top-down hierarchical decision-making (Jentoft et al., 1998; Döring and Egelkraut, 2008). Although stakeholder knowledge may be influenced by memory and recall bias (Daw et al., 2011), it is greatly beneficial to management. The inclusion of local knowledge and diverse perspectives leads to improved understanding of the respective social-ecological system, including different associated values and interests, this improves mutual understanding and thereby reduces conflicts and increases rule acceptance and compliance (Berkes et al., 2000; Berghöfer et al., 2008; Mulvaney and Gottschalk-Druschke, 2017; Mease et al., 2018), thus providing a more stable basis for sustainable management and use. In concurrence, the European Common Fisheries Policy (CFP) aiming for the "conservation of marine biological resources and the management of fisheries targeting them" (European Union, 2013) requires the inclusion of other relevant sectors in addition to the fishery sector at all stages of policy development and implementation (European Union, 2002, 2013). According to the CFP, Advisory Councils (ACs) representing the fisheries sector, scientists, non-governmental organizations with mainly voluntary participants and an environmental focus (eNGOs; Vakil, 1997) and other stakeholders (e.g., recreational anglers) with an interest in fisheries management should be consulted when adopting management plans (European Union, 2004). The prototypical design for stakeholder involvement is a series of stakeholder workshops where the issues at hand (e.g., a nearing stock decline, reasons for the decline, new harvest regulations for fisheries) are discussed and possible solutions developed, which should ideally result in the aforementioned improved understanding and moderation of conflicts in a structured decision-making setting (e.g., Cleland and San Jose, 2018; Ehrlich et al., 2023). The idealized stakeholder inclusive process results in the development of constructive consensus about issues of relevance to stakeholders, i.e., the future management of a fishery (Ehrlich et al., 2023) and ultimately builds trust between the different parties, which constitutes the foundation for sustained efforts and investment to reach the goal of participation, the sharing of power and responsibility between government, fisheries authorities and local resource users (Linke and Jentoft, 2014; Röckmann et al., 2012; Hakkarainen et al., 2022). Stakeholder involvement can also take place in the setting of one-off-initiatives located at the interface of scientific and governmental agencies, which was the case for the study presented here. While research institutes only have advisory competence, ACs are stakeholder-led formal structures which provide recommendations on fisheries management matters to the European Commission. Stakeholders considered the hosting institute, the Thünen Institute of Baltic Sea Fisheries (TI), sufficiently connected to decision-makers to invest their time and energy, because the TI is a federal research institute under the auspices of the German Federal Ministry of Food and Agriculture (BMEL) and provides policy advice.

This case study describes a series of stakeholder workshops with representatives from different stakeholder groups (i.e., commercial fishers, recreational anglers, conservationists, state-level policy makers and fisheries administrators) regarding the German cod fisheries in the western Baltic Sea. The workshops aimed to examine stakeholders' perceptions of the western Baltic cod (WBC) stock, a dwindling resource targeted by a mixed commercial/recreational fishery, with a focus on which factors they hold responsible for the decline, which management they prefer to protect the resource as well as revealing conflicts and opportunities for reaching consensus. The workshops were part of a project ("marEEshift", https://www.idiv.de/en/mareeshift.html) situated at the interface between research and fisheries management. The goal of the project was to identify processes that influence the resilience of marine ecological-economic systems and initiate transdisciplinary engagement between science, fisheries management, conservation and different stakeholders with the aim to develop a common concept of sustainability for western Baltic cod from stakeholders' perspectives.

Our case study contributes an example where an unexpected stock collapse took place during the course of the stakeholder workshops. While the relevant stock was considered a yet-to-be salvageable resource (ICES, 2018) at the beginning of the process in 2019, by 2022 the stock had deteriorated to the point of closure of the fishery (ICES, 2022a). This development not only lent a sense of urgency to the proceedings but also brought into focus the broader implications to stakeholder involvement when resource supporting ecosystems suddenly become highly dynamic. The objective of this paper is to document our workshop results and experiences, report our lessons learnt and translate these into possible steps forward.

2. Material and methods

2.1. The study system

The study area was the western part of the Baltic Sea, a semi-enclosed sea located in north-eastern Europe with pronounced temperature and salinity gradients from warmer and saline waters in the south-western parts to colder and nearly freshwater conditions in the north-eastern parts (Ojaveer and Kalejs, 2008). Affected by multiple anthropogenic stressors including shipping, habitat destruction, overfishing, eutrophication, pollution, invasive species, and global warming (Reckermann et al., 2022), the Baltic Sea has been subjected to regime shifts in the last century (Möllmann et al., 2009) and is viewed as a "time machine for coastal marine changes" and a "marine management laboratory" (Reusch et al., 2018). Infrequent and irregular inflows of salty and oxygen-rich water from the North Sea are responsible for deep-water ventilation in the central Baltic basins, and to a large extent determine the environmental conditions below the permanent halocline (Mohrholz, 2018). The German Baltic coastline extends for approximately 2350 km and has various large and small fishing harbours in two federal states Mecklenburg-Western Pomerania (MWP) and Schleswig-Holstein (SH) that enabled the development of local markets for fish (Papaioannou et al., 2012). The commercial fishery, which is overwhelmingly small-scale, using fishing boats with sizes <12 m and in some cases still made of wood (Natale et al., 2015, Döring et al., 2020), targets primarily cod (*Gadus morhua*), herring (*Clupea harengus*), and various flatfish species (*Pleuronectiformes*) in coastal waters within the 12 nautical miles zone (Lewin et al., 2023). The western Baltic Sea is also attractive for recreational anglers who target mainly the same species as commercial fishers (Strehlow et al., 2012; Weltersbach et al., 2021). Various eNGOs regularly campaign for the protection of marine mammals, water birds, and the Baltic environment (Krause et al., 2006). The

management of the fisheries in territorial waters within the 12 nautical miles zone are the responsibility of the German coastal federal states (Centenera, 2014), whereas the implementation of the national fisheries quota allocation for Germany within the CFP for selected species such as cod and herring is the responsibility of the national authority, the Federal Ministry of Food and Agriculture (BMEL).

The WBC stock, an exceedingly productive resource in the 1990s (ICES, 2022b) started to significantly decline in the late 2000s (ICES, 2022a) and is now considered a collapsed stock (Möllmann et al., 2021; ICES, 2022a, 2023). Reasons for the stock collapse remain under investigation, however, a decline in the system's carrying capacity for cod can be linked to warming surface water coupled with oxygen deficiency in deep water due to decades of eutrophication (Receveur et al., 2022; Kjesbu et al., 2023). A recent study confirmed that the interaction of climate warming and eutrophication is currently most likely the driver for changes in the functionality of the food-web (Steinkopf et al., 2024). Neither changing trophic interactions nor a declining carrying capacity were initially accounted for in the WBC stocks' management (Möllmann et al., 2014; Scotti et al., 2022). The decline of the ecological quality of the Baltic Sea correlates with decades-long overfishing, where quotas were systematically set higher than its productivity would support. Today, the interactions of overfishing and global environmental change are considered the main interacting drivers that have caused the WBC stock collapse (Möllmann et al., 2021). The decrease in productivity and the previous first sharp decline of the stock in 2016 had led to a cascade of social, economic and institutional responses. Total allowable catches (TACs) for cod are decided at the European level for the community waters, including the Baltic Sea, which have been steadily reduced during recent years. Since 2022, the directed commercial fishery for WBC has been closed and only a small bycatch quota of 340 t is in place 2024, to ensure the continuation of the flatfish fishery (European Union, 2023). The German recreational fishery which previously was open access and had only been managed by minimum-size limits and a license requirement, was confronted with the introduction of a bag limit (5 cod per angler and day and 3 cod per angler and day during the spawning season) in 2017. The bag limit implementation caused social conflicts within some angler groups, who have lobbied against bag limits or for more liberal levels and some angling tourists left the fishery in response to the new regulations (Lewin et al., 2021; Bronnmann et al., 2023). While the bag limit was further reduced in 2022 and 2023 to 1 cod per angler and day, the recreational cod fishery in the western Baltic Sea has been closed completely as of 2024 and angling tourists have either left the coastal sites or have directed effort to alternative species (e.g., flatfish).

2.2. The workshops

A series of four moderated 1-day stakeholder workshops involving four stakeholder groups (authorities, commercial fishery, recreational fishery, eNGOs) was held in the winter half-year of 2019/2020. At the time, the WBC stock was already declining and quotas were being decreased. These grouped workshops were followed by a joint final workshop in September of 2022 during which the same participants compiled and discussed the results of the previous workshops. In total 46 commercial fishers, 37 representatives of the recreational fishery, 22 representatives of different authorities and 34 representatives of eNGOs, selected from a list compiled by scientists working on Baltic Sea fisheries management, received invitations. The workshop “commercial fishery” was attended by 16 representatives of the commercial fishery (small-scale and large-scale fishers, spokespersons of fishing associations from the two Baltic coastal federal states SH and MWP) and the workshop “recreational fishery” by 17 representatives of local, regional and national angling associations, angling guides, angling shops, and tourism organizations. The workshop “authorities” was attended by 6 representatives of federal and regional fisheries and environmental authorities and the workshop “eNGOs”, which fell into the initial period of the COVID-19 pandemic, was attended by six representatives from nature conservation organizations. All workshops were led by a professional facilitator.

To start the discussion, the participants were asked to outline their vision for future Baltic Sea fisheries. Subsequently, participatory cognitive system mapping (PCM) was used to promote the discussion within the workshops and gain insights into the system understanding of the stakeholders. PCM is a flexible and transparent process of drawing and discussing “mental models” through networks of factors and their causal relationships (Barbrook-Johnson and Penn, 2022). “Mental models” form the cognitive basis of reasoning, decision making, and (partly) behaviour and thus adaptation potential (Jones et al., 2011). Shaped by individual experiences, goals, pertinent knowledge and social, cultural, and environmental influences (Johnson-Laird, 2001), they are valid to those who hold them, even though they do not represent reality accurately (Jones et al., 2011). The resulting system maps can reveal consensus and conflicts between stakeholders' understanding of the functioning of the respective social-ecological system and integrate different perspectives, including local knowledge, to aid the subsequent discussion while also improving communication between stakeholders (Gray et al., 2012; Shephard et al., 2021). In practical terms, the participants listed relevant factors affecting the WBC stock by free association, which were then put into relation to each other regarding their causal relationships (positive or negative) distinguishing between proximal and distal factors. Subsequently, management options were identified and added to the corresponding factors. Finally, participants were asked to rate the importance of the factors based on their influence an WBC using sticky dots. When weighting the factors, each participant could allocate a total of five points to the factors. It was also possible to allocate several points to one factor. At the end of the model development process, the participants discussed the desired state of the fishery and management measures that would be required to achieve the goals. Due to time constraints, PCM was not completely finished in the workshop with the authorities. Additionally, questionnaires were distributed among the stakeholder groups to gauge confidence and desire for involvement in fisheries management. All participants were asked to rate statements regarding confidence and involvement in fisheries management. Following the workshops, the cognitive maps, audio recordings of the workshops and the notes of five scientists who observed the discussions without actively taking part were analysed. A detailed workshop plan is presented in the Supplementary Material.

The joint final workshop was designed to compile the results from the previous workshops and to discuss them together. After a short summary presentation of the results of the previous workshops, all participants got the opportunity to discuss in small mixed ‘scenario camps’ what could be done if the collapsed WBC stock recovers to the previous level, the WBC stock stabilizes at a low level and the collapsed stock does not recover. Afterwards, a panel discussion in fishbowl format took place. The discussion began with opening remarks by four representatives of the stakeholder groups on the topics “next steps in cod management” and “aspects needing more attention in the future”. Subsequently, the fishbowl format was used to facilitate an interactive discussion among the participants at which further topics with regard to drivers, perspectives, and management measures were discussed. Afterwards the stakeholder groups discussed which action each group could take to improve the WBC stock status.

3. Case study results

The following section summarizes results from the single stakeholder workshops and the joint final workshop with a focus on the i) most discussed factors influencing the WBC stock as identified by the stakeholders and ii) conflicts and consensus between and within the stakeholder groups with regard to fisheries management. A third section synthesizes key aspects of the discussion on necessary next steps in fisheries with regard to trust building and participation and aspects that

should be given more attention by the stakeholders in the future.

3.1. Drivers influencing western Baltic cod

All groups mentioned predation by seals and cormorants, habitat destruction, climate warming, low oxygen in deep water layers, fisheries and eutrophication as key drivers impacting western Baltic cod (WBC). The importance of these drivers, however, was assessed differently by the groups. A full tabular overview of drivers and assessments of their significance by the stakeholders are presented in Supplementary Table 1.

Commercial fishers rated impacts of climate warming, nutrient inflow from agriculture, and recreational fishing mortality due to high numbers of anglers as the most important drivers influencing the WBC stock, particularly emphasizing the impact of predation. In addition, high release rates by anglers and poor control of the recreational fishery were also cited as drivers. Some small-scale fishers also mentioned trawling by large vessels as a factor affecting the WBC stock. Also prevalent was the opinion that scientific models and the resulting management advice do not accurately reflect the biological reality as perceived by the commercial fishers (Fig. 1).

Recreational anglers emphasized the negative impacts of habitat destruction, predation, and eutrophication on WBC. Poor water quality would impair reproduction of WBC, so that even a large spawning stock would not contribute sufficiently to reproduction. Fishing mortality was rated as less important compared to the other drivers, while recreational fishing mortality was rated as less important than commercial fishing mortality. There was consensus that the commercial trawl fishery in particular has a detrimental impact on fish stocks. This opinion was almost but not completely unique to recreational anglers but shared by some small-scale gillnet fishers (Fig. 2).

The **eNGOs** emphasized low reproduction of WBC due to the lack of saltwater inflow from the North Sea and high nutrient inflows in combination with unsustainable commercial fishing as drivers negatively influencing the WBC stock. Predation was considered less important because predator-prey relationships were considered natural and not causing lasting damage to healthy populations. In particular commercial fishing for large cod would negatively affect reproduction, and trawling would destroy habitats and disrupt spawning. The impacts of anglers, in contrast, would be lower as anglers would not affect habitats and have lower bycatch due to high gear selectivity (Fig. 3).

Authorities cited predation, parasites, eutrophication, consumer demand for fish and the trawl fishery in the past as drivers impacting the WBC, among others (Fig. 4). The discussion focussed on management aspects, for example, whether WBC should be managed without quotas analogous to other coastal fish stocks. A valid scientific basis was seen as having a strengthening effect on management acceptance. In some cases, the evidence basis was considered too be to weak and time would

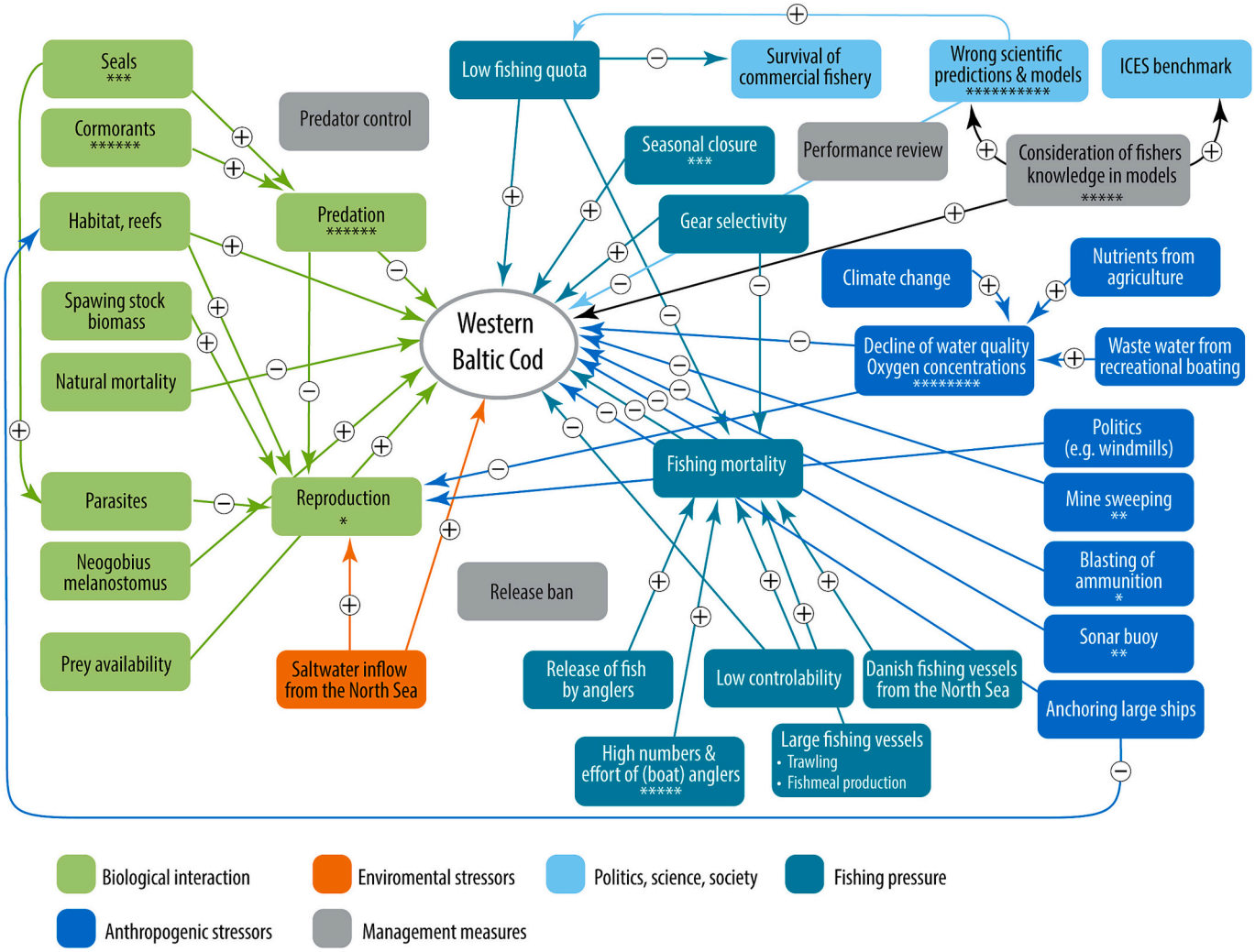

Fig. 1. Cognitive map by commercial fishers showing the proximate and distal drivers influencing the WBC stock. The arrows indicate the direction of the influence, plus (+) or minus (−) signs indicate a positive or negative influence. The asterisks indicate the rating of the importance of the respective factor by the participants, each of whom could distribute a total of five asterisks as they wished.

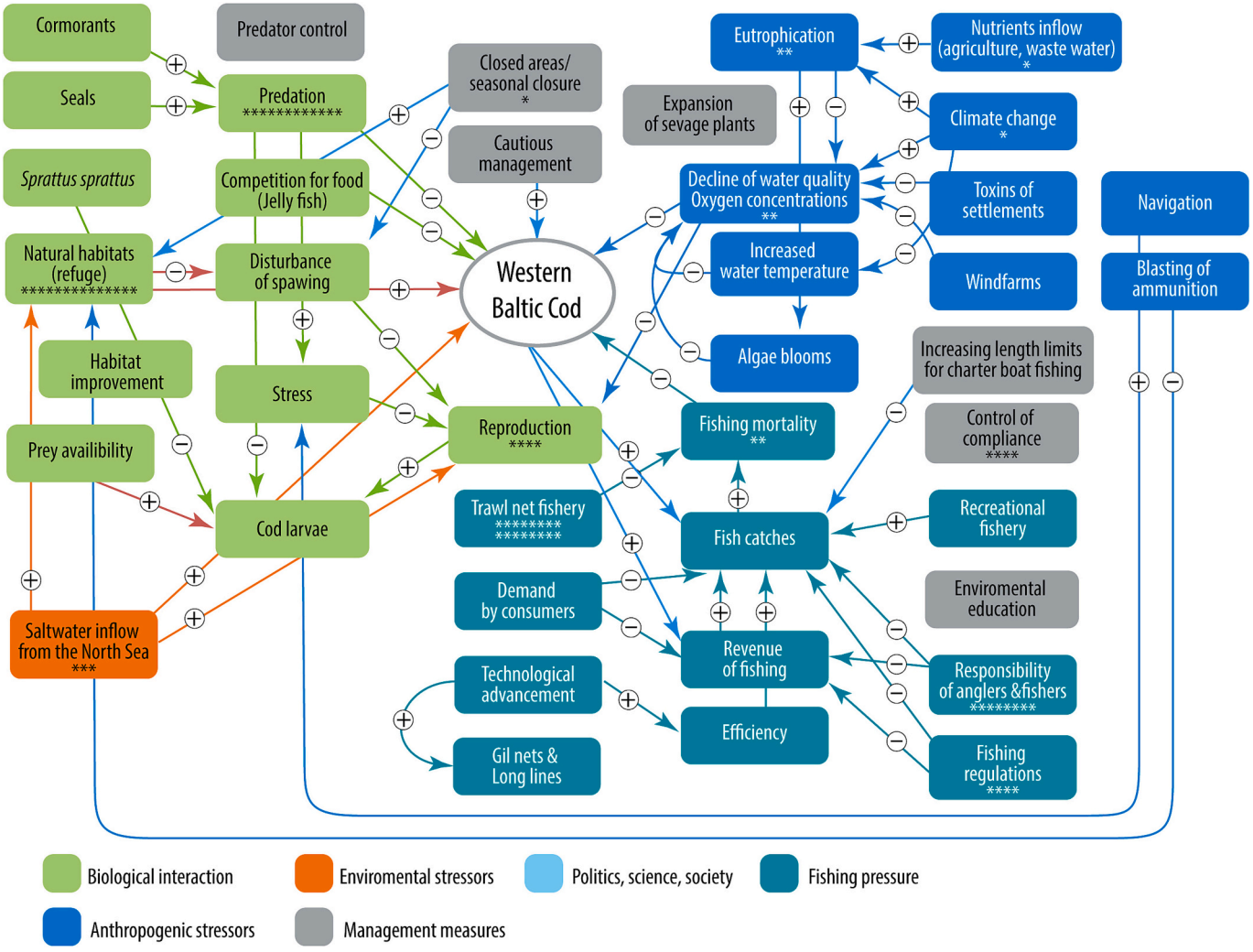

Fig. 2. Cognitive map by recreational anglers showing the proximate and distal drivers influencing the WBC stock. The arrows indicate the direction of the influence, plus (+) or minus (−) signs indicate a positive or negative influence. The asterisks indicate the rating of the importance of the respective factor by the participants, each of whom could distribute a total of five asterisks as they wished.

have been lost in evaluating and communicating data, leading to inadequate management. The decoupling of scientific knowledge and political decisions was identified as a cause of declining compliance.

3.2. Consensus and conflict with regard to fisheries management and conservation

The following section summarizes the results from the single workshops and the joint final workshop. All participants in the final workshop agreed that the ecological status of the western Baltic Sea was poor, shared the vision of an ecologically intact Baltic Sea with sustainable recreational and commercial fisheries and emphasized the restoration of natural biodiversity as the basis for this. The conditions for WBC were perceived as deteriorating due to environmental factors that can neither be compensated for in the short term nor influenced by fisheries management. Above all, the restoration of natural habitats and the reduction of nutrient inflow were considered to be urgently needed.

Conflicts occurred over the need for stricter regulation of the fishery in general (Table 1). Only the eNGOs highlighted the importance of precautionary principles and ecosystem approaches for fisheries management. Both, recreational anglers and eNGOs emphasized the need to regulate and control in particular the large-scale bottom trawl fishery more strictly. Commercial fishers focussed on the weak influence of commercial fishing on WBC and emphasized that the effects of fishery management measures were limited. They discussed the impact of the trawl fishery (in particular of summer rockhopper trawling) controversially but emphasized the importance of reducing recreational fishing mortality. Bag limits were deemed ineffective because they don't limit recreational fishing effort. From the commercial fishers' point of view, voluntary releases of fish by anglers should be prohibited, as it is for commercial fisheries (landing obligation) because fishers assumed that released cod would have low post-release survival rates. Strict bag limits were not considered appropriate by the anglers, primarily because their impact on the stock would be unclear and would have to be weighed against the negative economic consequences for coastal angling tourism. There was, however, no consensus among the anglers regarding the setting of bag limits.

3.3. Predator management

Conflict occurred regarding predator management. While authorities, commercial fishers and anglers considered a Baltic Sea wide management of seals and cormorants to be necessary to rebuild and protect the WBC stock, predator management was controversial among the representatives of the eNGOs who, nonetheless, considered a monitoring of relevant predators. If necessary, compensation should be provided for reduced catches and damage of fishing gear. The topic predator management remained controversial and the participants

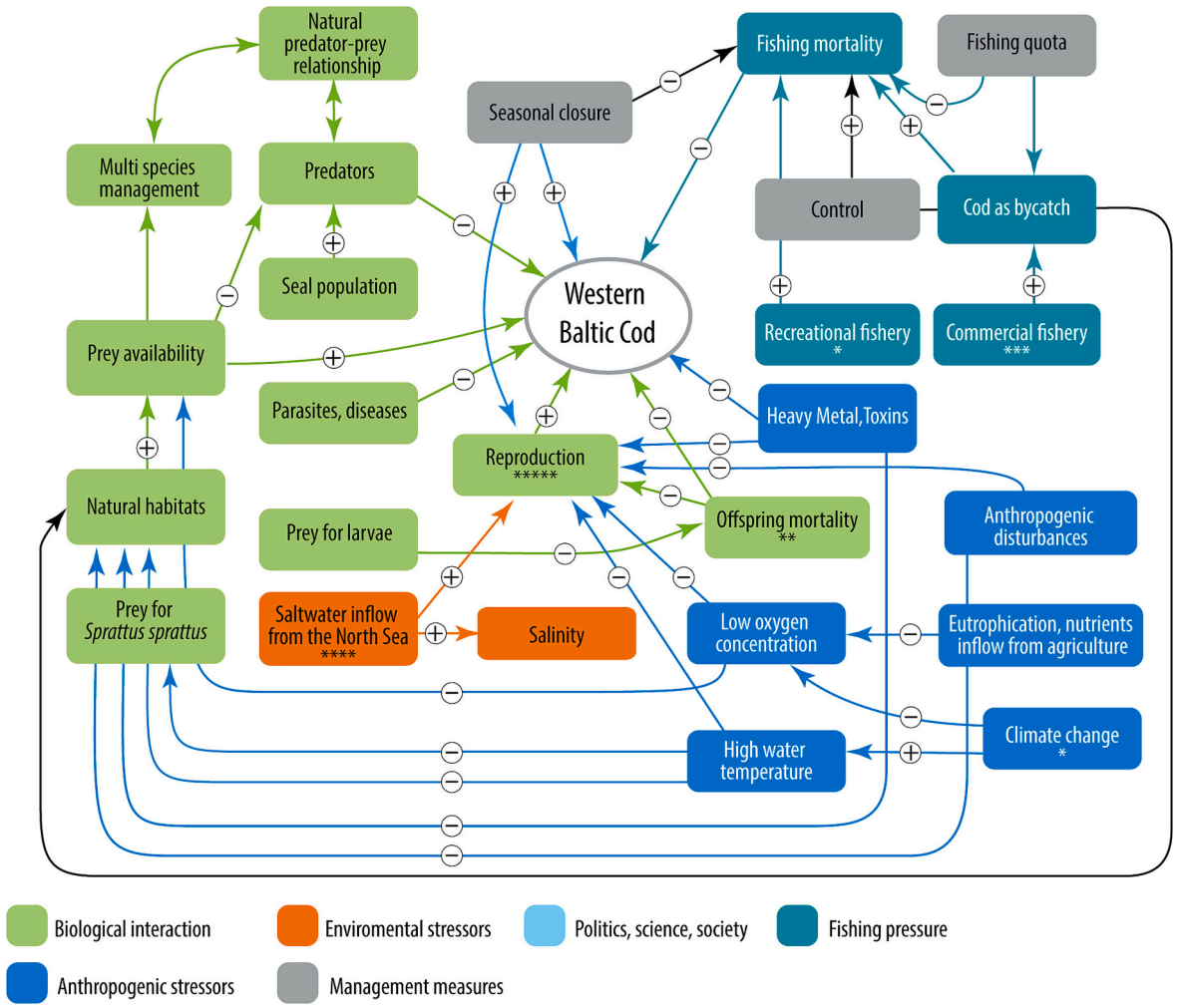

Fig. 3. Cognitive map by representatives of the eNGOs showing the proximate and distal drivers influencing the WBC stock. The arrows indicate the direction of the influence, plus (+) or minus (−) signs indicate a positive or negative influence. The asterisks indicate the rating of the importance of the respective factor by the participants, each of whom could distribute a total of five asterisks as they wished.

agreed that no consensus could be reached on this and that further discussions were needed.

3.4. Fishing quotas and the role of fishery science

Fishing quotas were also debated controversially. The quota system itself was assessed as efficient by fisheries authorities whereby some of them argued that WBC could be managed without quotas, analogous to other coastal fish species that lack quota systems, for example through the establishment of large-scale protected areas. They pointed out that quotas cannot be based exclusively on scientific assessments, but have to be negotiated and comply with legal requirements. The eNGOs, in contrast, emphasized that fishing quotas should be based solely on scientific advice. Commercial fishers agreed that fishing quotas generally are beneficial for WBC but stated that scientific models, predictions and advice on which current quotas rely were biased. They emphasized that individual quotas should be linked to fishers rather than vessels and that quotas should be fixed for the longer term to offer planning security. The management should focus on minimum quotas, which could only be changed, if necessary, with a range of a maximum of 15 % per year.

3.5. Protected areas

Conflict existed over protected areas and seasonal and spatial closures. A majority of commercial fishers considered these to be useful if designed flexibly in terms of time and space and in consultation with the respective fishery. Protected areas on a voluntary basis could be realized in the short term and with a high level of consent. However, commercial fishers also pointed out that protected areas might be ineffective if the habitat quality is not sufficient. Representatives of the authorities stressed that spatial or seasonal closures should be adapted to the WBC biology and the implementation of control measures. The majority of anglers considered protected areas and seasonal closures effective, however, it was discussed that seasonal closures would affect angling tourism without their effectiveness being proven. The eNGOs emphasized the importance of protected areas that exclude fisheries, but agreed that seasonal and spatial closures should be adaptive, temporally and spatially adjusted, and designed in coordination with the fisheries.

3.6. Adaptive management, self-responsibility, and stakeholder involvement

Confidence in the current fisheries management was generally low and lowest among commercial fishers (Table 2). Recreational anglers and commercial fishers stated that they have no real influence on fisheries management decisions and rated management decisions as rather non-transparent. The representatives of the authorities and eNGOs rated their ability to influence fisheries management somewhat higher (Table 2). Accordingly, the importance of participatory approaches in fisheries management was generally acknowledged in the discussions

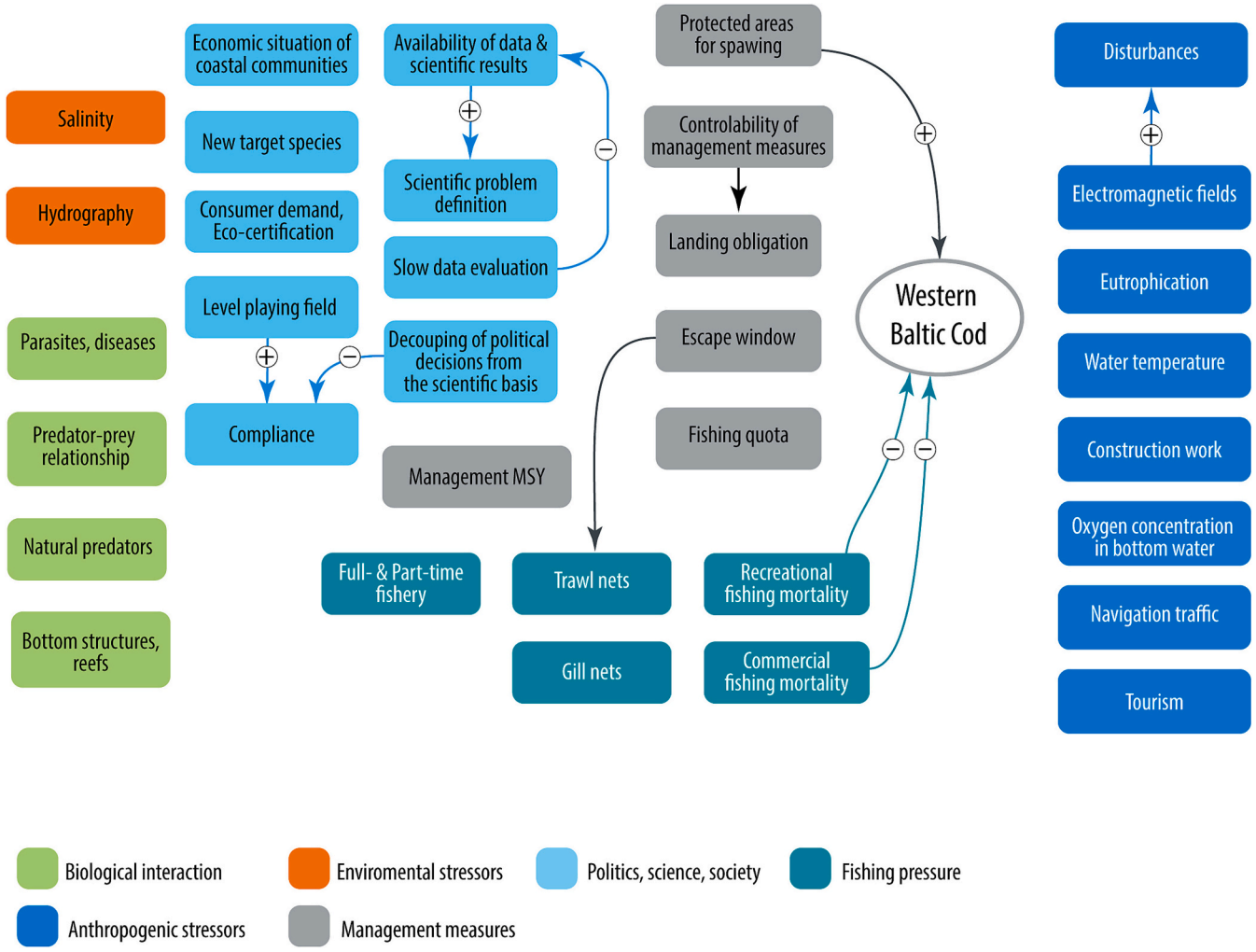

Fig. 4. Cognitive map by the representatives of the authorities showing the proximate and distal drivers influencing the WBC stock. The arrows indicate the direction of the influence, plus (+) or minus (−) signs indicate a positive or negative influence. Due to time constraints, the rating of the importance of the respective factors was not assessed in this workshop.

and all stakeholder groups wanted greater involvement in decision-making processes of fisheries management. Representatives of the authorities pointed out the importance of communication between stakeholder groups, for example in the Regional Advisory Councils (RACs, Linke et al., 2011), and emphasized that the will to compromise is a prerequisite for achieving common goals. They stressed the value of cooperation and voluntary agreements, as these are much faster than legislative changes that have in most cases to be initiated through the institutions of the European Union.

From the anglers' perspective, more emphasis should be placed on anglers' personal responsibility and education/information than on new regulations and controls. Anglers would support measures to improve sustainable fishing, but these would need to be better and more proactively communicated to avoid acceptance problems. Similarly, commercial fishers emphasized that fishers' knowledge should be given greater consideration in the future and that cooperation in particular with fishery science and fisheries authorities should take place on an equal footing.

All stakeholders demanded more adaptive management. The effectiveness of new regulations should generally be monitored so that the measures can be adjusted if necessary or discontinued if unsuccessful. Additionally, representatives of the authorities stressed that management measures are only effective if they can be controlled, monitored and are perceived as fair. Management measures should, as far as possible, apply uniformly to all users in order to increase compliance.

Further aspects that were addressed but not discussed in detail were the refining of fishery products to increase added value to compensate for lower catch volumes. According to the eNGOs, corresponding incentives should be provided and direct marketing of WBC as a regional and organic food should be encouraged. Diversification and alternative livelihood strategies, including diversified harvesting activities and supplementary income-generating activities, such as running boat trips for tourist and "pesca-tourism" (Piasecki et al., 2016) or the involvement of fishers in monitoring and conservation (Piñeiro-Corbeira et al., 2022) could open up new opportunities for commercial fishers and were viewed positively by all stakeholders. There was also consensus that the improvement of the current state of the Baltic Sea requires not only cooperation among the present stakeholders, but also the involvement of other stakeholders, especially from agriculture. Accordingly, the representatives of eNGOs planned to hold workshops on marine protected areas in the near future, to which not only scientists and representatives from administration and politics but also commercial and recreational fishers would be invited. Despite the different assessments of fishing mortality by anglers and commercial fishers, closer cooperation between representatives of the two fisheries was agreed on at the final workshop as there was mutual understanding that both groups depend on the same resource.

Table 1
The table shows management aims, and management measures with consensus and conflict.

Management aims	Management measures	Conflict/ consensus/ addressed
Overall improvement of the ecological status of the western Baltic Sea	• Analysis of causes of stock depletion	Consensus
	• Stocking of cod	Addressed
	• Protection and improvement of habitats	Consensus
	• Reduction of nutrient inflow	Consensus
	• Co-operation with agriculture	Consensus
	• Interdepartmental communication between the departments of fisheries and agriculture	Consensus
	• River bank management	Consensus
Commercial fishery (CF)	• Improving selectivity of fishing gear Involvement of CF to develop and test corresponding methods	Consensus
	• Support (funding) for diversification	Consensus
	• Reduction of bottom trawling	Conflict
Recreational fishery	• Information and training of anglers	Consensus
Protected areas	• Participation of the fishery in planning and implementation of protected areas	Consensus
	• Temporal and spatial flexibility	Consensus
	• No take zones with exclusion of fisheries and recreational boating	Conflict
	• Assessment of success and adaptive management	Consensus
Predator management	• Monitoring of natural predators	Consensus
	• Reduction of natural predators	Conflict
Quota management	• More flexibility	Conflict
	• Quotas that allow planning security	Consensus
Research and data collection	• Improvement of data collection (catch data from recreational and commercial fisheries)	Consensus
		Consensus
	• Further research on causes of stock declines	Addressed
	• Application of fitness indices for cod in addition to mortality estimates.	Consensus
	• Anglers could provide data to science as part of "Citizen Science".	

4. Discussion

4.1. Case study results

Transforming the existing resource use system into a socially and economically sustainable system requires insights into the system understanding of stakeholders but also trustful communication and cooperation between the stakeholders (Jentoft et al., 1998; Erkkilä-Välimäki et al., 2022). In our specific case, the workshops could, as intended, initiate a discussion between the invited stakeholder groups. The cognitive maps revealed consensus among the stakeholders about the impacts of eutrophication and global warming on WBC. This was in accordance to the recent ICES advice which identified high natural mortality due to the poor ecological status of the Baltic Sea as the main cause of the decline of WBC (ICES, 2023; ICES, 2022b). Consequently, there was general agreement at the final workshop that changes in agriculture to mitigate eutrophication are necessary to improve the ecological status of the Baltic Sea. The impacts of global warming were not discussed further as the participants agreed that it was far beyond the control of fisheries stakeholders.

4.1.1. Perceptions of human-wildlife conflicts

Pronounced differences were identified in the assessment of some drivers and the specification of corresponding management approaches, especially when it came to fisheries management. First, predator management was discussed controversially during the single workshops and no consensus was found in the final workshop. Conflicts between fisheries and eNGOs over predation impacts occur regularly in the Global North (Königson et al., 2009; Östman et al., 2013) where conservation efforts have led to the recovery of marine predators to the point where they are exploiting natural resources that are also harvested by humans (Yodzis, 2001; Arlinghaus et al., 2021, 2023). With conservationists prioritizing the protection of the predators, these conflicts are likely to intensify (Rauschmayer et al., 2008). They are to some extent grounded in different perspectives on processes and outcomes. For conservationists, there can be a difference between a cod killed by a seal and one killed by a human as the latter can choose not to do so (Everett, 2001). While for a fisher there is a difference between a fish not caught due to well-founded and transparent management decisions and one not caught due to political negotiations which disregard fishers and biological realities (Oyanedel et al., 2020). The response to these conflicts may be disproportionate to the actual conflict or damage (Dickman, 2010) because they are not only the result of competition for scarcer resources but can also be attributed to different social and economic perspectives, perceptions of reality, immaterial needs including such as respect and identity and different values regarding nature and environment associated with social or cultural differences (Bennett, 2016; Boucquey, 2020; Levin et al., 2021; Arias-Schreiber and Gillette, 2023). This type of human-wildlife conflict might only be minimized if policy shifts from strict species protection to effective management of predator populations (Rauschmayer et al., 2008; Redpath et al., 2013), which requires a transboundary multinational intervention in the context of the marine ecosystem. Additionally, education and financial incentives could be useful to avoid or mitigate hostility towards conflict species. Furthermore, more effort is needed to identify processes that most

Table 2
Rating of the perceptions of the participants from the four stakeholder groups about the current fisheries management and their ability to influence management decisions. The participants rated the statements shown below on a five-point Likert scale (1: does not apply at all, 2: rather not applicable, 3: applies partly, 4: rather applies, 5: fully applies). The table shows the median and 95 % confidence interval of the ratings. Confidence intervals could not be calculated for the representatives of the authorities due to the low number of valid responses.

Statement	Authorities ($n = 5$)	Commercial fishery ($n = 13$)	Recreational fishery ($n = 17$)	Environmental NGO ($n = 6$)
I have confidence in the current fisheries management/policy.	3	1 (1,2)	2 (2,3)	3 (2, 3)
Fisheries management and policy decisions are transparent.	NA	2 (2,2)	2 (2, 3)	3 (1.5, 3)
I am adequately informed about the decisions of fisheries management/policy.	4	3 (2, 3)	3 (2, 4)	3 (2.5, 3.5)
I am sufficiently informed about the status of the Baltic Sea fish stocks.	4	3 (3, 4)	3 (3, 4)	3 (3.5, 4.5)
I am able to influence fisheries management and policy decisions.	3	2 (2, 4)	2 (2, 4)	3 (2, 3.5)
I would like to be more involved in the decision-making process of fisheries management/ policy.	5	5 (4, 5)	5 (4, 5)	4 (3.5, 5)
I am able to influence the WBC stock through my activity.	3	3 (2, 4)	3 (3, 4)	2.5 (1.5, 3.5)

effectively support the coexistence of different species on a transparent evidence base (Guerra, 2019). Human-wildlife interactions can also provide an alternative source of income to stakeholders, for example in the ecotourism sector (Nyhus, 2016; Guerra, 2019), an opportunity to diversify for commercial fishers, which was also discussed in the final workshop.

4.1.2. Conflicts between commercial and recreational fisheries

Conflicts between anglers and commercial fishers similar to those shown in the cognitive maps were observed elsewhere if both blame each other for unsustainable fishing, habitat damage, or high bycatch rates (Arlinghaus, 2005; Johnson and Griffith, 2010; Nguyen et al., 2016). These conflicts reflect divergent interests of both stakeholder groups (fishing for sport, leisure and personal consumption vs. capture fish products for sale; Cooke and Cowx, 2006; Arlinghaus et al., 2023), associated moral economies (Boucquey, 2020), value differences (Arlinghaus et al., 2023), and different cultural and political constructions of nature. A "blame game" occurs in particular when each sector is confronted with the decline of important target fish stocks, political and social instabilities, and financial challenges (Boucquey, 2017; Arlinghaus et al., 2021) or when one sector perceives to be unfairly treated in harvest regulations. Stakeholders, for example, may agree with statements that fish is a valuable resource that should not be wasted, but perceptions of value and waste may substantially differ between groups (Boucquey, 2017). In the case of the WBC, the recreational fishing mortality cannot be held responsible for the cod declines, because with liberal quotas commercial fisheries were largely responsible for the bulk of fishing mortality; this situation has shifted in recent times with declining commercial quotas. Conflicts between commercial and recreational fisheries also have a social underpinning in terms of visibility of impacts often reinforcing discord by focusing on regulating commercial fishing as stocks collapse and competition increases (May, 2015). This is reflected in the lack of consideration of recreational fisheries objectives in the CFP. This conflict can be even further exacerbated if the considerable economic importance but also the impacts of recreational fishing on fish stocks and environment are ignored by policy and fisheries management (Abbott, 2015; Arlinghaus et al., 2019). So far there are no universal solutions to this conflict, in particular in marine systems, because the management of marine recreational fisheries is confronted with a low level of organisation of anglers and a lack of data regarding the number of anglers, angling effort, magnitude of fish catches, heterogeneity of angler motivations and specialisation, as well as the broader economic dimension of the sector (Borch, 2010; Hyder et al., 2018). Suggestions for conflict solution range from, for example, co-management approaches to spatial separation of the sectors to the distribution of the allocated catch quotas between commercial and recreational fisheries (Sutinen and Johnston, 2003; Borch, 2010; Brown, 2016). The main reason for the inequalities of the sectors is, however, the poor integration of marine recreational fisheries into the CFP (Grati et al., 2025). A stronger inclusion of MRF in the future CFP would require overcoming fragmented MRF governance, specific explicit targets for MRF and their economic and social importance, and a reorganization of stakeholder participation in RACs and regional groups (Grati et al., 2025). A future policy that fully embraces marine recreational fisheries should pursue multiple objectives, such as the provision of food and recreational opportunities, and establish a framework for the allocation of fishing opportunities between commercial and recreational fisheries to redress power imbalances, ensure fair and equitable access to fish resources, and maximize the social benefits of fishing (Grati et al., 2025).

4.1.3. Stakeholder perceptions of scientific contributions

The workshops revealed comparatively little distrust of science among anglers whereas some commercial fishers expressed distrust in scientific models and argued in favour of taking greater account of fisher's knowledge in management. The distrust might result from different perspectives with regard to spatial and temporal scale of observations or fishers' experiences versus averages estimated by scientists but particularly also from scientific uncertainties concerning data and predictions arising from the increasingly complex social-ecological systems under climate change (Degnbol, 2003; Hauge, 2011; Ojea et al., 2020) Distrust might be particularly high if participation occurs only at lower levels in the context of asymmetric power dynamics between different stakeholder groups. As quotas for commercial fisheries have decreased over time and the setting of these quotas is at least partly based on stock assessments, scientists are held responsible for management measures that have a negative impact on the fishery (Dedual et al., 2013; Boucquey, 2020). Distrust can be reduced by communication and collaboration, transparent communication and stakeholder involvement at all stages of the underlying research and particularly the management initiative (Silver and Campbell, 2005; Ebel et al., 2018). Commercial fishers expressed no doubts about the collapse of the WBC stock during the final workshop but pointed out that the causes must be better investigated in the future. The expressed high confidence of eNGOs in science might be explained by the fact that eNGOs take scientific arguments as "absolute truth" to strengthen their position in public discussions (Stöhr and Chabay, 2010).

4.1.4. Dynamics of stakeholder participation

All participants expressed their desire for more participation in sustainable fisheries management. Differing stakeholder perceptions of the impacts of fishing, climate change, pollution including eutrophication, and resource management, however, can prevent effective stakeholder participation (McClenachan et al., 2022).

Commercial fishers may deny threats to stocks and blame the causes of problems on factors outside their control, thus maintaining their identity as misunderstood victims of special interest groups and government bureaucracy (Nguyen et al., 2016; Boucquey, 2020). From this no implementable solutions can be derived, while the narratives of other stakeholder groups may have a better chance of influencing fisheries policy in the long run (Boucquey, 2020). On the other hand, it has been shown that the commercial fishery particularly large-scale trawlers dominate narratives in the field of marine environmental governance, potentially leading to a weakening of sustainability narratives (Veneroni and Jacobsen, 2024). This can be to the advantage of additional stakeholders, such as recreational anglers, who may attribute complex environmental and governance problems to the singular cause of some commercial fishing and faulty management, making simple solutions such as stopping overfishing and tightening commercial fishing regulations seem reasonable. Veneroni and Jacobsen (2024) also come to the conclusion that stakeholder representation needs to be broadened to develop multifaceted solutions at the sub-regional level. Different perceptions of nature may lead to divergence between the fishery sector and eNGOs, which hampers sustainable fisheries management when these organizations are dogmatic and campaign-oriented (Larsson, 2019). Comparable argumentation patterns have also been observed in our workshops and illustrate that the development of communicative and collaborative processes that transform competitive or antagonistic interests into transparent cooperative management is challenging (Jentoft et al., 2010). The biggest challenge for implementation, however, remains the establishment of regional co-management that devolves authority to the regional level, overcoming power imbalances and creating legitimacy that leads to meaningful stakeholder involvement and co-design of management measures (Griffin, 2007; Hegland et al., 2012).

4.2. General limitations of the applied methods

The collaborative creation of cognitive maps as part of the workshops allowed to document the system understanding and, based on this, the identification of possible conflicts, the understanding of values and perceptions of fisheries stakeholders, promoted discussion among them and incorporated different knowledge into discussion. The finalized

maps created a transparent and collective representation of the social-ecological mental models shared by stakeholders with regards to factors affecting the WBC (Penn et al., 2013). It has to be considered, however, that mental models (and other cognitive maps) are influenced by selective exposure to information (Pahl-Wostl, 2007). Scientists and eNGOs may form mental models based on scientific literature which provide them access to stock assessments and a range of further perspectives on the marine ecosystems but may also be biased by, for example, the growing emphasis on climate change in scientific literature. Recreational and commercial fishers, in contrast, may rather focus on catch rates and their respective mental models might be predominantly influenced by their daily experiences at sea and these observations might be spatially limited and fragmented, but have a high spatio-temporal resolution (Verweij et al., 2010; McClenachan et al., 2022). Aminpour et al. (2021) showed that every group has a certain bias, but the collective of all users represents scientific understanding of fish stock dynamics reasonably well. Furthermore, although the moderation tried to establish equality in the group, it cannot be completely ruled out that the dominance of some individuals influenced the group-based outcomes (Kempf et al., 2016). In addition, drawing the maps collectively conceals contradictions within the respective stakeholder groups, for example, conflicts regarding trawl fishing (commercial fishers), bag limits (anglers) and predation (eNGOs). Considering the heterogeneity of stakeholders, however, is a precondition for a fisheries management adapted to specific characteristics of the fisheries (Castello et al., 2013; Knoche and Lupi, 2016) while also increasing the potential for conflict resolution between different stakeholder groups (Johnson and Griffith, 2010). To cover heterogeneity, the creation of individual maps could be a useful alternative, which also allows further analyses to be carried out (see Gray et al., 2015 as example).

4.3. Lessons learned, long-term perspectives and steps forward

In this section we want to reflect first, on structural implications for fisheries management, second, on the timing of stakeholder involvement, third on the scope of stakeholder involvement and, finally, on specific measures as implied by the identified obstacles and challenges.

With regard to the structure of fisheries management, it has been discussed for some time that traditional and inflexible fisheries management structures, which focus heavily on the impacts of fishing, delay the processing of environmental signals, slow down the response to environmental changes and cannot adapt well to the high speed and variability of current ecosystem dynamics (Hanna, 1999). With differences regarding fisheries structures and marine environment, significant parallels can be drawn to the collapse of the Newfoundland cod stock during the 1990s where fisheries management was unable to cope with competing and partly unsustainable fisheries under variable environmental conditions (Hutchings and Myers, 1994; Rice, 2018). The comparatively short period of time in which the WBC stock suddenly collapsed for a second time underlines the urgent need of an adaptive resource management capable of dealing with uncertainties and abrupt and rapid environmental changes, whose frequency will most likely increase with future climate warming (Cheung et al., 2021) and possibly additional anthropogenic stressors. Adaptive approaches based on continuous monitoring with sufficient feedback loops and indicators (Holsman et al., 2019; Bell et al., 2020) are more suitable to cope with uncertainties associated with complex social-ecological systems including fisheries (Khan and Neis, 2010). More flexibility, for example in the design and management of closed areas and seasons, as it has been discussed in the workshops, could take into account uncertainties and variability of ecosystem changes (Vigo et al., 2024) and allow more flexibility regarding fishing opportunities (Bastardie et al., 2024).

With regards to timing, our study indicates that stakeholder involvement should take place as early as possible and not only after problems and conflicts have arisen - as it is often the case (Chuenpagdee and Jentoft, 2007).

Regarding the extent of stakeholder involvement, it also became clear during the workshops that the broad range of factors and causalities affecting the ecosystem clashed with a narrow understanding of fisheries stakeholders, who have also lost relative importance in resource management due to the strong influence of external factors on the resource and its management (Bossier et al., 2021; ICES, 2023). Unfortunately, the CFP currently considers it sufficient to involve only directly affected stakeholders, i.e., those with a declared interest (eNGOs) or those who use or manage the resource in question (commercial fishers, anglers, authorities). Our case study illustrates that in addressing key issues, the most influential stakeholders may have an asymmetric connection to the ecosystem in question, e.g., agriculture, which has neither a declared interest nor reliance on the declining resource, but has considerable power to support its restoration and work towards sustainable use. Involving representatives from agriculture and other stakeholders that use or impact the marine environment (Mikalsen and Jentoft, 2001) in management processes might help to overcome the "blame game" between fisheries and agriculture which was also observed to some extent in the workshops, and foster future cooperation and reform (Galaz et al., 2010).

Ultimately, we come to the conclusion that the key factors identified in our case study that impact WBC cannot be addressed by fisheries stakeholders and management alone; they all have a long-term impact and require deep systemic changes that are very difficult to translate into reality. In the long term, fish stocks and fisheries of the western Baltic Sea can only be maintained if the fragmentation of environmental and fisheries management is overcome and fisheries management is extended beyond TACs and catch quotas towards ecosystem-based management that can address the full range of stressors (Pinsky and Mantua, 2014; Bryndum-Buchholz et al., 2020). There is also a need for cooperation and thus unform legislation between the various European commissions and ministries. The relevant environmental problems can only be managed at a macroregional level (Reusch et al., 2018), for example by a river basin management at national and international level that prevents the progressing eutrophication. A wide range of additional research is needed to explore which governance models and institutional frameworks work well at which spatial and temporal scales, how cooperation within as well as between local, national and transnational levels could be improved and how these approaches can deal with power dynamics and different levels of agency among stakeholders (Jentoft, 2017; Hassler et al., 2019).

That said, neither strict quotas, the closure of fisheries (both commercial and recreational) nor the establishment of protected areas can ensure sustainable exploitation of the WBC stock if the stock responds in a non-linear or discontinuous manner to fishing pressure and, in particular, to unfavourable environmental conditions (Viitasalo and Bonsdorff, 2022; Langlet, 2023; Steinkopf et al., 2024). These insights lead directly to the question of how to move forward? The WBC stock is collapsed, the fishery is now closed. Will we see the same trajectories as in Newfoundland? Or something else? None of us know, and the same holds true for the stakeholders who face a highly uncertain, mostly bleak future with regards to the WBC. In the short-term fishers will need to move to alternative species or increase revenue through direct marketing with lower catch volumes as has been observed in recent years (Lewin et al., 2023). Another possibility for diversification which was also discussed in the final workshop could be working as a "sea ranger" in the fields of, e. g., habitat management and monitoring of coastal fish populations and environments to support the scientific and regulatory monitoring needed to address the multidimensional nature of climate variability (Lomonico et al., 2021). The required training has already been introduced in MWP in 2023 (de Graaf et al., 2023). Aquaculture, processing and marketing could also become important components of an enhanced regional future seafood value chain in the medium term (Lasner and Barz, 2023).

Finally, all of the suggested measure will require long-term and continuous communication and coordination. This can be provided by

firmly established and securely financed bridging organizations backed by sustained political and institutional support. Without the current fragmentation of approaches such an organisation can manage the integration of diverse knowledge, values and perceptions of stakeholders and most importantly address power imbalances and governance integration across ministries and policy makers (Berkes, 2009). Bridging organizations (Kowalski and Jenkins, 2015) can also provide information to decision makers, provide negotiation mechanisms, ensure transparency of decisions, and provide feedback mechanisms and opportunities for co-decision at earlier stages of management compared to the already established (R)ACs and thus represent a fundamental first step on regional and national levels to foster transition (Rockloff and L. ockie S., 2004; Berkes, 2009; Schwermer et al., 2021).

5. Conclusions

Whilst the positive impact of stakeholder workshops in terms of exchange, alignment of understanding and building trust is undisputed and reflected in our results, our case study also illustrates limitations with regards to long-term outcomes in highly dynamic ecosystems. The comparatively short period of time in which the resource of interest to our study collapsed unexpectedly (and for the second time) illustrates the urgent need to adapt resource management to rapid environmental changes. Although these types of workshops are generally perceived as an initial step towards co-management, it must be recognized that ecological resources can face significant impacts that are beyond the control of direct stakeholders. In such cases, the impossibility of achieving short−/mid-term solutions, can be highly frustrating to the participants. Moreover, it is likely that the number of such cases will increase as ecosystems continue to be strongly altered under large-scale and global anthropogenic pressures such as climate change and habitat destruction. It is therefore important to recognize both, the limitation to reach tangible short−/midterm solutions for fisheries stakeholders and the benefit of their empowerment required for trust building, greater involvement and responsibility which can counter alienation and ultimately foster cooperation and sustainable fisheries (Jentoft, 2005).

The (western) Baltic Sea as a show case highlights that fisheries management and environmental policies should not be separated, this is illustrated by the fact that the natural mortality of WBC now far exceeds the fishing mortality which reflects the environmentally-driven reduced carrying capacity of the ecosystem. Equally, restoring the ecological functionality of the ecosystem is now essential but not the remit of fisheries management but that of environmental policies. Therefore, the decision-making process for stakeholder involvement in the form of workshops should take these potential limitations into account by ensuring that the intervention takes place either in the context of a reasonably stable ecosystem or early enough in its decline to still be responsive to measures that the immediate stakeholders can influence. In the case of highly dynamic ecosystems the benefits of the aforementioned positive impacts of stakeholder workshops remain while the contribution of local stakeholder knowledge becomes invaluable as it can provide early warnings for unforeseeable social and ecological developments.

This entails that the structural and institutional framework legitimizes stakeholders and allow for co-management and co-design of management measures. Alternatively, and especially regarding recourses embedded in highly dynamic ecosystems, successful stakeholder involvement for sustainable co-management requires broader and more sustained efforts which break down existing approaches, foster equity, and build and maintain responsiveness.

CRediT authorship contribution statement

W.-C. Lewin: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **M.E. Pierce:** Writing – review & editing, Conceptualization. **R. Arlinghaus:** Writing – review & editing, Conceptualization. **M.S. Weltersbach:** Writing – review & editing, Conceptualization. **H.V. Strehlow:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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Data availability

Data will be made available on request.

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