



Fishers' willingness to report incidental bycatches of endangered, threatened and protected fish species: The case of European sturgeon in the Northeast Atlantic Ocean

Niels W.P. Brevé^{a,b,c,*}, Kateryna Urbanovych^{a,2}, AlberTinka J. Murk^{b,3},
Paul A.M. van Zwieten^{a,4}, Leopold A.J. Nagelkerke^{a,5}, Marloes Kraan^{d,e,6}

^a Wageningen University, Aquaculture & Fisheries Group, De Elst 1, Wageningen 6708 WD, the Netherlands

^b Wageningen University, Marine Animal Ecology Group, Droevendaalsesteeg 1, Wageningen 6708 PB, the Netherlands

^c Sportvisserij Nederland, the Royal Dutch Angling Alliance, Leijenseweg 115, Bilthoven 3721 BC, the Netherlands

^d Wageningen Economic Research, Prinses Beatrixlaan 582, Den Haag 2595BM, the Netherlands

^e Wageningen University, Environmental Policy Group, Hollandseweg 1, Wageningen 6706 KN, the Netherlands

ARTICLE INFO

Keywords:

Conflict resolution
Fisheries management
Perceptions
Interviews
Stakeholder participation
Trust

ABSTRACT

Incidental fisheries bycatch contributes to the dire situation of endangered, threatened and protected (ETP) species. Few published estimates of the severity of fisheries impacts exist as incidental bycatch is difficult to monitor, and reporting can be a sensitive matter for fishers. This paper addresses these sensitivities, the reasons for non-reporting, and possible solutions, using bycatch of the critically endangered European sturgeon (*Acipenser sturio* L.) in the Northeast Atlantic fisheries as a case study. This study comprises 36 interviews with fishers, fisher representatives, environmental non-governmental organizations (NGOs), researchers, and governments involved in European sturgeon conservation from four countries: France, Germany, the Netherlands, and the United Kingdom. Fishers experience difficult economic circumstances, while fear of restrictions in their fishing area and gear makes them reluctant to report such rare bycatch. Adequate management of the European sturgeon and other marine ETP species is worsened by a lack of governmental coordination, and trust issues fuelled by some NGOs' communication strategies using iconic species to lobby for fishing restrictions. This paper discusses solutions to strengthen fishers' cooperation in ETP species research. This would need to include developing a shared vision, clear role separation between stakeholders, communication and trust building.

1. Introduction

Incidental fisheries bycatches and associated post-release mortality contribute to the dire situation of endangered, threatened and protected (ETP) species. The magnitude of the impact of incidental bycatch and associated mortality is however, unclear as few estimates are reported. This is partly due to the inherently rare nature of ETP species interactions with fisheries, and because incidental bycatch reports rely largely on voluntary action of fishers, as it is difficult to design observer

programs to effectively monitor (extremely) rare ETP species bycatch [8]. As a consequence, inaccuracies in bycatch recordings cause uncertainty in population assessments [33,8]. If fishers decide to report incidental ETP species bycatches, this will help us to gain insights into the spatiotemporal distributions and the localisation of key habitats of ETP fish species (e.g. spawning, nursery, foraging, and wintering grounds), and strengthen the design, implementation and monitoring of best-practice measures [50]. Improving fishers' participation in reporting incidental, rare marine bycatches is therefore of paramount

* Corresponding author at: Sportvisserij Nederland, the Royal Dutch Angling Alliance, Leijenseweg 115, Bilthoven 3721 BC, the Netherlands.

E-mail address: niels.breve@wur.nl (N.W.P. Brevé).

¹ ORCID 0000-0002-2152-3690

² ORCID 0000-0003-2731-1629

³ ORCID 0000-0002-4881-4236

⁴ ORCID 0000-0003-2627-2373

⁵ ORCID 0000-0003-1130-749X

⁶ ORCID 0000-0003-4189-746X

importance for (monitoring) the conservation of ETP species populations.

One ETP species of which the population assessment at sea largely depends on voluntary bycatch reports is the anadromous European sturgeon (*Acipenser sturio* L., 1758). Today, IUCN lists the European sturgeon as critically endangered (facing a high risk of extinction), and it is protected under the legal systems of the Bern Convention, the Bonn Convention, the OSPAR Convention, the Rhine Convention, and the EU Habitats Directive [42,70]. This makes European sturgeon currently one of the most endangered, threatened, and protected fish species in

Northwest Europe [42].

Historically, the ‘common sturgeon’ occurred in all Northwest European marine basins and major river basins [70]. Around 1850, the species was still widespread, but 150 years later, the species had almost entirely vanished due to overfishing and degradation and loss of spawning grounds in the natal rivers [15,3,48]. In the 1990 s, only one relict population survived in the Garonne and Dordogne rivers and the Gironde estuary (Gironde river basin from now on) in southern France. From this basin, approximately 50 European sturgeon individuals were captured and raised to build two *ex situ* brood stocks to save the species

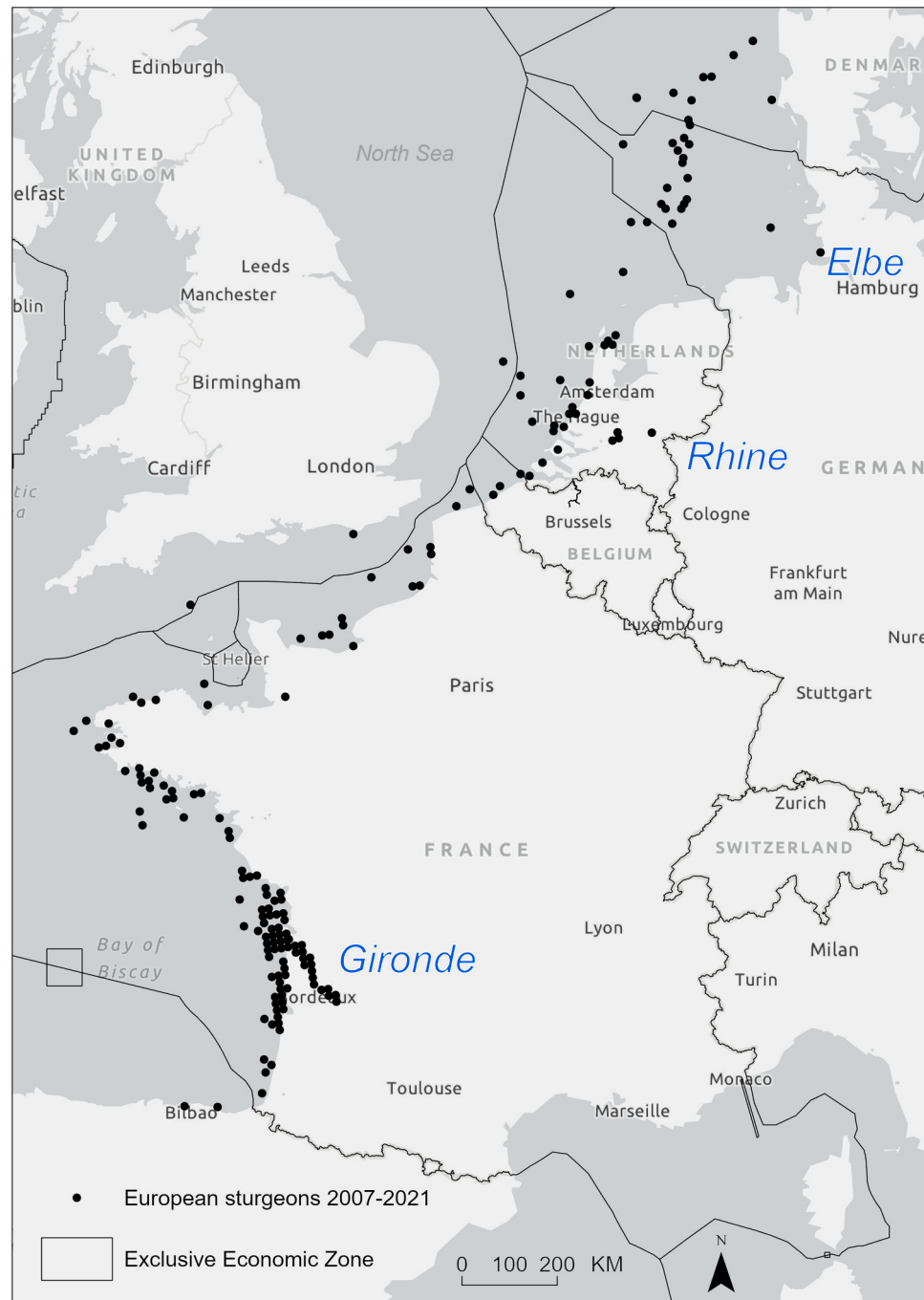


Fig. 1. Study area. Black dots indicate the distribution of European sturgeon bycatch, reported between 2007 and 2021. European sturgeon have been stocked in the Gironde (1.7 million), Elbe (20,000) and Rhine (161 individuals) river basins, and this map shows that the sturgeon mainly occurred in the Gironde estuary and along the coasts of the Bay of Biscay, English Channel and North Sea. Dotted lines indicate the Exclusive Economic Zones (EEZ). The interviewed Dutch fishers mainly fished the North Sea and English Channel, while interviewed French fishers mainly fished the Bay of Biscay and the Gironde estuary. Data was collected by the institutes of INRAE, CAPENA, IGB and ARK Nature, and collated to make this figure.

from extinction: one in France and one in Germany [72]. Artificial reproduction of European sturgeons was challenging [72]; it succeeded once in 1995, and later between 2007 and 2015, and again in 2022. In total 1.7 million larvae and juveniles were released in the Gironde river basin and 20,000 in the Elbe river basin [22,37], while a total of 161 individual juveniles were experimentally released in the Rhine river basin [17]. As a result, currently, European sturgeon occur in nearshore areas and form marine aggregations near the mouths of river basins [21]. Even though the numbers of fish released may seem high, the species' survival rate during the first year of life is naturally low [3]. Although the stocked European sturgeon individuals are nearing maturity, no natural spawning has been observed yet. In fact, the last observed natural reproduction was reported in 1994 [52,71].

As any additional mortality due to anthropogenic stressors will greatly impact the species' chances of recovery these should be reduced as much as possible [52]. Therefore, even the rare, incidental bycatch, as currently reported for the different fisheries along the Northeast Atlantic coast (Fig. 1), may already further reduce the number of subadult specimens [9,29,52]. European sturgeons live at sea for the greatest part of their life [3], but monitoring the sturgeon population's development at sea is challenging, given the large extent of the species' home range and the low catch rate [21,20]. Although migration patterns of European sturgeon juveniles in rivers and estuaries have been studied using biotelemetry techniques [1,2,17], these techniques have not yet been used to study the species' movements in the marine environment. This is largely due to the required investments in time, money and effort related to such techniques, and to the extremely limited availability of (sub) adult individuals of this critically endangered species [31]. Therefore, systematic incidental bycatch reporting by fisheries (including any mark-recaptures) would greatly contribute to obtaining accurate knowledge about the developments of the population of European sturgeon.

Since the 1950 s, fisheries across the Northeast Atlantic have provided data showing declining numbers of European sturgeon populations [19,49,56]. Fishers continued to declare (part of) their bycatch between 2007 and 2020 [21], which demonstrated that the French-German stocking efforts resulted in more sturgeon occurrences at sea [26]. However, reporting suddenly stopped in 2020, in particular in France and the Netherlands. Officers from the Centre pour l'Aquaculture, la Pêche et l'Environnement de Nouvelle-Aquitaine (CAPENA), who represent the fishers from the Gironde estuary were consulted, and confirmed that fishers indeed refrained from reporting. In addition, the Dutch environmental NGO ARK Nature reported that they had not received any sturgeon bycatch reports since 2020, and now experienced a reluctance in reporting from fishers.

Reporting European sturgeon bycatch clearly has become a sensitive topic, while it previously was much less of an issue, in particular with French fishers who have a long record of reporting their sturgeon bycatch [18]. As this reluctance of reporting negatively affects the international conservation and restoration efforts, the current study aims to understand the reasons for this, by inquiring about the perceptions of fishers and other stakeholders on the need and consequences of bycatch reporting. The main questions are: What has caused fishers to stop reporting sturgeon bycatch, and what is needed to restore their willingness to report again? European sturgeon is one of the longest studied ETP species in the Northeast Atlantic, is highly migratory, and highly vulnerable to overfishing. This case study therefore exemplifies many of the problems and challenges in ETP species conservation management and provides a basis for reflection on a better understanding of bycatch reporting in conservation efforts for marine ETP species in general [28, 47].

2. Materials and methods

2.1. Study area

The case study area covers the current distribution area of European sturgeon. Sturgeon were reported from the Gironde river basin and along the coastal regions of the Bay of Biscay, the English Channel, and the southern North Sea, including the marine territories of France, Belgium, and the Netherlands, and to a lesser extent those of the United Kingdom, Germany, and Denmark (Fig. 1).

2.2. General approach

This study used semi-structured interviews [12] to assess what drives or hinders fishers from reporting sturgeon bycatch (and other marine ETP species), and investigates the complexity of interpretations, values, attitudes, and insights of sturgeon conservation among all stakeholders, i.e. fishers, fisher representatives, researchers, governments and environmental non-governmental organisations (NGOs).

2.3. Research population

The research population for this study was selected from the four countries (FR, NL, DE, UK) in two steps. **Step 1** listed all fishers that had reported European sturgeon bycatches in previous years. From that group the author team identified fisheries métiers that were prone to catching sturgeon based on target species, gear, area fished, and seasonality [62]. As the European sturgeon belongs to the same clade as the very similar, Atlantic sturgeon (*Acipenser oxyrinchus* Mitchell, 1815) [54], which is regularly caught in bottom trawl and gill-net fisheries [14], we focussed on this fishing gear [21]. We further concentrated the research on France and the Netherlands, because data on sturgeon bycatch mainly originated from within their Exclusive Economic Zones (EEZ) (Fig. 1), and it is within these countries that the sudden drop in reports occurred. Fishers involved in reporting were mainly French and Dutch. The French fishing in the Bay of Biscay using various types of trawl gear, and the Gironde estuary seasonally targeting meagre (*Argyrosomus regius*, Sciaenidae) using drift nets (gill-nets) [56,69]. The Dutch, fishing the southern North Sea and English Channel, i.e. fishers who predominantly employ various types of beam trawl gear [58]. CAPENAS' officers assisted in the interviews with French fishers, because this topic was very sensitive and finding willing fishers to be interviewed was difficult. In the Netherlands, the snowball sampling technique [4] was used, whereby recommendations were given from interviewed fishers to find new fishers. This clearly aided to acquisition of access to most interviewees. An article was posted in the digital newsletter of the Nederlandse Vissersbond in June 2022, through the help of a fishers' representative, but this did not yield any responses. Fishers organisations interviewed were CAPENA, the National Maritime Fisheries Committee (CNPMM), the Nederlandse Vissersbond (NVB), Eendracht Maakt Kracht (EMK), the Institute of Fisheries Management (IFM), the Marine Management Organization (MMO), and the Royal Society of Fish (RSF).

Step 2 identified the different stakeholder groups, involved in sturgeon conservation in each country (FR, NL, DE, UK). Involved NGOs were the Défense des Milieux Aquatiques (DMA), ARK Nature, and the Blue Marine Foundation (BMF). Involved research institutes were the National Research Institute for Agriculture, Food and the Environment (INRAE), Wageningen Marine Research (WMR), and the Leibniz Institute for Freshwater Ecology and Inland Fisheries (in German: IGB). Involved government departments were the French DREAL Nouvelle-Aquitaine (regional Directory of de l'État relevant des Ministères de la Transition écologique et de la Cohésion des territoires et de la Transition énergétique), and the Dutch Ministry of Agriculture, Nature and Food Quality.

2.4. Interview guide, interviews and saturation

To ensure consistency whilst working with multiple interviewers, all interviews were based on an interview guide, which touched on four themes: (1) sturgeon captures (if any); (2) pros and cons of reporting rare marine fish bycatches; (3) interactions between stakeholder groups; and (4) awareness and criticism of the sturgeon programme. The guide was tested during two interviews and subsequently translated, resulting in English, French, Dutch, and German versions (see [Supplementary material A](#) for the English version). Before the interview, each interviewee was informed of the purpose, method and intended use of the interview, and was asked to give consent through either a confirmation e-mail or a signed consent form ([Supplementary material B](#)). Although face-to-face interviewing was preferred [12,10], due to Covid-19, the majority (27 out of 36) of the interviews were conducted via Microsoft Teams, Zoom or telephone. Interviews lasted between 30 and 60 minutes. After the interview a brief written note was made of the first impression of the interview and its context to be used in the analysis [12]. All interviews were audio-recorded, transcribed verbatim and shared with the interviewees. The interviewees consisted of a total of 18 fishers and five fisher representatives. The fishers and their representatives were selected by purposeful sampling (described in 2.3) and interviewed until no further variation of the main themes occurred, i.e. saturation was reached, meaning that no new information was discovered, resulting in qualitative representativeness and no further interviews were therefore deemed necessary [27,32,34]. The other interviewees were selected from the different organisations (research institutes, NGOs, government departments per country) involved in European sturgeon conservation ([Table 1](#)). We ensured that a diversity of roles and countries was reached.

2.5. Anonymisation, transcription and thematic analysis

A list of interviewee codes was created to anonymise the data, using two capital letter country codes, three letter stakeholder group codes, and a serial number, e.g. Nlfr1 = interview with Dutch fisher representative #1 ([Table 1](#) and [Supplementary material C](#)). The interviews were transcribed and translated into English, imported into a qualitative data analysis software ATLAS.ti. [5], and coded. Coding used the different themes of the interview guide.

3. Results

For fluent reading quotes from the interviewees that support the results are given separately per paragraph.

3.1. Pros of reporting rare bycatch

The pros and cons for reporting incidental bycatches of marine ETP fish species are summarized in [Table 2](#). Pros are related to: (1) fishers interest in rare, iconic species; and (2) fishers wanting to express their responsibility towards good stewardship for marine resources.

First, catching a sturgeon is generally perceived by fishers as a rare and impressive event. For some it is even seen as a “party moment” (Nlfr3). Fishers interviewed found an interest to share their extremely rare (sturgeon) bycatch throughout their social networks and were (in

principle) certainly willing to report it as they realise that otherwise researchers would be unable to find them. Fishers and all other stakeholders claim sturgeon capture reports to be an essential and instrumental source of data that is extremely difficult to obtain otherwise.

Second, fishers feel that reporting is a sign of ‘good stewardship’ for marine life as it underlines a connection between the quality of the ecosystem and its users. Reporting sturgeon bycatch showcases fishers’ sense of responsibility for the sturgeon population.

- Sturgeon is a very emblematic, very beautiful fish that doesn’t look like a fish from our time. (FRfis1)
- Since you catch something special, you just report it... If no one brings these fish up, the scientists will be unable to find them. (Nlfr1)
- That’s our job, not only catching the fish, it’s also caring for nature. (Nlfr2)
- Bycatch reports of rare fish are a very good indicator of the relationship, the bond, you [i.e. other stakeholders] create with the fisher. (FRfre1)
- Fishers are partners in the [sturgeon restoration] programme. They contribute to the monitoring of sturgeon in the natural environment and provide all relevant knowledge for the evaluation of the programme and more generally for the evaluation of the sturgeon population... Reporting sturgeon bycatch could be a great opportunity to do some good PR [for fishers], by disseminating it widely when someone catches a sturgeon. (FRgov1)

3.2. Cons of reporting rare bycatch

The interest fishers have in sturgeon and other rare iconic species is a good basis for reporting the rare bycatch (and release). However, there are also four reasons for fishers to not report the bycatch of sturgeon, which surfaced from the interviews: (1) a lack of (financial) interest; (2) a lack of time; (3) a lack of understanding (awareness) of how important the information about the species is for the species conservation management; and (4) the trust (or lack thereof) that fishers have in the other stakeholders involved, plus concerns about how the information might be used to result in more regulations, such as closed areas and/or technical measures to reduce bycatch.

First, most fishers commented that such reports do not carry any inherent (economical) benefit for themselves. The critically endangered European sturgeon is protected, and it is illegal to land and sell.

Second, fishers explained that sharing photographs and footage of incidental bycatch through social media is done often and can be done quickly. Reporting, however, requires measuring the fish, writing down the coordinates and sending out an accurate report, which takes time and interferes with their regular work. Interestingly, several French fishers previously did not find it so much of a problem to report sturgeons and had often done so.

- So we take a photo of [the sturgeon], we weigh it, we measure it if we have the means and we take the GPS position, so that’s all we do, so we can’t say that it’s very difficult... I’m interested in seeing sturgeon again. Financially, it doesn’t bring me anything, but... it’s not a constraint at all, I don’t see who couldn’t comply with it. (FRfis3)

Table 1

Number of interviewees per stakeholder group per country.

Country	Fishers (fis)	Fisher representatives (fre)	Researchers (res)	NGO representatives (ngo)	Governmental representatives (gov)
France (FR)	5	2	2	1	1
The Netherlands (NL)	12	3	2	3	1
United Kingdom (UK)	1	0	1	1	
Germany (DE)	0	0	1	0	
	18	5	6	5	2

Table 2

Summary of perceived pros and cons of fishers reporting incidental sturgeon bycatch, per stakeholder group.

Stakeholders' perceptions	Fishers	Fishers organisations	NGOs	Research institutes	National governments
Pros	Sturgeon reports are of interest to fishers' and their social network. Reporting expresses 'Good stewardship' of the marine environment.	Indication of the bond between fishers and other stakeholders. Good PR.	Shows that fishers are taking responsibility for a healthy ecosystem. Increase of public awareness.	Essential data for population assessment and monitoring spatiotemporal distributions.	Useful for making management decisions. Lack in bycatch reports hampers making management decisions.
Cons	No inherent economic profit. Takes time (costs money). May create severe problems for fishers, such as closed areas and forced gear adaptations and restrictions.		Lacking declarations of dead sturgeons are misleading.	No cons.	No cons.

Third, we reasoned that fishers willingness to report sturgeon bycatch would be higher if they were aware of how important the information about the species is for the species conservation management, but this is not *per se* true. In France, researchers promoted the sturgeon restoration through an awareness campaign (Michelet, 2011), while fishers are currently informed about the sturgeon restoration through regular updates from CAPENA and CNPME (FRres2). In France, even though well informed, fishers suddenly stopped reporting in 2020 (see §3.2). In the Netherlands, fishers were informed about the European sturgeon re-introduction through several articles in fisheries newsmagazines. Fishers were rewarded 100 euro per confirmed European sturgeon capture report and given a flag with a printed sturgeon on it. This information helped to collect data, but certainly did not reach all fishers. Several fishers were not interested in such a reward, nor the conservation activities. In the Netherlands, sturgeon reports had also stopped by 2020. In Germany, information meetings with fishers are the preferred method of communicating official action plans (DEres1). Still, DEres1 stressed a lack of general knowledge about sturgeon restoration among fishers and the general public. In the United Kingdom, UKfis1, when contacting the Marine Management Organization, was not offered any instructions on what to do with his rare sturgeon report. Support was offered after contacting the Blue Marine Foundation through the website 'Save the sturgeon'. This illustrates how rare sturgeons are around the British Isles and that the sturgeon restoration programme is not well known among fisher organisations in the UK.

- Most people should be aware of the release of these baby sturgeons [but they are not]. (FRfre1)
- I know it [sturgeon] is back and for me that was an indication that the North Sea is doing better. I didn't know that it was because of a programme, or some hatchery or whatever. (NLfis3).
- I do think that at some point there could be some kind of professionalization towards the wider public... that could be the final push for such a project [sturgeon restoration programme] to succeed. (NLgov1)
- Despite multiple news items it is plausible that a large part of the general public [and fishers] in Germany is still mostly unaware of the sturgeon rehabilitation programme. (DEres1)
- Sturgeon is preferably seen as the source of caviar, not as a flagship species that represents the restoration of an aquatic ecosystem. (UKres1)

Fourth, the fishing industry is faced with difficult economic circumstances, including high fuel costs. Fishers have experienced a sharp decline in the number of operational fishing vessels. For most interviewed fishers it has become a challenge to remain economically viable. Fishers are highly concerned about the loss of space at sea due to closures of Natura 2000 areas and of wind farms, and other no-go areas where fisheries are restricted like the 'plaice box' in the Netherlands.

- In the 1980 s there were around 240 beam trawlers, now we have 80, and more are going, I think 30 or 40. (NLfis5)

- The local fishermen are extremely threatened, because their numbers are declining over the last 30 years. So, we initially started out with around about 1200 fishermen. And in the meantime, there's like 10% of them who are still active. (DEres1)
- If they say: 'Oh, it's like the panda of the ocean and we should make a no-go area'. Yeah, then it's obviously worrying. (NLfis3)
- We [fishers] want to cooperate in everything, except closed areas. (NLfis5)
- The ocean and North Sea is getting taken from us, from the fishermen, as we feel, by wind farms. (NLfis2)
- The [government] have already closed 40,000 km² of the North Sea for the big fishing ships. It's called the Plaice Box. And that's why the fishermen say we don't want to close anything anymore, because it doesn't have an effect. (NLfre2)

Fishers also worry about forced gear adaptations to reduce bycatch risks. This fear reduces fishers' willingness to report rare bycatch. They have experience that such information could be used by NGOs to lobby for further restrictions of fishing opportunities. Dutch fishers refer to the ban on pulse fishing [35,46], but in other countries fishers also express a fear of gear restrictions. For example, DEres1 explained how his research team worked on adapting the settings of gill-nets, these being the predominant gear used in German nearshore coastal waters. These nets rest on the bottom and reach up 2.5 m into the water column. Through sections of rope the researchers lifted the nets 30 cm off the ground, which reduced sturgeon bycatch by 90%, as the sturgeons move along the bottom. This researcher had organised three meetings with fishers to ask them if they would be willing to test this adaptation in gear-setting, to see whether the numbers of fish that they would catch (target fish as well as bycatch) would differ between those two different net settings. However, it never came to anything, as the researchers were threatened during the first meeting by the fishers and removed from the property. German fishers were not willing to comment, but fishers interviewed from the Netherlands were quite clear. Fishers feel misunderstood and that they should be considered and hired as experts to design solutions to reduce rare bycatch, not constantly be told what to do.

- The boss of the cooperative told us that if we wouldn't get off his property within the next 10 minutes, they would certainly arrange for beating up. (DEres1)
- I know you can report it [sturgeon and other rare fish bycatch], but [fishers] are pretty careful about that... That's how a fisherman thinks! Everything you say is used against you! You cannot change the whole fleet [adapt gear] for only two or three sturgeons. (NLfis1)
- [Researchers and NGOs] are working too little with fishermen even if it's fishermen who know a lot about the sea... I'm often treated like a criminal [by NGOs], but I never did something else than providing food... We [fishers] don't see the future that positive anymore... We are really afraid that another negative development will come, based on what [researchers and NGOs] find in the data we deliver. Speech is silver, silence is golden. (NLfis4, a third-generation fisherman who recently had to put his two trawlers on a chain and find another job.)

Notably, some interviewees claimed that there is a general, substantial lack of sturgeon bycatch reporting. FRres2 explained how the French research institutes survey the Gironde estuary for sturgeons every two months and how they capture (measure, check the tag, and release) far more sturgeon than the numbers of sturgeon bycatch reported by individual fishers, fishing the same area, using the same fishing gear. In addition, it is important to mention that non- or underreporting does not *per se* means that fishers do not support the presence of rare species. Several fishers interviewed claim that they do release their rare bycatch alive.

- Even if a report is not produced, this does not mean that the bycaught fish [sturgeon] is treated badly or injured. Sturgeons are released alive, without reporting. (NLfis4)

3.3. Sudden drop of reporting

In France, the number of bycatch reports decreased substantially in 2020, then stopped. The French fishers' reason was, that one of the NGO's - active in sturgeon management in the Gironde area - had gone to court aiming to force the French administration to enforce Habitat Directive, article 12 (EEC, 1992). The article prohibits any form of capture, disturbance or intentional killing in the wild of the species listed in Annex IV (including European sturgeon) and *oblige* fishers to release and report such species bycatch. The reason for the court case was that the NGO suspected the French government of using the bycatch reports to suggest that fisheries have no negative impact on sturgeons, thereby undermining effective sturgeon management. According to the French NGO the best solution to conserve sturgeon is therefore, to ban fishing in the Gironde. French researchers stated that since then French fishing organizations are far less open to collaboration and fishers have stopped reporting sturgeon bycatch. Remarkably, in the Netherlands sturgeon bycatch reports stopped as well in 2020, but interviewees expressed no link between the French and Dutch situation.

- The government uses bycatch reports to assure that the bycatches are not fatal for the fish, since dead sturgeons are never reported... Catch declarations are as useful as they are misleading! (FRngo1)
- This [court case] had the effect of a bomb in the [Gironde] region, resulting in fishers to become very hesitant to report anything as they feel that everything they [fishers] do in terms of transparency ultimately backfires... They don't want to inform that in a certain area [Gironde] they [fishers] catch a lot of sturgeon because they don't want to have restrictions to access to this area. (FRres2)

3.4. Interviewee suggested solutions to improve reporting

The interviewees also mentioned examples that improved reporting may improve sturgeon conservation. In France, tag readers were handed out (as most stocked juvenile European sturgeons are chipped) and visits to the rearing station were organised. Fishers' involvement and willingness improved when they participated in the programmes' research. This was underlined by FRfre1, "My main advice would be to create a trust relationship with fishers to involve them. And to put them at the same level as scientists... I think that's the main key to the success of the reintroduction programme". In the Netherlands, fishers and their representatives also expressed a wish to participate in research. It was stressed by all stakeholders that the researchers needed to be fully transparent towards fishers about the ways in which bycatch reports would be used.

- Fishers can be an arm of the scientists, because we're on the water all the time. (FRfis2)
- Involve [fishers] above all in the research, involve them as researchers! (NLfre3)

- Research should create a clear feedback loop between what is reported and what is achieved from these reports. (NLres2)
- I think it would be a good idea in itself if [government and organizations managing the sturgeon action plan] could sit around the table with [fishers] more often. That [fishers] know what is happening in the action plan, and what might come their way. (NLgov1)

3.5. Perceptions of sturgeon management

All interviewees were asked to reflect on the sturgeon action plans, as these are managed differently across the four countries (Table 3). In France, the government officially controls the action plan whilst the activities are carried out by researchers [26]. French researchers explained the strength of the governments' legal, administrative and financial help. In contrast, the French NGO expressed a strong dissatisfaction and underlined that the French government is not actively involved. In Germany, the sturgeon action plan is also driven by research, yet without any governmental involvement [30,43]. The German researchers explained how most of the implementation work (including fund raising) is being carried out by volunteers, which is less than optimal. In the Netherlands, the Dutch action plan was initiated and has also been run by NGOs, since 1995. The NGOs also finance research on a feasibility assessment of reintroducing the species in the river Rhine. NGOs developed the required sturgeon action plan, which was offered to the government [66]. The government partially supports this plan, financially. Yet, the NGOs sketched the necessity for a stronger, long-term governmental collaboration. In the United Kingdom, sturgeon reintroduction is in its initial phase, and governmental resistance was experienced in accepting European sturgeon as a native species. Only after an evidence report was produced and enough pressure from researchers and NGOs did the UK government started taking notice of the possibility of the rehabilitation of sturgeon.

- The French Action Plan is the last hope for the species. (FRgov1)
- The [French] administration does not want to protect nature and only takes decisions that create an illusion of improving the situation. (FRngo1)
- In Germany the government is not involved in the rehabilitation. But it should be. Bring authorities together to implement changes that were requested in the action plan. (DERes1)
- By putting people on the project, putting out the actions, and getting more involvement from the fishers. (NLngo3)
- I don't think UK authorities were really taking this [sturgeon's return to UK waters] seriously. (UKres1)

Outside France and the Netherlands, other administrations of European member states are not directly involved in the sturgeon action plans. European sturgeon conservation in Germany and the United Kingdom (and partially in the Netherlands) is left to project-based funding. As a consequence, overall, coordinated tasks are driven by NGOs and researchers. No other countries are involved, even though the species occurs within their EEZ (e.g. Spain, Portugal, Belgium, Denmark, Ireland). The interviewees see this lack of European and national governmental involvement as a source of problems, as this causes gaps in international engagement, continuity in long-term funding, coordination of actions, monitoring of fisheries measures, and consistent application of legal documents to assure mitigation of anthropogenic stressors and sturgeon protection (e.g. mitigation of bycatch mortality). The challenge is that EU member states are responsible for (fisheries) management measures in their inland and coastal waters, whereas management at sea is agreed upon at EU level. By default therefore coordination is required, but currently this is not the case for the European sturgeon and other marine ETP species.

Table 3

Stakeholder groups' relevance to bycatch reporting and their (current) role in European sturgeon conservation.

Stakeholder group	Reports on sturgeon bycatches	Current role in sturgeon conservation
Fishers	Fishers bycatch reports are highly useful to researchers and policy makers. Good handling of the fish on deck (and careful release) will save individuals of a rare species.	Eyes and ears (and hands) at sea. Potentially impacted by restrictions determined by the sturgeon conservation. Not directly involved in sturgeon Action Plans.
Fisher organisations	Main communication channel to and from fishers. Represent the interests of fishers. May inform fisheries-management on bycatch mitigation of ETP species.	Manage eventual restrictions determined by the sturgeon conservation. Voice to evaluate the fisheries management measures from a fishers' perspective. Not directly involved in sturgeon Action Plans.
Research institutes	Collect, collate and analyse bycatch data. May use data to assess ETP species' populations, spatiotemporal distributions, and advice on sustainable fisheries management measures.	Main drivers of sturgeon conservation in France (since 1980) and Germany (since 1990).
NGOs	Use bycatch data and research outcomes in their respectful (to other actors involved) communication strategies to lobby for adaptations in fisheries management measures.	Main drivers of sturgeon conservation in the Netherlands (since 2010) and the United Kingdom (since 2015).
National governments	Use bycatch data and research outcomes and translates advice into fisheries management measures in collaboration with other countries to rehabilitate these ETP fish species in European waters.	Responsible for the restoration of ETP species and therefore of the (sturgeon) conservation programme. Only in France actively involved in European sturgeon conservation. European collaboration and coordination would be extremely helpful for the national governments involved.

4. Discussion

In recent years fishers have been increasingly challenged by reduced space to fish and are competing for space with an increasing amount of other users [64]. This comes on top of a history of increased fisheries management interventions, reduced fishing opportunities and rising fuel costs [53]. Fishers perceive that others (researchers, policy makers, NGOs) are, both directly and indirectly limiting their fishing opportunities for different reasons. These issues make them extra sensitive about disclosing information that they perceive could worsen their situation [64]. In consequence of the sensitivities, finding willing interviewees was challenging. For example, the French fishers interviewed were approachable only through mediation by their organisations. Yet, fishers sharing information is key to the management of ETP species and thus fishers' cooperation could be instrumental in species conservation.

4.1. Core aspects of successful cooperation with fishers

A vast body of literature exists on fishers and researchers cooperating in data gathering [40,41,44,59,60,61]. Reported core aspects of successful cooperation are: 1.a shared vision; 2.a clear role separation; 3. communication and 4.trust. However, this study shows that all these core aspects of cooperation are seriously hampered. It is governments who are legally responsible for European sturgeon conservation [42] and other ETP species. Apart from in France, the management of European sturgeon action plans is not carried out by governments but by researchers and/or NGOs. Several countries where the species occurs within the EEZ are not even involved in European sturgeon conservation and rehabilitation. The interviewees see this lack of an international shared vision and approach as a source of problems, as it impairs consistent international collaboration, coordination, optimized approaches and long-term finance.

In addition, there are issues of communication and trust of fishers in the intentions of NGOs and (vice versa) trust of NGOs in data gathered by fishers, and neither of these are unique to this case [60]. There is a strong trend of environmental NGOs, emphasizing scientific evidence for the negative effects of fishing in lawsuits, to obtain strengthened ecosystem and species protection [36]. NGOs and fishers often have different forms of causal reasoning from available data and observations, information, and knowledge, e.g. scientific vs. lay reasoning, and differences in knowing what is really going on at sea, and thus diverging points of view [65]. They have different perceptions. Where NGOs demand fishers to take more responsibility for the state of the marine resources, fishers perceive themselves to act responsibly for 'their' resources and feel connected to the sea itself. While fishers indicate that fishing is essential as it feeds the human population, NGOs point to the

negative effects of fishing on marine ecosystems and fish habitats [38,6]. NGOs call for preserving and closure of marine ecosystems opposes the interests of commercial fishers who demand the continued access to space and resources [11,36,67,68]. The observed conflict and different objectives can be summarized as one between preservation (NGOs) versus utilization (fisheries) [36]. The experiences in France demonstrate that when this difference is not bridged, dispute will arise and the much-needed cooperation with fishers will come to an end.

4.2. Ways forward

The interviewees explained how three pragmatic solutions may aid to improve fishers cooperation potential (thus touching on the four core aspects listed in 4.1): (1) involve fishers in sturgeon conservation activities and research, make clear what is in it for fishers, and thus build trust between fishers and researchers; (2) improve completeness, accuracy and speed in fishers reporting incidental bycatch through technological means and social media; and (3) solve trust issue between fishers and NGOs.

First, fishers need to perceive much more benefit (including intrinsic rewards) and value in declaring ETP species bycatch. The interviewees stated that this can be achieved by fishers cooperation in research. Fishers show (in principle) willingness to participate in such research, and contribute data and experiential knowledge [60]. Those that currently participate may do so out of their own interest or understanding of the importance. For fishers to fully collaborate in research, it is required that they be acknowledged for their knowledge, expertise and skills [73]. However, no fisher is likely to report on ETP species if the information could be used to advise on, or lobby for closed areas or forced gear adaptations. Researchers are interested in facilitating the participation of fishers in cooperative research as it has multiple benefits, such as improving (rare) fish population assessments, improved relevance of research to fisheries management, and improved relationships and trust between fishers, researchers, and managers [41,55]. Motivating each group of actors and including them in a collective project can help to achieve the goals of the European sturgeon restoration action plans. Fishers are more likely to trust researchers if: (1) they are allowed to participate in the research project formulation [51]; (2) understand how scientific reporting works [41]; and (3) understand what the consequences of their data delivery could be. With good role separation fishers can also see that science is responsible for data analysis and advice based on the data, and that policy is responsible for making decisions based on different sources of information. Research cooperation is also useful as it often takes place in projects in which the settings and rules of engagement can be made clearer [73]. Research cooperation opens up the ability to address trust issues between fishers

and researchers, and can do so, much faster than by depending on voluntary reporting of bycatch by fishers alone. This approach implies that researchers must work on improved relations, i.e. deliver positive feedback on capture reports, and on a regular basis via social and fishers' corporate media. Inviting fishers to visit rearing stations, as done in France, in addition to handing out tag readers is a good idea as it gives fishers an idea of the purpose of their work. Increased communication can also minimize negative relationships between fishing communities and management agencies (refs in [73]).

Second, bycatch reports must be collected in ways that are acceptable to fishers (also in terms of time and money spent). Researchers wish to facilitate fishers' self-sampling studies [45], including training and strengthened communication. This approach would imply that fishers aid researchers to develop protocols on how to minimize handling time on deck and could result in fishers licensed to tag fish [13,25]. It should be carefully assessed how such tasks can be designed to consume minimal time and effort on the part of the fishers (see for example Doddema et al. [25]). Data declaration and collection could also be facilitated by internationally standardized monitoring methodologies to improve speed, accessibility, accuracy and anonymisation [33,57,63]. However, certainly not all fishers are interested in implementing electronic monitoring techniques [63]. The data collection should be acceptable for the users of the data by making use of accepted quality assurance frameworks [60].

Third, ideally, obtaining fishers cooperation must be based on trust and willingness, not on constant monitoring as this may be ineffective as fishers could feel victimised (Ford & Stewart, 2021). Trust issues between fishers and NGOs are often based on differing interpretations and opinions of species conservation, and such interpretations depend heavily on specific social, cultural, and historical contexts [7]. Obtaining fishers' and NGOs cooperation to the European sturgeon Action Plans can therefore be characterised as a complex, or a "wicked problem" [39] in the sense that the problem is difficult to define, delineates from other and bigger problems, and tends to reappear.

For comparison purposes: the (successful) rehabilitation of the beaver (*Castor fiber*) in Scotland was described by Coz and Young [24] to be an example of such a "wicked problem". In this case, conflicts and trust issues existed between NGOs and farmers or landowners, as such groups held different views on the beaver's return [24]. By engagement in effective discussions all stakeholders came to agree on a shared vision and clear role division, resulting in a broad and long-term conservation plan. Gradually, issues were finally set aside, which led to successful rehabilitation in certain designated areas in Scotland [24]. Another successful example can be found in Canada, where an imperilled population of Atlantic salmon (*Salmo salar*) in the Northwest river rapidly and sustainably recovered, after managers decided to turn to an adaptive management approach with fishers based on local cooperation and transparency [23]. Both examples show how important it is to involve local users. In the case of European sturgeon restoration and conservation, this means strongly improving the cooperation with local fishing communities fishing in the European sturgeon's essential habitats, e.g. the Gironde estuary, and fishers from the town of Urk (currently the largest Dutch fishing fleet using bottom trawls), and shrimpers fishing the Belgian, Dutch and German shallow coastal zones of the North Sea [16]. This also requires that the local NGOs (that are already involved) understand the difficulties of data acquirement of ETP species at sea, and how their communication campaigns may raise unwanted conflicts, even work in a counterproductive manner as they may push fishers further away from conservation activities.

5. Concluding remarks

Because of the Endangered, Threatened and Protected status, the management of the European sturgeon and any other ETP fish species must be at the top of the agenda of Europe's fisheries management. However, under-reporting of these species bycatch (and mortality) is

still left largely unaddressed. Apart from France and partially in the Netherlands, governments are not recognizing the European sturgeon conservation activities. Researchers and/or NGOs lead the activities. This holds true for France, Germany, the Netherlands, and the United Kingdom. Other countries where the species occurs within their EEZ are not even involved. The interviewees see this as a main source of problems, as it impairs consistent international collaboration, coordination, optimized approaches and long-term finance.

This study also shows that all core aspects for fishers' cooperation in ETP species conservation (a shared vision, a clear role separation, communication and trust) are seriously hampered. Fishers feel a responsibility for the sea and its natural resources, and are inclined to report rare bycatch, but most have stopped doing so since 2020 for many reasons. Fishers experience difficult economic circumstances and feel that the sea is taken from them through closure of fishing grounds (e.g. wind farms, natura 2000 areas). Fishers feel misunderstood as their knowledge and expertise is not recognized and they are not involved in planning. Fishers feel threatened by NGOs who use iconic species in their communication strategies to reduce fishing possibilities.

To solve the issue, all interviewed stakeholder groups pointed to the required national and international, governmental uptake of European sturgeon conservation. Another solution is to involve fishers in research, improve communication and build trust. This could be done by training fishers to participate in the scientific data collection (e.g. self-sampling of data and fin-clipping for molecular biology studies), and by organisation of participatory workshops involving all the stakeholders, whereby fishers would be encouraged to propose specific mitigation measures. The latter also implies that NGOs need to understand that they should not be dominant in the debate about what needs to be done to improve sturgeon bycatch reporting and subsequent protection. It also implies that researchers keep fishers in a constant feedback loop and explain what their data is used for.

If the shared goal is to express 'good stewardship' of the marine environment, then all stakeholder groups involved should develop best practice methods, and solve any issue that might hamper the restoration and conservation of marine ETP fish species. We therefore invite the fishery management councils, in which member states come together (e.g. the Scheveningen Group for the North Sea), to put the subject of reporting rare marine fish species on their agendas.

CRedit authorship contribution statement

Breve Niels: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft. **Urbanovych Kateryna:** Data curation, Investigation, Methodology. **Murk Tinka:** Writing – review & editing. **van Zwieten Paul:** Conceptualization, Writing – review & editing. **Nagelkerke Leo:** Conceptualization, Writing – review & editing. **Kraan Marloes:** Conceptualization, Supervision, Writing – review & editing.

Declaration of Generative AI and AI-assisted technologies in the writing process

No Generative AI and AI-assisted technologies were used in the writing or any other aspect of this manuscript.

Declaration of Competing Interest

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

Data Availability

The data that has been used is confidential.

Acknowledgements

We thank all anonymous interviewees for their time and expertise given during the interviews. A special ‘thank you!’ goes out to: Tom Buijse for his comments on a first draft of this manuscript; Bart van Woerden for conducting interviews amongst ten Dutch fishers; Ingmar Rondeel, Luuk Wilbers and Laura Zirnheld for translating French interviews into English; two anonymous reviewers; and Nigel Gardiner-Harvey for copy editing the reviewed manuscript throughout.

Supplementary material

The following Supplementary material is available online: Appendix A provides the Interview Guide in English; Appendix B the Informed consent form in English; Appendix C an overview of the Organisations’ acronyms, 2 letter country codes & 3 letter stakeholder codes.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.marpol.2024.106056](https://doi.org/10.1016/j.marpol.2024.106056).

References

- [1] D. Abecasis, A. Steckenreuter, J. Reubens, K. Aarestrup, J. Alós, F. Badalamenti, L. Bajona, P. Boylan, K. Deneudt, L. Greenberg, A review of acoustic telemetry in Europe and the need for a regional aquatic telemetry network, *Anim. Biotelemetry* 6 (1) (2018) 1–7, <https://doi.org/10.1186/s40317-018-0156-0>.
- [2] M.L. Acolas, C. Le Pichon, E. Rochard, Spring habitat use by stocked one year old European sturgeon *Acipenser sturio* in the freshwater-oligohaline area of the Gironde estuary, *Estuar. Coast. Shelf Sci.* 196 (2017) 58–69, <https://doi.org/10.1016/j.eccs.2017.06.029>.
- [3] M.L. Acolas, G. Castelnaud, M. Lepage, E. Rochard, Biological cycles and migrations of *Acipenser sturio*, in: *In Biology and Conservation of the European Sturgeon Acipenser sturio* L., 1758, Springer, 2011, pp. 147–152, https://doi.org/10.1007/978-3-642-20611-5_10.
- [4] R. Atkinson, J. Flint, Accessing hidden and hard-to-reach populations: Snowball research strategies, *Soc. Res. Update* 33 (1) (2001) 1–4.
- [5] ATLAS.ti. (2022). *Scientific Software Development GmbH [ATLAS.ti 22 Windows]*. (<https://atlasti.com/>). In.
- [6] P.J. Auster, R.W. Langton, *The Effects of Fishing on Fish Habitat*, American Fisheries Society Symposium, 1999.
- [7] R.E. Auster, S.W. Barr, R.E. Brazier, Renewed coexistence: learning from steering group stakeholders on a beaver reintroduction project in England, *Eur. J. Wildl. Res.* 68 (1) (2022) 1–22, <https://doi.org/10.1007/s10344-021-01555-6>.
- [8] Babcock, E.A., Pikitch, E.K., & Hudson, C.G. (2003). *How much observer coverage is enough to adequately estimate bycatch?* Pew Institute of Ocean Science Miami, FL.
- [9] Background Document for the Common sturgeon - *Acipenser sturio*. New Court48 Carey Street London WC2A 2JQ United Kingdom: +44 (0)20 7430 5200f: +44 (0) 20 2009 7430 5225e.
- [10] K. Bailey, *Methods of social research*, Simon and Schuster., 2008.
- [11] B. Baker, Fisheries management faces many challenges, *BioScience* 50 (8) (2000), 652–652. [https://doi.org/DOI:10.1641/0006-3568\(2000\)050\[0652:FMFCJ\]2.0.CO;2](https://doi.org/DOI:10.1641/0006-3568(2000)050[0652:FMFCJ]2.0.CO;2).
- [12] K.L. Barriball, A. While, Collecting data using a semi-structured interview: a discussion paper, *J. Adv. Nurs.* 18 (1994) 328–335.
- [13] J.W. Beardsall, M.J.W. Stokesbury, L.M. Logan-Chesney, M.J. Dadswell, Atlantic sturgeon *Acipenser oxyrinchus* Mitchill, 1815 seasonal marine depth and temperature occupancy and movement in the Bay of Fundy, *J. Appl. Ichthyol.* 32 (5) (2016) 809–819, <https://doi.org/10.1111/jai.13175>.
- [14] J.W. Beardsall, M.F. McLean, S.J. Cooke, B.C. Wilson, M.J. Dadswell, A.M. Redden, M.J. Stokesbury, Consequences of incidental otter trawl capture on survival and physiological condition of threatened Atlantic sturgeon, *Trans. Am. Fish. Soc.* 142 (5) (2013) 1202–1214, <https://doi.org/10.1080/00028487.2013.806347>.
- [15] N. Brevé, L. Nagelkerke, A. Buijse, T. Van Tuijn, A. Murk, H. Winter, H. Lenders, Historical reconstruction of sturgeon (*Acipenser* spp.) spatiotemporal distribution and causes for their decline in North-Western Europe, *Biodivers. Conserv.* 31 (2022) 1149–1173, <https://doi.org/10.1007/s10531-022-02381-1>.
- [16] N. Brevé, H. Vis, B. Houben, G. de Laak, A. Breukelaar, M. Acolas, Q. de Bruijn, I. Spierts, Exploring the possibilities of seaward migrating juvenile European sturgeon *Acipenser sturio* L., in the Dutch part of the River Rhine, *J. Coast. Conserv.* 18 (2) (2013) 131–143, <https://doi.org/10.1007/s11852-013-0281-0>.
- [17] N.W.P. Brevé, H. Vis, B. Houben, A. Breukelaar, M.L. Acolas, Outmigration pathways of stocked juvenile European sturgeon (*Acipenser sturio* L., 1758) in the Lower Rhine River, as revealed by telemetry [Article], *J. Appl. Ichthyol.* 35 (1) (2018) 61–68, <https://doi.org/10.1111/jai.13815>.
- [18] Castelnaud, G. (1988). *The sturgeon tagging programme in the Gironde estuary (France): A European dimension*. ICES, COPENHAGEN (DENMARK).
- [19] G. Castelnaud, E. Rochard, P. Jatteau, M. Lepage, Données actuelles sur la biologie d'*Acipenser sturio* dans l'estuaire de la Gironde, *Acipenser. Cemagref, Antony* (1991) 251–275.
- [20] A. Charbonnel, P. Lambert, G. Lassalle, E. Quinton, A. Guisan, L. Mas, G. Paquignon, M. Lecomte, M.-L. Acolas, Developing species distribution models for critically endangered species using participatory data: The European sturgeon marine habitat suitability, *Estuar. Coast. Shelf Sci.* (2022) 108136, <https://doi.org/10.1016/j.eccs.2022.108136>.
- [21] Charbonnel, A., & Acolas, M. (2022). Identification des habitats marins utilisés par l'esturgeon européen et fréquentation des aires marines protégées, projet MOMIE MOuvements Migratoires de l'Esturgeon européen *Acipenser sturio*: habitats en mer et retour des géniteurs en fleuves. Rapport final Tâche 1, contrat de recherche et développement INRAE/OFB 2019-2022. 117p.
- [22] P. Chèvre, B.F. Goncharov, E. Rochard, European sturgeon (*Acipenser sturio*) mass propagation, *J. Appl. Ichthyol.* 35 (1) (2019) 94–102, <https://doi.org/10.1111/jai.13694>.
- [23] D. Cote, T. Van Leeuwen, A. Bath, E. Gonzales, A. Cote, Social-ecological management results in sustained recovery of an imperiled salmon population, *Restor. Ecol.* 29 (5) (2021) e13401, <https://doi.org/10.1111/rec.13401>.
- [24] D.M. Coz, J.C. Young, Conflicts over wildlife conservation: learning from the reintroduction of beavers in Scotland, *People Nat.* 2 (2) (2020) 406–419, <https://doi.org/10.1002/pan3.10076>.
- [25] M. Doddema, G. Spaargaren, B. Wiryawan, S.R. Bush, Fisher and trader responses to traceability interventions in Indonesia, *Soc. Nat. Resour.* 33 (10) (2020) 1232–1251, <https://doi.org/10.1080/08941920.2020.1739358>.
- [26] France Ministère de l'Écologie. (2020). Plan National d'Actions Esturgeon Européen 2020-2029.
- [27] Fusch Ph D, P.I., & Ness, L.R. (2015). Are we there yet? Data saturation in qualitative research. (<https://nsuworks.nova.edu/tqr/vol20/iss9/3/>).
- [28] J. Gerrig, What is a case study and what is it good for? *Am. Polit. Sci. Rev.* 98 (2) (2004) 341–354, <https://doi.org/10.1017/S00030554004001182>.
- [29] J. Gesner, P. Williot, E. Rochard, J. Freyhof, M. Kottelat, *Acipenser sturio*. The IUCN Red List of Threatened, Species (2010) e.T230A13040963, <https://doi.org/10.2305/IUCN.UK.2010-1.RLTS.T230A13040963.en>.
- [30] J. Gessner, M. Tautenhahn, S. Spratte, G. Arndt, H. von Nordheim, Development of a German Action Plan for the restoration of the European sturgeon *Acipenser sturio* L. - implementing international commitments on a national scale, *J. Appl. Ichthyol.* 27 (2) (2011) 192–198, <https://doi.org/10.1111/j.1439-0426.2011.01697.x>.
- [31] J. Gessner, P. Williot, E. Rochard, J. Freyhof, M. Kottelat, *Acipenser sturio*. The IUCN Red List of Threatened, Species 2022 (2022) e.T230A137215851, <https://doi.org/10.2305/IUCN.UK.2022-1.RLTS.T230A137215851.en>.
- [32] B.G. Glaser, A.L. Strauss, The discovery of grounded theory: Strategies for qualitative research, Aldine Pub. Co., 1967, <https://doi.org/10.4324/9780203793206>.
- [33] C.A. Gray, S.J. Kennelly, Bycatches of endangered, threatened and protected species in marine fisheries, *Rev. Fish. Biol. Fish.* 28 (3) (2018) 521–541, <https://doi.org/10.1007/s11160-018-9520-7>.
- [34] G. Guest, A. Bunce, L. Johnson, How many interviews are enough? An experiment with data saturation and variability, *Field Methods* 18 (1) (2006) 59–82, <https://doi.org/10.1177/1525822x05279903>.
- [35] T. Haasnoot, M. Kraan, S.R. Bush, Fishing gear transitions: lessons from the Dutch flatfish pulse trawl, *ICES J. Mar. Sci.* 73 (4) (2016) 1235–1243, <https://doi.org/10.1093/icesjms/fsw002>.
- [36] R. Hilborn, Defining success in fisheries and conflicts in objectives, *Mar. Policy* 31 (2) (2007) 153–158, <https://doi.org/10.1016/j.marpol.2006.05.014>.
- [37] Jatteau, P. (2015). Programme de recherche et de conservation de l'esturgeon européen *Acipenser sturio* (Publication Number Etude N° 187) Irstea. Bordeaux. (<https://hal.inrae.fr/hal-02596673>).
- [38] S. Jennings, J. Kaiser, The effects of fishing on marine ecosystems. *Advances in Marine Biology*, Elsevier, 1998, 201–352, 10.1016/S0065-2881(08)60212-6.
- [39] S. Jentoft, R. Chuenpagdee, Fisheries and coastal governance as a wicked problem, *Mar. Policy* 33 (4) (2009) 553–560, <https://doi.org/10.1016/j.marpol.2008.12.002>.
- [40] T.R. Johnson, Fishermen, scientists, and boundary spanners: cooperative research in the US Illex squid fishery, *Soc. Nat. Resour.* 24 (3) (2011) 242–255, <https://doi.org/10.1080/08941920802545800>.
- [41] T.R. Johnson, W.L. van Densen, Benefits and organization of cooperative research for fisheries management, *ICES J. Mar. Sci.* 64 (4) (2007) 834–840, <https://doi.org/10.1093/icesjms/fsm014>.
- [42] K. Bastmeijer De Juridische Status van de Europese Steur (*Acipenser sturio*) en de Positie van Nederland (The Legal Status of the European Sturgeon (*Acipenser sturio*) and the Position of the Netherlands (with English summary)): Een onderzoek in opdracht van ARK Natuurontwikkeling en het Wereldnatuurfonds Nederland. 83 (2019).
- [43] F. Kirschbaum, J. Gessner, Re-establishment programme for *Acipenser sturio* L., 1758: Ger. Approach BOLETIN-Inst. ESPANOL DE OCEANOGRAFIA 16 (1/4) (2000) 149–156.
- [44] M. Kraan, S. Uhlmann, J. Steenbergen, A. Van Helmond, L. Van Hoof, The optimal process of self-sampling in fisheries: lessons learned in the Netherlands, *Wiley Online Library*, 2013, pp. 963–973.
- [45] M. Kraan, S. Uhlmann, J. Steenbergen, A. Van Helmond, L. Van Hoof, The optimal process of self-sampling in fisheries, *Lessons Learn. Neth.* 83 (4) (2013) 963–973, <https://doi.org/10.1111/jfb.12192>.
- [46] M. Kraan, R. Groeneveld, A. Pauwelussen, T. Haasnoot, S.R. Bush, Science, subsidies and the politics of the pulse trawl ban in the European Union, *Mar. Policy* 118 (2020) 103975, <https://doi.org/10.1016/j.marpol.2020.103975>.

- [47] Leedy, P.D., & Ormrod, J.E. (2005). *Practical research* (Vol. 108). Pearson Custom Saddle River, NJ, USA.
- [48] H.R. Lenders, Fish and fisheries in the Lower Rhine 1550–1950: A historical-ecological perspective, *J. Environ. Manag.* 202 (2017) 403–411, <https://doi.org/10.1016/j.jenvman.2016.09.011>.
- [49] R. Letaconoux, Note sur la fréquence de la distribution des captures d'esturgeons (*Acipenser sturio* L.) dans le Golfe de Gascogne, *Rev. Des. Trav. De. l'Inst. Des. Pêches. Marit.* 25 (1961) 253–261.
- [50] I. Lutchman, A review of best practice mitigation measures to address the problem of bycatch in commercial fisheries, *Mar. Steward. Coun. Sci. Ser.* 2 (2014) 1–17.
- [51] National Research Council, Cooperative Research in the National Marine Fisheries Service, National Academies Press, 2003.
- [52] OSPAR Commission. (2021). *BDC2020/European or Common sturgeon*. Retrieved from (<https://oap.ospar.org/en/ospar-assessments/committee-assessments/biodiversity-committee/status-assessments/european-or-common-sturgeon/>).
- [53] R.W. Parker, P.H. Tyedmers, Fuel consumption of global fishing fleets: current understanding and knowledge gaps, *Fish Fish.* 16 (4) (2015) 684–696, <https://doi.org/10.1111/faf.12087>.
- [54] Z. Peng, A. Ludwig, D. Wang, R. Diogo, Q. Wei, S. He, Age and biogeography of major clades in sturgeons and paddlefishes (Pisces: Acipenseriformes), *Mol. Phylogenetics Evol.* 42 (3) (2007) 854–862.
- [55] G. Pustelnik, O. Guerri, Analysis of partnership and conservation requirements for a threatened species, *Acipenser sturio* L., 1758: Towards the implementation of a recovery plan, *BOLETIN-Inst. ESPANOL DE OCEANOGRAFIA* 16 (1/4) (2000) 209–216.
- [56] E. Rochard, M. Lepage, L. Meauzé, Identification et caractérisation de l'aire de répartition marine de l'esturgeon européen *Acipenser sturio* à partir de déclarations de captures, *Aquat. Living Resour.* 10 (2) (1997) 101–109, <https://doi.org/10.1051/alr:1997011>.
- [57] M.S. Savoca, S. Brodie, H. Welch, A. Hoover, L.R. Benaka, S.J. Bograd, E.L. Hazen, Comprehensive bycatch assessment in US fisheries for prioritizing management, *Nat. Sustain.* 3 (6) (2020) 472–480, <https://doi.org/10.1038/s41893-020-0506-9>.
- [58] Schadeberg, A., Kraan, M., & Hamon, K.G. (2021). Beyond métiers: social factors influence fisher behaviour. *ICES Journal of Marine Science*.
- [59] N.A. Steins, M.L. Kraan, K.J. van der Reijden, F.J. Quirijns, W. van Broekhoven, J. J. Poos, Integrating collaborative research in marine science: Recommendations from an evaluation of evolving science-industry partnerships in Dutch demersal fisheries, *Fish Fish.* 21 (1) (2020) 146–161, <https://doi.org/10.1111/faf.12423>.
- [60] N.A. Steins, S. Mackinson, S.C. Mangi, M.A. Pastoors, R. Stephenson, M. Ballesteros, K. Brooks, J. McIsaac, M. Baker, J. Calderwood, A will-o'-the wisp? On the utility of voluntary contributions of data and knowledge from the fishing industry to marine science, *Front. Mar. Sci.* (2022) 2420, <https://doi.org/10.3389/fmars.2022.954959>.
- [61] R.L. Stephenson, S. Paul, M.A. Pastoors, M. Kraan, P. Holm, M. Wiber, S. Mackinson, D.J. Dankel, K. Brooks, A. Benson, Integrating fishers' knowledge research in science and management, *ICES J. Mar. Sci.* 73 (6) (2016) 1459–1465, <https://doi.org/10.1093/icesjms/fsw025>.
- [62] C. Ulrich, D.C. Wilson, J.R. Nielsen, F. Bastardie, S.A. Reeves, B.S. Andersen, O. R. Eigaard, Challenges and opportunities for fleet-and métier-based approaches for fisheries management under the European Common Fishery Policy, *Ocean Coast. Manag.* 70 (2012) 38–47, <https://doi.org/10.1016/j.ocecoaman.2012.06.002>.
- [63] A.T. van Helmond, L.O. Mortensen, K.S. Plet-Hansen, C. Ulrich, C.L. Needle, D. Oesterwind, L. Kindt-Larsen, T. Catchpole, S. Mangi, C. Zimmermann, Electronic monitoring in fisheries: lessons from global experiences and future opportunities, *Fish Fish.* 21 (1) (2020) 162–189, <https://doi.org/10.1111/faf.12425>.
- [64] L. Van Hoof, N. Steins, S. Smith, M. Kraan, Change as a permanent condition: A history of transition processes in Dutch North Sea fisheries, *Mar. Policy* 122 (2020) 104245, <https://doi.org/10.1016/j.marpol.2020.104245>.
- [65] M.C. Verweij, v W.L.T. Densen, A.P.J. Mol, The tower of Babel: Different perceptions and controversies on change and status of North Sea fish stocks in multi-stakeholder settings, *Mar. Policy* 34 (3) (2010) 522–533, <https://doi.org/10.1016/j.marpol.2009.10.008>.
- [66] Visser, S., De Bruijne, W., Houben, B., Roels, B., & Brevé, N. (2020). *First Action Plan for the European Sturgeon (Acipenser sturio) for the Lower Rhine*.
- [67] M. Voyer, W. Gladstone, H. Goodall, Understanding marine park opposition: the relationship between social impacts, environmental knowledge and motivation to fish, *Aquat. Conserv.: Mar. Freshw. Ecosyst.* 24 (4) (2014) 441–462, <https://doi.org/10.1002/aqc.2363>.
- [68] M. Voyer, W. Gladstone, H. Goodall, Obtaining a social licence for MPAs—influences on social acceptability, *Mar. Policy* 51 (2015) 260–266, <https://doi.org/10.1016/j.marpol.2014.09.004>.
- [69] P. Williot, F. Kirschbaum, The French–German cooperation: the key issue for the success of the preservation and restoration of the European sturgeon, *Acipenser sturio*, and its significance for other sturgeon issues, in: *In Biology and Conservation of the European Sturgeon Acipenser sturio*, 1758, Springer, 2011, pp. 499–513, https://doi.org/10.1007/978-3-642-20611-5_38.
- [70] P. Williot, G. Castelnaud, Historic overview of the European sturgeon *Acipenser sturio* in France: surveys, regulations, reasons for the decline, conservation, and analysis, in: *In Biology and Conservation of the European Sturgeon Acipenser sturio*, 1758, Springer, 2011, pp. 285–307, https://doi.org/10.1007/978-3-642-20611-5_20.
- [71] P. Williot, T. Rouault, R. Brun, M. Pelard, D. Mercier, Status of caught wild spawners and propagation of the endangered sturgeon *Acipenser sturio* in France: a synthesis, *Int. Rev. Hydrobiol.: A J. Cover. all Asp. Limnol. Mar. Biol.* 87 (5–6) (2002) 515–524, [https://doi.org/10.1002/1522-2632\(200211\)87:5/6<515::AID-IROH515>3.0.CO;2-%23](https://doi.org/10.1002/1522-2632(200211)87:5/6<515::AID-IROH515>3.0.CO;2-%23).
- [72] P. Williot, T. Rouault, M. Pelard, D. Mercier, M. Lepage, B. Davail-Cuisset, F. Kirschbaum, A. Ludwig, Building a broodstock of the critically endangered sturgeon *Acipenser sturio*: problems and observations associated with the adaptation of wild-caught fish to hatchery conditions, *Cybiu* 31 (1) (2007) 3–11.
- [73] N. Yochum, R.M. Starr, D.E. Wendt, Utilizing fishermen knowledge and expertise: keys to success for collaborative fisheries research, *Fisheries* 36 (12) (2011) 593–605, <https://doi.org/10.1080/03632415.2011.633467>.