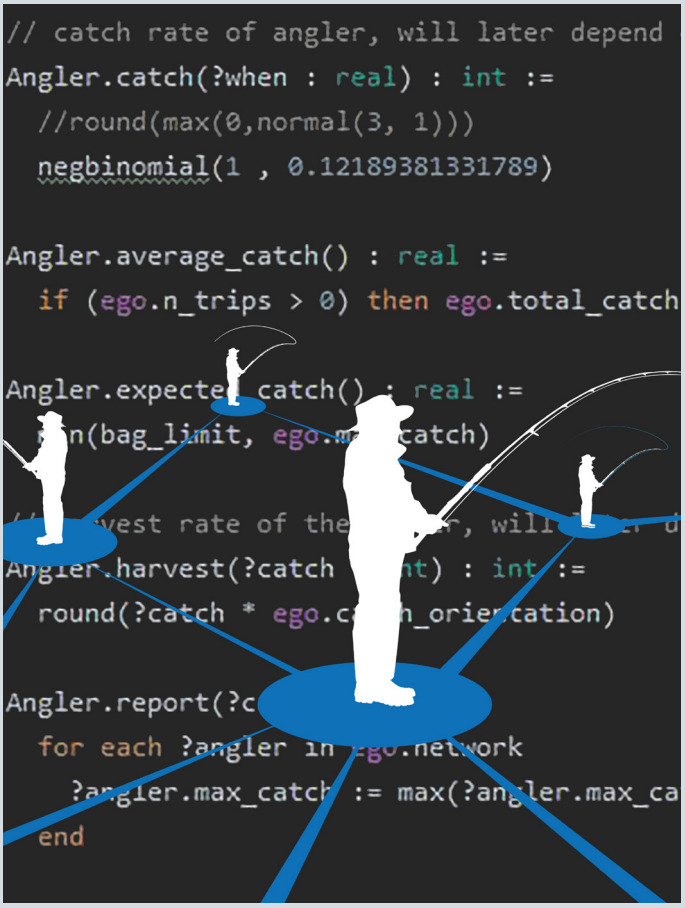
20 Years of Work on Marine Recreational Fisheries at the Thünen Institute of Baltic Sea Fisheries



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Thünen Working Paper 234

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Thünen Working Paper 234

Braunschweig/Germany, March 2024

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1 Summary

Following the advice of the 2014 evaluation of the Thünen Institute by the German Science and Humanities Council, the Thünen Institute has started to encourage its working groups to be evaluated by external experts as part of its quality management. The Marine Recreational Fisheries Working Group of the Thünen Institute of Baltic Sea Fisheries was selected to undergo this evaluation process. Two external scientific experts on recreational fisheries, Dr. Kieran Hyder (CEFAS, UK) and Prof. Dr. Warren Potts (Rhodes University, SA) were requested to evaluate the working group based on the following terms of references:

(i) Quality assessment and technical evaluation of the recreational fisheries survey and monitoring programme run by the working group;
(ii) Evaluation of the scientific excellence in terms of methods used, technical expertise of the staff and scientific and popular science outputs;
(iii) Evaluation of research priorities with focus on their effectiveness and usefulness for the advisory competence of the Thünen institute;
(iv) Evaluation of national and international research collaborations and participation in national and international scientific committees and advisory boards.

The evaluation was conducted as a face-to-face workshop at the Thünen Institute of Baltic Sea Fisheries in Rostock, Germany in November 2022. This report served to familiarize the evaluators with the Thünen Institute and the work of the Marine Recreational Fisheries Working Group in the past 20 years. It contains detailed information on the genesis and development of the working group, the research and monitoring activities, the technical expertise of the group members, the scientific and popular science results, the advisory competencies and the national and international networking of the group. The evaluation was concluded with a summary statement by the two evaluators (see Appendix 2), which includes an assessment of the current work and recommendations for future areas of development.

Keywords: angling, cod, evaluation, marine recreational fisheries working group, recreational fishing, research, survey methods, Thünen Institute of Baltic Sea Fisheries

2 Zusammenfassung

Auf Grundlage einer Empfehlung des Deutschen Wissenschaftsrats nach der Evaluierung des Thünen-Instituts im Jahr 2014 hat das Thünen-Institut damit begonnen, seine Arbeitsgruppen im Rahmen des Qualitätsmanagements durch externe Fachleute evaluieren zu lassen. Die Arbeitsgruppe (AG) „Marine Freizeitfischerei“ des Thünen-Instituts für Ostseefischerei wurde ausgewählt, um sich diesem Evaluierungsprozess zu unterziehen. Zwei externe wissenschaftliche Fachleute für Freizeitfischereiforschung, Dr. Kieran Hyder (CEFAS, UK) und Prof. Dr. Warren Potts (Rhodes University, SA), wurden gebeten, die Arbeitsgruppe auf der Grundlage der folgenden Vorgaben zu evaluieren:

(i) Qualitätsbewertung und fachliche Evaluierung des von der Arbeitsgruppe durchgeführten Survey- und Monitoringprogramms für die marine Freizeitfischerei in Deutschland;

(ii) Bewertung der wissenschaftlichen Exzellenz in Bezug auf die angewandten Methoden, die fachliche Kompetenz der Mitarbeitenden und die wissenschaftlichen und populärwissenschaftlichen Produkte;

(iii) Evaluierung von Forschungsschwerpunkten mit Fokus auf deren Effektivität und Nützlichkeit hinsichtlich der Beratungskompetenz des Thünen-Instituts;

(iv) Bewertung der nationalen und internationalen Forschungskooperationen und der Mitarbeit in nationalen und internationalen wissenschaftlichen Gremien und Beiräten.

Die Evaluation wurde in Form eines Workshops am Thünen-Institut für Ostseefischerei in Rostock im November 2022 durchgeführt. Dieser Bericht diente dazu, die Gutachter mit dem Thünen-Institut und der Arbeit der AG „Marine Freizeitfischerei“ in den vergangenen 20 Jahren vertraut zu machen. Er enthält detaillierte Informationen über die Entstehung und Entwicklung der AG, die Forschungs- und Monitoringaktivitäten, die fachliche Expertise der Gruppenmitglieder, die wissenschaftlichen und populärwissenschaftlichen Ergebnisse, die Beratungskompetenzen sowie die nationale und internationale Vernetzung der Gruppe. Die Evaluation wurde mit einer zusammenfassenden Beurteilung der beiden Gutachter abgeschlossen (siehe Appendix 2), die eine Bewertung der aktuellen Arbeiten und Empfehlungen für künftige Entwicklungsbereiche enthält.

Schlagwörter: Angeln, Dorsch, Evaluation, Forschung, Marine Freizeitfischerei, Survey-Methoden, Thünen-Institut für Ostseefischerei

3 Preface and Terms of References (ToRs)

The Johann Heinrich von Thünen Institute recently started to encourage its working groups to invite evaluation by external experts as part of its quality assessment. This approach was explicitly recommended by the German Science and Humanities Council (Wissenschaftsrat, WR) during their evaluation of the Thünen Institute in 2014. The working group on Marine Recreational Fisheries at the Thünen Institute of Baltic Sea Fisheries has since been selected as one of the first working groups to undergo this evaluation process. The external evaluators were requested to assess the working group on Marine Recreational Fisheries of the Thünen Institute of Baltic Sea Fisheries in Rostock, Germany based on the following Terms of References (ToRs):

> A central activity of the working group is conducting various recreational fisheries surveys. Ideally, these would be evaluated from a scientific standpoint with regard to survey design, data collection, and data quality, as well as analyses. If shortcomings are identified feedback from the evaluators in the form of concrete suggestions for improvement would be highly valuable.
>
> Furthermore, the scientific excellence of the working group in terms of methods used and the technical expertise of the staff should be evaluated. This is meant to include outputs such as articles in international peer-reviewed journals but also popular science media as well as public relations, especially with representatives of angling associations, and supervisory and regulatory authorities.
>
> The working group is also tasked with advising the federal ministries and the committees of the EU Commission. As a basis for this, it conducts strategically relevant research regarding the ecological, economic, and social impacts of recreational fishing. These research priorities should be evaluated with a particular focus on their effectiveness and usefulness for the advisory competence of the Thünen Institute and feedback could point towards new strategic research approaches if deemed necessary.
>
> Finally, the working group is also involved in various national and international research collaborations and participates in several national and international scientific committees and advisory boards. The evaluators should assess these and, where applicable, make suggestions for future collaborations and networking.

The evaluation was conducted by Dr. Kieran Hyder from the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) in the UK and Prof. Dr. Warren Potts from Rhodes University in South Africa in November 2022. This report aimed to familiarize the evaluators with the Thünen Institute and to provide information on the research and monitoring activities of the working group on Marine Recreational Fisheries located at the Thünen Institute of Baltic Sea Fisheries. The evaluation was concluded with a summary statement (see annex) with an assessment of the current work and recommendations for future work in the relevant fields.

Chapters 4-6 of this report provide a description of the structure, expertise, research activities and tasks of the Thünen Institute, the Thünen Institute of Baltic Sea Fisheries and its working group on Marine Recreational Fisheries. In chapter 7 all regularly conducted recreational fisheries surveys and data collections are described. Chapter 8 summarises additional research activities of the working group. In Appendix 1 all relevant peer-reviewed journal articles, scientific reports, conference presentations, public outreach activities, committee contributions and national and international collaborations are listed. Appendix 2 summarizes the quality assessment based on the quality assurance toolkit (QAT) developed by the International Council for the Exploration of the Sea (ICES) Working Group on Recreational Fisheries Surveys (WGRFS) that was conducted for each of the major Thünen Institute recreational fisheries surveys. Appendix 3 provides the evaluation report from the two external reviewers.

4 The Thünen Institute

The Johann Heinrich von Thünen Institute, Federal Research Institute for Rural Areas, Forests and Fisheries was founded in 2008 as a federal research institute under the remit of the German Federal Ministry of Food and Agriculture (BMEL) from three previous government research agencies. With the headquarter in Braunschweig, the Thünen Institute comprises 15 specialized institutes and additional joint service units (Fig. 1).

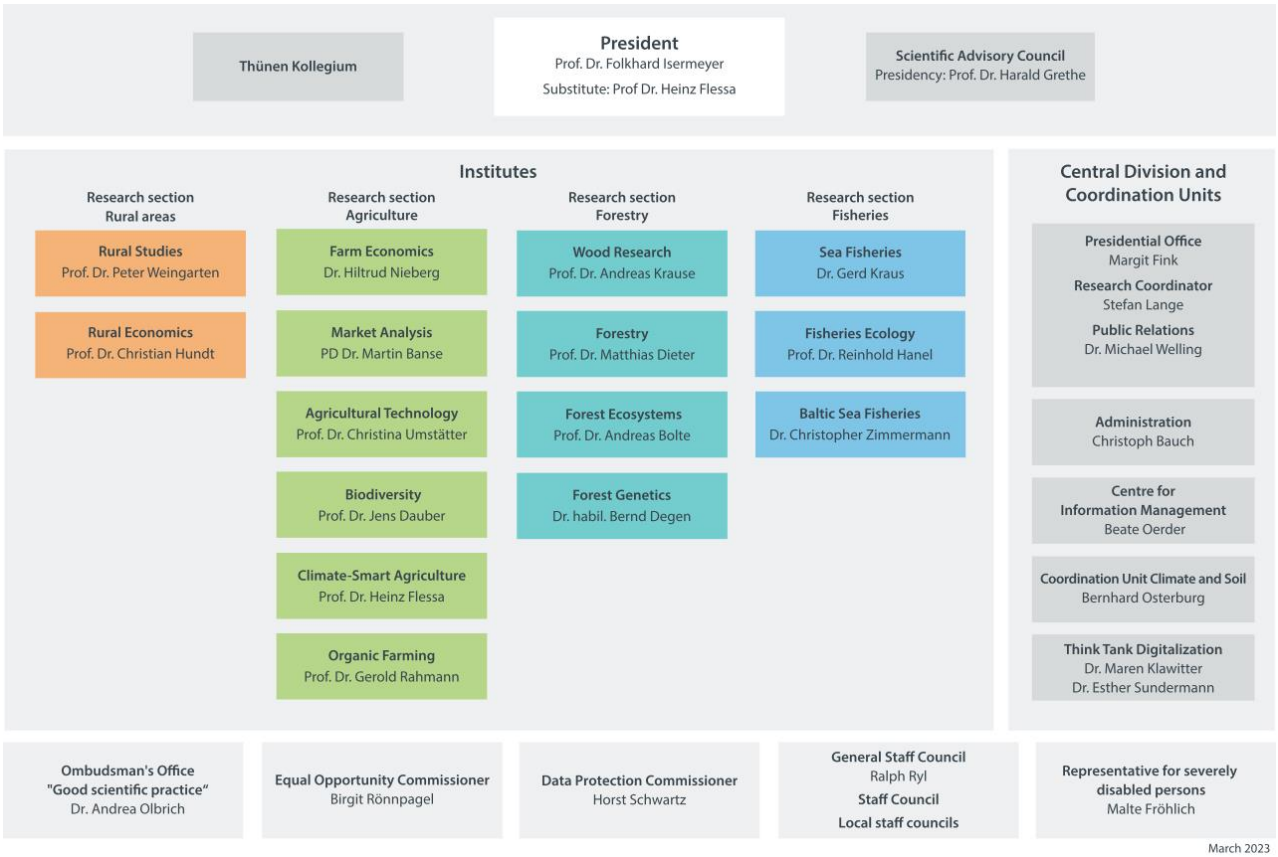

Fig. 1: Organigram of the Johann Heinrich von Thünen Institute.

Six of the 15 institutes are located in Braunschweig, the others are located in Hamburg, Grosshansdorf, Trenthorst, Eberswalde, Bremerhaven, and Rostock, with sub-units in Waldsieversdorf and Barsbüttel. The 15 different institutes have competencies in natural science, technology and socio-economy and conduct research in the fields of rural areas, agriculture, forestry, and fisheries. In order to develop promising policy solutions, research must be interdisciplinary. Thus, the Thünen Institute links the three dimensions of economy, ecology, and technology (humans, nature, technology) in its approach. In total, more than 1100 people currently work at the Thünen Institute with almost 50% being scientists. The institute directors and the president are scientists appointed by the BMEL, based on a proposal from an appointment committee consisting of internal and external scientists.

The Thünen Institute is in a position to quickly provide policy-makers with competent expertise when needed. It develops and provides a scientific basis to serve as a decision-making aid for the policies of the German Federal Government. Instead of analysing individual aspects, the Thünen Institute conducts its research in such a way that all possible relevant factors are considered and thus provides authoritative recommendations for national and international policies. At the same time, our working groups also aspire to look far into the future and develop viable long-term proposals for solutions. We carry out extensive monitoring activities, develop options for action to better manage our livelihoods, and assess the expected consequences. The Thünen Institute cooperates with more than 500 universities and non-university research institutions worldwide, participates and successfully competes in the realm of science, and is committed to promoting young scientists. We are scientifically independent and publish our research results and present our findings, conclusions, and recommendations transparently.

5 Thünen Institute of Baltic Sea Fisheries

The core of the research at the Thünen Institute of Baltic Sea Fisheries in Rostock is the determination of the status of the marine living resources of the Baltic Sea. We do this by focusing on three pillars (Fig. 2).

In the first pillar, we either conduct fundamental research, where we try to anticipate which topics will become relevant in the next years, and intensify our activities there. Or we try to address fundamental ecological questions in relation to commercially exploited fish stocks, and mainly use our long data series to address these questions. On occasion, we are commissioned by the government, fisheries or associations to address questions at short notice and are generally able to comply.

The second pillar of our work is providing policy advice. Science and research are the basis of our advice. We utilise the results of our baseline work and our long-term data sets to develop different policy options. These recommendations are always science-based, and we aspire to communicate the effects of specific decisions as well as the limitations of our advice transparently.

The third pillar of our work is the collection of long-term monitoring data series. These are the basis for our understanding of the functioning of ecosystems, and thus also for the sustainable use of these ecosystems. Many of our monitoring data series are used directly for assessing commercially and recreationally important fish stocks. For this purpose, a large number of samples and data from commercial and recreational fisheries are processed every year. The timely collection and delivery of these data are required under international law, and the German Federal Government has tasked us with fulfilling this obligation. Furthermore, the institute collects fishery-independent data, such as data on stock recruitment, with the help of specialised research vessels. These data are mainly used in the stock assessments of the International Council for the Exploration of the Sea (ICES) to generate state-of-the-art advice for Baltic fishing opportunities. These form the basis for sustainable management of Baltic Sea fish stocks.

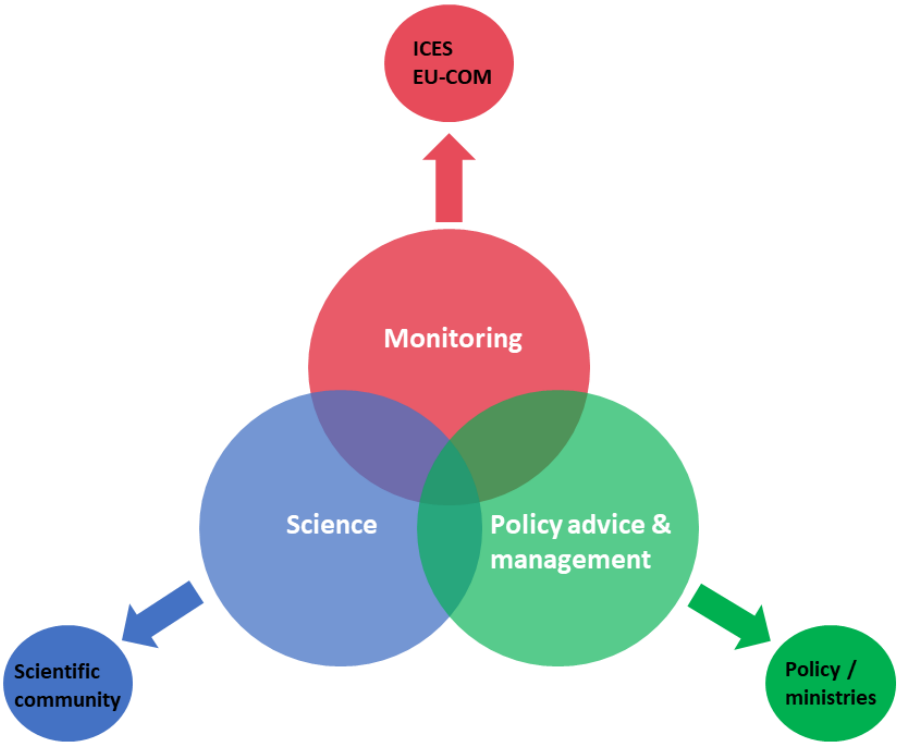

Fig. 2: Schema of the three pillars (i) monitoring, (ii) science and (iii) policy advice and management and their corresponding end-users reflecting the work of the Thünen Institute of Baltic Sea Fisheries.

Currently, 65 people work at the Thünen Institute of Baltic Sea Fisheries of which 35 are researchers and 30 are technicians or administrative staff. Close cooperation with the other Thünen Institutes, especially in the areas of fisheries and social research, is intentionally cultivated and considered good practice. However, the research areas are delimited from the work of the other institutes either regionally (Baltic Sea) or in terms of content (e.g. fishing and survey technology, recreational fisheries). In these areas, the Thünen Institute of Baltic Sea Fisheries has acquired comprehensive expertise and is well regarded for its excellence, making it one of the

leading research institutions in Europe. We are linked to universities and non-university research institutions through several joint projects and the training of young scientists, and our fields of activity complement each other very well. To these collaborations, we contribute our crucial expertise on commodity use and fisheries, as well as valuable long time series on the status of fish stocks and our experience in policy advice.

6 Working Group on Marine Recreational Fisheries

The Thünen Institute of Baltic Sea Fisheries has been conducting research in the field of marine recreational fisheries for 20 years and has, over the last ten years, established a dedicated working group named “Marine Recreational Fisheries”. Through the development of the working group, the Thünen Institute of Baltic Sea Fisheries has achieved a leading position in recreational fisheries research in Europe. The data collected and analysis done have been used to raise the profile of marine recreational fishing at national and European levels. There is now both qualification and recognition of the social and economic importance of marine recreational fishing and the potential impact on stocks and the environment. The need is clear for robust data and to embed marine recreational fishing into fisheries management to ensure sustainable exploitation of fish stocks. The working group delivers data of known quality that are regularly used both for fisheries stock assessments (e.g., by ICES for western Baltic cod, Baltic salmon and sea trout and northern sea bass) and for European fisheries management (e.g., western Baltic Sea cod recreational fisheries). At a European level, the leadership of the working group has raised the profile of marine recreational fisheries with different stakeholder groups, including national and European angling associations, national governments, regional coordination groups, and the European Commission and Parliament.

The Institute's research in the field of marine recreational fisheries began with the entry into force of regulation (EC) No. 1639/2001. It required European Member States to sample catches of Atlantic bluefin tuna (*Thunnus thynnus*) in all areas and Atlantic salmon (*Salmo salar*) in the North Sea and Baltic Sea. With the amendment by regulation (EC) No 1581/2004, the list of species to be sampled in recreational fisheries was extended in Annex XI to include Atlantic cod (*Gadus morhua*) in ICES zones III, IV, V, VI and VII. The regulation required European Member States to carry out pilot studies to establish the basis for future requirements. The German pilot study "Cod catches by German recreational fisheries of the North Sea and Baltic Sea, 2004-2006" (Zimmermann et al., 2007) showed that catches by recreational fisheries were particularly relevant for cod in the western Baltic Sea. This led to the establishment of the German recreational catch sampling program, including on-site and off-site surveys and biological data collection, which have been successively improved and expanded over time (Fig. 3).

During the early years, the work was carried out by one scientist and one technician. In 2010, the Working Group on Marine Recreational Fisheries was founded at the institute and staffed with Dr Harry V. Strehlow as its leader (PI) and 1.5 technician positions (permanent). Dr Strehlow also co-headed the working group "Fisheries & Society" at the Thünen Institute of Baltic Sea Fisheries and

thus has comprehensive expertise in social science survey methods. In 2013, a PhD student joined the group who finished his PhD in 2018 and was hired as research associate (permanent position) to support the increasing amount of work and tasks of the working group. Since 2017, a further research associate position has been acquired through various third-party funds, albeit with minor interruptions. In 2019, a new PhD student joined the group. In autumn 2022, the working group "Marine Recreational Fisheries" consisted of the PI (Dr Harry V. Strehlow), two research associates (1 permanent position – Dr Simon Weltersbach), 1 project-based position – Dr Wolf-Christian Lewin), one junior scientist (0.5 project-based position – Josefa Eckardt), one PhD student (0.5 project-based position – Kevin Haase), and 2 technician positions (permanent – Andreas Gebel, Tom Jankiewicz 0.5 and Frank-Michael Conrad 0.5). Furthermore, two student assistants are regularly hired as survey agents to support the recreational fisheries data collection.

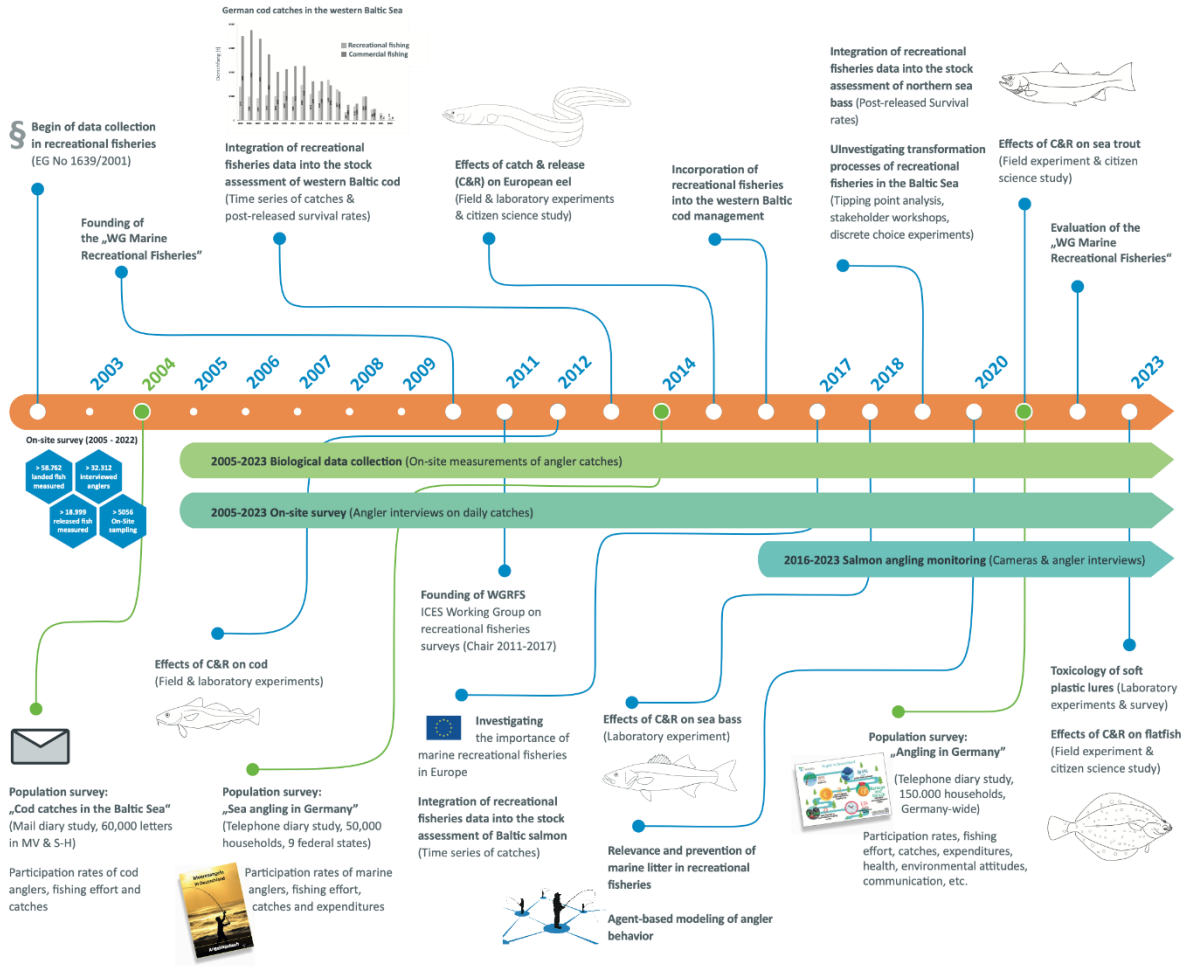

Fig. 3: Timeline showing the development of the Marine Recreational Fisheries Working Group and major tasks, studies/surveys and outcomes at the Thünen Institute of Baltic Sea Fisheries since 2002.

The main focus of the working group is survey planning and implementation of sovereign data collection in marine recreational fisheries within the European fisheries data collection framework (DCF). Additional special research interests and foci include recreational fisheries and their ecological, economic, and social impacts, as well as knowledge transfer between science and the public. In more detail the activities of the working group involve:

- Survey methods: large- and small-scale on- and off-site surveys to quantify effort, catches, and expenditures of anglers such as telephone-diary surveys, roving creel and access point surveys, i.e., video counts of salmon trolling boats;
- Development of socio-economic criteria for the allocation of resources and fishing opportunities by assessing the social and economic impacts of recreational fishing;
- Research on post-release mortality and sub-lethal effects after Catch-and-Release in recreational fisheries in the field and laboratory;
- Development and testing of management approaches using empirical time-series data, discrete choice experiments or agent-based modelling approaches, consulting on monitoring of recreational fisheries, and development of guidelines for anglers;
- Capturing angler heterogeneity to improve survey data and inform management of expected behavioral responses of anglers;
- The use of interviews and questionnaires to identify motivations and catch orientation of anglers to assess management objectives beyond Maximum Sustainable Yield (MSY);
- Participatory approaches to integrate stakeholder interests and goals into public welfare-oriented management.

The scientific output of the working group is tangibly reflected by 30 peer-reviewed publications (plus four currently being under review; see 8.1), 17 scientific reports (see 8.2), 29 oral and poster contributions as well as five co-chaired theme sessions at international scientific conferences in the past ten years (see 8.3). In the past five years, nine applications for third-party funding were submitted, of which five were approved, with a total volume of 1,415,000 €.

Data collected by the working group have fed into scientific advice and policy at both national and European level. For instance, the working group's data and advice contributed significantly to the development of sustainable management for the western Baltic recreational cod fishery. Policy advice is provided through the preparation of statements for federal and state ministries and the development of scientific recommendations for the European Commission, the European Parliament and the International Council for the Exploration of the Sea (ICES). For example, 34 official advisory statements have been prepared for federal and state ministries in the last five years. Public outreach to end-users such as national governments and regional fisheries authorities, the European Commission and Parliament, the public in general, and international and national angling bodies is evident in 40 presentations, 20 media contributions and 14 popular science contents over the last ten years (see 8.4).

Committee work involves regular participation in six ICES working groups (WGRFS [2012-2017 H Strehlow co-chair], WGBAST [S Weltersbach stock coordinator for Baltic salmon and sea trout

since 2016], WGBFAS, WGMARS, WGMEDS, WGTRUTTA), two Regional Coordination Groups (ISSG DIAD and MRF), regular participation in ICES stock assessment benchmark workshops, specific participation in five ICES Advice Drafting Groups as well as formal invitations to participate in international committees such as the European Parliament Fisheries Forum, Baltic Sea Advisory Council (BSAC), Baltic Sea high level group (Baltfish), and the MEDAC Working Group on Recreational Fisheries (see 8.5).

The broad expertise of the Thünen marine recreational fishing working group builds on regional and international networks and close collaborations (three federal and state authorities, three angling associations, 14 non-university research organisations, and 15 universities). Some of these collaborations have entered into formal cooperation agreements, e.g. with the State Office for Agriculture, Food Safety and Fisheries Mecklenburg-Western Pomerania (M-V), the State Research Institute for Agriculture and Fisheries M-V and the Institute of Marine Research, Norway (see 8.6). In total, the working group has collaborated with 179 scientists from 28 different countries on all continents except Antarctica on scientific publications in the past years (Fig. 4).

Fig. 4: Map showing the geographical distribution of scientific collaborations that resulted in at least one peer-reviewed publication. The size of the bubbles represents the number of scientists per country involved in the collaborations.

The working group is also involved in teaching and supervising master and bachelor students as well as PhD candidates. One bachelor, three masters and two PhD theses have been supervised in the last five years. Teaching activities include teaching in the MSc program Integrative Zoology (iZoo) of the University of Rostock as part of the course “Methods of fisheries biology”.

Reviewing for scientific journals is another important activity, and members of the working group are regularly requested to serve as reviewers for more than 20 different national and international journals such as Fish & Fisheries, Canadian Journal of Fisheries and Aquatic Sciences, Ocean and Coastal Management, Fisheries Research, Fisheries Management and Ecology and ICES Journal of Marine Science. Furthermore, Dr Weltersbach is a member of the editorial board of the ICES Journal of Marine Science with a focus on the handling of manuscripts covering recreational fisheries research. In addition, members of the working group have also been involved in reviewing national recreational fisheries data collection work plans (EU-MAP) for the European Commission and grants, e.g. for the Saltonstall-Kennedy Grant Program.

7 Recreational fisheries surveys and monitoring

7.1 Background

The working group is responsible for the German marine recreational fisheries data collection in the waters of the North Sea (ICES division 4.b) and Baltic Sea (ICES subdivisions 22 and 24; Fig. 5) within the European fisheries data collection framework (DCF).

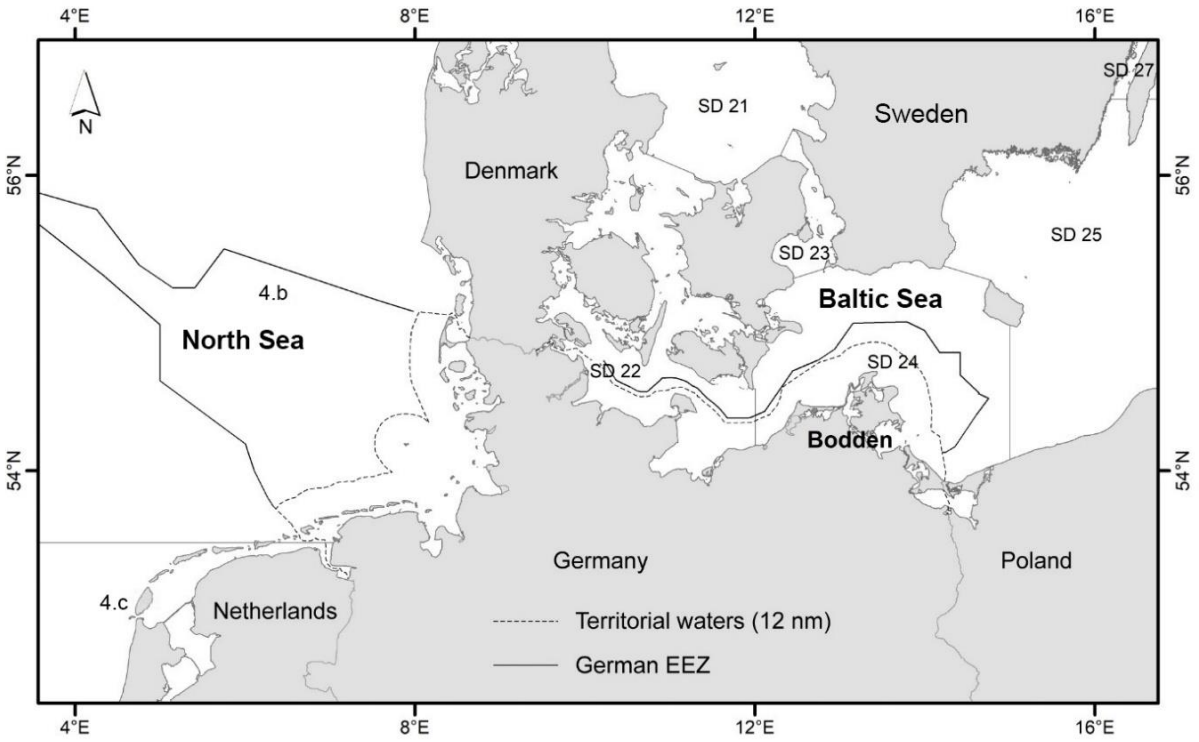

Fig. 5: Map of the German marine waters including ICES subdivisions (SD).

The current version of the data collection framework, the so-called "EU Multi-annual Programme 2017-2019 (EU-MAP)", obliges European Member States to collect data from recreational fisheries on an annual basis regarding catches and releases for Atlantic cod (*Gadus morhua* L.), European sea bass (*Dicentrarchus labrax* L.), European eel (*Anguilla anguilla* L.), Atlantic salmon (*Salmo salar* L.), pollock (*Pollachius pollachius* L.), sea trout (*Salmo trutta* L.), all shark and ray species (Elasmobranchii) and highly migratory ICCAT (International Commission for the Conservation of Atlantic Tunas) species, e.g. tunas, although the species to be considered vary by region (EU, 2016). Relevant species for the data collection in Germany are eel, cod, salmon and sea trout in the Baltic Sea and eel, cod, pollock, sea bass, salmon, and elasmobranchs in the North Sea. For diadromous species (eel, salmon, sea trout) member states are obliged to also collect data from freshwater recreational fisheries.

In Germany, regulation and control of recreational fishing is the responsibility of the 16 federal states. The fisheries legislation for the coastal states of Lower Saxony (NI), Schleswig-Holstein (SH), and Mecklenburg-Western Pomerania (MV) differ in detail (Nds. FischG, 1978; LFischG, 1996; LFischG M-V, 2005). In SH and MV, a general fishing license and, if necessary, authorization from the owner of the respective body of water (fishing permit) are required to fish in coastal waters (LFischG, 1996; LFischG M-V, 2005). In NI, a German identity card is sufficient to fish in coastal waters (Nds. FischG, 1978). In SH, a fishing permit issued by the state of SH must be purchased in addition to the existing fishing license in order to fish in coastal waters (LFischG, 1996). In MV, anglers also need an additional fishing permit for coastal waters (LFischG M-V, 2005). Both SH and MV offer individuals without a fishing license the opportunity to purchase temporary tourist fishing licenses (LFischG-DVO, 2018; FSchVO M-V, 2018). In SH, individuals on charter vessels may also fish under the supervision of a fishing license holder or trained fisherman (LFischG-DVO, 2018). In general, catches from recreational fishing may only be used for personal consumption and are not allowed to be sold.

In German marine waters, two forms of recreational fishing can be distinguished regarding the main fishing gear used:

1. Angling: use of rod-and-line or small drop nets (e.g., to obtain bait fish);
2. Hobby fishing: use of passive fishing gear e.g., fish traps, gill nets, and longlines, as used in commercial fisheries, but to a much lesser extent and only for personal consumption.

Previous studies have shown that the number of German hobby fishermen (1,684 active individuals in the North Sea and Baltic Sea) and their catches in German coastal waters are small compared to the number and removals of anglers and show a strong decreasing trend (Zimmermann et al., 2007; Lucas, 2015). Therefore, the main focus of the working group lies on recreational rod-and-line fisheries (angling).

Depending on the body of water and target species, marine anglers in Germany use different angling methods. Popular fishing methods in the Baltic Sea include surf fishing from the shore with natural bait targeting cod, flatfishes, whiting, and garfish, lure fishing from the shore/beach or with waders targeting cod, sea trout, and garfish, lure/bait fishing and trolling from small private boats,

kayaks, float tubes or rental boats targeting cod, sea trout, flatfishes, salmon and whiting, and lure and natural bait fishing from charter vessels targeting cod, flatfishes, and whiting. In addition, there is a seasonal fishery (mainly in spring) for herring with special herring rigs (Weltersbach et al., 2021). In the North Sea, year-round fishing is carried out with natural baits from the shore/beach as well as in harbours targeting flatfishes, whiting, cod, sea bass, and eel whereas fishing from small boats and charter vessels mainly takes places during the summer months targeting mackerel and cod (Weltersbach et al., 2021). However, the North Sea has a strong tidal influence (mean spring range 4 m) and large tidal flats, and because of this shore angling concentrates on the Frisian Islands and harbours. Boat angling is limited in this area due to challenging boating and unfavourable fishing conditions. The Baltic Sea has minimal tidal currents, and a rugged coastline characterized by alternating sandy beaches and rocky shores that are suitable and popular for shore angling. Boat angling in this area is even more popular due to favourable conditions. Hence, the majority of the recreational fishing effort is conducted in Baltic Sea waters (Strehlow et al., 2012; Weltersbach et al., 2021).

The Thünen Institute of Baltic Sea Fisheries has been collecting marine recreational fisheries (MRF) data since 2002 and consistently on an annual basis since 2005 (see Fig. 6 for an example of the data collection and biomass removal estimation procedure for western Baltic cod).

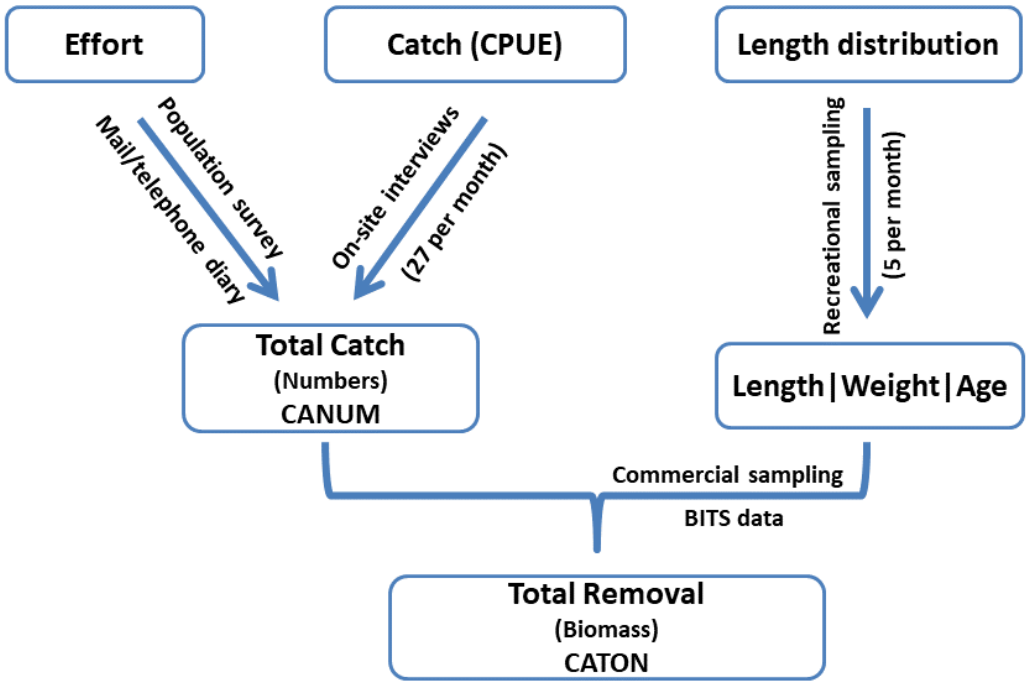

Fig. 6: Schematic overview of the German western Baltic cod recreational fishing data collection and catch estimation procedure.

The German data privacy protection legislation prevents the general use of personal data from fishing license registries for research purposes. Thus, no representative sampling frames such as all German fishing license holders, are available for recreational fisheries surveys (Strehlow et al.,

2012). Therefore, a data collection programme using various survey methods has been developed over the years to provide the required data, in particular, recreational catches and releases for stock assessment purposes. Off-site population screening surveys of the general population which are complemented with diary studies are regularly conducted (only every 5-7 years due to cost constraints) to estimate participation rates, fishing effort, and catches and releases for several species. A stratified random on-site access point intercept survey is conducted annually since 2005. The on-site survey follows a multi-annual survey design and collects information based on completed fishing days on socio-demographics of anglers, fishing characteristics, and annual catch rates for stock assessment purposes. The focus is on western Baltic cod even though all species are considered. A remote camera survey supplemented with an on-site access point intercept survey has been conducted annually since 2017 to monitor the highly specialized recreational salmon (*Salmo salar*) trolling fishery in the Baltic Sea around the Island of Rügen (ICES SD 24). The following sections provide more detailed information on the regularly conducted surveys. The working group also collects biological data from recreational fisheries. Length distributions of sea-based recreational catches (harvest and releases of all species) are collected during onboard measurements by survey agents on charter vessel trips along the German Baltic coast. Occasionally, additional data or samples such as individual weights, otoliths and tissue samples are collected during these onboard samplings for certain end-user needs. Length data from salmon and sea trout are collected by the survey agents during the on-site access point survey that complements the remote camera survey.

7.2 Multi-species off-site surveys

Three different off-site surveys have been conducted so far. For the latest one, the data collection ended in summer 2022 and the data analyses are currently ongoing.

The first off-site survey consisted of two complementary mail surveys carried out in MV (2004–2005), with 2004 as the base year, and in SH (2005–2006), with 2005 as the base year (Zimmermann et al., 2007; Strehlow et al., 2012). The main objective was to obtain effort data, i.e. how many days did an angler go fishing in the Baltic Sea and using which fishing method? For this purpose, 26,924 questionnaires were distributed to anglers who purchased a coastal fishing permit in MV. In SH, 39,693 questionnaires were distributed to organized anglers with the help of the two regional angler associations. Respondents could indicate if the provided effort data came from their records, i.e. catch diaries, or was recalled. Fishing effort was only derived from diary data as the recalled data were significantly different and assumed to be biased. Fishing effort data together with license sales numbers were used to calculate overall fishing effort and subsequently biomass removals of western Baltic cod for assessment purposes (Strehlow et al., 2012).

The second survey consisted of a computer-assisted telephone interview (CATI) screening survey and a complementary one-year diary study that were conducted in 2014/2015 (Weltersbach et al., 2021; Lewin et al., 2021[a]; Lewin et al., in press[a]). The survey focused on marine anglers in Germany. A total of 50,000 randomly selected German households were contacted in order to determine the incidence of marine angler households in the German population. The screening interviews were

distributed over the eight northern, near-coastal German federal states and identified a total of 562 marine angler households. The federal states further south (e.g. North Rhine-Westphalia and Bavaria) were not covered due to the expected low incidence of marine anglers and the resulting low cost-efficiency of the data collection. However, by using distributions of angler origins from the on-site survey and an additional boost sample, the number of marine anglers, their fishing effort, catches and socio-economic impact could be extrapolated to the whole country. The resulting data provided the basis for several peer-reviewed publications (Arlinghaus et al., 2021; Lewin et al., 2021[a]; Haase et al., 2022; Lewin et al., in press[a]; Lewin et al., in press[b]).

The latest nationwide representative CATI screening survey targeting 150,000 German households has been carried out from October 2020 to April 2021 followed by a one-year diary survey. The off-site CATI survey was designed to identify marine and freshwater anglers in the German population, collect their socio-demographic parameters, and estimate fishing effort as well as to recruit participants for a subsequent diary survey. Information on angler heterogeneity was also collected as part of the survey. An external market and social research company (USUMA GmbH, Berlin, Germany), which has many years of experience in conducting scientific population surveys, was commissioned to conduct the telephone screening survey, the diary study and quarterly follow-up calls.

The CATI survey used a dual frame approach with 70% landline numbers and 30% mobile numbers. A mixture of random-digit dialling and number sampling from an official number registry (landline only) was used to derive telephone numbers and contact households, with selection probabilities being proportional to the number of households per municipality. However, a disproportional sampling approach was chosen to increase the number of marine anglers in the diary survey. Therefore, the probability of sampling telephone numbers originating from eight of the 16 German federal states that are closer to the German coasts (Schleswig-Holstein, Mecklenburg-Western Pomerania, Lower Saxony, Bremen, Berlin, Hamburg, Brandenburg, and Saxony-Anhalt) was doubled. A total of 1,541,182 numbers were used to realize 150,232 interviews. Of these numbers, 683,135 (~44%) were mobile numbers and 858,047 (~56%) were landline numbers. Up to ten attempts were made to contact a household. Thereafter, a telephone number was considered a quality-neutral failure.

All interviewers were trained at the beginning of the survey. During the training, the interviewers were familiarised with the general purpose of the survey, the background, and the concrete contents of the survey. The different possibilities of the interview process, which could arise due to different combinations of statements and household distributions, were also discussed. In total, about 75 interviewers were involved in the CATI survey.

Household size and the number of persons in a household being recreational anglers were determined. An angler was defined as a person who had fished at least once in Germany during the last 12 months preceding the survey or who planned to do so in the next 12 months. Survey participants had to be older than 14 due to the German Youth Protection Act. This resulted in a total of 5,781 German households with at least one angler. Following this screening procedure, the identified angler was asked to complete a 15-min interview. If there was more than one angler in

the household, the target person for the interview was determined randomly using the Kish-Selection-Grid, i.e. independently of the interviewer or the contact person. The following interview contained questions regarding fishing effort in different waters, target species, angler heterogeneity, impact of COVID-19 on fishing effort, and socio-demographics of the anglers. In total, 2,774 angler interviews could be completed.

At the end of the interview, all anglers were asked to participate in a one-year diary survey. If they agreed to participate, their contact details were recorded. This resulted in a total of 1,891 diarists. Together with the diary, all participants received a personal introductory letter, a privacy policy statement, a pre-addressed, postage-paid envelope for the return of the diary at the end of the study and a complimentary German angling magazine ("Blinker") as an incentive to increase the response rates (Church, 1993). In addition, all diarists received a postcard during Christmas season. At the end of the study period, another motivation letter including some preliminary results of the study was sent together with a spinnerbait with Thünen branding to encourage participation and minimize nonresponse (Willcox et al., 2010; Anderson et al., 2021). All diary participants were asked to report every single angling day in Germany over an observation period of 12 months starting from the day they received the diary. For every angling day, the date, fishing time, fishing location, travel distance, expenditures, number of other anglers sighted, angling platform (boat, charter boat, shore), target species, and the number of fish caught, harvested, and released per species had to be reported. In order to maintain the motivation to participate, retrieve diary data, and reduce panel attrition bias, the participants were contacted by telephone at quarterly intervals during the entire observation period. The diary data was collected between October 2020 and June 2022 and anglers were able to either fill out a paper diary or an online diary.

As already mentioned, the follow-up calls were used to retrieve diary data (data from up to five fishing days per quarter). In addition, detailed data on angling-related expenditures for the past three months divided into 11 categories were collected at each follow-up call. These categories were a) licenses and permits, b) fees for Put&Take and pay lakes, c) fishing tackle, d) memberships in fishing associations/clubs, e) angling-related clothing, f) guiding and rental/charter boats, g) expenses for own boats, h) transportation, i) food, j) accommodation, and k) literature and other media.

Furthermore, each follow-up call was used to obtain information about various other aspects of recreational fishing. The questions from the first follow-up call centred around motivation and satisfaction. Therefore, the diarists were asked to rank i) 21 reasons to go angling on a five-point Likert scale and ii) reasons that prevented them from going angling as often as they would like. The diarists were also asked to indicate their satisfaction with their fishing experiences over the last 12 months with regard to *i.a*. the angling opportunities, management measures, quality of the angling sites/waters, and the number and size of caught fish.

The second follow-up call was used to investigate the potential influence of recreational fishing on human health and well-being. The health status of diarists was assessed by using the standardized Short-Form-Health-Survey-12 (SF 12) complemented with some additional questions, e.g. about fish consumption. It is planned to compare the data with corresponding data that are regularly and

representatively collected from the entire German population in the framework of the German Socio-Economic Panel (SOEP).

During the third follow-up call, anglers were asked which sources of information they use to inform themselves about angling, which sources they trust most, how much they are influenced by this information, and with how many friends/acquaintances they regularly talk about angling. Moreover, the New Ecological Paradigm (NEP) scale was used to assess the environmental concern and attitudes of anglers. The NEP scale was supplemented with questions on personal environmental behaviour. To compare the environmental attitudes of German anglers with a representative sample of the general German population, an additional CATI survey of 1,000 randomly selected German households was conducted, asking the same questions.

During the fourth and last follow-up call, anglers were asked to assess the perceived and expected impacts of climate change on recreational fisheries in terms of their preferred angling water, its fish stock, and their future angling opportunities.

In order to obtain representative estimates of the size of the German angler population, the corresponding fishing effort and catches, harvests, and releases for all species from both the data of the CATI and the diary survey will be weighted and extrapolated in various ways following the data collection. This work is currently ongoing.

A quality assessment of the most recent multi-species off-site survey based on the quality assurance toolkit (QAT) developed by the ICES Working Group on Recreational Fisheries Surveys (WGRFS; ICES, 2013; 2020) is provided in the Appendix (see 9.1).

Relevant publications:

Strehlow HV, **Schultz N**, Zimmermann C, Hammer C (2012). Cod catches taken by the German recreational fishery in the Western Baltic Sea, 2005-2010: implications for stock assessment and management. ICES J Mar Sci 69(10):1769-1780.

Lewin W-C, **Weltersbach MS**, **Haase K**, **Riepe C**, Skov C, Gundelund C, **Strehlow HV** (2021[a]). Comparing on-site and off-site survey data to investigate survey biases in recreational fisheries data. ICES J Mar Sci 78(7):2528-2546, DOI:10.1093/icesjms/fsab131.

Arlinghaus R, Lucas J, **Weltersbach MS**, Kömle D, Winkler HM, **Riepe C**, Kühn C, **Strehlow HV** (2021). Niche overlap among anglers, fishers and cormorants and their removals of fish biomass: A case from brackish lagoon ecosystems in the southern Baltic Sea. Fish Res 238:105894, DOI:10.1016/j.fishres.2021.105894.

Haase K, **Weltersbach MS**, **Lewin W-C**, Zimmermann C, **Strehlow HV** (2022). Potential effects of management options on marine recreational fisheries - the example of the western Baltic cod fishery. ICES J Mar Sci: in press, DOI:10.1093/icesjms/fsac012.

Lewin WC, **Weltersbach MS**, **Haase K**, **Riepe C**, **Strehlow HV** (in press[a]). Potential biases in angler diary data: the impact of the diarist recruitment process on participation rates, catch, harvest, and effort estimates. Fish Res: in press

7.3 Multi-species on-site survey

The multi-species on-site survey follows a multiannual multistage survey design and aims at collecting information on socio-demographics of anglers, fishing characteristics, and catch rates, in particular for western Baltic cod, for stock assessment purposes. It has been annually conducted since 2005 with some modifications over time. The on-site survey is carried out along the outer German Baltic coastline and uses a stratified random sample of sampling days and access points selected without replacement out of a list of 79 access points (harbours, boat ramps, piers, and beaches; Strehlow et al., 2012; Lewin et al., 2021[a,b]). The coastline was divided into five strata for sampling, with harbours and beaches as access points and days as primary sampling units (Fig. 7).

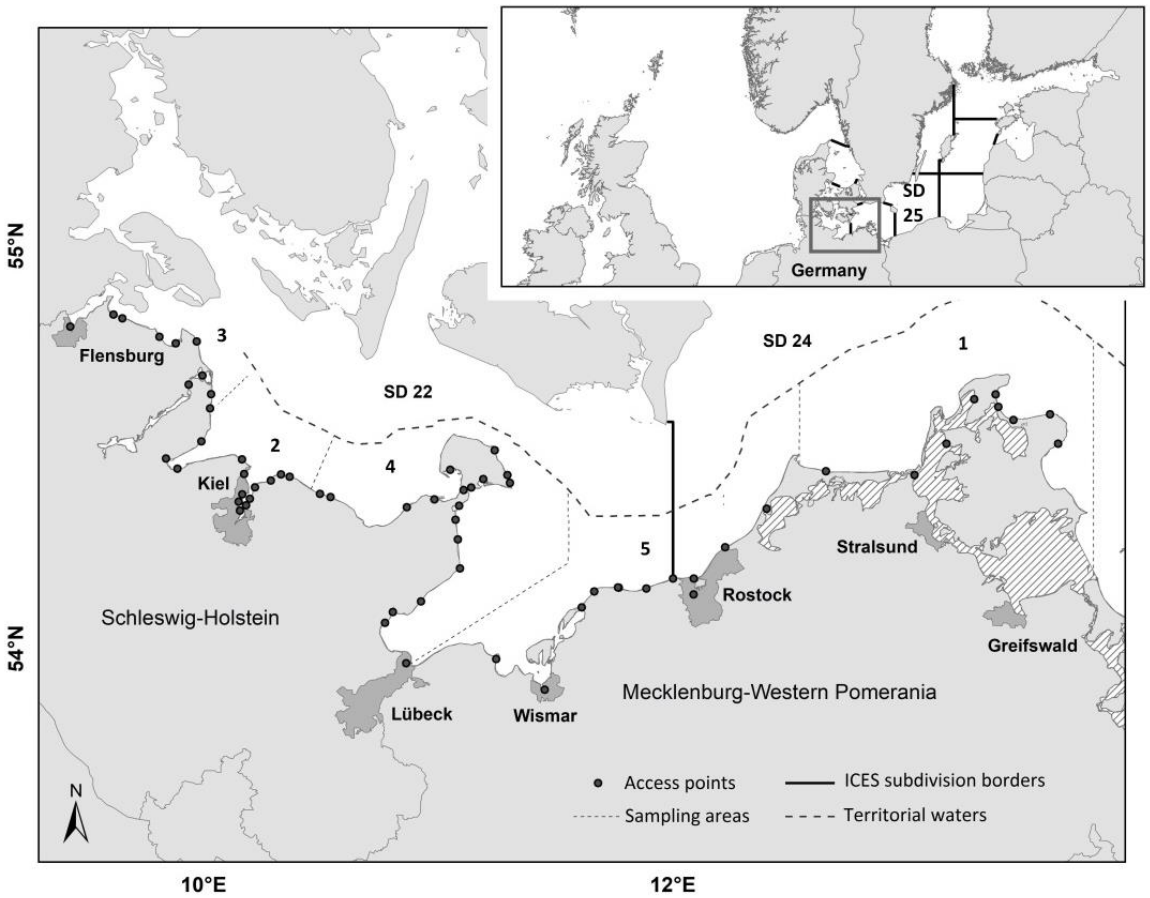

Fig. 7: Map showing the locations of the access points used for the multi-species on-site survey along the German Baltic Sea coast, the federal states, and the ICES subdivisions (SDs). The numbers indicate the strata (figure derived from Lewin et al., in press[b]).

Access points and days (currently 27 days per month) are randomly selected within the strata. The interviews are conducted by five survey agents during peak activity times in the afternoon/evening when most anglers are expected to end their fishing day. The sampling effort is increased for sea-based fishing methods and for those days when anglers most frequently go fishing (weekends and public holidays). Observation time per access point is usually three to five hours. Anglers (14 years

and older) are interviewed after they have finished their fishing day and only data from completed fishing days are used. The fishing methods are grouped into shore fishing (surf angling and wading), boat fishing (including float tubes and kayaks), and charter vessel fishing. The following data are collected during the interviews: the number of caught and released fish per species, the sociodemographic factors gender, age, place of residence (postal code), avidity (measured as the reported number of fishing days in the German Baltic Sea in the past 12 months), seven questions covering aspects of angler heterogeneity, weather conditions and the coastal state and specific location at which the interview took place. The survey agents are equipped with protocols to record the data.

From 2005 to 2008, the number of on-site samples was lower (126-149 sampling days per year) due to a lower budget (Fig. 8). From 2009, sampling was increased and kept at about 321-411 on-site sampling days in the past ten years. In 2020, fewer samplings were conducted due to a prolonged absence of one survey agent and COVID-19 travel restrictions that could not be compensated (Pita et al., 2021). The number of interviewed anglers varied between years but was rather stable around 1,500 anglers per year from 2012 until 2019. In 2020 and 2021, the number of interviewed anglers decreased as a result of COVID-19 restrictions and a lower number of on-site sampling days.

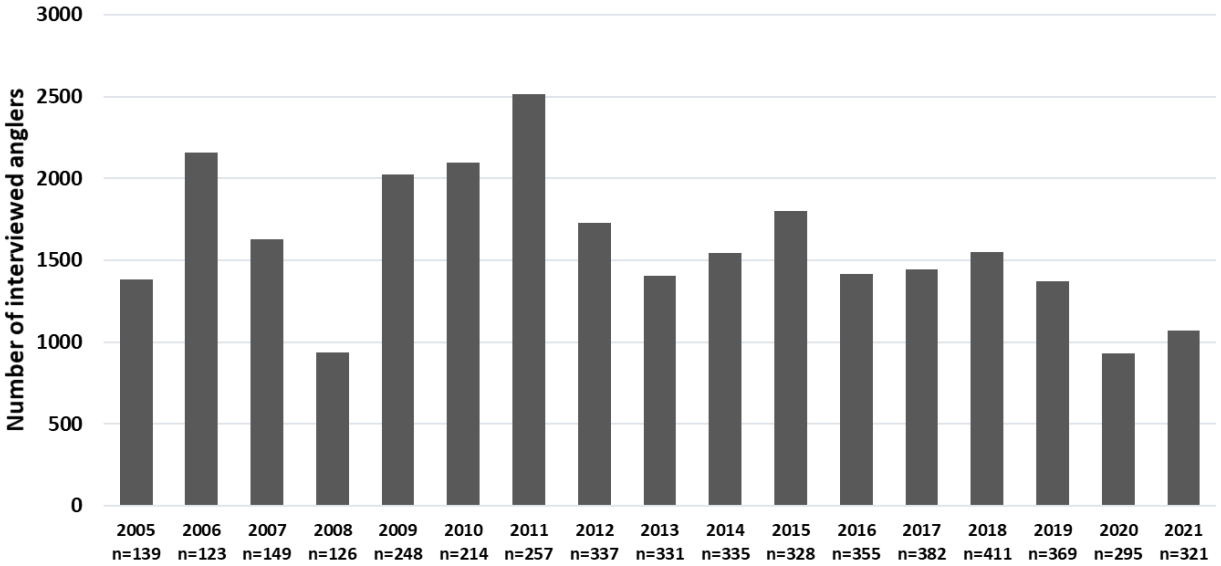

Fig. 8: Time series of the number of on-site access point samplings and the number of interviewed anglers per year from 2005 until 2021.

A quality assessment of the multi-species on-site survey based on the quality assurance toolkit (QAT) developed by the ICES Working Group on Recreational Fisheries Surveys (WGRFS; ICES 2013; 2020) is provided in the Appendix (see 9.2)

Relevant publications:

Strehlow HV, **Schultz N**, Zimmermann C, Hammer C (2012). Cod catches taken by the German recreational fishery in the Western Baltic Sea, 2005-2010: implications for stock assessment and management. ICES J Mar Sci 69(10):1769-1780.

Lewin W-C, **Weltersbach MS**, **Haase K**, **Riepe C**, Skov C, Gundelund C, **Strehlow HV** (2021[a]). Comparing on-site and off-site survey data to investigate survey biases in recreational fisheries data. ICES J Mar Sci 78(7):2528-2546, DOI:10.1093/icesjms/fsab131.

Lewin W-C, **Weltersbach MS**, **Haase K**, **Strehlow HV** (2021[b]). Who travels how far: German Baltic sea anglers' travel distances as precondition for fisheries management and coastal spatial planning. Ocean Coastal Manag 209:105640, DOI:10.1016/j.ocecoaman.2021.105640.

Haase K, **Weltersbach MS**, **Lewin W-C**, Zimmermann C, **Strehlow HV** (2022). Potential effects of management options on marine recreational fisheries - the example of the western Baltic cod fishery. ICES J Mar Sci: in press, DOI:10.1093/icesjms/fsac012.

Lewin W-C, **Weltersbach MS**, **Haase K**, Arlinghaus R, **Strehlow HV** (in press[b]). Change points in marine recreational fisheries – the impact of stock status and fisheries regulations: A case from the western Baltic Sea. Fish Res: in press.

7.4 Remote camera survey (Salmon survey)

The multi-species off-site survey from 2014/2015 indicated very low participation rates for some small, highly specialized marine recreational fisheries that are important in terms of stock exploitation, in particular, recreational trolling for Atlantic salmon (*Salmo salar*) in the Baltic Sea (ICES, 2017; Hartill et al., 2020). In Germany, recreational trolling for salmon occurs only from specialized boats in a relatively small area off the island of Rügen (ICES subdivision 24) in the Baltic Sea. Catch estimates from the telephone diary survey were not considered reliable because of the limited number of salmon anglers participating in the survey. Therefore, remote cameras were installed in 2016/17 at three marinas (Glowe, Lohme, Wiek) that collectively provide access to > 65% of all trolling boats participating in the German salmon trolling fishery. The aim was to quantify launch-based fishing effort departing from these marinas (ICES, 2017; Hartill et al., 2020). In the beginning, it was planned to install a fourth camera in the marina of Schaprode which would have increased coverage to ~ 85% of all trolling boats. However, the local municipality denied permission for camera installation in this marina.

Each system consists of a network camera connected to a wireless network router via Ethernet cable. Images are stored on a 250 GB Solid-State Drive (SSD) connected to the router. The system can be configured using the wireless network. The router and the SSD are placed in a weatherproofed box located at a suitable place nearby the camera and connected to 220 V power mains (Fig. 9). Recently, the routers have been upgraded so that they provide an internet connection using the mobile phone network. This allows off-site control, maintenance and configuration of the systems and facilitates the quick detection of malfunctions. In addition to the

image storage on SSDs, it is planned to use the mobile internet connection to download the images on a server in regular intervals in the future.

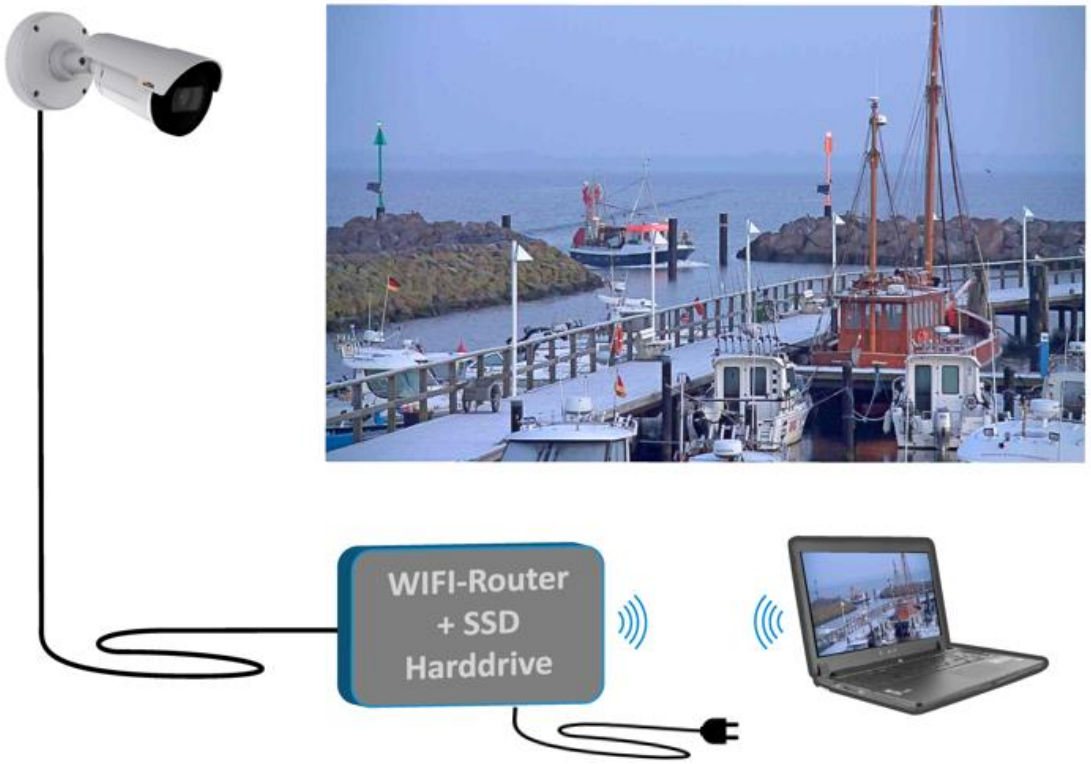

Fig. 9: Setup of the remote camera systems used to monitor the recreational salmon trolling effort around the Island of Rügen.

Marina entrance choke points are monitored, providing coverage of all boats leaving the marinas. The recording is restricted to the salmon trolling season (15th December to 31st May) and images are only taken between 5 am and 3 pm when trolling boats are known to leave the marinas, to increase cost efficiency. Depending on mounting location, the cameras take 12-20 time-stamped images per minute aiming to reach a census of all boats leaving the marina. This results in 7,200-12,000 images per marina and day. In the beginning, images were downloaded via the wireless network. However, due to high time requirements when downloading large amounts of files the SSDs are now manually exchanged every two months. Image analysis and boat counting are conducted via manual visual inspection of the images in time-lapse (30 frames viewed per second). Image analysis is conducted by the same two technicians since 2017 and takes on average eight minutes per harbour and day. Trolling boats that leave the marina are identified by means of the equipment of the boats, i.e. the presence of special salmon trolling gear such as downriggers, multiple rod holders and salmon fishing tackle. A cross-check of the picture analysis has been conducted resulting in very similar effort counts between the two analysts ($R^2 \geq 0.95$). Salmon trolling effort from marinas not monitored by cameras is extrapolated using regular instantaneous trolling boat counts (every two weeks at night or on storm days) covering all relevant marinas with salmon trolling boats and the proportions of trolling boats that went out for fishing derived from the marinas with camera monitoring (ICES, 2017; Hartill et al., 2020).

The camera monitoring is complemented by an on-site access point survey. Random on-site interviews (10-12 assignments per month with replacement) of trolling anglers in four relevant marinas are conducted (including the marinas where the cameras are installed) to determine catch, harvest, and release rates (each per boat) in order to estimate catches for stock assessment purposes and collect biological catch data and socio-economic information (Table 1).

Table 1: Summary of the number of on-site access point samplings, the number of sampled salmon trolling boats, and the number of interviewed anglers from the salmon survey between 2016 and 2021.

Year	No. samplings	Sampled boats	Interviewed anglers
2016	37	309	355
2017	45	232	581
2018	57	272	720
2019	56	423	974
2020	60	252	513
2021	60	251	449

The calculations of salmon trolling effort and subsequently salmon trolling harvest and releases are conducted as follows: Initially, trolling effort per month for marinas with cameras is calculated as the sum of the daily counted boats from the image analyses. In the rare event of camera malfunctions individual days are extrapolated using the camera data from the same day from the other harbours. For this, a weighted daily mean proportion based on the number of boats that left the respective marinas (with camera observations on that day) and the number of boats that were counted in these marinas during the instantaneous trolling boat counts in the same period is calculated. This weighted mean proportion is then multiplied by the number of trolling boats in the marina with the camera malfunction from the instantaneous trolling boat counts in the same period to derive an estimate of the daily number of trolling boats that went out for fishing from this marina on a specific day.

Trolling effort for marinas without camera monitoring is calculated in a similar manner. Again, a weighted daily mean proportion based on the number of boats that left the three marinas with camera observation and the number of boats that were counted in these marinas during the instantaneous trolling boat counts in the same period is calculated. This weighted mean proportion is then multiplied by the number of trolling boats in the four marinas without cameras from the instantaneous trolling boat counts in the same period individually for each marina to derive an estimate of the daily salmon trolling effort (in boat days) for each of the marinas without cameras. Daily estimates of salmon trolling effort are then summed to obtain monthly trolling fishing effort per marina.

Mean monthly harvest-per-unit-effort (HPUE) and release-per-unit-effort (RPUE) are calculated as the number of salmon harvested or released per day and boat based on the data from the on-site access point survey. Data from individual marinas (n=4) is pooled per month. In addition, 95% confidence intervals are calculated for the monthly HPUEs and RPUEs.

Monthly harvest and release per marina are then calculated by multiplying the monthly trolling effort with the mean monthly HPUE and RPUE, respectively. The same is done for the upper and lower 95% confidence limits of the HPUE and RPUE, respectively. Total harvest and release for the German Baltic salmon trolling fishery is calculated by summing the monthly harvest and release numbers of all relevant marinas.

A validation of the trolling effort estimation procedure for the marinas without camera observation has been conducted in 2018. To this end, visual counts of trolling boats leaving the marina for fishing were conducted by a survey agent throughout the salmon trolling season on 26 randomly selected days in the marina of Schaprode (the largest relevant marina without a camera). These visual counts were compared with the estimated trolling effort for Schaprode on the same days. The trolling effort estimation procedure seemed to be reasonable with an overall overestimation of 9% compared to the visual counts.

Only a few studies have been conducted testing the long-term use of remote cameras. However, our camera systems have been running stable over the past six years with very few technical failures. The camera monitoring will be continued in combination with the regular on-site intercept survey on an annual basis to provide catch estimates for inclusion in the Baltic salmon stock assessment.

A quality assessment of the remote camera survey and the complementary on-site access point survey based on the quality assurance toolkit (QAT) developed by the ICES Working Group on Recreational Fisheries Surveys (WGRFS; ICES 2013; 2020) is provided in the Appendix (see 9.3).

Relevant publications:

Hartill BW, Taylor SM, Keller K, **Weltersbach MS** (2020). Digital camera monitoring of recreational fishing effort: Applications and challenges. Fish Fish 21(1):204-215, DOI:10.1111/faf.12413.

7.5 Biological data collection

The working group also collects biological data in the framework of its recreational fisheries data collection programme. Length frequency distributions of sea-based recreational catches (harvest and releases of all species, particularly western Baltic cod) are collected during onboard measurements by survey agents on charter vessel trips along the German Baltic coast. The sampling frame covers the entire German charter boat fleet in ICES subdivisions 22 and 24. Length measurements are conducted via random onboard sampling based on a recreational charter boat registry (for details see Strehlow et al., 2012 and Weltersbach et al., 2019). This registry includes all recreational charter boats used for recreational fishing along the German Baltic coast. For sampling, the coastline is divided into five strata. In recent years three to five assignments (one per

stratum) were carried out per month where a survey agent carries out onboard length measurements (Table 2).

Table 2: Number of length samplings, measured retained and released cod, and measured retained and released fish of other species from onboard samplings and fishing competitions between 2005 and 2021.

Year	No. samplings	Cod retained	Cod released	Other retained	Other released
2005	17	1461	0	253	0
2006	6	362	0	178	0
2007	6	516	8	176	0
2008	32	620	33	3336	8
2009	84	1351	885	5432	349
2010	87	3634	1635	1054	61
2011	80	4673	1102	3955	205
2012	32	1546	533	295	30
2013	47	2257	1345	875	120
2014	45	3721	1104	926	25
2015	42	2853	949	674	40
2016	53	2521	398	2481	288
2017	56	968	1318	1550	713
2018	44	1758	1381	1672	191
2019	42	1955	1399	760	181
2020	24	585	665	936	481
2021	33	511	1858	970	332

Information on the overall recreational catch composition and sociodemographic data of the individual anglers are also collected. The sampling date and the individual charter boat are randomly selected for each sampling day and stratum. However, random selection can be affected by weather conditions (i.e., weather-related cancellations) and the availability of the selected charter boat (e.g., level of bookings, dry dock phase, approval of the crew) and sometimes sampling dates or charter boats have to be changed (Weltersbach et al., 2019). During some trips, not all fish can be measured because of very high catch rates. In such cases, all fish are separately counted and representative subsamples are measured. This approach ensures that all fish caught on the charter boat fishing trip are registered by the survey agents, minimizing the risk of under- and non-reporting (Weltersbach et al., 2019). Occasionally, additional data or samples such as individual weights, otoliths and tissue samples are collected during these onboard samplings for certain end-user needs. In addition, length measurements from fishing competitions are collected in cooperation with angling associations whereby most of this data derive from shore-based fishing.

Biological data from salmonids (salmon and sea trout) are collected in the framework of the salmon survey since 2016. The survey agents collect length and weight data from released and retained salmon and sea trout during the on-site access point survey. Lengths and weights are usually reported by the anglers and not self-measured. Sampling days and access points are randomly selected with replacement. Between 10 and 12 samplings days are planned per month during the salmon trolling season from December until May (Table 3). Occasionally, additional data or samples such as individual weights, and scale and tissue samples are collected for certain end-user needs.

Table 3: Number of on-site access point samplings and number of length samples from retained and released salmon and sea trout, respectively, between 2016 and 2021.

Year	No. samplings	Salmon retained	Salmon released	Sea trout retained	Sea trout released
2016	37	209	2	7	2
2017	45	139	10	15	2
2018	57	213	42	34	5
2019	56	434	20	54	16
2020	60	131	5	17	4
2021	60	237	9	13	6

In addition, biological data are also collected for certain species upon request, e.g. samplings of European sea bass in the German North Sea and garfish in the Baltic Sea have been conducted for population analyses following requests from other institutions.

Relevant publications:

Weltersbach MS, **Lewin W-C**, Gröger JP, **Strehlow HV** (2019). Effect of lure and bait type on catch, size, hooking location, injury and bycatch in the western Baltic Sea recreational cod fishery. Fish Res 210:121-130, DOI:10.1016/j.fishres.2018.10.002.

Lewin W-C, **Weltersbach MS**, **Haase K**, Arlinghaus R, **Strehlow HV** (in press[b]). Change points in marine recreational fisheries – the impact of stock status and fisheries regulations: A case from the western Baltic Sea. Fish Res: in press

8 Further research activities

8.1 Social, economic and ecological dimensions of recreational fishing

Marine recreational fishing is a high-participation activity with large economic value and social benefits globally, and with impacts on some fish stocks. Therefore, a major focus of the research of the working group is on the social, economic and ecological dimensions of (marine) recreational fisheries. The working group was intensively involved in a study that aimed to collect and synthesize data on the numbers of fishers, participation rates, days fished, expenditures, and catches of two widely targeted species to provide European estimates of marine recreational fishing (Hyder et al., 2018). There were an estimated 8.7 million European recreational sea fishers corresponding to a participation rate of 1.6%. An estimated 77.6 million days were fished, and expenditure was 5.9 billion € annually. Comparisons with other regions showed that European MRF participation rates and expenditure were in the mid-range, with higher participation in Oceania and the United States, higher expenditure in the United States, and lower participation and expenditure in South America and Africa (Hyder et al., 2018). For both northern European sea bass (*Dicentrarchus labrax*) and western Baltic cod (*Gadus morhua*) stocks, marine recreational fishing represented 27% of the total removals. The study highlighted the importance of marine recreational fishing and the need for bespoke, regular and statistically sound data collection to underpin European fisheries management (Hyder et al., 2018). A recent study investigated the economic contribution of resident and tourist anglers to a local economy in Germany (Strehlow et al., in prep). Using the telephone-dairy survey from 2014/2105, we estimated the number of marine recreational anglers and their expenditures in Germany over the course of one year. A total of 200,000 marine anglers spent 248 million €. Zooming in and using local economic multipliers, we estimated the number of resident anglers and angling tourists from Germany in the coastal and transitional waters of the coastal state MV to specifically examine the economic impacts of non-resident angling. We estimated the total number of jobs generated by recreational fishing in MV to be slightly over 2,000. We also found that tourist (nonresident) anglers were responsible for a larger economic impact than resident anglers, for both coastal and transitional brackish waters. The activity by nonresident anglers generated economic output particularly in the touristic off-season between fall and spring, benefiting structurally weak or peripheral rural regions (Strehlow et al., in prep).

Several studies have been conducted by the working group and in collaboration with other institutions to investigate the impacts of recreational fishing on fish stocks. We used our data from the off-site and on-site survey and from the biological data collection to estimate the German recreational cod (*Gadus morhua*) catches in the western Baltic Sea between 2005 and 2010 (Strehlow et al., 2012). Annual recreational fishery cod harvests accounted for a significant share of the total landings, with a yearly variation from 34 to 70% of the German commercial cod landings from the western Baltic Sea. As a result of this study, German recreational western Baltic cod removals were included in the stock assessment from 2013. A study by Radford et al. (2018) aimed to estimate (i) European marine recreational fisheries removals, which were defined as landings plus dead releases; and (ii) impacts at stock levels by comparing the percentage contribution to

total removal by marine recreational and commercial fishing. As marine recreational fisheries data were limited for some European countries, catches were reconstructed using a mixture of average release proportions, average fish weights, and extrapolation using the catch per fisher of the nearest country providing catch estimates. Furthermore, as marine recreational fisheries survey methodology can be variable, semi-quantitative estimates of bias and error were calculated for each stock. The study indicated that removals by marine recreational fisheries can represent a high proportion of the total removals for some European marine fish stocks, so inclusion in stock assessments should be routine (Radford et al., 2018). Another study used data from our telephone diary survey from 2014/2015 in combination with data from other angler surveys, commercial fisheries data, and cormorant (*Phalacrocorax carbo sinensis*) diet studies to examine the potential for conflict in brackish lagoon fisheries of the southern Baltic Sea in Germany. This work specifically focussed on interactions among commercial and recreational fisheries as well as fisheries and cormorants (Arlinghaus et al., 2021). In this context, a recent study synthesized a large body of literature involving peer-reviewed work, grey literature and novel data analysis of public data and surveys to generate a comprehensive review of the lagoon pike (*Esox lucius*) fishery in the southern Baltic Sea (Arlinghaus et al., under review). Based on a multidisciplinary synthesis covering both general ecology and pike ecology as well as social and economic sciences, implications for management and research related to the lagoon fishery were derived (Arlinghaus et al., under review).

Environmental impacts of marine recreational fishing are also investigated by the working group. During a comprehensive literature review, activities and potential risks associated with marine recreational fishing were identified and ranked using a risk assessment matrix based on ecological and fisheries-related literature (Lewin et al., 2019). The majority of the impacts were rated to be of minor importance (impacts that occur locally, are reversible, and comparably easy to manage on local scales). Three impacts were ranked as high-risk impacts (severe impacts that are difficult to reverse and to manage, and that may require management measures on a broad spatial scale): (1) the direct and indirect impacts of high and selective fishing mortality (truncation of the natural age and size structure, depensatory mechanisms, loss of genetic variability, evolutionary changes, and food web changes) because they potentially contribute to the decline of fish stocks and undermine biodiversity and ecological resilience, (2) the use of live bait organisms that originate from bodies of water elsewhere because released or lost live bait organisms potentially impact the genetic, species, and ultimately ecosystem diversity, and (3) the loss of lead-containing fishing tackle that potentially causes environmental contamination (Lewin et al., 2019). Another study aimed to assess the behaviour, motivations and attitudes of Baltic Sea anglers towards marine litter by using data from a telephone survey (Lewin et al., 2020). The telephone survey was supplemented by face-to-face angler interviews during our on-site survey along the German Baltic coast to estimate the amount of lost fishing tackle based on anglers' self-reports over the course of a year. Most anglers were concerned about marine litter, recognized their responsibility and

were willing to contribute to litter avoidance and mitigation. According to the self-reports, the loss of fishing tackle was a rare event for individual anglers. Nonetheless, given the high number of Baltic Sea anglers and angling effort, local environmental impacts on marine environments due to lost fishing tackle could not be excluded (Lewin et al., 2020).

Also, unforeseen events and developments are covered by the research of the working group. For example, two studies have been conducted that investigated the impacts of the COVID-19 pandemic on recreational fisheries. The first one (Pita et al., 2021) assessed the impacts of the pandemic on (1) access to fishing, derived from lockdowns and other mobility restrictions; (2) ecosystems, due to alterations in fishing intensity and human presence; (3) the blue economy, derived from alterations in the investments and expenses of the fishers; and (4) society, in relation to variations in fishers' health and well-being. For this, a consultation with experts from 16 countries was carried out, as well as an international online survey aimed at recreational fishers, that included specific questions designed to capture fishers' heterogeneity in relation to behaviour, skills and know-how, and vital involvement (Pita et al., 2021). The second study (Britton et al., under review) aimed to identify temporal changes in angling interest, license sales, and angler effort in different regions of the world by comparing data in the 'pre-pandemic' (2019 and earlier); 'acute pandemic' (2020) and 'COVID-acclimated' (2021) periods, ultimately aiming to identify how changes can inform the development of more resilient and sustainable fisheries.

8.2 Survey methods

The working group has established comprehensive expertise in the development and application of recreational fisheries surveys over the years, which has led to several national and international collaborations that resulted in various peer-reviewed publications. An important research area of the working group includes the development and improvement of survey methods. This includes traditional off-site and on-site methods as well as novel data collection methods.

A recent study investigated whether and to what extent the data obtained from our on-site survey differed from those of the simultaneously conducted telephone diary survey (Lewin et al., 2021[a]). The comparison of the data revealed avidity and recall bias. Diarists, for example, were more avid than anglers identified during the telephone survey who refused participation and were also more avid than anglers who were encountered during the onsite survey. Nonetheless, both catch rates and release rates were rarely affected by the survey method but differed significantly between charter boat, boat, and shore anglers. For the same angling platform, catch as well as release rates of diarists and anglers encountered during the on-site survey were reasonably precise and similar. The low explanatory power of the regressions modelling catch and release rates based on common socio-demographic variables indicated that the heterogeneity of anglers in terms of, for example, centrality and catch orientation should additionally be included in future surveys (Lewin et al., 2021[a]). Another recent study (Lewin et al., in press[a]) compared socio-demographic data as well as catch, harvest, and release rates obtained from diaries from German Baltic Sea cod anglers who were recruited from a list of fishing permit holders (non-probability-based sample) to those who were recruited simultaneously during a probability-based representative telephone survey among

the general population. It could be shown that both groups of diarists were similar regarding their socio-demographic characteristics. Avidity as well as the number of recalled and reported angling days differed between both samples, which indicated that sampling from the list of fishing permit holders could amplify the risk for avidity and recall biases. The catch and the release rates, in contrast, were rather influenced by the angling platform than by the recruitment methods (Lewin et al., in press[a]).

In a study led by Norwegian colleagues, a novel approach for spatial sampling (modified Voronoi polygons with continuous sea-surface area, with clusters of polygons as primary sampling units) was developed and tested in on-site surveys, as part of a national study of marine recreational fishing in Norway using multiple sampling frames including a telephone screening survey based on the national telephone directory (Vølstad et al., 2020). In another study, we used this novel spatial sampling frame in combination with a sample survey of tourist fishing businesses in which we combined logbooks with on-site sampling to estimate boat-based catches for resident marine anglers and tourists in Norway, and to identify potential bias sources in these catch estimates Ferter et al., in press).

The working group is also involved in research regarding novel data collection methods. In a recent study by Skov et al. (2021), expert opinions from 20, mostly European, countries were surveyed to assess the current and future status of the use of smartphone applications (apps) in marine recreational fisheries. The survey revealed that a few countries already use app data to support existing data collection, and that this number is likely to increase within 5–10 years. The strongest barriers to using app data were a scarcity of useful apps and concern over data quality, especially biases due to the opt-in nature of app use. Experts generally agreed that apps were unlikely to be a "stand-alone" method, at least in the short term, but could be of immediate use as a novel approach to collect supporting data such as fisheries-specific temporal and spatial distributions of fishing effort, and aspects of fisher behaviour (Skov et al., 2021). In another study, lessons learnt from four early adopter studies in New Zealand, Australia and Germany (salmon survey), where digital cameras have been used to monitor recreational fishing effort, were shared (Hartill et al., 2020). The study suggests solutions and strategies to address issues and challenges that may occur when using remote cameras to monitor recreational fisheries. We concluded that all aspects of a camera-based monitoring system should be considered from the outset, to optimize the utility and value of the information they provide over the long term (Hartill et al., 2020).

8.3 Recreational fisheries management

Another research focus of the working group is the development and testing of management approaches using empirical time-series data, choice experiments or agent-based modelling approaches. This includes the development of frameworks for incorporating recreational fisheries in fisheries management, stock assessments and advice, questions regarding resource allocations between commercial and recreational fisheries, the use of interviews and questionnaires to identify motivations of anglers to assess management objectives beyond purely catch-oriented

motives, and participatory approaches to integrate stakeholder interests and goals into a public welfare-oriented management.

A recent study examined the effects of the first-time introduction of a bag limit on a previously largely unregulated marine recreational fishery using the example of the German western Baltic Sea recreational cod fishery (Haase et al., 2022). Furthermore, the study simulated and compared the effects of different bag limits, seasonal closures, minimum length, and harvest slot limits to inform scientists, stakeholders, and managers about alternative management strategies and their potential effects on the fishery. After the first-time introduction of the bag limit, recreational removals decreased more than expected and fishing participation slightly declined. The simulations showed that management measures adapted to the fishing methods reduced recreational removals but with different effects on cod length distributions and angler welfare. The study demonstrated that recreational fisheries management measures need to be evaluated considering fishing methods and angler preferences before their implementation to avoid unexpected biological, social, and economic consequences (Haase et al., 2022).

As a follow-up, another study aimed to analyse the preferences of German western Baltic cod anglers for harvest regulations and catch outcomes (Bronnmann et al., in press). We developed four different choice experiments, which were embedded in a large online survey of 1,795 German marine anglers. Four different choice experiments were used to investigate the consistency of anglers' preferences in different choice contexts and with varying payment vehicles. We additionally assessed preferences for harvest regulations with opinion-type questions where no obvious trade-offs were involved in the question framing. The study showed that German cod anglers received benefits from catching and harvesting cod, catching species other than cod, and catching cod as large as possible. There was no utility associated with catching and releasing cod, indicating the highly consumptive nature of this fishery. Anglers preferred stricter quotas for commercial cod fishery and stricter length-based harvest limits for recreational fishery compared to the current management. Preferences for the specific configuration of the daily bag limit were found to vary depending on the choice treatment, but a reduction to a daily bag limit of two cod per day and angler consistently resulted in a significant reduction in the willingness to pay (Bronnmann et al., in press).

Another study aimed to extend the knowledge about German marine angling tourism and to evaluate the effects of changing management measures on travel distances (Lewin et al., 2021[b]). Therefore, activity hot spots and travel distances of 8,429 German Baltic Sea anglers were evaluated using data obtained from the on-site survey. Angling effort clustered along the coast primarily according to the available infrastructure and the spatial distribution of the target species. The high percentage of non-resident anglers, most of whom travelled more than 200 km to the coast, suggested that particularly cod and salmonid anglers conducted multiple-day trips and contributed to local economies. The period 2016/17 was characterised by a severe decline of the western Baltic cod stock and the first-time implementation of harvest limitations. The number and travel distances of cod charter vessel anglers decreased after the implementation, whereas the numbers and travel distances of boat and shore anglers targeting cod remained constant despite

overall decreasing catch rates. The delineation of areas where marine recreational fishing concentrates may help to define areas relevant for tourism development and destination branding and equally those that require a risk assessment to evaluate the potential extent and consequences of marine recreational fishing on local environments. The travel distances underlined the heterogeneity of the marine recreational fishery and may be used as a tool to identify stakeholder groups, estimate the species-specific attractiveness for resident and non-resident anglers, and evaluate the outcome of management actions (Lewin et al., 2021[b]).

In collaborative work, we investigated the sensitivity of the calculated commercial total allowable catch (TAC) to include recreational catches in the stock assessment of western Baltic cod (Eero et al., 2015). The results showed that the most crucial aspect in terms of the impact on commercial TAC was the assumption about recreational catch dynamics relative to that of commercial fisheries used in the forecast. The results were less sensitive to the information on the historical amount and age structure of recreational catch. The study intended to inform potential debates related to resource allocation between the commercial and recreational sectors and contribute to developing a general framework for incorporating recreational catches in fisheries management advice in ICES (Eero et al., 2015).

Another study used text mining tools to identify key concepts and analyse the text of legal regulations on marine recreational fisheries in the European Union (EU), Portugal, Spain and the United Kingdom (Pita et al., 2018). Additionally, the Ecosystem Fisheries Legal Assessment (EFLA) framework was used to assess the alignment of the regulations with the Ecosystem Approach to Fisheries (EAF). The EFLA framework showed that the European public policies on marine recreational fisheries follow the EAF principles. Enough attention is paid to ecological components, but socio-economic sustainability could be improved. However, policy efficiency could be lower than expected because of potential institutional misfits derived from the eventual confluence of different spatial scales (Pita et al., 2018).

8.4 Catch-and-Release research

For many marine and diadromous fish species and stocks in Europe, there has been a lack of information on the extent of Catch-and-release (C&R) in recreational fisheries and, in particular, on the lethal as well as non-lethal impacts of C&R. In order to ensure sustainable fisheries management that includes recreational fisheries, it is therefore of fundamental importance to consider release rates and lethal and non-lethal effects of C&R in stock assessments and in the development of fisheries management measures. The institute's working group on Marine Recreational Fisheries recognised this knowledge gap at an early stage and started with its research on C&R in 2012. In the following years, several studies on the lethal and non-lethal effects of C&R for various species have been conducted by the working group (including a PhD thesis, Weltersbach et al., 2018) and in collaboration with other researchers. This led to an extensive gain in knowledge and expertise on how to conduct C&R studies with different methodologies, which now makes the working group one of the leading research groups on this topic in Europe.

One of the first studies aimed to establish an overview of the practice of C&R among marine recreational anglers in Europe. Therefore, the existing knowledge on C&R and its potential associated release mortality was collected and summarized (Ferter et al., 2013). This synthesis revealed that in several European marine recreational fisheries over 50% of the catch is released and that post-release mortality rates of many European marine and diadromous species are unknown.

Three studies have been conducted focusing on Atlantic cod (*Gadus morhua*). The first study investigated post-release mortality of undersized cod, potential factors affecting mortality, and consequences of the catch-and-release process on cod in the western Baltic sea-based recreational cod fishery (Weltersbach and Strehlow, 2013). During four experimental trials, western Baltic cod were angled from a charter vessel and thereafter observed together with control fish in net pens for 10 d at holding temperatures between 6.2 and 19.8°C. Adjusted post-release mortality rates varied between 0.0 and 27.3% (overall mean 11.2%). Bleeding and holding-water temperature were the only significant predictors of mortality. Slow hook injury healing (>10 d) and bacterial wound infections were observed in some surviving cod (Weltersbach and Strehlow, 2013). The post-release mortality estimates from this study are used in the stock assessment of western Baltic cod since 2013. The second study focused on the effects of capture depth on barotrauma and the post-release survival of cod in recreational fisheries (Ferter et al., 2015). Using a range of field experiments and a supplementary radiology study, the study described different external and internal barotrauma signs in cod after rapid decompression from capture depths up to 90 m and the recovery process from these. Moreover, the study quantified the effect of capture depth (down to 90 m) on short-term post-release mortality of angled cod – without substantial hooking injuries – using different study designs (i.e. containment in a floating net pen vs. submerged cages). Mouth-hooked, non-bleeding cod kept in a floating net pen showed mortalities ≥40% when angled from >50 m depth, likely because of cumulative stress from ongoing barotrauma and exposure to warm surface water. In a follow-up study, 97.8% of similarly selected cod managed to dive following immediate release, whereas 2.2% were floaters. No mortality was observed for divers kept in cages, which were lowered to capture depth for 72 h. While the floaters would likely have died in a natural setting, no mortality was observed when they were recompressed and kept at capture depth for 72 h. The occurrence of swim bladder ruptures, swollen coelomic cavities, venous gas embolisms, and gas release around the anus was significantly influenced by capture depth. A supplementary radiology study showed inflated swim bladders in 87% of the cod after 72 h, and most barotrauma signs had disappeared after 1 month (Ferter et al., 2015). The third study evaluated the influence of the lure/bait type on: (1) size of fish, (2) catch and harvest, (3) proportion of bycatch, (4) hooking location, and (5) injury (bleeding) in the western Baltic Sea recreational cod fishery using data from our biological data collection (Weltersbach et al., 2019). Natural baits caught 43% more cod below minimum conservation reference size than artificial lures. Deep hooking and severe bleeding occurred significantly more often during bait angling. Bait angling significantly increased the bycatch of other species. The results were used to provide guidelines to improve selectivity and the fate of released cod in recreational fisheries (Weltersbach et al., 2019).

Three studies have been conducted focusing on European sea bass (*Dicentrarchus labrax*). The first study investigated post-release mortality of sea bass captured with common recreational fishing gear under experimental conditions in an aquaculture facility over 10 d (Lewin et al., 2018). Three experiments investigated: (i) the effects of different bait types; (ii) the impact of prolonged air exposure; and (iii) the impact of deep hooking on post-release mortality. By combining the experimental results with country-specific information on sea bass angling practices, estimates of post-release mortality are provided for the northern sea bass stock. No mortality was observed for sea bass captured on artificial baits. The use of natural baits resulted in a mortality of 13.9% (95% CI = 4.7–29.5%), which was associated with deep hooking, hooking injuries, and prolonged air exposure. The use of artificial baits and short air exposure (≤30 s) increased survival probability, whereas deep hooking resulted in 76.5% (95% CI = 50.0–93.2%) mortality. Depending on country-specific angling practices, post-release mortality estimates ranged from 2.8% to 9.1% (mean = 5.0%, 95% CI = 1.7–14.4%) for northern sea bass (Lewin et al., 2018). The post-release mortality estimates from this study are used in the stock assessment of northern sea bass since 2018. The second study used sea bass as a case study to assess the sublethal effects of catch and release angling on fish (Watson et al., 2020). Building on established fish bioenergetic models, a general method for using the population consequences of disturbance framework was developed to investigate how stressors influence ecologically relevant life processes of fish. Its application to C&R fishing of European sea bass revealed sublethal impacts ranging from zero to losses of up to 100% growth and 62% fecundity (Watson et al., 2020). The third study aimed to estimate a fleet-wide discard survival rate for the UK commercial hook-and-line sea bass fishery (Lamb et al., 2021). This was achieved by characterising how commercial fishers caught, handled and discarded sea bass using a questionnaire, and subsequently combining the responses with post-release mortality estimates from Lewin et al. (2018) and commercial fleet census data. The responses to the questionnaire suggested that fishing was selective with a reported estimated mean discard rate of 12.9% (±3.3% SE). Low rates of foul and deep hooking and short periods of air exposure were reported. Combined with data from Lewin et al. (2018), a fleet-wide discard survival rate of 89.3% (±2.6% SE) was calculated for the UK commercial hook-and-line sea bass fishery (Lamb et al., 2021).

Two studies were conducted to investigate the effects of C&R on European eel (*Anguilla anguilla*). The first study investigated hook shedding mechanisms of deep-hooked, line-cut eels via radiography, and quantified hook shedding rates, post-release mortality and sub-lethal effects in captivity (Weltersbach et al., 2016). Eels were caught with four different hook treatments, monitored in a tank for 23 weeks, and radiographed 0, 1, 3, 10, 24, 54, 115 and 163 days after capture. After 163 days, total hook shedding rate was significantly higher for smaller hooks (41.2%) compared to larger hooks (0.0%), and increased with fish length. Post-release mortality rates ranged between 27.3% and 50.0% after 23 weeks (not adjusted for handling and holding) and did not differ significantly between hook treatments. The majority of dead eels showed gastric perforations caused by the hooks leading to internal haemorrhaging and the intrusion of digestive fluids into the body cavity inducing lethal degradation and inflammation of vital organs (Weltersbach et al., 2016). In the second study, a field experiment was conducted with pre-tagged eels in a semi-natural environment to investigate the lethal and sublethal impacts of C&R

(Weltersbach et al., 2018). The experiment aimed to (i) estimate post-release mortality rates, (ii) identify factors affecting mortality, and (iii) investigate sublethal effects of C&R on the physical condition of eels. The experiment was combined with a citizen science study evaluating the effects of different hooks on catch rates, fish size, and hooking location to develop best practice guidelines. Short-term mortality (≤72 h) ranged from 0.0–18.2%, and adjusted long-term mortality (>72 h) from 0.0–46.2% depending on treatments, resulting in adjusted total mortality rates between 8.4% and 64.4% at the end of the study period (≥43 d). The only significant predictor of mortality was the occurrence of bleeding from hooking injuries. Deep hooking was common, and only a few deep-hooked eels for which the fishing line was cut and the hook left in place shed the hook after release. However, no significant effect of C&R on eel condition was found. The citizen science study showed that anglers can significantly decrease the catch of small eels, and thus release rates, by using large J-hooks. Furthermore, large J-hooks or circle hooks reduced the likelihood of deep hooking compared to small J-hooks (Weltersbach et al., 2018). The results of both studies were used to develop species-specific best practice guidelines to increase post-release survival, mitigate the catch of undersized eel, and thus reduce recreational fishing mortality.

Recently, two studies on sea trout (anadromous brown trout, *Salmo trutta*) were conducted. In the first study, a citizen science approach using 35,826 sea trout caught by anglers and reported to a citizen science platform was used to investigate C&R practices of Danish sea trout anglers and to explore drivers for hooking location and bleeding (Skov et al., 2022). Spin fishing was the most popular angling method (46%), followed by fly fishing (35%), bombarda fishing (19%) and natural bait fishing (1%). The results confirmed that C&R is a very widespread practice among Danish sea trout anglers. ≥80% of all sea trout captured are being released, the majority because they are below the minimum landing size. Twenty-five percent of the caught sea trout bled, and 2% showed heavy bleeding. Bleeding was related to hooking location (deeply hooked fish bled the most) and to the angling method (fly-caught sea trout bled less than fish caught on spin fishing gear), but the role of these two factors varied with fish length. When looking at fish above the legal minimum size, the share of bleeders among the released sea trout was significantly lower compared to harvested fish, suggesting that anglers were more prone to harvest fish that bled (Skov et al., 2022). In the second study, we used a flow-through seawater raceway (4-10 °C) to investigate impacts on survival and growth of angled and released sea trout (<40 cm) up to 29 days post release (Skov et al., under review). Bleeding was common among angled sea trout, but differed between angling treatments i.e., spin fishing with treble hook (size 4), spin fishing with single hook (size 1/0) and fly fishing with single hook (size 12). However, no mortality and no significant differences in growth were found after a 26-29 days monitoring period among a control group and the three treatment groups (Skov et al., under review).

In addition, a study focusing on sublethal effects of C&R (particularly fighting time and air exposure duration) on Atlantic halibut (*Hippoglossus hippoglossus*) was conducted (Ferter et al., in prep.). Seventy halibut were caught with angling gear and exposed to different air exposure treatments (0, 4 and 10 minutes). Blood samples were either taken directly after capture (baseline) or after a one hour holding period. Moreover, RAMP (reflex action mortality predictor) testing was performed on all individuals after blood sampling.

8.5 Agent-based modelling of angler behaviour

The importance of angler heterogeneity and behaviour is increasingly recognised for the management of recreational fisheries. An example that illustrates the importance is the introduction of a bag limit for the recreational cod fishery in the western Baltic Sea. The bag limit led to changes in angler behaviour and thus to a divergence between actual and estimated catches, with effects differing between fishing methods and anglers (Haase et al. 2022). The PhD project "Agent-based modelling of angler behaviour" aims to contribute to a better understanding of recreational angler behaviour and their responses to management decisions as a prerequisite for sustainable recreational fisheries management. Agent-based models (ABMs) are a promising tool to further understand human behaviour in fisheries as they facilitate the explicit representation of individual decisions and interactions and allow to represent angler's heterogeneity. In the project, the first steps for the development of such an ABM were taken. First, a literature review of existing ABMs in the field of fisheries was conducted using a classification scheme developed specifically for this purpose (Haase et al., under review). The literature review revealed that the existing fisheries-related ABMs employ a variety of decision theories, policies, social interactions, agent memories, and data sources, and demonstrated a wide potential for applications of ABMs to a broad range of research questions and management recommendations. It is, however, so far virtually unexplored how environmental factors influence fishing decisions or how social norms and learning influence fishing behaviour. Nevertheless, it also became clear that the documentation and provenance information of ABMs needs to be improved – e.g., by applying standardized documentation procedures, such as ODD+D (Overview, Design concepts, and Details protocol, Grimm et al., 2006; Müller et al., 2013) and TRACE (TRAnsparent and Comprehensive model Evaluation, Grimm et al., 2014), – to enhance the credibility, transparency, and reusability of ABMs in fisheries science. In addition, an ABM for angler site choice was developed and a structured workflow was established to develop, extend, compare and validate the simulation models (Haase et al., in press). Using an exploratory modelling approach, the travel distance dependent on angler origin was identified as a key element in the site choice of western Baltic cod anglers to rebuild travel patterns and distances. The 5-year average catches at a fishing site had a subdominant role in the travel patterns but could recreate the angler's distribution among the fishing locations realistically. Future modelling should incorporate more decisions (e.g. how often and when anglers go out (fishing effort), and whether angler harvest or release fish) into the model, make the angler agents more realistic and replicate communication between anglers using the new data from the last off-site survey.

8.6 Project "marEEshift"

The project "marEEshift" (Marine ecological-economic systems in the Western Baltic Sea and beyond: Shifting the baseline to a regime of sustainability) funded by the Federal Ministry of Education and Research of Germany is based on a cooperation with researchers from multiple disciplines (Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), (Berlin, Germany), University of Hamburg (Hamburg, Germany), Albert-Ludwig University Freiburg (Freiburg,

Germany), German Centre for Integrative Biodiversity Research (iDiv) (Halle-Jena-Leipzig, Germany). The project pursues the following overall scientific goals: (i) to identify processes that increase or decrease the resilience of marine ecological-economic systems and (ii) to identify and initiate measures, institutions, and processes that could foster a resilient ecological-economic system of marine resource use in a regime of sustainability. This may require a regime shift from the current state of over-use towards a new resilient regime of sustainability. The main responsibility of the working group on marine recreational fisheries at the Thünen Institute of Baltic Sea Fisheries were the identification of change points in time series of recreational fisheries data (Lewin et al., in press[b]). Another important task was the planning and implementation of a workshop series with different stakeholders from recreational and commercial fisheries, environmental NGOs and fisheries authorities, to foster a participatory approach that integrates different stakeholder interests and goals into a public welfare-oriented management (Lewin et al., in prep.). In the individual workshops, the respective system understanding of the different stakeholder groups was captured and major influences impacting the stock of western Baltic cod were identified (mental modelling approach). Furthermore, existing measures were discussed and new ideas for possible management options were collected. The workshops, which were guided by an external moderator, showed that although there were influencing factors that were evaluated differently between all stakeholder groups – such as the cod removals by commercial and recreational fisheries which were perceived differently by those two groups of fishers –, impacts of environmental quality and climate were similarly assessed. In particular, the objectives of the different stakeholder groups were similar, such as the attainment of a "healthy" cod stock and sustainable fisheries, indicating a common solution space. In the final workshop, representatives of all stakeholder groups discussed the existing measures and new ideas for possible management options. The workshop served primarily as a platform for discussion between the various stakeholder groups and politicians and was positively evaluated by the participants in this respect.

Besides the recreational fishery, the coastal and in particular the coastal small-scale commercial fishery is an important stakeholder in coastal fisheries management. The development of management measures for a mixed-species commercial/recreational fishery that reduces conflicts between stakeholder groups with differing interests requires a sound knowledge of both fisheries. Therefore, recently a study was conducted in cooperation with sociologists in the framework of the marEEshift project (Lewin et al., under review). The study is based on a 21-year time series of coastal fisheries data supplemented by a questionnaire sent to part-time fishers and on excerpts from in-depth interviews with full-time fishers. With a focus on the small-scale fishery, the study aims to provide insights into the German coastal Baltic Sea fishery and reveals recent trends in participation, catches and revenues against the background of collapsing stocks of the western Baltic cod and spring spawning herring.

References

Anderson L, Jans M, Lee A, Doyle C, Driscoll H, Hilger J (2021). Effects of survey response mode, purported topic, and incentives on response rates in human dimensions of fisheries and wildlife research. Hum Dimens Wildl 27(3):201-219.

Arlinghaus R, Rittweg T, Dhellemmes F, Koemle D, van Gemert R, Schubert H, Niessner D, Möller S, Droll J, Friedland R, Lewin W-C, Dorow M, Westphal L, Ehrlich E, Strehlow HV, Weltersbach MS, Roser P, Braun M, Feldhege F, Winkler HM (under review). A synthesis of a coastal northern pike (*Esox lucius*) fishery and its social-ecological environment: implications for management and research of pike in brackish lagoons in the southern Baltic Sea, Germany. Submitted to Fish Res.

Arlinghaus R, Lucas J, Weltersbach MS, Kömle D, Winkler HM, Riepe C, Kühn C, Strehlow HV (2021). Niche overlap among anglers, fishers and cormorants and their removals of fish biomass: A case from brackish lagoon ecosystems in the southern Baltic Sea. Fish Res 238:105894, DOI:10.1016/j.fishres.2021.105894.

Britton JR, Pinder AC, Alos J, Arlinghaus R, Danylchuk AJ, Edwards W, Freire KMF, Gundelund C, Hyder K, Jaric I, Lennox R, Lewin W-C, Lynch AJ, Midway SR, Potts WM, Ryan KL, Skov C, Strehlow HV, Tracey SR, Tsuboi J, Venturelli PA, Weir JL, Weltersbach MS, Cooke SJ (under review). Global responses to the COIVD-19 pandemic by recreational anglers: considerations for developing more resilient and sustainable fisheries. Submitted to Rev Fish Biol Fish.

Bronnmann J, Koemle D, Meyerhoff J, Weltersbach MS, Strehlow HV, Arlinghaus R (in press). Context-dependency of preferences for harvest regulations and catch outcomes: A case study of German cod (*Gadus morhua*) anglers. Fish Res: in press.

Church AH (1993). Estimating the effect of incentives on mail survey response rates: a meta-analysis. Public Opin Q 57:62-79. https://doi.org/10.1086/269355.

Eero M, Strehlow HV, Adams CM, Vinther M (2015). Does recreational catch impact the TAC for commercial fisheries? ICES J Mar Sci 72(2):450-457, DOI:10.1093/icesjms/fsu121.

EU 2016. Commission Implementing Decision (EU) 2016/1251 of 12 July 2016 adopting a multiannual Union programme for the collection, management and use of data in the fisheries and aquaculture sectors for the period 2017-2019 (C (2016) 4329). Official Journal of the European Union, L207: 113–177.

Ferter K, Otterå H, Christman M, Kleiven AR, Weltersbach MS, Gundersen S, Djønne C, Bjelland O, Hartill B, Lyle J, Hyder K, Borch T, Vølstad JH (in press). Integrating complementary survey methods to estimate catches in Norway's complex marine recreational hook-and-line fishery. ICES J Mar Sci: in press.

Ferter K, Weltersbach MS, Humborstad OB, Fjelldal PG, Sambraus F, Strehlow HV, Volstad JH (2015). Dive to survive: effects of capture depth on barotrauma and post-release survival of

Atlantic cod (*Gadus morhua*) in recreational fisheries. ICES J Mar Sci 72(8):2467-2481, DOI:10.1093/icesjms/fsv102.

Ferter K, Weltersbach MS, Strehlow HV, Volstad JH, Asos J, Arlinghaus R, Armstrong M, Dorow M, Graaf M de, Hammen T van der, Hyder K, Levrel H, Paulrud A, Radtke K, Rocklin D, Sparrevohn CR, Veiga P (2013). Unexpectedly high catch-and-release rates in European marine recreational fisheries: implications for science and management. ICES J Mar Sci 70(7):1319-1329, doi:10.1093/icesjms/fst104.

FSchVO M-V (2018). Verordnung über die Erteilung der Fischereischeine und Erhebung der Fischereiabgabe (Fischereischeinverordnung - FSchVO M-V). GS Meckl.-Vorp. Gl. Nr. 793 - 3 - 10. Source: https://www.lallf.de/fileadmin /media/PDF/fischer/3_ Gesetze/MV_2018_FischereischeinVO_2018.pdf

Grimm V, Berger U, Bastiansen F, Eliassen S, Ginot V, Giske J, Goss-Custard J, Grand T, Heinz SK, Huse G, et al (2006). A standard protocol for describing individual-based and agent-based models. Ecol Modell, 198(1-2):115–126. doi:10.1016/j.ecolmodel.2006.04.023.

Grimm V, Augusiak J, Focks A, Frank BM, Gabsi F, Johnston ASA, Liu C, Martin BT, Meli M, Radchuk V, et al (2014). Towards better modelling and decision support: Documenting model development, testing, and analysis using TRACE. Ecol Modell 280:129–139, https://doi.org/10.1016/j.ecolmodel.2014.01.018

Haase K, Reinhardt O, Weltersbach MS, Lewin W-C, Strehlow HV, Uhrmacher A (under review). Agent-based simulation models in fisheries science. Submitted to Rev Fish Sci Aquac.

Haase K, Reinhard O, Lewin W-C, Strehlow HV, Uhrmacher AM (in press). Site Choice in Recreational Fisheries – Towards an Agent-Based Approach. Proceedings of the 2022 Winter Simulation Conference.

Haase K, Weltersbach MS, Lewin W-C, Zimmermann C, Strehlow HV (2022). Potential effects of management options on marine recreational fisheries - the example of the western Baltic cod fishery. ICES J Mar Sci: in press, DOI:10.1093/icesjms/fsac012.

Hartill BW, Taylor SM, Keller K, Weltersbach MS (2020). Digital camera monitoring of recreational fishing effort: Applications and challenges. Fish Fish 21(1):204-215, DOI:10.1111/faf.12413.

Hyder K, Weltersbach MS, Armstrong M, Strehlow HV, et al (2018). Recreational sea fishing in Europe in a global context : participation rates, fishing effort, expenditure, and implications for monitoring and assessment. Fish Fish 19(2):225-243, DOI:10.1111/faf.12251.

ICES (2013). Report of the Working Group on Recreational Fisheries Surveys (WGRFS). Esporles, Spain. ICES CM 2013/ACOM, 23, 49 pp.

ICES (2017). Report of the Baltic Salmon and Trout Assessment Working Group (WGBAST), 27 March - 4 April 2017, Gdańsk, Poland: ICES, CM 2017/ACOM, 10, 298 pp.

ICES (2020). Working Group on Recreational Fisheries Surveys (WGRFS; outputs from 2019 meeting). ICES Scientific Reports. 2:1. 78 pp. http://doi.org/10.17895/ices.pub.5744.

Lamb PD, Randall P, Weltersbach MS, Andrews B, Hyder K (2021). Estimating discard survival of European sea bass (*Dicentrarchus labrax*) in the UK commercial hook-and-line fishery. Fish Manag Ecol: in press, DOI:10.1111/fme.12518.

Lewin W-C, Weltersbach MS, Haase K, Riepe C, Strehlow HV (in press[a]). Potential biases in angler diary data: the impact of the diarist recruitment process on participation rates, catch, harvest, and effort estimates. Fish Res: in press.

Lewin W-C, Weltersbach MS, Haase K, Arlinghaus R, Strehlow HV (in press[b]). Change points in marine recreational fisheries – the impact of stock status and fisheries regulations: A case from the western Baltic Sea. Fish Res: in press.

Lewin W-C, Barz F, Lasner T, Weltersbach MS, Strehlow HV (under review). Trends in an European small-scale fishery 2000-2021 - implications for fisheries policies and management. Submitted to Mar Policy.

Lewin W-C, Weltersbach MS, Haase K, Riepe C, Skov C, Gundelund C, Strehlow HV (2021[a]). Comparing on-site and off-site survey data to investigate survey biases in recreational fisheries data. ICES J Mar Sci 78(7):2528-2546, DOI:10.1093/icesjms/fsab131.

Lewin W-C, Weltersbach MS, Haase K, Strehlow HV (2021[b]). Who travels how far: German Baltic sea anglers' travel distances as precondition for fisheries management and coastal spatial planning. Ocean Coastal Manag 209:105640, DOI:10.1016/j.ocecoaman.2021.105640.

Lewin W-C, Weltersbach MS, Denfeld G, Strehlow HV (2020). Recreational anglers' perceptions, attitudes and estimated contribution to angling related marine litter in the German Baltic Sea. J Environ Manag 272:111062, DOI:10.1016/j.jenvman.2020.111062.

Lewin W-C, Weltersbach MS, Ferter K, Hyder K, Mugerza E, Prellezo R, Radford Z, Zarauz L, Strehlow HV (2019). Potential environmental impacts of recreational fishing on marine fish stocks and ecosystems. Rev Fish Sci Aquacult 27(3):287-330, DOI:10.1080/23308249.2019.1586829.

Lewin W-C, Strehlow HV, Ferter K, Hyder K, Niemax J, Herrmann JP, Weltersbach MS (2018). Estimating post-release mortality of European sea bass based on experimental angling. ICES J Mar Sci 75(4):1483–1495, DOI:10.1093/icesjms/fsx240.

LFischG (1996). Fischereigesetz für das Land Schleswig-Holstein (Landesfischereigesetz - LFischG). GVOBl. 1996 211. Source: http://www.gesetze-rechtsprechung.sh.juris.de/jportal/?quelle=jlink&query=FischG+SH&psml=bsshoprod.psml&max=true&aiz=true

LFischG-DVO (2018). Landesverordnung zur Durchführung des Landesfischereigesetzes. GVOBl. 2018 354. Source: http://www.gesetze- rechtsprechung.sh.juris.de/ jportal/?quelle=jlink&query=FischGDV+SH&psml=bsshoprod.psml&max=true&aiz=true

LFischG M-V (2005). Fischereigesetz für das Land Mecklenburg-Vorpommern (Landesfischereigesetz - LFischG M-V). GVOBl. M-V 2005, p. 153. Source: http://www.landesrecht-mv.de/jportal/portal/page/bsmvprod.psml?showdoccase=1&st=lr&doc.id=jlr-FischGMV2005rahmen&doc.part=X&doc.origin=bs

Lucas JS (2015). Aalfänge (Anguilla anguilla L.) durch die Hobbyfischerei mit passiven Fanggeräten in den deutschen Küstengewässern der Nord- und Ostsee. BSc Thesis. Cottbus, Germany: Brandenburgische Technische Universität Cottbus - Senftenberg, 56 pp.

Müller B, Bohn F, Dreßler G, Groeneveld J, Klassert C, Martin R, Schlüter M, Schulze J, Weise H, Schwarz N (2013). Describing human decisions in agent-based models – ODD + D, an extension of the ODD protocol. Environ Model Softw 48:37–48, doi:10.1016/j.envsoft.2013.06.003.

Nds. FischG (1978). Niedersächsisches Fischereigesetz. Nds. GVBl. 1978, 81, 375. Source: http://www.nds-voris.de/jportal/portal/t/nx5/page/bsvorisprod.psml/action/portlets.jw.MainAction?p1=0&eventSubmit_doNavigate=searchInSubtreeTOC&showdoccase=1&doc.hl=0&doc.id=jlr-FischGNDrahmen&doc.part=R&toc.poskey=#focuspoint

Pita P, Ainsworth GB, Alba B, Anderson AB, Antelo M, Asos J, Artetxe I, Baudrier J, Castro JJ, Chicharro B, Erzini K, Ferter K, Freitas M, Garcia-de-la-Fuente L, Garcia-Charton J, Gimenez-Casalduero M, Grau AM, Diogo HM, Strehlow HV, Weltersbach MS, et al (2021). First assessment of the impacts of the COVID-19 pandemic on global marine recreational fisheries. Front Mar Sci 8:735741, DOI:10.3389/fmars.2021.735741.

Pita P, Villasante S, Arlinghaus R, Gomes P, Strehlow HV, Veiga P, Vingada J, Hyder K (2018). A matter of scales: Does the management of marine recreational fisheries follow the ecosystem approach to fisheries in Europe? Mar Policy 97:61-71, DOI:10.1016/j.marpol.2018.08.039.

Radford Z, Hyder K, Zarauz L, Mugerza E, Ferter K, Prellezo R, Strehlow HV, Townhill B, Lewin W-C, Weltersbach MS (2018). The impact of marine recreational fishing on key fish stocks in European waters. PLoS One 13(9):e0201666, DOI:10.1371/journal.pone.0201666.

Skov C, Ferter K, Jepsen N, Pedersen L-F, Lewin W-C, Weltersbach MS (under review). Post-release effects of catch and release angling for sea trout: Mortality, growth and wound healing. Submitted to Fish Res.

Skov C, Gundelund C, Weltersbach MS, Ferter K, Bertelsen SK, Jepsen N (2022). Catch and release angling for sea trout explored by citizen science: Angler behavior, hooking location and bleeding patterns. Fish Res 255:106451, DOI:10.1016/j.fishres.2022.106451.

Skov C, Hyder K, Gundelund C, Ahvonen A, Baudrier J, Borch T, Carvalho Sde, Erzini K, Ferter K, Grati F, Hammen T van der, Hinriksson J, Houtman R, Kagervall A, Kapiris K, Karlsson M, Lejk AM, Strehlow HV, Weltersbach MS, et al (2021). Expert opinion on using angler Smartphone apps to inform marine fisheries management: status, prospects, and needs. ICES J Mar Sci 78:967-978

Strehlow HV, Korzhenevych A, Lucas J, Lewin W-C, Weltersbach MS, Riepe C, Arlinghaus R (in prep.) Economic contribution of resident and tourist anglers to a local economy: the role of coastal and transitional brackish waters in Germany.

Strehlow HV, Schultz N, Zimmermann C, Hammer C (2012). Cod catches taken by the German recreational fishery in the Western Baltic Sea, 2005-2010: implications for stock assessment and management. ICES J Mar Sci 69(10):1769-1780.

Volstad JH, Christman M, Ferter K, Kleiven AR, Ottera H, Aas Ø, Arlinghaus R, Borch T, Colman J, Hartill BW, Haugen TO, Hyder K, Lyle JM, Junker Ohldieck M, Skov C, Strehlow HV, Voorhees D van, Weltersbach MS, Weber ED (2019). Field surveying of marine recreational fisheries in Norway using a novel spatial sampling frame reveals striking under-coverage of alternative sampling frames. ICES J Mar Sci 77(6):2192-2205, DOI:10.1093/icesjms/fsz108.

Watson JW, Hyder K, Boyd R, Thorpe R, Weltersbach MS, Ferter K, Cooke SJ, Roy S, Sibly RM (2020). Assessing the sublethal impacts of anthropogenic stressors on fish: An energy-budget approach. Fish Fish 21(5):1034-1045, DOI:10.1111/faf.12487.

Weltersbach MS, Riepe C, Lewin W-C, Strehlow HV (2021). Ökologische, soziale und ökonomische Dimensionen des Meeresangelns in Deutschland. Braunschweig: Johann Heinrich von Thünen-Institut, 210 p, Thünen Rep 83, DOI:10.3220/REP1611578297000 [in German with English summary]

Weltersbach MS, Lewin W-C, Gröger JP, Strehlow HV (2019). Effect of lure and bait type on catch, size, hooking location, injury and bycatch in the western Baltic Sea recreational cod fishery. Fish Res 210:121-130, DOI:10.1016/j.fishres.2018.10.002.

Weltersbach MS, Strehlow HV, Ferter K, Klefoth T, Graaf M de, Dorow M (2018). Estimating and mitigating post-release mortality of European eel by combining citizen science with a catch-and-release angling experiment. Fish Res 201:98-108, DOI:10.1016/j.fishres.2018.01.010.

Weltersbach MS, Ferter K, Sambraus F, Strehlow HV (2016) Hook shedding and post-release fate of deep-hooked European eel. Biol Conserv 199:16-24, DOI:10.1016/j.biocon.2016.04.015.

Weltersbach MS, Strehlow HV (2013) Dead or alive - estimating post-release mortality of Atlantic cod in the recreational fishery. ICES J Mar Sci 70(4):864-872, doi:10.1093/icesjms/fst038.

Willcox AS, Giuliano WM, Israel GD (2010). Effects of token financial incentives on response rates and item nonresponse for mail surveys. Hum Dimens Wildl 15:288-295.

Zimmermann C, Schultz N, Gebel A, Hammer C (2007). Dorsch/Kabeljau-Fänge durch die deutsche Freizeitfischerei der Nord- und Ostsee, 2004 - 2006: Bericht einer Pilotstudie im Rahmen des Nationalen Fischerei-Datenerhebungsprogrammes gemäß der Verordnung der Kommission (EC) No 1581/2004, 7. Appendix XI (Sektion E), para. 3. Rostock, Germany: Bundesforschungsanstalt für Fischerei, Institut für Ostseefischerei, 104 pp.

Appendix 1: Publications, reports, conference contributions, public outreach, collaborations, and committees

The following sections list relevant peer-reviewed publications, scientific reports, conference presentations and public outreach contributions that were produced by members of the working group since its formal foundation in 2010. Names of current and former members of the working group are highlighted in bold. Research products by members of the working group that do not contain recreational fisheries research content are not included. Furthermore, relevant national and international collaborations and contributions in national and international committees are listed.

Peer-reviewed publications

Skov C, Ferter K, Jepsen N, Pedersen L-F, **Lewin W-C**, **Weltersbach MS** (under review). Post-release effects of catch and release angling for sea trout: Mortality, growth and wound healing. Submitted to Fish. Res.

Britton JR, Pinder AC, Alos J, Arlinghaus R, Danylchuk AJ, Edwards W, Freire KMF, Gundelund C, Hyder K, Jaric I, Lennox R, **Lewin W-C**, Lynch AJ, Midway SR, Potts WM, Ryan KL, Skov C, **Strehlow HV**, Tracey SR, Tsuboi J, Venturelli PA, Weir JL, **Weltersbach MS**, Cooke SJ (under review). Global responses to the COIVD-19 pandemic by recreational anglers: considerations for developing more resilient and sustainable fisheries. Submitted to Rev Fish Biol Fish.

Arlinghaus R, Rittweg T, Dhellemmes F, Koemle D, van Gemert R, Schubert H, Niessner D, Möller S, Droll J, Friedland R, **Lewin W-C**, Dorow M, Westphal L, Ehrlich E, **Strehlow HV**, **Weltersbach MS**, Roser P, Braun M, Feldhege F, Winkler HM (under review). A synthesis of a coastal northern pike (Esox lucius) fishery and its social-ecological environment: implications for management and research of pike in brackish lagoons in the southern Baltic Sea, Germany. Submitted to Fish Res.

Haase K, Reinhardt O, **Weltersbach MS**, **Lewin W-C**, **Strehlow HV**, Uhrmacher A (under review). Agent-based simulation models in fisheries science. Submitted to Rev Fish Sci Aquac.

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Lewin W-C, **Weltersbach MS**, **Haase K**, Arlinghaus R, **Strehlow HV** (in press). Change points in marine recreational fisheries – the impact of stock status and fisheries regulations: A case from the western Baltic Sea. Fish Res: in press.

Lewin WC, **Weltersbach MS**, **Haase K**, **Riepe C**, **Strehlow HV** (in press). Potential biases in angler diary data: The impact of the diarist recruitment process on participation rates, catch, harvest, and effort estimates. Fish Res: in press.

Bronnmann J, Koemle D, Meyerhoff J, **Weltersbach MS**, **Strehlow HV**, Arlinghaus R (in press). Context-dependency of preferences for harvest regulations and catch outcomes: A case study of German cod (*Gadus morhua*) anglers. Fish Res: in press. https://doi.org/10.1016/j.fishres.2022.106536

Haase K, Reinhard O, **Lewin W-C**, **Strehlow HV**, Uhrmacher AM (in press). Site Choice in Recreational Fisheries – Towards an Agent-Based Approach. Proceedings of the 2022 Winter Simulation Conference.

Skov C, Gundelund C, **Weltersbach MS**, Ferter K, Bertelsen SK, Jepsen N (2022). Catch and release angling for sea trout explored by citizen science: Angler behavior, hooking location and bleeding patterns. Fish Res 255:106451, DOI:10.1016/j.fishres.2022.106451.

Haase K, **Weltersbach MS**, **Lewin W-C**, Zimmermann C, **Strehlow HV** (2022). Potential effects of management options on marine recreational fisheries - the example of the western Baltic cod fishery. ICES J Mar Sci: in press, DOI:10.1093/icesjms/fsac012.

Lewin W-C, **Weltersbach MS**, **Haase K**, **Riepe C**, Skov C, Gundelund C, **Strehlow HV** (2021). Comparing on-site and off-site survey data to investigate survey biases in recreational fisheries data. ICES J Mar Sci 78(7):2528-2546, DOI:10.1093/icesjms/fsab131.

Lamb PD, Randall P, **Weltersbach MS**, Andrews B, Hyder K (2021). Estimating discard survival of European sea bass (*Dicentrarchus labrax*) in the UK commercial hook-and-line fishery. Fish Manag Ecol: in press, DOI:10.1111/fme.12518.

Skov C, Hyder K, Gundelund C, Ahvonen A, Baudrier J, Borch T, Carvalho Sde, Erzini K, Ferter K, Grati F, Hammen T van der, Hinriksson J, Houtman R, Kagervall A, Kapiris K, Karlsson M, Lejk AM, Lyle JM, **Strehlow HV**, **Weltersbach MS**, et al (2021) Expert opinion on using angler Smartphone apps to inform marine fisheries management: status, prospects, and needs. ICES J Mar Sci 78(3):967-978, DOI:10.1093/icesjms/fsaa243

Pita P, Ainsworth GB, Alba B, Anderson AB, Antelo M, Asos J, Artetxe I, Baudrier J, Castro JJ, Chicharro B, Erzini K, Ferter K, Freitas M, Garcia-de-la-Fuente L, Garcia-Charton J, Gimenez-Casalduero M, Grau AM, Diogo HM, **Strehlow HV**, **Weltersbach MS**, et al (2021). First assessment of the impacts of the COVID-19 pandemic on global marine recreational fisheries. Front Mar Sci 8:735741, DOI:10.3389/fmars.2021.735741.

Arlinghaus R, Lucas J, **Weltersbach MS**, Kömle D, Winkler HM, **Riepe C**, Kühn C, **Strehlow HV** (2021). Niche overlap among anglers, fishers and cormorants and their removals of fish biomass: A case from brackish lagoon ecosystems in the southern Baltic Sea. Fish Res 238:105894, DOI:10.1016/j.fishres.2021.105894.

Lewin W-C, **Weltersbach MS**, **Haase K**, **Strehlow HV** (2021). Who travels how far: German Baltic sea anglers' travel distances as precondition for fisheries management and coastal spatial planning. Ocean Coastal Manag 209:105640, DOI:10.1016/j.ocecoaman.2021.105640.

Watson JW, Hyder K, Boyd R, Thorpe R, **Weltersbach MS**, Ferter K, Cooke SJ, Roy S, Sibly RM (2020). Assessing the sublethal impacts of anthropogenic stressors on fish: An energy-budget approach. Fish Fisheries 21(5):1034-1045, DOI:10.1111/faf.12487.

Hartill BW, Taylor SM, Keller K, **Weltersbach MS** (2020). Digital camera monitoring of recreational fishing effort: Applications and challenges. Fish Fisheries 21(1):204-215, DOI:10.1111/faf.12413.

Lewin W-C, **Weltersbach MS**, **Denfeld G**, **Strehlow HV** (2020). Recreational anglers' perceptions, attitudes and estimated contribution to angling related marine litter in the German Baltic Sea. J Environ Manag 272:111062, DOI:10.1016/j.jenvman.2020.111062.

Weltersbach MS, **Lewin W-C**, Gröger JP, **Strehlow HV** (2019). Effect of lure and bait type on catch, size, hooking location, injury and bycatch in the western Baltic Sea recreational cod fishery. Fish Res 210:121-130, DOI:10.1016/j.fishres.2018.10.002.

Volstad JH, Christman M, Ferter K, Kleiven AR, Ottera H, Aas Ø, Arlinghaus R, Borch T, Colman J, Hartill BW, Haugen TO, Hyder K, Lyle JM, Junker Ohldieck M, Skov C, **Strehlow HV**, Voorhees D van, **Weltersbach MS**, Weber ED (2019). Field surveying of marine recreational fisheries in Norway using a novel spatial sampling frame reveals striking under-coverage of alternative sampling frames. ICES J Mar Sci 77(6):2192-2205, DOI:10.1093/icesjms/fsz108.

Lewin W-C, **Weltersbach MS**, Ferter K, Hyder K, Mugerza E, Prellezo R, Radford Z, Zarauz L, **Strehlow HV** (2019). Potential environmental impacts of recreational fishing on marine fish stocks and ecosystems. Rev Fish Sci Aquacult 27(3):287-330, DOI:10.1080/23308249.2019.1586829.

Weltersbach MS, **Strehlow HV**, Ferter K, Klefoth T, Graaf M de, Dorow M (2018). Estimating and mitigating post-release mortality of European eel by combining citizen science with a catch-and-release angling experiment. Fish Res 201:98-108, DOI:10.1016/j.fishres.2018.01.010.

Lewin W-C, Strehlow HV, Ferter K, Hyder K, Niemax J, Herrmann JP, **Weltersbach MS** (2018). Estimating post-release mortality of European sea bass based on experimental angling. ICES J Mar Sci 75(4):1483–1495, DOI:10.1093/icesjms/fsx240.

Pita P, Villasante S, Arlinghaus R, Gomes P, **Strehlow HV**, Veiga P, Vingada J, Hyder K (2018). A matter of scales: Does the management of marine recreational fisheries follow the ecosystem approach to fisheries in Europe? Mar Policy 97:61-71, DOI:10.1016/j.marpol.2018.08.039.

Hyder K, **Weltersbach MS**, Armstrong M, **Strehlow HV**, et al (2018). Recreational sea fishing in Europe in a global context : participation rates, fishing effort, expenditure, and implications for monitoring and assessment. Fish Fisheries 19(2):225-243, DOI:10.1111/faf.12251.

Radford Z, Hyder K, Zarauz L, Mugerza E, Ferter K, Prellezo R, **Strehlow HV**, Townhill B, Lewin W-C, **Weltersbach MS** (2018). The impact of marine recreational fishing on key fish stocks in European waters. PLoS One 13(9):e0201666, DOI:10.1371/journal.pone.0201666.

Weltersbach MS, Ferter K, Sambraus F, **Strehlow HV** (2016) Hook shedding and post-release fate of deep-hooked European eel. Biol Conserv 199:16-24, DOI:10.1016/j.biocon.2016.04.015.

Ferter K, **Weltersbach MS**, Humborstad OB, Fjelldal PG, Sambraus F, **Strehlow HV**, Volstad JH (2015). Dive to survive: effects of capture depth on barotrauma and post-release survival of Atlantic cod (*Gadus morhua*) in recreational fisheries. ICES J Mar Sci 72(8):2467-2481, DOI:10.1093/icesjms/fsv102.

Eero M, **Strehlow HV**, Adams CM, Vinther M (2015). Does recreational catch impact the TAC for commercial fisheries? ICES J Mar Sci 72(2):450-457, DOI:10.1093/icesjms/fsu121.

Weltersbach MS, **Strehlow HV** (2013) Dead or alive - estimating post-release mortality of Atlantic cod in the recreational fishery. ICES J Mar Sci 70(4):864-872, doi:10.1093/icesjms/fst038.

Ferter K, **Weltersbach MS**, **Strehlow HV**, Volstad JH, Asos J, Arlinghaus R, Armstrong M, Dorow M, Graaf M de, Hammen T van der, Hyder K, Levrel H, Paulrud A, Radtke K, Rocklin D, Sparrevohn CR, Veiga P (2013). Unexpectedly high catch-and-release rates in European marine recreational fisheries: implications for science and management. ICES J Mar Sci 70(7):1319-1329, doi:10.1093/icesjms/fst104.

Strehlow HV, **Schultz N**, Zimmermann C, Hammer C (2012). Cod catches taken by the German recreational fishery in the Western Baltic Sea, 2005-2010: implications for stock assessment and management. ICES J Mar Sci 69(10):1769-1780.

Scientific reports

Kesler M, Amosova V, Bajinskis J, Bernas R, Dahlgren E, Dannewitz J, Debowski P, Kagervall A, Koljonen M-L, Kontautas A, Leinonen T, Lejk AM, Magnusson K, Mäntyniemi S, Nadolna-Altyn K, Pakarinen T, Palm S, Pedersen S, **Strehlow HV**, **Weltersbach MS**, et al (2021). Baltic Salmon and Trout Assessment Working Group (WGBAST). Copenhagen: ICES, 331 p, ICES Sci Rep 3(26), DOI:10.17895/ices.pub.7925

Storr-Paulsen M, Alade L, Andersen M, Balestri E, Berg CW, Baudron A, Brown E, Cadrin S, Coull K, De Oliveira JA, Dingsør GE, Dobby H, Ellis JR, Fallon N, Girardin R, Hyder K, Jaworski A, Junge C, Kempf A, **Weltersbach MS**, et al (2021). Benchmark Workshop on North Sea Stocks (WKNSEA). Copenhagen: ICES, 756 p, ICES Sci Rep 3(25), DOI:10.17895/ices.pub.7922

Uhlmann S, Quirijns F, Depestele J, **Strehlow HV**, Ferter K, **Weltersbach MS**, Nilsson H, Mehault S (2021). Explanatory variables. ICES Coop Res Rep 351:39-50, DOI:10.17895/ices.pub.8006

van Marlen B, Olsen RE, Vold A, Arregi L, Depestele J, Ferter K, Noak T, **Strehlow HV**, Mehault S, Breen M (2021). Captive observations. ICES Coop Res Rep 351:64-78, DOI:10.17895/ices.pub.8006

Weltersbach MS, **Riepe C**, **Lewin W-C**, **Strehlow HV** (2021). Ökologische, soziale und ökonomische Dimensionen des Meeresangelns in Deutschland. Braunschweig: Johann Heinrich von Thünen-

Institut, 210 p, Thünen Rep 83, DOI:10.3220/REP1611578297000 [in German with English summary]

Hyder K, Mugerza E, Ahvonen A, Baudrier J, Beukhof E, Colella S, de Groote A, Dedeu Dunton AL, Diogo HM, Ferter K, Garcia Asorey M, Gordoa Ezquerra A, Grati F, Hartill BW, Hinriksson J, Jiménez Alvarado D, Kagervall A, Kairyte L**, Strehlow HV**, **Weltersbach MS**, et al (2021). Working Group on Recreational Fisheries Surveys (WGRFS). Copenhagen: ICES, 54 p, ICES Sci Rep 3(113), DOI:10.17895/ices.pub.9673

Bogstad B, Vermard Y, Bell ED, Boje J, Cronne-Grigorov L, Dolder PJ, Fall J, Kristinsson K, Krumme U, Lamoni L, Lordan C, Martinez I, Millar S-L, Moore C, Ojaveer H, Readdy L, Roux M-J, Sköld M, Stötera S, **Strehlow HV**, Windsland K (2021). Workshop on Fisheries Overviews (WKFO). Copenhagen: ICES, 98 p, ICES Sci Rep 3(45), DOI:10.17895/ices.pub.8077

Ferter K, Hyder K, Ahvonen A, Baudrier J, Colella S, de Groote A, Dedeu Dunton AL, Diogo HM, Ezquerra AG, Grati F, Hartill BW, Hinriksson J, Alvarado DJ, Kagervall A, Kairyte L, Karachle P, Karlsson M, Laporta M, Lejk AM, **Weltersbach MS**, et al (2020). Working Group on Recreational Fisheries Surveys (WGRFS). Copenhagen: ICES, 57 p, ICES Sci Rep 2(102), DOI:10.17895/ices.pub.7563.

Amosova V, Boje J, Brown E, Carlshamre S, Eero M, Gröhsler T, Gutkowska J, Haase S, Hommik K, Horbowy J, Jounela P, Kaljuste O, Karpushevskaia A, Krumme U, Lövgren J, Mirny Z, Neuenfeldt S, Schade FM, Stötera S**, Strehlow HV**, et al (2020). Baltic Fisheries Assessment Working Group (WGBFAS). Copenhagen: ICES, 643 p, ICES Sci Rep 2(45), DOI:10.17895/ices.pub.6024.

Ferter K, Hyder K, Ahvonen A, Baudrier J, Diogo HM, Dunton A, Gordoa A, Grati F, Hartill BW, Hinriksson J, Alvarado DJ, Kagervall A, Kairyté L, Kapiris K, Karlsson M, Lafon J, Laporta M, Lejk AM, **Strehlow HV**, **Weltersbach MS** (2020). Working Group on Recreational Fisheries Surveys (WGRFS; outputs from 2019 meeting). Copenhagen: ICES, 78 p, ICES Sci Rep 2(1), DOI:10.17895/ices.pub.5744

Clay PM, Ferretti J, Bailey J, Dunkel D, Elegbede I, Fraga A, Fuller J, Goldsborough D, Goti L, Groenevold R, Hamon KG, Kellner J, Martin KS, Pedreschi D, Röckmann C, Santurtun M, Stephenson R, **Strehlow H**V (2020) ICES Working group on maritime systems (WGMARS). Copenhagen: ICES, 22 p, ICES Sci Rep 2(63), DOI:10.17895/ices.pub.6104.

Höjesjö J, Walker A, Aarestrup K, Alexandre C, Bernas R, Debowski P, Degerman E, Davidsen J, Davidson I, Diserud O, Ensing D, Finstad B, Finlay R, Jonsson B, Josset Q, Kagervall A, Kennedy R, Kesler M, **Strehlow HV**, **Weltersbach MS**, et al (2020). Working Group with the Aim to Develop Assessment Models and Establish Biological Refer-ence Points for Sea Trout (Anadromous *Salmo trutta*) Populations (WGTRUTTA; outputs from 2019 meeting). Copenhagen: ICES, 59 p, ICES Sci Rep 2(59), DOI:10.17895/ices.pub.7431

Lewin W-C, **Weltersbach MS**, **Denfeld G**, **Strehlow HV** (2019). Bedeutung und Bewertung von Meeresmüll aus der marinen Freizeitfischerei und Maßnahmen zur Vermeidung : Endbericht ;

erstellt im Auftrag des NLWKN und des LUNG M-V. Rostock: Thünen-Institut für Ostseefischerei, 114 pp.

Amosova V, Berg C, Boje J, Cardinale M, Carlshamre S, Eero M, Gröhsler T, Gutkowska J, Hommik K, Horbowy J, Huwer B, Jounela P, Kaljuste O, Karpushevskiy I, Klinger R, Krumme U, Rodriguez-Tress P, Schade FM, Stötera S, **Strehlow HV**, et al (2019) Baltic Fisheries Assessment Working Group (WGBFAS). Copenhagen: ICES, 653 p, ICES Sci Rep 1(20), DOI:10.17895/ices.pub.5256

Moesgaard Albertsen C, Amosova V, Andersen M, Behrens JW, Willestofte Berg C, Bergenius M, Brander K, Cardinale M, Carlshamre S, Casini M, Cormon X, Eero M, Gertseva V, Haase S, Krumme U, McQueen K, Pierce ME, Schade FM, **Strehlow HV**, **Weltersbach MS**, et al (2019). Benchmark Workshop on Baltic Cod Stocks (WKBALTCOD2). Copenhagen: ICES, 310 p, ICES Sci Rep 1(9), DOI:10.17895/ices.pub.4984.

Clay PM, Ferretti J, Röckmann C, Saturntún M, Bailey J, Dankel DJ, Dickey-Collas M, Fraga A, Gaichas S, Gardner S, Goldsborough D, Goti L, Groeneveld RA, Hamon KG, Kenny A, Kraan M, Lucey S, Mangi S, Münch A, **Strehlow HV**, et al (2019.) Working group on maritime systems (WGMARS). Copenhagen: ICES, 15 p, ICES Sci Rep 1(88), DOI:10.17895/ices.pub.5712

Hyder K, Radford Z, Prellezo R, **Weltersbach MS**, **Lewin W-C**, Zarauz L, Ferter K, Ruiz J, Townhill B, Mugerza E, **Strehlow HV** (2017). Research for PECH Committee - Marine recreational and semi-subsistence fishing - its value and its impact on fish stocks : Study. Luxembourg: European Commission, DOI:10.2861/2728.

Conference contributions

Haase K, Weltersbach, MS, Lewin, W-C, Reinhardt O, Uhrmacher A, **Strehlow HV** (2022). Using agent-based model to improve the management and sustainability of recreational fisheries. Fourth ICES PICES Early Career Scientist Conference, St John´s, Newfoundland, Canada (Oral).

Haase K, Weltersbach MS, Lewin W-C, Reinhardt O, Uhrmacher A, **Strehlow HV** (2021). Modelling angler behaviour using agent-based models to improve recreational fisheries management. 8th World Fisheries Congress, online conference (Oral).

Haase K, Weltersbach MS, Lewin W-C, Reinhardt O, Uhrmacher A, **Strehlow HV** (2021). Importance of angler behaviour for recreational fisheries management - a Baltic Sea case study. ICES Annual Science Conference 2021, online conference (Oral).

Haase K, Weltersbach MS, Reinhardt O, Uhrmacher A, **Strehlow HV** (2021). AGENT-BASED MODEL FOR THE BEHAVIOUR OF WESTERN BALTIC COD ANGLERS. 9th World Recreational Fishing Conference 9, online conference (Oral).

Haase K, **Weltersbach MS**, Lewin WC, Reinhardt O, Uhrmacher A, Strehlow HV (2019). Towards an Agent-Based Model for Managing Recreational Fisheries of Western Baltic Cod. Winter Simulation Conference, National Harbor, USA, WSC 2019:pos124s1 (Poster).

Vølstad JH, Christman M, Ferter K, Kleiven AR, Ottera H, Aas Ø, Arlinghaus R, Borch T, Colman J, Hartill BW, Haugen TO, Hyder K, Lyle JM, Junker Ohldieck M, Skov C, **Strehlow HV**, Voorhees D van, **Weltersbach MS**, Weber ED (2019). Field surveying of marine recreational fisheries in Norway using a novel spatial sampling frame reveals striking under-coverage of alternative sampling frames. ICES Annual Science Conference, Gotheburg, Sweden, ICES CM 2019/Q:362 (Oral).

Hyder K, **Strehlow HV** (2019). Marine recreational fishing in Europe: current status and future challenges. ICES Annual Science Conference, Gotheburg, Sweden, ICES CM 2019/Q:644 (Oral).

Hyder K, **Strehlow HV**, Pita C, Ferretti J (2019). Balancing the social, economic, and ecological impacts of small-scale and recreational fisheries. ICES Annual Science Conference, Gotheburg, Sweden, ICES CM 2019 session Q (Chair).

Lewin WC, **Strehlow HV**, Ferter K, Hyder K, Niemax J, Herrmann J-P, **Weltersbach MS** (2018). Estimating post-release mortality of European sea bass based on experimental angling. FSBI Symposium, Norwich, Großbritannien (Oral)

Ferter K, **Weltersbach MS**, Nilsson J, Humborstad O-B, Cooke SJ (2017). Evaluating catch-and-release impacts on Atlantic halibut in recreational fisheries. ICES Annual Science Conference, Fort Lauderdale, USA, ICES CM 2017/J:172 (Oral).

Weltersbach MS, **Strehlow HV**, Ferter K, Klefoth T, de Graaf M, Dorow M (2017). Estimating and mitigating post-release mortality of European eel by combining citizen science with a catch-and-release angling experiment. ICES Annual Science Conference, Fort Lauderdale, USA, ICES CM 2017/J:185 (Oral).

Ferter K, **Weltersbach MS**, Nilsson J, Humborstad O-B, Cooke SJ (2017). Evaluating physiological consequences of catch-and-release on Atlantic halibut. 8th World Recreational Fishing Conference, Victoria, Canada, H:27 (Oral).

Weltersbach MS, **Strehlow HV**, Ferter K, Klefoth T, de Graaf M, Dorow M (2017). Estimating and mitigating post-release mortality of European eel (*Anguilla anguilla*) in recreational fisheries. 8th World Recreational Fishing Conference, Victoria, Canada, H:22 (Oral).

Strehlow HV, **Weltersbach MS**, Zimmermann C (2017). Management scenarios in the western Baltic cod recreational fishery: design, impacts and efficiency. 8th World Recreational Fishing Conference, Victoria, Canada, E:20 (Oral).

Hyder K, **Strehlow HV** (2017). Session 4 - Management, Policy & Governance. 8th World Recreational Fishing Conference, Victoria, Canada, session 4 (Chair).

Hyder K, **Weltersbach MS**, Radford Z, Ferter K, Townhill B, Armstrong M, et al. (2017). Recreational sea fishing in Europe in a global context – participation rates, fishing effort, expenditure, & implications for monitoring & assessment. 8th World Recreational Fishing Conference, Victoria, Canada, A:39 (Oral).

Weltersbach MS, Kaiser F, **Strehlow HV** (2017). Using remote cameras to monitor the recreational Atlantic salmon trolling fishery in the Baltic Sea. 8th World Recreational Fishing Conference, Victoria, Canada, A:15 (Oral).

Hyder K, **Weltersbach MS**, Ferter K, Townhill B, Armstrong M, **Strehlow HV** (2016). Recreational Sea Angling – a European Perspective. ICES Annual Science Conference 2016, Riga, Latvia, ICES CM 2016/G:168 (Oral).

Hyder K, **Strehlow HV**, Mugerza E, Spedicato M (2016). The inshore challenge – management of recreational and commercial fisheries accounting for social benefits, economic value, and biological sustainability. ICES Annual Science Conference 2016, Riga, Latvia, ICES CM 2016 session G (Chair).

Weltersbach MS, Kaiser F, **Strehlow HV** (2016). Surveying 2.0 - Using remote cameras to monitor a highly specialized recreational fishery in the Baltic Sea. ICES Annual Science Conference 2016, Riga, Latvia, ICES CM 2016/G:285 (Oral).

Uhlmann SS, Davis MW, Ferter K, **Strehlow HV**, **Weltersbach MS**, Benoît H, et al. (2016). A Bayesian network approach to predict survival of caught-and-released fish. ICES Annual Science Conference 2016, Riga, Latvia, ICES CM 2016/G:179 (Oral).

Ferter K, Ring Kleiven A, Colman JE, Oddvar T, Stensland S, **Strehlow HV**, **Weltersbach MS**, et al. (2016). Developing a sampling scheme to evaluate Norwegian marine recreational fisheries - a case study in the Oslofjord. ICES Annual Science Conference 2016, Riga, Latvia, ICES CM 2016/G:481 (Oral).

Hyder K, Armstrong M, **Strehlow HV** (2015). Recreational Sea Angling – a European Perspective. 145th Annual Meeting of the American Fisheries Society, Portland, USA (Oral).

Ferter K, **Weltersbach MS**, **Strehlow HV**, Hyder K, Vølstad JH (2015). What´s the real fishing mortality? Revealing the hidden post-release mortality of Atlantic cod in marine recreational fisheries. 145th Annual Meeting of the American Fisheries Society, Portland, USA, A-105 (Oral).

Weltersbach MS, Ferter K, Sambraus F, **Strehlow HV**, Dorow M (2015). Post-release hook shedding mechanism of deep-hooked European eels (*Anguilla anguilla*). EIFAAC International Symposium on recreational fisheries, Lillehammer, Norway, D2-6 (Oral).

Hyder K, Armstrong M, **Strehlow HV** (2015). Recreational Sea Angling – a European Perspective. EIFAAC International Symposium on recreational fisheries, Lillehammer, Norway, A3-1 (Oral).

Ferter K, Humberstad O-B, **Weltersbach MS**, **Strehlow HV**, Vølstad JH (2015). Studying barotrauma and survival of physoclistous fish after rapid decompression: lessons learned from an Atlantic cod (*Gadus morhua*) experiment. EIFAAC International Symposium on recreational fisheries, Lillehammer, Norway, D2-8 (Oral).

Hyder K, **Strehlow HV** (2015). The Right Angle – Balancing Biological, Social and Economic Goals in the Management of Recreational Fisheries. EIFAAC International Symposium on recreational fisheries, Lillehammer, Norway, session A3 (Chair).

Weltersbach MS, **Strehlow HV**, Gröger J (2014). Lure versus bait – How anglers can influence catch in the recreational cod fishery. 7th World Recreational Fishing Conference, Campinas, Brazil, WRFC: 103 (Oral).

Weltersbach MS, **Strehlow HV**, Ferter K, Sambraus F, Dorow M (2014). Effect of hook size and handling on post-release survival of European eel (*Anguilla anguilla*). 7th World Recreational Fishing Conference, Campinas, Brazil, WRFC: 71 (Oral).

Ferter K, Humborstad O-B, **Weltersbach MS**, Fjelldal PG, Sambraus F, Vølstad JH (2014). Barotrauma and recovery of Atlantic cod (*Gadus morhua*) after rapid decompression: combining field observations and X-ray technology. 7th World Recreational Fishing Conference, Campinas, Brazil, WRFC: 23 (Oral).

Hyder K, **Strehlow HV** (2013). Marine recreational fisheries: understanding impacts and consequences for management. ICES Annual Science Conference 2013, Reykjavík, Iceland, session R (Chair).

Weltersbach MS & **Strehlow HV** (2013). Dead or alive - estimating post-release mortality of Atlantic cod in the recreational fishery. ICES Annual Science Conference 2013, Reykjavík, Iceland, R:16 (Oral).

Ferter K, **Weltersbach MS**, **Strehlow HV**, Vølstad JH, Alós J, Arlinghaus R, et al. (2012). Marine recreational fisheries in Europe – does only harvest matter? ICES Annual Science Conference, Bergen, Norway, CM 2012/C:09 (Oral).

Public outreach

Strehlow HV, **Weltersbach MS**, **Haase K**, **Lewin W-C** (2022). Data collection in European marine recreational fisheries – issues, needs, solutions. General assembly of the European Anglers Alliance (EAA), Hamburg, Germany (invited oral presentation in English).

Haase K, **Weltersbach MS**, **Strehlow HV** (2022). WESTERN BALTIC COD - Status and Management Options. General assembly of the European Anglers Alliance (EAA), Hamburg, Germany (invited oral presentation in English).

Weltersbach MS, **Strehlow HV** (2022). Using remote cameras to monitor the recreational salmon trolling fishery in the Baltic Sea. General assembly of the European Anglers Alliance (EAA), Hamburg, Germany (invited oral presentation in English).

Strehlow HV (2022). Is the Baltic Sea becoming a freshwater lake? Podcast 'Bis zum Biss', https://www.bild.de/bild-mobil/audio/bis-zum-biss/startseite-76549500.bild.html (Podcast with interview in German).

Weltersbach MS (2021). Salmon alarm on Rügen. NDR TV broadcast ‘Rute raus, der Spaß beginnt‘ (inquiry in German). https://www.ndr.de/fernsehen/sendungen/rute-raus-der-spass-beginnt/index.html

Strehlow HV (2021). Marine Recreational fisheries - Impact, Data Collection and CFP Requirements. European Parliament (EP) hearing "Data collection and recreational fisheries”, EP Peche Committee, Brussels, Belgium (invited oral presentation in English).

Weltersbach MS (2021). ‘Cod fishing ban would be our downfall‘. Ostsee-Zeitung newspaper article, https://www.ostsee-zeitung.de/lokales/rostock/kutter-kapitaen-aus-rostock-ein-dorschfangverbot-waere-unser-untergang-KLZUD2CP3AP6PUP7OWLAAUALFU.html (interview and inquiry in German).

Strehlow HV (2020). How many recreational fishers? How much fish? Where? EU Webinar: Recreational fisheries monitoring & control, DG MARE, Brussels, Belgium (invited oral presentation in English).

Strehlow HV (2020). Start of the largest nationwide telephone survey on angling in Germany. NDR radio broadcast (interview and inquiry in German).

Strehlow HV (2020). Management of recreational fisheries. Round table conducted by the German angling association (DAFV e.V.), Rostock, Germany (invited oral presentation in German).

Strehlow HV (2020). Marine Recreational Fisheries, Overview, Management & Enforcement. Workshop on western Baltic cod recreational fisheries, European Fisheries Control Agency (EFCA), Vigo, Spain (invited oral presentation in English).

Strehlow HV (2020). Value creation and management approaches in Baltic Sea recreational fisheries. Round table fisheries administrations M-V and S-H, Schwerin, Germany (invited oral presentation in German).

Weltersbach MS, Strehlow HV (2020). Fish stock development 2019: ICES advice for Western Baltic cod & herring. Round table recreational fisheries, Rostock, Germany (invited oral presentation in German).

Weltersbach MS (2019). A second chance - Catch & Release in recreational fisheries. Vortragsveranstaltung des Landesfischereiverband Westfalen und Lippe e.V., Dülmen, Germany (invited oral presentation in German).

Strehlow HV (2019). “RECOVERED STOCK OR ZOMBIE FISH? Here's what's really going on with Baltic cod”. Online article of the BILD-Zeitung, https://www.bild.de/news/inland/news-inland/erholter-bestand-oder-zombie-fische-so-steht-es-um-den-ostsee-dorsch-61228002.bild.html (interview and inquiry in German).

Strehlow HV (2019). “Overfishing by recreational anglers - protection for pike, cod and eel”. TV documentation on SWR2. https://www.swr.de/swr2/wissen/ueberfischung-durch-

freizeitangler-schutz-fuer-hecht-dorsch-aal-swr2-wissen-2019-09-18-100.html (interview and inquiry in German).

Weltersbach MS (2019). Integrating post-release mortality of recreationally caught and released fish in European fisheries management. General assembly of the German angling association (DAFV e.V.), Berlin, Germany (invited oral presentation in German).

Strehlow HV (2019). "ANGLERS IN TURMOIL - Submarine explosions in protected zone off Fehmarn" Online article of BILD-Zeitung, https://www.bild.de/news/inland/news-inland/angler-in-aufruhr-untersee-explosionen-in-schutzzone-vor-fehmarn-64302070.bild.html?fbclid=IwAR2A129huIZwu_aA3xRoAGJRQghPoRCp9HRwGoPFzBCdhnmt3ttkhTOR7xE (interview and inquiry in German).

Lewin W-C, **Weltersbach MS**, **Strehlow HV** (2019). Importance and assessment of marine litter from marine recreational fisheries and measures to avoid it. Round table marine litter, Federal Environment Agency, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, and Lower Saxony Ministry for the Environment, Energy, Building and Climate Protection, Hannover, Germany (invited oral presentation in German).

Strehlow HV (2019). "Fight for quotas – Angling cutters facing extinction?" Online article of BILD-Zeitung, https://www.bild.de/news/inland/news-inland/bitterer-kampf-um-die-fang-quote-angelkutter-vor-dem-aus-64699796.bild.html?fbclid=IwAR1Hj9pjY4DjpTPMINBw31haZcR0SHQgIzoxGIRjnp8kOuaUL4NftHfFvEs (interview and inquiry in German).

Strehlow HV (2019). Marine Recreational Fisheries - Potential Ecological Impacts. Projektwoche Energie und Klima, BUND, Rostock, Germany (invited oral presentation in German).

Strehlow HV, **Weltersbach MS** (2019). Fish stock development of Western Baltic cod. Round table recreational fisheries SH, Oldenburg/Holstein, Germany (invited oral presentation in German).

Strehlow HV, **Weltersbach MS** (2019). Recreational salmon trolling fishing in the Baltic Sea. Tomorrows Baltic salmon management conference, Lulea, Sweden (invited oral presentation in English).

Weltersbach MS (2018). Marine recreational fishing in Germany and Europe. International Green Week, Berlin, Germany (invited oral presentation in German).

Weltersbach MS, Strehlow HV (2018). Recreational fishing in the Baltic Sea - importance, data collection, management. Round table recreational fisheries, Rostock, Germany (invited oral presentation in German).

Strehlow HV (2018). "SOS Baltic charter vessels sound the alarm". Article of the BILD-Zeitung, https://www.bild.de/news/inland/angeln/dorsch-in-der-ostsee-54424502.bild.html (interview and inquiry in German).

Kammann U, **Weltersbach MS** (2018). A second chance - Catch & Release in recreational fisheries. Wissenschaft *erleben* 01/2018: 10-11 (article in German).

Strehlow HV (2018). Crisis in the Baltic Sea fishing tourism. NDR TV broadcast 'Markt', https://www.ndr.de/fernsehen/sendungen/markt/Aerger-um-Kutterfahrten-auf-der-Ostsee,markt11978.html (inquiry and interview in German).

Strehlow HV (2018). Fishing tourism in the Baltic Sea, stock recovery and outlook. Ostsee-Zeitung newspaper article (interview and inquiry in German).

Korn R**, Weltersbach MS** (2018). Report Baltic cod - Angling for numbers. Kutter & Küste, 73: 32-36 (Article in angling magazine in German)

Strehlow HV (2018). Economic importance of recreational fishing in the Baltic Sea & How endangered is the Baltic cod? Hamburger Abendblatt, newspaper article, https://www.abendblatt.de/hamburg/article212642943/Studie-Meeresangeln-ist-bedeutender-Wirtschaftsfaktor.html (interview and inquiry in German).

Strehlow HV (2018). Marine recreational fishing. Article in "Mare" magazine (interview and inquiry in German).

Hyder K, Radford Z, Prellezo R, **Weltersbach MS**, **Lewin W-C**, Zarauz L, Ferter K, Ruiz J, Townhill B, Mugerza E, **Strehlow HV** (2017). Marine recreational and semi-subsistence fishing - its value and its impact on fish stocks. European Parliament - PECH Committee (invited oral presentation in English).

Hyder K, Radford Z, Prellezo R, **Weltersbach MS**, Zarauz L, Ferter K, Mugerza E, **Strehlow HV** (2017). Recreational sea fishing in Europe – participation rates, fishing effort and expenditure in a global context. European Parliament – Recreational Fisheries Forum, Brussels, Belgium (invited oral presentation in English).

Weltersbach MS, **Strehlow HV**, Ferter, K., Klefoth, T., de Graaf, M. & M. Dorow (2017). Effects of hook depth and hook size on the survival of recreationally caught and released eels. AFGN meeting, Nienburg, Germany (invited oral presentation in German).

Strehlow HV, **Weltersbach S** (2017). Marine Recreational Fisheries: Impact, Data Collection, Management. The Future of Sustainable Coastal Angling Tourism (CATCH), EUCC - Die Küsten Union Deutschland e.V., Peenemünde, Germany (invited oral presentation in German).

Strehlow HV (2017). Marine recreational fishing: Importance and data collection. Information meeting for the CDU parliamentary group of the State parliament MV, Rostock, Germany (oral presentation in German).

Weltersbach MS, **Strehlow HV**, Klefoth T, Ferter K, Dorow M (2017). Effects of catch-and-release on eel in recreational fisheries. Fischerei Fischmarkt MV(4):44-46, http://www.lfvmv.de/download/zeitschrift/FF_4_2017.pdf [in German].

Weltersbach MS, **Strehlow HV**, Klefoth T, Ferter K, Dorow M (2017). Impacts of catch-and-release angling on eel - Presentation of different experimental approaches. Mitt Landesforschungsanst Landwirtsch Fischerei Mecklenburg Vorpommern 58:77-88 [in German].

Strehlow HV (2017). Marine recreational fishing: Importance, data collection and management. General assembly of the German marine angling association (DMV e.V.), Schönberger Strand, Germany (invited oral presentation in German).

Strehlow HV (2017). Recreational fishing in the Baltic Sea: Data collection and management. General assembly of the angling association Schleswig-Holstein (LSFV e.V.), Nortorf, Germany (invited oral presentation in German).

Strehlow HV (2017). Marine recreational fishing: Importance and data collection. Information meeting for the AFD parliamentary group of the State parliament MV, Rostock, Germany (oral presentation in German).

Arlinghaus R, **Weltersbach MS** (2017). Catch & Release. Meer Küste (6):23 [in German].

Strehlow HV (2017). The thing with the fishing hook... Meer Küste (6):21 [in German].

Strehlow HV (2017). Quota for anglers. Meer Küste (6):28 [in German].

Weltersbach MS, **Strehlow HV**, Ferter, K., Klefoth, T., de Graaf, M. & M. Dorow (2017). Effects of catch-and-release on eel in recreational fisheries. Fachforum Angelfischerei, Langenargen, Germany (invited oral presentation in German).

Strehlow HV (2017). 'Why a Rendsburg hobby angler fights against the cod quota'. SHZ newspaper article, https://www.shz.de/deutschland-welt/schleswig-holstein/artikel/warum-ein-rendsburger-hobby-angler-gegen-die-dorschquote-kaempft-41617955 (interview and inquiry in German).

Strehlow HV (2017). New cod regulation cripples angling tourism. NDR TV broadcast "Land und Leute" http://www.ndr.de/fernsehen/sendungen/land_und_leute/index.html (interview and inquiry in German).

Strehlow HV (2017). Eel threatened by extinction - Stock situation eel and scientific experiments on the subject of hook ejection mechanisms and survival probability of hooked and released eels in recreational fisheries. NDR TV broadcast "Nordmagazin" (interview and inquiry in German).

Strehlow HV (2017). Assessment of the Thünen Institute: How do you assess the situation for Baltic Sea anglers? To what extent is the fish stock threatened? "NDR Welle Nord" radio broadcast (interview and inquiry in German).

Strehlow HV (2017). Fishing ban in the Fehmarnbelt nature reserve. NDR TV broadcast "Schleswig-Holstein Magazin" (interview and inquiry in German).

Strehlow HV (2017). Public panel discussion on the current impairments of recreational fishing (bag limit & fishing ban in the N2000 area Fehmarnbelt). Burgstaaken/Fehmarn (in German).

Strehlow HV, **Weltersbach MS** (2017). Job engine sea angling - Two recent studies prove: Sea angling is a significant economic factor in Europe. Fischerei Fischmarkt MV(4):38-40, http://www.lfvmv.de/download/zeitschrift/FF_4_2017.pdf [in German]

Korn R, **Weltersbach MS** (2016). Can the Baltic cod still be saved? Kutter & Küste, 64: 20-21 (Article in angling magazine in German).

Strehlow HV (2016). We should see the measures as an opportunity. Angling magazine "Am Haken" 06/2016: 38-39 (interview and inquiry in German).

Strehlow HV (2016). Management measures in recreational fisheries - impacts, effectiveness, design. Round table conducted by the German angling association (DAFV e.V.), Rostock, Germany (oral presentation in German).

Strehlow HV (2016). Recreational fisheries in the North Sea and Baltic Sea - importance, impacts, management. General assembly of the German angling association (DAFV e.V.), Berlin, Germany (invited oral presentation in German).

Strehlow HV (2016). Marine Recreational Fisheries in the Baltic Sea. BSAC Executive Committee, Copenhagen, Denmark (invited oral presentation in English).

Weltersbach MS (2016). 'Fisch an der Angel – Achtsam angeln'. Information on fish handling best practice in recreational fisheries. Fish buying guide Mecklenburg-Western Pomerania (text for booklet in German).

Strehlow HV (2016). Recreational fisheries in the North Sea and Baltic Sea - importance, impacts, management. Federal Office for Agriculture and Food, Hamburg, Germany (invited oral presentation in German).

Strehlow HV (2016). Recreational fisheries in the North Sea and Baltic Sea - importance, impacts, management. State Office for Agriculture, Environment and Rural Areas of Schleswig-Holstein, Damp, Germany (invited oral presentation in German).

Ferter K, **Weltersbach MS**, Hoch C (2016). Das Tiefen-Experiment. Fisch & Fang Norwegen, 7: 52-57 (Article in angling magazine in German).

Weltersbach MS (2016). Information on Baltic cod stock development and data collection. Magdeburger Raubfisch- und Meeresangeltage (Angling exhibition), Magdeburg, Germany (invited oral presentation and panel discussion in German). https://www.youtube.com/watch?v=qk6dgiS_93k

Strehlow HV (2016). Data collection in recreational fisheries - German Marine Angling Programme. Round table conducted by the German angling association (DAFV e.V.), Rostock, Germany (oral presentation in German).

Strehlow HV (2015). Baltic cod and angling - data collection in marine recreational fisheries. General assembly of the German angling association (DAFV e.V.), Göttingen, Germany (invited oral presentation in German).

Weltersbach MS (2015). "Project MoreTrout" - For a sustainable future of sea trout fishing. ALS OPEN 2015 – Sea trout angling competition, Als, Denmark (invited oral presentation in German).

Strehlow HV (2015). Data collection in recreational fisheries - German Marine Angling Programme. Working group on angling tourism for the development of a statewide marketing concept for water tourism. Entwicklungsgesellschaft Ostholstein mbH (EGOH), Oldenburg, Germany (invited oral presentation in German).

Weltersbach MS (2015). Thünen study: Majority of cod survives catch and release. FischMagazin 09/2015: 60-63 (interview and inquiry in German).

Weltersbach MS (2015). The Baltic Sea – a very special Sea. Federal Youth Sea Fishing Days of the German angling association (DAFV e.V.), Schönberger Strand, Germany (invited oral presentation in German).

Weltersbach MS (2015). Dead or Alive? Post-release mortality of recreationally caught and released cod. Deutscher Fischereitag, Rostock, Germany (invited oral presentation in German).

Strehlow HV (2015). The importance of recreational fishing in the Baltic Sea - German Marine Angling Programme. Long Night of Sciences, Rostock, Germany (invited oral presentation in German).

Seiberlich A, **Weltersbach MS** (2014). The sea trout seminar. Blinker 03/2014 (video clip on enclosed DVD in German).

Hyder K, Armstrong M, Ferter K, **Strehlow HV** (2014). Recreational sea fishing - the high value forgotten catch. ICES Insight 51:8-15 [in English].

Liebetanz M, **Weltersbach MS** (2013). Auf Wiedersehen!? Catch & Release wird erforscht. Kutter & Küste, 48: 78-81 (Article in angling magazine in German).

Kammann U, **Strehlow HV** (2012). The cod got hooked. Wissenschaft *erleben* 02/2012: 12-13 (article in German).

Committee contributions

Year(s)	Organisation	Committee	Name(s)
2021-	International Council for the Exploration of the Sea (ICES)	Advice Drafting Group on Salmon (ADG salmon)	HV Strehlow S Weltersbach
2021-	Regional Coordination Groups	RCG ISSG Recreational Fisheries (ISSG MRF)	HV Strehlow (Chair)
2021-	Regional Coordination Groups	RCG ISSG Diadromous Fishes (ISSG DIAD)	HV Strehlow S Weltersbach
2021	ICES	Workshop on the Future of the Fisheries Overviews (WKFO)	HV Strehlow
2021	ICES	Benchmark Workshop for North Sea Stocks (WKNSEA)	S Weltersbach
2021	Federal Environmental Agency (Umweltbundesamt, UBA)	Working group on litter in aquatic systems	W-C Lewin
2020-	ICES Journal of Marine Science	Editorial Board	S Weltersbach
2019-	Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB)	Scientific advisory board for the project „Bodden pike“ (Boddenhecht)	HV Strehlow S Weltersbach
2019	ICES	Workshop on Integrating angler heterogeneity into the management of marine recreational fisheries (WKHDR)	HV Strehlow (Co-Chair) S Weltersbach K Haase WC Lewin
2016-	ICES	Working Group with the Aim to Develop Assessment Models and Establish Biological Reference Points for Sea Trout (Anadromous *Salmo trutta*) Populations (WGTRUTTA)	S Weltersbach HV Strehlow
2016/2017	ICES	Benchmark Workshop on Baltic Salmon (WKBaltSalmon)	S Weltersbach

2015, 2018/2019	ICES	Benchmark workshop on Baltic cod stocks	HV Strehlow S Weltersbach
2015	ICES	Review Group/Advice Drafting Group (RG/ADG) on Recreational Fisheries (EU) (RG/ADGRF)	HV Strehlow
2014-2019	ICES	Working Group on Methods for Estimating Discard Survival (WGMEDS)	HV Strehlow S Weltersbach
2014-	ICES	Working Group on Maritime Systems (WGMARS)	HV Strehlow
2013-	ICES	Working Group on Baltic Fisheries Assessment (WGBFAS)	HV Strehlow
2013-	ICES	Working Group on Baltic Salmon and Trout (WGBAST)	S Weltersbach HV Strehlow
2012-	ICES	Working Group on Recreational Fisheries Surveys (WGRFS)	HV Strehlow (Co-Chair from 2012-2017) S Weltersbach K Haase

National and international collaborations

Year	Country	Institution	Main contact person	Project(s)/Topic(s)
2018	Australia	Charles Darwin University, Research Institute for the Environment and Livelihoods	Dr Krystle Keller	Remote camera monitoring of recreational fisheries
2018	Australia	Department of Primary Industries and Regional Development	Dr Stephen Taylor	Remote camera monitoring of recreational fisheries
2013-2021	Australia	University of Tasmania, Institute for Marine and Antarctic Studies	Prof Jeremy Lyle	Projects: Survey methods
2018-2019	Belgium	Flanders Research Institute for Agriculture, Fisheries and Food	Dr Katrien Verlé	Project SECFISH (Socio-EConomic data collection for FISHeries, aquaculture and the processing industry)
2017-2019	Canada	Carleton University	Prof Steven Cooke	Project: Sublethal impacts of C&R
2019-2022	Denmark	Technical University of Denmark, National Institute of Aquatic Resources	Prof Christian Skov	Projects: Sea trout post-release survival; Angling Apps; Survey methods; ICES WKHDR
2019-2022	Denmark	University of Southern Denmark	Prof Julia Bronnmann	Project marEEshift
2018-2019	Finland	Natural Resources Institute Finland (Luke)	Dr Jarno Virtanen	Project SECFISH (Socio-EConomic data collection for FISHeries, aquaculture and the processing industry)
2021	Germany	FH Westküste University of Applied Sciences	Prof Anja Wollesen	Joint supervision of a master thesis on angling tourism in S-H
2019-2022	Germany	German Center for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig	Prof Martin Quaas	Project: marEEshift
2018-2022	Germany	Humboldt-Universität zu Berlin;	Prof Robert Arlinghaus	Projects: marEEshift; Boddenhecht; ICES WKHDR; Joint supervision of a master thesis titled:

		Leibniz Institute of Freshwater Ecology and Inland Fisheries		Recreational Fishing in the Bodden waters of the southern Baltic Sea – Touristic Potential and Implications for Management
2019-2022	Germany	University of Freiburg	Prof Stefan Baumgärtner	Project: marEEshift
2015-2022	Germany	University of Hamburg, Institute for Marine Ecosystem and Fishery Sciences	Prof Christian Möllmann	Projects: marEEshift; Sea bass post-release mortality
2018-2019	Germany	University of Greifswald	Prof Susanne Stoll-Kleemann	Joint supervision of a master thesis on angling-related marine litter in the Baltic Sea
2019-2022	Germany	Technische Universität Dresden; Leibniz Institute of Ecological Urban and Regional Development	Prof Artem Korzhenevych	Project: Economic contribution of resident and tourist anglers to a local economy: the role of coastal and transitional brackish waters in Germany
2020	Germany	German angling association (Deutscher Angelfischerverband e.V.)	Alexander Seggelke Olaf Lindner	Projects: Survey on the impacts of COVID-19 on recreational fishing in Germany; Marine litter from recreational fisheries
2016	Germany	University of Rostock, Faculty of Agricultural and Environmental Sciences	Prof Harry W Palm	Joint supervision of a master thesis titled: Estimating German recreational salmon catches in the Baltic Sea
2019-2022	Germany	University of Rostock, Institute of Computer Science, Chair of Modelling and Simulation	Prof Adelinde Uhrmacher	Joint supervision of a PhD student working on agent-based modelling of angler behaviour
2018-2019	Germany	Thünen Institute of Sea Fisheries	Dr Ralf Döring	Project SECFISH (Socio-EConomic data collection for FISHeries, aquaculture and the processing industry)
2018	Germany	State Office for the Environment, Nature Conservation and Geology Mecklenburg-Vorpommern	Dennis Gräwe	Project: Marine litter from recreational fisheries

2018	Germany	Lower Saxony State Office for Water Management, Coastal and Nature Conservation	Kirsten Dau	Project: Marine litter from recreational fisheries
2015-2018	Germany	Angling Association of Lower Saxony (Anglerverband Niedersachsen e.V.)	Prof Thomas Klefoth	Project: Post-release mortality of European eel
2014-2015	Germany	Boat angling association (Boots-Angler-Club e.V.)	Andreas Weber	Pilot study on the recreational trolling fishery for salmonids in the Baltic Sea
2014-2022	Germany	State Research Centre of Agriculture and Fisheries Mecklenburg-Vorpommern	Dr Malte Dorow	Projects: Post-release mortality of European eel; Boddenhecht
2018-2019	Italy	COISPA Tecnologia & Ricerca	Dr Isabella Bitetto	Projects: SECFISH (Socio-EConomic data collection for FISHeries, aquaculture and the processing industry)
2018-2019	Netherlands	Institute for Marine Resources and Ecosystem Studies	Dr Hans van Oostenbrugge	Project SECFISH (Socio-EConomic data collection for FISHeries, aquaculture and the processing industry); Study on post-release mortality of European eel
2017-2019	New Zealand	National Institute of Water and Atmospheric Research	Dr Bruce Hartill	Projects: Survey methods; Remote camera monitoring of recreational fisheries
2013-2022	Norway	Institute of Marine Research	Dr Jon Helge Vølstad Dr Keno Ferter	Projects: Survey methods; several projects on C&R, post-release mortality of fish and sublethal impacts e.g. for cod, sea bass, halibut, eel, sea trout.
2019-2021	Spain	University of Santiago de Compostela	Dr Pablo Pita	Projects: ICES WKHDR; Impacts of COVID-19 on marine recreational fisheries
	Spain	AZTI	Dr Estanis Mugerza Dr Raúl Prellezo	Projects: SECFISH (Socio-EConomic data collection for FISHeries, aquaculture and the processing industry); Research for the European Parliament (PECH Committee) - Marine

				recreational and semi-subsistence fishing - its value and its impact on fish stocks.
2017-2022	UK	Centre for Environment, Fisheries and Aquaculture Science (CEFAS)	Dr Kieran Hyder	Projects: Survey methods; Sea bass post-release mortality; Sublethal impacts of C&R; ICES WKHDR; SECFISH (Socio-EConomic data collection for FISHeries, aquaculture and the processing industry); Research for the European Parliament (PECH Committee) - Marine recreational and semi-subsistence fishing - its value and its impact on fish stocks.
2021-2022	UK	Bournemouth University	Prof Robert Britton	Project: Impacts of COVID-19 on recreational fisheries
2019-2020	UK	University of Reading	Joseph Watson Prof Richard Sibly	Project: Sublethal impacts of C&R

Appendix 2: Quality assessment of the survey and monitoring programme

As part of the evaluation process, a quality assessment of the (1) multispecies off-site survey, (2) multispecies on-site survey and (3) remote camera survey was conducted based on the quality assurance toolkit (QAT) developed by the ICES Working Group on Recreational Fisheries Surveys (WGRFS; ICES 2013; 2020).

Quality assessment of the most recent multispecies off-site survey

DEFINE THE SCOPE AND OBJECTIVE(S) OF THE SURVEY

List the main objective(s) and scope of the study. Some additional details should be provided on the recreational fishing modes being surveyed, scale (regional, national, multi-country), the study area, if it is a long-term monitoring survey, one-time study, etc.

A nation-wide representative computer-assisted telephone interview (CATI) screening survey targeting 150,000 German households has been carried out from October 2020 to May 2021 followed by a one-year diary survey. The off-site CATI survey was designed to identify anglers in the German population, collect their socio-demographic parameters and information on angler heterogeneity, and estimate fishing effort as well as recruit participants for the subsequent diary survey. The CATI survey used a dual frame approach with 70% landline numbers and 30% mobile numbers. A mixture of random-digit dialling and number sampling from an official number registry (landline only) was used to derive telephone numbers and contact households, with selection probabilities being proportional to the number of households per municipality. However, a disproportional sampling approach was chosen to increase the number of marine anglers in the diary survey. Therefore, the probability of sampling telephone numbers originating from federal states that are closer to the German coasts was doubled. Up to ten attempts were made to contact a household. Thereafter, a telephone number was considered a quality-neutral failure. Household size and number of persons in a household being recreational anglers were determined. An angler was defined as a person who had fished at least once in Germany during the last 12 months preceding the survey. Survey participants had to be older than 14 due to the German Youth Protection Act. All persons that had been fishing in Germany in the last 12 months, or who planned to go fishing there in the next 12 months were asked to participate in a one-year diary survey. All diary participants were asked to report every single angling day in Germany over an observation period of 12 months starting from the day they received the diary. For every angling day, the date, time, fishing location, angling platform (boat, charter boat, shore), target species, and the number of fishes caught, harvested and released per species had to be reported. In order to maintain the motivation to participate, retrieve diary data, and to reduce panel attrition bias, the participants were contacted by telephone at quarterly intervals during the entire observation period. The diary data was collected between October 2020 and May 2022. The analyses are still ongoing. Off-site population screening surveys of the general population which are complemented with diary studies are regularly conducted (every 5-7 years due to cost constraints).

DESIGN				
AREA	**QUESTION**	**ANSWER**	**MULTI-SPECIES OFF-SITE SURVEY**	
Target population	Have all components of the target population been identified?	Yes	*Yes. The off-site survey is a probability-based population dual-frame (30% mobile/70% landlines) survey of 150,000 German households stratified by municipalities. The sample is raised to the population based on demographics from the German census.*	
	Is there a component of the target fishery that is not covered by the survey and if so, what was it?	No	*Non-German fishers are not covered, but sea angling tourism in Germany by non-residents is thought to be minimal, so exclusion has little impact on estimates.*	
	Are there elements of the target population that are not accessible, and if so, what are	No	*All households are covered except those without telephone/mobile phones. This is extremely rare so exclusion has no impact on estimates.*	

	they (e.g. private access points or unlisted telephone numbers)?			
Sampling frame	What is the sample frame(s) and the associated PSU?	NA	*Frame is all valid RDD identified German telephone numbers (mobile/fixed) picked up by CATI and stratified by municipalities. PSU is a German household.*	
	Does the sampling frame adequately cover the target population?	Yes	*Yes, all German households are considered and probabilistic sampling enables all regions to be covered.*	
	Are there elements of the sample frame that have been deliberately excluded, and if so and what were they (e.g. quiet season)?	Yes	*Non-German fishers and all non-angling fishing methods are excluded*	
Stratification	Are the strata well-defined, and known in advance (spatial/temporal)?	Yes	*German demographics and households are well quantified by the German census.*	
	Is there adequate sampling within each stratum (e.g. days surveyed during weekends/summer)?	Yes	*However, the participation rate of sea anglers in the German population is extremely low and requires large population samples. It would be beneficial to have a license registry.*	
Selection	Is sampling probability-based (e.g. stratified random, PPS - Proportional to Population Size)?	Yes	*Northern states sampled twice as much to increase the sample size of sea anglers but corrected for in weighting procedure.*	
	Has the survey been designed to achieve target precision in an analytically optimal fashion?	Yes	*According to the low participation rates identified in previous surveys, the sample population was set to 150,000 households.*	
	Have issues associated with ethics/ permits and privacy been addressed?	Yes	*Ethical approval was granted and EU GDPR followed.*	
IMPLEMENTATION (FILL OUT IF THE SURVEY HAS STARTED)				
AREA	**QUESTION**	**ANSWER**	**MULTI-SPECIES OFF-SITE SURVEY**	
Selection	Has the survey actually followed the sampling design?	Yes		
	Have sampling protocols been documented and followed at each stage (selection of individuals, times, boats, biological samples)?	Yes	*The sampling protocol has been documented and followed. A full description of the sampling approach is in preparation.*	
	Have contingency protocols been specified to deal with issues such as incomplete interviews of un-surveyable weather and were they required?		*Refusals are documented and unreachable households are contacted up to ten times.*	
	Has there been any major departure from the survey design (frequent refusal to take observers on board a charter vessel)?	No		

	Is there a language barrier (tourist fishery)?	No	*Unknown but likely to be marginal.*	
	Have the planned number of sampling events and/or interviews taken place and have the completion rates been documented?	Yes	*Yes, the planned number of sampled households has taken place.*	
Nonresponse	Which following non-response rates were relevant? 3. Screening – blocked contact 4. Screening – no reply 5. Screening – language problem 6. Panel survey – not contactable 7. Creel survey – refusal 8. Creel survey – language problem 9. Other	Yes	*Blocked contact, no replies, refusals and nonresponses were relevant but documented and will be corrected for in weighting procedure using German household census data.* *Language problems are likely to be marginal.*	
Recall	What is the recall period and is it appropriate for the questions asked?	Yes	*12-month recall is only used to classify avidity per angler. One year diary used to capture actual angling effort and catches with no recall. Reporting was possible by paper diaries and online.*	
Effort	How is effort defined (unit, fishing mode, target species, location) and related to CPUE measures?	Yes	*Unit is one angling day per fishing mode and water body (location).*	
	Was the measure of effort clearly communicated to the fisher (i.e. time spent with gear in the water)?	Yes	*Diarist submit catches on a daily level.*	
	Is it possible to record incorrect fishing areas?	Yes	*Yes, but minimised through several different mechanisms. Diary provides German map with defined fishing areas and online diarists can mark geolocation on electronic map.*	
Catch	Is the retained catch verified by surveyors (e.g. all filleted, don't show)?	No	*No, as it is off-site diary data, but data validation occurs. Data entered into diary checked after submission (e.g., strange species, catches, data inconsistencies).*	
	Is species identification and naming reliable?	Partial	*Fish name guide provided to diarists to aid species naming. Where there are particular issues, species may be grouped together (e.g. cyprinids)*	
	Is there a clear division between fish kept and fish released?	Yes	*Diarists enter the numbers and fate of all fish caught.*	
	Is it possible that an individual will have also reported the catch of those fishing with them?	Partial	*Diary contains reminders that only own catches should be reported but large catches are identified during the data validation phase and checked with diarists.*	
	Is there a digit preference in the reports (catch numbers and/or length frequencies)?	Partial	*Catches of species with high catch rates (e.g. herring) may be biased.*	

ANALYSIS & REPORTING (fill out if the survey is complete)				
AREA	**QUESTION**	**ANSWER**	**MULTI-SPECIES OFF-SITE SURVEY**	
General	Does the estimation procedure follow the survey design?	Yes	*Weights will be applied to each of the respondents based on demographic information from the German census. An iterative weighting procedure will be applied to each individual taking into account demographics and angling specifics.*	
	Has imputation been used to account for missing observations and, if so, is the procedure documented?	No	*No imputation used so far but will be checked.*	
	Has there been weighting to correct for nonresponses/avidity bias	Yes	*Weighting procedure will address non-response and avidity bias.*	
	Has the precision of estimates been calculated and, if yes, how have they been calculated and where are they documented?	Yes	*Confidence intervals for participation rates have been calculated but analysis of the diary data is ongoing.*	
	Were estimates estimated with acceptable precision?	NA	*NA – ongoing work*	

Quality assessment of the multi-species on-site survey

DEFINE THE SCOPE AND OBJECTIVE(S) OF THE SURVEY

List the main objective(s) and scope of the study. Some additional details should be provided on the recreational fishing modes being surveyed, scale (regional, national, multi-country), the study area, if it is a long-term monitoring survey, one-time study, etc.

The multispecies on-site access point survey includes random intercepts of marine anglers (shore, boat and charter boat anglers) at access points along the German Baltic Sea coast. It aims to collect catch rates and fishing characteristics of marine anglers for both sea-based and land-based catches for both the harvest and release component (in particular of western Baltic cod for stock assessment purposes). The sampling frame covers all access points (79) along the entire German coast in ICES SD22 & SD24. Data is used for extrapolation of German recreational catch data using effort data from the off-site telephone/diary survey. The coastline is divided into five strata, with harbours and beaches as access points and days as primary sampling units. Access points and days (27 days per month) are randomly selected within the strata. The interviews are conducted by five survey agents during peak activity times in the afternoon/evening when most anglers are expected to end their fishing day. The sampling effort is increased for sea-based fishing methods and for those days when anglers most frequently go fishing (weekends and public holidays). Observation time per access point is usually 3-5 hours. The fishing methods are grouped into shore fishing (surf angling and wading), boat fishing (including float tubes and kayaks), and charter vessel fishing. The following data are collected during the interviews: the number of caught and released fish per species, the sociodemographic factors gender, age, place of residence (postal code), avidity (measured as the reported number of fishing days in the German Baltic Sea in the past 12 months), weather conditions and the coastal state and specific location at which the interview took place. The survey has been conducted annually since 2005 and will continue in the future.

DESIGN				
AREA	**QUESTION**	**ANSWER**	**ON-SITE ACCESS POINT SURVEY OF CPUE**	
Target population	Have all components of the target population been identified?	Yes	*Yes. The on-site survey covers all platforms and fishing methods focusing on rod-and-line fishing.*	
	Is there a component of the target fishery that is not covered by the survey and if so, what was it?	No	*All anglers fishing on/off the coast are covered. Hobby fishers using passive gear are identified but not covered but play a marginal role concerning catches (Strehlow et al. 2012)*	
	Are there elements of the target population that are not accessible, and if so, what are they (e.g. private access points or unlisted telephone numbers)?	No	*No private sites in Germany.*	
Sampling frame	What is the sample frame(s) and the associated PSU?	NA	*A list of all relevant access points on the German Baltic coast. PSU is an angler day.*	
	Does the sampling frame adequately cover the target population?	Yes	*All anglers fishing on/off the coast are covered but low avid (occasional) anglers may be underrepresented.* *Differences in demographics and catch rates between the sea angling population off-site and on-site were small.*	
	Are there elements of the sample frame that have been deliberately excluded, and if so and what were they (e.g. quiet season)?	Yes	*All non-angling fishing methods are not covered.*	

Stratification	Are the strata well defined, and known in advance (spatial/temporal)?	Yes	*Strata: Sampling area / weekday and weekend / platform*	
	Is there adequate sampling within each stratum (e.g. days surveyed during weekends/summer)?	Yes	*Weekends and holidays & sea-based fishing have a higher sampling probability and no 24h strata covered due to peak activity sampling.*	
Selection	Is sampling probability based (e.g. stratified random, PPS - Proportional to Population Size)?	Yes	*Occasional anglers may be under-sampled.*	
	Has the survey been designed to achieve target precision in an analytically optimal fashion?	No	*No prior data to inform sample size determination.*	
	Have issues associated with ethics/ permits and privacy been addressed?	Yes	*Data are anonymized.*	
IMPLEMENTATION (FILL OUT IF THE SURVEY HAS STARTED)				
AREA	**QUESTION**	**ANSWER**	**OFFSITE SEA ANGLING CATCH DIARY (SAD)**	
Selection	Has the survey actually followed the sampling design?	Yes	*Some sampling dates may change due to illness, extreme weather events, etc.*	
	Have sampling protocols been documented and followed at each stage (selection of individuals, times, boats, biological samples)?	NO	*A detailed sampling description is missing but detailed sampling protocols are available.*	
	Have contingency protocols been specified to deal with issues such as incomplete interviews of un-surveyable weather and were they required?	Yes	*Rules are in place to substitute for non-completed assignments of sampling dates.*	
	Has there been any major departure from the survey design (frequent refusal to take observers on board a charter vessel)?	Partial	*Some charter vessels refuse to take observers (survey agents) onboard.*	
	Is there a language barrier (tourist fishery)?	Partial	*Depends on individual survey agent but is likely to be marginal.*	
	Have the planned number of sampling events and/or interviews taken place and have the completion rates been documented?	Yes	*Yes - the completion rates for access point intercept surveys are documented.*	

Nonresponse	Which following non-response rates were relevant? 10. Screening – blocked contact 11. Screening – no reply 12. Screening – language problem 13. Panel survey – not contactable 14. Creel survey – refusal 15. Creel survey – language problem 16. Other	Yes	*Face-to-face interviews with very low refusal rates.* *Language problems are marginal due to very few anglers speaking no German.*	
Recall	What is the recall period and is it appropriate for the questions asked?	Yes	*No recall due to the same angling day covered.*	
Effort	How is effort defined (unit, fishing mode, target species, location) and related to CPUE measures?	NA	*Unit is one angling day per fishing mode*	
	Was the measure of effort clearly communicated to the fisher (i.e. time spent with gear in the water)?	Yes	*Face-to-face interview, same day*	
	Is it possible to record incorrect fishing areas?	No	*Face-to-face interview at the location.*	
Catch	Is the retained catch verified by surveyors (e.g. all filleted, don't show)?	Partial	*Partly if angler shows catch, releases cannot be verified.*	
	Is species identification and naming reliable?	Yes	*There are few species in the Baltic Sea and these are clearly distinguishable. Flatfish species maybe misidentified.*	
	Is there a clear division between fish kept and fish released?	Yes	*Face-to-face interview.*	
	Is it possible that an individual will have also reported the catch of those fishing with them?	No	*Face-to-face interview.*	
	Is there a digit preference in the reports (catch numbers and/or length frequencies)?	Partial	*Catches of species with high catch rates (e.g. herring) may be biased if cannot be counted by survey agents.*	
ANALYSIS & REPORTING (fill out if the survey is complete)				
AREA	**QUESTION**	**ANSWER**	**ON-SITE ACCESS POINT SURVEY**	
General	Does the estimation procedure follow the survey design?	Yes		
	Has imputation been used to account for missing observations and, if so, is the procedure documented?	No	*Some imputation is used for low sampling size or missing length data.*	

	Has there been weighting to correct for nonresponses/avidity bias	No	*Refusal rates are low but avidity bias may be an issue due to lower encounters of occasional anglers.*	
	Has the precision of estimates been calculated and, if yes, how have they been calculated and where are they documented?	No	*Inherently self-weighting data due to low in season variability of catches.*	
	Were estimates estimated with acceptable precision?	Yes	*Multi-species survey, so some species have low precision, some have very high precision*	

Quality assessment of the remote camera survey (Salmon survey)

DEFINE THE SCOPE AND OBJECTIVE(S) OF THE SURVEY

List the main objective(s) and scope of the study. Some additional details should be provided on the recreational fishing modes being surveyed, scale (regional, national, multi-country), the study area, if it is a long-term monitoring survey, one-time study, etc.

Remote cameras are installed at three marinas (Glowe, Lohme, Wiek) that collectively provide access to > 60% of all trolling boats participating in the German salmon trolling fishery, to quantify launch based fishing effort departing from these marinas. Marina entrance choke points are monitored, providing coverage of all boats leaving the marinas. Recording is restricted to the salmon trolling season (December to May) and images are only taken between 5 am and 3 pm when trolling boats are known to leave the marinas to increase cost efficiency. Image analysis and boat counting is conducted via manual visual inspection of the images in time-lapse. Salmon trolling effort from marinas not monitored by cameras is extrapolated using regular instantaneous trolling boat counts (every two weeks at night or on storm days) covering all relevant marinas with salmon trolling boats and the proportions of trolling boats that went out for fishing derived from the marinas with camera monitoring. The camera monitoring is complemented by random on-site interviews (10-12 assignments per month with replacement) of trolling anglers in four relevant marinas (including the marinas where the camera monitoring is conducted) to determine catch, harvest and release rates (each per boat) and to collect biological catch data and socio-economic information. The survey is conducted annually since 2017 and will continue in the future.

DESIGN				
AREA	**QUESTION**	**ANSWER**	**CAMERA SURVEY OF EFFORT**	**ON-SITE ACCESS POINT SURVEY OF CATCH RATES**
Target population	Have all components of the target population been identified?	Cam: Yes ON: Yes	*German Baltic salmon fishing is only conducted by trolling around the island of Rügen. Therefore, relevant harbours are sampled.*	*German Baltic salmon fishing is only conducted by trolling around the island of Rügen. Therefore, relevant harbours are sampled.*
	Is there a component of the target fishery that is not covered by the survey and if so, what was it?	Cam: No ON: No	*Boat-based trolling fishery only.*	*Boat-based trolling fishery only.*
	Are there elements of the target population that are not accessible, and if so, what are they (e.g. private access points or unlisted telephone numbers)?	Cam: Yes ON: No	*Cameras in three harbours account for 65% of the fishing effort. Fishing effort of the other harbours is raised using the camera data.*	*Four harbours accounting for 85% of the fishing effort are sampled. Catch rates of these harbours are used for extrapolation of catches of the other harbours.*
Sampling frame	What is the sample frame(s) and the associated PSU?	Cam: NA ON: NA	*All boats leaving the harbours are sampled. PSU is a trolling boat day.*	*Four main salmon trolling harbours on the island of Rügen. PSU is a trolling boat day.*
	Does the sampling frame adequately cover the target population?	Cam: Partial ON: Yes	*Sampled harbours cover 65% of the total fishing effort.*	*Sampled harbours cover 85% of the total fishing effort.*
	Are there elements of the sample frame that have been deliberately	Cam: Yes ON: Yes	*Harbours that are not sampled, but accounted for in the raising process.*	*Harbours that are not sampled, but accounted for in the raising process.*

	excluded, and if so and what were they (e.g. quiet season)?			
Stratification	Are the strata well-defined, and known in advance (spatial/temporal)?	Cam: Yes ON: Yes	*Strata: Harbour*	*Strata: Harbour / weekday and weekend*
	Is there adequate sampling within each stratum (e.g. days surveyed during weekend/summer)?	Cam: Yes ON: Yes	*Sampling occurs from 5am to 3pm in the salmon trolling season (December-May) targeting trolling boats that leave for fishing.*	*Weekends and holidays have a higher sampling probability and no 24h strata covered due to peak activity sampling (when boats return in the afternoon/evening).*
Selection	Is sampling probability-based (e.g. stratified random, PPS - Proportional to Population Size)?	Cam: No ON: Yes	*Census during the sampling time and in sampled harbours.*	*Random sampling of access points and days, with replacement. Occasional anglers may be under-sampled.*
	Has the survey been designed to achieve target precision in an analytically optimal fashion?	Cam: Yes ON: Yes	*Harbours are chosen to cover 65% of the fishing effort.*	*Number of sampling dates is chosen to reach an adequate sample size.*
	Have issues associated with ethics/ permits and privacy been addressed?	Cam: Yes ON: Yes	*Ethical approval was granted and EU GDPR followed.*	*Data are anonymized.*
IMPLEMENTATION (FILL OUT IF THE SURVEY HAS STARTED)				
AREA	**QUESTION**	**ANSWER**	**CAMERA SURVEY OF EFFORT**	**ON-SITE ACCESS POINT SURVEY OF CATCH RATES**
Selection	Has the survey actually followed the sampling design?	Cam: Yes ON: Yes		*Some sampling dates may change due to illness, extreme weather events, etc. Weather-related cancelations are replaced to ensure adequate sample sizes.*
	Have sampling protocols been documented and followed at each stage (selection of individuals, times, boats, biological samples)?	Cam: Yes ON: Yes	*The sampling protocol has been documented and followed.*	*The sampling protocol has been documented and followed.*
	Have contingency protocols been specified to deal with issues such as incomplete interviews of un-surveyable weather and were they required?	Cam: Yes ON: Yes	*Missing data due to camera outages are imputed using data from the other harbours and boat counts.*	*Rules are in place to substitute for non-completed assignments of sampling dates.*

	Has there been any major departure from the survey design (frequent refusal to take observers on board a charter vessel)?	Cam: No ON: No		*Face-to-face interview few refusals.*
	Is there a language barrier (tourist fishery)?	Cam: NA ON: Partial		*Depends on individual survey agents but is likely to be marginal.*
	Have the planned number of sampling events and/or interviews taken place and have the completion rates been documented?	Cam: Yes ON: Yes	*Census with very few missing observations due to technical problems or low visibility (fog).*	*Yes - the completion rates for access point intercept surveys are documented.*
Nonresponse	Which following non-response rates were relevant? 17. Screening – blocked contact 18. Screening – no reply 19. Screening – language problem 20. Panel survey – not contactable 21. Creel survey – refusal 22. Creel survey – language problem 23. Other	Cam: NA ON: Yes		*Face-to-face interviews with very low refusal rates.* *Language problems are marginal due to very few anglers speaking no German.*
Recall	What is the recall period and is it appropriate for the questions asked?	Cam: NA ON: Yes		*No recall due to the same angling day covered.*
Effort	How is effort defined (unit, fishing mode, target species, location) and related to CPUE measures?	Cam: NA ON: NA	*Unit is one trolling boat day per harbour.*	*Unit is one trolling boat day per harbour.*
	Was the measure of effort clearly communicated to the fisher (i.e. time spent with gear in the water)?	Cam: NA ON: Yes		*Face-to-face interview, same day*
	Is it possible to record incorrect fishing areas?	Cam: NA On: No		*Face-to-face interview at the location.*
Catch	Is the retained catch verified by surveyors	Cam: NA	*Only trolling effort is observed.*	*Partly, if the angler shows catch, releases cannot be verified.*

	(e.g. all filleted, don't show)?	ON: Partial		
	Are species identification and naming reliable?	Cam: NA ON: Partial		*Large sea-trout may be misidentified as salmon.*
	Is there a clear division between fish kept and fish released?	Cam: NA ON: Yes		*Face-to-face interview.*
	Is it possible that an individual will have also reported the catch of those fishing with them?	Cam: NA ON: No		*Catch is recorded per boat.*
	Is there a digit preference in the reports (catch numbers and/or length frequencies)?	Cam: NA ON: No		*Very low catch rates.*
ANALYSIS & REPORTING (fill out if the survey is complete)				
AREA	**QUESTION**	**ANSWER**	**CAMERA SURVEY OF EFFORT**	**ON-SITE ACCESS POINT SURVEY OF CATCH RATES**
General	Does the estimation procedure follow the survey design?	Cam: Yes ON: Yes	*Effort is summed for harbours with camera monitoring and extrapolated for harbours without cameras based on a weighted mean proportion of outgoing boats from the camera harbours and the corresponding number of boats per harbour based on two-weekly instantaneous boat counts covering all harbours multiplied by the numbers of trolling boats per harbour in the corresponding harbour.*	
	Has imputation been used to account for missing observations and, if so, is the procedure documented?	Cam: Yes ON: No	*Imputation is used for missing observations due to technical problems or low visibility (fog). Documented in the sampling protocols.*	*Missing assignments are replaced.*
	Has there been weighting to correct for nonresponses/avidity bias	Cam: NA ON: No		*Refusal rates are low but avidity bias may be an issue due to lower encounters of occasional anglers.*
	Has the precision of estimates been calculated and, if yes, how have they been calculated and where are they documented?	Cam: No ON: Yes	*Census of 65% of fishing effort.*	*Confidence intervals are calculated and documented for catch rates.*

	Were estimates estimated with acceptable precision?	Cam: Yes ON: Yes	*Census of 65% of fishing effort.*	*Low catch rates with low variability.*

Appendix 3: Summary Statement of an External Evaluation of the Marine Recreational Fisheries Working Group at the Thünen Institute of Baltic Sea Fisheries, Germany

Dr Kieran Hyder (UK) and Prof Warren Potts (SA)

Summary statement of an external evaluation of the Marine Recreational Fisheries Working Group at the Thünen Institute of Baltic Sea Fisheries, Germany

Summary

An evaluation was undertaken of the Marine Recreational Fisheries Working Group (MRFWG) at the Thünen Institute of Baltic Sea Fisheries in Rostock by two external scientific experts in recreational fisheries. The evaluation covered: the survey programme; scientific excellence and expertise of staff; research priorities in the context of fisheries advice; and collaborations. A summary report was provided and a face-to-face workshop was held that, in combination, were used to generate the evaluation. This includes an assessment against each of the terms of reference and recommendations for areas to develop in future.

Since its establishment, the MRFWG has done an excellent job in creating one of the longest and most comprehensive monitoring databases for marine recreational fisheries in Europe. The group has a strong and correct blend of expertise, and is well-respected in Europe, where it plays a leading role in integrating recreational fisheries into general fisheries policy. There have been real policy and societal impacts from the work done, and research has been focused on developing novel science in the right areas. Collaborations have been extensive and have generated both significant additional funding and many scientific publications.

Given the level of resources and the organic growth, the MRFWG is performing well in all areas evaluated within the terms of reference. As a result, we would suggest that there is no need to make large-scale changes, but there are changes that could be made in certain areas to improve the profile and sustainability of the MRFWG in the longer term. Recommendations are made covering: development of strategy; extensions to survey approaches; data sharing; creation of impact case studies; continuation of postdoctoral research to exploit data; resource and succession planning; reviewing teaching partnerships; and broadening collaborations.

Introduction

The Marine Recreational Fisheries Working Group (MRFWG) is part of the Thünen Institute of Baltic Sea Fisheries in Rostock, Germany. Research on recreational fisheries has been underway for around 20 years, with the MRFWG established around 12 years ago. The overall aims of the group are threefold: satisfy EU Data Collection Framework (DCF) requirements for monitoring the participation and catches by MRF in Germany; provide advice for decision makers on MRF; and collaboratively generate science to shape future monitoring and management. The MRFWG is led by Dr Harry Strehlow and includes a mixture of part-time and full-time permanent and project-based staff totaling 6 full time equivalent positions.

The Thünen Institute encourages its working groups to invite evaluation by external experts as part of its quality assessment, following recommendations by the German Science Council in 2014. As a result, Prof.

Warren Potts (Rhodes University, South Africa) and Dr Kieran Hyder (Cefas, UK) were asked to evaluate the MRFWG as recognised experts on MRF. The terms of reference for the review were:

1. Evaluation of the survey and monitoring program with regard to survey design, data collection, data quality, and analyses.
2. Evaluation of the scientific excellence of the WG in terms of methods used and the technical expertise of the staff.
3. Evaluation of research priorities with focus on their effectiveness and usefulness for the advisory competence of the institute.
4. Evaluation of national and international research collaborations and participation in national and international scientific committees and advisory boards.

Initial evidence was provided in a detailed report in October 2022, and the face-to-face evaluation was conducted from 1-3 November 2022 in Rostock, Germany. Together, the meetings and report provided sufficient information to evaluate all the terms of references. This has been used to generate a short summary of the findings against each of the terms of reference, create an overall summary, and make recommendations for future work.

Evaluation of the survey and monitoring program with regard to survey design, data collection, data quality, and analyses

The MRFWG has done an excellent job in creating one of the longest and most comprehensive monitoring databases for marine recreational fisheries in Europe. They have used a sensible combination of onsite (catches by anglers, sizes of fish kept and returned) and offsite (mail and telephone surveys to understand angling effort, catch diaries) surveys. These approaches have delivered data of known quality that has been used both for fisheries assessment (e.g. International Council for the Exploration of the Sea; ICES) and European fisheries management (e.g. Western Baltic cod).

The design, implementation and analyses of the surveys has been reviewed by the ICES Working Group on Recreational Fisheries Surveys, and deemed robust. After closely examining the monitoring programs and based on discussions at the workshop, there are no fundamental problems with any of the approaches and no significant redesign is needed. However, there are some opportunities to fine-tune some approaches, especially in terms of the analyses, expand the approaches to cover additional species and/or regions (e.g. sea bass in the North Sea), and improve the provision of data.

One of the largest uncertainties in the current programme is the recreational fishing effort. Currently, this is done infrequently due the complexity and expense, with surveys done in 2004-5, 2014-15, and 2020-21. However, it is likely that the effort is highly dependent on the catch rate, and may vary dynamically especially where strong year classes appear in the fisheries. Licence frames are not comprehensive and vary between federal states meaning that they cannot be used to assess national effort. However, licenses from a particular state could be used to infer interannual trends, perhaps in combination with data from the onsite survey. This should be investigated further.

Biological data on the size and age of the fish caught and returned is another area that could be developed. Currently, onsite approaches are used to generate data from charter boats, but not from shore anglers or private boats. It would be useful to consider collecting size information of both retained and released fish during the onsite surveys and considering other approaches such as small panels of "scientific anglers" or other citizen science projects (e.g. provision of filleted fish frames for analysis; Fairclough et al., 2014).

In terms of future analyses, it would be useful to consider modelling approaches rather than simple post-stratification as this is a more efficient use of the data and could result in more general conclusions around what is driving catches and effort. This requires significant additional effort to develop, so would require a post-doctoral researcher to complete. If simple post-stratification approaches are continued, it would be

useful to consider how the choice of strata affects the error generated for both effort and catch per unit effort. Secondly, it is important to ensure that all sources of error (effort, catch per unit effort, and size of fish) are included in outputs generated. Finally, it would be beneficial to use some kind of code repository (e.g. GitHub) to ensure version control and so that analyses can be easily shared and repeated. This will ensure that robust outputs are generated.

The current programme has been optimised for cod and salmon in the Baltic Sea. However, it would be useful to consider how this can be extended to more species (e.g. herring, garfish, sea trout), and additional areas (e.g. sea bass in the North Sea). This could include the use of non-probability-based approaches such as angler mobile apps and citizen science to boost sampling effort generating data for additional species and enhancing spatiotemporal resolution. Although this may be possible with the current capacity and levels of funding, it may require academic collaborations for testing. Regardless, of the process, non-probability approaches should be considered to maximise the utility of the programme.

It should be noted that there is no such thing as a perfect survey – they all involve compromises and choices to fit within budgets and logistical constraints. This is, without doubt, one of the most comprehensive and robust programmes globally in its diversity, output and robustness. As a result, it is an amazing knowledge-base and dataset that should be made open to all users. This could take the form of an open data portal that allows users to investigate data (e.g. R-shiny) and should be combined with publishing a data paper in a journal resulting in a doi that can be cited and used to track use of this valuable data set. This will allow the full potential of the data to be both realised and recognised.

Evaluation of the scientific excellence of the WG in terms of methods used and the technical expertise of the staff

Approach

The MRFWG has a broad range of complementary skills that are required for monitoring marine recreational fisheries. MRFWG has over time developed fit-for-purpose methods for monitoring the range of recreational fisheries sub-sectors. For example, the methods for the low participation salmon trolling fishery, which includes a remote camera survey, are completely different to the popular multispecies fishery, which uses on-site roving creel and access point surveys. Besides the use of appropriate methods for the different sub-sectors, it was clear that there was not only careful consideration of the choice of method, but its efficacy was also thoroughly interrogated by the working group. An example of the depth of their methodological interrogation was their recent manuscript that compared the different recruitment methods for angler diarists (Lewin et al., 2023). This study identified potential bias in traditional recruitments methodology (recruitment from the angling permit holders) and this has led the group to attempt to correct for the bias in the future. This level of self-evaluation is seldom observed in recreational fisheries monitoring programs and the working group should be commended for their dedication to methodological rigour and scientific excellence in their monitoring methodology.

Besides continuous self-reflection of the existing methods, there was clear evidence that the working group is engaging with novel data collection methods. Their salmon fishery is at the forefront of the use of technology to monitor effort in marine recreational fisheries (Hartill et al., 2020), while their collaboration on a publication that evaluated the use of angler Smartphone apps for recreational fisheries monitoring and management (Skov et al., 2021) is a further indication of their engagement with novel methods. They are currently exploring the utility of Smartphone apps in a German marine recreational fisheries context.

While survey technology has been at the forefront of the monitoring programs by the working group, one potential area that could be considered is the importance of monitoring technological innovations in the German marine recreational fishery. Technological innovation can directly influence catch rates by improving the ability of anglers to find fish (e.g. improved echosounding technology, drone cameras), access fish (e.g. dropping baits using drones), catch fish (e.g. lure and other gear development) to information sharing (e.g.

smartphone apps to spread information) (Cooke et al 2021; Winkler et al 2021). Understanding the extent of technological changes over time is critical for long-term monitoring programs as they may provide information to understand patterns of change and any improvements to the efficacy of recreational angling practices may lead to improved catch rates and the assumption of building fish stocks.

Outputs

The outputs generated by MRFWG are numerous and diverse. Over the last 10 years, these include: traditional scientific outputs (34 papers, provision of peer review, journal editing, 17 reports, 29 conference presentations, 5 conference sessions); public outreach (40 presentations, 20 media contributions, and 14 popular science articles); international working groups on fisheries assessment (6 ICES working groups, 2 RCGs); and advisory statements (34 official, numerous unofficial). This represents significant level of output given the size of the MRFWG, and the group is recognised internationally within the recreational fisheries scientific community.

It is noted that the publication rate has increased markedly in the past few years through the employment of Dr Lewin and collaborations with a broader range of academics. There is a lot more that can be done with the amazing data set that has been collected over the past 20 years, so it is imperative that the employment of Dr Lewin continues to support leveraging the maximum benefits from the data and sharing the findings with the broader audience.

As noted in the monitoring section above, it would be very useful to provide open access to data through an open science portal as this would allow a broader set of people to use the data and maximise the utility of the data collected.

It would be also be beneficial to understand the outcomes of the work that has been done from an advisory perspective, and the societal impact of the work. This was not covered in detail in the report nor the workshop. There are clear examples of the impact of MRFWG work on, for example, bag limits for recreational cod anglers and European data collection. These could be demonstrated through the use of impact case studies that show clearly how the MRFWG has shaped policy direction and generated societal impacts. These would be of great benefit in demonstrating the strengths of MRFWG more broadly and could be used for communication with a wide range of stakeholders.

People

Dr Harry Strehlow has a wealth of experience in the monitoring and management of recreational fisheries. Much of his research focusses on the human dimension of these fisheries and his technical skills in monitoring and data analyses are outstanding having worked in this area for more than a decade. He plays international leadership roles particularly for the International Council for the Exploration of the Sea and various Regional Coordination groups and has collaborated with scientists around the world.

There is ample evidence that Dr Strehlow regularly engages with the recreational angling public through oral presentations to angling groups, television interviews and articles in angling magazines. Although his contributions to ISI rated scientific journals are not exceptional (33 peer-reviewed manuscripts) for his career stage, his focus on recreational fisheries and their management and the high number of citations of these publications has placed him as a leader in this research field. In addition, his (and the rest of the working group's) publication rate is on an upward trajectory, and it is recommended that this should be encouraged to promote further recognition of his excellence in this field. Other considerations would be the further development of formal partnerships, particularly with academic institutions both locally and internationally (see section on strategic partnerships above). Strategic relationships such as these will both promote further recognition but also provide opportunity for the recruitment of postgraduate students and young researchers for the working group.

Dr Weltersbach has maintained a research focus on the impacts of catch and release in recreational fisheries since his early work during his PhD, alongside his large contribution to the development, planning, coordination, implementation and evaluation of the different monitoring programmes. He has a satisfactory publication record (26 publications in ISI-rated journals) for his career stage, with evidence of increasing output over the past couple of years. While his technical skills in monitoring methods are extremely strong and have developed through his involvement in the working group, his clear research focus on the impacts of catch and release on marine fishes has firmly established him as a leader in this field. This is apparent from his appointment as a subject editor for the ICES Journal of Marine Science and involvement in several European recreational fisheries working groups. In addition, he represents the institute as an active member in a number of ICES working groups. While his research collaborations extend widely across Europe and the United Kingdom, there are opportunities for him to expand his collaborative networks more broadly and the development of formal collaborative links with local and foreign academic institutions is recommended to improve his status as an international leader in this research field. Dr Weltersbach is well-positioned to lead or co-lead to the development of global overviews on the impacts of catch and release in recreational fisheries and this will no doubt further his international reputation.

Dr Lewin has a rapidly growing research profile on the human dimension of marine recreational fisheries since he completed his PhD thesis and joined the working group. His recent research outputs have been considerable, and this has contributed considerably to the outputs of the MRFWG. His advanced technical skills in biostatistics make him a valuable member of the group due to his ability to apply a range of models to the enormous volume of data that have been collected by the group over the years. In terms of progression, it is recommended that Dr Lewin be encouraged to join international data analyses and human dimension working groups of ICES WGRFS. Further, the attendance of international conferences with specific focus on recreational fisheries is advised for broader networking and collaboration

Although still a PhD student, Mr Haase has made excellent progress for his career stage, with six published peer-reviewed manuscripts. This can no doubt be attributed the recent productivity of the working group, which has placed Mr Haase in an excellent position as a young researcher. From a technical perspective Mr Haase is rapid building skills in agent-based modelling, which is an especially useful tool for predicting the response of anglers to changes in the management of recreational fisheries and will be useful for the working group. As with Dr Lewin, encouraging Mr Haase to join fisheries working groups and facilitating his travel to appropriate international conferences is recommended to further his professional growth.

Whilst the expertise and resourcing appear to be sufficient at present to generate the data and outputs, it is worth considering the future needs of the MRFWG and identify approaches for successional planning. This should consider the numbers and skills of the people required, and development of collaborations to support successional planning (see below). In addition, the diversity of the group is low both in gender and ethnicity, so approaches to increase diversity within the MRFWG should be identified and implemented. This could be included as part of the development of strategy described above.

Evaluation of research priorities with focus on their effectiveness and usefulness for the advisory competence of the institute

The main research priority for MRFWG is described as ecological, economic, and social impacts of recreational fishing. To date, the main focus of the research has been twofold: firstly, to improve knowledge of the impacts of recreational fisheries (e.g. robustness of surveys, novel methods, post-release mortality); and secondly, a more recently focus on the social and economic dimensions (e.g. economic impact, choice experiments, local benefits, agent-based models). This is entirely appropriate as the focus of the of the working group is on recreational fisheries.

Good progress has been made in particularly around the impact of MRF on fish stocks and recreational fisheries management that is very important to policy makers (e.g. western Baltic cod). The recent move towards human dimensions is important strategically as it recognises the key policy drivers and how

arguments around policy and management will be generated in future. It is clear that members of the MRFWG are aware of the national and European advisory arena, and have good knowledge of how new science needs to be developed to support future advice. This has been used to develop the programme, which has grown to a certain extent organically moving from monitoring, to social and economic, and then to fisher behaviour. This approach is appropriate as funding is limited and has had to be generated in an ad hoc fashion to support additional posts.

Now the MRFWG has reached critical mass, it is really important to develop an overall vision and strategy for the group that would outline opportunities, priorities and approaches needed for the next 5 years. Currently, the overall research topic is very broad covering all aspects of MRF, so breaking this into simpler objectives and themes, with associated priorities, would help to focus development in the right areas going forwards. In addition, the vision does not, at present, explicitly include the interactions with other fishing sectors (e.g. commercial fishing) or competition for space (e.g. windfarms, HPMAs). As a result, the vision should include an assessment of the resources needed and metrics to judge success. This would generate a clear direction for the group, its priorities, and how its progress will be measured. If agreed by the Thünen Institute, this would then signify support for the direction and associated resource requirements, and could be used to leverage additional support from external bodies.

Evaluation of national and international research collaborations and participation in national and international scientific committees and advisory boards

Evidence was provided of a broad and diverse range of national and international collaborations including federal states and authorities (3), angling associations (3), non-academic science (15) and academic science (15). The collaborations have generated over €1.4 million of third-party funding in the last 5 years, and numerous papers and reports. In addition, MRFWG has participated and chaired in numerous ICES working groups, and participated in many international committees (e.g. European Parliament Fisheries Forum, Baltic Sea Advisory Council, Baltic Sea Fisheries Forum, MEDAC Working Group on Recreational Fisheries). Finally, MRFWG has contributed to teaching through the MSc program Integrative Zoology at the University of Rostock, alongside student supervision. These levels of collaboration and participation are what would be expected based on the size of the MRFWG.

Whilst the current levels of collaboration and participation are good, it is possible to identify areas where a different approach could generate benefits. Firstly, engagement and training in fisheries is limited at the University of Rostock, so a broader range of teaching provision would benefit the group. For example, participating in teaching at the University of Hamburg would generate benefits both in terms of student projects on fisheries, but also increase the potential for future recruitment. It would also be useful to broaden the range of universities for supervision of postdoctoral students, particularly in social sciences. Finally, MRFWG would benefit from building further links at a European level with similar fisheries institutes, and work more closely with institutions involved in managing shared stocks.

Summary and recommendations

Generally, we were impressed with the robustness of the methods used, breadth of technical expertise and outputs, research priorities identified, and the levels of collaboration and participation. Given the available resources and the organic growth, the MRFWG is performing well in all areas evaluated within the terms of reference. As a result, we would suggest that there is no need to make large-scale changes to the operation of MRFWG. However, there are changes that could be made in particular areas to improve the profile and sustainability of the MRFWG in the longer term. As a result, we would make the following recommendations:

1. A strategy should be developed for the MRFWG that sets the vision and goals for the next 5 years. The strategy should include objectives and a plan for implementation with associated resource requirements and metrics against which performance can be measured.

2. Extension of existing survey approaches should be considered to cover new analytical approaches (e.g. modelling), citizen science, and multispecies surveys, alongside the use of a code repository to ensure robust analytical approaches.
3. Utility of the programme could be improved through creation of an open data portal that allows anyone to access data (within the constraints of GDPR) alongside publishing a data paper with doi to track use of the data and information generated.
4. Impact case studies should be created to demonstrate the societal benefits of the programme generated through advice, as this would bring to life the important work of MRFWG in support policy and aide communication.
5. The postdoctoral researcher position currently held by Dr Lewin should be continued in order to exploit the existing data sets, maintain the publication rate, and maximise the knowledge generated from the data collected.
6. Resource and succession planning should be done to ensure that the MRFWG is able to meet future delivery, has the right mix of expertise, increases in diversity, and key roles can be filled where staff are lost.
7. Teaching should be focused on universities with a strong fisheries programme (e.g. Hamburg) in order to increase the utility of student projects and provide suitable candidates for future recruitment.
8. Collaborations with more universities should be explored to increase the range of topics focusing on current gaps, alongside partnerships with fisheries institutes in Europe involved in managing shared stocks.

References

Cooke, S.J., Venturelli, P., Twardek, W.M. et al. (2021) Technological innovations in the recreational fishing sector: implications for fisheries management and policy. Rev Fish Biol Fisheries 31, 253–288. 8

Fairclough, D., Brown, J., Carlish, B. et al. (2014) Breathing life into fisheries stock assessments with citizen science. Sci Rep 4, 7249.

Hartill, B.W., Taylor, S.M., Keller, K et al. (2020). Digital camera monitoring of recreational fishing effort: Applications and challenges. Fish Fish. 21, 204-215.

Lewin W.-C, Weltersbach, M.S., Haase, K. et al. (2023). Potential biases in angler diary data: The impact of the diarist recruitment process on participation rates, catch, harvest, and effort estimates. Fish. Res. 258, 106551.

Skov, C., Hyder, K., Gundelund, C. et al. (2021). Expert opinion on using angler Smartphone apps to inform marine fisheries management: status, prospects, and needs. ICES J. Mar. Sci. 78, 967-978.

Winkler, A.C., Butler, E.C., Attwood, C.G. et al. (2022) The emergence of marine recreational drone fishing: Regional trends and emerging concerns. Ambio 51, 638-651

Bibliografische Information:
Die Deutsche Nationalbibliothek verzeichnet diese Publikationen in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet unter www.dnb.de abrufbar.

Bibliographic information:
The Deutsche Nationalbibliothek (German National Library) lists this publication in the German National Bibliographie; detailed bibliographic data is available on the Internet at www.dnb.de

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Zitationsvorschlag – *Suggested source citation:*
Weltersbach MS, Lewin W-C, Haase K, Eckardt J, Strehlow HV (2024) 20 Years of Work on Marine Recreational Fisheries at the Thünen Institute of Baltic Sea Fisheries. Braunschweig: Johann Heinrich von Thünen-Institut, 87 p, Thünen Working Paper 234, DOI:10.3220/WP1710484687000

THÜNEN

Thünen Working Paper 234

Herausgeber/Redaktionsanschrift – *Editor/address*
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DOI:10.3220/WP1710484687000
urn:nbn:de:gbv:253-202403-dn067789-4