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# SEAwise Report on fisher behaviour submodels

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# DELIVERABLE 2.5

# Report on fisher behaviour submodels

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| Deliverable 2.5 |
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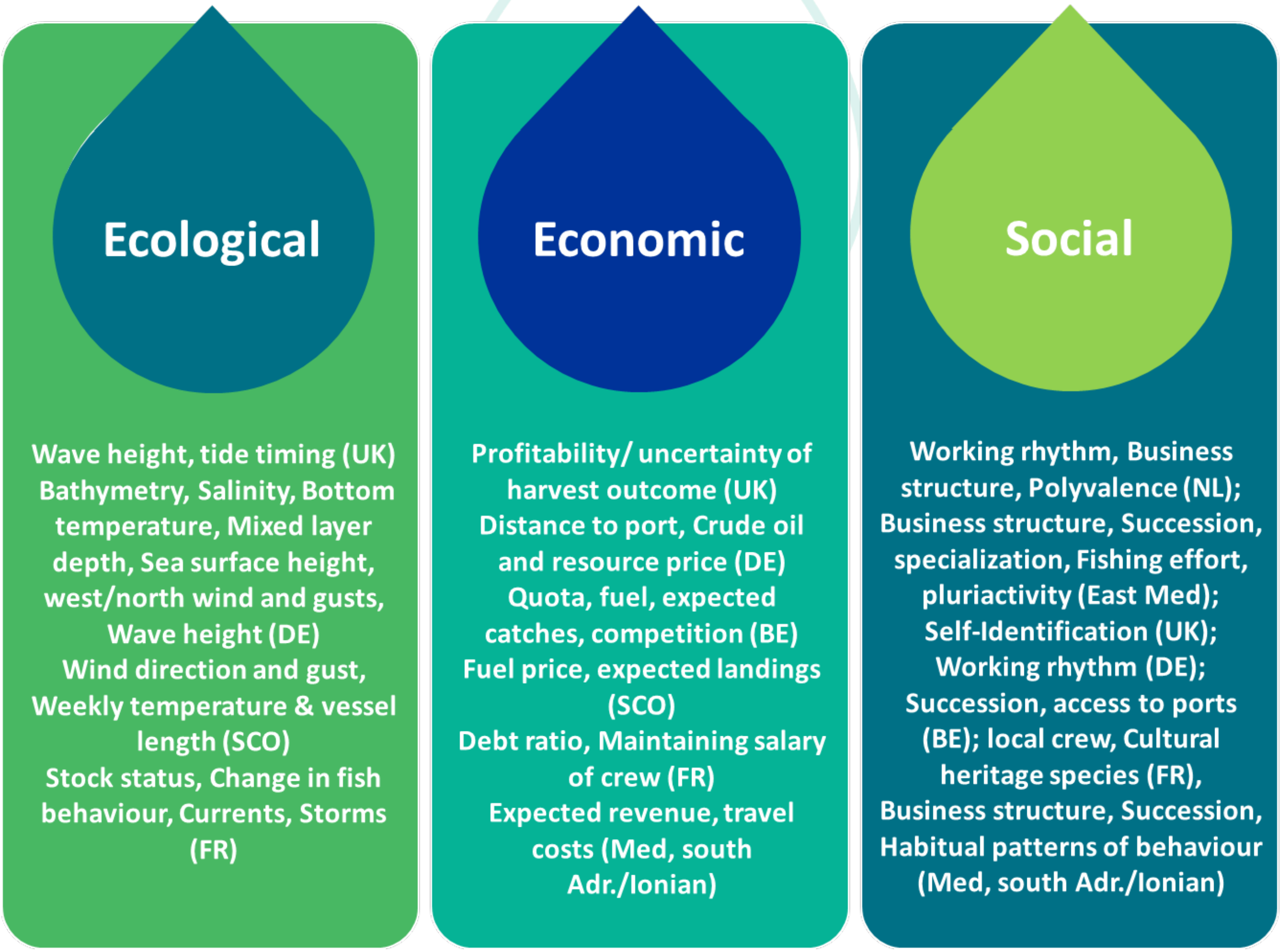
# Executive summary

The SEAwise project works to deliver a fully operational tool that will allow fishers, managers, and policy makers to easily apply Ecosystem Based Fisheries Management (EBFM) in their own fisheries. One of the key uncertainties in fisheries science and management can be linked to (our understanding of) fishers behaviour. In this deliverable we seek to better understand fishers behaviour by assessing literature, interviews and data to advance towards a better representation of fisher behaviour in our modelling. A better understanding of fisher behaviour is especially needed in the context of change affecting Europe's marine ecosystems. Change is both related to the natural part of the ecosystem (i.e. climate change) as to the social side of the ecosystem (i.e. building of windparks).

To that aim we present 9 different case studies in Europe as examples of how fisher behaviour has been studied and which factors are (or can be) relevant for a better understanding of fisher behaviour. Each case study ends with a table summarising the factors influencing behaviour, the categories within that factor and the (potential) application in modelling as well as the implications for management. The table below summarises the factors found / used in the case studies and the elements (social, cultural, ecological, economic and institutional) to which the relate. A variety of social factors were identified that are promising for use in modelling. A key conclusion is that social data are often context dependant and cannot be copy pasted from one situation to the other and in some case, additional data needs to be collected. The cases also demonstrate that mixed methods approaches and interdisciplinary approaches are key to get in-depth of understanding of fisher behaviour in fisheries science.

### Summary of the factors identified in the case studies influencing behaviour in different areas and countries



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# 1. SEAwise background

The SEAwise project works to deliver a fully operational tool that will allow fishers, managers, and policy makers to easily apply Ecosystem Based Fisheries Management (EBFM) in their own fisheries. With the input from advice users, SEAwise identifies and addresses core challenges facing EBFM, creating tools and advice for collaborative management aimed at achieving long-terms goals under environmental change and increasing competition for space. SEAwise operates through four key stages, drawing upon existing management structures and centered on stakeholder input, to create a comprehensive overview of all fisheries interactions in the European Atlantic and Mediterranean. Working with stakeholders, SEAwise acts to:

- Build a network of experts - from fishers to advisory bodies, decision makers and scientists - to identify widely-accepted key priorities and co-design innovative approaches to EBFM.
- Assemble a new knowledge base, drawing upon existing knowledge and new insights from stakeholders and science, to create a comprehensive overview of the social, economic, and ecological interactions of fisheries in the European Atlantic and Mediterranean.
- Develop predictive models, underpinned by the new knowledge base, that allow users to evaluate the potential trade-offs of management decisions, and forecast their long term impacts on the ecosystem.
- Provide practical, ready-for-uptake advice that is resilient to the changing landscapes of environmental change and competition for marine space.

The project links the first ecosystem-scale impact assessment of maritime activities with the welfare of the fished stocks these ecosystems support, enabling a full-circle view of ecosystem effects on fishing productivity in the European Atlantic and Mediterranean. Drawing these links will pave the way for a whole-ecosystem management approach that places fisheries at the heart of ecosystem welfare. In four cross-cutting case studies, each centered on the link between social and economic objectives, target stocks and management at regional scale SEAwise provides:

- Estimates of impacts of management measures and climate change on fisheries, fish and shellfish stocks living close to the bottom, wildlife bycatch, fisheries-related litter and conflicts in the use of marine space in the Mediterranean Sea,
- Integrated EBFM advice on fisheries in the North Sea, and their influence on sensitive species and habitats in the context of ocean warming and offshore renewable energy,
- Estimates of effects of environmental change on recruitment, fish growth, maturity and production in the Western Waters,
- Key priorities for integrating changes in productivity, spatial distribution, and fishers' decision-making in the Baltic Sea to create effective EBFM prediction models.

Each of the four case studies will be directly informed by expert local knowledge and open discussion, allowing the work to remain adaptive to change and responsive to the needs of advice users.

## 1.1 The role of this deliverable

As part of the SEAwise endeavour to advance ecosystem-based fisheries management in EU fisheries we need to understand how fishers will act in response to specific management measures. This requires a better understanding of fisher behaviour, in particular in the context of change affecting Europe's marine ecosystems. Changes in fisher behaviour are related to the natural part of the ecosystem (i.e. climate change) as well as the social side of the ecosystem (i.e. building of windparks). This deliverable describes how fisher behaviour can be defined based on literature, then discusses ways to arrive at a better understanding of fisher behaviour by presenting case study work accross the EU, concluding with a list of factors influencing fisher behaviour that can be taken into account when modelling. This deliverable can be used by participants involved in modelling in tasks 2.2., 5.3 and 5.5 in Seawise. The figure below illustrates the use of this deliverable.

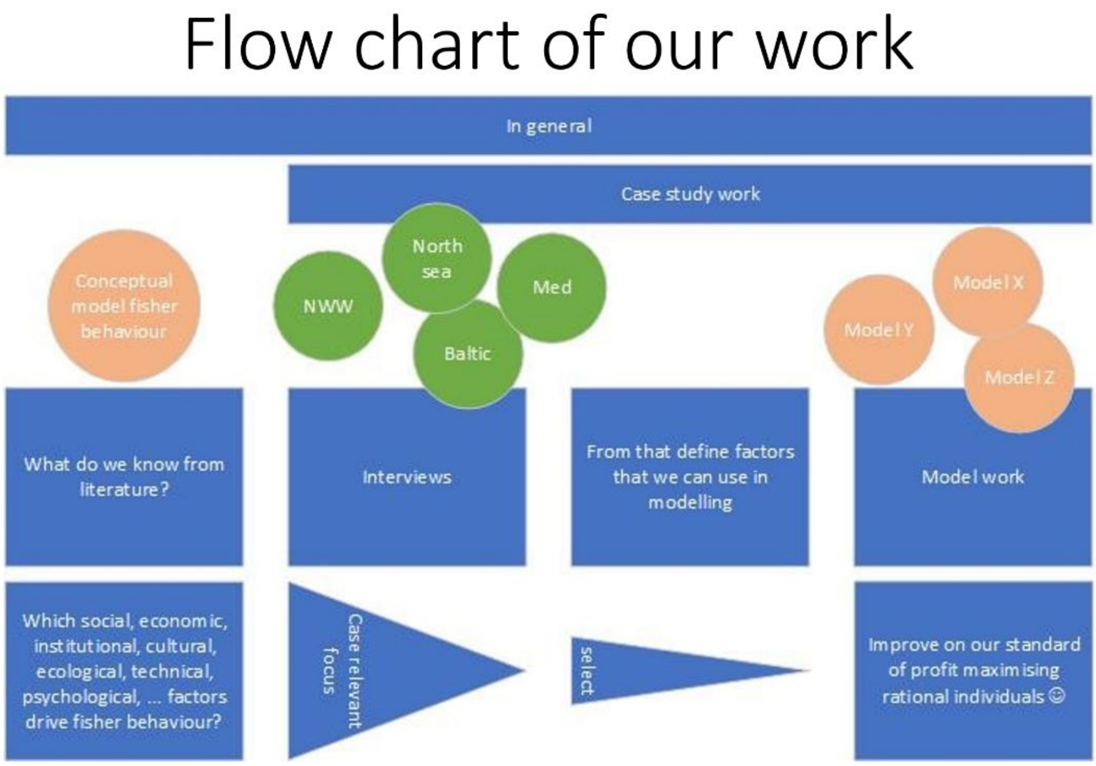


*Figure 1.1.1 Illustration of how this deliverable is produced and how it links to the case studies in Seawise and the modelling in the project.*

## 1.2 Contributors

Marloes Kraan, Isabella Bitetto, Manuel Bellanger, Elliot Brown, Jochen Depestele, Katia Frangoudes, Katell Hamon, Troels Hegland, Sigrid Lehuta, Jonas Letschert, Angelos Liontakis, Tania Mendo, Angela Muench, Simon Northridge, Ellen Pecceu, Maria Teresa Spedicato, Vanessa Stelzenmüller, Klaas Sys and Anna Rindorf

## 1.3 Acronyms and abbreviations

ABM: Agent Based Model

EBFM : Ecosystem Based Fisheries Management

EU: European Union

GSA: Geographical Sub-Areas

MPA: Marine Protected Area

MSE: Management Strategy Evaluation

OWF: Offshore Wind Farm

# 2. How do fishers make decisions? – a key EBFM question

Seawise is about advancing ecosystem-based fisheries management in EU fisheries. One of the important aspects of an EBFM is the understanding that the social and natural parts of the ecosystem are strongly interlinked, and that humans too are part of the ecosystem. Their activities, such as fishing, impact on the ecosystem and are in return also impacted by the ecosystem's natural and social processes. One of the questions central to fisheries management and science is how do fishers make decisions. How do they decide where to fish? With what gear? To catch what? We (scientists) are particularly interested in understanding why do they do what they do. This knowledge is highly relevant for policy to determine how can their activities best be managed to achieve the most sustainable outcomes.

Understanding the drivers of behavior has become more prominent in the context of change. Climate change, political changes (war affecting the oil price, Brexit), societal changes (social license to operate) and the increase of other users of marine ecosystems (such as wind energy) are strongly impacting the opportunities and space available to fisheries. This means that fishing patterns from the past cannot be applied to project what the fleets will do in the future. Having a better understanding of the underlying drivers of behavior is required in order to be able to project future fleet activities and developments.

In addition, there is increased understanding that fisheries science needs to become more inter- multi- and transdisciplinary (Macher et al 2021). Insights from social science (understanding behavior of people and social structures), economics (including behavioural economics) are best combined with insights from biology (fish populations) and ecology (natural part of the ecosystem) to make predictions of where the system can go. In addition, or as part of the scientific methods used, one can make use of stakeholder knowledge, either as research subjects (in social science projects) or as experts (in focused groups or participatory modelling see examples in Steins et al 2020 or Essington et al 2016). Making use of mixed methods strengthens the approach taken.

## 2.1 Reviews

In task 2.1 the Seawise research team performed a systematic literature review (se Deliverable 2.1) amongst others looking at the quantitative variables used in models or indicators to assess the socio-economic impact of fisheries policies (Figure 2.1.1). The most frequently used socio-economic indicators were also assessed (Figure 2.1.2)

*Table 8 Quantitative Variables Identified in T2.1*

| | | | |
|---|---|---|---|
| Average capacity per vessel | Costs (operational) | Gross Operating Surplus (GOS) | Return on Fixed Tangible Assets |
| Average Investments per vessel | Costs (other) | Gross profit | Return on investment |
| Bycatch (volume) | Costs (provision) | Gross tonnage | Revenues (total) |
| Capital costs | Costs (repair & maintenance) | Indirect output value | Revenues per unit of effort (RPUE) |
| Capital value of unit effort (CapPUE) | Costs (total) | Initial Abundance | Sea Surface Salinity (SSS) |
| Cash flow (gross) | Costs (variable) | Labor cost | Sea Surface Temperature (SST) |
| Catch (size) | Discards | Landing probability | Seasonal sea ice extent |
| Catch (volume) | Earnings Before Interest and Taxes (EBIT) | Landings (value) | Social contributions |
| Consumption | Employment on board (crew) | Landings (volume) | Socio-economic data |
| Continental shelf surface | Engine power | Landings per unit Effort | Spawning stock biomass (SSB) |
| Cost of Ice | Escape probability | Length of the fleet | Taxation |
| Cost of sales | Estimated vessel value | Maximum Sustainable Yield (MSY) | Total Investment |
| Cost per unit of fishing effort (CPUE) | Family members | Mean individual weight | Total surface of nursery area |
| Costs (depreciation) | Fish price | Number of vessels | Turnover |
| Costs (fixed) | Fishers age | Profit (gross) | Unspecified |
| | Fishing capacity (Gross Tonnage) | Profit (net) | Value Added (gross) |
| | Fishing Effort (days at sea) | Profit (operating) | Value Added (net) |
| | Fishing gear material | Quota allocation | |
| | Fuel costs | | |

*Figure 2.1.1 Quantitative variables identified in the Seawise review D2.1*

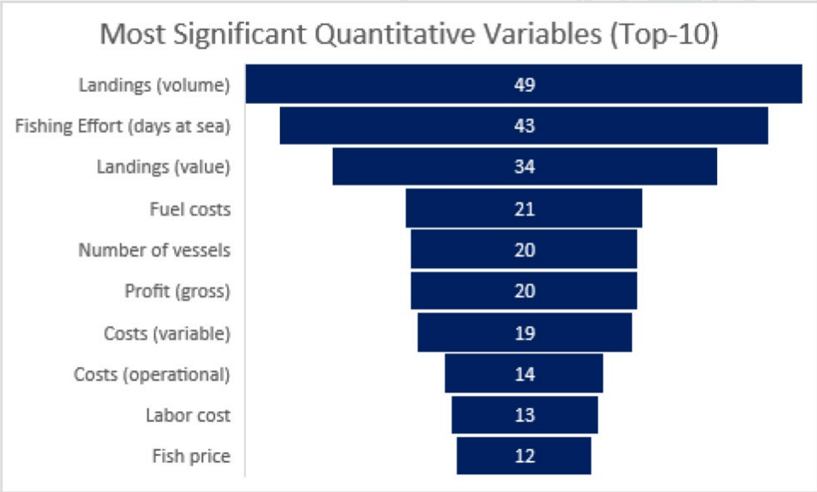


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*Figure 2.1.2 Most frequent used socio-economic indicators identified in the Seawise review D2.1*

In 2012, van Putten et al. (2012) performed a systematic review of studies addressing fisher behaviour and modelling. They identified two key issues in relation to social and economic drivers of behaviour. First, economic factors are 'usually included as a dominant driver in most studies, this is often based on the use of proxy variables for the key economic drivers, for which adequate data are lacking' and second, where economic factors are used in modelling social and social-psychological factors inclusion in fishing fleet dynamic models is still very limited, although many studies 'acknowledge that social and social–psychological factors play a significant role in explaining observed fishing behaviour'(Van Putten et al 2012). From their review, it is clear that a lot can be achieved by also assessing social and institutional factors next to (more!) economic factors. In this deliverable, we will first discuss what fisher behaviour is and how it can be studied. Then we will discuss what factors might help explain fisher behaviour better based on work we have done previously.

The mechanisms identified in this task will be characterized according to the degree to which they are relevant for managers and usable in modelling. Those mechanisms will also be discussed with participants in Tasks 2.2, 5.3 and 5.5 to determine how best to include these in quantitative models. This deliverable is particularly useful as input for deliverable 5.3 (report on fisheries spatial responding to climate etc.).

## 2.2 A better understanding of fisher behaviour

Hilborn pointed out in 1985 that a 'lack of knowledge on fishers behaviour may underlie the failure of fisheries management' (Hilborn in Batsleer, 2016). In his seminal paper on the subject, Hillborn (1985) listed 4 elements which needed to be better understood, three of them related explicitly to fisher decisions (1, 2 and 4):

1) The investment process: why and when do fishers invest in new gear and vessels?
2) Effort allocation: when where and what do fishers fish for?
3) Harvesting efficiencies: how efficient are different gear and vessel types?
4) Discarding: which species are kept and which discarded and why?

Adding to the three decision elements of Hilborn, van Putten et al (2012) identified that the short and long term decisions made by fishers could be divided in 5 categories:

1) short term decisions – which basically is about which fishing capacity is used in practice (where do they fish, when, which species are targeted, what is discarded and compliance related choices)
    a. location choice
    b. discarding
    c. compliance

2) long term decisions – which is about decisions that affect the level of fishing capacity (investment, entry and exit and technological innovation)
    a. exit entry
    b. strategic choices

This division between short term and long term decisions is often dealt with when discussing fisher behaviour. This has also been referred to as tactical (short term) and strategic (long term) behaviours (Christensen and Raakjaer 2006). Choices fishers make during a fishing trip are tactical choices and can include: how long is the haul, do I continue fishing here or move on and how to respond to (changing) weather conditions. Strategic decisions often take place on land, and are for instance about investment choices in vessel, gear and quota, making annual or seasonal fishing plans and finding and keeping crew.

The key drives that should be included in empirical models of fleet dynamics relate to:

1) the characteristics of decisionmakers, from individual fishers to groups of firms, including technical and demographic attributes of the individuals (or group) as well as their motivations;
2) the expected economic outcomes of alternative choices, and the factors that influence these; and
3) the other factors that influence and/or constrain individual (or group) decisions, such as technical and regulatory constraints, or the behaviour of others

(van Putten et al 2012).

## 2.3 Fisher behaviour in models

In fisheries science, we study the impact of fishing on the fish stocks, the ecosystem and what the value is of the landings. Marine biologists perform stock assessments so that they can advise managers how much fish the fishers can sustainably catch. Fisheries are monitored closely which delivers a lot of data that science can use; VMS data shows where fleets operate, catch data show what has been caught and sales data gives the prices that were obtained per species. Fishing fleets have been categorized according to the métiers in which they operate structuring where they fish, what they catch, which fishing gear they use and when they go out fishing (e.g. Biseau and Gondeaux, 1988, Deporte et al., 2012). Marine economists study the costs and revenues of fishing, the trade-offs between short- and long-term business decisions taken and the economic viability of fishing fleets. Together biologists and economists advise policy makers on how to attain sustainably managed fishing fleets whilst conserving fish stocks.

By making use of models, biologists and economists can, in a simplified way, understand the complex world of the ecosystem and fisheries interactions. Models help scientists, by making use of data from the past and assumptions about how the world works, to say something about a possible future. They can evaluate different scenario's (if fishing effort increases, what will happen to this stock in that area), they can test the effect of management measures (what if the mesh size will be increased).

The behaviour of fishing fleets is an important aspect that needs to be explicitly included in models to predict the effect of management measures (Fulton et al 2011). Behaviour can be modeled at different scales; individuals (here the fishers), groups (fleets) or at the population level (the fishery). It is good to realise that 'fishers' (making decisions) is not always a singular unit; they could be skipper owners, but also fleet managers or fisher families (van Putten et al. 2012: 217). At the fishery level, only average or distributional behaviour can be accounted for. While this average behaviour may be enough to understand the pressure of the fishery on the ecological system (e.g. fishing mortality or habitat disturbance), it fails at understanding the tensions in the social system created by differences (in efficiency, access, skills, etc) between individuals. Individuals and (homogenous) groups can best be described using agent based models (ABM). ABMs are commonly used to model individual behaviour with more or less simple rules. ABMs need to be given some behavioural rules and these can be i) rules of thumb that differ based on individual characteristics, 'fisher type x always fishes in area k', ii) optimisation rules e.g. 'fisher will try to optimize profit or landings volume' or iii) discrete decision rules such as random utility models where discrete choices are set using statistical relationships between choices and factors affecting behavior (Girardin et al., 2017).

Regardless of the scale or the type of model used, scientists need to understand the drivers for behaviour. The behaviour of all individual fishers, based on many purposeful choices, norms and habitual behaviour together culminates in what we call fleet dynamics (Hilborn, 1985). In an ideal world we have a thorough understanding of fisher behaviour in all sorts of situations and contexts so that we can predict fleet responses to changing circumstances. In reality we only have observations and data for a limited range of situations, and when the (ecological, economic, political and social) environment is changing, we can rapidly fall outside the range of our observations and we have to make assumptions. In many studies on fisher behaviour, economic considerations are the main driver for choices of fishers (Batsleer 2016, referring to Gordon 1953, Gilles et al 1995, Babcock and Pikitch 2000, Poos et al 2010, Dowling et al 2012).

One of the most popular assumptions (and also one of the biggest clichés) is that fishers are individuals that always act economically rationally and seek to maximise profit: they all want only one thing and that is earn as much money as possible given the biological, economic, physical (repairs needed, weather) and regulatory constraints. Or to put it differently: they trade off costs and benefits to maximise their profits. While economic considerations are necessary (in order for a fishing company to be economically viable they must at least cover their costs), we also know from talking to fishers, observing their behaviour, from social science literature and from behavioural economics that other drivers are also important. Fishers can prefer to have the largest catch (*'meeste kisten aan de wal' – Dutch for 'bringing most crates of fish to the shore'*) instead of the highest profit; fishers can be risk averse and avoid new areas, they can simply do what they always do (personal habits) or always go to the area they know because they have always fished on the grounds 'of their father and grandfather' (family tradition), they can decide not to comply with the rules and do something unexpected (Batsleer 2016). But fisher behaviour can also be driven by social factors not per se related to the amount of catch such as trip duration. For instance, the most traditional part of the Dutch fishery only fishes from Monday to Friday in order to be at church on Sunday (Schadeberg et al 2021).

## 2.4 Theories about human decision making

Besides identifying influential factors, theories for human decision-making are another important pillar of dynamic fisher models, such as ABMs. Potential theories for human behavior are, among others, bounded reality, the theory of planned behavior, habitual learning, prospect theory, and descriptive norm (see Schlüter et al. 2017 for an overview).

From social science literature we know that choices made by people are often a mix of conscious, intended, rational considerations and habits or culturally determined (via norms) value oriented, implicit choices. This also holds true (off course) for fishers, they do things in a certain way, influenced by their familiy, their environment, yet when asked about it they might reflect on their behaviour and present an answer to the question. Fishing is also a habitual practice. Taking into account that (fishing) behaviour is understood as a mix between ('rational') choice and habit, the term 'fishing styles' was introduced by Boonstra and Hentati-Sundberg (2016). This term is based on rural sociology work that looked at farming styles, classifying the diverse ways that people use primary resources. These patterns of use are influenced by the context in which people live and by individual choices they make. It recognised that such patterns of behaviour 'create congruence between normative notions about how fishing should be practiced and fishers' dependence on different social and ecological contexts' (Boonstra and Hentati-Sundberg 2016). Styles are also *shared* ways of doing and thus are influenced by cultural and social factors. Boonstra and Hentati-Sundberg applied the concept to understand the Swedish fleet. Schadeberg et al (2021) used the concept fishing styles to identify social factors that motivate behaviour in the Dutch demersal fleet. The 'fishing styles lense' was used to find such social factors in addition to the often already identified factors such as environment, regulation and economics (see the first case study in section 3 of this deliverable).

# 3. Case studies

## 3.1 Overview

In this section we will provide examples of how fisher behaviour has been studied and which factors are (or can be) relevant for a better understanding of fisher behaviour (Table 3.1.1). The case studies are a mix of work that Seawise researchers have been involved in in the past or work that has been undertaken in Seawise itself. Some case studies will only describe how behavioural factors were found (i.e. Belgian case study) other case studies will also describe how these factors then were modelled (i.e. the Scottish case study). In some cases factors were found by asking fishers (via questionnaires or interviews) (i.e. the Southern Adriatic and Ionian sea case study) in other cases factors were derived from available data via modelling (i.e. the German case study). And some cases used a mixed methods approach of quantitative and qualitative data (i.e. the Dutch case study). All cases will end by providing an overview of: the factors (and in some cases the categories within that factor) found in the case to be influencing behavior of fishers, the application of the factor in modeling and the implications for management of the factor.

Table 3.1.1 Overview of case studies.

| Authors | Case study | Title | Seawise case study area |
|---|---|---|---|
| **Marloes Kraan, Katell Hamon** | Dutch case study | Social factors influencing fisher behaviour in the Dutch demersal fleet | North Sea case |
| **Angelos Liontakis, Vassiliki Vassilipoulos, Vasiliki Sgardeli** | Eastern Ionian Sea (GSA 20) | Factor influencing fishers' behaviour in the Eastern Ionian Sea (GSA 20) | Mediterranean case |
| **Angela Muench** | English case study | Explaining the behaviour of the English inshore fleet | North Sea case |
| **Katia Frangoudes, Manuel Bellanger Sophie Leonardi** | French case study | Understanding the behaviour of French small scale fishers in English Channel/Celtic Sea and Bay of Biscay | Western Waters case |
| **Jonas Letschert, Vanessa Stelzenmüller** | German case study | Defining the socio-ecological niches of demersal North Sea fishing fleets | North Sea case |
| **Ellen Pecceu, Jochen Depestele, Klaas Sys** | Belgian case study | | North Sea case and Western Waters case |
| **Simon Northridge and Tania Mendo** | Scottish case study | Case Study on the Scottish Creel (lobster and crab pots) fishery: identification of drivers affecting the decision to go fishing and where to fish | North Sea case and Western waters case |
| **Isabella Bitetto and Maria Teresa Spedicato** | Southern Adriatic and Ionian Sea | Understanding the behaviour of small and large scale fishers in the southern Adriatic and Ionian Sea | Mediterranean case |
| **Sigrid Lehuta** | French pelagic Fishery case study | | Mediterranean case |

Seawise has case studies in the regions North Sea, North Western Waters, Mediterranean Sea and Baltic Sea. Within these regions different actions are undertaken by the researchers all contributing to eventually a better ecosystem approach to fisheries management. The knowledge derived from the case studies described in this section will be used in the case study work throughout Seawise. Some specific factors are culturally specific (i.e. religious norms in the Dutch case) and can only be used in specific Seawise case study work (in this case the North Sea). Some Seawise cases have a clear link between the case described here ( i.e. the Southern Adriatic and Ionian Sea case) and future modelling in the Seawise case (i.e. the Mediterranean case). Other factors influencing are more generally applicable (i.e. the oil price). The Seawise cases we use different models alongside each other in order to provide both specific knowledge for future modelling and general knowledge for future research.

Figure 3.1.2 demonstrates how two cases described in this deliverable may be useful in modelling work in different Seawise case study areas. Both the Dutch and Belgian case studies will inform modelling in the North Sea. For instance the fleet dynamic modelling that will be linked to OSMOSE (Task 5.5) will be informed by the factors found in these cases. Some of these might also prove to be useful for other modelling exercises that take place in the North Sea case study. But as the Belgian fleet is also active in the North Western Waters, the factors found and the wider understanding in displacement behaviour found in the Belgian case will be useful for the modelling that will take place in the North Western Waters case.

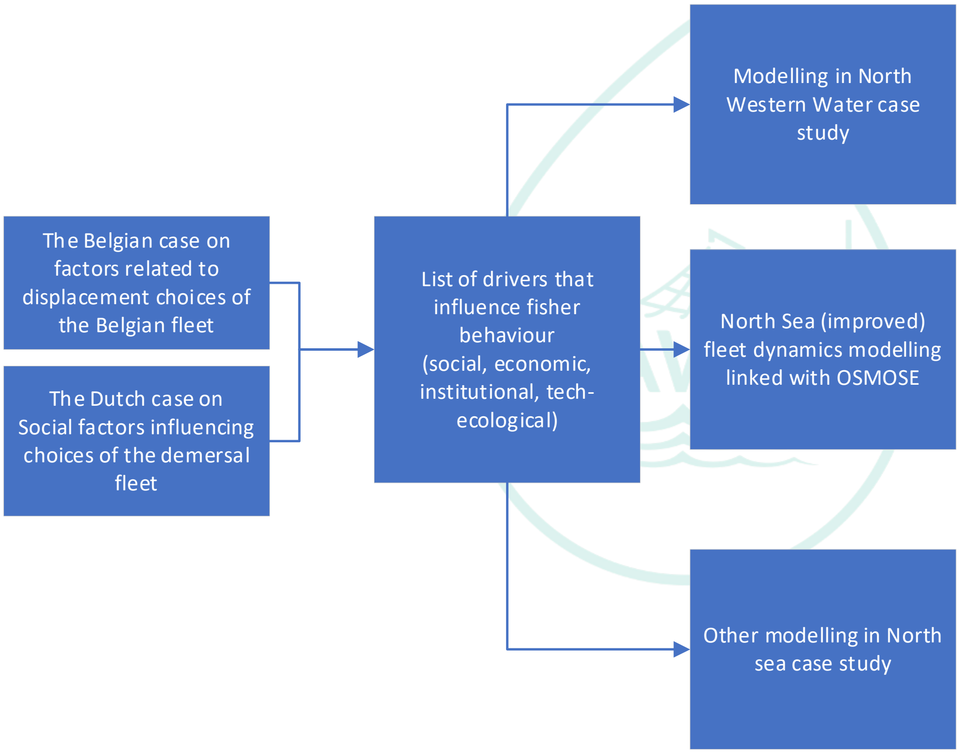


*Figure 3.1.2 Linkages between case studies in this deliverable and modelling in Seawise case study areas*

# 3.2 Social factors influencing fisher behaviour in the Dutch demersal fleet

What is the case about?

This case study is about the social factors that were found in a recent study in the Netherlands to influence behaviour of fishers and explain the heterogeneity of the demersal flatfish fleet (Schadeberg et al 2021). The Dutch demersal fishing sector is experiencing several interacting drivers of change: climate change, the construction of windmill parks in traditional fishing grounds, Brexit, the ban on the pulse fishing technique, and the landing obligation. Recently also the high oil price can be added to this list, but this happened after the case study period of this study. Fishers will change their fishing behaviour to adapt to these changes in circumstances. We identified which social factors matter for the Dutch demersal fleet. These factors were selected by making use of mixed methods (see methods section) and resulted in 3 factors that were stable over time, observable in the data, and relevant to the stakeholders themselves. The social factors are a useful addition to métier analysis. Métier analysis uses logbook data to analyse what fishers do at sea: where they fish, when and with what gear resulting in which landings. They cannot (nor do they claim to) understand why fishers make those choices nor the habitual and normative aspects of behaviour. But also these factors can be known.

Method used

The methods used in this case study was a mix of quantitative (iterative métier analysis) and qualitative (interviews and focused groups) methods (figure 3.2.1 and Schadeberg et al 2021 and the supplementary material available at https://academic.oup.com/icesjms/article/78/4/1530/6207634#supplementary-data).

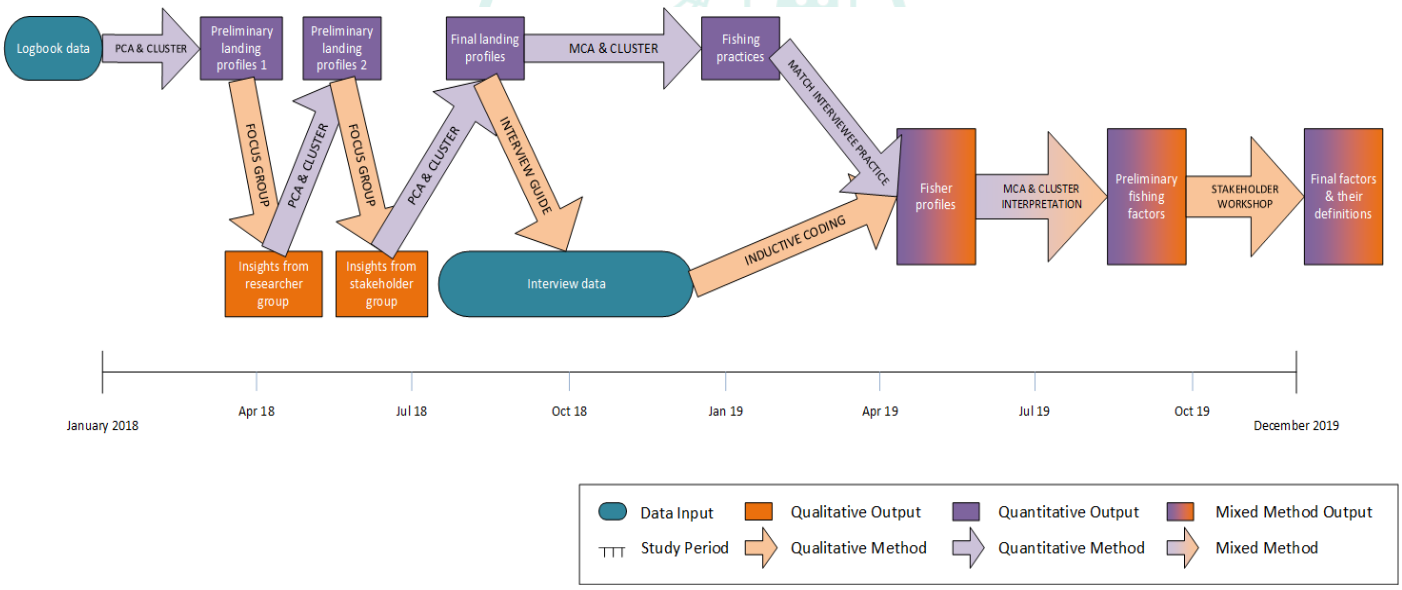


*Figure 3.2.1 Overview of quantitative and qualitative methods used in Schadeberg et al 2021*

Results

The quantitative analysis identified 16 métiers in the whole Dutch fishing fleet. Of those métiers, five clearly captured the activities of the demersal fishing fleet (Table 3.2.1).

After analysing text data from 25 interviews with demersal fishermen we identified three factors that can be used to differentiate different groups of fishers and that drive how they behave.

| Métier code | Métier | Landings per trip (mean kg) | Main Gears (% trips) | Mesh Size (mean mm) | Vessel length (mean m) | Trip length (mean days) | Peak season |
|---|---|---|---|---|---|---|---|
| 1 | Flyshoot | 5,000 | SSC (43) OTB (34) PTB (11) | 87 | 27 | 3 | Summer |
| 2 | Coastal sole | 4,000 | TBB (98) | 77 | 29 | 4 | Spring |
| 3 | 80mm mesh flatfish | 10,000 | TBB (100) | 80 | 41 | 5 | Autumn/winter |
| 4 | Wide range flatfish | 8,000 | TBB (86) OTB (10) | 82 | 37 | 5 | No peak |
| 5 | Mixed gears plaice | 13,000 | TBB (44) OTB (24) SSC (19) OTT (11) | 90 | 34 | 6 | No peak |

SSC: Scottish seine; OTB: otter trawl; OTT: twin trawl; PTB: pair trawl; TBB: beam trawl (incl. adaptations to traditional beam trawls such as pulse trawl and sumwing).

*Table 3.2.1. Description of the demersal metiers of the Dutch fleet from Schadeberg et al 2021*

1) Business structure (family owned vs skipper as employee): Traditionally, fishing in the Netherlands has been conducted by family businesses, where the skipper of the vessel is also the owner (usually in conjunction with his father and/or son). Recently, large fishing companies are acquiring multiple vessels, hiring skippers as employees who have fewer responsibilities than skipper-owners. Decision-making processes are very different for the two skipper roles.

2) Working rythm (works mon-fri vs works wed to wed, on and off): Traditionally, demersal fishers have maintained a weekday fishing rhythm: they go to sea in the early hours of Monday morning and return to auction their catch on Thursday or Friday, leaving the weekend for the crew to rest. Due to changing social norms and economic pressures, some fishers are choosing to work in shifts so that the vessel is continuously operating.

3) Polyvalence (specialist vs switcher): Demersal fishers can operate their business in a manner that specialises in gear, target species, and area (i.e. they use as few fishing practices as possible), or they can operate with some flexibility, changing seasonally or in reaction to market price. Both are currently viable strategies, but result in different behavioural patterns.

| Factor | Categories | Definition & Application in modeling | Implications for management |
|---|---|---|---|
| **Working rythm** | Weekday | The vessel leaves the harbour at midnight on Sunday or on Monday morning and returns before Saturday midday, lying still in the harbour over the weekend<br><br>Some are what fishers refer to as a “good weather fisher”: they do not go out if the weather is very bad, or if there is a holiday period, even though it might be lucrative financially. | These fishers might be more willing to comply with management interventions that use hours or days at sea (rather than quotas or motor power restrictions) as the mechanism to limit effort.<br>Crew is able to maintain social connections within local community every weekend.<br>Skippers of these vessels can potentially increase their fishing effort if they are willing to switch to continuous fishing. |
| | Continuous fishing | The vessel spends less than 24 h in the harbour at a time. There are alternating crews. Fishing trips are longer than a week | These fishers might be more willing to comply with management interventions that use quotas or motor power restrictions (rather than hours or days at sea) as the mechanism. |
| **Business structure** | Owner operator | The owner of the ship is or was the skipper (in the case of a son skippering for a father who has not yet retired) or the skipper has a large ownership stake in the business. There is the expectation of succession (son or other relative coming in as skipper) if possible in the family. Usually one vessel per family, but it can be multiple vessels if operated by sons, brothers, cousins who have an ownership stake (current or future) | These fishers might maintain the fishing business despite failing to satisfy profit-maximization expectations because of the cultural value of the work and its link to their identity, and/or thanks to the “invisible” contributions of non-fisher family members to the profitability of the business (e.g. wives conducting unpaid administration or bookkeeping work).<br>The families of these fishers might be more vulnerable to economic hardship given how concentrated their dependence is on the vessel for income.<br>These fishers might be less inclined to invest in innovations, given the involvement of the past generation of fishers, who might prefer traditional or familiar techniques. |

| | | | |
|---|---|---|---|
| | | | These fishers might have greater contributions to cultural heritage, and therefore might be supported more by their local communities. |
| | Skipper as employee | Skipper(s) are employees, not owners.<br>The company operates two or more vessels, and<br>One or more of the additional Criteria.<br>Fleet manager (not related directly to owner) makes many long-term decisions.<br>Any form of vertical integration (within the company). Large investment capabilities and/or a financial buffer Use of salaries (in place of traditional maatschap payment). | Working as an employee for a company makes it easier for someone who is not the child of a skipperowner to become skipper of a vessel.<br>These fishers are not concerned with the business strategy, and can remain focused on tactical decisions at sea.<br>These fishers have less influence over the selection of crew, gear, fishing area, and even market orientation.<br>These fishers are often directed by fleet managers, who may control or influence several vessels simultaneously in order to maximize the use of available quota within the company. |
| **Polyvalence** | Specialist | 1–3 key target species throughout the year<br>1–2 gear and mesh size combination(s) throughout the year<br>Consistent annual fishing pattern year to year<br>Returning to the same area each season<br>Returning to the same fishing lines (not just areas) | These fishers might flourish in single stock management regimes, where specialization is implicitly encouraged by single-species quotas.<br>These fishers are likely to invest heavily in gear and quota in order to target specific species with specific techniques.<br>These fishers might be less resilient to area closures due to conservation or other uses of the sea such as wind farming. |
| | Switcher | 4+ target species in a year<br>3+ gears or mesh sizes used in a year<br>Non-quota species as target species<br>Visiting unfamiliar fishing grounds | These fishers might flourish in multi-species management regimes, where they can fish for a morediverse range of species.<br>These fishers are likely to have a more diversified portfolio of gears and target species in order to facilitate their switching throughout the year.<br>These fishers might be more resilient to area closures due to conservation or other uses of the sea such as wind farming. |

*Table 3.2.2. Summary of the factors used in the Dutch case influencing behavior, the categories, the application in modeling and the implications for management*

## 3.3 Eastern Mediterranean case study

The fishing sector has a high socioeconomic importance in Greece. It provides income and employment in coastal areas while it is acknowledged as part of their cultural heritage, strongly connected with their culture and traditions. Thereby, the fishing sector is vital for local economies and contributes to the social cohesion of coastal communities (STECF, 2019). In the Eastern Ionian Sea, there are small pelagic fishery operating by seiners and demersal fishery, operating by bottom trawlers (OTB) and the small-scale fishery (SSF). The latter comprising vessels of low capacity (the majority is less than 8-meters length, therefore unable to execute fishing trips far away from the coast), multi-licence coastal vessels exploiting a variety of gears (mainly longlines and gillnets, but also pots and traps.

The Med CS of the SEAwise project focuses on the bottom trawl fishery and the small-scale demersal fishery. In 2020, about 26 OTB vessels and 3000 SSF vessels were active in the eastern Ionian Sea waters (DCF, 2021, SEAwise deliverable 6.9). The demersal fishery catches a varied mix of species (up to 100 commercial species) with European hake (*Merluccius merluccius*), Red mullet (*Mullus barbatus*) and Deep water rose shrimp (*Parapenaeous longirostris*) being the most important stocks, comprising the 25% of total catch and total landings value. Other important stocks are Picarel (*Spicara smaris*), Bogue (*Boops boops*), Octopus (*Octopus vulgaris*), Common pandora (*Pagellus erythrinus*), and Common cuttlefish (*Sepia officinalis*) (Anonymous, 2021). Fishers are not specialised in specific target species, but may be considered as switchers who allocate their fishing effort into different target species and/or gears depending on their availability. The latter is particularly true for the SSF sector (e.g., Politikos et. al., 2022).

The OTB fleet is allowed to operate 8 months per year between October and May (except 24-31 December and 24-31 May) whereas the SSF fleet is allowed to fish all year long (with the exception of a ban on targeted fishing of hake during February). However, the actual days at sea of the SSF fleet are much less (about 140 days, on average) due to seasonalities in fish abundance, the weather conditions, fuel costs, but also due to the fact that for many vessels owners, fishing is not the sole occupation and consequently not the only source of income. The latter is associated with the pluriactivity, the phenomenon where there is a combination of a household's fishing and non-fishing activities. Pluriactivity is a frequent coping strategy for income diversification in rural households (Salmi, 2005), and very common in Greek rural areas (e.g., Liontakis et al., 2020). Therefore, SSF activity is not always a full-time job, it could be a part-time job or even an occasional/seasonal job, especially in summer time, during the peak of the touristic season that skyrockets the demand for fresh fishery products.

Mantziaris et al. (2021), divide the Greek fishing enterprises in two main groups: the family-run and the business-oriented (Figure 3.3.1). This categorisation is based on two indicators; the Average Full-Time Equivalents (FTEs) per crew member and the Average share of Paid labour. Regarding the former indicator, higher values indicate that a fishing enterprise has a higher level of business activity i.e., a business-oriented activity needs to be organised in such a way that full effective use is derived from the available production factors, in this case, the workforce. As for the latter indicator, a higher value also suggests that a fishing enterprise has a higher level of business activity as the fishing operation is too intensive for the required number of working hours to be covered by non-remunerated (usually family) labour. Consequently, the enterprise must recruit paid workers. The analysis indicates that all small-scale fleet segments which use passive fishing gears (HOK: Vessels using hooks; DFN: Drift and/or fixed netters; FPO: Vessels using pots and/or traps) are family-run, as the majority of the engaged crew is unpaid labour, mainly members of the captains' family that work on-board and/or on-shore. In addition, underemployment (i.e., the condition in which members of the labour force are employed at less than full-time) is common.

By contrast, all large-scale segments which use active fishing gears (DTS: Demersal trawlers and PS: Purse seines) are business-oriented. The Greek part of the Mediterranean case study focuses on the three main species of demersal fisheries (*M. merluccius*, *M. barbatus* and *P. longirostris*) and will therefore focus on large-scale segments bottom trawlers associated with a commercial or business model type of fishing activity (e.g., Cashion et al., 2018), while the SSF vessels (netters and longliners) that target *M. merluccius* and *M. barbatus* are associated with self-employed or family-run business (e.g. FAO, 2019).

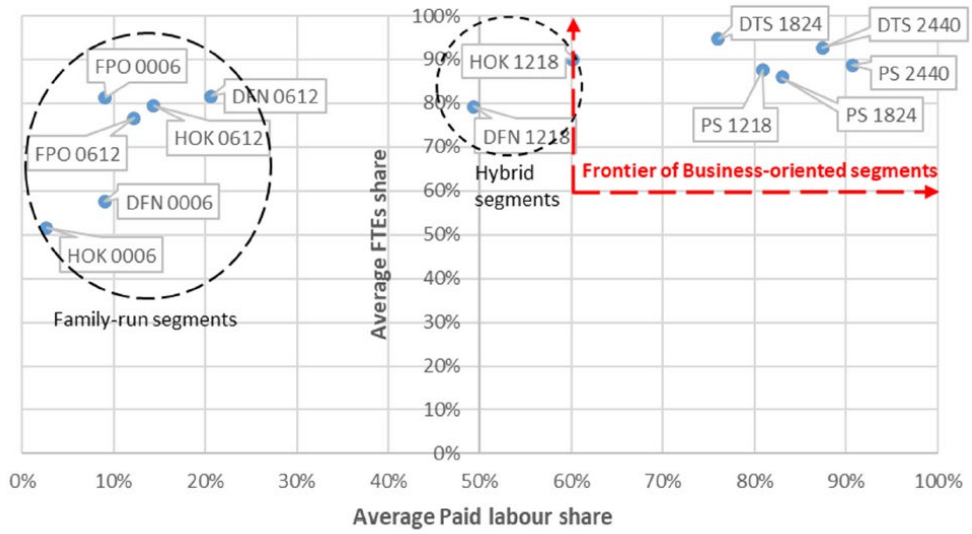


*Figure 3.3.1. Clustering of fleet segments per fishing activity model. Source: Mantziaris et al. (2021).*

The family-run fishing enterprises of the Eastern Ionian Sea SSF sector faces several structural deficiencies, such as the aged vessels with dated equipment and low human capital (Anonymous, 2018). In addition, they are involved in short supply chains as they usually channel their catch directly to consumers, restaurants, and fish shops. In this way, they take advantage of the existing connections with various actors in the local communities, the interpersonal relationships between fishers and locals, and the ability to sell the catch just outside of the vessels, making personal contact with the consumers. These personal relationships create a sense of trust in the customers about the high quality of the catch and are among the significant factors that increase the market price (Mantziaris et al., 2021).

One of the most important issues for the SSF sector in Western Greece (and in the country in general) is the poor level of succession. The number of fishing enterprises are steadily reduced in later years, and this trend is expected to continue in the following years (STECF 2019; STECF 2021). Moreover, the age structure of the fishers highlights the generational renewal issue, an urgent issue around EU primary sector that jeopardizes the evolution of the sector and its future competitiveness and sustainability (Figure 3.3.2, Liontakis et al., 2021).

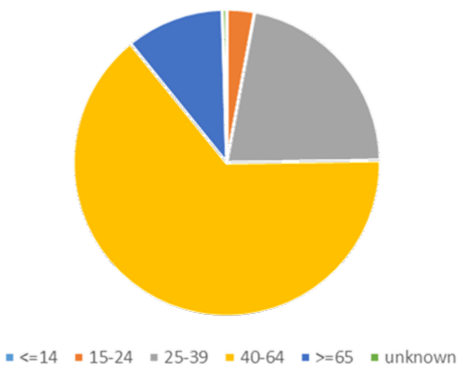


*Figure 3.3.2. Age structure of Greek fishers Source: STECF (2019)*

An important aspect of fishing behaviour is the fishers' level of compliance. In general, willingness to comply with certain management measures (e.g. minimum landing sizes) depends on individual motives and mindsets, shaped by a set of inherent factors (such as trust, knowledge/education, culture, social well-being and other values, see e.g.Treviño et al., 2006). It can be also associated with other factors such as demographic ones (age, education), level of information flow and affect by social norms (see e.g. Thomas et al., 2016, Boonstra, and Sundberg,, 2016; Al-Qartoubi et al, 2020). Although there are no targeted studies regarding this issue in Greece, years of experience from interactions with fishers corroborate the above, and will be further addressed in the field research/questionnaires, which will clarify the potential inclusion of such factors in the behavioral sub-models that will be developed.

There is no existing literature regarding fishers' behaviour classification in the case of the Eastern Ionian Sea (Anonymous, 2022) as for example in Dutch fisheries. Therefore, there is no a priori information that may be used to perform a principal component or a cluster analysis to identify main types of fishers. The field research (face-to-face-interviews with a semi-structured questionnaire) under the framework of WP2 will improve this situation.

| Factor | Categories | Definition & Application in modeling | Implications for management |
|---|---|---|---|
| **Business Structure (based on Mantziaris et al., 2021)** | Family-run | This category includes fishers that utilize family-owned capital (including vessels) and labour to run the family business. The majority of the engaged crew in Greek small-scale fisheries (SSF) is under unpaid labour, mainly members of the captains' family that work on-board and/or on-shore.<br>Underemployment (i.e. the condition in which members of the labour force are employed at less than full-time) is usual in this type of business. Usually, this type of business structure refers to small-scale fisheries.<br>Frequently, the family usually owns one vessel, but there are few cases with more (in most of the cases less than 5) (STECF, 2021) | A big impediment related to tracking fishing activity of those vessels is the fact that they do not have VMS equipment as most of them are smaller than 8m.<br>Determining the fishing activity model could assist fisheries management, policies, and governance to fully acknowledge their roles and contributions to society (Mantziaris et al., 2021), and a number of proxies are usually used (e.g., Kavvadas et al., 2015).<br>These fishers don't aim at profit maximization but rather at family income maximization (returns of family-owned factors of production i.e. profit plus unpaid labour plus opportunity cost of capital) (e.g. Sgardeli et al., 2022). This will be taken into consideration in the FLBEIA model in WP6. They are less willing to invest in new technologies and innovations, given the involvement of the past generation of fishers but also the economic shortage and the low access to credit (the minimization of implicit costs can be also considered as a possible target of fishers in this group).<br>These fishers might have greater contributions to cultural heritage, and therefore might be supported more by their local communities but also EU-driven policies related also to diversification options. Following Boonstra and Sundberg (2016) and Schadeberg et al. (2021), the compliance of the fishers that belong in this category is more possible when it is based on economic incentives and community-based management (i.e. co-management). |
| | Business-oriented | Those are the vessels of medium scale fisheries and in the case of the Seawise study, the bottom trawlers (OTB). Skipper is usually included in the payroll even if they are owners. Investments are larger than family-run type and, in general, fishing enterprise operation corresponds to the typical business-oriented model. | Following Boonstra and Sundberg (2016) and Schadeberg et al., (2021), but also fishers knowledge, the compliance of the fishers that belong in this category is more possible when it is based on economic incentives and more effective enforcement. |
| **Succession prospect** | Yes/No | The variable will be collected through the interviews using a binary question (Yes/No).<br>A possible (but still under discussion) way to utilize succession prospect in the model is to include it as a variable that | Succession often has a positive impact on the performance of social and environmental responsibilities of family firms (Baily et al., 2022), partly due to the fact that taking social responsibility can improve the legitimacy of successors (Dou et al., 2020). Assuming that |

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| | | improves the level of fishers' compliance to the management plans. This variable is going to be determined by the correlation of succession prospect and level of compliance that will be estimated by the questionnaires. | the above fact also holds in fisheries, we consider that succession prospect affect fisher behavior by increasing their social and environmental responsibility and consequently their interest on the sustainability of the social-economic system of fisheries and hence their willingness to comply with potential management plans that focus on sustainability. |
| **Speciali-zation** | Level of Speciali-zation | Specialization levels will be determined through the field research, taking into consideration the existing data sources and the local fisher knowledge. The variables that will be used to determine specialization level include the number of target species, the variety of fishing gears and the characteristics of the fishing trips.<br>The level of specialization can be used to inform behavioural sub-models in Management Strategy evaluation Models (MSE in WP6). | The higher the specialization level, the lower the level of adaptiveness to management measures (e.g. closed areas, catch restrictions for key species). On the contrary, fishers with low specialization (switchers) are more flexible to adjust their strategies regarding their target species, their fishing gears and the fishing grounds they exploit. In general, fishers involved in demersal fisheries exploit the multispecies fishery aggregations with OTBs and SSF gears. Their main aim is for their catches to have more high quality and value species, and less low demand ones (e.g., mackerels) and less discard quantities of no commercial value species. A key issue for OTBs is to avoid hake nursery grounds as due to selectivity constraints of the Med multispecies fishery, hake juveniles may constitute an important part of the catch during the respective part of the year. As for longliners targeting hake, and aiming at large adults the only legal provision refers to the ban on February. During winter months hakes reproduction activity peaks and it is crucial to protect spawners. The above will be tackled within SEAwise. |
| **Fishing Effort** | Full-time/ Part-time/ Occasional fishers | The fishing frequency is strongly connected with economic aspects but also with social ones. Employment opportunities may affect the decision of the fisher how much time to spend on fishing but possibly also other social factors and norms.<br>Full-time fishers are those in OTBs whose income is connected to fishing and spend about one full-time equivalent (1 FTE) in fisheries, while a number of SSF ones are also included in this category.<br>Part-time SSF fishers spend far less than 1 full-time equivalent in fisheries (threshold still need to be determined e.g., 0.75 FTE following Liontakis et al., 2020). They usually own (or work in) smaller vessels, and they often work seasonally. They usually have more occupations and their income is based on a portfolio of jobs. They are a very common case among Greek SSF.<br>Occasional fishers are those that work in fisheries only on specific occasions | Full-time fishers possibly care more about ecosystem and are willing to adapt to new situations if this is in favor of a long-term sustainability of the ecosystem. However, this is only a speculation that should be verified by the field research.<br>For part-time and occasional SSF fishers, it is possible that a change in the regulatory framework (esp. a temporal exclusion) may severely affect their fishing effort. These fishers are also possible to switch a part of their working effort to different occupations (e.g., agriculture or other jobs related to the tertiary sector). The actual implication for fisheries management is yet to be determined after the field research.<br>In any case, determining the fraction of full-time, occasional and part-time fishers is the first step towards incorporating the fishers' behavior with respect to fishing frequency in WP6 models. If such information becomes available, it is foreseen that the effort excreted by these fishers will depend on the management measures in action, e.g., a management measure foreseeing increasing restrictions or effort reduction can lead to |

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| | | (e.g., seasonally). Their work load is far below 0.5 FTE. | withdrawal of part-time and occasional fishers from the fishery.<br>In any case the usefulness of this indicator is yet to be discussed and decided. |
| **Pluriactivity** | Yes/No | Pluariactivty is the phenomenon where there is a combination of a household's fishing and non-fishing activities. It is a frequent coping strategy for income diversification in rural households (Salmi, 2005), and very common in Greece (e.g., Liontakis et al., 2020).<br>The usefulness of this indicator and the exact way to utilize habitual patterns of fishing frequency in the model is yet to be discussed and decided. | The existence of pluriactivity (yes) is possibly coexist with the habitual patters of "part-time" or "occasional" fishers. However, there is a substantial difference is that in the case of pluriactive fishers, switch to other activities (substantial reduction or even drop down fishing activity) seems to be an easier choice for the fisher. |

*Table 3.3.3. Table summarizing the factors used in the Eastern Mediterranean case influencing behavior, the categories, the application in modeling and the implications for management*

## 3.4 Case Study: Explaining the behaviour of the English inshore fleet.

UK waters are frequently used by various sectors, e.g., fisheries, offshore windfarms, transport and marine aggregates. Nevertheless, the UK government is currently committed to increase offshore wind energy generation from around 10 GW of current capacity up to 50GW by 2030, as set out in the British Energy Security Strategy, with further ambitions into the future. Simultaneously, in its 25-year Environment Plan, published in 2018, the UK government has committed to develop a sustainable and profitable fishing sector, while in the '30 by 30' initiative the UK government pledges to protect at least 30% of the global ocean within Marine Protected Areas (MPAs) by 2030. In UK waters, MPA protection has exceeded 30% and, along with other marine management actions, looks towards the ambition to achieve Good Environmental Status under the UK Marine Strategy. As such, it can be expected that spatial conflicts between fishing activity and other economic interest are to increase, which makes spatial planning essential. Within the discussion on spatial planning, the topic of impact of fisheries displacement as well as adaptive capacity of the fishing sector occurs frequently. The question raised in these discussions is whether the fishing sector can adapt to the changes in policy and what consequences these new policies will have consequently on coastal communities dependent on the fishing industry. In the following, three studies are introduced which aim to understand the behaviour of the English inshore fishers.

The English inshore fleet is defined as vessels under 10-meter length predominantly harvesting within 6 nautical miles from shore. In 2020, about 82% of the 2,800 vessels registered in England were part of the inshore fleet which contributed about 12% of total landing values of the English fishing fleet. The lack of economic contribution is related to the lack of quota for demersal species (Davies et al. 2018). As such, most of these fishers are polyvalent in their gear use or are targeting shellfish. Although, this fleet is relatively small regarding landing values, they are seen as big contributors to employment and cultural identity (Anbleyth-Evans and Williams 2018). Due to their sheer number of different vessels operating in different areas, it can be expected that their behaviour is driven by various factors, for example, economic, environmental, or social.

Economic drivers of fishers' behaviour were assessed by Muench & Spence (2020) who updated the location choice model of Hutniczak & Münch (2018) for the UK demersal fleet. This model assumes that the location choice is a function of fishers' individual preference for certainty of the harvesting outcome, his private expectation of revenues at the potential fishing grounds as well as the additional distance the vessel would need to travel to reach the fishing ground. In this model, the fisher learns at each haul about the productivity of the current fishing ground but also transfers this knowledge to the adjacent grounds. However, this knowledge is decaying over space and time and will become common general knowledge if the fisher is not active for some time. Although simplifying the location choice extremely to profitability and uncertainty concerns, the model explained correctly 86% of the location choices when implemented for the Polish demersal fleet. However, applying the same model for the UK demersal fleet, only 43% of the location choices were predicted correctly. This was driven by the larger heterogeneity of fishers' preference for certain outcomes but also the wider variation of target species inherent in the UK demersal fishing fleet. Moreover, about 36% of the fishers in this study reported to only have harvested one fishing ground irrespective of the outcome and whether it is the most profitable option. This lack of adapting their harvest location choice based on previous outcomes could not be modelled in this version of the model. Hence, for these fishers the model proposed by Tidd et al. (2012) or Dépalle et al. (2020) might be more appropriate as they restrict individual past choices as alternatives for harvesting grounds and do not assume learning and adapting as the Hutniczak & Münch (2018) approach does.

Watson et al. (2022) assessed how wave height and tide affect fishers' decision to leave the port. Based on logbook data of the English inshore fleet targeting European seabass, this study focuses on four English ports. The likelihood of leaving port decreased significantly with increased wave height. However, the effects varied between ports. Vessels leaving West Mersea reacted less sensitive to wave height as vessels leaving from Burry Port (strongest decline – Figure 3.4.1 - A). Similarly, while fishers leaving from Weymouth and West Mersea reacted more strongly to time of the first high tide (i.e., large variation between times in Figure 3.4.1B), fishers in the other two ports showed less sensitivity to time of the high tide. These results might be driven by accessibility of the ports and/or by fuel use considerations of the skippers. While fuel prices were part of the study as well as prices of seabass, results were not further reported due to hinting on more complexity with regards to profit considerations of fishers. Port accessibility was not further examined in the study as the study aimed to highlight the local aspects of vulnerability of fishers to extreme weather.

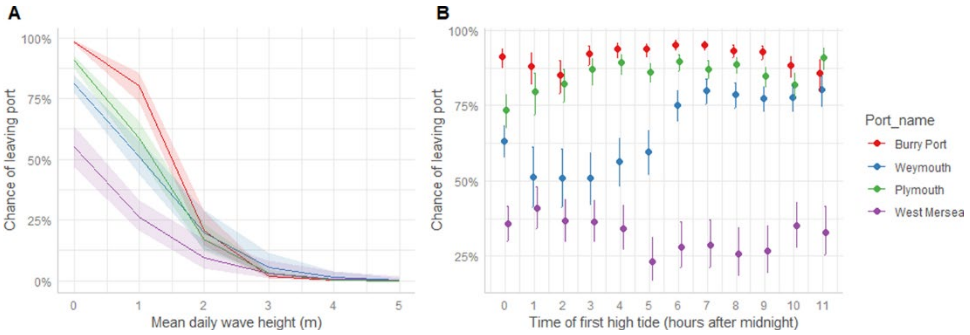



*Figure 3.4.1 Predictors of whether a vessel will leave port from the binary logistic regression. A) mean significant wave height, B) time of first high tide. Bars and bands indicate confidence intervals. For both figures, colours are used to distinguish between ports where Red = Burry port, Blue = Weymouth, Green = Plymouth and Purple = West Mersea.*

While the two studies described above used information as reported by fishers in logbooks or sales notes to infer the potential driver of their decision, Conejo-Watt et al. (2021) used a participatory method instead to shed some lights on social drivers of fishers' behaviour. Conejo-Watt et al. (2021) conducted several workshops with fishers of the English inshore fleet to understand their perception of the feasibility to diversify their income by adding aquaculture practices into their business or harvesting strategy. While Jeffery et al. (2021) compiled examples of fishers who have successfully and unsuccessfully integrated aquaculture practices and technologies into their business, the workshops were used to understand fishers perspectives on the feasibility of such combination of different methods of providing food to the consumer. Applying the Q-sort method in which stakeholders are asked to sort given opinions in a predefined way according to their preferences allowed to identify four different viewpoints: (A) The Traditional Fisher, (B) The Financial Worrier, (C) The Thrill Seeker, and (D) The Inexperienced .

The Traditional Fisher perceived fishing as important to them because it is a family tradition, and they had a strong sense of pride attached to their job. They strongly felt that even with the lack of quota for key stocks, aquaculture is not the long-term solution for the inshore fleet. For these fishers, there seems to be a real sense of cultural tradition deeply rooted in his community that made him reluctant to consider other career paths. Preserving the traditional way of life of fishing was of utmost importance for these fishers.

Although The Thrill Seeker are similar to The Traditional Fisher in that they showed a strong sense of family ties to the occupation, what was most apparent about this fisher was that they loved their job not only due to the family ties, but also due to the sheer enjoyment they gain from wild-capture fishing. They simply love what they do and do not see the point in adopting a new occupation that does not have the same "thrill" to it.

The Financial Worrier and The Inexperienced are rather open to integrate aquaculture into their business but have some concerns with regards to financial constraints and technical knowledge. These groups of fishers seems to have less strong ties to fishing as life style than The Traditional Fisher or The Thrill Seeker, who were rather opposed to the idea of integrating aquaculture into their fishing business. Most of the inshore fishers positive towards aquaculture were targeting shellfish and were familiar with aquaculture practices due the practice of mussel relaying and so the change would be less significant compared to fishers targeting mainly finfish with various gears. However, irrespective of their perspective on the feasibility of aquaculture, a striking result of this study was that most of the fishers taking part in the workshop voiced how important fishing is to them either as being part of a family tradition they want to keep up or based on their self-identification with the occupation fisher. There was talk about "the buzz of fishing", "proud to be a fisherman" or "fishing is a family tradition". Hence, fishing was not seen by the participants as just a job or business but rather a way of living. As such, it can be assumed that a significant proportion of the English inshore fishing fleet will adapt to changes within the limits of the traditions and cultural values they believe in – results similar found by Morgan (2017).

While some of the information gathered in these studies will inform the updated location choice model (Hutniczak & Münch, 2018; Muench & Spence, 2020) for the English fleet, it also informed already a dynamic allocation model of European seabass stock between commercial and recreational fishers (Tidbury et al., 2021). The results of the studies are summarised in Table 3.4.1.

| Factor | Categories | Definition & Application in modeling | Implications for management |
| --- | --- | --- | --- |
| **Profitability/ uncertainty of harvest outcome** | economic | Expected revenue and uncertainty of expected revenues vs additional travel cost driving the location choice of the fisher | Understanding location choices of fishers can inform the potential of displacement within spatial planning processes. |
| **Wave height & time of high tide** | environmental | Some ports are more sensitive to exit/entry under increased wave height, forcing the fisher to adapt and move ports to adapt to future extreme weather | If no measures are taken, some ports will be less likely able to host fisher boats in the future with increasing extreme weather and lower chance of fishers able to leave/enter the port which will impact coastal community employment and culture. |
| **Self-Identification** | Social/cultural norms | Some fishers identify themselves with the job and see it as a way living, hence will adapt as much as possible but will not take up other job opportunities providing them similar lifestyles. Other fishers consider diversification of their income along the supply chain. | If income diversification is a goal to increase financial resilience in the fishing industry, targeted programs are necessary towards the fishers open to diversify |

*Table 3.4.1. Table summarizing the factors used in the UK case influencing behavior, the categories, the application in modeling and the implications for management*

## 3.5 Understanding the behaviour of French small scale fishers in English Channel/Celtic Sea and Bay of Biscay

As part of the Seawise project, French small-scale fishers have been interviewed with the objective to gather Local Ecological Knowledge which can support the implementation of fisheries ecosystem based management. All fishers interviewed belong to the category of small-scale fisheries, vessels under 12m length and practising mainly passive gears. The gears used by the 10 interviewees are lines, targeting mainly European Seabass (*Dicentrarchus labrax*) and Pollack (*Pollachius pollachius*) (n8) and netters (n2), targeting Pollack, European Seabass, Monkfish (*Lophius* spp.), Abalone (*Haliotis tuberculata*) and Crawfish (*Palinurus elephas*)(Table 3.5.1).

| Interview | Type of gear | Targeted species | Number of vessels they own <12m length | Fishing area | Crew members on board | Family business |
|---|---|---|---|---|---|---|
| 1 | Liner | European seabass | 1 | Celtic Sea | No | Yes |
| 2 | Liner | European Seabass<br>Pollack | 1 | Celtic Sea<br>Bay of Biscay | No | Yes |
| 3 | Liner | European Seabass<br>Bluefin Tuna<br>Pollack | 1 | Bay of Biscay<br>Celtic Sea | 2 | Yes |
| 4 | Netter | Monkfish<br>Crawfish<br>Pollack | 1 | Celtic Sea<br>Channel<br>(+12nm) | 3 | Yes |
| 5 | Liner | Pollack | 1 | Channel<br>(+12nm) | No | Yes |
| 6 | Liner | Pollack | 1 | Channel<br>(+12nm) | 2 | Yes |
| 7 | Liner<br>Traps/pots | Pollack<br>Abalone | 2 | Celtic Sea<br>Bay of Biscay | No | Yes |
| 8 | Liner | European Seabass<br>Pollack<br>Red porgy | 1 | Bay of Biscay | No | Yes |
| 9 | Netter | European Seabass<br>Pollack | 1 | Bay of Biscay | No | Yes |
| 10 | Liner/ fish shop | European Seabass<br>Pollack | 1 | Bay of Biscay | 2 | Yes |

*Table 3.5.1: Main characteristics of interviewees (small scale fishers)*

Vessels are operating mainly within the 12nm in Bay of Biscay, Celtic Sea and the English Channel. All vessels are family-owned and the skipper is also the owner of the vessel. Liners are employing one or two crewmembers and netters often work with 3 people, usually originating from the same municipality.

All vessels use the share system to pay their crew, a percentage of vessel income is dedicated to the ownership (often 50%) and the other part (50%) is shared between crew members and skipper(owner).

In this type of vessels, decisions related to the business are taken within the household and often include the wives of fishers. Wives of fishers often sign the loans of the fishing enterprise and have a say in the new investments in the business. The sons or daughters of fishers owning fishing vessels often work on board with their father. This allows them to take over the family vessel, which will be transferred to the child interested in continuing the activity. This is particularly the case of the net fleet.

The liners fleet is divided into 3 main categories:

1. Those practising exclusively lines and diversifying their target species (such as red porgy, bluefin tuna)
2. Those diversifying their activity by using different gears (nets or pots)
3. Those who cannot diversify species and/or gears and own a second vessel that allows them to work during the whole year (abalone fishing by diving, dredge for scallops (*Pecten Maximus*), nets).

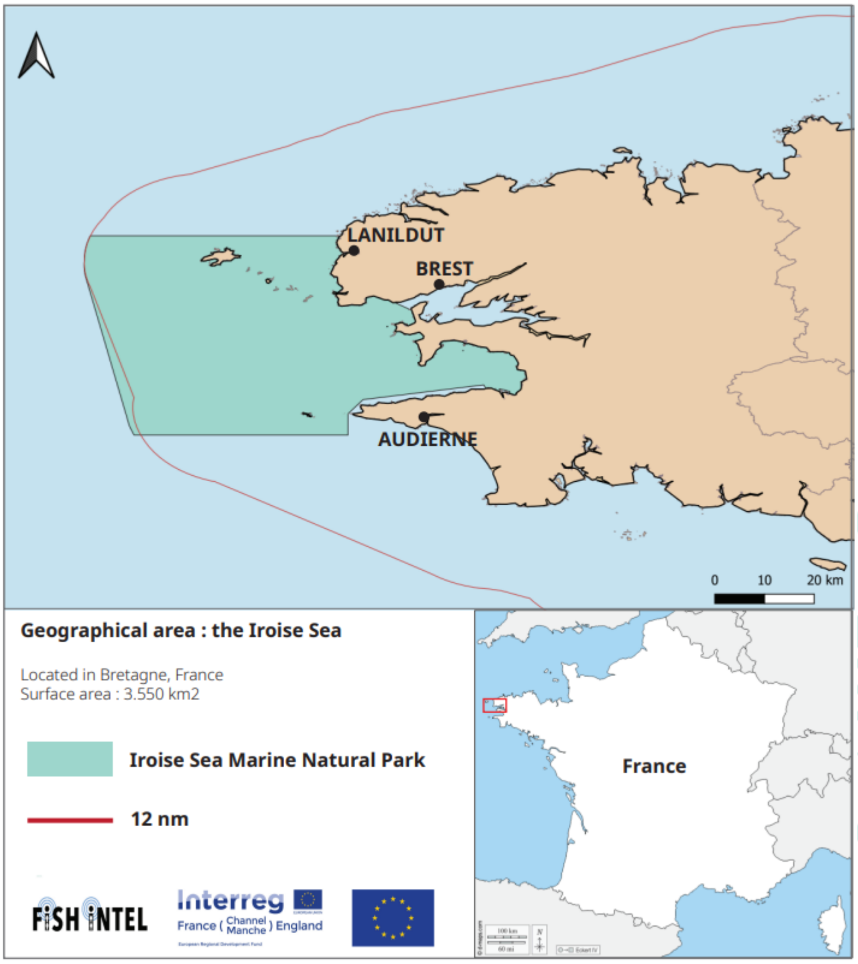



*Figure 3.5.1 Map of case study sites*

**Working rhythm**

Almost all vessels are practising daily fishing from Monday to Saturday morning (direct sale). They are leaving early in the morning and come back around 4pm to land the fish in the local auctions (Audierne and Brest, Figure 3.5.1), where the sale takes place in the afternoon. Auctions are closed on Saturdays and Sundays so that fisher usually do not go fishing on Saturdays or they sell catches directly to customers in the harbour (e.g. in Le Conquet) or at the local market on Sunday.

For this Small-Scale fleet employment of crew during the whole year obliges owners to diversify species, gears and/or to buy a new vessel. During seasonal closures for sea bass and pollack, fishing owners must pay the crew if they want to maintain them. Using other gears and vessels to catch other species during this period is a good strategy. One of the persons who couldn't diversify its activity told us that his crew is working in scallop fishing elsewhere. This year many of the liners used pots to target octopus, a new species in the area.

**Fisher behaviour (long term / short term decisions (tactic, strategic)**

Fishers behavioural choices such as choice of target species, fishing areas and gears have changed due to the lack of resources (seabass and pollack) in the near fishing areas. As an adaptation strategy, some increased the number of targeted species (mainly in Audierne) and continued to be exclusive liners. Others, being entitled to fishing licences allowing them to use other gears (Audierne in Bay of Biscay), have increased the number of gears. This allows them to work year-round, particularly during the seasonal closure of fishing for seabass and pollack.

In the Celtic Sea/English Channel (eg. Le Conquet, Lanidult) as liners didn't have any alternative solution in term of species the only strategy has been to own a second vessel entitled of a fishing license allowing to use other gears (dredge for scallop, pots or nets) or to fish for another target species (eg. Abalone by diving). In the particular case of abalone, the fisher whom would want to dive for Abalone in multiple area's was obliged to buy two vessels to be able to obtain one license for the English/Channel and one for Bay of Biscay as these licenses are granted by the regional fishing committees and are linked to the vessels.

Netters of Le Conquet and Audierne as in other places cannot change fishing areas because each vessel traditionally has its own area and they can't move from one place to another. This type of spatial allocation is transmitted from father to son/daughter and it can be called "informal individual territorial rights".

| Drivers contributing to modification of fishers behaviour | | |
|---|---|---|
| **Ecological** | Local ecosystem changes resulting in an increase or decrease of species in the area, the seasonality of the species, the weather conditions (currents, wind, storms), changes in fish behaviour (lack or presence of food), fishing areas depending of the nature of the seabed (soft or hard), nurseries. | |
| **Economical** | market demand, rate of bank credits (vessel, new engine, etc…), maintaining household standards of living, providing sufficient income to crew members. | *''I had to tell my crew to work elsewhere this winter. If there's no pollack in March or April, what do I do? Usually I give my crew seasonal contracts. I don't even know if I'm going to be able to keep my crew. I have to make a living myself too.'' (liner, North Finistère)*<br><br>*"There are so many credits. Some fishers say " if I don't have this much money coming in each month... I have 800,000 euros in credit". Well, I have my boat, but then I have a 4x4, a house, a chalet in the mountains! They buy everything at the same time ! At 22 years old ! So money has to follow". (netter of Audierne)* |
| **Social** | Maintaining local auctions is another social objective of small-scale fishers (Audierne and Brest) as they benefit of the supply facilities and also maintain local employment. The director of Audierne's auction was very proud to tell us that it was ranked 2nd in terms of price, which was around 8,70€ in 2021. | *''It is a shame what is happening today. Since mid-August we haven't fished any pollack. My crew is paid per share, he made 700 euro of salary in August, and 750 euro of salary in September''. (liner North Finistère)*<br><br>*"I prefer to be on my own. Before there were four people on board, but now I have more freedom. I go fishing when I want to and I don't go when I don't want to, that's it". (liner of Audierne)* |
| **Cultural** | The inhabitants of Bretagne perceive species such as seabass, pollack, crawfish or abalone as part of their natural and cultural heritage. They are part of Breton local identity and are often consumed locally. Pollack is consumed mainly in coastal areas and more particularly in Bretagne. Pollack is a | |

| | |
|---|---|
| | species regulated under the quota system, but which has not yet received the attention of scientists and for which there is very little knowledge about its behaviour. Auctions and selling fish in harbours are also part of the maritime culture heritage (tourist visits are organised in Audierne and Le Conquet, netters are selling fish directly to the consumers at the harbours). |
| **Institutional** | Local fishers' organisations (local fisheries committees in case of Brittany, Regional Fisheries Committees in the case of Normandy) are facing difficulties to solve space conflicts within the SSF fleet and large scale vessels targeting the same species (pelagic or bottom trawls), which are national or from other EU countries (mostly Dutch). The second conflict to be underlined is the opposition between professional and recreational fishers. Brittany is the only region maintaining the local committees (that have been dissolved in the other regions), which are a total of 4 corresponding to each district (Morbihan, Finistère, Côtes d'Armor and Ile-et-Vilaine). The objective is to maintain a better contact and assistance to local fishers. Regional management issues are discussed at local fisheries committees but decisions are taken only by the regional fisheries committees. The National Fisheries Committee takes national decisions, like the regulation of seabass fishing, and in both cases, the authorities representing the state at a regional level validate them. |

*Table 3.5.2 Drivers contributing to modification of fishers behaviour*

**Discussion of key issues resulting from the interviews (Channel and Celtic sea):**

**Perceptions**: The Seabass stock is decreasing (according to the respondents the species modified its route due to changes in food distribution), so it was necessary for the fishers to diversify their activity by targeting others species that are not under a quota system, such as Red Porgy (*Pagrus pagrus*), Octopus or species for which quota is never reached, like Pollack, or even ''new'' species such as Bluefin Tuna (*Thunnus thynnus*) for which only few quotas are available to the liners fleet.

**Seabass**: Past scientific studies and observations showed that the seabass stock of Bay of Biscay and the one of the English Channel are different stocks. Since then, the two regional seas have applied different regulations for this species (mainly size and a seasonal closure). Liners have been following a biological rest closure since 2002, but not the other fleets (pelagic trawl, etc). Recent scientific work (through fish tagging) showed that the stock of the Bay of Biscay and the Western Channel is actually the same stock. Fishers were informed about these results during focus groups and their reactions were very negative and critical towards European policies and underlying scientific work. An important number of fishers (liners) were obliged to change the gear they used or to buy a new vessel to target new species. It becomes urgent for them to re-discuss the stock assessment model at ICES and initiate the revision of the current EU policy for seabass.

The decrease of seabass stock has obliged fishers to diversify their activity and target Pollack, for which France has a large part of the quota. According to fishers the fishing effort (professional and recreational fisheries) increased in the last years, and according to them the stock is now overexploited. Many professional fishers that are dependent on this species for their livelihood demand the implementation of new regulations (legal size of fish for professional fishers, seasonal closure, etc.), and for the regulation of recreational catches. Fisheries committees did not yet take these claims into account and that is because: the quota of these species was never reached; the lack of available scientific data showing the overexploitation of the stock and because pollack is a very local species that is mostly sold locally.

Professional fishers requested the support of the local MPA and local authorities to organise meetings for the two groups. The local fisher's committee of Brest was associated to this process.

Bluefin tuna is seen by professional fishers as an alternative species but for the moment they can't access this stock as there are only few quotas available which are distributed by the regional fisher's organisation on social criteria: priority is given to holders of a license of "exclusive liners" and to the youngest fishers.

| Factor | Categories | Definition & Application in modeling | Implications for management |
|---|---|---|---|
| **Fluctuation of fishing stock** | Stock of target species is abundant<br>Stock of target species is scarce | Choice of fishing location and/or target species | Relevant to determining the number of fishing licenses locally |
| **Change of fish behaviour** | Target species located near the coast<br>Target species located offshore | Choice of fishing location | Relevant to determining the number of fishing licenses locally |
| **Weather conditions** | Current & storms<br><br>Wind direction | Bad weather => no fishing<br><br>Wind direction influences the presence/absence of target species | Possibility of adaptive management (dynamic spatio-temporal closures) |
| **Business and personal debts (vessel, new engine, house, etc…)** | Debt ratio | If debt ratio is high, necessity to earn more continually | Lock-in: fisher who are highly indebted have no choice, they have to continue fishing. |
| **Providing sufficient income to crew members** | Crew salary | Maintaining high enough crew salary requires diversification of target species to include high-valued species that are not under quota restriction, which often requires fishing in new fishing areas further away | Change of fishing area can create conflicts with other fishers |
| **Maintain crew and local employment** | strategies to maintain local and young crew (diversify, pay them during closures) | Fishing strategies are adapted to maintain crew and local auctions | contribute to local employment, maintain local auctions |
| **Cultural heritage species** | Target species are natural cultural heritage species | Local demand is higher for natural cultural heritage species | May create conflicts between commercial and recreational fisheries |

*Table 3.5.3. Summary of the factors used in the French case influencing behavior, the categories, the application in modeling and the implications for management*

## 3.6 German case study

In this case study, we assessed the environmental, economic, and socio-cultural drivers of fishing effort for three German fishing fleets. This research has been submitted to Ocean & Coastal Management (Letschert et al., n.d.)

Research about fisher behaviour progressively considers social and cultural factors in addition to the more conventional environmental and economic drivers. However, empirical methods combining these elements are still rare. With our approach we attend to contribute filling this research gap by applying boosted regression trees (BRT), a supervised machine learning technique, to analyze the spatio-temporal dynamics of fishing effort by using a wealth of explanatory variables. In this case study, we focus on three German North Sea fishing fleets catching mainly (i) brown shrimp (BS), (ii) flatfish such as plaice and sole (FF), and (iii) mixed demersal species (MDS) such as Norway lobster and plaice. Per fleet, we constructed one BRT model with fishing effort as our response variable and the following explaining variables: bottom temperature, salinity, bathymetry, sea surface height, mixed layer depth, significant wave height, wind speeds, sediment types, resource prices, resource quotas, crude oil price, spatial fishing restrictions, weekends, and holidays. Our models were spatially (0.25° Longitude × 0.25° Latitude) and temporally (daily) resolved. We used variable importance (VI) scores to rank the relative importance of explaining variables (Friedman, 2001). Prior to modelling, we added random numbers between 1 and 100 to the models' explaining variables. We then distinguished relevant and irrelevant explaining variables based on whether their VI scores were higher or lower than the VI score of the random number (Soykan et al., 2014).

Oceanographic parameters achieved the highest VI scores across the three fleets, followed by weather, economic, and socio-cultural parameters (Fig 3.6.1). The most important explaining variables were bathymetry, salinity, and bottom temperature. In contrast to the other fleets, fishing effort of the BS fleet was also strongly influenced by distance to port.

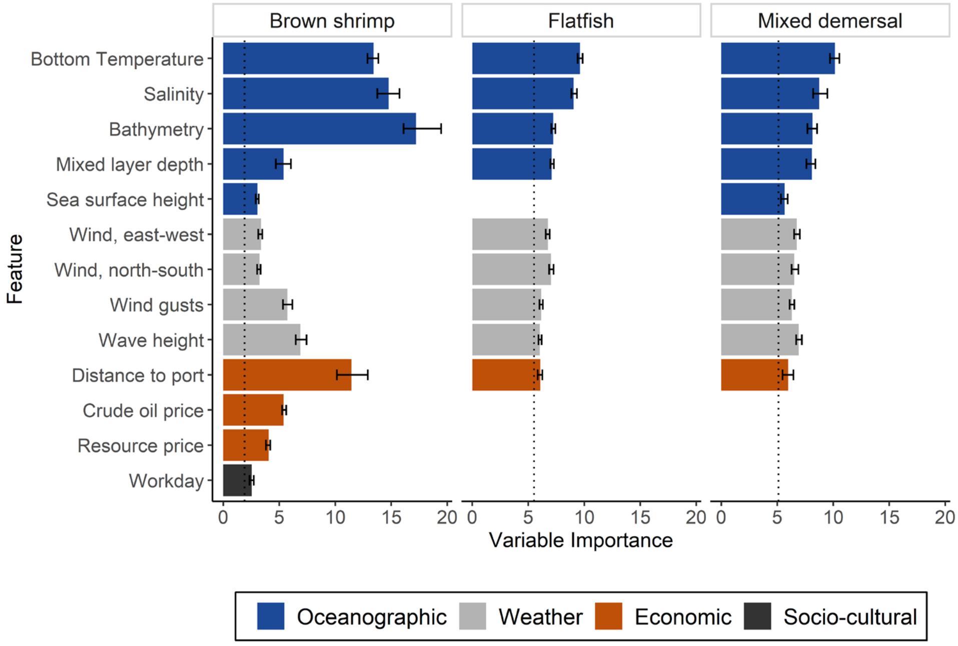



*Figure 3.6.1: Variable Importance (VI) scores for relevant explanatory variables. The dotted line shows the VI score of the random variable, which was used to identify relevant parameters.*

In order to assess the effect of relevant explanatory variables on fishing effort in detail, we used accumulated local effects (ALE) plots (Apley & Zhu, 2016), which display the change of the modelled average fishing effort per interval of the respective explanatory variable. ALE plots showed that fishing effort increased with decreasing depth for the BS and FF fleet, whereas the opposite trend was observed for the MDS fleet (Fig 3.6.2A). Higher bottom temperatures and lower salinities are affiliated with higher fishing effort for all three fleets. In general, the effects of oceanographic variables resemble the ecological niches of the fleets' target species. All fleets were more active when the weather was calmer, revealed by lower ALEs at strong wind gusts and high waves (Fig 3.6.2B). The FF fleet poses an exception, as its average fishing effort is above zero even with high waves. This is likely due to larger vessel sizes in the FF fleet, making them more resistant to storms. The only relevant economic variable for the FF and MDS fleets was distance to port. In comparison, the BS was also affected by resource and fuel price (Fig 3.6.1 & 3.6.2C). Positive average fishing efforts of distance to port represented a gradient among fleets starting with the BS (20km), and followed by the FF (139km), and MDS fleet (175km), suggesting higher coastal dependency of the BS fleet. This goes in line with the environmental requirements of the fleets' target species, as brown shrimp live in shallower waters than flatfishes and Norway lobster. Surprisingly, low resource prices influenced BS fishing effort positively. There are two possible explanations for this, the first being a well-functioning offer and demand dynamics where fish mongers lower the price when the offer is high. The other explanation is a self-imposed fishing effort restriction by fishers to either control price dynamics or simply being satisfied (and stopping to fish) earlier when resources prices are high. With regard to fuel price, the distribution of available data was skewed towards the extremes, suggesting that ALEs between 70$ and 100$ are unreliable. If only oil price ranges with sufficient data are considered, ALEs indicate that low crude oil prices lead to higher BS fishing effort. The BS fleet was the only fleet being affected by the socio-cultural variable workdays, demonstrating that fishers prefer to leave the port on workdays and stay home on weekends and holidays (Fig 3.6.2D).

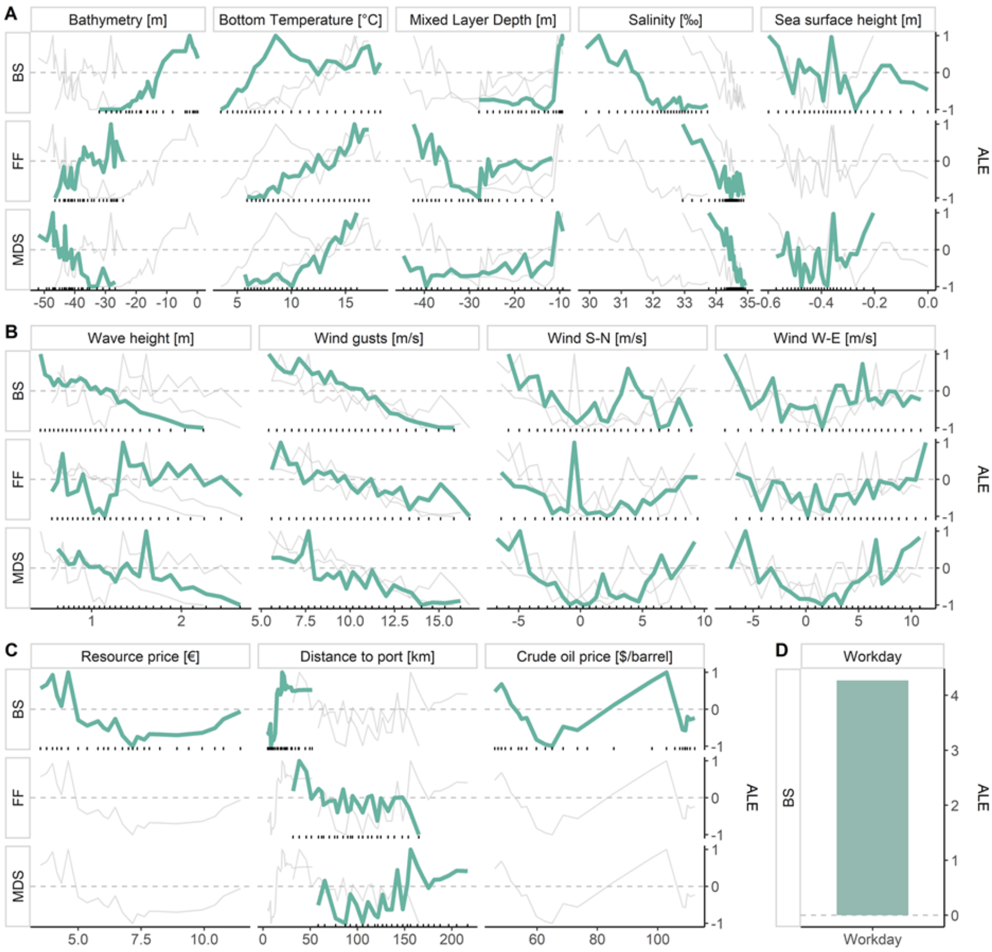



*Figure 3.6.2: Accumulated local effects (ALE) of relevant explanatory variables of the Brown Shrimp (BS), Flatfish (FF), and Mixed Demersal (MDS) fleet. Panels are grouped into oceanographic (A), weather (B), economic (C), and socio-cultural (D) variables. ALE of numeric variables (A-C) are standardized. Dark grey lines represent ALE of the respective fleets, light grey lines relevant ALE of other fleets, and rug plots the distribution of intervals used to calculate the ALE.*

| Categories | Factor | Definition & Application in modeling | Implications for management |
|---|---|---|---|
| **Oceanographic** | Bathymetry<br>Salinity<br>Bottom temperature<br>Mixed layer depth<br>Sea surface height | Oceanographic variables influence the productivity and distribution of target species, which in turn affect the spatio-temporal decision-making of fishers. | Oceanographic parameters are primarily subject to seasonal variations. However, some variables such as bathymetry and salinity are shaped by spatial circumstances. When releasing spatial or temporal fishing restrictions, biophysical “niches” of fleets should be considered to foresee potential displacement and/or concentration of fishing effort. |
| **Weather** | Wind, east-west<br>Wind, north-south<br>Wind gusts<br>Wave height | Stormy weather events restrain the capability of fishers to leave the port. This effect is variable with regard to technical vessel details, i.e. vessel | Similar to the implication of oceanographic factors (see above). |

| | | | |
|---|---|---|---|
| | | size, engine power, and used gear. | |
| **Economic** | Distance to port | The distance from the fishing event to the starting/landing port. The longer this distance is, the more time and fuel it will cost the fisher. | Should be considered when planning spatial fishing restrictions, e.g. nature conservation sites or offshore windfarms. Navigating corridors in windfarms would be an option to mitigate longer steaming distances. |
| | Crude oil price | Directly linked to fishing costs. This factor was only relevant for the brown shrimp fleet. | Increases of fuel prices will directly affect the performance of fishing businesses. Especially small family-owned businesses, e.g. those run by brown shrimp fishers, will be harshly affected from increasing fuel prices. This study was done prior to the recent strong increase of fuel prices. Given the current circumstances, we would expect similar effects for the other fleets as well. |
| | Resource price | Directly linked to the profits of fishing businesses. This factor was only relevant for the brown shrimp fleet. Surprisingly, in our BRT analysis, low brown shrimp prices coincided with higher fishing effort. | For certain species (i.e. brown shrimp), resource prices are regulated by offer- and demand-dynamics. Precautious management should regulate fishing effort when prices are high, so that the resource does not get overfished. In the case of brown shrimp, fishers self-regulate their effort, since there is no quota for brown shrimp. |
| **Socio-cultural** | Workday/holiday/ weekend | Some fishers prefer to be home on weekends and holidays. This factor was only relevant for the brown shrimp fleet. | The importance of being home on weekends and holidays represents a personal norm. These norms should be considered when drafting management plans that have implications on the temporal behavior of fishers. Examples are seasonal closures, which would force fishers to concentrate their fishing effort to a shorter period of time, which might violate their personal norm of only fishing on workdays. Possible consequences could comprise fisher protests, illegal activities, or reduction of fisher profits. |

*Table 3.6.1. Table summarizing the factors used in the German case influencing behavior, the categories, the application in modeling and the implications for management*

## 3.7 Belgian case study

### What is the case about?

The objective of this case study was to describe how Belgian fishers respond when fishing opportunities cease due to other causes than quota restrictions. The questionnaire's objective was more specifically to find out how fishers reallocate fishing effort in space due to (*i*) restricted access, (*ii*) increased fishing efficiency of competitors, and (*iii*) decreased fuel efficiency. We surveyed fishers to understand their perceptions about displacement, trying to understand which choices they make in different contexts of potential displacement, with a spatial extent of the interactions ranging from pan-regional scale (across the NE Atlantic), over regional scale (within stock level) to local scale (localized impacts within the region). This objective was complemented with the deduction of social factors on the choice of fishing locations. Both, the displacement of fishing activities and the identification of social factors affecting displacement is intended as input for fleet modelling, such as the OSMOSE model for the North Sea (to be developed by the WU team). The twofold objective was investigated using a questionnaire that was sent out to Belgian vessel owners.

### Method used

#### *Belgian commercial fishing fleet*

The Belgian commercial fishing fleet consisted of 64 vessels at the end of 2021. This is the same as the number of vessels in 2020 but half of the number of vessels in 2000 (Departement Landbouw en Visserij, 2022). The Belgian fishing fleet decreased sharply in the last decades. Nevertheless, 7 new, modern fishing vessels were introduced last year to replace older, outdated fishing vessels. Although the Belgian fleet is rather small, it operates in a wide region and is subjected to a variety of spatial constraints that affect fishing operations. Belgian fishers operate in the central and southern North Sea, the English Channel, the Celtic Sea, the Irish Sea and the Bay of Biscay. The Belgian's fishing activities consist mainly of beam trawling targeting sole (*Solea solea*) and plaice (*Pleuronectes platessa*). It also engages in shrimp (*Crangon crangon*) fishing, otter trawling and *Nephrops* fishing.

#### *Questionnaire*

The online questionnaire was built around 4 concrete causes of potential displacement: (1) Brexit, (2) Offshore windmill farms (OWF) and marine protected areas (MPAs), (3) competition with Dutch pulse trawlers and (4) increasing fuel prices.

1. Brexit was envisaged as a pan-regional example of reduced fishing opportunities due to a potential loss of fishing grounds and rights for Belgian fisheries. The UK left the EU on 1 January 2021, which implies a transition period of 5.5 years whereby access to the 12 and 200 nm zone of British waters is granted with a gradual reduction (2021-2026) in quota share of EU/Belgium fisheries to the benefit of the UK. Annual negotiations between EU and UK will subsequently follow in later years to discuss access of EU fishing vessels to British waters.
2. Offshore windmill farms (OWF) and marine protected areas (MPAs) in response to the Natura2000 Habitat's Directive were evaluated as sub-regional, local areas which are causing a threat to fishing opportunities through either *de facto* exclusion of fishing activities or envisaged closures for Belgian fishing vessels (De Backer et al., 2019).
3. The competition between Belgian fishing vessels and Dutch pulse trawlers took place over more than a full decade (2009-2021), and was considered as a regional, medium-scale competition of the recent past.
4. The fuel crisis of 2008 and the recently increased fuel prices due to the Russian-Ukrainian war were evaluated as large-scale, pan-regional situations of decreased fishing opportunities in distant fishing grounds. This is particularly relevant for the larger Belgian beamers that cover a vast part of the NE Atlantic and have high fuel use during trawling and steaming. The status of the fish stock and the fish prices by landings composition may counteract high fuel prices, but we did not consider this aspect explicitly.

The questionnaire was structured in such a way that vessel owners only had to fill in the parts of the questionnaire that were applicable. For example, if a vessel owner doesn't fish in the German Bight, these questions didn't have to be answered.

*Analysis*

To gain insights into how fishers reallocate fishing effort in relation to loss of fishing grounds at different spatial scales, competition with other fishers, and increased fuel prices, a descriptive analysis of the questionnaire was performed. This was done by visualizing the responses. To identify potential social drivers, we examined whether the age of the vessel owner, succession, and whether the vessel owners is part of the seafaring crew or not had an impact on how they respond to closures and increased competition.

## Results

The questionnaire was sent out to all Belgian vessel owners of the commercial fishing fleet. There were 29 unique responses of which 15 belong to the large fleet segment (LFS) and 14 to the small fleet segment, consisting of 11 eurocutters and 3 coastal fishers ('restKVS'). Response rate was high for eurocutters and large fishing vessels, but low for coastal fishers (Table 3.7.1).

| Fleet segment | Number of responses | Nr of vessels (2020) | Response rate |
|---|---|---|---|
| LFS | 15 | 32 | 47% |
| Eurocutter | 11 | 13 | 85% |
| | | | |
| 'Rest KVS' | 3 | 21 | 14% |

*Table 3.7.1.1 Response rate of the Belgian commercial fleet to the ILVO SEAwise questionnaire*

## Fishing effort allocation

*Brexit*

From all the respondents, 93% (n=27) have fished in UK waters in the last 5 years and more than 50% of these respondents (n=14) state that they have fished less on UK fishing grounds in the last year (2021). Access to the UK harbours and administration were pointed out as the main causes for reduced fishing in British waters. Other reasons were changes in access regulations to the UK territorial waters (N=3), and less quota (N=1).

We also asked to what extent certain factors play a role in changing fishing activities and the most important factors are 1) available quota, 2) fuel cost, 3) consultation with skipper and crew and 4) choose the same target species in other areas.

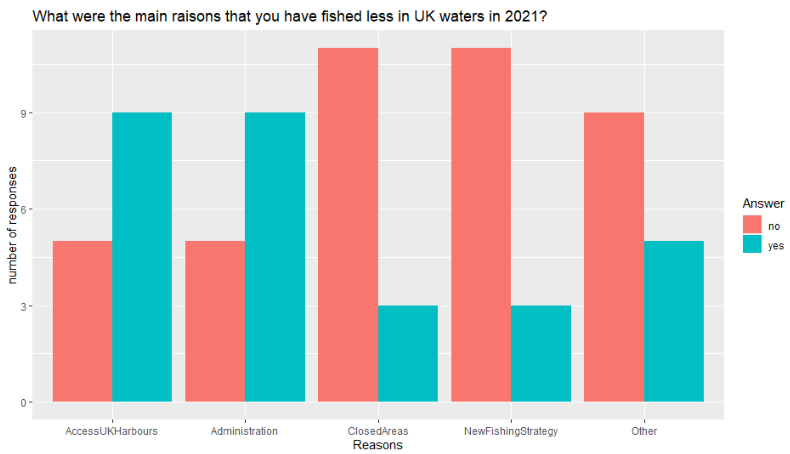



*Figure 3.7.1. Drivers of reduced fishing effort in British waters.*

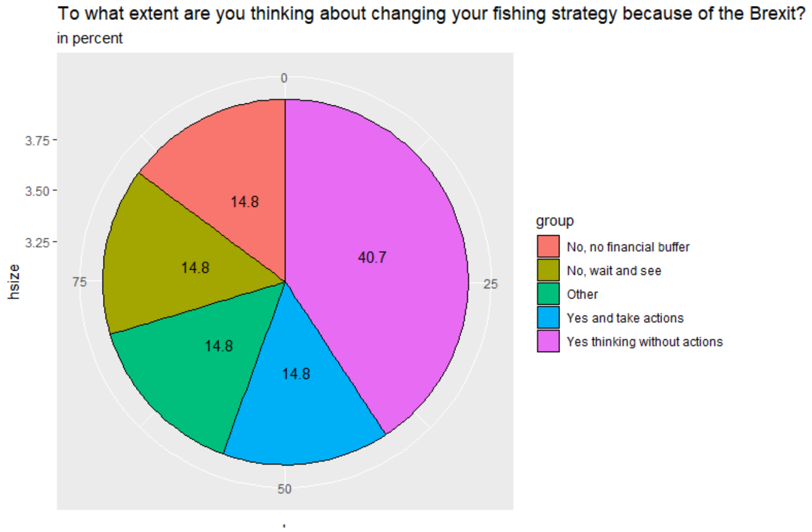



*Figure 3.7.2. Piechart with the responses to the question "To what extent are you thinking about changing your fishing strategy because of the Brexit?" (in percent)*

Over half of the respondents are concerned by the consequences of the Brexit, but are not taking any concrete actions yet. Those that do take action are exploring new fishing grounds, make the vessel polyvalent or are fully focusing on fishing methods which do not take place in British waters, such as shrimp fishing. Those who chose 'other' have already changed their fishing technique in the recent history, choose to stop fishing, or hope that policy makers will come up with solutions.

The Brexit leads to mixed responses in their willingness to invest. Some vessel owners are reluctant to invest, while others attempt accounting for the consequences of the Brexit by investing in polyvalent fishing vessels. The latter is being demonstrated by recent investments in 7 new fishing vessels in the Belgian fleet.

## Small scale closures

### *Existing small scale closures in the German Bight and the Irish Sea*

The vessel owners active in the Irish Sea or in the German Bight responded that they have largely changed their activities as a result of small scale closures (Figure 3.7.3). Most vessel owners (60%) have moved to other fishing grounds within the same ICES area or to other fishing grounds where they have already fished in the past (Figure 3.7.4).

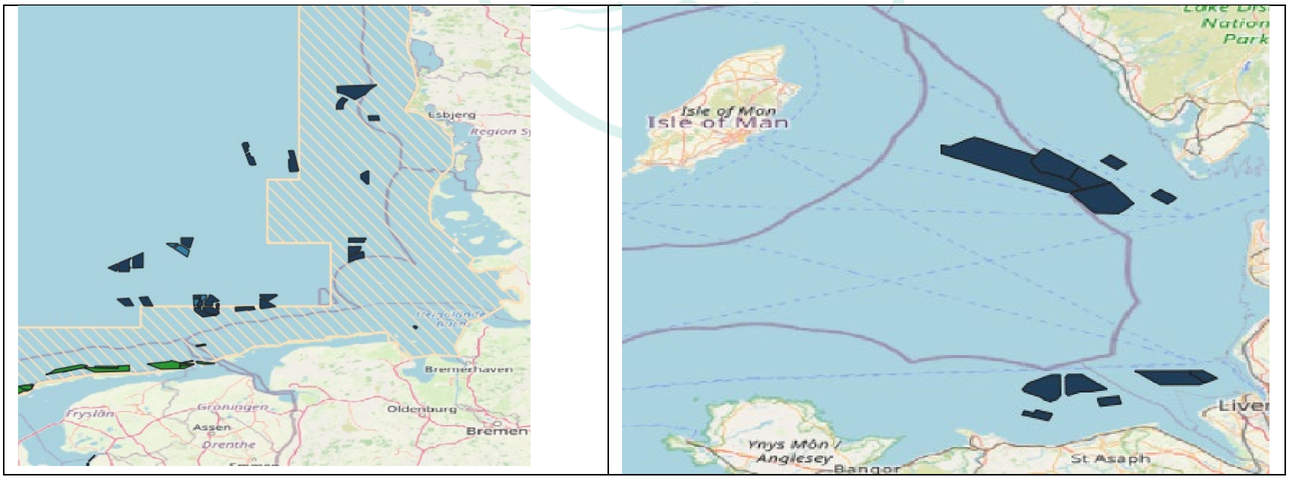



*Figure 3.7.3. Offshore windfarms (blue) and MPAs (green) in the German bight (left) and the Irish Sea (right)*

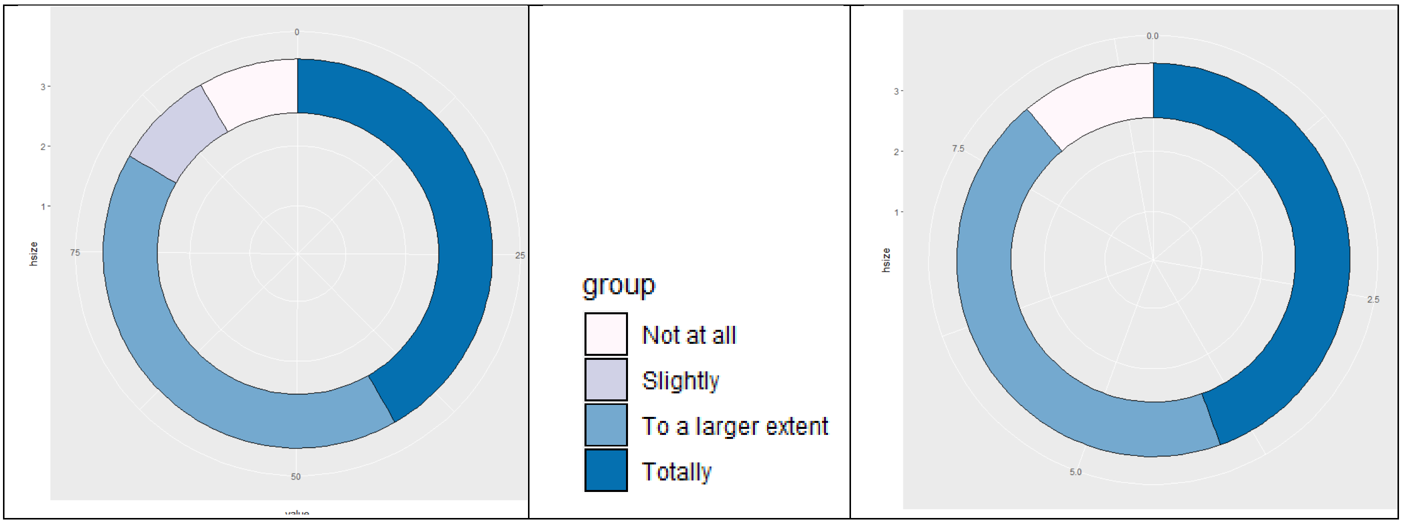



*Figure 3.7.4 To what extent (%) have you changed your activities because of small scale closures? Left: Irish Sea, Right: German Bight.*

The choice of fishing ground depended on the availability of quota, fuel costs, consultation with skipper and crew, similar target species in other regions. These are the same factors that emerged from the consequences of the Brexit.

### *New closures in the future in the Celtic sea and the Irish Sea*

Most of the respondents (70% in the Celtic Sea, 58% in Irish Sea) are not taking any actions yet to change their fishing activities in response to planned closures, but the responses indicated a high degree of discontent of the envisaged plans, as well as the perception that fisheries is not taken into account in government policy.

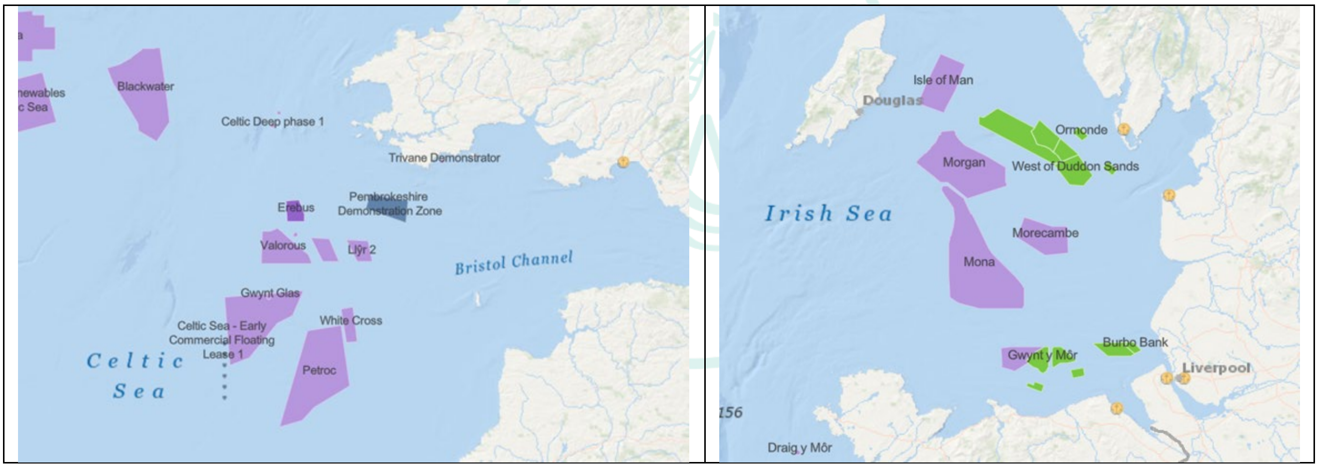



*Figure 3.7.5. planned Offshore Windfarms (OWF, purples) in the Bristol Channel (left panel) and the Irish Sea (right panel)*

| | Celtic Sea | Irish Sea |
|---|---|---|
| No, lack of financial buffer | 35.7 | 41.7 |
| No, wait and see | 35.7 | 16.7 |
| Yes, thinking without taking actions | 28.6 | 16.7 |
| Yes and take actions | 21.4 | 25 |

*Table 3.7.2. To what extent (%) will you change your activities because of planned small scale closures?*

### Pulse

Approximately 75% of the respondents have changed their fishing activities as a result of the high competition with the Dutch pulse fishery (Figure 3.7.6). Most changes implied that fishers started looking for new fishing grounds outside the southern North Sea region (ICES division 27.4.c) or that they searched for alternative fishing grounds within the southern North Sea. One respondent switched fishing gear to cope with the increased competition. The prohibition of pulse fishing in early 2021 did not result in a return of the respondents (>60%) to their original fishing grounds in the SNS. Low catch rates and the occurrence of OWF were identified as the main reasons.

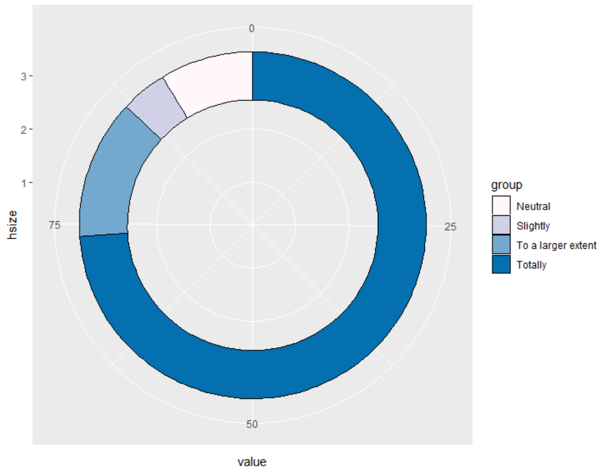



*Figure 3.7.6. Percentage of changes in fishing activity in response to pulse fishing*

## High fuel prices

In the questionnaire, we hypothesise that increased fuel prices may displace fishing activities, but responses did not confirm that increased fuel prices lead to a different choice of fishing grounds. Instead of dislocating their fishing activities, fishers prefer to invest in a technological solution such as fuel-saving gears or fuel-efficient engines. Fishers also modified their steaming and fishing speeds, and altered other aspects of fishing such as longer campaigns and reduced steaming between trips. While priority of those adaptations to increased fuel prices changed over the course of time, none of the top 5 responses in the past, today or in the future highlighted that fuel costs lead to a displacement of fishing activities. Fuel costs were not identified as a main driver of shifting fishing locations from this questionnaire.

| What have you done during fuel crisis in 2008-2009 | What are you currently doing with the increased fuel prices? | What has the most potential to cope with increasing fuel prices in the future? |
|---|---|---|
| **Fuel saving fishing techniques** | Slower steaming (cruise control) | Subsidy |
| **Slower steaming (cruise control)** | Fuel saving fishing techniques | Fuel saving fishing techniques |
| **Slower fishing** | Engine modifications | Slower steaming |
| **Longer campaigns** | Considering temporarily stop fishing | Slower fishing |
| **Less steaming between trips** | Longer trips | Less steaming between trips |

*Table 3.7.3. Top 5 answers of actions taken in response to increased fuel costs*

## Social factors

The questionnaire respondents were male vessel owners with an average age of 52.6 years, the youngest being 44 and the oldest vessel owner 73 years old. More than half of the vessel owners (62%) think that their relatives will take over the business, while 38% have no succession. Most (82.8%) respondents had their father working in the fishing industry as well.

| | Succession | Average age vessel owner | Father in the sector? |
|---|---|---|---|
| **Eurocutter** | 4 | 53 | 10 |
| **LFS** | 9 | 52 | 11 |
| **restKVS** | 2 | 54.3 | 3 |
| **TOTAL** | **51.7%** | **52.6** | **82.7%** |

*Table 3.7.4. Responses on succession, average age and father active in the sector divided per fleet segment*

The majority of responding vessel owners are running small companies with 1 or 2 vessels and they generally join the crew during campaigns at sea (44.8% joins all fishing campaigns, 17% some), while 38% never goes on campaigns.

In this example, we look at whether having succession has an effect on the responses. In case of the Brexit, there are many more vessel owners with succession who are already taking action and thinking about changing their fishing strategy compared to the vessel owners without succession. However, this pattern cannot be found in case of the small-scale closures. This could indicate that succession may influence long term strategical decisions that need to be taken in case of large scale closures, that are considered as a threat for the continuation of the fishery.

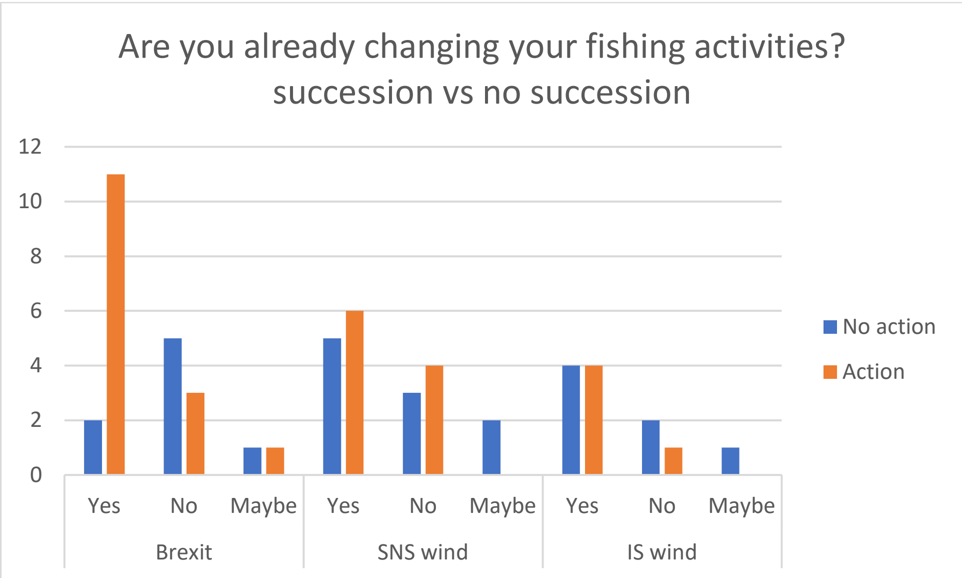



*Figure 3.7.7. In the X-axis for each case the number of vessel owners with or without succession is marked, orange is when the respondents are already changing their fishing activities, blue when they do not take any actions yes.*

There is no clear relationship between the age of the vessel owner and the answers. This may be related to the fact that the majority of the Belgian vessel owners are in the same age range (40-60). There is also no clear link between the fleet segment they belong to or whether they go at sea or not in relationship to displacement.

We also looked at whether there is a relationship between the answers concerning fuel saving and vessel owners that are active fishers or not. No significant differences can be found between these groups based on the questionnaire, although it can be hypothesized that fuel savings are more important when the vessel owners join the fishing vessels since they rather aim at optimizing the profit, while the crew is paid a fixed share of the landed value and is therefore expected to maximize the total value of the landings.

## Discussion and conclusion

All the topics included in the questionnaire affected fishing behaviour of the Belgian fishing fleet, although most of the identified factors referred to economic drivers, notably fishing opportunities (quota), envisaged catches (choice of target species, consultation with the skipper) and fuel costs. The Brexit led to an additional, institutional factor, being logistical constraints and the administrative burden of access to the fishing harbours. Obviously, direct loss of fishing grounds results in an immediate change of fishing location. Nevertheless, it was not entirely clear from the questionnaire why some respondents stay in the same ICES division, and others move to other ICES divisions. We hypothesise that polyvalence of the fishing vessel and access rights are major drivers of this effect. It appears that the degree to which they are flexible has a large impact on the perception of the 'threats' to their current fishing behavior. On the one hand, greater flexibility can be due to having fishing rights in multiple fishing grounds or by having a polyvalent fishing vessel that can deploy different fishing gears (the ability to switch between target species and/or fishing methods). This also reflects on vessel owners who see opportunities to adapt and vessel owners who mainly wait and hope for subsidies or political interference so that they can continue their current fishing activities.

This could be further investigated by accompanying this questionnaire with technical information on the fishing vessels, and by looking at historical fishing patterns of individual vessels based using VMS or logbook data. Alternatively social factors can play a role, such as 'family fishing grounds' or risk behaviour / how adventurous fishers are to explore new grounds. This could be investigated by interviews. There was a clear difference in responses with respect to the spatial scale of the closures and whether vessel owners had succession or not. In case of large spatial closures that are considered as a potential threat for the continuation of the fishery by most fishers, as is the case of the Brexit, vessel owners with succession more often answered to think about what actions they can take to adapt to those new circumstances than vessel owners without succession. From previous research we know that succession affects strategical long term decision making (such as this study on family farms: Schadeberg et al., 2021, Potter and Lobley, 1992).

Our questionnaire did not indicate a spatial change of fishing effort allocation in relation to changing fuel prices. We found that technical changes (i.e. fuel saving fishing techniques, efficient engine) or speed of fishing and steaming are considered more important, and that fishing closer to harbours is hardly seen as a solution to reduce fuel costs. This finding is corroborated by quantitative studies showing that, in response to high fuel prices, vessels reduce the speed during fishing/steaming (Poos et al. 2013). Fishing closer to harbours (Poos et al. 2013, Bastardie et al. 2010) was not found as an important factor in this study, which may be related to the fact that most fishers already fish close to harbours as also indicated in the study of Poos et al. (2013) and as small-scale fishing vessels have more access rights within the three and twelve nautical miles zones.

The major change in fishing effort allocation was found in response to increased competition with the Dutch pulse trawl fleet. This may be related to the fact that the southern part of the North Sea was an important fishing ground for most of the small fleet respondents as it represents the closest fishing grounds to their home harbours. Although competition is hardly highlighted in the literature, our questionnaire identified it as a major cause of fishing effort reallocation of the Belgian fleet in recent years. Nevertheless, it remains difficult to understand the underlying mechanisms of competition. In case of the pulse trawl fleet, Sys et al. (2016) found that interference competition between Belgian beam trawlers and Dutch pulse trawlers was a plausible driver of the fact that Belgian fishers reduced their activity in the southern North Sea. Rijnsdorp et al (2022) corroborated these findings by comparing Dutch pulse trawlers and tickler-chain beamers. Pulse trawlers were more affected by resource depletion, while interference competition contributed more to declining catch rates than resource depletion in tickler-chain beam trawlers.
Yet, alternative mechanisms of competition such as exploitation competition resulting in (local) depletion, or social status (i.e. compare each other's catch) cannot be excluded.

In this study a couple of potential social drivers were tested to see if they have impact on the displacement responses of the respondents: age, succession and ownership. In case of succession, differences were found in strategic decision making regarding large spatial closures. It should be good to state that this study was not specifically designed to identify social drivers but rather to understand responses to spatial management or interactions, and changing economics. These mainly affect short term decision-making that require considerations on a shorter time horizon and are often driven by economics. Furthermore, the Belgian fishing industry consist of a small community, of mostly family owned companies. Most respondents show some similarities like gender, age and company structure (owning 1-2 vessels). As a consequence, contrasts related to social drivers are hard to detect.

## 3.8 Case Study on the Scottish Creel (lobster and crab pots) fishery: identification of drivers affecting the decision to go fishing and where to fish

The decision-making processes involved in small-scale fisheries need to be highly adaptable and varies with individual fishers. Fishers have different preferences and switch tactics by, for instance, selecting different fishing grounds, target species, gear type or even engage in other activities that generate income. Fishers' short-term behaviour is affected by economic, social, cultural, weather and/or ecological factors. In order to manage the fishery effectively we have to understand what motivates fishers to fish in a given manner at any point in time. However, we currently have a limited knowledge of what drives fishers to go fishing or not and this limits our ability to understand and thus effectively manage this dynamic fishery.

To address this concern, a total of 105 creel fishers at 42 Scottish ports were interviewed to identify the main drivers that stopped fishers from going out on a particular day and that made them place their gear in a particular area. These responses were then used to inform a model which explored fisher's behaviour (probability of going fishing) based on several environmental and economic variables, which were then compared with logbook and on-board positional tracking systems.

The most common driver category that stopped fishers from going out on a particular day was bad weather (95.2% of fishermen surveyed), followed by low catch rates (37.1%) and vessel problems (32.4%). Other driver categories mentioned were personal problems (28.6%), economic reasons (14.3%), lack of bait (6.7%), and ground closure (1.0%).

Bad weather included variables such as gust speed, temperature and wind direction which all affect the probability of going fishing on a particular week. Bad weather negatively affects the probability of going fishing but this depends on vessel size, with smaller vessels being more affected by high gust speeds than larger vessels. The probability of going fishing is also affected by the expected landings (higher expected landings leads to greater number of fishing events) and increased fuel prices negatively affect fishing trips.

The probability of going fishing was modelled using a hierarchical Generalised Additive Models (GAMs). Vessel ID was incorporated as a random effect smoother, to account for potential variability between skippers. An interaction between wind direction and area was added as the four geographical areas were subject to different wind directions that were flagged as preventing fisher's from going fishing. An interaction between gust and vessel size was also incorporated, as small vessel size was flagged by fisher's as limiting their operating capabilities under windier weather conditions. To account for additional correlation amongst vessels, a random effect was included.

Further modelling work will be undertaken to better explore the factors, and it is anticipated that this information could inform strategic investment decisions to facilitate transition to a Scottish fleet that is better suited to future weather scenarios.
Relevant economic data on fishing activity can be linked to individual vessels, classes of fishing activity or region, to model what the consequences of different impact scenarios (e.g. changes in fuel price) will be on fishing behaviour.

Furthermore, this type of analysis could identify which actors might be more vulnerable to these changes (e.g. smaller vessels) and could help to inform the scale and equitable distribution of publicly funded compensation for example.

The ability to predict fishing activity, likely success and landings will have implications for markets and logistics support, particularly where complex, costly and time sensitive supply chains may be involved. By capturing and understanding some of the key drivers for fishing behaviour we should be able to provide more robust and timely information to support decision making.

Factors driving decisions of where and when to fish are listed in Table 3.8.1.

| Factor | Categories | Definition & Application in modeling | Implications for management |
|---|---|---|---|
| **weather** | Wind direction | Area specific – more days in a week with wind in the wrong direction, less likelihood of going to sea | Climate change driven changes in wind or changes in wind direction reliability likely to influence number of trips |
| | Weekly temperature | Probability of going to sea increased to 8° but then declined | Climate change may effect likelihood of going to sea |
| | Wind gust & Vessel length | Smaller vessels less likely to go to Sea with high wind gusts | Climate change driven changes in wind or changes in wind direction reliability likely to influence number of trips |
| **Fuel Price** | Fuel price | Higher prices leads to fewer days at sea | Reductions in effort and landings when with fuel price volatility. |
| **Expected landings** | | Increases in expected landings increased likelihood of going to Sea | Changes in management measures and / or stock productivity will affect fishing effort |

*Table 3.8.1 Table summarizing the factors used in the Scottish case influencing behavior, the categories, the application in modeling and the implications for management*

## 3.9 Understanding the behaviour of small and large scale fishers in the southern Adriatic and Ionian Sea

### What is the case about?

This case study aims at identifying the drivers of fishers' behavior in reaction to fishery management measures as well as to other external events like the fuel price increase and the fish market dynamics. The investigation covers both small and large scale fisheries, targeting demersal fish and applying different métier: demersal trawlers (OTB_DES), mixed demersal and deep-water trawlers (OTB_MDD), longlines (LLS) and nets (gillnets and trammel nets).

The study area is subdivided in two Geographical Sub-Areas (GSAs according to the General Fishery Commission for Mediterranean, GFCM): GSA 18 - southern Adriatic Sea - and GSA 19 western Ionian Sea (Figure 3.9.1).

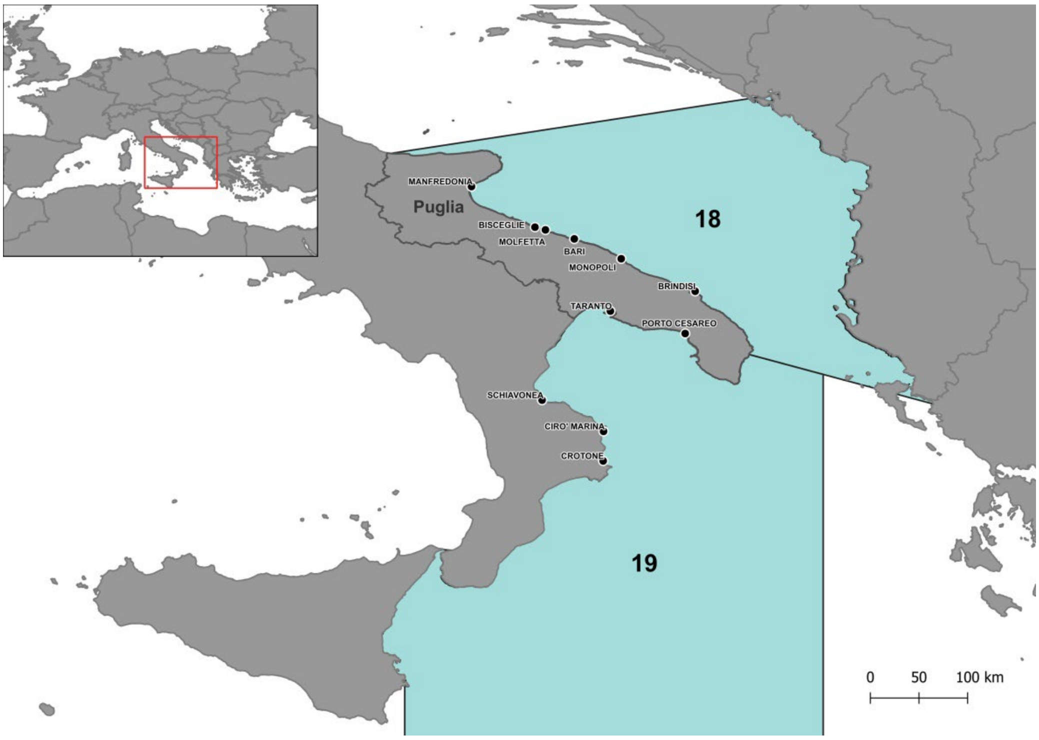
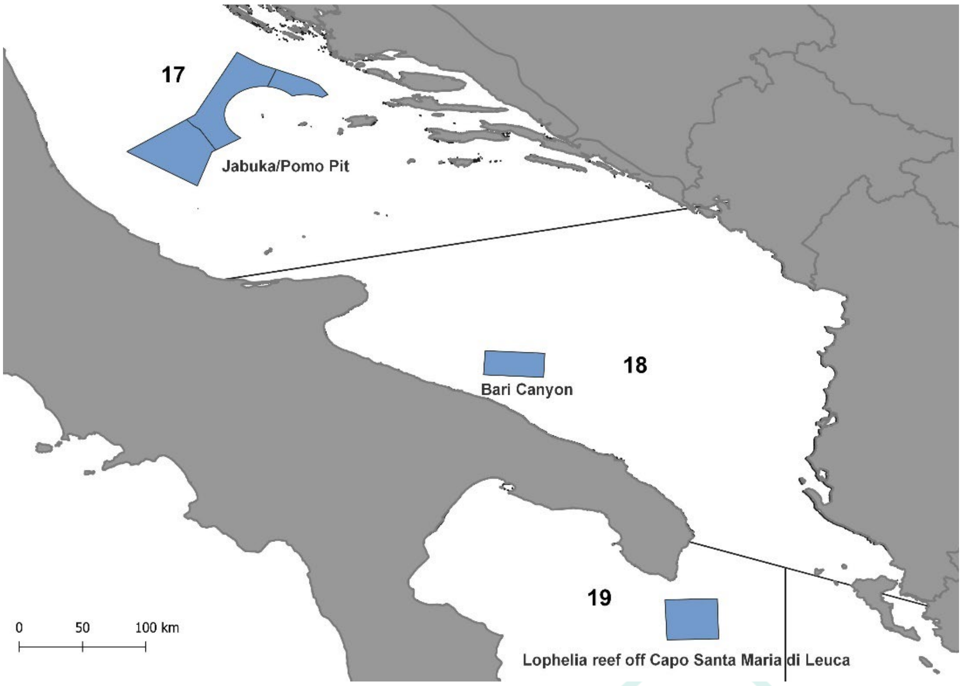



*Figure 3.9.1 Geographical Sub-Areas 18 -southern Adriatic Sea- and 19 -western Ionian Sea; the Puglia region is also indicated as well as the ports covered by the interviews.*

### Method used

In SEAwise, a local survey was conducted using an ad hoc questionnaire (available here) distributed to 52 vessel owners exploiting demersal resources using trawls or long lines or nets (gillnets or trammel nets) as main gear. The questionnaire aim was to collect information on how the fishers react to the management measures, in particular to the institution of Fishery Restricted Areas (FRAs), Natura2000 sites and vessel decommissioning as well as to other external events, as fuel crisis and the availability of workforce. The FRAs considered are located in the Pomo/Jabuka Pit, in Santa Maria di Leuca and in the Bari Canyon (Figure 3.9.2).




*3.9.2 Map showing the FRAs*

During SAMA-18 and SAMA-19 regional projects (SAMA-18, SAMA-19, 2022) interviews to fishers were carried out with the aim to identify the main fishing grounds visited by the fishing operators working in Puglia Region. This information was taken into consideration in this deliverable. During SAMA-18 and SAMA-19 interviewed fishers were required to indicate on a map the areas visited in the four quarters, reporting in the cells the level of frequency of fishing, using a scale from 1 to 3 (1 = much frequently visited, 2= routinely visited, 3 = occasionally visited). This information, available by registration port, main gear and vessel length, can be associated to the habits of visiting fishing grounds even distant from the registration port.

## Results

*Social aspects*

In Table 3.9.1 the number of questionnaires collected during the survey is presented by fishers' age class of and gears used in the GSA 18 and GSA 19. From a social point of view, the interviewed were all fisher*men* (the presence of women did not occur in the sample) between 40 and 60 years old. In almost the totality of the cases, the fishers confirmed to have followed the footsteps of their fathers. Yet only in the 23% of the cases, the fishers said to have a son who intends to continue his father's business. Moreover, almost all fishers highlighted the difficulty to find local workforce.

| GSA | Age range | N° of questionnaire | Main Gear | | | Main Gear | | |
|---|---|---|---|---|---|---|---|---|
| | | | Trawl | Longline | Nets | Trawl | Longline | Nets |
| 18 | 30-40 | 4 | 3 | 1 | | 75% | 25% | |
| 18 | 41-50 | 10 | 8 | 2 | | 80% | 20% | |
| 18 | 51-60 | 16 | 11 | 2 | 3 | 69% | 13% | 19% |
| 18 | 61-70 | 5 | 4 | | 1 | 80% | | 20% |
| 19 | 30-40 | 1 | | | 1 | | | 100% |
| 19 | 41-50 | 7 | 2 | 4 | 1 | 29% | 57% | 14% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **19** | 51-60 | 6 | | 5 | 1 | | 83% | 17% |
| **19** | 61-70 | 3 | 1 | | 2 | 33% | | 67% |

*Table 3.9.1 Coverage of age classes of interviewed fishers and main gears used.*

*Drivers of fisher's behaviour*

As a consequence of the FRAs recently instituted and the Natura2000 sites in the area, fishers indicated the sanctions as the main factor impacting on their fishing strategy, highlighting a general intermediate-high level of compliance with the spatial closure regulation. In both the GSAs, the general answer to the spatial management measures was "to fish the same target species moving to other fishing grounds"; these were selected as much as possible close to the port, considering the impact of the fuel price, which is thus in turn a relevant driver shaping fisher's behavior.

When interviewed on the discard issue, fishers explained they prefer to reduce the amount of unwanted catches by avoiding nursery areas of key stocks in recruitment periods rather than to change the selectivity of their gear. Moreover, they highlighted several difficulties when finding a regulated way to process and dispose the discards at the landing ports.

Regarding the fuel crisis, all fishers indicated that they have changed fishing strategies as a consequence of the increase in fuel price, except the ones using nets; the fishers of smaller trawlers (6-12 m) indicated the reduction of fishing trips and the reduction of the trip duration as strategies applied to reduce the costs. Fishers with bigger vessels (12-24 m) added to these two solutions also the change towards gears/techniques (e.g. to lighten the ground gear) allowing the reduction of fuel consumption (in GSA 18, Figure 3.9.3) . The biggest vessels, finally, enlarged the range of possible options, also including "fishing closer to the port" (in GSA 19, Figure 3.9.4). In some cases, fishers indicated also "Targeting species with a higher market value".

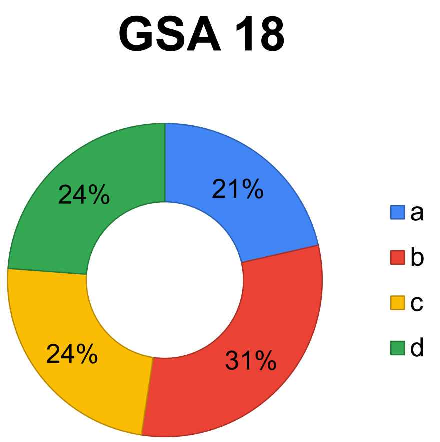



*Figure 3.9.3. Trawlers 12-18 m in GSA 18. Answers to the question on how they react to the fuel price crisis. a) Fishing gear modification, b) Reduction of the number of fishing trips, c) Reduction of the trip duration, d) Other*

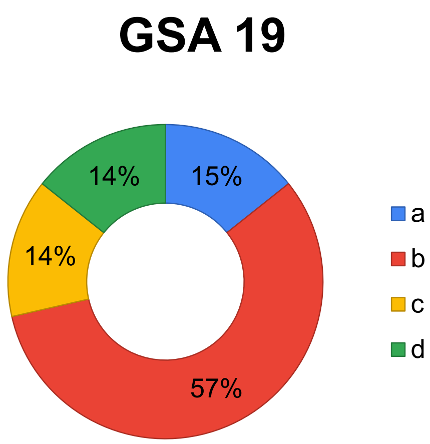



*Figure 3.9.4. Trawlers 12-18 m in GSA 19. Answers to the question on how they react to the fuel price crisis. a) Fishing closer to port; b) Reduction of the trip duration; c) Technical solutions regarding the engine in order to reduce fuel consumption, d) Reduction of the number of fishing trips.*

This survey was complemented using the results of SAMA18 and SAMA19 projects. The results of these sub-regional projects highlighted that the behavior of the fishers in Puglia Region is very different from one port to the other one.

Indeed, the trawlers between 12 and 18 m, registered in Monopoli port (Figure 3.9.5) are used to visit fishing grounds very far from their registration port, followed by vessels located in Molfetta. On the other hand, the vessels of the other ports considered in SAMA project (i.e. Taranto) have the habit to fish more close to the port (Figure

3.9.6).

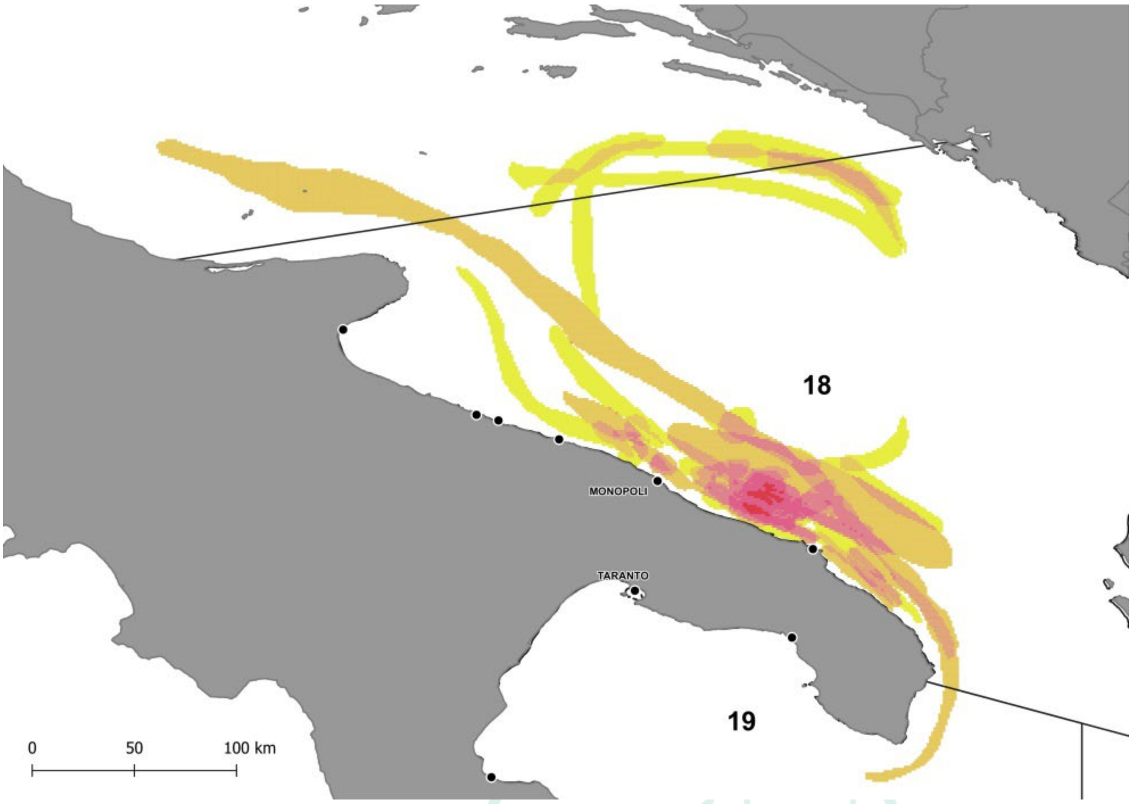



*Figure 3.9.5 Fishing areas indicated by fishers interviewed during SAMA-18 project, owners of trawlers between 12 and 18 m located in the southern ports of the GSA18.*

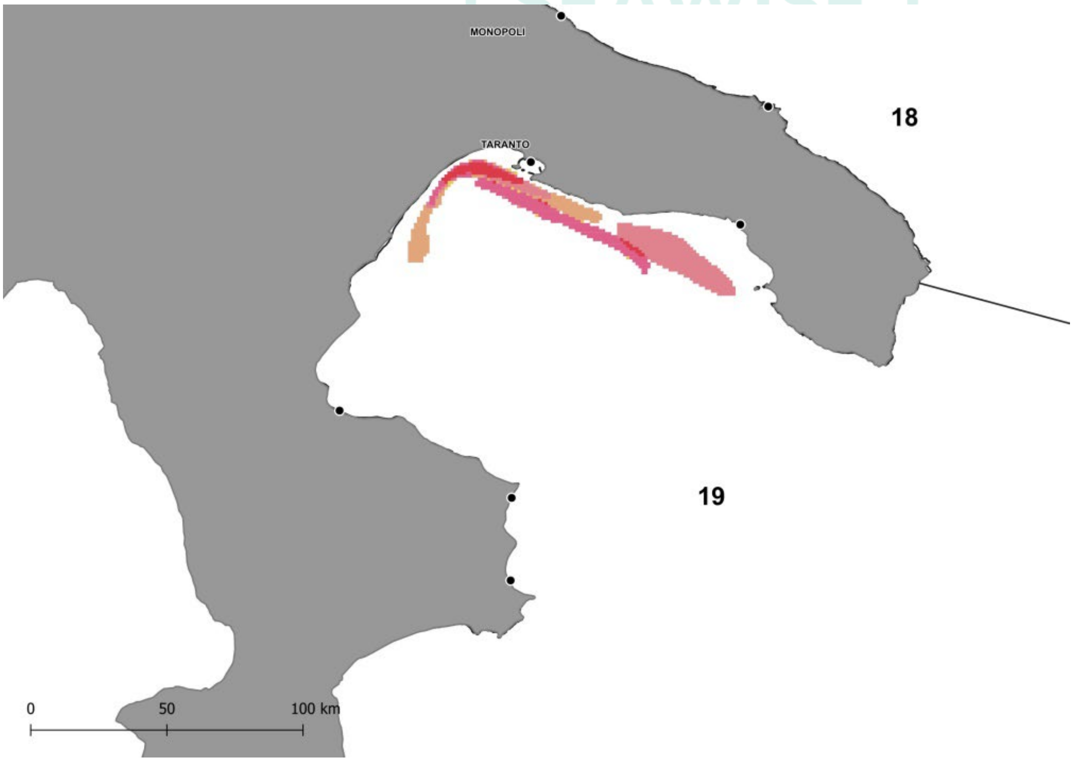



*Figure 3.9.6 Fishing areas indicated by fishers interviewed within SAMA-19 project, owners of trawlers between 12 and 18 m registered.in the northern ports of GSA19.*

| Factor | Categories | Definition & Application in modeling | Implications for management |
|---|---|---|---|
| **Business Structure (based on Mantziaris et al., 2021)** | Family-run | This category includes fishers that utilize family-owned capital (including vessels) and labour to run the family business. Usually, this type of business structure refers to small-scale fisheries, but in this Case study is also referred to trawlers between 18 and 24 m. | These fishers might be less motivated to invest in innovations, given the involvement of the past generation of fishers, who might prefer traditional or familiar techniques.<br>These fishers might have greater contributions to cultural heritage, and therefore might be supported more by their local communities.<br>These fishers could be incline also to self-governance measures. |
| **Succession prospect** | Yes | This variable can be considered as a driver that may affect fisher behavior because it affects the perspective of the enterprise (long-term future vision) and the willingness to invest in capital.<br>*In modelling the fishers behaviour in BEMTOOL model this information could be taken into account acting on the level of investments by fleet segment. The categorization of the fleet segments involved in the case study between "Succession prospect Yes" and "Succession prospect No" can be attempted for this purpose.* | Succession prospect can be considered as a catalyst that increases willingness to invest and switch the perspective of the fisher (from short- to long-term). |
| | No | It is referred to cases where there are no members of the (broader) family who express their willingness to take the business after the retirement of the present owner and therefore the fishing enterprise is going to cease its operation after fisher/skipper retirement | Absence of Succession prospect may relate with less willingness to invest. |
| **Habitual patterns of fishing practices** | Specialist | • Same target species throughout the year<br>• 1 gear (trawler, nets or long lines) and 1 metier throughout the year<br>• Consistent annual fishing pattern from year to year<br><br>According to the information gathered, the fishers working in the study areas decide to fish the same target species in other areas rather than modify their target assemblage. | |
| | Switcher | • Change of the gear;<br>• Visiting unfamiliar fishing grounds;<br>• Change of métier (from OTB_DWS, deep-water trawling, to OTB_DEM, coastal trawling)<br>• Change of fishing grounds<br>• Moving far from the port<br>*The inclusion of this information in BEMTOOL is expected to be done after the categorization of the fleet by fleet segment,* | These fishers might flourish in multi-species management regimes, where they can fish for a more diverse range of species.<br>These fishers are likely to have a diversified portfolio of gears and target species in order to facilitate their switching throughout the year. |

| | | | |
|---|---|---|---|
| | | *main gear, vessel length and port. The fleet dynamic will be modelled differently for the switcher respect to the specialist to mimic the different inclination of the fishers working in the GSAs 18 and 19.* | These fishers might be more resilient to area closures due to conservation or other uses of the sea. |
| **Profitability/ uncertainty of harvest outcome** | Economic | Expected revenue and uncertainty of expected revenues vs additional travel cost driving the location choice of the fisher.<br>*This factor will be included in BEMTOOL through the development of a fleet dynamic spatial component based on revenues and travel costs.* | Understanding location choices of fishers can inform the potential of displacement within spatial planning processes. |
| **Fuel Price** | Economic | Higher prices leads to reduce the days at sea and fish more closer to the registration port.<br>*This factor will be included in BEMTOOL through the development of a fleet dynamic spatial component based on revenues and travel costs.* | Reductions in effort and landings when with fuel price volatility. |

*Table 3.9.2. Table summarizing the factors used in the Med case influencing behavior, the categories, the application in modeling and the implications for management*

## 3.10 French pelagic Fishery case study

Pelagic fleets specifically need to quickly adapt to the fluctuations of the species they target, as well as regulatory and market changes. They have been shown to be less driven by habits and more opportunist than demersal fleets (Girardin et al. 2017). In the Bay of Biscay, the pelagic fleets suffered a severe crisis in 2005-2010 with the closure of the anchovy fishery, leading to an important reorganisation of the fleets, that now heavily depend on sardine. However, the fishery currently faces a new challenge with the diminishing size of sardine and the consequent reduction in market opportunities. In order to support fishers' adaptation, we need to understand and clearly establish the limits of their behavioural flexibility by evidencing the drivers and constraints to which they respond. To do so, two approaches are combined: interviews and statistical modelling. The interviews were conducted along 2020 and serve as an input to the statistical analyses that are still ongoing.

The importance of the time scale of the decision has been highlighted, and therefore the work distinguishes between four time scales: long term decisions, strategic decisions (annual scale), seasonal decisions and short term decisions (fishing trip scale). Within each scale, a list of expected drivers was established based on literature and categorised in six classes: biological resource, market opportunities, production costs, social context, regulation, technical aspects. One open question was asked per time scale about the main drivers of decisions taken into account by the respondent. In order to allow the questionnaire to support more quantitative assessment of the drivers, two strategies were used to complete the open questions: First, the order in which the drivers were cited was recorded assuming that the firsts that came to mind were the most important. Second, if the most expected drivers listed in literature were not mentioned spontaneously by the fisher, he was asked directly about their importance. If the fisher recognised these factors as important although not mentioned in the first place, they will be listed but flagged as afterthought.

The fishery comprises a diversity of fleets, the predominant distinction being the main gear used (pelagic trawl or purse seine), which have first been classified and then studied separately and compared. The fleet segmentation allowed us to stratify the interviews by fleet.  Due to the covid 19 pandemic and consequent lockdown, the number of interviews was limited and we focussed on the two main fleets depending on sardine among the 14 identified. Additionally, we relied on fisher representatives at producer organisations to help us identify the fishers with the most representative activity. Interviews were conducted with three trawlers and five purse seiners, and although this low number calls for precaution in the interpretation, the consistency of responses and the feedback of producer organisations were reassuring about at least its qualitative representativeness.

The results were exhaustively presented in Lahellec et al. (in prep) and summarised here. They confirmed that different factors are accounted for at different scales. Fish availability was mentioned at all scales, but with a different meaning depending on the scale (at annual scale, quotas and global stock level were considered, while local availability on the fishing grounds and catchability were important at trip scale). The main difference across scales related to technical factors (weather, fuel costs) that were drivers of the short term while the long term decisions (entering and staying in the fishery) were driven by social aspects pertaining to life choices, work pace, ethics. The annual scale was judged less relevant because it was mostly a result of decisions made at seasonal scale, which was expected in a seasonal fishery.

Differences appeared between trawlers and purse seiners, that reflected the very different organisation of the fleets and dependency to species. Cooperation is important among the seiners to identify fishing grounds but also because the sector is organised to optimise the market opportunities and distribute them fairly among boats. This explains the importance of social factors at short scale. On the contrary, trawlers work in pair, so social aspects are seen more as a long term driver. Seiners depend mostly on sardine, which does not have quota, so regulatory aspects are negligible. Surprisingly they were also seldom mentioned by trawlers as decision factors but the discussion revealed that these constraints are integrated in their seasonal fishing pattern and now seen as habits. For both fleets, market opportunities were crucial at annual and seasonal scale, but reflected various concerns depending on the fleet.

Indeed seiners, sell sardines to canneries and require high quality, while trawlers deal with a larger panel of species and need to manage the competition with other providers and quality is of lower interest.

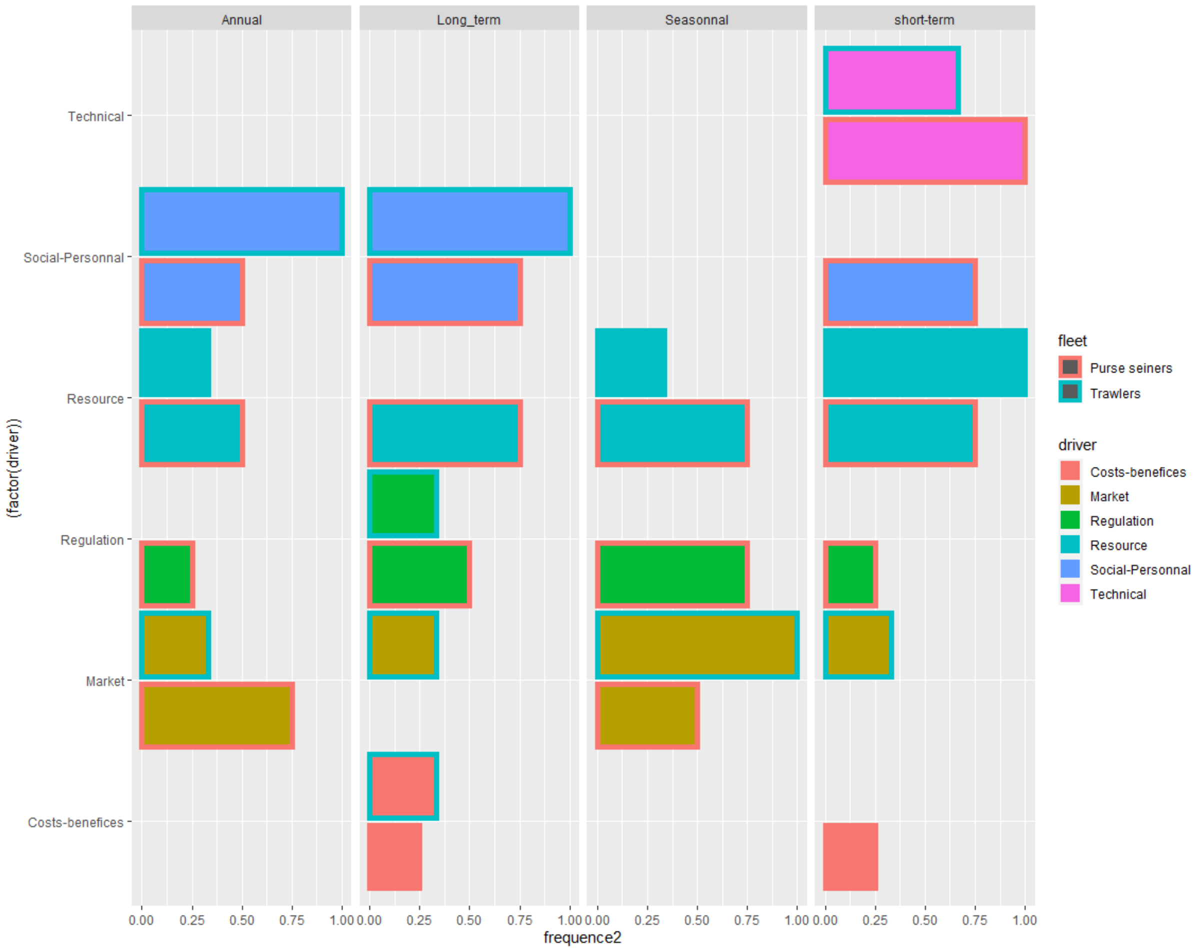



*Figure 3.10.1: survey results showing the frequency at which each category of drivers was mentioned by fishers for the different time scales.*

The study demonstrated that the drivers also differed a lot depending on the target species, because they show very different biological, economic and regulatory status. However, the survey was not designed in a way that allowed these differences to be recorded and rigorously analysed. Another limit lied in the correlation between some factors: such as between sardine quality conditions, market opportunity and price. Therefore some respondent may have mentioned market opportunities as a driver, while others would have talked about fish quality. Similarly, some drivers relatively stable in time were unconsciously taken into account such as quotas. Although we tried to collect information in such a way that we could quantify them to use them in modelling, the discussion between the fishers and the scientist around the questions asked was essential to complete and interpret the numbers correctly.

# 4. Discussion and Conclusion

In the different case studies, we have seen which factors have been identified in previous work or by work undertaken in the Seawise project that influence the short – and / or long term choices fishers make in response to change. The context of change can be both short term (i.e. weather changes – such as high waves and strong winds) or long term (institutional change such as new closures like MPAs or windparks). How fishers respond to such changes is something we try to understand. Traditionally we thereby have focussed on economic and ecological factors, more and more we broaden the perspective to also include social (including cultural) and institutional aspects.

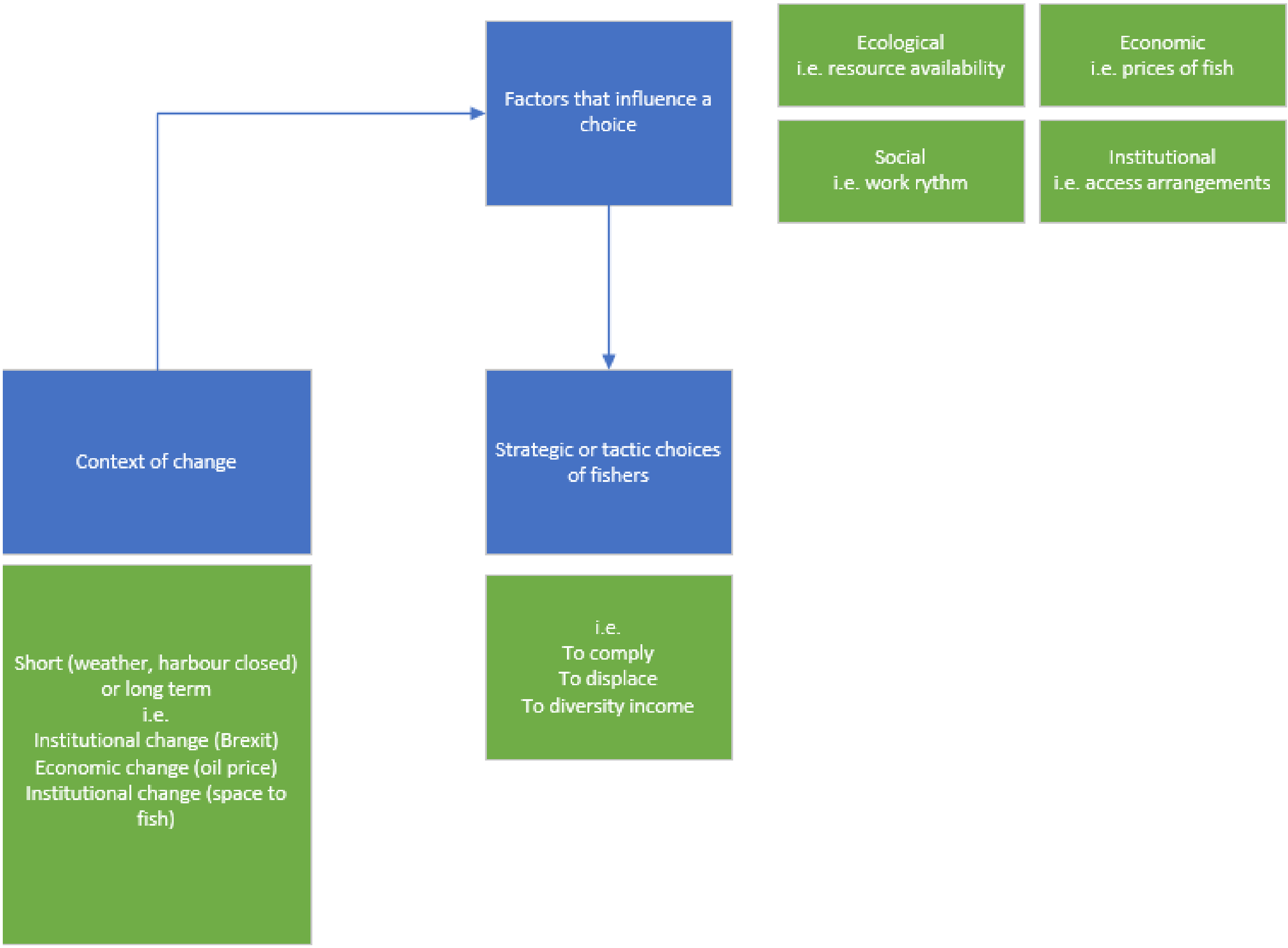



*Figure 4.1. The blue boxes show how a context of change results in strategic or tactic choices of fishers, which are influenced by ecological, economic, social and institutional factors. In the green boxes examples are given.*

Sometimes elements relate to the context of change and sometimes they function as a factor influencing a choice. Analytically it is important to make that differentiation. So for instance fluctuating fish and oil prices can function as factors influencing fishers where to fish and what to catch. Yet a sharp increase in the oil price (for instance due to the war) can also be part of a context of change we like to understand. Weather can also function as a context of change (short term) or as a factor influencing the decision of fishers.

In the table below we see the overview of factors that have been identified above and therefore possibly can be modelled in Seawise case studies. The case studies function as inspiration and demonstration how it has been done before (in modelling) (i.e. the German case, the UK case) or how it can be studied (i.e. the Belgian case, the French case, the Dutch case, the Adriatic and Ionian sea case) or both (the Scottish case, the French pelagic case).

| Case | Element | Factor | Categories |
|---|---|---|---|
| **NL case** | social | Working rhythm | Weekday or Continuous fishing |
| | social | Business structure | Owner operator or Skipper as employee |
| | social | Polyvalence | Specialist or Switcher |
| **East Med case** | social | Business structure | Family-run or business oriented |
| | social | Succesion prospect | Yes/no |
| | social | Specialization | |
| | social | Fishing effort | Full-time, part-time, occasional |
| | social | Pluriactivity | Yes/no |
| **UK case** | Social / economic | Profitability/ uncertainty of harvest outcome | |
| | ecological | Wave height & time of high tide | |
| | Social/cultural norms | Self-Identification | |
| **German case** | ecological | Bathymetry | |
| | ecological | Salinity | |
| | ecological | Bottom temperature | |
| | ecological | Mixed layer depth | |
| | ecological | Sea surface height | |
| | ecological | Wind, east-west | |
| | ecological | Wind, north-south | |
| | ecological | Wind gusts | |
| | ecological | Wave height | |
| | economic | Distance to port | |
| | economic | Crude oil price | |
| | economic | Resource price | |
| | social | Working rythm | Workday/holiday or weekend |
| **Belgian Case** | social | succession | have or haven't succession |
| | institutional | access to ports (UK due to Brexit) | |
| | economic | quota | |
| | | fuel | reduce speed / investments |
| | | envisioned catches | |
| | | competition | social status, interference competition, exploitation competition |
| **Scottish case** | ecological | Wind direction | |
| | | Weekly temperature | |
| | | Wind gust & vessel length | |
| | economic | Fuel price | |

| | | | |
|---|---|---|---|
| | Social / economic | Expected landings | |
| **French case study** | ecological | Stock status | Abundance or scarce |
| | ecological | Change of fish behaviour | Located near shore or not |
| | ecological | Currents | Target species to be present or not |
| | | storms | Bad weather no fishing |
| | economic | Debt ratio | High debt puts pressure on fisher to fish |
| | Social / Economic | Maintaining salary of crew | Pressure to fish for high value non quota species in other areas |
| | | Maintaining local crew | Pressure to maintain an income for them |
| | social | Cultural heritage species | Pressure to maintain catching these species |
| **Southern Adriatic and Ionian sea case** | social | Business structure | Family- run or not |
| | social | Succession | have or haven't succession |
| | social | Habitual patterns of behaviour | Specialist or switcher |
| | Social / economic | Expected revenue | |
| | economic | Travel cost | |

*Table 4.1. Summary of the factors influencing behavior, the categories, ordered by elements (social, institutional, ecological and / or economical)*

Getting a better understanding of fisher behaviour can be approached in different ways. One can work with models and look in the data for patterns that show different behaviours. Such as in the German case study where the spatio-temporal dynamics of fishing effort were analysed by using a wealth of explaining variables that are present in the dataset (e.g. bathymetry, oil price and working rhythm). Using empirical methods, such as boosted regression trees, relevant explanatory variables can be filtered out, as some influence fishing effort more than others.

Another way of working is to question fishers about their behavioural choices and based on that decide what factors play an important role. And then assess whether these can be modelled. Do we have indicators in the data for the factor? Ideally both ways of working can complement each other, such that factors derived from querying fishers can be found back in the data or vice versa important variables in the data are discussed with fishers to see what they think.

In the case studies described in this report, first attempts have been made to identify and model social factors. In some cases, the standard available data can be used to differentiate between groups of fishers, for instance we can assess the data to find working rhythm differences in fleets. In other cases, we might need additional data, such is the case with the business structure (family owned or not).

What also becomes clear is that often social data is context dependant. The way these factors are defined differ between fleets. Especially factors influencing the behaviour of small- and large-scale fisheries or family businesses and large companies may differ substantially. So if in a certain case study a factor is found and defined, this cannot always be easily copied to another context. The factor may also be important, yet how the factor is defined (and which categories can be used) may differ. Likewise environmental factors like wave height have a different impact on small scale vessels vs large scale vessels. Finally, different cultural influences across Europe will likely play an important role.

One of the challenges for the Seawise project is that the case studies are rather large (at sea basin level), so it may be difficult to model specific social factors. In all cases the topic of displacement and that of the high oil price is relevant. It The next step will involve discussion with the modelers about available data that can be used to understand certain displacement and high fuel price adjustment behaviour better. Length of fishing trips and landing ports are two observable indicators of behaviour that can be used.

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# 6. Document Information

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