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SCIENCE FOR A SUSTAINABLE DEVELOPMENT

AN ECOSYSTEM APPROACH IN SUSTAINABLE FISHERIES MANAGEMENT THROUGH LOCAL ECOLOGICAL KNOWLEDGE

LECOFISH

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SCIENCE FOR A SUSTAINABLE DEVELOPMENT

(SSD)

North Sea

FINAL REPORT

AN ECOSYSTEM APPROACH IN SUSTAINABLE FISHERIES MANAGEMENT THROUGH LOCAL ECOLOGICAL KNOWLEDGE

LECOFISH

SD/NS/11

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SUMMARY

A. Context

The SPSD II projects GAUFRE (Maes et al., 2005) and BALANS (Maes et al., 2005) made it clear that there are serious knowledge gaps related to fisheries in the Belgian Part of the North Sea (BPNS). Data on the distribution of fishery activities in the BPNS were very limited, while using the Vessel Monitoring System (VMS) was unsuccessful at that time due to privacy concerns. A study on Biological Valuation for the BPNS (Vincx, 2007) confirmed that certain spatial information is only fragmentary available, such as on epibenthos, macro benthos and demersal fish species. ICES boxes and their data do not sufficiently provide spatial information that can be used for well-balanced fisheries management that takes into account local ecosystem processes in the BPNS (due to the large grid used). This does not mean that there is no local ecosystem information. The problem is that quite some valuable information might be captured in the minds of people/experts and is not accessible for the scientific community and the public. A clear call was made from science to explore other ways of data gathering, besides classical monitoring (Maes et al., 2007; Derous et al., 2007), by inter alia capturing “Traditional Ecological Knowledge” (TEK). The project ‘De Zee van Toen’ (Rappé, 2008) gave an initial impetus to exploring the historical ecology in the Southern part of the North sea and to collect ecological information by means of interviews of old Flemish fishermen.

Local/traditional ecological knowledge adds significant insight in locally important resources and management practices, revealing information and understanding that is not reflected in a global assessment (MEA, Summary for Decision-makers, 2005, 92). This data/information from practice and expert judgment of fishermen can be used to fill data gaps in Scientific Ecological Knowledge (SEK). Information gaps in SEK are mostly due to restrictions on monitoring in terms of time/money/scale. Key uncertainties in fisheries SEK, as experienced in BALANS, include limitations on spatial or temporal resolution of data, bias or random error in input data, poor or unknown correspondence between modelled mechanisms and natural processes and the lack of information about model parameters. The Millennium Ecosystem Assessment (MEA) further recognizes inter alia that “*the loss of traditional knowledge has significantly weakened the linkages between ecosystems and cultural diversity and cultural identity. This loss has also had a direct negative effect on biodiversity and the degradation of ecosystems, for instance by exceeding traditionally established norms for resource use. This knowledge is largely oral*”. (MEA, Summary for Decision-makers, 2005, 38) An important objective of this project is to capture this oral information from fishermen.

B. Objectives

LECOFISH aims to collect fisheries and ecosystem-related data and information through the use of “Local Ecological Knowledge” (LEK) from professional and recreational fishermen in order to improve our ecosystem knowledge and sustainable fisheries management in the BPNS. The main goal of an ecosystem based approach is the sustainable use of resources covering all components of the marine ecosystem and their interactions (Sherman et al., 2005). A parallel movement is the growing interest in LEK as a knowledge system and the recognition that LEK can make a contribution to sustainable use of resources (Neis et al., 1999; Usher, 2000; Berkes et al., 2000; Wilson et al., 2006).

The objective of LECOFISH is to improve our fisheries knowledge of local ecosystems in the BPNS, by means of new and additional information in order to fill in knowledge gaps that exist in SEK. LECOFISH does not intend to be a substitute for SEK, but can be supportive to SEK. LECOFISH aims to collect fisheries - and ecosystem related data and information during a period of 50 years by making use of oral information gathered from professional and recreational fishermen in order to allow analyzing spatial and temporal distribution of fishery activities and fish abundance in the BPNS based on catches. LECOFISH is the first Belgian study to translate fishermen’s LEK into spatial maps for the BPNS.

C. Conclusions and recommendations

1. LECOFISH research scope: novel research

The scope of LECOFISH was very broad: to capture fishermen’s LEK during a time span of 50 years. Through an open approach (snowball sampling) a natural selection of respondents was made, resulting in a focus on species that are important for the respondents from a perspective of target species or species they observed almost daily. Not all the information provided by fishermen could be captured in this report. This report reflects the most representative information according to the authors, taking into account time limits and financial limits. Information that was based on one or a number of respondents about certain species (e.g. birds) was considered less relevant in contributing to SEK. Information about relations of particular fish species with other species or its habitat is not reported in detail due to the fact that this information could not be checked with scientists.

LECOFISH is quite unique by capturing information from recreational fishermen. This group of fishermen is mostly neglected by policy and scientists due to limited accessibility, problems of representation as a group or doubts about their knowledge. From LECOFISH we can conclude that their knowledge is as relevant as the knowledge from commercial fishermen. Both groups provided us with an excellent mix of fisheries knowledge. For example eel is exclusively dealt with by recreational fishermen, while for cod, sole and shrimps much information was collected from commercial and recreational fishermen together. In this sense, LEK for those species is more representative due to the number of fishermen that provided information. For other species, LEK has captured less representative information, which does not imply that fishermen would have no information about those species.

To capture LEK for particular species, more focused research will be necessary which involves more fishermen in an approach that aims to capture knowledge dedicated to particular species or more focused on single research questions. A more focused species research requires contacting interviewed fishermen for a second time to validate their answers. Apart from this, the research was not able to test the whole range of LEK with the available SEK. Although focus groups with fisheries scientist and benthos scientist have been organized, and a workshop was organized with scientists and fishermen together to discuss the LEK results, constructive responses by both groups were rather limited. Time constraints did not allow for further communications with both groups. For that reasons, the LECOFISH report should be considered as capturing fishermen’s knowledge only, without being able to check compatibility or contradictions with SEK in depth.

2. Spatial information

LECOFISH made clear that specific spatial information can be collected and visualized in maps, which did not exist before. Data focusing on particular fisheries locations in the BPNS during a long time frame is almost nonexistent, except for certain benthic communities. These spatial data and maps are relevant for policy makers involved in maritime spatial planning and sustainable management of marine living resources. One can conclude that the spatial data gathered in LECOFISH are less biased than if fishermen would be asked to provide data in the framework of a fisheries policy reform or as a specific reaction towards initiatives of governmental spatial planning at sea. Spatial data provided are based on trust between fishermen and researchers. LECOFISH made clear that good cooperation with fishermen is possible if knowledge of fishermen is given a central place in the research.

This report cannot present all the maps that have been made. For that reason a selection of maps is available in the annex to this report. Maps have been made in Corel Draw, but can be converted into GIS maps.
We can conclude that:

1. Most of the spatial data in this report are highly reliable, as has been proven at the focus group meetings with scientist and the work shop with scientists and fishermen. Of course we recognize that fishermen probably did not provide all the information they posses, partly for commercial reasons, partly because a second round of interviews is necessary to check some contested information or to ask for further clarifications.
2. LEK is a technique that should be used more often, because it gives fishermen a more central place in fisheries research and reveals new information or brings new research questions at the surface.

D. Contribution of the project in a context of scientific support to a sustainable development policy

The main contributions of LECOFISH to support a sustainable development policy are:

1. providing new or additional information relevant for a sustainable fisheries policy and sea use management policy;
2. better understanding and recognition of the uses of certain areas by fishermen in the BPNS as a contribution to maritime spatial planning;
3. providing specific information that is interesting for further scientific research at the level of species as such or at the level of species in relation to other species or habitats;
4. testing LEK methodology as a scientific discipline.

E. Key words

Local ecological fisheries knowledge; fisheries; Belgian Part of the North Sea.

1 INTRODUCTION

1.1 LOCAL ECOLOGICAL KNOWLEDGE (LEK)

Ecological knowledge is used to define and understand the way ecosystems function. More precisely, it is about gathering knowledge on mutual relations between organisms and relations between organisms and their environment (Sinclair, 1999; Purdy, 1999; Bundy, 1999; Olsson and Folke, 2000). For Olsson and Folke ecological knowledge links social systems with ecological systems to understand and explain changes in an ecosystem. It is accepted that human beings are part of the ecosystem.

In literature on ecological knowledge a variation of terminology is used, such as Local Ecological Knowledge (LEK), Traditional Ecological Knowledge (TEK), Indigenous Ecological Knowledge (IEK) and Scientific Ecological Knowledge (SEK), with a common objective to improve knowledge of ecosystems. In fisheries, it is about stocks and the structure of stocks of certain fish species, their migration patterns, their seasonal variations, their spawning and breeding grounds, feeding patterns and predator behaviour (Neis et al., 1999; Silvano and Valbo-JØrgensen, 2008; Gerhardinger et al., 2009). In addition, potential explanations of changes in the ecosystem can be part of this knowledge system (Bart, 2006). The way this knowledge is gathered can be different. For example, TEK is seen as a cumulative body of knowledge, practice and belief on the relationship of living beings (including humans) with each other and their environment, evolving by adaptive processes and handed down through generations by cultural transmission (Berkes, 2000). In TEK traditions and beliefs are more central, while IEK is more narrowly focused on indigenous people (Berkes, 2000).

LEK is seen as systems knowledge in the hands of a group of people, in particular the users of a specific local ecosystem. In this sense local refers to a specific environment and not to a local population (Neis, 1999). LEK can be collected in different ways and is often broader than TEK. LEK can be the result of years of observation and experience (Davis et al., 2004; Bart, 2006), practical skill in order to generate an income from local ecosystems (Brook and McLachlan, 2008), continuous interactions with a certain environment and the knowledge transfers between generations (Silvano and Begossi, 2005), scientific information (Olsson and Folke, 2000; Brook and McLachland, 2008) and technology (Brook and McLachland, 2008). In this sense LEK can be considered as a broader concept than TEK (Brook and McLachlan, 2008; Gerhardinger et al., 2009) and is applied in a less ambiguous way (Ruddle, 1994). LECOFISH opted to use LEK, since LEK is also considered to be more neutral (McKenna et al., 2008).

1.2 LEK AND SOCIAL SCIENCES

LEK needs to be gathered by a precise methodology in order to avoid loss of potential important information, in particular information that at first glance seems to be anecdotal. The development of a scientific based method for LEK can contribute to a better acceptance and integration of these data in natural sciences and ecological research in general (Fischer, 2000; Davis and Wagner, 2003). For that reason, methodological issues are an important element to achieve the LECOFISH objectives.

The methodology can be found in social sciences (Huntington, 2000), more precisely in the qualitative research design that considers LEK to be a socio-ecological product of construct. This implies that knowledge of people is partial and the gathering and transfer of this knowledge is mediated by social processes (Murray et al., 2008). LEK is dynamic and often not uniform within one population (Baird, 2001). The following influences can have an effect on the knowledge of local ecosystems by fishermen: 1. geographical location of fish (onshore-offshore; west coast - east coast) together with bio-physical and ecologic conditions that may vary in time and place, such as depth, tides, substrate development and period of fishing (Baird, 2001; Silvano and Begossi, 2005; Crona, 2006; Murray et al., 2006; McKenna et al., 2008); 2. fishing techniques and target species (Valbo-Jørgensen and Poulsen, 2000; Baird, 2001; Silvano and Begossi, 2005; Gerhardinger et al., 2006); 3. type of fishing – commercial and recreational (Crona, 2006); 4. fishery performance and duration of the fishing career (Maurstad, 2000; Davis et al., 2004). Besides this, also cultural and social elements have an influence on the knowledge of fishermen: 1. the position of the fishermen in the family structure and in the fisheries community, alongside with respect for and by the other (Davis, 2000; McGoodwin et al., 2000; Crona, 2006); 2. the way knowledge is obtained and transferred, such as by observation, education, experiments, use of technology such as GPS, relation and interaction within and between groups of people (previous generations), formal and informal rules, scientific input, the market (Davis, 2000; Maurstad, 2000; Wilson, 2000; Silvano and Begossi, 2005; McKenna, 2008). The focus of the research plays an important role in this respect. Even if the target species, the geographical area and the sampling methods are identified beforehand, the information gathered is often not uniform (Murray et al., 2008). This means that the nature of LEK is heterogeneous. Social sciences are able to take this heterogeneous nature into account, together with the (cultural) context of LEK (Kvale, 1996; Huntington, 2000). Social sciences also focus on *who* is saying what (Wilson, 2001). This is important to engage fishermen actively in fisheries management, next to classical fisheries sciences and economic impulses (McGoodwin et al., 2000).

2 METHODOLOGY AND RESULTS

2.1 METHODOLOGY

2.1.1 Geographical area

The fisheries grounds for Belgian fishermen are spread out over the southern part of the North Sea, the mid-east and mid-west of the North Sea, the English Channel, the Irish Sea, the Celtic Sea and the Gulf of Biscaje. LECOFISH only deals with Belgian fishermen in the Belgian Part of the North Sea (BPNS), comprising the territorial sea and the exclusive economic zone (Maes et al., 2005c) (fig. 1). The BPNS covers 3457 km^2 and extends seawards up to 87 km from the coast line which is 67 km long. Shallow waters characterize the area with an average depth of 20 meters and a maximum depth of 45 meters. Despite its small size, the BPNS covers several valuable habitats due to a complex system of sand banks. The sand bank area is transboundary and stretches out from Zeeland to Calais. There is only one comparable area in the North Sea: near the south-east of England. The sand banks in the BPNS are situated more or less parallel with the coast and form a fascinating underwater dune landscape (Maes et al., 2005c). There are four coastal ports (two for commercial shipping) three of which have fish auctions (Nieuwpoort, Oostende and Zeebrugge.) (Lescrauwaet et al., 2011).

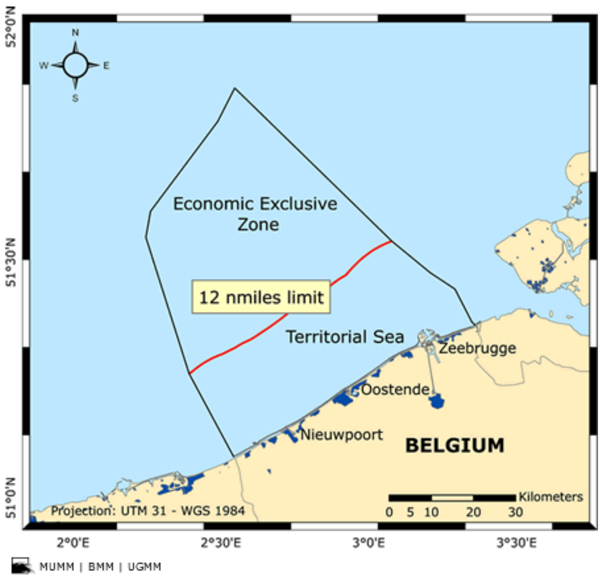


Figure 1: Belgian Part of the North Sea (source: MUMM)

2.1.2 Population and sampling

The fishermen selected for LEK are or have been active in fishing in the BPNS during the period from 1950 until 2000, and comprise commercial as well a recreational fishermen. The number of fishing vessels is in constant decline since the 1950s. In 1955, 421 Belgian fishing vessels were active. In 2011 there were only 87. Not all these fishing vessels are or have been active in the BPNS. The Belgian fisheries fleet consists of a small and large segment of the fleet. The large fleet segment comprises vessels with an engine power ranging from 300 horse power (hp) to 1,633 hp. The small fleet segment comprises vessels with an engine power up to maximum 300 hp. Within the latter there is a coastal segment of vessels with an engine power up to maximum 150 hp. The engine power is a decisive factor for indicating the locations where Belgian fishermen fish (in or outside the BPNS). Fisheries in the BPNS are mainly performed by the small fleet segment. Belgian fisheries are mixed, in which the most important commercial target species are: sole, plaice, cod, sea bass and shrimp. The vessels active today are mainly engaged in beam trawling (more than 90%), otter trawling and the use of standing rigs.

Recreational fishing needs to be differentiated from sport fishing, although the latter can be included in recreational fishing. Sport fishing makes use of fishing rods in a competitive setting (angling), while recreational fishing can comprise different fishing techniques and is not performed in a competitive sports environment. Recreational fishing can take place at sea or along the coastline (beach, pier, harbour, and breakwater) by making use of fishing hooks and lines, entangling nets or nets that are dragged. In Belgium there are no reliable data on the number of recreational and sport fishermen. It is estimated that 20,000 recreational fishermen are active at the coast and in the BPNS, of which only 2,500 are members of a club.

Since the population of recreational fishermen is large, the population that fished between 1950 and 2010 needs to be carefully selected to be representative and reflecting their ecological knowledge (Mason, 1996, Crona, 2006, Prigent et al., 2007). This needs to be captured in a sample based on expertise about the local ecosystem or sub-systems (see Davis and Wagner, 2003).

LECOFISH did not intend to be statistically representative by making use of a random selection of fishermen. There are two reasons for not using at random sampling: 1. focus is on knowledge and experience; 2. LEK is heterogeneous and situated within a social context with its own characteristics and influences in time and space (Kirk and Miller, 1986). This means that there are no general rules or that there is no such thing as *the* knowledge within fishermen's LEK. To be able to achieve some theoretical generalization, the research opted for targeted sampling of fishermen based on their LEK (Bijleveld, 2005) by using peer recommendation (Davis & Wagner, 2003). To respect the time frame, a chain referral sampling method has been used (Blaikie, 2000; Billiet, 2003). Both elements can be captured by snowball sampling (Tremblay, 1957; Davis and Wagner, 2003; Prigent, 2007).

Snowball sampling starts from the principle that the last interviewed fisherman proposes the next fishermen to be interviewed as being local experts (peer recommendation). A maximum of five fishermen with local knowledge have been asked to be recommended for further co-operation (Davis and Wagner, 2003). This technique creates different stages of response, starting with the very important zero-stage or start (Bijleveld, 2005) (see fig. 2). At the zero-stage fishermen were recommended by members of the guidance committee of LECOFISH based on their LEK and willingness to co-operate in an open and transparent matter.

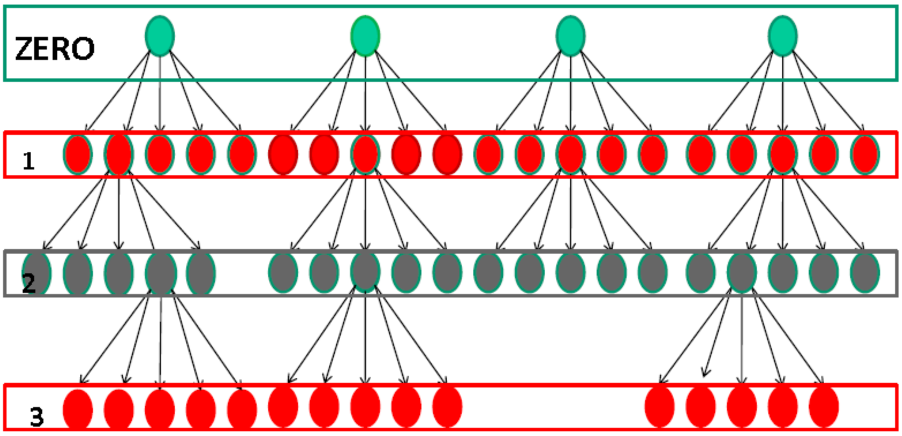


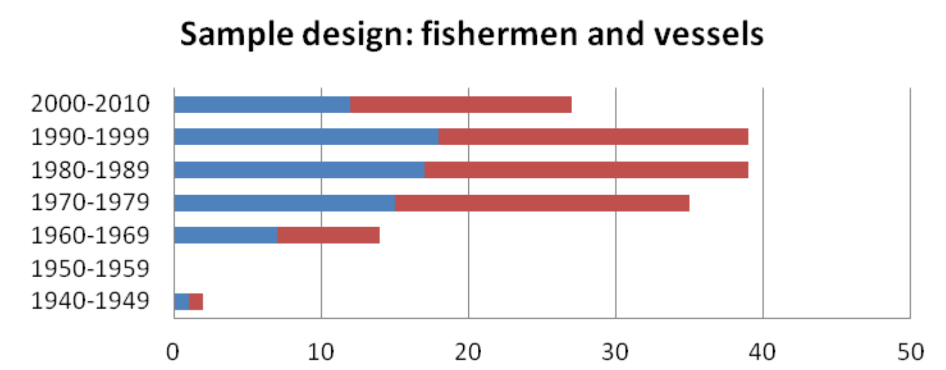
Figure 2: Example of snowball sampling

A snowball sample can be affected by bias or systematic errors. Oversampling of the same subgroups can generate the same LEK (Maurstad, 2000). Another form of bias can be the peer recommendation by fishermen recommending other fishermen who may not have LEK, but are recommended because they are friends (Davis & Wagner, 2003) or they have worked together on the same vessel. To manage this bias and to obtain real LEK, the snowball sample is supported by network analysis (Bijleveld, 2005), to ensure distribution in space/time, and the key-informant sampling strategy (Tremblay, 1957; Marshall, 1996; Heckathorn, 1997), excluding fishermen with whom the respondent worked together on the same vessel (Johnson, 1990; Dijkstra and Smit, 1999; Anadón et al., 2009). Nevertheless, some bias cannot be excluded since active fishermen work in a highly competitive environment. For that reason, a mix (50/50) of active and non-active fishermen has been interviewed.

2.1.3 Sampling framework

By using peer recommendation, the sample of commercial fishermen consisted of 7 layers and the sample of recreational fishermen of 4 layers. For commercial fisheries the peer recommendation resulted in 47 fishermen. Of those 47 there were 14 fishermen that could not be contacted for an interview (29%), while 13 fishermen were not willing to co-operate (non-response of 28%). Since the non-response was not selective, this is not a limitation on the diversity of the group of respondents within the sample. The sample of recreational fishermen was 27 of which 12 fishermen (44 %) could not be contacted for an interview, while 3 were not willing to co-operate (non-response of 11%). A total of 20 commercial and 12 recreational fishermen were interviewed.

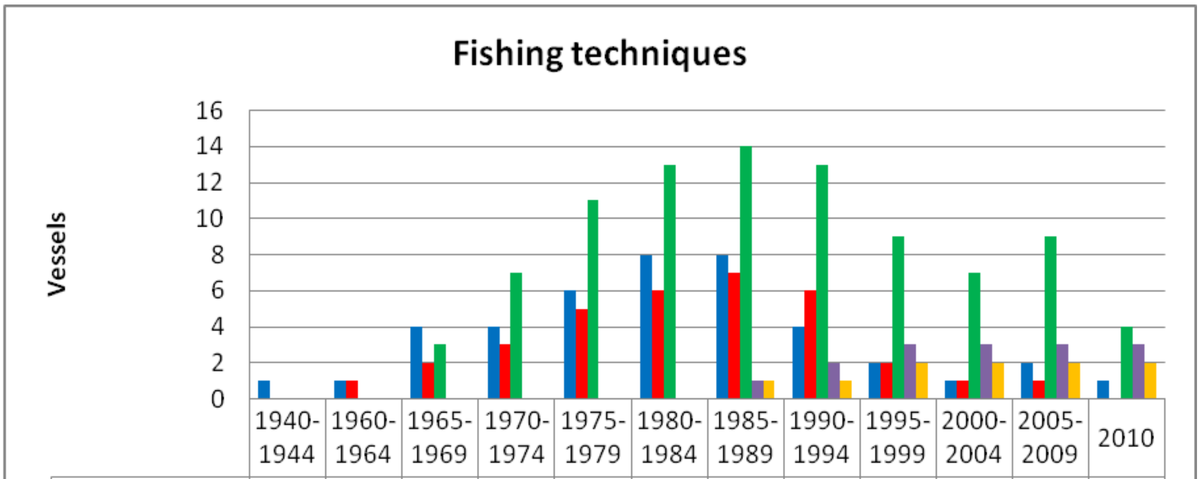
The 20 commercial fishermen provided information related to 64 different fishing vessels spread over a period from 1940 until 2010 (fig. 3). In 2010 half of the commercial fishermen interviewed were still active, the other half were retired. The youngest fisherman was 33 years old, the oldest 84. The majority of the fishermen started fishing at the age of 15 and 10 fishermen had more than 38 years of fishing experience.



	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2010
Fishermen	1	0	7	15	17	18	12
Vessels	1	0	7	20	22	21	15

Figure 3: Commercial fishermen and vessels

Within the sample population of commercial fishing, otter trawling was highest during the eighties, often in combination with other techniques. Beam trawling throve in the seventies and eighties and still remains the major fishing technique. The use of standing rigs started in the mid-eighties, increased and continued to increase until today. Since the mid-eighties rods are increasingly being used. The use of drift nets is prohibited now, but used to be popular from the seventies until the mid-nineties (fig. 4). Often different techniques are used, such as the beam trawling with drift nets (fig. 5), standing rigs with otter trawling or/and rods/angling (fig. 6), otter trawling with beam trawling or driftnets or all three techniques together (fig. 7).



	1940-1944	1960-1964	1965-1969	1970-1974	1975-1979	1980-1984	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010
otter trawling	1	1	4	4	6	8	8	4	2	1	2	1
drift nets		1	2	3	5	6	7	6	2	1	1	
beam trawling			3	7	11	13	14	13	9	7	9	4
standing rig							1	2	3	3	3	3
angling							1	1	2	2	2	2

Figure 4: Commercial fishermen and fishing gear

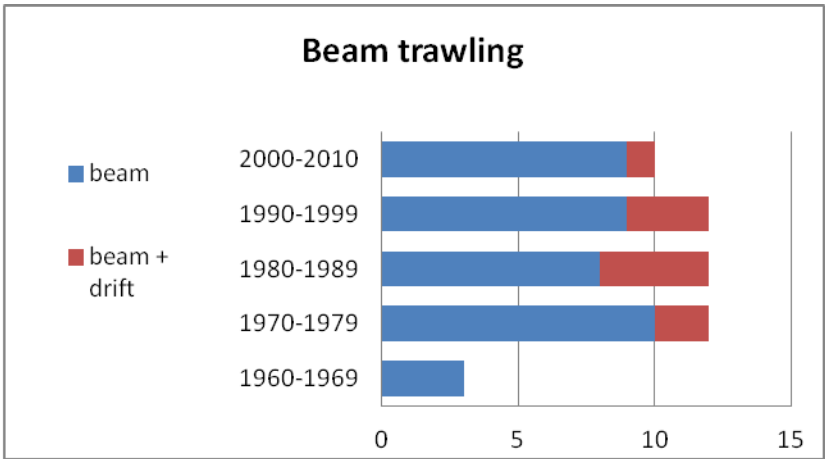


Figure 5: Combination of beam trawling and drift nets

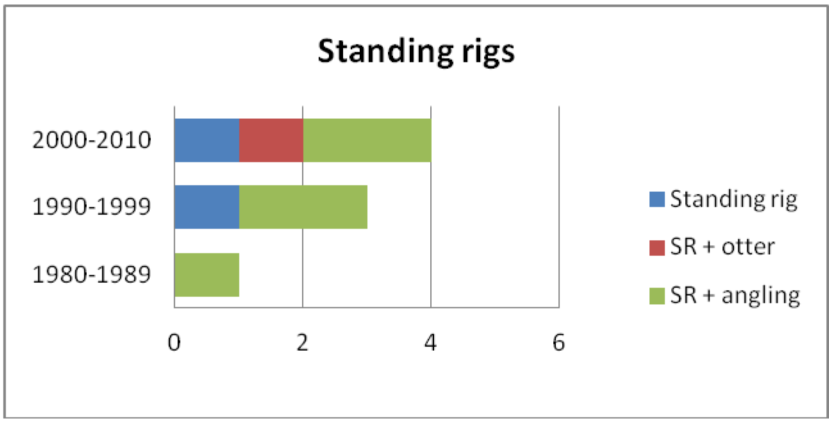


Figure 6: Combination of standing rigs with otter trawling or/and angling

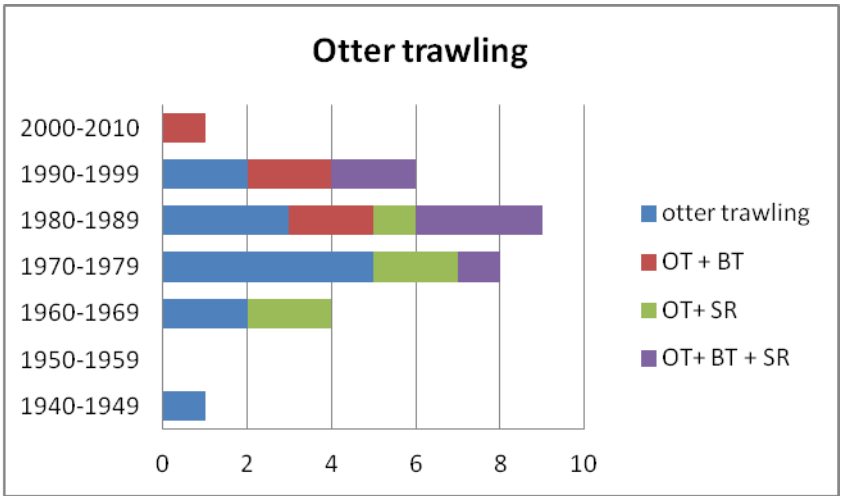


Figure 7: Combination otter trawling with beam trawling (BT) or/and standing rigs (SR)

Fisheries by the 12 interviewed recreational fishermen were spread over the whole coast line. The youngest fisherman was 34 years old, the oldest 72. The average years of fishing experience was 42 years. Fishing techniques used from land and at sea were well represented. Fishing from the beach dates back to the forties, while the use of fishing vessels or other boats started in the sixties. Various techniques are used that differ if fishing takes place from the beach or at sea. On the beach mainly nets (standing rigs, flat rigs, dragged) or fishing lines and hooks (rod) are used (fig. 8). At sea otter trawling, drift nets or fishing lines (on anchor or around ship wrecks) are used (fig. 9).

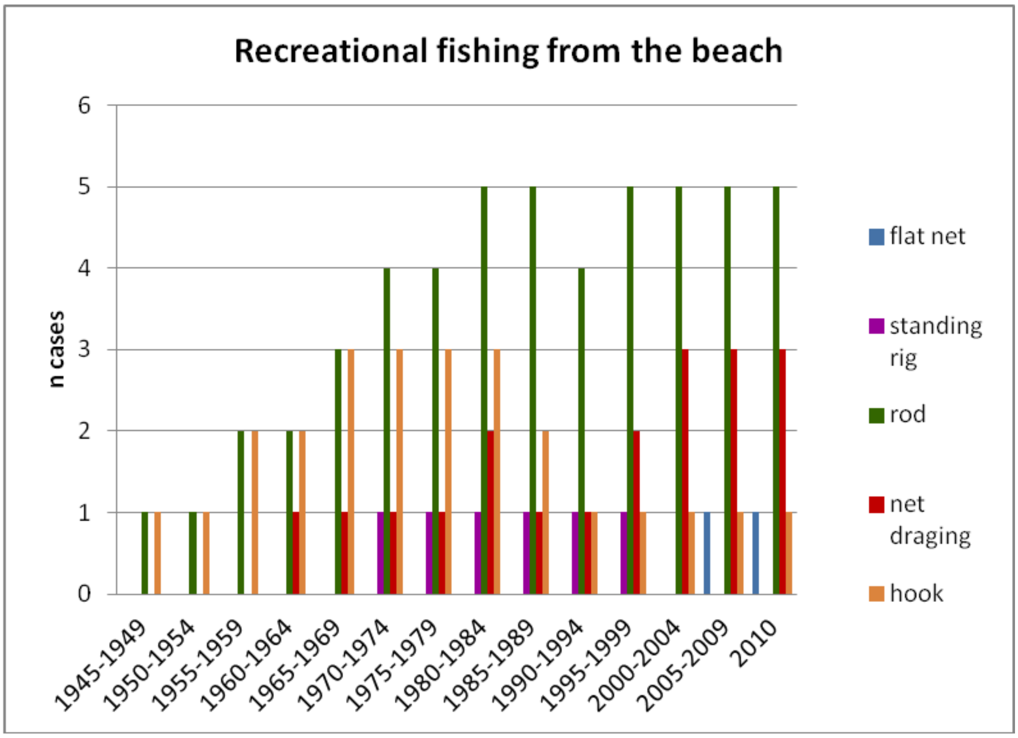


Figure 8: Evolution recreational fishing techniques from the beach

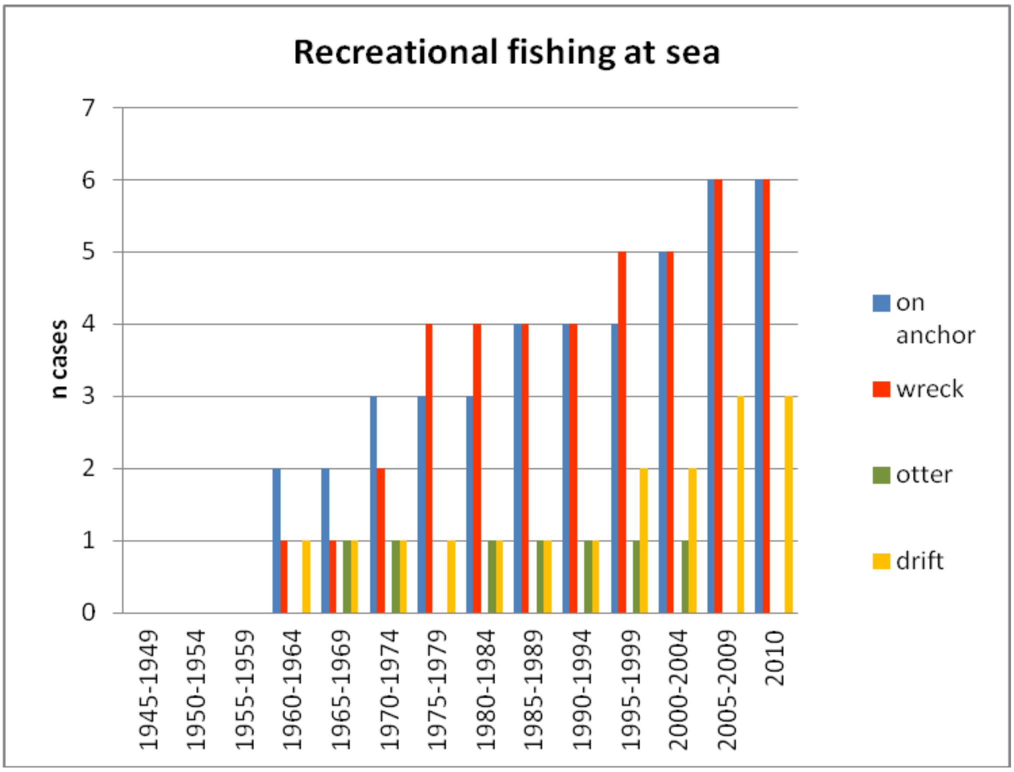


Figure 9: Evolution recreational fishing techniques at sea

2.1.4 Data collection

The study opted for three different data collection approaches: a questionnaire, a semi-structured interview and a nautical map for collecting ecological information. The questionnaire as a guiding instrument was tested both internally (within the research group) and externally (fisherman). Since LEK is a social construction, the semi-structured interview was required to collect ecological information (Huntington, 1998; Neis et al., 1999; Gerhardinger, 2006). By means of a short questionnaire the respondents were asked about their opinions and perceptions of their socio-economic and cultural surroundings in order to capture an image of their socio-economic, legal and cultural environment and to assess how LEK is constituted. Both methods were used in a face-to-face interaction with the researcher. Next to the questionnaire and interview, a nautical map was used to collect geographical information on fishing locations and observations of sea mammals, birds, benthos species, etc. The nautical map was a tool for prodding the fisherman's memory (Huntington, 1998; Neis et al., 1999; St. Martin). The fishermen were able to draw on the map during the interview. The basic nautical map that fishermen used during fishing was covered with several plastic layers. On each layer it was possible to draw particular information: a layer for fish species separately, a layer for birds, for sea mammals etc. depending on the information the fisherman was able to provide.

A semi-structured interview based on a topic list is advisable due to the variability of ecological knowledge in time and space that cannot be captured by a structured questionnaire only (Johannes et al., 2000). Each respondent had the freedom and opportunity to address the more important topics for him and how he understands them. In this way a broad scale of information could be gathered (Huntington, 1998). However, *bias* during the interview is possible due to the 'shifting baseline syndrome' since the interview started with the beginning of the fishing career of the respondent as a point of reference. Gradual shifts are possible and this applies to fishermen, fisheries scientists and managers too (Pauly, 1995). The research results are therefore to be used with some caution.

Furthermore, attention was paid to avoid accidental measuring mistakes by excluding socially desirable answers (Sapsford and Jupp, 2006), but also by making sure that answers were as complete and reliable as possible (Brinkman, 2000; Palmer and Wadley, 2007). To enhance reliability, all the face-to-face interviews took place at home of the fishermen, considered to be his most comfortable setting. In addition, every interview provided a basic structure: starting with the objectives of the interview, the guarantee of anonymity and asking the permission to record the interview, followed by some general questions about the fisherman and his career in order to create confidence. After the introduction, focus was on LEK based on topics such as specific fish species, bio-physical features, etc. that were selected on the basis of literature and communications with fisheries scientists.

Social and political issues were dealt with at the end of the interview to avoid any commotion or controversy during the actual LEK interview. Every respondent agreed with the full recording of the interview. Scientific information from the interviewer, such as definitions and fisheries management issues, was avoided to focus precisely on the personal experiences and the particular language of the fishermen (Brinkman, 2000; Palmer and Wadley, 2007).

The validity is a result of the way the questions were asked: starting with the formulation of each question in the same manner with each respondent. The respondent was able to answer according to his interpretation. Afterwards, it was possible to ask the question again but in a different way or by asking additional questions to obtain a maximum of information (Brinkman, 2000). Secondly, two memory stimulating techniques were used (Kirk and Miller, 1986): the vessel and nautical map. The major reference point in time was splitting the career of the commercial fisherman according to the vessel he worked on. Fishermen have specific memories dedicated to these vessels. These vessels were used to construct the timeline of the LEK information as a more reliable technique than asking how and where they fished, in for e.g. 1965. Furthermore, the written information collected by the fisherman was mostly linked to these vessels, based on personal notes or muster-book. Commercial fishermen were asked to focus on maximum four vessels active in the BPNS on which they worked during the period 1950 and 2010. Particular information about the vessels was asked: engine power, fishing gear and position of the fisherman. For each vessel the starting question was the target species (see fig. 10), as a basis for questions about other species. In the case of recreational fishermen, the time line 1950-2010 was split in three periods. In addition, a basic nautical map of the BPNS was used as a visual memory support (Tremblay, 1957). For each vessel, the fisherman was given the opportunity to draw on a separate transparent plastic layer covering the map. This allowed the collection of spatial data linked to a timeline (Kirk and Miller, 1986; Neis et al., 1999) and provided more details (Huntington, 1998).

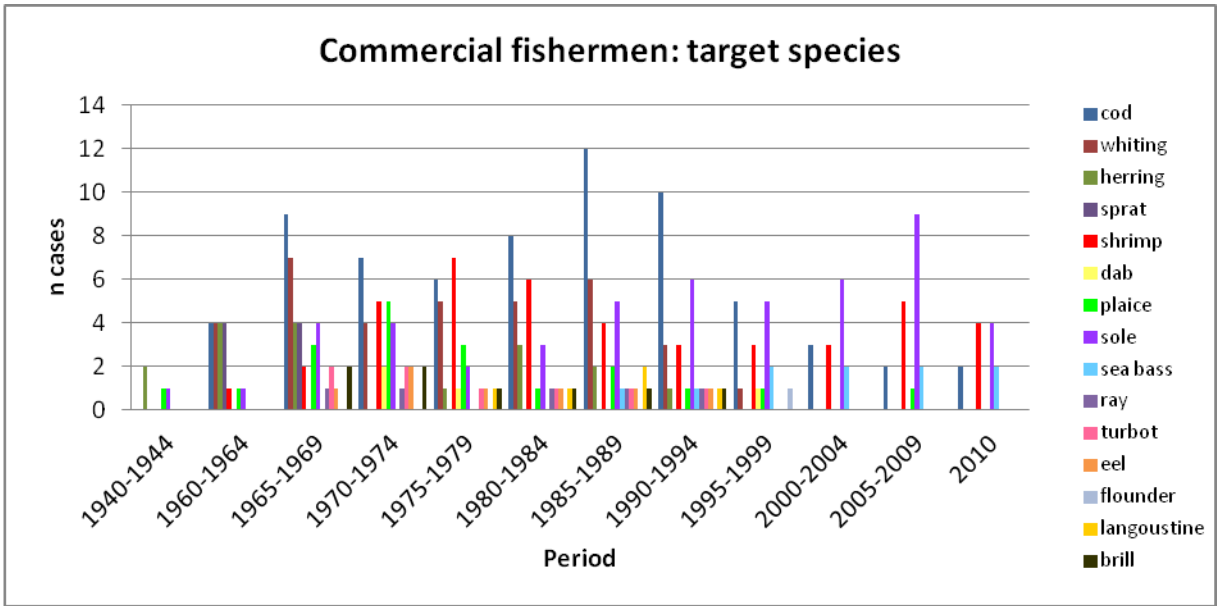


Figure 10: Target species of commercial fishermen interviewed

2.1.5 Data analysis

The interviews took place between March and September 2010 lasting between 1 ½ to 3 hours. Older fishermen had more problems understanding the questions or to refresh their memory, resulting in more difficulties to draw specific locations on maps. Each interview is recorded on tape and is transcribed in detail, which took more than three months. Difficulties in transcribing were due to the language (dialect) and the particular terminology used by the fishermen. Names of *inter alia* fish species in dialect were different depending on the fishing harbour the fisherman operates or used to operate (Ostend, Zeebrugge or Nieuwpoort). During the analysis of interviews several books on fisherman's dialect have been consulted (Great dictionary of Flemish dialects: Vandenberghe, 2000; Rappé, G. (2008)).

For the data analysis NVivo 9 software is used. This software allows coding the transcribed interviews, in particular all relevant and important terms relevant for LEK (fig. 11). The results of the data analysis reflect the themes that were used during the interviews, based on a topic list. LEK was able to collect information about 58 fish species, 11 benthos species, 11 bird species and 5 sea mammals. The number of hits can be an indication for the reliability of the information. For e.g. shrimps have been mentioned 210 times by 22 fishermen, cod is mentioned 501 times by 31 fishermen, sea mammals have been mentioned 4 times by 3 fishermen and squid has been mentioned 2 times by 2 fishermen. Furthermore, it was possible to make relations between certain species and their habitats (fig. 12). Apart from this, there is coded information related to biophysical properties, such as turbidity, sediments, currents etc. and information on weather patterns and other typical phenomena (blooms) important to fishermen. Not every species is mentioned by the fisherman, because this is not necessarily related to the target species, the by catch or the use of particular fishing gear. Finally, relations can be drawn between species (predator) or changes in fish abundance according to years or seasons. Relations between two or more other species or their habitats or with biophysical properties have been mentioned by the fishermen. The researchers have never given their own opinion or interpretation. This means that the results of LECOFISH in this report are pure LEK results obtained from the fishermen.

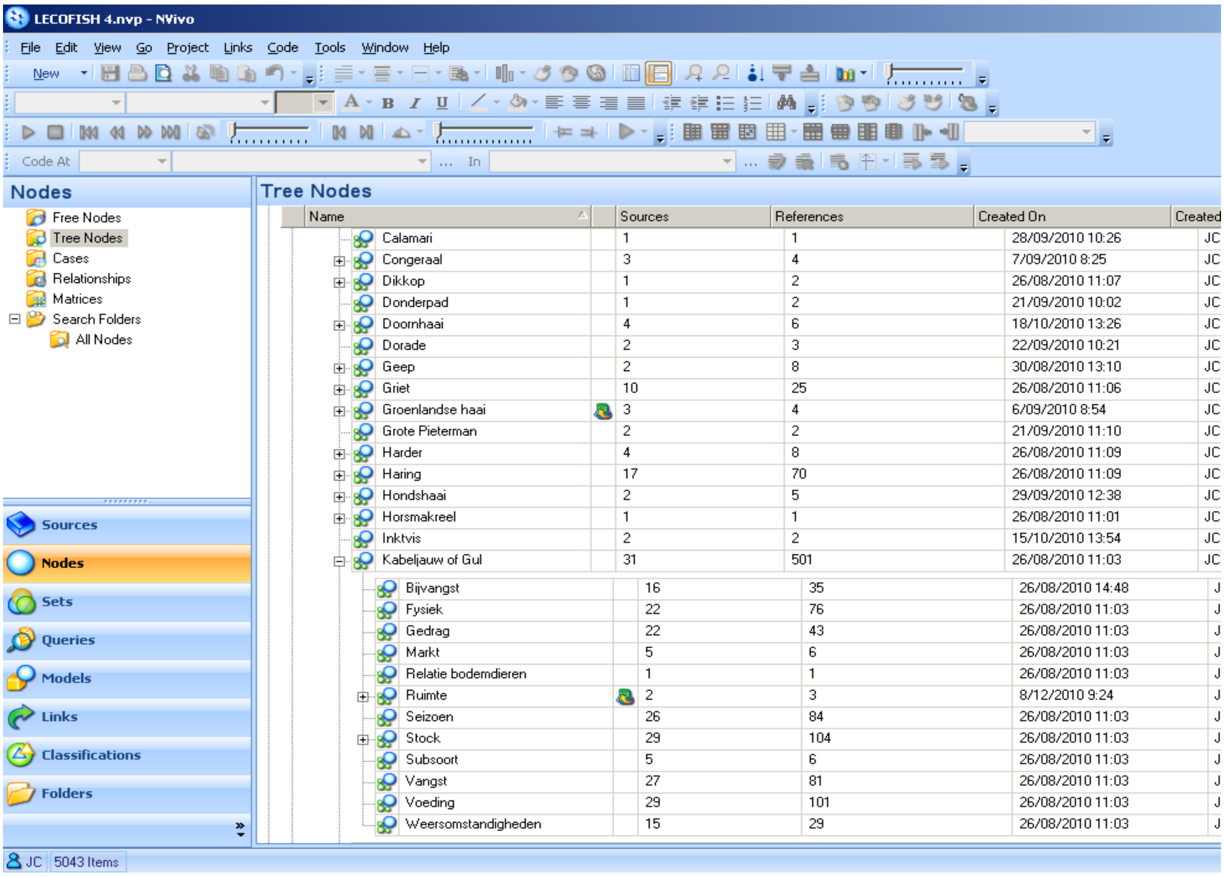


Figure 11: Example of coded information in NVivo 9

Name	Sources	References	Created On	Cre
Kabeljauw of Gul	32	522	26/08/2010 11:03	
Fysiek	24	85	26/08/2010 11:03	
Cyclus	5	6	10/12/2010 21:27	
Evolutie grootte	17	31	10/12/2010 20:18	
Grootte	15	30	10/12/2010 21:10	
Jaarklasse	5	9	10/12/2010 21:27	
Kleur	8	11	10/12/2010 21:20	
Vangst	3	3	11/12/2010 7:52	
Ruimte	30	129	9/12/2010 8:19	
Beweging	10	12	26/08/2010 11:03	
Habitat	22	52	26/08/2010 11:03	
Locaties	12	19	9/12/2010 18:54	
Migratie	20	33	26/08/2010 11:03	
Paaien	19	39	26/08/2010 11:03	
Verspreiding	4	4	26/08/2010 11:03	
Vislocatie	1	23	9/12/2010 8:23	
Seizoen	26	84	26/08/2010 11:03	
Herfst	14	18	10/12/2010 13:34	
Lente	8	13	10/12/2010 13:34	
Verandering periode	1	1	10/12/2010 14:39	
Winter	17	24	10/12/2010 13:34	
Zomer	5	8	10/12/2010 13:34	
Stock	29	104	26/08/2010 11:03	
Vangst	27	81	26/08/2010 11:03	
Bijvangst	16	35	26/08/2010 14:48	
Invloeden	17	32	11/12/2010 11:11	
Uitkomst	8	10	11/12/2010 11:11	
Vislocaties	7	11	11/12/2010 11:11	
Voeding	29	102	26/08/2010 11:03	
Als prooi	1	1	11/12/2010 15:07	
Foerageergedrag	10	14	11/12/2010 14:18	

Figure 12: Example of cod and relations in NVivo 9

Drawings and information on the maps were converted into digital maps using Corel Draw v.12 software. Digital maps are made per species, fishing locations, fishing techniques, seasons, etc. This information is expanded by digitalizing spatial information mentioned in the interviews, but not drawn on maps by fishermen (fig. 13). The drawings of fishermen are considered to have a greater level of reliability because these are not biased by an interpretation of the researchers. Furthermore, the quality of the drawings differs from fisherman to fisherman: some draw circles to indicate more general certain areas, while other draw very specific lines indicating the position where they fish or fished on certain species. On the maps a differentiation is made between information from commercial fishermen and recreational fishermen, as well as how many fishermen contributed to the information on the maps (fig. 14). Maps are made for various species, catch areas, evolution in time, etc. and structure maps combining this information in a time span of 50 years per fish species (fig. 15).

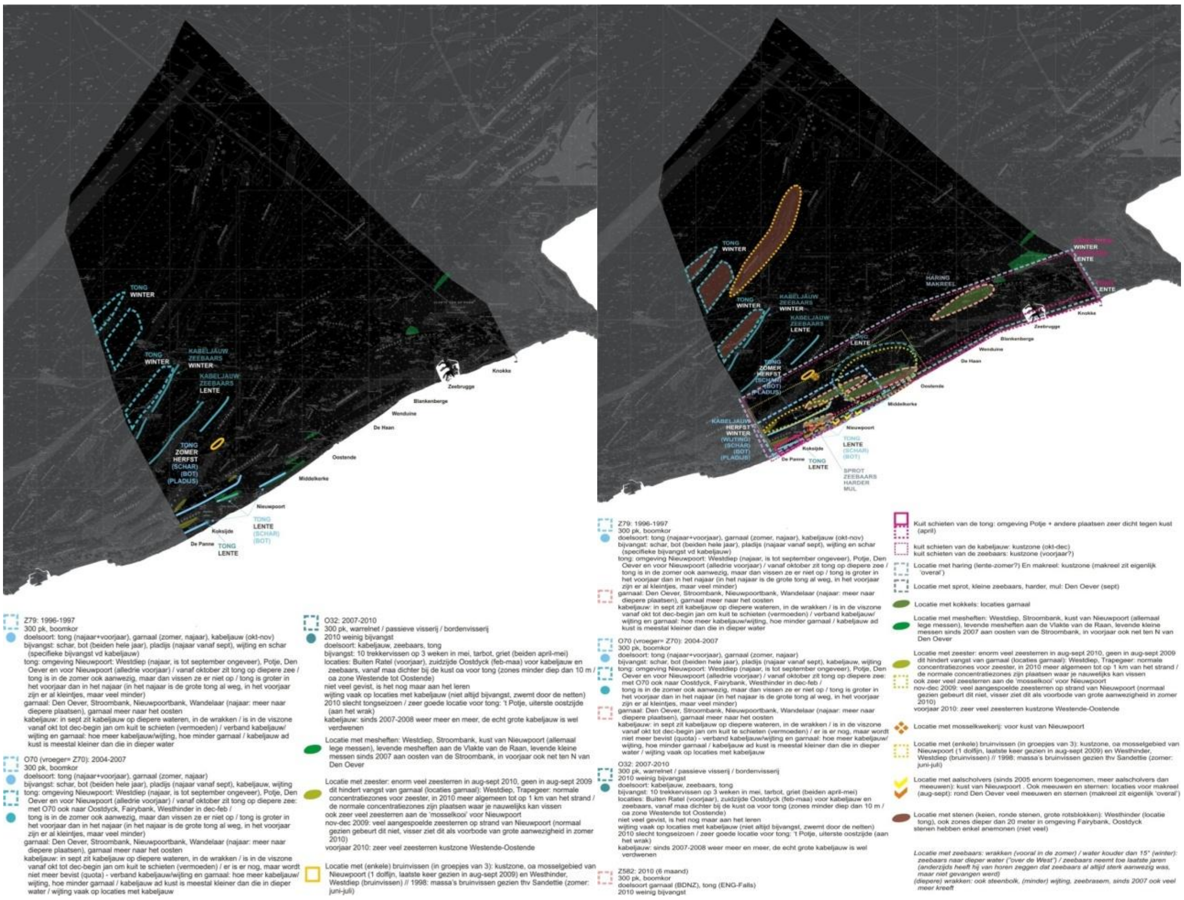


Figure 13: Left information drawn by fisherman. Right information supplemented with information from the interview with the same fisherman

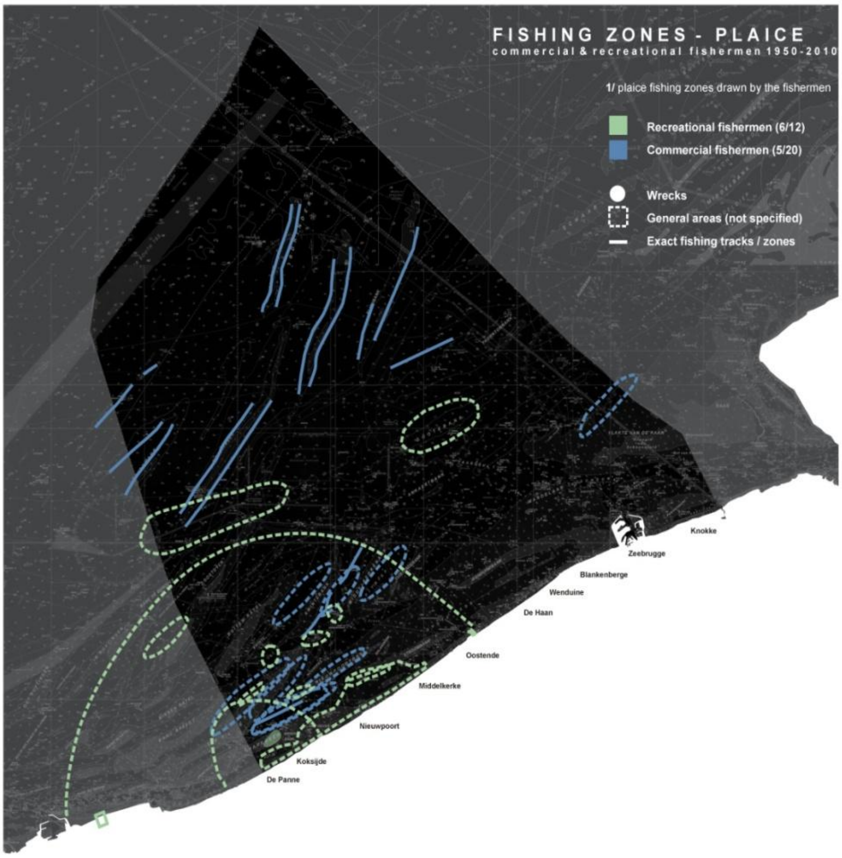


Figure 14: Example of different drawings (circles and lines), differentiation between commercial (blue) and recreational fishermen (green) and the number of fishermen contributing to the map

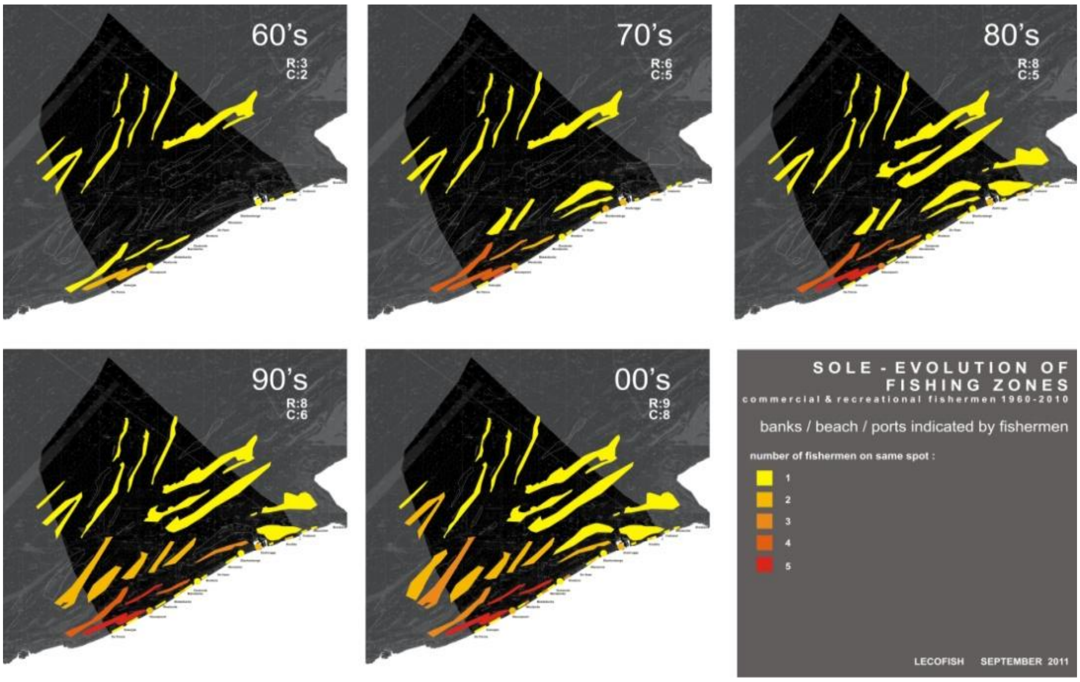


Figure 15: Example of structure maps

2.2 RESULTS

2.2.1 Biophysical features of the Belgian Part of the North Sea (BPNS)

2.2.1.1 Sediment types in the BPNS

The BPNS is characterized by the occurrence of sand banks (fig. 16). The sand banks can be categorized in: Coastal Banks (Wenduine Bank, Stroom Bank, Nieuwpoort Bank, Trapegeer, Vlakte van de Raan and Smal Bank), Flemish Banks (Oostende Bank, Middelkerke Bank, Kwinte Bank, Buiten Ratel, Oostdyck and Bergues Bank), Zeeland Banks (Akkaert Bank, Goote Bank and Thornton Bank) and the Offshore Banks (Bligh Bank, Oosthinder, Noordhinder, Westhinder and Fairy Bank).

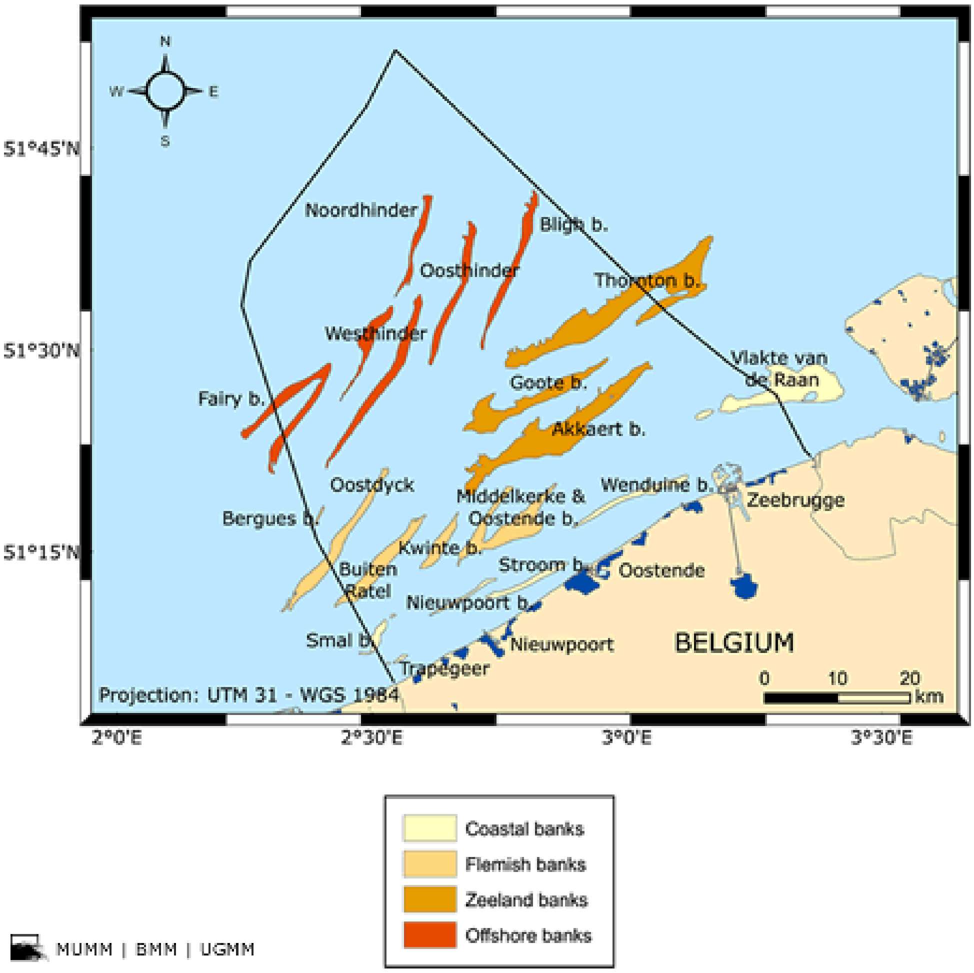


Figure 16: Sand banks in the Belgian Part of the North Sea (source: MUMM)

2.2.1.1.1 The Coastal Bank and fishermen experiences

According to one commercial fisherman (1C), the Wenduine Bank contains a mud flat and is a very difficult spot to fish with beam trawls due to this mud. However, if there is an eastern wind, fishing there is very easy. Besides mud, the Wenduine Bank also contains big stones (1C). Between the Wenduine Bank and the Stroom Bank, there is an area called 'the Grote Rede'. In this region, there is a location fully covered with bricks (3C + 1R). It is called 'Verzonken Oostende' (2C). A recreational fisherman is of the opinion that there used to be a wall that was pulled down. Fishermen that caught stones dumped them on this spot (1C). A commercial fisherman described a specific spot at the Stroom Bank as a very 'soft place'. The inner side of the Stroom Bank is characterized by dirt (1C + 1R). Dirt can be described as shells, rocks and mud. It is a good place to catch fish (1R), but should be avoided during a rising tide as much of this dirt ends up in the nets (1C). A recreational fisherman uttered that the Trapegeer used to be a forest and mentioned he often has peat on his anchor. The Trapegeer region contains different areas: 'Potje' is the cove closest to the beach and is characterized by mud and dirt (2C). One called it the goldmine of the Belgian coast (1C). In accordance to a commercial fisherman the little channel above Potje is also made up of mud as well as the Broers Bank (1R) and Westdiep (2R). The Westdiep is also described as an area containing dirt (shells, rocks and mud.), with a black colour and a place where dredged material has been dumped (1R). The Wandelaar is mentioned only once as an area consisting of mud (1C).

2.2.1.1.2 Flemish Banks

The Oostdyck is known as an area with big ripple marks and a strong current (2C + 1R). One recreational fisherman explained that there are sudden changes in depth ranging from 26-27 meters in depth to only 3 m. Therefore, it is dangerous to sail at this spot. The Oostdyck is also characterized by the occurrence of rocks (3C + 1R). On the outer side of the Oostdyck, the place is full with small brown stones and is a good place for cod (1C). Other fishermen mentioned that rocks can always be found at the sides of a sand bank and in pits. It is a layer of stone. Underneath this layer is hard clay, not sand (1R). At a depth of 20 m. there are small, round stones and big boulders. Both the inner side as the outer side of the Buitenratel is covered with stones (1C). Depth is an important factor for the occurrence of a rocky bottom, big boulders and stones that break easily (1C + 1R). In this case, a depth of 20 m. is mentioned (1C) like the other fisherman at the Oostdyck. Between the Buitenratel and the Binnenratel (France) the soil contains sand (1R). The Kwinte Bank is mainly associated with stones and rocks (5C + 1R) and is described as 'sharp ground'. The rocks are many-sided: sharp rocks of 100-150 kg with sea anemones living on them

(1C) and stones that can easily be broken (1C). A commercial fisherman described the soil of the Middelkerke Bank as muddy and mentioned that in former days, the sediment was sandier. This is the same assessment as for the Oostende Bank. This sediment type declined due to dredging with detrimental consequences for shrimp and fish. Furthermore, another commercial fisherman stated that the outer side of the Middelkerke Bank is covered with rocks.

2.2.1.1.3 Zeeland Banks

Three commercial fishermen stated that at the outer side of the Akkaert Bank there are a lot of rocks. One mentioned a dumping zone where big rough rocks are dumped (1C). At Scheur 2, there are rocks too (1C). At the Goote Bank there are a lot of small brown stones with holes (2C). One commercial fisherman uttered they lay on the outer side of the sand bank and both are claiming this is a good fishing place, but causes damage to their nets due to the rubbing of the stones. A recreational fisherman described that at the inner side of the Goote Bank there are big rocks that make it impossible for him to fish.

2.2.1.1.4 The offshore banks

Only one fisherman (1C) mentioned the presence of cobbled stones at the Oosthinder. Stones are also present at the Fairy Bank (1C). Apart from this, three commercial and two recreational fishermen confirmed the occurrence of a lot of stones at the southern part of the Westhinder. In this case, two mention the occurrence of ‘natural stones’. Ones deeper than 20-25 m. these natural stones occur (1C).

2.2.1.2 Water turbidity

Very often, the concepts of turbid water and clear water popped up during the interviews. In total, 12 commercial and 6 recreational fishermen explained the causes of turbid water and the effects of it on fish behaviour and catches.

2.2.1.2.1 Causes of turbid water

According to most fishermen (8C + 5R) wind is linked with turbidity of water. Wind coming from east (3C), north (2R) or northeast (1C) leads to turbid water at the west coast of the BPNS. Two fishermen stated wind from the east or the northeast leads to turbid water at the entire coastline (2C). In contrast, one recreational fisherman stated wind coming from the south or southwest leads to turbid water at the west coast. The east coast is characterized by turbid water when the wind is coming from the south or southwest (2C + 1R). Furthermore, turbid water is also created in stormy conditions, specifically in autumn (2C + 1R). The tides (3C) and the currents (2C) have an impact on the turbidity too and are mostly mentioned as a strengthening aspect together with the wind (4C). The 'bloom' also creates a period of turbid water across the entire coastline (1C) or at the west coast (2C). Apart from this, one fisherman (1C) stated the west coast is characterized by turbid water, more than at the east coast because the west coast contains more mud in contrast to the east coast where there is more sand. Turbid water is always linked with the coast. One recreational fisherman explained that in deeper water (17 m), the water is not as turbid as in shallow water as it takes more time for the water at the bottom to break up. A commercial fisherman gave the same clarification.

2.2.1.2.2 Effects of turbid water

The turbidity of water has a major influence on fish catches and is linked to fishing techniques, target species and fish locations (see further in the case studies of certain fish species). A few fishermen explained that fish will have different behaviour depending on the turbidity of the water. Turbid water goes well together with fish moving close to the bottom such as flat fish, shrimp or eel (2R). One recreational fisherman told he has to go to deeper water (more clear water) for whiting and round fish when there is turbid water at the coast. Another commercial fisherman explained fish will change its hunting strategy and move to another height in turbid water.

2.2.1.2.3 Causes of clear water

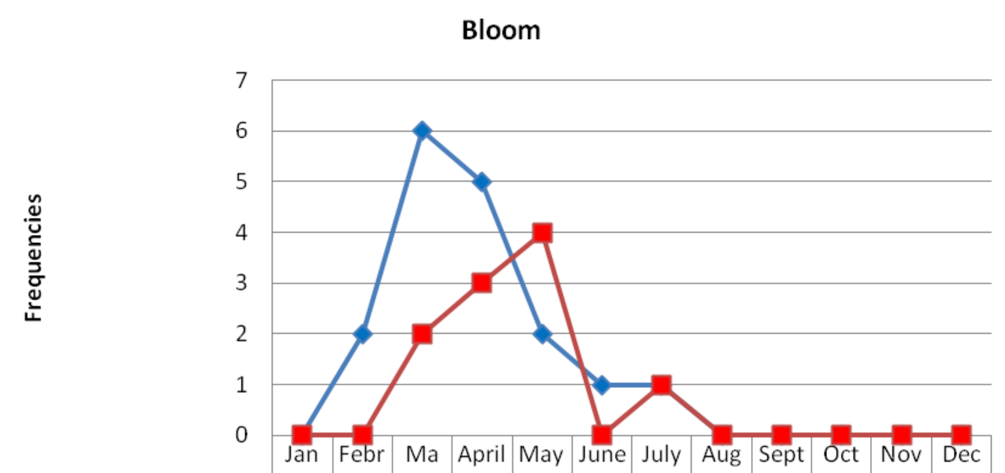
As wind is linked with turbid water, it is also linked with clear water (7C + 4R). Southern wind (1R) leads to clear water in the entire region, as does wind coming from southwest (1R). Two commercial fishermen stated the west coast is marked by clear water if the wind is coming from southwest. A western wind also goes together with clear water at the west coast (3C). On the other hand, one recreational fisherman stated northern wind is related to clear water (1R). Wind from the east is linked with clear water at the east coast (1C) or the entire region (1C). Besides wind, good weather and the summer period are uttered conditions for clear water (2C). Low tide also leads to clear water according to a few fishermen (1C + 1R). During the interviews a number of fishermen (7C) declared that they observed an evolution in the turbidity of the water. They all stated that the water is clearer than in former days. The causes given by those fishermen are multiple. Two mentioned the dredging (2C). As a consequence, there is no sand or mud that can turn up. The extraction of phosphates out of the washing-powder and a fish decline (as there is less food) is another explanation (2C). One commercial fisherman claims washing-powder and chemical substances in general lead to clear water. Overfishing is mentioned once (1C).

2.2.1.2.4 Effects of clear water

Clear water, like turbid water, has an effect on fish catches. According to one fisherman, clear water is good for predatory fish (sea bass, whiting ...) (1R). Furthermore, a number of fishermen stated their catches are not good in clear water, especially for shrimp, sole or eel (3R). In this case, two recreational fishermen explained that fish moves towards deeper water. Two fishermen, fishing with a standing rigging system, confirm they do not have good catches in turbid water in contrast to the catches in clear water.

2.2.1.3 Blooms

During the interviews most fishermen were asked their opinion about foam at the beach or on the water. Every fisherman linked foam with the phenomenon of 'bloom' (fig. 17). There are multiple definitions of bloom. A number of fishermen believe that it is caused by the dying of plankton (3C + 1R) or algae (1R). On the other hand, a few fishermen believe the opposite, because if the water blooms (2C + 2R), plankton (1C) or algae die (1R). Two fishermen (1C + 1R) also mentioned the activity of ultraviolet radiation. The foam can have different colours (1C + 2R) like white, brown or pink. One fisherman described (1R): *"Algae move slow and bloom at its best on sand banks because the currents are less strong. ... And you can see that. You can see the sand banks because of the algae ... it foams and is a lot darker."* One recreational fisherman mentioned that the period of the bloom goes together with a certain smell.



	Jan	Febr	Ma	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Commercial (13)	0	2	6	5	2	1	1	0	0	0	0	0
Recreational (11)	0	0	2	3	4	0	1	0	0	0	0	0

Figure 17: Bloom season

In general, the bloom is a phenomenon occurring in spring. Figure 17 shows that bloom occurs earlier according to commercial fishermen (end of winter) and at the beginning of spring, while recreational fishermen believe there is a peak towards the end of spring. A number of fishermen mentioned no real evolution or shifts in seasons (7C + 4R). Few stated that the period of bloom fluctuates depending on winter (2R) or weather conditions (1C).

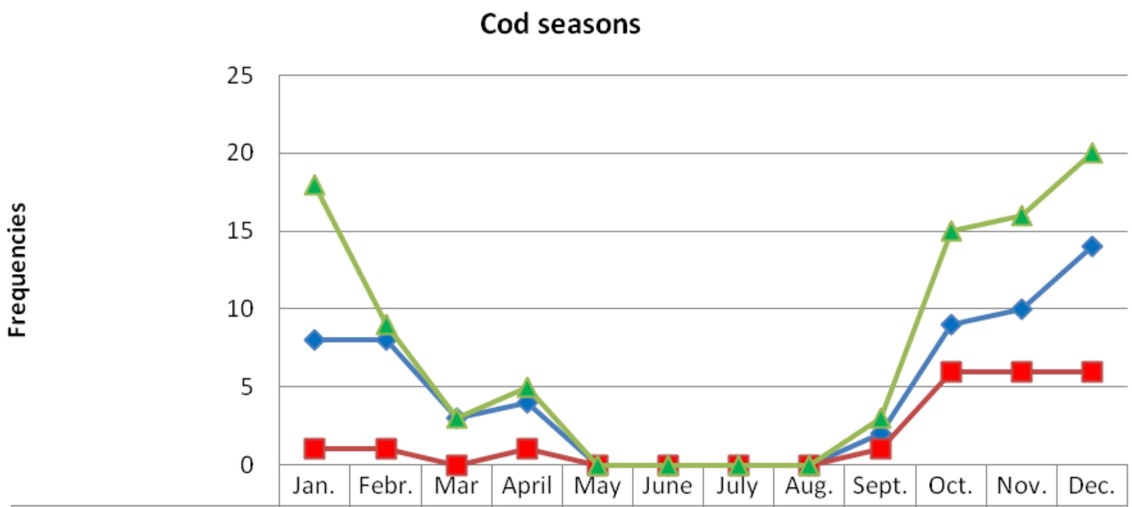
The bloom goes together with the start of sea-gooseberries (1C) and attracts jellyfish as plankton serves as a food source (1C). Bloom is a period of food delivery according to a number of fishermen. Two fishermen believe that at the beginning of bloom, fish leave their eggs and this bloom delivers important food sources for these fishes (1C + 1R). This period is also linked with the appearance of worms and shells (1C + 1R). Two recreational fishermen stated that within this ‘bloom’ less fish can be caught because there is less oxygen. Underneath the layer of bloom the water is clear and this serves as a good hiding place for small fishes. As bloom has an effect on fauna, it also has an effect on catches. Only one fisherman does not experience any effect on his catches. Two commercial fishermen stated their catches are bigger because bloom creates turbid water. However, most fishermen (7C + 4R) stated it has a rather negative effect on their catches. The most mentioned reason is the vegetation in the form of ‘slime’ or ‘gruel’ that sticks to the net. In this way, the fishing material does not work properly. Other reasons are by catches of sea-gooseberries and jellyfish (2C) and one commercial fisherman claimed that the taste of fish is different (1C).

2.2.2 Fish species

2.2.2.1 COD (Gadus Morhua) – see maps series I (I.1-I.10)

2.2.2.1.1 Seasons

Cod is not caught during summer. The frequencies are the highest in autumn and during winter with a peak in December and January (fig. 18).



	Jan.	Febr.	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Commercial (17)	8	8	3	4	0	0	0	0	2	9	10	14
Recreational (10)	1	1	0	1	0	0	0	0	1	6	6	6
Total number (27)	18	9	3	5	0	0	0	0	3	15	16	20

Figure 18: Cod season

2.2.2.1.2 Physical condition

Observations concerning the physical appearance of cod are highly reliable as fishermen catch the species and can directly observe colour, size and health. Consequently, they are skilled in making associations between the environment and the effects on the physical appearance of cod. The specific location of cod has an influence on its colour as it adapts itself to its surroundings. For example, cod caught in the neighbourhood of wrecks has a darker colour like red or black (1C + 3R). Its colour is also darker in deeper parts as in the high seas or at the coasts in the northern part of the North Sea or the Atlantic (2C). In the region of the BPNS, cod is paler (2C). Moreover, food also affects its colour and physical appearance. If cod has eaten herring or sand eel, the cod is fatter (2C). Another fisherman explained that the cod's anus colours red if it has eaten a lot of shrimps (1R).

Furthermore, the location has an influence on the size of cod (9C + 1R). When comparing the BPNS with regions in the north, like the Channel or Iceland (3C), cod is smaller in the BPNS. One commercial fisherman stated that cod at the east coast of the BPNS (starting from Ostend) is longer compared to those at the west coast. Moreover, a small area, called ‘Potje’, is characterized by the occurrence of juvenile cod. Additionally, small cod can be found between rocks at the Thornton Bank or rocks close to ‘the Golden wreck’ at the Westhinder (2C). The size of cod varies depending on the season. Catches contain larger cod in spring time (March and April). One explanation is that cod has spawned and eaten a lot. As a consequence the cod is larger (1C) and it weighs a lot more, but you can catch less (1C + 1R). Two fishermen declared that during autumn and winter, cod is smaller.

Table I summarizes the evolution of cod size experienced by 11 commercial and 8 recreational fishermen. The reliability of the responses varies at different levels. Firstly, not every person provided profound information, for example about the time frame. In this way an exact insight in the evolution is less reliable. Secondly, the given size is not always expressed in the same unit (centimetre vs. kilogram) or is more abstract (large or small). In general, recreational fishermen express themselves by using more exact weights in comparison to commercial fishermen. Possible explanations can be found in their participation in fishing contests and/or their catch unit of several species only when using hooks and lines. Irrespective of the reliability, a trend in the reduction of the size of captured cod can be clearly observed. Almost everyone uses expressions such as ‘small(er)’ or the given weight is lower than the weight in previous times. One fisherman uses even the word ‘dwarfism’. When reorganizing the data, we see a declining pattern in weight during the decades. During the 1960s the size varied between 7 and 15 kg. During the 1970s the weight varied between 7 and 12 kilogram. The weight dropped to between 3.5 and 9 kg in the 1980s. In 2010, the weight of cod is situated between 1 and 5 kilogram (see table 1). A few fishermen (4C) mention that cod today is not large, but there are ‘a lot’ of them. At this point, we have to ensure not to confuse the evolution of cod size with the year classes of cod. Two fishermen (1C +1R) explained that the size of cod and their cod catches are evolving in a cycle of 4 years (1C) or in a cycle of 5 to 6 years (1R). However, the commercial fisherman did not observe this cycle by himself as he heard it from his father-in-law. Overall, the trend is that small cod goes together with a greater abundance. Where the cod grows larger, their number declines.

Table 1: Cod size evolution based on catches

Black: High reliability (answers by the fishermen and own observations.)
Green: Medium reliability (no direct information from fishermen. Answers are distracted from general sample data.)
Red: Low reliability (cod is not a real target species and/or fishing techniques used are too broad.)
NI: No Information

Fishing technique	Period of reflection	Size	Size 2010
Commercial fishermen (11)			
Trawl in pair	1970-1979	7-8 kg.	3-4 kg.
Otter trawl	1970's	8-10 kg.	A lot, but not big
Standing rigging	1987	3.5-4 kg. (gutted)	Smaller
No target species		Bigger	Rather small
Beam trawl	Started cod fishing in 1980	Bigger	Smaller
Beam trawl	Started cod fishing in 1965	NI	A lot, but 60-70 cm. in 2008 and 2009
No target species		NI	Small
Otter- and Beam trawl	Started cod fishing in 1965	NI	A lot, but 45-50 cm. in 2008
No target species		NI	A lot, but 1-2 kg.
Standing rigging	Started cod fishing in 1987	NI	10 kg. 2009 and 2010
Otter trawl & standing rigging	Started cod fishing in 1965	Variations	Big
Recreational fishermen (8)			
1971		10-12 kg.	3 kg.
1980's		8-9 kg.	3-4 kg.
Started fishing in 1961		14-15 kg.	3-4-5 kg.
Started fishing in 1983		5-6 kg.	2-2,5kg. / 3-4kg.
Started fishing in 1995		4 kg.	2 kg.
Started fishing in 1974		NI	4-5 kg.
Started fishing in 1964		7-8 kg.	Smaller
Started fishing in 1956		NK	Dwarfism

2.2.2.1.3 Habitat

In general, cod prefers cold water (4C + 5R) and is sensitive to warm water. For example, during summer when the seawater is becoming too warm, cod moves towards deeper water at least 6 miles off the coast (1C). As the water temperature is cold during spring, cod will stay at the coast side longer (1R). Cod cannot tolerate water temperature above 15°C (1R). One recreational fisherman mentioned water temperature of 10°C as normal, but cod can also be caught by a temperature of 4, 5 or 6°C (2R). Some fishermen explain that frost has an effect on the movement of cod. Once the water is too cold due to frost or when it is snowing, cod is moving away from the coast to deeper water with depths of 30 to 40 meters (2C +1R). On the other hand, 2 fishermen argue that cod is resistant to frost (2C). Additionally, according to two fishermen (1C +1R) cod will also move to deeper water during snow. Cod has no real preference for a certain type of sediment as it can be found around mud (1C) or sand (1C + 1R). Some mentioned that cod is located between stones (1C + 1R) and between sand ridges on the surface of sand banks (3C). Wrecks are preferable places for cod (6C + 5R). There are three reasons for this. Firstly, wrecks are important since more food is to be found (2C + 1R). Secondly, wrecks serve as a hiding place for cod or a place to rest (2C + 3R). Lastly, wrecks form part of the hunting strategy (2C + 1R). Around wrecks cod is interacting with other species, namely sea bass and pout (2C). Those species are not mentioned as cod's food, but rather as species that live in and around wrecks as well. One fisherman told that a distinction can be made between wrecks. Cod can be found both in and around a wreck and seems to have the best spot. Cod can be found between 1 and 2 meters off the bottom. Underneath cod swims spout and above cod swim sea bass (1C). The turbidity seems to have a direct effect on the behaviour of cod and indirectly on the catches (5C). Cod will lie down on the sea bottom (1C) when the water is clear during daytime or when there is full moon at night. In the same condition of clear water, cod will move towards deeper water (1C). Overall, cod catches are better during the night or in turbid water (5C). If catches are low during the day because of clear water, they can be doubled during the night (1C). Wind and more specifically wind from the north, northeast and northwest during winter is good for cod catching in coastal areas (1C). Furthermore, after a storm the Westhinder is a good area to catch cod (1C).

2.2.2.1.4 Food web position

According to most fishermen, cod prefers crab, shrimp, razor clams and worms. Plastic is not a natural food source, but is mentioned several times to be found in the stomach of cod (fig. 19). Most of the fishermen related the feeding pattern of cod to the seasons and to their locations. Cod eating shrimp is closely associated with autumn (3C +1R) and spring (1C +1R) and their movement towards the coast (3C + 2R) during these two seasons. This direction is also influenced by the water temperature during spring. More concretely, as soon as the water is starting to warm up cod will hunt for shrimp in the coastal area (1C + 1R). Crab as a food source is also associated with spring and autumn (1C + 1R) and the coastal region (1C + 1R). The winter period is only marked once for those two food sources. In this case, one recreational fisherman stated that cod is not present on the coast if it is very cold, because crabs cannot endure cold water and are starting to move in the direction of deeper water. Consequently, cod will follow its food chain (1R). Herring and sand eel are linked with the top of sand banks (2C) and with deeper sand banks during summer (1C). In the first case, a fisherman clarified that most cod is situated around wrecks closely situated near sand banks because cod can hunt for sand eel on the sand banks and then return back to its wreck (1C). In total, 14 fishermen (9C + 5R) talked about the forage behaviour of cod. However, this kind of knowledge is rather fragmented. Cod hunts for food in and on the seabed (2C), but also in higher levels of the water column (2C). When hunting for shrimp or worms on the seabed cod will turn over the bottom (1C). In addition, two fishermen believe cod hunts during the day. This information is inconsistent with information received from two other fishermen who assume that cod hunts during the night. Information from a few fishermen indicates that cod uses different methods to find its prey: scent (1C + 1R), sense of touch (1R) and sight (1C).

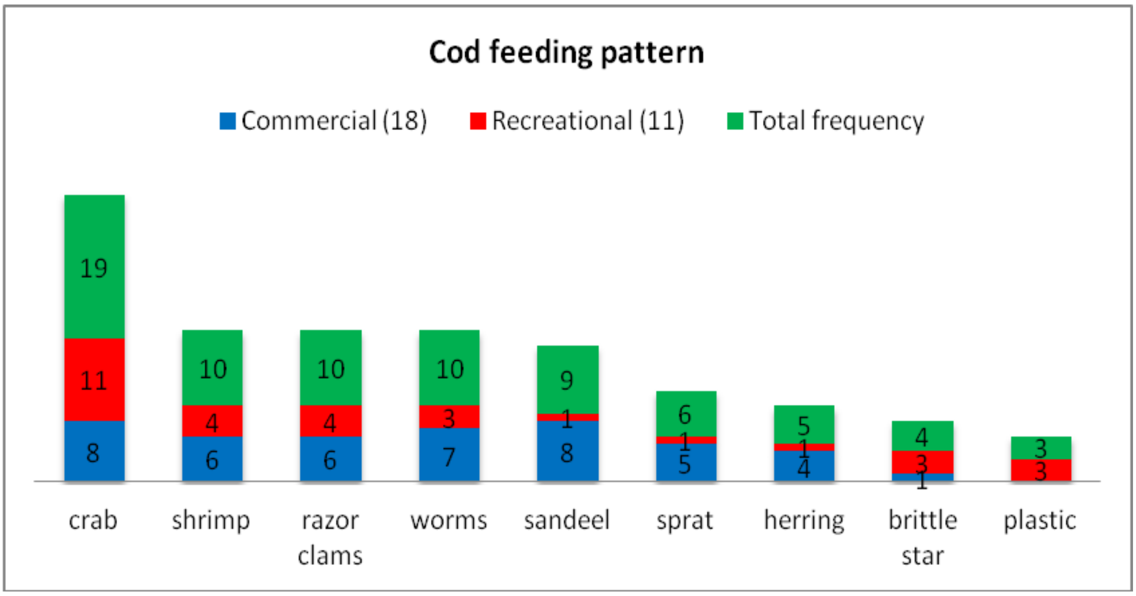


Figure 19: Cod feeding patterns

2.2.2.1.5 Spawning

Spawning locations of cod are not available on maps. Nevertheless, during the interviews the coastal region was cited 7 times (5C + 2R). Sand banks were only mentioned 4 times divided into the Flemish Banks (1R), Sea land Banks (1C + 1R) and the Coastal Banks (1C). For the most part fishermen said cod is spawning from October to December. Spawning has an effect on cod's forage behaviour as spawned cod eats as much as possible and eats anything it can (1R). In addition, the spawning period has an effect on the catches depending on the used fishing technique. For example: fishing for cod during the spawning season is more difficult when using hooks and lines. However, by fishing with the standing rigging system you can catch them more easily (1R).

2.2.2.1.6 Locations

In the 1960s five commercial fishermen fished for cod. In comparison to the 1950s, this represents a flare-up as showed on the map with the marked fishing locations. The fishing positions are immediately widespread across the BPNS. Additionally, specific spots are mentioned by several fishermen. This can indicate the importance of certain areas. For example: the Kwinte region between the Kwinte Bank and the Buitenratel is drawn by three of the five fishermen. Secondly, the outer part of the Thornton Bank is mentioned two times, as well as the area on the northeast of the Akkaert Bank. On the other hand the fishing locations of recreational fishermen are more concentrated on the beach in the east and close to the coastline on the west coast (maps I.3-I.5 in Annex).

During the 1970s the fishing locations of the eight commercial fishermen were not really extended in space, but rather in intensity. More particularly, the Westhinder region is a common fishing place among the commercial fishermen. Furthermore, the Thornton Bank and the northern part of the Goote Bank were pointed out at least 4 times. In comparison to the 1960s, the fishing spots of the recreational fishermen extended as far as the bottom of the Hinder banks. The beach and piers are still presented. The region underneath the Westhinder Bank and the Goote Bank is also indicated more than once. Although the recreational fishing spots were also closely situated to sand banks, they do not represent trails as they rather fish with hook and line and often close to wrecks (maps I.3-I.5 in Annex).

For commercial fishermen, the Goote Bank and the Thornton Bank were still common fishing places in the 1980s. In this decennium, fishing on wrecks first began. Those wrecks most mentioned are situated at the west coast, in the region of the Flemish

Banks. The fishing locations of the recreational fishermen remain stable during this decade and were also characterized by an expansion of wreck fishing (maps I.3-I.5 in Annex).

Following a period of intensity and extension, the 1990s were characterized by a general fall-down. The Zeeland Banks were almost not mentioned by the commercial fishermen. Still, wrecks are highly presented. In general, the fishing locations for the recreational fishermen remained the same for this period and there was no real extension in space (maps I.3-I.5 in Annex).

The start of the 21st millennium has been characterized by a further decline in fishing on cod. Wrecks and sand banks under the Hinder Banks were not mentioned anymore by commercial fishermen. The sand banks in the deep end of the BPNS are still presented. The fishing areas of the recreational fishermen are similar in general terms, but are slightly extended since more recreational fishermen have drawn on the maps (maps I.3-I.5 in Annex).

In general, we can conclude that cod fishing in the area of the current BPNS rose in the 1960s. The fishing techniques most frequently used by commercial fishermen were otter trawl and trawl in pair. The 1970s and the 1980s were characterized by an expansion in fishing locations and intensity and represent the most intensive decennia of cod fishing. Fishing around ship wrecks appeared during the eighties whereby the otter trawl and trawling in pair were still the most popular fishing techniques. The 1990s were characterized by a decline in the indicated fishing spots, mainly areas across sand banks. During this period, a further increase can be noticed for fishing on wrecks (map I.9 in Annex). Notably, this period goes together with the use of the standing rigging system as fishing technique (map I.9 in Annex). The decline continues in the new millennium both for sand banks and wrecks. Even though the standing rigging system is still present in the first decade of the new millennium, fishing on wrecks is declining since they are not represented on the maps. One fisherman explained that he shifted his target species in 2000 towards sole and sea bass because the stock of cod was characterized by a serious decline. The other two fishermen explained that cod can be found around wrecks but strict quota are enforced as a result of which cod fishing is restricted around those spots.

Fishing trails are parallel with and close to the sand banks. In total, 15 fishermen (13C + 2R) pointed out accurately where they found cod in the surrounding of sand banks (map I.6 in Annex). Most of the fishermen (9/15) stated that they fish for cod on the slope of a sand bank. Several of those fishermen (5/9) fished at the beginning of the slope and one fished at the end of the slope, close to the top. Five fishermen (5/15) fished on top of a sand bank.

2.2.2.1.7 Locations in relation to seasons

During summer, only the Noordhinder region is indicated by commercial fishermen as well as the wrecks around this area. The coastline is not mentioned on the maps. Autumn is marked by an increase of cod fishing in the BPNS. When analyzing the months separately, a sudden rise appears in October. Remarkably, in September only fishing spots along the coast side were indicated and none in the deeper part of the BPNS. Wrecks that are pointed out are mostly situated at the West coast and are closely located to the coastline. This degree of activity remains during winter with a further extension of wreck fishing in the deeper part of the BPNS. From February onwards the cod fishing declines. During springtime, there is a further decline and marked fishing locations are becoming more fragmented. The Vlakte van de Raan is the only indicated region (maps I.7-I.8 in Annex).

In case of recreational fishermen, the fishing locations indicated on maps remain stable during the four seasons. In summer, recreational fishermen indicated wrecks as fishing points mostly in the west coast region. Also the Goote Bank and the area above the Oostdyck are marked. Those areas remain during autumn and winter. The east coast is only indicated during wintertime. In general, fishing areas of recreational fishermen in the research sample are situated south of the Westhinder (maps I.7-I.8 in Annex).

During the interviews, five fishermen (4C + 1R) pointed out that the fishing locations for cod are situated in the deeper part of the BPNS during summer, from the Westhinder as far as the Noorhinder with depths up to 40 m. This can be applied to both sand banks as well as wrecks. One recreational fisherman mentioned that cod can be found on particular wrecks in the summer, whereas in the winter other wrecks are mentioned. The coastline was cited 7 times (4C + 3R) as an area linked with the season's autumn (4C + 3R) and winter (2C + 2R). Three fishermen (1C +2R) declared that cod 'is coming back' towards the coast during spring (March and April) (maps I.7-I.8 in Annex).

Besides this, several fishermen explained why cod is present on very particular places. Two commercial fishermen pointed out that on the surface of the Westhinder there are sand ridges where cod is located. One commercial fisherman explained that cod is present in these sand ridges for a short period in December because of the migration of herring and these herring serves as a food source for cod. In addition, shrimp and crab are two species linked by a number of fishermen (2C + 1R) with the behaviour and location of cod. Shrimp is related with the appearance of cod in the coastal zone during spring and autumn. Additionally, a commercial fisherman finds cod in December at the top of the Wenduine Bank because of the appearance of sand eel. Food sources seem to be particularly influential in respect to cod and its locations. Another influence on the location of cod can be found in their spawning behaviour (1C + 2R).

2.2.2.1.8 Cod migration

Information concerning the migration behaviour of cod is rather limited and fragmented. Four fishermen (3C + 1R) said cod is coming from ‘the North’ in autumn (2C). On the other hand, two fishermen offered that cod is not migrating but is staying in the deeper part of the BPNS, at least 30 nautical miles off the shoreline (2C). Although little is stated about the migration pattern of cod, a few fishermen (3C + 3R) put forward certain reasons why cod is coming towards the BPNS and more particular to the coast. The two main reasons are spawning (2C + 2R) and the food web (2C + 1R).

2.2.2.1.9 Cod stock evolution

In the 1940s cod was present in the waters of the current BPNS (2C). One fisherman stated cod was present, but fishermen did not know very well how to catch it. Additionally, during the Second World War, there were no real cod catches. One recreational fisherman told that his father as a child did not catch cod on the old dike of Zeebrugge. On the other hand when the interviewee was a child in the 1950s he could always catch cod on the same spot. Another explanation is that cod only appeared in the 1960s after the rise of herring (1C).

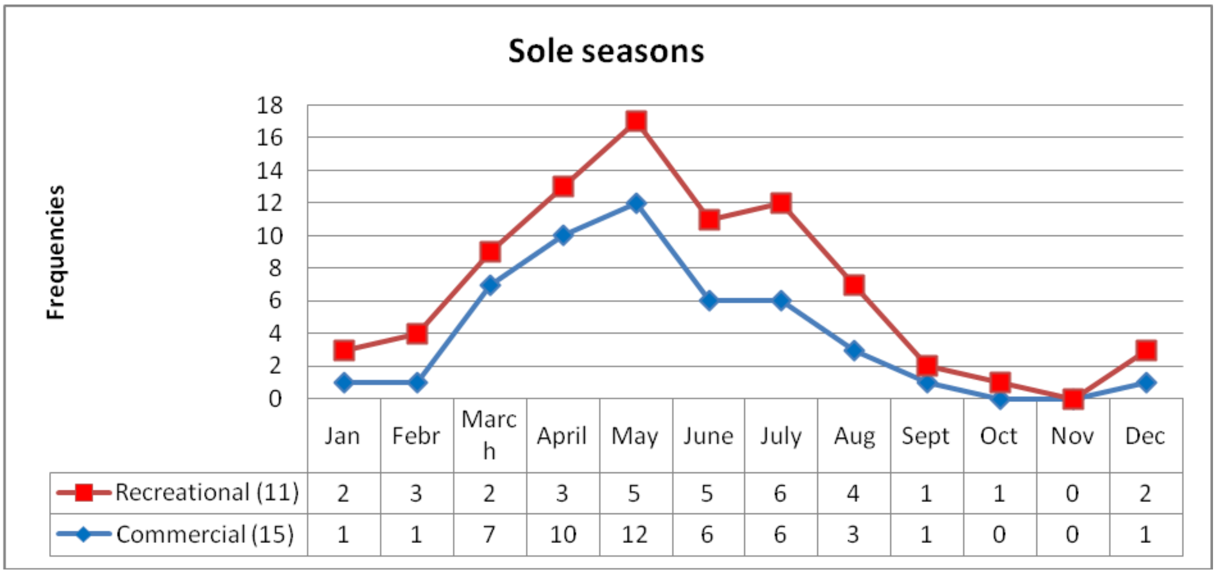
Information on the evolution of the stock size indicates that time frames are dissimilar as a result of the fact that the fishing vessels of the interviewees vary over time. As a consequence, the starting point for making comparisons in terms of time is a rather individual issue. For example, a fisherman who started fishing in the 1980s will believe that in those days there was a lot of cod whereas a fisherman who started in the 1960 saw already a decline in the 1980s in comparison with the 1960s. Nevertheless, a few trends can be noticed. Everyone (11C + 5R) mentions a decline in the stock size during their fishing carrier. The 1980s constitute an absolute low (3C + 1R). The causes of the decline can be categorized in overfishing (2C + 2R), global warming (1C + 1R), massive migration of cod to other regions (1C), the entrance of larger vessels and more engine power (1C). Those 16 fishermen also indicate that the stock increased or restored over the last years. The impulse to this evolution can be found in the use of quota (2R) and the removal of vessels out of the fleet (2R). The decline of the stock size has had an effect on the behaviour of fishermen. During the 1980s, the profitability of the otter trawl decreased causing a switch to the beam trawl (1C). Another effect is the market price for cod. As the catches for cod are low, the price rises. In this way, the search for cod goes on (1C). The increase of the stock together with quota measure resulted in avoiding fishing in areas where cod is located, for example around wrecks (2C). Besides this, it leads to discards and the death of cod. In this framework, one commercial fisherman stated that there was a plague of starfish in 2010 due to these discards, since dead fish attracts scavengers like starfish (1C).

2.2.2.2 Sole (Solea solea) – see maps series II (II.1-II.11)

2.2.2.2.1 Seasons

81% of the fishermen gave an indication of the seasons in which sole is caught in the BPNS. As we can conclude from figure 20, sole is mainly caught during spring and summertime with the highest concentration in April, May and July. The peek in July is mainly due to fishing by recreational fishermen. A subdivision can be made as fishing techniques are linked to certain periods and the rate of catch successes. Four fishermen (1C + 3R) stated that they cannot fish with hooks and lines before June, because sole has to spawn and consequently is not interested in the bait or in food generally (1C + 2R). One commercial fisherman noted that once sole has spawned, cod is located at the bottom of the sea in search of food. Only then, the catches are successful for those who use fishing techniques like the beam trawl or hooks and lines. However, during the same period, the use of flat nets on the beach (2C + 1R) and the standing rigging system (3C + 1R) are common fishing techniques.

Many fishermen linked the sole season with spawning behaviour (8C + 3R), the co-appearance of shrimp (3C) and in a lesser degree their feeding pattern (2C).



	Jan	Febr	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Recreational (11)	2	3	2	3	5	5	6	4	1	1	0	2
Commercial (15)	1	1	7	10	12	6	6	3	1	0	0	1

Figure 20: Sole seasons

2.2.2.2.2 Physical appearance

The physical appearance of sole is often related to the seasons and the fishing locations. More concretely, seasons are related to the size of sole. Throughout spring, sole is lager (3C) as they are full of spawn (2C), during summer and autumn sole is smaller because they have spawned (C22). Additionally, the coastline is considered as a place full of juveniles in this period (2R).

Sole is one of the main target species for a majority of Belgian commercial fishermen and the fishing grounds for sole are situated both in and outside the BPNS. Using this framework, fishermen can compare the size and colour of sole between the different areas. For this reason, information about regions outside the BPNS will be included. One commercial fisherman stated that sole has the same colour throughout the whole North Sea region, together with sole in the Channel and in the Irish Sea. Except in the region of the northern coast of France, sole is characterized by marks on their skin. Fishermen describe it as 'flowers' or little 'circles'. These 'circles' on their skin are also spotted near the English coastline (1C). Sole adapts its skin colour to its surroundings. If sole is situated in sand (2C), in mud (1C) or when the bottom is 'hardened' during winter (1C), its colour changes (2C). In the case of severe winters, sole can have white spots on the upper side of its body (1C).

2.2.2.2.3 Habitat

In general, the seabed forms the main habitat of sole and the sediment type is regarded as an important criterion. Six commercial fishermen believe sole is located in sand because sand serves as a good hiding place for small sole (1C) or is ideal for spawning (1C). On the other hand, 9 fishermen (7C + 2R) perceive areas consisting of mud as the main habitat for sole. The reasons for this can be found in the abundance of food, mainly worms (2C + 2R).

The temperature of the soil (2C) is also a main factor since sole prefers warm surroundings. During March, the water temperature can still be too cold. In this case, sole will move towards places containing mud. Although sole prefers mud and sand, it appears that sole can also be present in a rocky environment (1C). However this kind of bottom is not really common in the BPNS. Conversely, the BPNS includes 'dirty soil'. "Dirty soil" is the local name fishermen give to indicate the characteristics of a certain area that consists of rocks, starfish and worms. These are locations in which sole can be easily found (2C).

Furthermore, sole is mentioned a few times together with shrimp as they both prefer warm water and share the same period during the year (4C). Sole needs a minimum water temperature of 8°C (2C). Cold water temperature or periods of frost influence the location of sole as it will move to deeper waters (3C + 1R), meaning water depth of at least 40 meters (2C) or pits (2C). This is confirmed by catch records. On the other hand, 2 commercial fishermen believe sole does not go away towards deeper waters. Sole in foul waters becomes rather slow and goes into a sort of coma. In this way, it is very easy to catch them.

The severe winters of 1962 (3C), 1986 (1C) and 1996 (1C) are indirectly related to good catches during these periods. In the winter of 1962-1963, the sea was full of sole and sole even washed ashore (1C). Continuous cold and frost during weeks directs sole to places in the west. When it is really cold, the French coast and the English coast are better places to find sole (1C).

Two commercial fishermen stated that sole is sensitive to wind. When the wind is blowing from the north east (1C) or the east (1C) sole will crawl deep into the bottom or will push itself off the bottom (2C).

2.2.2.2.4 Food web position

Almost 72% of the fishermen gave information about the feeding pattern of sole (fig. 21), stressing that worms are a significant food source. Moreover, they could discern the different subspecies (fig. 22). In case of recreational fishermen, this knowledge is acquired by using hooks and lines and different species as bait. A few fishermen (2C) pointed out that the sole favours places with fields of worms. Sole also eats small fish like sand eel. Alongside, sole prefers shellfish, essentially razor clams (3C + 2R). In this case, one commercial fisherman stated that only large sole catches razor clams as smaller ones cannot break the shell. Furthermore, sole is described as rather shy (2R). Sole lays mainly still and only swims when hungry, although not over long distances.

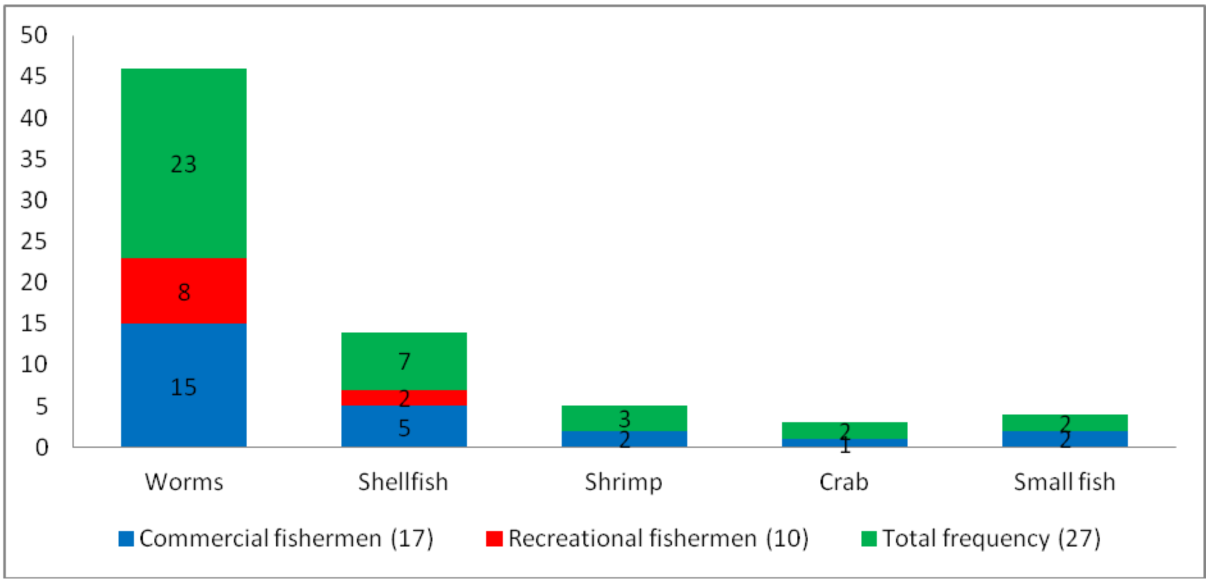


Figure 21: Sole feeding pattern

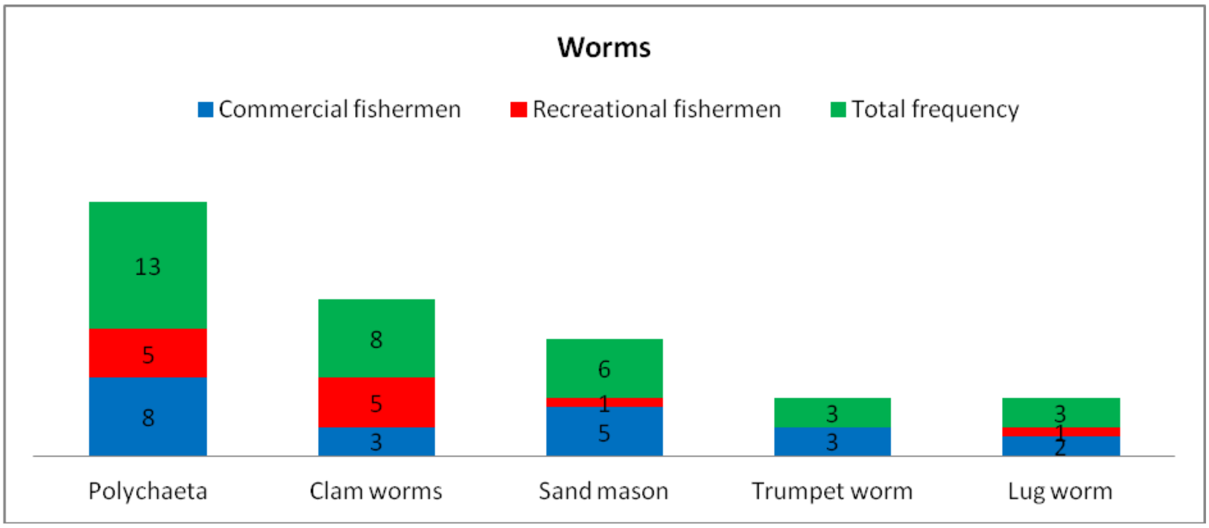


Figure 22: Worm subspecies

2.2.2.2.5 Spawning

In total, 3 fishermen indicated the spawning places for sole on maps (map II.10.2 in annex). Furthermore, 12 commercial and 8 recreational fishermen gave spatial information during the interviews. In general, the spawning zones do not lie more to the south than the Flemish Banks and the coastline is pointed out by every fisherman. The beach (1C + 1R) and Potje (3C) are places frequently mentioned.

Furthermore, sand banks and dry places were indicated as well. In terms of the beach as a spawning area, one fisherman explained that when sole arrives in the area of the BPNS, it can move 1 or 2 meters above the seabed (1R) along with the currents and gather at a about 50 meter off the shoreline. Warm water temperature is an important condition for sole to spawn (2C + 1R).

The season for sole to spawn is during springtime, more precisely in March (2C + 3R), April (2C + 2R) and May (3C). In June, the spawning period is finished (2C). There exist an overlap between the spawning period and the higher frequencies of sole caught in March, April and May. The spawning behaviour of sole can explain these high frequencies. The presence of Sole declines from June onwards. This can denote the end of the spawning season. After the spawning period, sole remains in the BPNS, yet the months during summer are less cited.

The spawning behaviour of sole has a great influence on the catches of the fishermen. As already mentioned there is a link with the different fishing techniques. This relation has an effect on the behaviour of fishermen as it determines their fishing locations and therefore their catches (2C + 2R).

2.2.2.2.6 Migration

Knowledge of sole migration is mostly focused on the BPNS itself. After sole has arrived in this region and the fish has spawn, fishermen’s information concerning further directions is rather fragmented. In general, sole is coming from the West (7C) with the Channel as its point of departure, according to most fishermen (5C). The sole enters the BPNS via the east coast of France (5C). Furthermore, sole reaches the west coast. After a certain period spent mostly in this region, sole migrates again. A number of fishermen claimed sole is shifting towards the east in the direction of the east coast and the Netherlands (1C + 1R). A few declared sole is going to the north, into deeper waters (3C).

The migration of sole to the coast of France and Belgium is strongly related with their intention to spawn. This migration and spawning behaviour of sole contributes to the catch locations and the magnitude of catches (5C + 5R). A few fishermen acknowledged their displeasure with French fishermen that catch sole with standing rigs. This means that they catch the larger soles with spawn and disturb the migration of sole (2C both fishing with beam trawl.).

2.2.2.2.7 Locations drawn on maps

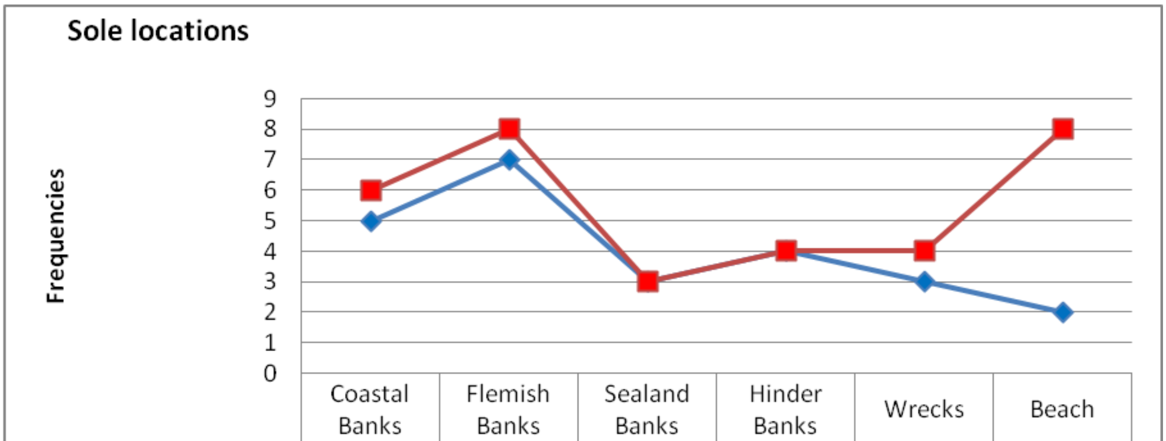
In total, 11 commercial fishermen illustrated their fishing locations for sole since the 1960s until 2010 (maps II.3-II.5 in Annex). Although three fishermen fished for sole in the 1940s and 1950s, these fishing locations are not drawn on the maps. The fishing technique used by most fishermen is beam trawling. Both vessels from the small fleet segment as well as the large fleet segment are represented on the maps. Except for the Hinder banks, most locations are situated at the west coast and the central coast of the BPNS. During the 1960s, fishing locations of only 2 fishermen were drawn. The areas close to the coast line are immediately represented with a focus on 'Potje'. Since the 1970s, fishing for sole is started to increase as well as the fishing locations, mainly around the Flemish Banks and the Coastal Banks. No overlaps between fishing areas are registered for this period. A further spread is noticed in the next decade, although the amount of commercial fishermen in the sample population remained stable. Besides this, the intensity increased for certain spots. For example, the Westdiep area is cited 3 times, Potje and the area above the Smal Bank 2 times. Since the 1990s, the intensity also increased in other regions, mainly on the inner side of the Wenduine Bank, the Stroom Bank and the area above the Smal Bank. In general, the fishing locations since 2000 are still the same. Nevertheless, the fishing intensity rose. The Westdiep, 'Potje' and the area under the Stroom Bank and Wenduine Bank are still the main hotspots.
Additionally, 9 recreational fishermen pointed out their fishing locations for sole since the 1960s until 2010 (maps II.3-II.5 in Annex). A variety of fishing techniques are used, although hooks and lines are mentioned most. Most fishing places are at the beach, on breakwaters, on dikes or jetties both at the east coast as well as at the west coast. Still, the west coast region, containing 'Den Oever', 'Potje' and the wreck 'Basilisk', is highly stressed. The period between 1960 and 1970 is mainly focused on the port channel of Nieuwpoort, the old left dyke of Zeebrugge and breakwaters in front of the Appelzak and on the right dyke of Zeebrugge. These areas remain unchanged until 2010. During the 1970s, locations at the beach are spreading in the direction of the central coast. Additionally, the concentration on different spots is increasing. The Trapegeer and 'Potje' are cited at least 2 times. The wreck 'Basilisk' is very central as it is cited three times. Fishing locations at the east coast are spreading during the 1980's towards deeper places. Still, those spots are close to dykes and the beach. Again, the intensity at the west coast remains high. As described above, this goes on until 2010.

When combining the fishing locations of both commercial and recreational fishermen, the sole fishery in the BPNS is mainly focused on the Flemish Banks and the Coastal

Banks. However, the intensity of certain places at the west coast is high since the 1970s until 2010. Since the 1970s, the wreck 'Basilisk' on the Trapegeer is mentioned at least 5 times by recreational fishermen. The 'Westdiep' district and 'Potje' are cited at least 4 times in every decade. Other important spots are the Smal Bank, the spot under the Wenduine Bank and the area under the Stroom Bank. In conclusion, an overlap exists between the commercial and the recreational fishing locations.

2.2.2.2.8 Locations mentioned during interviews

Generally, commercial fishermen cited sand banks more than recreational fishermen. The stress falls mainly on the Flemish Banks and the Coast Banks (fig. 23 and map II 2 in Annex). The fishing locations of the fishermen are close to sand banks and fishing trails lay parallel with the sand banks. In total, 4 fishermen (3C + 1R) fish on the slopes of a sand bank. According to one fisherman, sole is more present at these locations because the slopes are made of mud (1C). On the other hand, three commercial fishermen prefer the top of the sand bank. Two of them explained that sole can also be found on the slopes, but fishing at the top will be more selective as there will be less by catch of other fish and benthos (2C).



	Coastal Banks	Flemish Banks	Sealand Banks	Hinder Banks	Wrecks	Beach
Recreational(12)	1	1	0	0	1	6
Commercial(19)	5	7	3	4	3	2

Figure 23: Sole catch locations

On the maps, recreational fishermen expressed the importance of the wreck 'Basilisk' at the Trapegeer. During the interviews, wrecks were also cited by commercial fishermen. One commercial fisherman declared sole is present on and in wrecks from June onwards. As from August, sole leaves the wreck areas. This makes it a perfect moment to fish around the wrecks. Nevertheless, sand banks are more common places to locate sole.

The coastline and the beach are significant places to find sole, mainly for recreational fishermen (6R) (map II.2 in Annex). A distinction can be made between the east coast and the west coast. The west coast as far as Ostend is mostly mentioned with regard to the spawning behaviour and the migration pattern of sole. The east coast from Zeebrugge and more specifically Knokke is a good area to find sole during summer (3R) and are not mentioned during spring.

The area close to the border between France and Belgium forms an important region for sole. It includes Westdiep (2C), Broersbank (1C), Den Oever (2C), Trapegeer (1C) and Potje (7C). 'Potje' is characterized by its location very close to the beach with a depth of 6 to 7 meters and is enclosed by Trapegeer and Broers Bank. Four commercial fishermen recognize these areas as important for catches because it is the place where the migrating sole from the Channel arrives first in the BPNS.

2.2.2.2.9 Fishing locations in relation to the seasons

A number of fishermen provided information on seasonal differences when pointing out their fishing locations (maps II.7-8 in Annex). Recreational fishermen linked most locations with spring time and summer. In autumn, certain areas remain attractive for fishing. The east coast is only presented from April until October. During winter only the port of Nieuwpoort is indicated. On the other hand, there is a boom of fishing locations on the maps since April and this continues until September. In autumn, commercial fishery locations at the coast are limited. As from December, no coastal area is spotted and fishing locations for sole are located in the region of the Oostdyck.

2.2.2.2.10 Catches

As described, catches are determined by different factors. Firstly, the migration of sole and its spawning behaviour leads to a rise of sole catches from March, especially at the west coast of the BPNS. Secondly, the water temperature and severe winters influence the movement of sole and therefore the fishing behaviour of fishermen. Fishermen know where the sole is migrating to and follow them. The results are catch records. In the winter of 1962, one fisherman caught 1000 kg every night (1C). In the winter of 1986, a commercial fisherman caught 24 ton in one week. The results of these records are reflected in the following years because caught sole in such an amount interrupts the reproduction (2C). This also has an effect on their catch rates. Thirdly, wind from the north east is not favourable to catch sole (1C), although one commercial fisherman stated he did nice trails in ‘Potje’. Fourthly, the tide influences the catches as well, in particular in ‘Potje’. One commercial fisherman who fishes with standing rigging explained that the best catches are in the period of slack water. Another fisherman who fishes also with the standing rigging system states his best catches are during high tide, not during low tide. Lastly, the best time to catch sole is during the night according to two commercial fishermen.

2.2.2.3 Sea bass (Dicentrarchus labrax) – see maps series III (III.1-III.7)

2.2.2.3.1 Fishing techniques

In the research sample, sea bass is a species caught by commercial fishermen using mainly the standing rigging system in combination with angling or otter trawling (fig. 24). Furthermore, fishing sea bass by commercial fishermen in this study is a recent activity because, when asked for target species, the species was not mentioned before the 1980s. Recreational fishermen fished sea bass already in the 1950s, but equally the booming of recreational sea bass fishing was situated in the late 1970s - early 1980s. Today sea bass fishing is still done by almost all of the recreational fishermen interviewed. Sea bass fishing in the BPNS for commercial reasons is not of significant importance for the interviewed commercial fishermen (see maps III.3 in Annex).

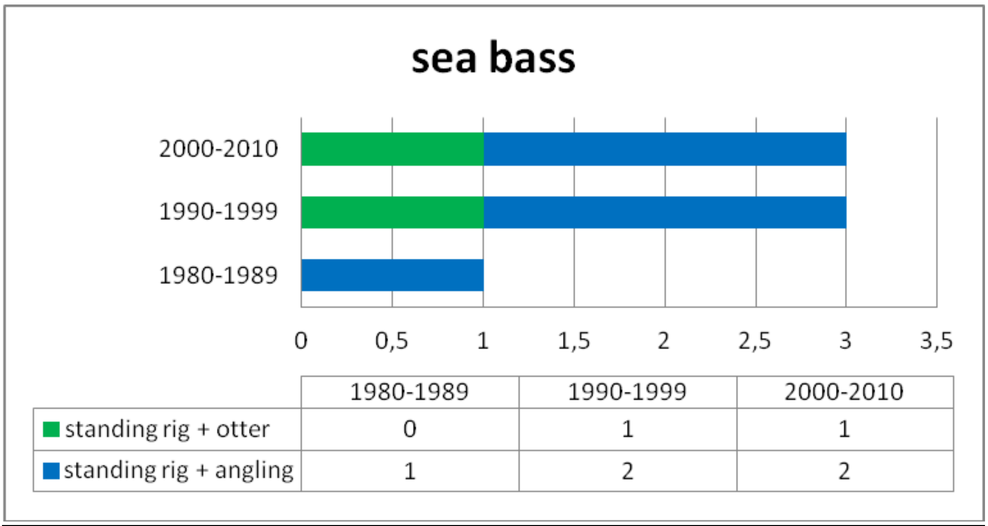


Figure 24: Commercial fishing techniques on sea bass

2.2.2.3.2 Catch locations and seasons

Information concerning the physics of sea bass is fragmented. The fishermen in the research sample rather talked about 'small' sea bass (1C + 4R). Four fishermen linked the size of the fish species with the location they were caught: off the coast in Koksijde and the sand banks near Sint-Idesbald (Koksijde) sea bass is rather small (2R). One fisherman (1R) mentioned that sea bass is largest during summer at the Kwinte bank, with a length of maximum 45 cm. When sea bass arrives in late May, it has a 'wild flavour' and the fish is lean (1R).

According to most fishermen the occurrence of sea bass is mainly from late spring onwards and reaches its peak during the summer (fig. 25 and maps III.5-6 in Annex). From September onwards, the appearance of sea bass declines. One fisherman claimed that the presence of sea bass has shifted. Sea bass was only present during the summer in the middle of the 1990s. In 2010, finding sea bass the entire year round is no longer an exception (1R).

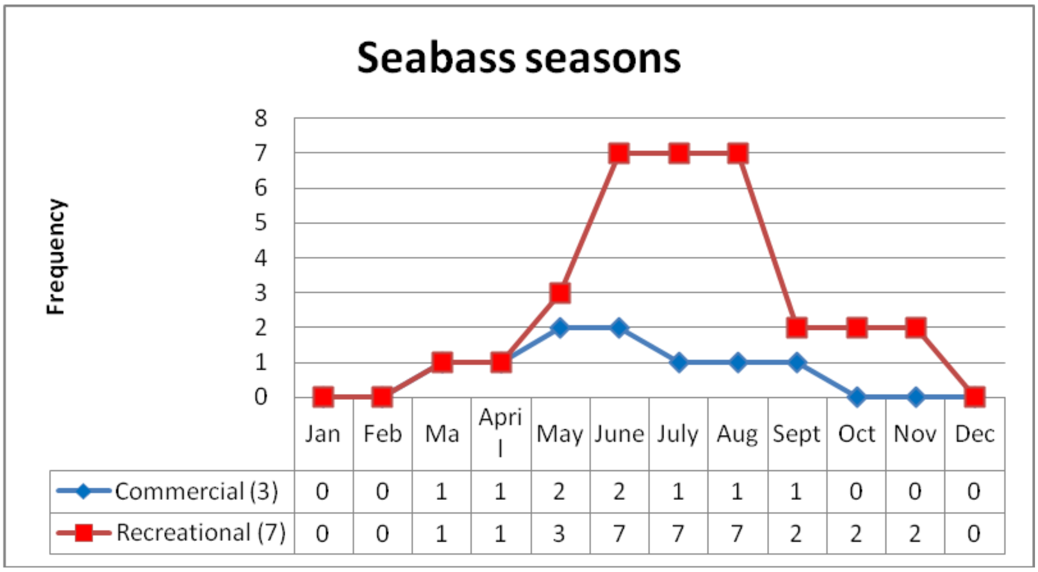


Figure 25: Sea bass seasons

A water temperature of 8° is necessary for sea bass (2R). When the temperature drops below 8°C, sea bass will migrate to the Channel or wrecks at deeper places (1R). One commercial fisherman stated a temperature less than 15°C leads to migration of sea bass.

A number of fishermen in the research sample stated that the locations for sea bass have shifted towards the Belgian coast. According to a few fishermen, sea bass is migrating from the Channel (1C), from England (1R) or from places where the water has a higher temperature, such as the Mediterranean Sea (1R). A warming of the water temperature (2C + 2R) and the observation that the water temperature is not as low as in former days (1C) are stated as possible explanations. One recreational fisherman explained that sea bass is migrating towards Scheveningen and the Wadden.

Wrecks form an important place according to ten fishermen (5C + 5R) and are related to bigger sea bass (1C + 2R). One recreational fisherman explained that the biggest sea bass are located in the wrecks. Food (2R) and the need for a stronger current (1C) are the main reasons mentioned. Besides this, sea bass is also located at sand banks, more specifically the Coastal Banks (1C + 2R) and the Flemish Banks (3R) (see maps III.1-2 in Annex).

2.2.2.3.3 Feeding

A total of 11 recreational and 2 commercial fishermen provided information concerning the prey of sea bass. Horse mackerel (1C + 2R), mackerel (1C + 2R), crab (1C + 2R) and sand eel (1C + 4R) were the species most mentioned. Furthermore herring, worms and razor clams were also cited. In this framework, sea bass uses wrecks as a hunting strategy. When small fish pass by a wreck, sea bass will shoot out of the wreck to get its prey (3R). According to a number of fishermen (1C + 3R) sea bass hunts relying on eyesight. Therefore, as an important condition to successful hunting, the water should not be turbid (3R). One commercial fisherman explained that sea bass will also hunt in turbid water but at other species, such as worms. Bait used by recreational fishermen is also adjusted to this characteristic by using artificial bait (3R). Clear water is also an important condition to catch sea bass (2C + 2R). Further, being quiet is important on because sea bass are really shy (2C).

2.2.2.3.4 Stock

Thirteen fishermen stated that the appearance of sea bass in the BPNS has increased (8C + 5R). More precisely, four of them (3C + 1R) were talking of an increase of sea bass fisheries instead of an increase of the sea bass population in the region of the BPNS. The period of the start of the stock rise varies. Fishermen first noticed an increase in the 1970s (1R), in the 1980s (3C) or in the new millennium (3C). Eight fishermen (5C + 3R) believe sea bass was not present in former days. Six other fishermen (4C + 2R) are of the opinion that sea bass was present, but fishermen did not have the knowledge and/or master the proper fishing techniques to catch them. Four recreational fishermen stated that sea bass is in decline and that something must be done to halt this decline (2R). In this regard, sea bass is presented as an expensive fish at the market (2C + 1R) and is not bound to quota restrictions (2C + 1R). Two fishermen said the sea bass stock had remained stable over the years (1C + 1R) (see maps III.3-4 in Annex)

2.2.2.4 Eel (Anguilla Anguilla) – see maps series IV (IV.1-IV.8)

According to recreational fishermen (8R), eel is convincingly present in late spring (from May) and during summer. After October, eel is no longer present as it will migrate (4R) (see maps IV.7-8 in Annex). Few fishermen make a distinction in colour, age and taste of eel. One recreational fisherman explained that eel (Glass eel) is coming to the rivers to grow. If the eel has grown sufficiently and is ready to spawn (Silver eel), it will migrate to the open sea for spawning (2R), in particular the Sargasso Sea (3R). The migration of eel is also recognized by a fisherman who told the fish has a silvery colour with a thick greasy skin. Further he told that: *“There are different eels though. I have already mentioned the silvery one. You have also eels that are more yellow, but I don’t know the reason for this.”* The quotation may indicate that the fisherman makes a distinction between subspecies according to the colour of eel, although yellow eel is a life stage of the same species. The flavour is different depending on the place where the eel is caught. Eel caught in the open sea that did not migrate to the rivers is considered the best, as they swam more and contain more substantial meat (1R). In his view, such eel can be recognized by the fish bones that are white as snow. Another fisherman claimed eel caught in the sea has a purer taste because they eat crabs, lugworms and little fish in contrast to eel living in rivers (1R).

The size and weight of eel is, according to two recreational fishermen, linked to their gender: females are bigger than their opposite sexes and have a higher weigh. One fisherman told that until the 1990s when he still caught lots of eel, males weighted 200 to 300 grams. Females weighted more than one kilogram (1R). Besides this, when eels mature and are ready to migrate to the open sea, they weigh 750 to 900 grams. In an earlier stage of life the glass eel is 10 cm long. (1R).

The Sargasso Sea is mentioned by 7 recreational fishermen as an important place in the migration of eel. Five recreational fishermen stated eel is coming from the Sargasso Sea. Two of those fishermen explained that the eel travels with the stream across the Atlantic Ocean. After eel has arrived in the North Sea area, it will migrate inland, by using rivers (4R). Besides this, according to one fisherman eel is also staying near the sea, in the coastal area (1R). Three recreational fishermen explained that young eel that migrates up rivers is called glass eel.

In the BPNS eel is living mostly in rivers to grow (4R), but can also appear at the coast in the salty sea (3R). Fishermen mentioned eel is found in mud (3R) and prefers places in shallow water (2R) for reasons of feeding (3R) or warmth (1R). Crab and more concretely peeled crab (3R) was the main bait for the recreational fishermen to catch eel. One recreational fisherman mentioned the use of a rod. Furthermore, eel eats worms (4R) and small fish (1R). Two fishermen stated eel is a hunter based on the smell of pray.

2.2.2.4.1 Location

In the research sample more recreational than commercial fishermen fished for eel. The fishing technique generally applied is angling. Additionally, fishermen talked more about the locations for eel than they were able to draw them on the maps. The port of Zeebrugge is mentioned several times as a location where eel could be found (4R). Three of the fishermen referred to the port before the construction of the two recent dykes (before 1985). According to two fishermen eel can still be found today in the harbour and between the rocks of the dykes (2R). Furthermore, the channels of Nieuwpoort and Ostend together with the port of Zeebrugge were also mentioned as places to find eel in the 1940s. Channels more inwards and rivers are also favourite spots such as: Leopold Channel, the polder waterway Noordede and the Blankenbergse Vaart and the river the Yzer. Only one commercial fisherman has drawn a location for eel on the map: between Oostende Bank and the Nedervaan (maps IV.1-IV.2 in Annex).

2.2.2.4.2 Stock

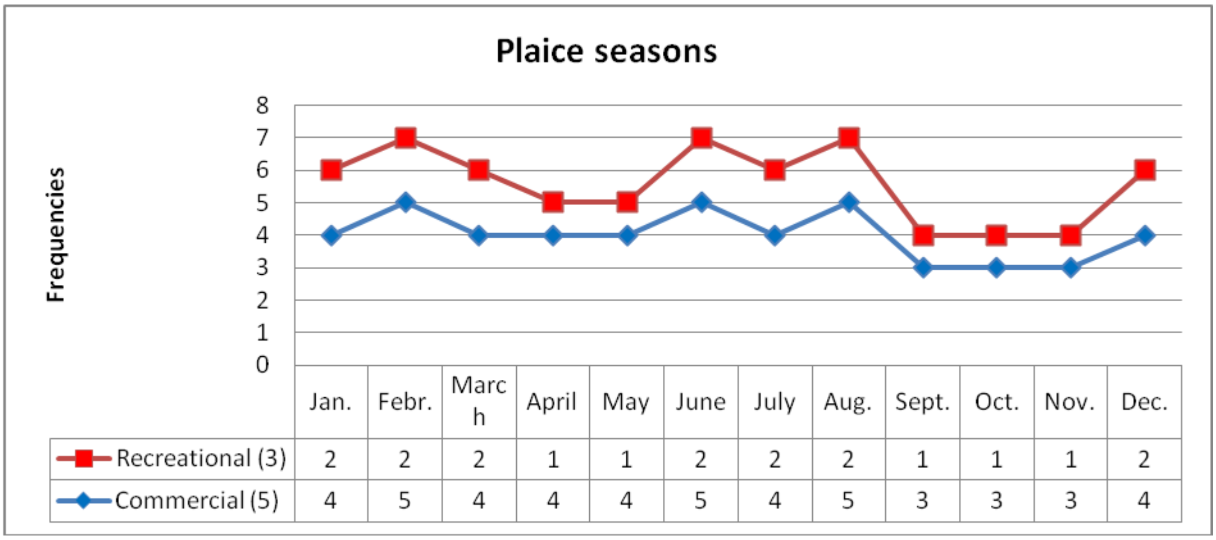
According to eight recreational fishermen, eel is almost no longer present or is characterized by a continuous decline. Some fishermen expressed the severity by words like ‘extinct’ (2R), ‘doomed to extinct’ (1R) or ‘rarity’ (1R). The start of the decline varies. Two fishermen mentioned they could catch a lot of eel in the 1980s. One of them claimed lots of eel was present in the Eastern Scheldt. Since the Eastern Scheldt Storm Surge barrier in 1985, the abundance of eel declined. Another fisherman, mainly fishing at the West coast, claimed the decline started in 1994 (1R). Other fishermen perceive the decline since the new millennium (3R) and ‘over the last years’ (2R). The causes claimed by the eight recreational fishermen can be categorized into four groups: Firstly, six fishermen explained eel and more specifically glass eel is caught massively in France and Spain (4R), to be sold as a delicacy on the Japanese market (2R). Secondly, when eel is arriving in the area its migration route up the rivers is blocked by locks or a storm surge barrier (2R). Thirdly, the use of pesticides and dioxins mainly in the 1960s and 1970s was detrimental: *"Eel can reach the age of 15, 20 years. So, eel that is leaving the river in the 1980s entered those already in the 1970s. (...) We live in an area with a lot of agriculture, a lot of pesticides. So, eel is a really fat fish and accumulates this (pesticides). According to me, this has an effect on the reproduction. (...) During the migration a lot of energy is used and those fats are getting used and all these pesticides are released (...). According to me, a lot of eel have gotten infertile."*

Furthermore, PCB's (1R) and polluted water in general (1R) are also mentioned. Fourthly, the appearance of worms in eel is also described as a possible cause for the decrease of eel (3R). One fisherman described eel was affected by worms in its swimming bladder. The other two fishermen spoke about round-worms in their intestines and the weakening effect of it on the eel during the migration (see maps IV.3-6 in Annex).

2.2.2.5 Plaice (Pleuronectes platessa) – see maps series V (V.1-V10)

2.2.2.5.1 Seasons

The seasonal occurrence of plaice does not go hand in hand with sudden high peaks in a certain month. Nevertheless, the frequencies are higher during summer and winter. The months in autumn are less cited (fig. 26 and maps V.7-8 in Annex).



	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Recreational (3)	2	2	2	1	1	2	2	2	1	1	1	2
Commercial (5)	4	5	4	4	4	5	4	5	3	3	3	4

Figure 26: Plaice seasons

2.2.2.5.2 Physical appearance

The size of plaice is related to its finding location, as 5 fishermen made this connection. Every fisherman mentioned the abundance of small plaice at the coast in general (1C +1R) and the west coast (4C) in particular. Besides this, only one recreational fisherman explained plaice contains more fat during the months November, December and January. Two recreational fishermen observed that plaice is lean during the months April, May and June.

2.2.2.5.3 Habitat

Plaice prefers places with sand (2C + 1R) and covers itself with it (1R). Plaice is also spotted in 'dirty water' characterized by rocks and coral. However this is linked with the Danish waters (1C). A warm surrounding is the most preferred surrounding for plaice and it looks for dry and sunny places (1R). It moves towards deeper waters when it is cold (1C).

2.2.2.5.4 Feeding pattern

In most cases, fishermen mentioned plaice prefers shellfish and/or worms (fig. 27). More concretely, razor clams and lug worms are the most frequently mentioned species. According to one commercial fisherman plaice does not eat cat worms.

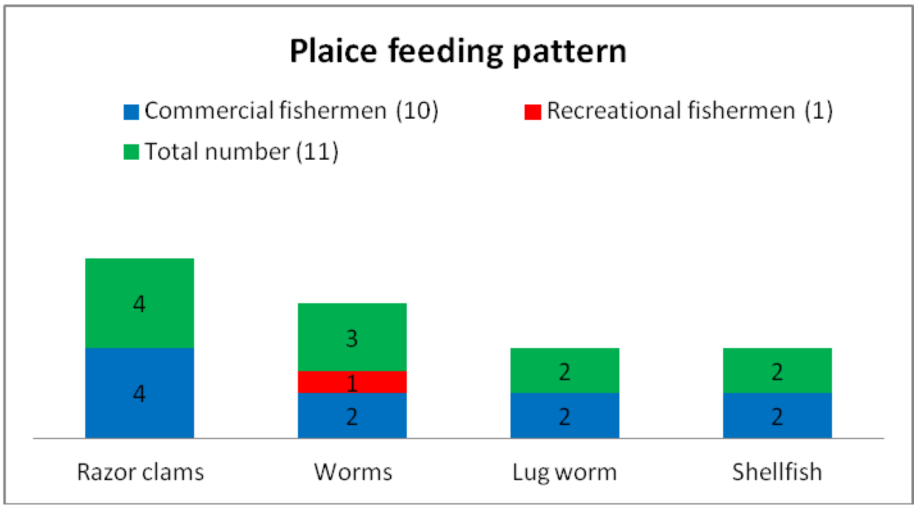


Figure 27: Plaice feeding pattern

2.2.2.5.5 Spawning

Four commercial fishermen and 2 recreational fishermen stated that plaice is spawning at the coast of the BPN. More specifically, the coastline (1R) and the beach (2R) are mentioned. Besides this, the west coast area including ‘Potje’, Broers Bank and ‘Den Oever’ are cited. According to one fisherman, plaice spawns in February together with cod and whiting because the eggs are hatching at the beginning of the ‘bloom’. According to the fisherman, the bloom serves as a food source to feed the small juveniles (1R) (see map V.9 in annex).

2.2.2.5.6 Fishing locations on maps

A total of nine commercial fishermen cited that they fished for plaice during the course of their fishing careers. With the exception of 2 vessels (400 - 1200 hp), the maximum engine power was 300 hp. The main fishing technique is the beam trawl. Additionally, the otter trawl and span were also common. Five of them have drawn their fishing locations for plaice on the maps. The west coast region and the Hinder Banks are the main spots to find plaice (maps V.1-2 in Annex). The west coast area is also the main spot for the recreational fishermen. The fishing technique most commonly used by the recreational fishermen is boat angling. One recreational fisherman fished with a trawl system.

During the 1940s, one commercial fisherman fished for plaice. However, fishing locations on maps are only drawn from the 1960s onwards. From the beginning until 2010, the Hinder Banks are represented. From the 1970s, the coastal zone is indicated and specifically around the west coast. The 'Vlakte van de Raan' is pointed out only in this decade. The fishing locations remain stable over the years. Except for one fisherman who fished for cod during the 1960s, most recreational fishermen started in the 1970s. Likewise, the West coast is a highly fished area. This focus is represented until 2010 too (maps V.3-5 in Annex).

After taking a closer look at the West coast area, different fishermen cite specific locations. The 'Westdiep' is cited four times by the fishermen since 2000. Subsequently, the Smal Bank is mentioned at least three times. Over the years, there appears to be no shift in fishing locations for plaice in the BPNS. Conversely, the observation can be made that specific locations are favoured by multiple fishermen over the years.

2.2.2.5.7 Locations mentioned during interviews

Table 2: Plaice locations

	Coastal Banks	**Flemish Banks**	**Zealand Banks**	**Hinder Banks**	**Beach**
Commercial (8)	3	3	2	2	0
Recreational (2)	0	0	1	0	1
Total (10)	3	3	3	2	1

Two commercial fishermen stated that plaice is located at the slopes of sand banks and also the deeper parts. When the wind is coming from the south, a lot of small plaice is located at the outer side of the Buitenratel (1C).

2.2.2.5.8 Fishing locations in relation to the seasons

The Hinder Banks form the only region represented throughout the entire year. The coast and more specifically the west coast are only drawn during winter and summer. During springtime, the West coast area is almost not indicated on the maps and in autumn it is not marked at all (maps V.7-8 in Annex).

2.2.2.5.9 Catches

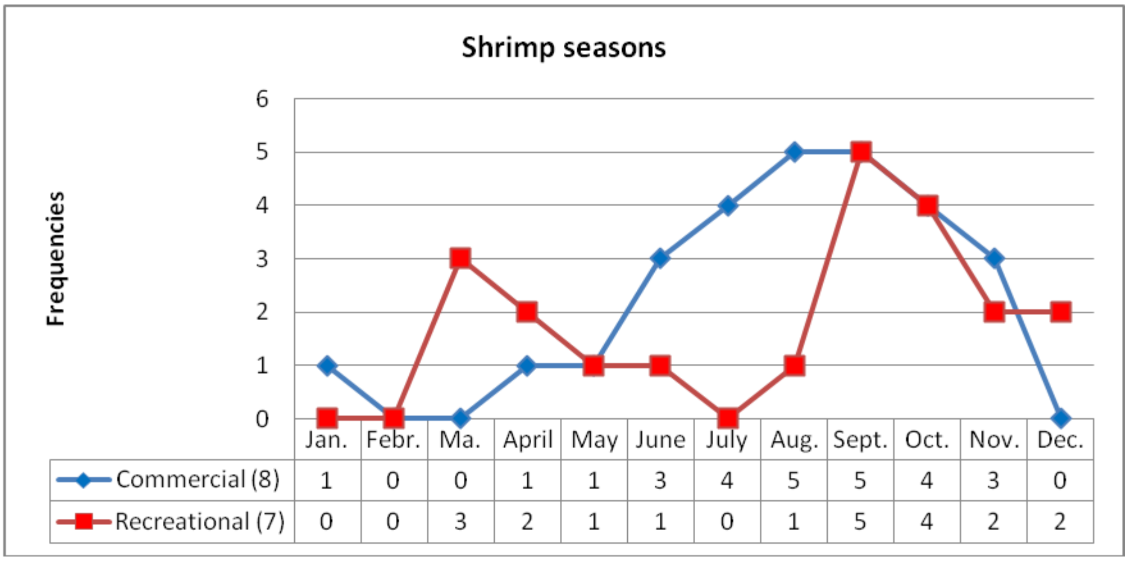
The wind has a great effect on the catching of plaice. Wind coming from the west, northwest or southwest is positive (2C + 1R) as plaice comes closer to the coast (1R). If plaice is present near the coast together with wind coming from the south, it will stay there because the sea is still (1R). Bad weather or storm will result in no plaice catches (1R). The tide plays an important role as well. At the palisade of Ostend, catches of plaice decline with low water. If the water rises and there is a rising tide, plaice will take the bait and catches rise again. In contrast, catches of plaice are likely with low water in break waters, not between break waters (1R). One commercial fisherman explained that catches of plaice go together with sole and the amount of plaice caught is bigger than sole (1C). Besides this, big plaice does not occur together with small plaice (1R). Plaice is mentioned several times as a by catch of sole (3C + 1R), cod (1C), whiting (1C) and shrimps (2R).

2.2.3 Benthos species

2.2.3.1 Shrimp (Crangon crangon) – see maps series VII (VII.1-VII.10)

2.2.3.1.1 Seasons

Figure 28 demonstrates that shrimp is rather common from spring until November. Nevertheless, the peak for both commercial and recreational fishermen occurs during late summer and autumn. The main difference between the sightings by commercial fishermen and the recreational fishermen is during late spring and summer. This can be explained by the fact that they use different fishing locations and they apply different fishing techniques (see maps VII.7-8 in Annex).



	Jan.	Febr.	Ma.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Commercial (8)	1	0	0	1	1	3	4	5	5	4	3	0
Recreational (7)	0	0	3	2	1	1	0	1	5	4	2	2

Figure 28: Shrimp seasons

2.2.3.1.2 Physical appearance

Information concerning the physical appearance of shrimp is mainly related to the fishermen's knowledge of the seasons and where they can catch shrimp. Firstly, the appearance of shrimp varies according to the seasons. During winter, springtime and summer, shrimp is rather small and not commercially interesting (2C + 2R). On the other hand, September and October are stated as the best months to catch shrimp as they are bigger and contain more fat (1C +2R). Additionally, shrimp is present in large numbers (1C + 1R) during these months.

Secondly, the skin colour of shrimp adapts to its location. If shrimp is located in deeper water or between rocks or mud, the colour of shrimp is darker (2C). On the other hand, the colour will be paler when shrimp is located under the coastline (2C).

2.2.3.1.3 Habitat

Shrimp lives close to the seabed. According to a number of fishermen, shrimp is mostly situated in sand (2C + 3R) but it is also spotted in mud or between rocks (1C). Notably, four commercial fishermen stated that shrimp is located in the ground as deep as 20 cm (1C). The water temperature has a significant influence on shrimp as it has an effect on its movements and therefore on its locations. More precisely, shrimp prefers warm surroundings (4C + 1R). If the water temperature drops below 7 or 8 degrees, shrimp will move away towards deeper water (2C). A good water temperature is around 10-12 degrees according to a few fishermen (1C + 1R).

2.2.3.1.4 Food web position

In most cases, shrimp is characterized as a scavenger (fig. 29). Fishermen call them 'the dustbins' of the sea as they eat death fish and other rotten organisms (3C + 2R). Additionally, shrimp serves as a food source to other species such as cod (6C + 4R), sole (2C + 1R) and whiting (1R).

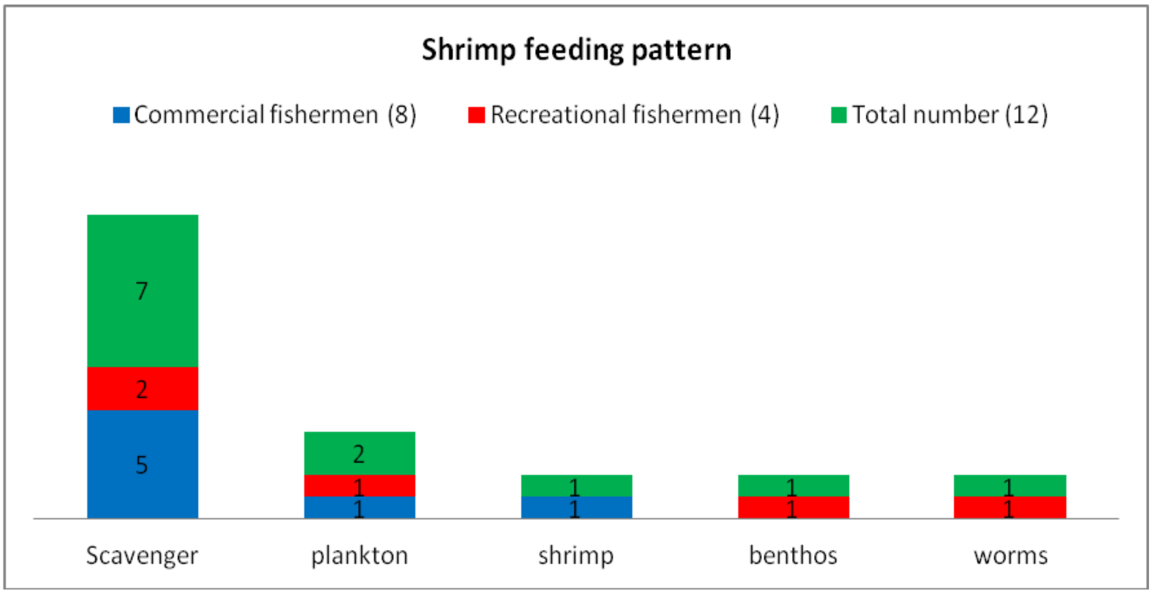


Figure 29: Shrimp feeding pattern

2.2.3.1.5 Nurseries

In general, little is known about the recruitment and the nursery zones of shrimp. Only 3 commercial fishermen and 1 recreational fisherman gave further information about possible nursery zones. Two stated shrimp 'spawns' in the ground. Other fishermen said they rather prefer dryer places. Although one fisherman pointed out nursery zones on the map (map VII.9 in Annex), the area between Ostend and Nieuwpoort is an area with a lot of juvenile shrimp. This can be clarified by the food supply in that area.

2.2.3.1.6 Fishing locations

Eleven fishermen (7C + 4R) indicated their catch areas for shrimp on maps. Overall, commercial fishermen fish within the 12 nautical mile zone. This is related to the engine power of their vessel as the maximum engine power in the research sample is 300 hp. Therefore, only vessels from the small fleet segment fish for shrimp. Besides this, every commercial vessel is a beam trawler. Maps VII.1-2 show that the West coast is less highlighted by the commercial fishermen. The sand banks Buitenratel, Kwinte, Smal Bank or the Nieuwpoort Bank are never mentioned as fishing locations. Notable is also that the main focus of the fishing locations is at the centre and the east coast of the BPNS together with the border region with the Netherlands. A possible clarification why fishermen never mention the Kwinte Bank and the Buitenratel is the more rough sediment in these regions.

Table III demonstrates that shrimp fisheries are richer at the east coast. Two recreational fishermen observed that there is less shrimp when going to the French coast. Fishermen declared this by the presence of the Scheldt estuary and its trait as an area with rich food supply and fresh water (2C).

Table 3: Shrimp locations

	Coastal Banks	Flemish Banks	Zeeland Banks	Hinder Banks	East coast	Beach	Wrecks
Commercial (9)	6	5	3	1	5	2	4
Recreational (7)	3	0	0	0	2	5	0
Total (16)	8	5	3	1	7	7	4

The Hinder Banks are only cited once by a commercial fisherman. The other sand bank groups are mentioned several times except for the Zeeland Banks and the Flemish Banks, but these were not brought up by recreational fishermen. More in detail, 3 out of 6 commercial fishermen who mentioned the coastal banks pointed out the Vlakte van de Raan and the Droogte van Schooneveld. The recreational fishermen located shrimp more at the beach.

When taking a closer look at the whereabouts of shrimp in relation to sand banks, information varies (5C + 4R). Both the top of the sand bank (1C + 2R) as well as the slopes (2C + 1R) are taken by shrimp. However, the exact location seems to be influenced by food supply and weather conditions such as wind or currents. For example, shrimp moves to the inner slope of a sand bank (2C) during flood (1C) or if the wind is coming from the sea side (1C). Shrimps are mostly located very close to the beach. One commercial fisherman who uses beam trawling stated that he fished at a depth of 4 meter. On the land side of his vessel he caught 100 kg of shrimp. On the other side of his vessel he caught only 50 kg. (1C). A recreational fisherman noticed he did not fish deeper than 3 meters to find shrimp.

Furthermore, the Wandelaar is an area described by several fishermen as a good place for shrimp (3C). However, two of those fishermen explained that the value of this spot is declining. Up to 4 years ago, there was shrimp at all times on the upper part of the Wandelaar, but since the appearance of brittle stars, shrimp is gone (1C). Another fisherman claimed that the upper part of the Wandelaar is a very good place for shrimp, but he expressed his displeasure about future plans to wade this place to widen the channel. In this case, an important shrimp area will disappear (1C). Additionally, the district of the port of Zeebrugge used to be a good fishing spot for shrimp (3C). However, since the two dikes (each dike is 4 km. long.) were completed in 1985, shrimp declined immediately. The Paardenmarkt used to be a good place to find shrimp and sole as well (2C). One commercial fisherman stated this decline can be declared by the construction of the two dikes together with a decline of the water quality of the Scheldt area. One fisherman told shrimp locations are shifting (1C).

2.2.3.1.7 Evolution of fishing locations

Neither commercial nor recreational fishermen in the research sample fished for shrimp during the 1950s. Only one commercial fisherman started fishing in the 1960s and it is not until the 1970s that a number of fishermen (5C) started fishing for shrimp in the BPNS. The fishing locations were concentrated within the 12 nautical mile zone and this border did not shift until 2010 (maps VII.3-5 in Annex). The period between 1970 and 1980 is characterized by both a spatial spread and the use of specific spots by different fishermen. In this decade the inner side of the Wenduine Bank is mentioned by four fishermen as well as the north eastern part of the Wandelaar. Additionally, wrecks on the north eastern part of the Wandelaar were also frequently mentioned as important spots for shrimp (3C). This spatial pattern persists during the period between 1980 and 1990. The use of the inner side of the Wenduine Bank and the Wandelaar increased with the rising number of commercial fishermen (6C). Although the fishing locations remained identical since the 1990s, the overall intensity dropped. This trend continues in the new millennium. In total, four recreational fishermen pointed out their fishing locations since the 1960s until 2010. These areas are rather small and close to the coast line, due to the fishing techniques used. Most recreational fishermen use a seine net on the beach side. The west coast area is drawn by recreational fishermen who used otter trawl (map VII.3-5 in Annex).

In general, fishing locations for shrimp did not shift over the decennia (map VII.10 in Annex). The Wenduine bank is the area most cited by the fishermen since the 1970s, peaking in 1980s (5 fishermen) and declining since the 1990s. The Wandelaar region is also popular among fishermen and the highest frequency occurs in the 1980s, even though the intensity decreased since.

2.2.3.1.8 Fishing locations related to seasons

A few fishermen mentioned the seasons when indicating shrimp locations on the map. In general, the fishing locations remained stable over the course of the seasons. The Wenduine Bank and the Wandelaar are not marked as fishing locations during winter. In December the border territory, including the Vlakte van de Raan and the Thornton Bank, is still a fishing area. In January and February, the Vlakte van de Raan is less fished. From March onwards, an increase of fishing locations takes place. In this period, the Wenduine Bank and the Wandelaar together with the Vlakte van de Raan are areas used for fishing. Furthermore, April and May are months characterized by an extension of fishing places. Existing locations are broadened and new locations entered into. These locations remain identical during the summer. September is the month mostly mentioned by the fishermen in general. This continues until October (maps VII.7-8 en VII.10 in Annex).

2.2.3.1.9 Catches

Shrimp catches are affected by certain natural conditions. Fishing for shrimp in clouded water is the best condition (1C + 1R). Clear water is poor for catching shrimp (6C). In clear water, the catches will be better during the night (1C). Recreational fishermen confirm that catches during the night are better (3R). Nowadays, recreational fishing at sea during the night is forbidden. Furthermore, wind and storm affect shrimp catches. Wind coming from the north has a positive influence (2C + 1R). The first day after a storm from the north results in good catches (1C). On the other hand, wind from the west (1C) or the south (1C) is linked to smaller catches. The occurrence of other species at certain spots determines the catches as well. Shrimp catches are not good if brittle stars are present at the location (2C). A few fishermen (3C) reported successful catch years. Nevertheless, no overlaps are registered. The year 1981 was an exceptional year. A commercial fisherman explained this by the warm and long summer. As a result of this, the water temperature stayed warm longer during autumn. Other excellent years were 1987 (1C) and 2009 (1C).

2.2.3.1.10 By-catches

Figure 30 demonstrates by-catches of shrimp fisheries in order of frequency. In most cases, fishermen stated that fish caught as by-catch is rather small. Sole is the most cited species, followed by crab and starfish. In the case of crab, 3 fishermen (2C + 1R) described the caught crab as small and linked it with the month of August (2C). One commercial fisherman called the specific crab by name: Swimming crab. Starfish are not good for shrimp fisheries because of the higher weight in the nets (1C). Apart from that, starfish are a plague (1C). The Wandelaar is marked as a specific area with starfish (1C).

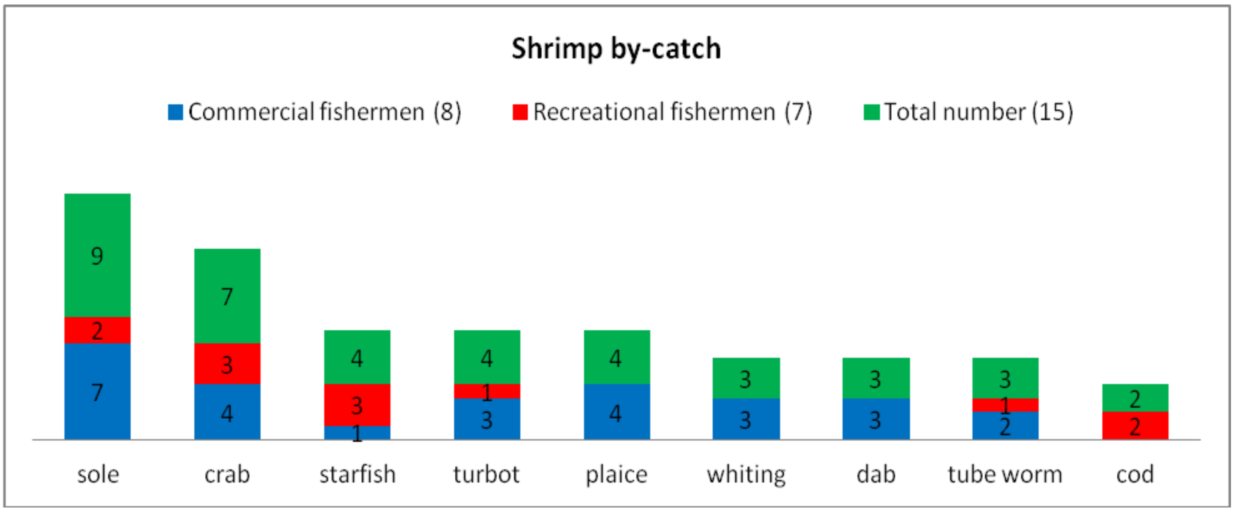


Figure 30: Shrimp by-catches

2.2.3.2 Sand mason (Lanice conchilega) and other worms – see maps series VIII (VIII.1-VIII.5)

2.2.3.2.1 Physical condition

Sand masons are known by most fishermen as worms surrounded by a small tube. One recreational fisherman stated this tube is made of little pieces of shell. Notably, having a tube is also a common characteristic for other worm species. In this case, fishermen may confuse different species. One commercial fisherman believes sand masons are born in these tiny tubes. One fisherman described the worm as a tiny red worm that is not useful as bait because it breaks easily (1R). A commercial fisherman described the worm as vermicelli: small and thin. 'Vermicelli' is the name frequently used for sand masons, especially at the east coast.

The lug worm or sand worm is described as a tall worm (1C + 1R). Furthermore, a few fishermen (2C) make a distinction in species as they talk about a worm with a yellow tail.

2.2.3.2.2 Habitat and food web position

In general, knowledge concerning sand masons is limited and mostly focused on its locations, physics and relation to other species. This knowledge is the result of catches and the difficulty to fish when fishermen are in areas with sand masons. Only one commercial fisherman stated that sand masons are not present in deeper water because they need a rather warm minimum water temperature. Sand masons are spotted in areas with a high density as fishermen describe their presence in 'colonies' (1C), fields (2C) or in big packets (2C). One recreational fisherman explained that sand masons are also present on beaches.

Information concerning other worm species is rather fragmented. Firstly, the lug worm relieves itself at the beach and lives in a burrow under the sand that has a curved form (1R). Secondly, the black lugworm would occur more in mud as it does not prefer loose sand (1R). Lastly, according to one recreational fisherman, king rag worms prefer mud flat especially after the process of eutrophication as it leads to a good mud flat (1R).

The benthic community, including worms, is located at different places in relation to sand banks. Nine commercial and 6 recreational fishermen stated that worms are located more at the slopes of a sand bank; 3 of these fishermen believe they are located on the slope in the deeper part (2C + 1R) and one commercial fisherman mentioned the slope more closely to the top. Four commercial fishermen believe worms are also present in the channel of sand banks.

No information is given about the feeding pattern of the sand mason. Nevertheless, sand masons are a food source for other species such as sole (5C + 1R). However, worms in general form an important food source to other species such as plaice (4C + 1R) and cod (7C + 3R). Sole prefers worms as well (15C + 8R), including king rag worms (5C + 8R), trumpet worms (3C) and lug worms (2C + 1R). Additionally, according to two recreational fishermen king rag worms form good bait to catch fish.

2.2.3.2.3 Seasons

Three fishermen indicated that sand masons are more frequent at the end of springtime and during the summer (2C + 1R). In the case of other worm species, 4 fishermen mentioned they are mostly present during summer.

2.2.3.2.4 Locations drawn on maps

In total, 7 commercial fishermen and one recreational fisherman have drawn locations for the sand mason (map VIII.2 in Annex). Generally, the locations are oriented near the coastal region and are close to the coastline: certain areas close to the Wenduine Bank and the Wandelaar are mentioned, the north-eastern part of the Wandelaar, 'Ribzand' and the upper area of the Wenduine Bank. The east coast is presented by the 'Bay of Heist' and 'Wielingen'. Additionally, the western part of the 'Westdiep', the western part of the Stroom Bank and the 'Grote Rede' are also specific locations for the sand mason. The recreational fisherman cited the west coast up to the port of Nieuwpoort. Besides this, the area parallel with the outer side of the Nieuwpoort Bank and the Smal Bank is also spotted as an area with sand masons.

2.2.3.2.5 Locations cited during the interviews

When adding locations of sand mason cited during the interviews (map VIII.2 in Annex), these locations are not deeper than the coastal area. Only one commercial fisherman added the Kwinte area during the interview. Most recreational fishermen indicated spots at the coastline and mostly focused on the west coast region. In this case, beaches and the Coastal Banks are the most mentioned locations for the sand mason.

Information concerning locations of the lug worm is scarce (map VIII.4 in Annex). The Westdiep area was mentioned twice (2C). Besides this, the Bay of Heist is mentioned as a place full of black lugworms (1R).

Most recreational fishermen buy king rag worms (3R) even though they stated that the worm can be found at specific places. Within the BPNS king rag worms can still be found near the port of Nieuwpoort (2R). Outside the BPNS, recreational fishermen catch the worms mostly in the Bay of Somme (France) (2R). One fisherman explained that the king rag worm is not common in the BPNS. As a consequence he goes to France (1R). The trumpet worm can be found at the top of the Trapegeer and near Blankenberge (map VIII.4 in Annex).

2.2.3.2.6 Worms and fish catches

Locations with sand masons are difficult areas for the fishermen to fish at (3C +1R). Catches are not good when fishermen remain in those areas for too long. The main reason is sand that sticks into their nets, increasing the weight in the nets with 10 000 kg or more. Consequently, nets tear up and may get lost (1C). A recreational fisherman mentioned that a vessel of 18 hp in such an area comes to a standstill. Nevertheless, these areas are good spots to catch certain fish species. Commercial fishermen stated that regions with sand masons are good fishing locations for sole (4C). Two commercial fishermen linked those areas with good sole catches. Two other commercial fishermen stated that fields of sand masons are good places for shrimp. Another species linked to these spots is cod (1C). For this reason, fishermen will search for the borders of those ‘fields’ to fish at these borders (1C). Another technique is to fish in the field and release the nets on the bottom for a really short time (2C).

2.2.3.3 Razor clams (Ensis) – see maps series IX (IX.1-IX.3)

2.2.3.3.1 Physical appearance

Two recreational fishermen described the inner side of a razor clam as a small white tongue that is leathery like cephalopod. Besides this, little information is known.

2.2.3.3.2 Habitat

According to a few fishermen, razor clams are situated in the ground (3C + 3R). However, the given depths differ. One recreational fisherman believes razor clams are located at the sea bottom at a depth of 50 cm. Another fisherman mentioned they use a siphon (1R). On the other hand, one fisherman explained razor clams lay in the ground except for the head (1R).

The wind has an influence on the position of razor clams. If the wind is coming from the southwest and the weather is good, razor clams will stand vertical in the ground. However, if the wind is coming from the northeast (1C) or it is bad weather (1C), razor clams will be exposed and cannot get into the ground. This condition is useful for starfish and fish as they will lie down on the razor clams to eat them (2C). As a consequence, many empty shells wash ashore (1C). The phenomenon of washing ashore also occurs after a storm (1R). In the case of a north-western storm, the sea will be full of razor clams in winter (1R)

2.2.3.3.3 Seasons

Razor clams are more common during springtime (2C + 1R) and summer (1C + 1R). One fisherman mentioned the appearance of razor clams during winter, especially after a north-western storm (1R).

2.2.3.3.4 Locations

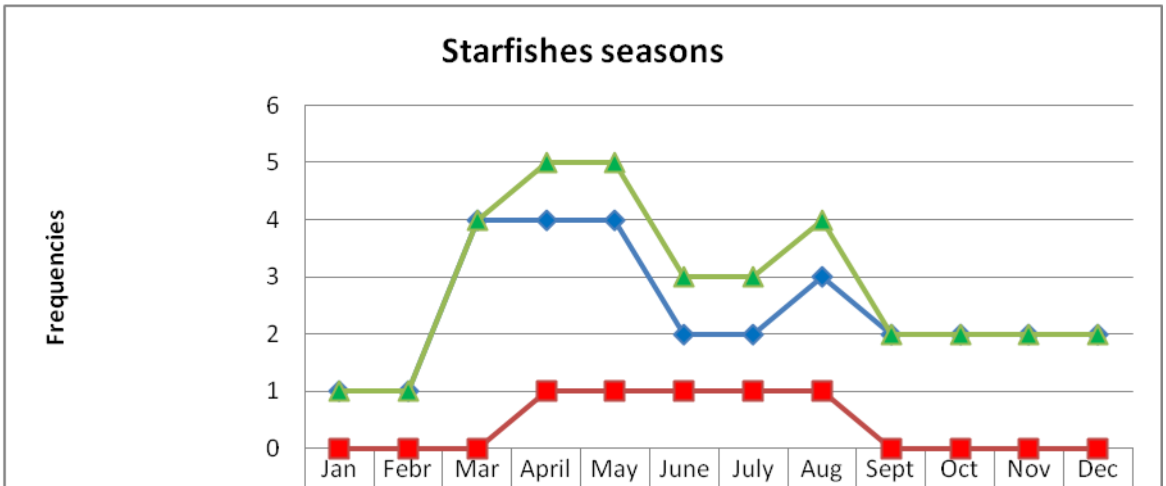
An overview of locations of razor clams is given, based on drawings by fishermen and supplemented with the locations mentioned during the interview. Maps IX.1 and IX.3 in Annex explain how many fishermen have indicated the several locations.

2.2.4 Starfish (Asterias Rubens) and Brittle star (Ophiura ophiura) – see maps series X (X.1-X.4)

2.2.4.1 Seasons

The appearance of starfish is higher during springtime and during summer. We can notice an increase from March and April for both commercial and recreational fishermen. From September there is a decline, and frequencies are low until March (fig. 31).

In addition to starfish, fishermen stated sand brittle stars are also more common during springtime and summer (3)



	Jan	Febr	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Commercial (6)	1	1	4	4	4	2	2	3	2	2	2	2
Recreational (2)	0	0	0	1	1	1	1	1	0	0	0	0
Total number (8)	1	1	4	5	5	3	3	4	2	2	2	2

Figure 31: Starfish seasons

2.2.4.2 Physical appearance

Information concerning colour or size was not exchanged during the interviews. Two recreational fishermen mentioned starfish are capable to regeneration. Starfish are observed both in sand (1C + 1R) and in mud (1R). One commercial fisherman believes starfish are poisonous as they have a toxic substance in their stomach. Another commercial fisherman explained starfish are not moving on the seabed, but pile up air and let themselves flow with the current until they find a new food source such as shells. In case of brittle stars, fishermen in the research sample described them as a kind of spiders.

2.2.4.3 Food web position

Starfish prefer shellfish (1C) such as razor clams (1C) or mussels (2C+1R). Fishermen also referred to small or sick cod (2C). What is more, two fishermen claimed starfish have no enemies in their food web in contrast to the brittle star, which is sometimes found in the stomach of other fish (1C).

2.2.4.4 Locations drawn on the map

The Westdiep area is pointed out the most by both commercial and recreational fishermen. This can mean that this area is a common place for starfish. Further the area above the Smal Bank, the Nieuwpoort Bank and the northern part of the Wandelaar are also places frequently indicated. In general, starfish are more located at the west coast of the BPNS close to the coastline. The northern part of the Goote Bank is the most indicated area for brittle stars. Additionally, the region on the northern side of the Wandelaar and the area above the Oostdyck are also specified places for brittle stars (map X.2 in Annex).

2.2.4.5 Locations cited during the interviews

Most commercial fishermen refer to the Coastal Banks. Within this region, the ‘Westdiep’ is cited at least 7 time (7C). The Trapegeer, the Smal Bank and the Nieuwpoort Bank are quoted at least three times each. Additionally, the west coast as far as Ostend is indicated as a region characterized by a higher appearance of starfish (3C). The Vlakte van de Raan is cited two times. Besides this, starfish are common close to the beach but keeping a distance of 800 to 1000 meter seawards from the beach (2C). Three fishermen stated that the spread of starfish has changed during recent years. In the past starfish were more concentrated at certain spots. Today, they are more widespread (2C +1R).

In the case of brittle stars following regions are quoted twice: The Westhinder (1C + 1R), the Goote Bank (1C + 1R) and the Wandelaar (2C) (map X.1 in Annex). In general, brittle stars are more observed in the deeper parts of the BPNS.

Although starfish and brittle stars share the same seasons, it seems they do not appear together at the locations drawn and cited by the fishermen.

2.2.4.6 Catches

Fishing in areas where starfish are present is sometimes a dangerous activity (2C). If fishermen fish with the beam trawl, they cannot drag their nets too long on the bottom as the nets will contain a lot of starfish (2C). The amount of starfish can be 3 to 4 tons (1C) in one catch. In this case, fishermen leave their nets on the bottom for only 5 minutes (2C). Another solution is to fish when it is low tide or slack water (1C) to avoid too much starfish in the nets. One commercial fisherman mentioned fishing with the otter trawl system in these areas is better because starfish are not caught using this system. Using the standing rigging in those regions will often lead to dead fish or no fish as starfish will crawl on the nets and eat the caught fish (3C). This pattern was also observed in mussel cages in front of Nieuwpoort as starfish eat the mussels (3C). Starfish are strongly linked to shrimp as they form an important by-catch of shrimp fishing (1C + 3R). Areas with starfish are related to difficult fishing and bad catch, for example the northern part of the Wandelaar.

2.2.4.7 Stock

A number of fishermen stated that starfish were present in large numbers in 2010 (4C + 4R). In 2009, starfish were not present according to two commercial fishermen. On the other hand, other fishermen claimed they formed a plague in 2009 (3C). Only one recreational fisherman mentioned a decrease, more concretely on the breakwaters.

The causes given for the sudden appearance of starfish are different. Firstly, few fishermen believe that fishing with beam trawl has an effect on the starfish population. One commercial fisherman uttered that beam trawling has caused a decline in the diversity and in the competition between food sources. For this reason crabs decreased and were replaced by starfish. However, a recreational fisherman said starfish are plentiful because beam trawling had declined. Secondly, two fishermen perceived the cultivation of the mussels in front of Nieuwpoort as the main source of the appearance of starfish (2C). Thirdly, the entrance of razor clams since 1995 is also mentioned (1C). Fourthly, discards of cod in 2008 from another theory as dead fish attract scavengers such as starfish, which could create a plague (1C). Lastly, rising water temperature is also mentioned as a possible cause (1R). The appearance of brittle stars at the Wandelaar is linked to a degradation of shrimp at this location (1C).

2.2.5 Marine Mammals – see maps series XII (XII.1-XII.3)

Marine mammals were spotted in the BPNS by several fishermen (12C + 4R). Four fishermen stated that their observations of sea mammals remained the same during their individual fishing careers (3C + 1R). Five fishermen mentioned an increase of observations (4C + 1R). One commercial fisherman observed a decline. The fishermen were asked if they make use of observations of marine mammals to locate fish. Thirteen commercial fishermen and six recreational fishermen answered that they did not. In general, observation of porpoises, dolphins and seals were mentioned most often.

2.2.5.1 Porpoises

From a seasonal perspective, eight fishermen (6C + 2R) provided information on observations of porpoises. Porpoises are more present during springtime (4C) and during summer (3C + 2R) although autumn (2C) and winter (1C + 1R) were cited too. The feeding pattern of the porpoise (2C + 3R) is not really known by the fishermen. Several fishermen answered the question with “I don’t know” (1C + 2R) or “think” they eat sprat or herring (2R). Porpoises are animals that live in group. Only two fishermen stated they observed porpoises swimming alone (1C + 1R). Eleven commercial and 7 recreational fishermen observed porpoises always swimming in group. The most common group size according to the fishermen is 4 (8C + 2C) to 5 (6C). Two mentioned they have seen a lot of porpoises outside the BPNS. Another fisherman told he has seen a lot of porpoises at the Sandetti Bank 12 years ago: *“I have seen once (…) at the Sandetti, everywhere I could see with my naked eyes there were porpoises (…) If I did not see millions (…) everywhere you could look. That was maybe 12 years ago at the beginning of the summer (May-July). I had never seen this before. They were migrating.”*

Besides this, some fishermen mentioned certain conditions are needed to spot porpoises, such as clear water and a flat water surface (2C) during day time (1C). Two commercial fishermen stated that porpoises are more common in deeper water. Porpoises are described as animals that keep their distance and that are not as playful as dolphins (1C + 2R), but are rather hunting for food (1C + 1R). Furthermore, they do not swim as high as dolphins (1C + 1R). Other fishermen explained that they play and come to the boat and swim alongside the boat (1C + 2R).

Locations were porpoises have been observed by fishermen are indicated in map XII.2 in Annex. Those locations have been drawn or mentioned during the interviews.

2.2.5.2 Seals

Seals are spotted the entire year: summer (3C + 2R), winter (3C + 1R), autumn (2C + 1R) and spring (2C). Spotted seals were mostly alone (7C + 4R) or in small groups ranging from 2 to 4 animals per group (2C + 3R). When seals are spotted by fishermen, they are mostly laying on breakwaters in front of Wenduine (1C) or Koksijde (1C + 1R). Furthermore, they are also spotted in the port of Nieuwpoort (1C + 3R). The beach of De Haan is cited one time (1R). Seals are also spotted on sand banks (7C). In this case, most fishermen indicated shallow sand banks that become exposed by low tide (4C). Seals are observed at the top of a sand bank (2C) or at the side of the sand bank to catch food (1C).

Observations are also made of seals at wrecks. Three fishermen connected this with hunting (2C + 1R). One fisherman described: *“Once (...) 30 miles off the coast (...) a seal was diving to a wreck and he came up with a beautiful sea bass. Within 15 minutes, he caught 6 or 7 sea basses and 6 hours later he came back to that wreck.”* Herring is cited by three fishermen as a food source for seals next to whiting, sea bass and cod.

Three commercial fishermen and 5 recreational fishermen stated the seal stock is increasing. Map XII.2 in Annex provides locations were seals have been observed by fishermen. Those locations have been drawn or mentioned during the interviews.

2.2.5.3 Dolphins

Dolphins are described as more playful and curious compared to porpoises (1C + 2R). Concerning the location of dolphins, one recreational fisherman mentioned that dolphins are not coming as close to the coast as porpoises do. Either way, three fishermen claimed they always saw one particular dolphin at the mussel area in front of Nieuwpoort (2C + 1R). A recreational fisherman declared that the dolphin stayed there for 2 years. Two mentioned it was 2 years ago (2008) they last saw the dolphin. Further, the recreational fisherman stated he saw the same dolphin at the Thornton Bank for 6 months (the fisherman recognized the dolphin by the markings on its back). Afterwards, the dolphin left.

When taking a closer look at map XII.3 in Annex, the locations where fishermen observed dolphins are in the deeper part of the BPNS. Only one spot is drawn more closely to the coast: the mussel area.

2.3 LEK AND THE SOCIAL FRAMEWORK OF THE FISHERMEN INTERVIEWED

The purpose of this chapter is to capture an image of the socio-economic, legal and cultural environment of the respondents and to examine how their LEK is constituted. At the end of the interviews questions regarding their perceptions were asked. Although it is not the main focus of the LECOFISH study, we must consider their perceptions and how they could be linked with LEK and communication patterns.

In general, institutions can be interpreted as rules and values that give meaning to human activities and social behaviour (Berkes et al., 2000). Institutions can be unravelled into a regulative pillar, a normative pillar and a cultural-cognitive pillar (de la Torre-Castro & Lindström, 2010). The regulative pillar concerns rules, regulations and measures, formulated by the European Common Fishery Policy (ECFP), underpinned by formal surveillance and sanctions by the Belgian and Flemish Governments. The normative pillar has a morally binding nature. In this manner, informal control within the fishing community is a very important issue as it handles responsibilities, privileges, duties and values. The culture-cognitive pillar concerns shared conceptions, worldviews and the meaning that is given to it. Institutions are also influencing one another. The ECFP and its measures such as decommissioning of the fleet, closed areas and quota restrictions are influencing the employment and the structure of the fishing community, their fishing activities and therefore their LEK (Symes & Phillipson, 2009).

2.3.1 Belgian fishermen vis-à-vis policy measures

2.3.1.1 The Common Fisheries Policy

The European Common Fisheries Policy (CFP) as a common source management system was created in 1983 with the purpose of restoring the depleted fish stocks, allowing recovery and creating a basis for sustainable fisheries (Symes & Hoefnagel, 2010; Urquhart et al., 2011). In the combat against overfishing, most effort is invested in establishing the annual Total Allowable Catches (TACs) and secure those with quota restrictions, minimum landing sizes, closed areas, technical measures and decommissioning of the fleet (Symes & Phillipson, 2009; Symes & Hoefnagel, 2010; Urquhart et al., 2011).

The reform of the CFP in 2002 is marked by a change of perspective towards an ecosystem-based fisheries management. This means that the input of the decision-making process is based on sound scientific advice. Although the CFP wants to provide sustainable economic, environmental and social conditions (Council Regulation No. 2371/2002), the prime influence on policy is the more biological oriented annual stock assessment (Symes & Hoefnagel, 2010).

Social aspects of fisheries and social sciences in general are underrepresented in the CFP. This direction goes hand in hand with changing employment structures, the loss of human capital and a downfall of social and cultural values such as community bonds, values, knowledge, etc. (Symes & Phillipson, 2009; Urquhart et al., 2011). Nevertheless, this is considered as an important concern, since the CFP as a management institution, together with the measures, is perceived by its stakeholders as legitimate - or not (Degnbol, 2005). Fisheries management is only effective if the measures are considered legitimate. In this way, the CFP has to consider a co-evolution by means of institutional change and a broadening of its scientific input, namely information of the different forms of social organizations, the social and cultural values of the different fisheries in Europe.

2.3.1.2 Policy effects and perceptions

In general, most policy measures are perceived as a negative evolution during the career of the Belgian fishermen. The quota system is the most mentioned problematic measure, followed by a policy support system and closed areas.

The quota system affects different standards (biological, economical, cultural and legitimacy). Firstly, interviewees mention that fish stocks have not improved remarkably and discards pose a vast problem, especially in connection with cod. Secondly, the viability of the fisheries reduces as the allowable fish to catch is less than needed to be profitable. In this context, some respondents referred to the opening of a black market. Thirdly, several respondents stated that the ever diminishing quotas in combination with a decommissioning of the fleet are destroying the Belgian fishery. In 1955, a total of 421 fishery vessels were active. Today, no more than 98 vessels are left. Furthermore, euro-cutters (up to 24 meters length and to 221 kW) gradually come into the hands of Dutch shipping companies. Apart from this, some respondents mentioned that the arrangement of the quotas is in favour of the large beam trawlers and less in favour of the small fleet segment (up to 221kW). In this context, one fisherman mentioned that the small segment is always depending on the big fleet segment (up to 1200 kW). Various respondents explain that the Belgian commercial fishery will be become a folklore because young family members do not want to fish anymore and it is hard to find new crew members. Finally, the quota system has failed because it has failed to keep certain promises to the resource users. The aim of the decommissioning of the fleet was to admit higher quota to the fishermen that remained. Nevertheless, the quota diminished continuously together with the number of vessels, and they do not stabilize. Fishermen perceive they have to sacrifice a lot but they never receive anything in return. They would have expected some positive results, especially after 30 years of policy.

Some respondents have criticized the support policy of the CFP during the 1980s and 1990s and the Flemish Government today. During the last century, focus was on increasing engine powers and building larger vessels. Although the purpose of the CFP and the Flemish Government is sustainability, the Flemish government decided in 2010 to give 60%financial support for modernizing vessel engines, but only for the big fleet segment. Before the promise of a subsidy, one interviewee changed from beam trawl toward the standing rigging fishery. To his knowledge, he did not receive any funding with the aim of sustainability. In this point of view, Belgian policy supported a growing fishery in favour of larger vessels and at the expense of the small fishing segment and ecological sustainability.

Finally, seasonal closed areas are perceived as a measure that increases fishing pressure. Fishermen are going from one area to another on a fixed date with an intensified concentration of vessels. In the past, they could fish everywhere and more in line with the seasons. Nowadays, some respondents mention they have to change their ‘fishing plans’ every week because formal rules are changing constantly. They have to behave more economically as they have to think how they are going to divide their quota for several months and what kind of fish they are going to catch as bigger fish has more value on the market. This notion, together with spatial restrictions, can lead to a narrowing of the fishing activities together with ecological knowledge in favour of economic thinking and survival.

Although the respondents perceive the current policy measures and their enforcement as negative, they do believe that measures were needed because without them, there would be no more fish to catch. Very often, measures are perceived as problematic and not legitimate, and many respondents prefer other kinds of policy measures. Most of the respondents would prefer a restriction of the sea days where they would be allowed to catch and land all fish, except for undersized fish.

Policy measures and the way they are managed have a major impact on the perceptions and activities of the fishermen and on its community. The measures are leading to economical, social and cultural loss in the fishermen opinion. This perception goes together with mistrust and leads to dissatisfaction, as the respondents perceive a negative evolution in policy measures. Moreover, policy measures together with the market seem to steer their activities.

2.3.1.3 Fishermen and communication

Most respondents believe science is not the most reliable source of information regarding where to find fish and how to catch it. This is because fishermen either do not receive any information or they perceive it as wrong. To the resource users in the research the most reliable information is delivered from the fisherman in general and his own individual experience over the years. As appears from the interviews, the father is often mentioned when talking about ecological topics (specific biophysical information about a certain area, evolution of species ...). This is often the case when talking about the past. Although fishermen believe the most reliable information comes from colleagues, they are very cautious to share it, especially information concerning fishing places related to big catches. Competition determines what kind of knowledge is exchanged and between who. Several decades ago, they would mislead others by turning off the lights on the vessel or lying on the radio with the purpose of hiding good fishing places and good catches. According to the fishermen knowledge about good fishing places is more widespread through the entire fishery community nowadays because of the introduction of the Global Positioning System and the Vessel Monitoring System. However, while fishermen can track down the fishing places of other fishermen, they cannot tell if their catches are good.

Fishermen want to protect their knowledge if they perceive it as something valuable to them in the light of catches. Fishermen will channel their knowledge and whom they share it with. This kind of information is located at individual level disconnected of the subgroups they belong to and is strongly related to competition and economic survival.

2.3.2 Belgian fishermen vis-à-vis science

As mentioned above, fisheries management works effectively if the measures are considered as legitimate by the resource users (Degnbol, 2005). Apart from this, fisheries management input is based on sound scientific advice (Council Regulation No. 2371/2002) and more specifically on the annual stock assessment (Symes & Hoefnagel, 2010). Therefore, we have to consider how the constitution of scientific knowledge together with the communication patterns is perceived among Belgian fishermen.

2.3.2.1 Knowledge and perceptions

During the interviews, two questions were asked the respondents: how do they perceive scientific knowledge regarding the fish stocks, and how do they perceive scientific knowledge regarding ecological information about the flora and fauna. The reason for this distinction is based on the different nature of knowledge. In the study, a slightly positive response with reference to scientific information on the flora and fauna is noticeable. However, most of the respondents do not know whether or not this kind of scientific knowledge is truthful in their perspective and knowledge. Scientific knowledge with reference to fish stocks is believed to be less accurate and fishermen are more sceptical.

In the framework of scientific knowledge concerning fish stocks, most fishermen notice the way scientists collect their data is not the appropriate approach. To them, a biologist possesses great knowledge but does not have the knowledge that is required to find the fish and to catch it. To the fishermen this is essential, since the quota system is based on that scientific knowledge. Often, scientist's fish in the wrong places and/or under wrong biophysical conditions and/or with no modern fishing gear. Furthermore, some acknowledge that logbooks of some fishermen are not always correct. This leads to skewed figures and masked scientific knowledge.

Fishermen can be considered as carriers of different kinds of knowledge that are all interesting for science. These different kinds of knowledge are communicated towards science in very different ways and in different degrees. Firstly, fishermen have valid knowledge of where they can find fish and the size of their real catches. This kind of knowledge has to be coded in the logbook system. Furthermore, fishermen are involved into tagging studies where they have to fill out forms in function of scientific research. Secondly, fishermen have ecological knowledge about fish habitats, migration patterns, feeding habits and the bio-physical environment of the species. Thirdly, fishermen have knowledge about fishing techniques (position of the vessel and the fishing nets). This fishing knowledge is closely related to their ecological knowledge as they have to combine ecological knowledge with efficient fishing techniques and gear to catch the fish ultimately (St. Martin et al., 2007; Johnson, 2010).

2.3.2.2 Information flow, participation and communication instruments

The respondents were asked to consider in what degree they give correct information and share their knowledge with science. The responses were twofold as they were linked with the exchange instrument. In the case of logbooks, respondents report that the information is not always truthful. The justification can be found in self-protection and quota pressure. On the other hand, they declare that face-to-face questions could lead to more valid answers and they would try to answer them completely and truthfully. However, they mention that there is no or little contact with scientists in a structural way.

In general, it may be put forward that no face-to-face communication or collaboration exists between science and the fishery community as a group. In the perception of the respondents, there is no real communication between them and scientists, since scientists never ask anything or do not listen to them.

In case of tagging studies, the fishermen involved never receive further information of the fish they caught notwithstanding the fact they wish more information about the age of the fish or its growth pattern.

With reference to stock assessment, respondents mention biologists can learn from fishermen, as they wish a better cooperation. More concrete, fishermen suggest biologists can accompany fishermen on their vessels to collect their scientific data. This would allow biologists to learn where they can find fish, and when and how to catch it. It can thus be deducted that fishermen wish to share their ecological and technical knowledge with scientists in a personal and collaborative way. Although fishermen want better communication, some believe fishermen will never tell scientists about specific locations, hot spots or which fishing technique is effective to find and catch fish because they are afraid that stricter measures will result from it or that they will lose competitive advantages. Furthermore, fishermen are sceptical about the knowledge of scientists based on log books. This is because some resource users perceive logbooks as not always valid, since fishermen wish to protect themselves against lower quota and other measures. Apart from this, most fishermen seem to have a different perspective on the fish stock levels. They do not perceive the scientific information as valid or accurate and conflicts arise between their observations and scientific perspectives.

At the level of technical research, collaboration takes place between one specific scientific institution and one or several individual fishermen. The main purpose of this collaborative research is to improve sustainable fishing techniques and take the form of periodic scientific projects.

Apart from collaborative research, some individual fishermen know biologists in person and sustain a good relationship. Respondents who perceive they have a good relationship with scientists are mentioned more than once by colleagues in the snowball sample as someone with profound knowledge about the flora and fauna in the BPNS. Therefore, we submit that their ecological knowledge is strengthened because of their personal relationships with scientists and collaborations. Nevertheless, we must consider the exchange of that knowledge because it is selective, specialized and personalized. It seems that no exchange of knowledge exists between the fishery as a community and science. At the same time we have to bear in mind that knowledge within a community is not uniform, as every fisherman has different specialties and LEK. Most of the respondents are in favour of more communication with scientists and want to exchange their experience and fishing knowledge. Next to this, more information and literature is wanted.

The instruments of communication and consequently learning are related to the degree of participation of the fishermen and the type of knowledge that is shared. In the study, we could identify three forms of communication instruments.

Fishermen are obliged to keep scientific information in the form of standardized forms and logbooks, assessing fish stocks and collaborating in tagging studies. In this case, the information flow is one way, without further participation in the decision process or feedback about tagged fish. No face-to-face contact is made. Ultimately, the outcome in the form of lower quota is perceived as not very valid as fishermen do not consider the logbooks to be always trustworthy.

Collaborative research today takes the form of periodic scientific projects. These are mainly focused on improving sustainable fishing techniques. This form of collaboration is often organized between individuals who participate in different subgroups within the fishery community (beam trawling or the standing rigging system) and one scientific institution. Here, communication works both ways and technical knowledge is shared. Fishermen are involved because they are willing to cooperate and willing to use their boats and knowledge to try new fishing techniques and new species. Fishermen who are collaborating in those kinds of studies are more satisfied about their relationships with science. Moreover they are perceived by other fishermen as individuals who know a lot of the environment.

Individual relationships are a third communication instrument. Some fishermen maintain personal relationships with scientists. Contact is made when specific questions occur. The questions are most of the time related to ecology or the biology of certain fish species. In this way, relationships are less formal and are characterized by a two way communication. The ecological knowledge of individual fishermen is strengthened as scientists answer their questions.

The information flow between fishermen and scientists can be categorized as fragmented. Sharing of knowledge depends on the kind of knowledge, the types of communicators, the instrument of communication and the purpose of sharing knowledge (leading to management measures). Collaboration and sharing of knowledge can lead to transparency, relationships and trust (Johnson, 2010). Additional, this can lead to higher effectiveness of marine management (Kaplan & McCay, 2004) and legitimacy (Degnbol, 2005). Trust and relationships form two main features of social capital, together with common rules and social networks (Pretty & Ward, 2001).

The relationships and communication patterns between scientists and fishermen can be categorized in six different participation types: passive participation, consultative participation, bought participation, functional participation, interactive participation and self-mobilization (Pretty, 1995). For the Belgian fisheries, only the first three types can be applied. Fishermen take a rather passive role, meaning they do not form groups that represent common interests or goals (Pretty & Smith, 2003). Real connections or social networks between science and the fishery community are lacking.

3 DISSEMINATION AND VALORISATION

3.1 PARTICIPATION IN INTERNATIONAL CONFERENCES AND WORKSHOPS

COPPENS, J., A social and cultural framework of local ecological knowledge: case study of the Belgian fisheries, in “It’s not just about fish” – Social and cultural perspectives of sustainable marine fisheries, School of Science and the Greenwich Maritime Institute, University of Greenwich, UK, 4-5 April 2011.

MAES, F., Key note speaker on Local ecological knowledge in support of decision-making and marine spatial planning, LOICZ Open Science Conference “Coastal Systems, Global Change and Sustainability”, Yantei, China, 14 September 2011.

MAES, F., MSP and Dynamic Activities at Sea: Closing the Fisheries Gap by LEK? BLAST Annual Conference ‘Closing the Gap’, Ostend, 22 September 2011

MAES, F., Local ecological fisheries knowledge in support of decision-making and maritime spatial planning, Université de Bretagne Occidentale, Brest, 12 December 2011.

3.2 PARTICIPATION IN NATIONAL CONFERENCES AND WORKSHOPS

COPPENS, J. & MAES, F., LECOFISH guidance meeting, Ghent University, 18 September 2009.

COPPENS, J., LEK methodology for LECOFISH, PhD research meeting, Ghent University, 14 December 2009.

COPPENS, J., MAES, F. & VANHULLE, A., LECOFISH guidance meeting, Ghent University, 26 March 2010.

COPPENS, J., MAES, F. & VANHULLE, A., LECOFISH guidance meeting, Ghent University, 16 December 2010.

VANHULLE, A., Lokale ecologische kennis van de visserij: pladijs in een ruimer ‘plaatje’, Studiedag ‘Vissen in het verleden. Een multidisciplinaire kijk op de geschiedenis van de Belgische zeevisserij’, Oostende, 25 November 2011

MAES, F., Local ecological fisheries knowledge (LECOFISH) in support of decision-making and maritime spatial planning, TransMasp Workshop Marie Curie, Ghent University, Ghent, 26 April 2012.

3.3 PUBLICATIONS

VANHULLE, A., Lokale ecologische kennis van de visserij: pladijs in een ruimer 'plaatje', in: A.-K. Lescrauwaet *et al.* (Ed.) (2011). *Abstractenboek studiedag "Vissen in het verleden. Een multidisciplinaire kijk op de geschiedenis van de Belgische zeevisserij". VLIZ Special Publication,* 54: pp. 98-103

MAES, F., COPPENS, J. & VANHULLE, A., LECOFISH. An ecosystem approach in sustainable fisheries management through local ecological knowledge, Brugge, Vanden Broele, 2012, part 1 -61 p.; part 2 (Atlas), 117 p.

3.4 ORGANISATION OF WORKSHOPS

Focus groups on cod, sole and shrimps, Ghent University, 17 August 2011

Focus groups on plaice and worms, Ghent University, 24 August 2011

LECOFISH workshop, Ostend, 21 September 2011

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6 ANNEXES

The annexes (maps) are available on our website:

http://www.belspo.be/belspo/SSD/science/pr_terrestrial_en.stm