Lobster fisheries in the Oosterschelde

An overview of biology, management & available data

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Contents

Lobster fisheries in the Oosterschelde

Summary **4**

Samenvatting **5**

1 Introduction **6**

1.1 Lobster fisheries in the Oosterschelde 6
1.2 Problem definition 7
1.3 Research questions 7

2 Methods **8**

2.1 Literature study 8
2.2 Interviews 8

3 Results **10**

3.1 *Homarus gammarus* 10
3.1.1 Description Oosterschelde lobster 10
3.1.2 Distribution 11
3.1.3 Biology and habitat 11
3.1.4 Reproduction 12
3.1.5 Mobility and population dynamics 13
3.2 Management of lobster fisheries 13
3.2.1 Fishing techniques 13
3.2.2 Management in the past 15
3.2.3 Current management and regulations 16
3.2.4 Research on lobster fisheries 19
3.2.5 Bottlenecks in current management and regulations 20
3.3 Perception of lobster fishers 20
3.3.1 Available data on lobster fisheries in the Oosterschelde 20
3.3.2 Private sales and the auction 21
3.3.3 Lobster fishers and their perception of the Oosterschelde lobster fishery 22

4 Conclusions and recommendations **25**

4.1 Discussion 25
4.2 Conclusion 26
4.3 Recommendations 26

5 Quality Assurance **28**

References **29**

Justification **31**

Annex 1 Interview script **32**
Annex 2 Format interviews **34**
Annex 3 Maps of lobster fishing line plan **35**
Annex 4 Maps other fishing grounds **43**

Summary

Lobsters have been fished in the Oosterschelde since 1881. The so-called Oosterschelde lobster (*Homarus gammarus*) is very popular with the consumer, but little is known about the lobster fishery. This report summarises the available data on the lobster fishery. The study was carried about by students of University of Applied Sciences Van Hall Larenstein Leeuwarden, as part of the Bachelors' *programme Kust en Zee Management*. The three main questions are: What do we know about lobster biology, how is the lobster fishery currently managed and what data is available?

The research project was commissioned in cooperation between the fishing association OWV (*Vereniging van Beroepsvissers op de Oosterschelde, Voordelta en Westerschelde*) and Wageningen Marine Research, as part of preparations for a research grant proposal towards the development of a stock assessment. For implementing optimal management and to develop a stock assessment of the lobster population in the Oosterschelde in future, it is necessary to obtain a detailed overview of the current situation. A literature study was conducted and six lobster fishers who fish in the Oosterschelde were interviewed for this study. The fishers were asked to share information about their use of fishing gear, their license, how much lobster they catch and their views on the development of the lobster stock.

In the Oosterschelde, there are 42 active lobster fishing licenses, of which 37 are affiliated with the fishing association OWV. Two years ago, a major change was made in the system. The "lobster race" has been changed into a lottery system, organized by OWV. This lottery system is an improvement in the lobster sector, as with the new system every lobster fisher has equal opportunities.

The abundance of lobster varies due to natural factors, but a continuing downward trend has been observed in recent years by lobster fishers and recreational divers. An overview of available data on the stock is shown in Table 2, but these have not been structurally analysed. The observed downward trends can therefore not be explained. An overview of the different views on stock decline by interviewed fishers can be found in Table 4 and 5.

Since the exact reasons for the declining lobster population are unknown, no focused action or policy can be undertaken and made. Plans to reduce the number of licences to reduce fishing effort and increase the economic viability failed in 2015 after a process of ten years. There was no stock assessment to base these decisions on, and lack of support to carry out the proposed changes.

The study leads to four recommendations:

1. The early benthic phase (EBP) of the lobster is not feasible to use in a future stock assessment. Assessing larger individuals will give a more reliable view of the lobster population in the Oosterschelde;
2. Further research should be carried out into which natural and anthropogenic factors (Table 4 and 5) impact lobster stocks in the Oosterschelde;
3. A survey should be held among all lobster fishers to further improve insights into the perceptions on stock development and management as well as their willingness to contribute to future data collection projects. This will inform the development of a stock assessment and research priorities.
4. Communications between the fishers and the Ministry of Agriculture, Nature and Food Quality in relation to monitoring of (illegal) fishing activities should be improved.

Samenvatting

Sinds 1881 wordt er in de Oosterschelde op kreeften gevist. De zogenaamde Oosterscheldekreeft (*Homarus gammarus*) is erg populair bij de consument, maar er is weinig bekend over de visserij. Dit rapport geeft een overzicht van de beschikbare gegevens. De studie is uitgevoerd door drie studenten van de Bachelor-opleiding Kust- en Zee Management, van Hogeschool Van Hall Larenstein in Leeuwarden. De drie belangrijkste vragen zijn: Wat weten we van de biologie van de kreeft, hoe wordt de visserij beheerd en welke gegevens zijn er beschikbaar?

Het onderzoek is uitgevoerd in het kader van een gezamenlijke opdracht van de Vereniging van Beroepsvissers op de Oosterschelde, Voordelta en Westerschelde (OWV) en Wageningen Marine Research, als onderdeel van de voorbereidingen voor een projectaanvraag voor het ontwikkelingen van een bestandsschatting voor Oosterscheldekreeft. Om de informatie te verkrijgen is er een literatuuronderzoek uitgevoerd en zijn er zes kreeftenvissers die in de Oosterschelde vissen geïnterviewd. Deze vissers zijn gevraagd om informatie te delen over hun gebruik van vistuig, wat voor vergunning ze hebben, hoeveel kreeft ze vangen en wat hun visie is over de ontwikkeling van het kreeftenbestand.

In de Oosterschelde zijn er 42 actieve vergunningen waarmee op kreeften gevist wordt, hiervan zijn 37 vergunningen aangesloten bij visserijvereniging OWV. Twee jaar geleden is er een belangrijke verandering in het systeem doorgevoerd. De 'kreeftenrace' is veranderd in een loterijsysteem, georganiseerd door OWV. Dit loterijsysteem is een verbetering in de kreeftensector; met het nieuwe systeem heeft iedere visser gelijke kansen.

Het kreeftenbestand kent pieken en dalen door natuurlijke factoren, maar de laatste jaren wordt er een blijvende dalende trend waargenomen door vissers en duikers. Tabel 2 geeft een overzicht van de beschikbare gegevens over Oosterscheldekreeft, maar deze zijn nooit structureel geanalyseerd. De waargenomen dalende trend kan daarom niet worden verklaard. De geïnterviewde vissers hebben verschillende vermoedens, welke te vinden zijn in tabel 4 en 5.

Aangezien de exacte redenen voor de afnemende kreeftenpopulatie niet bekend zijn, kan er geen gerichte actie of beleid worden ondernomen. Plannen om het aantal vergunningen te verminderen om de visserij-inspanning te verminderen en de economische levensvatbaarheid te vergroten, zijn in 2015 na een proces van tien jaar mislukt. Er was geen goede bestandschatting om deze beslissingen op te baseren, en er was niet genoeg steun van de sector om deze veranderingen door te voeren.

Het onderzoek leidt tot vier aanbevelingen:

1. Het vroege benthische stadium van de kreeft is minder geschikt voor gebruik in een bestandsschatting. Een toekomstige bestandsschatting zou zich moeten richten op grotere individuen;
2. Er is vervolgonderzoek nodig naar de impact van natuurlijke en menselijke factoren op de kreeftenpopulatie in de Oosterschelde (Tabel 4 en 5).
3. Een enquête onder alle kreeftenvissers draagt bij aan het verbeteren van de inzichten over de ontwikkelingen van het bestand en mogelijke beheermaatregelen vanuit het perspectief van de vissers. Het biedt ook de mogelijkheid om te inventariseren in welke mate vissers zelf bereid zijn aan gegevensverzameling bij te dragen. Deze informatie helpt de ontwikkeling van een bestandsschatting en het vaststellen van onderzoeksprioriteiten.
4. Communicatie tussen de vissers en het Ministerie van Landbouw, Natuur en Voedselkwaliteit rond het monitoren van (illegale) visserijactiviteiten zou moeten worden verbeterd.

1 Introduction

1.1 Lobster fisheries in the Oosterschelde

In the Netherlands, the European lobster (or Oosterschelde lobster), *Homarus gammarus*, has been actively fished in the Oosterschelde since 1881. The Oosterschelde lobster can be found in the Oosterschelde, lake Grevelingen and lake Veerse Meer, and are fished in all three areas (Stralen & Smeur, 2008). Allozyme research suggest that the lobster in the Oosterschelde has a strong genetic relationship with the lobster population in the South of Norway (Jørstad, Farestveit, Kelly, & Triantaphyllidis, 2005). The waters of Zeeland became a preferable habitat for *H. gammarus*, probably because of the use of rocks to construct and strengthen the dykes. While the lobster population increased, so did the lobster fisheries. Until in the fierce winter of 1962/1963, which made the lobster population collapse. It took until the end of the 80's for the population to recover and with the recovery of the population, so did the lobster fishery sector.

Between 2001 and 2008, around 16.200 kg of lobster has been landed from the Oosterschelde (Figure 1) (Stralen & Smeur, 2008). The lobsters are mainly fished with fykes, cages and traps, but also with gill nets and trawlers. Fishers need a license and are allowed to fish for the lobsters from the last Thursday in March till July 15th. It is not allowed for fishers to land or transport undersized lobster, soft shelled lobster or egg-bearing female lobsters (Stralen & Smeur, 2008). The lobsters are marketed and sold alive. The majority of these lobsters are being sold directly to local restaurants and distributors (Stralen & Smeur, 2008).

Figure 1 *Overview Zeeland: Grevelingen, Oosterschelde and Westerschelde (Kaartenplattegrond, n.d.).*

1.2 Problem definition

There is not much known about the lobster fishery in the Oosterschelde and currently there is no comprehensive document available that combines all relevant information. Accurate estimates of abundance of the Oosterschelde lobster in the Zeeland area (Oosterschelde, Grevelingen, Veerse Meer: Figure 1) are lacking. By knowing the status of the Oosterschelde lobster, management can be developed and implemented in order to preserve a healthy population while value is added to both recreational and commercial fisheries. This research collects and summarizes all available information of the lobster fishery and points out current data gaps. For example, how many active licenses are actively used, how many fixed fishing gear do the fishers use and what is the average catch? It is also important to understand the biology of the lobster. Information about developments in catches and lobster biology are an important basis for future stock assessment. The information in this report can be used as crucial first step to review the status of the fishery, assist in policy making and give a better understanding in general of the lobster fishery and its management in the Oosterschelde.

This report was commissioned by Wageningen Marine Research (WMR) and the Association of Professional fishers on the Oosterschelde, Westerschelde and Voordelta[1] (from now on OWV). The two parties are working together on the development of a research grant proposal to develop a stock assessment for *H. gammarus* in the Oosterschelde.

1.3 Research questions

For (potential) future management of the lobster population in the Oosterschelde it is important to summarize the available information and give a detailed description of the lobster fishery in order to preserve a healthy population.

To get an updated image on the current state of the Oosterschelde lobster, the following research questions were formulated:

1. What do we know about the biology of the Oosterschelde lobster (*Homarus gammarus*)?
2. How is fishing for lobster in the Oosterschelde currently managed?
3. What data on the Oosterschelde lobster fisheries are available?

[1] In Dutch 'Vereniging van Beroepsvissers op de Oosterschelde, Westerschelde en Voordelta'

2 Methods

2.1 Literature study

A literature study was conducted focusing on the biology as well as the past and current management and regulations of the Oosterschelde lobster. With literature study, research question one was answered and a part of question two, because some policy documents were available on the internet. To make sure the used data was as relevant as possible, the preference was to use recent sources (<10 years). For biology related parts, it was not always necessary to use recent sources. Many books and articles about biology and physiology were written many years ago are still considered relevant.

To find information about the biology and the common practices of the fisheries of *Homarus gammarus*, search terms as stated below were used:

- Fisheries management Oosterschelde lobster/*Homarus gammarus*;
- Biology *Homarus gammarus*;
- Kreeftenvisserij Oosterschelde.

Relevant sources were found through Greeni, the online databank of Van Hall Larenstein and Google Scholar.

2.2 Interviews

Since available information from public sources on the Oosterschelde lobster fishery is limited, interviews were conducted to answer the second and third research question. Question two was partly answered by literature study but some of the documents were outdated. Also, by conducting interviews, it was possible to improve insights on why certain management decisions were made. Interviews were also needed to obtain information about fishing practices and developments in catches (research question three).

In order to obtain information about available research data on lobster fisheries, we identified the necessary parties to be interviewed by consulting the fishing association OWV and the research institute WMR. There was not much information available about the lobster fishery sector and a starting point was needed. That is why the Chair and Secretary of the fishing association OWV were consulted. They provided information about the sector, its management and the developments it went through, and selected fishers to interview. To get a good overview of the fishers, there were criteria given to the fishing association for selecting the fishers. Withing the group of interviewees preferably there must be at least one fisher who:

- fishes with cages;
- fishes with fykes;
- fishes with traps;
- fishes with a gillnet;
- fishes with a trawl net;
- has a license to fish on the free fishing grounds;
- has a fixed fishing ground;
- fishes for 5 years or less;
- fishes for at least 10 years;
- fishes for at least 20 years.

The goal was to interview at least six license holders, out of the 42 licenses in the Oosterschelde. Due to the time limit, it was not possible to interview all the fishers. A limited amount of time was available to conduct the research, divided over 9 weeks. Also, due to COVID-19 it was not possible to visit the

interviewees to do the interview. The interviews were done through Microsoft Teams or though telephone. Additional information was gained through mail contact. While six interviews is only a small sub-set of the 42 license holders active in the lobster fishery, the number of interviews was sufficient to provide an initial overview of possible opinions on developments in the fishery and in this context can be considered representative from a qualitative perspective (Dinklo, 2006) To get a more comprehensive picture, we recommend additional interviews or a survey amongst all license holders. Next to interviewing the lobster fishers, an employee of United Fish Auctions in Colijnsplaat, Zeeland, provided auction information about lobsters. Also a policy officer from the Ministry of Agriculture, Nature and Food Quality was interviewed.

An interview script was made in order to check whether all questions were answered during an interview. The questions were made in consultation with WMR. The script of the interview can be found in Appendix I. All interviews were processed anonymously. For the fishers it was important to remain anonymous because of competition in the fishery sector. Interviews were recorded with permission of the interviewee, when necessary. All interviews were conducted by a minimum of two interviewers, where one interviewer would lead the interview and the other(s) would register the answers. We tried to ask the questions as neutral as possible to prevent possible bias. A maximum of one interview per day was done in order to make sure the interviewers could be focused. The planned time per interview was between 45 and 120 minutes.

After each interview a summary was made and sent to the interviewee for review, but no corrections of the summary were needed. Hereafter the information was anonymised. An overview containing the answers to the questions was made after the interviews were conducted, generating an overview on comparisons and contrasts. The template format can be found in Appendix II.

3 Results

3.1 *Homarus gammarus*

The European lobster, *Homarus gammarus* (Linnaeus, 1758) is mostly found along the continental shelf in the Northeast of the Atlantic Ocean (Agnalt, Farestveit, Gundersen, Jørstad, & Kristiansen, 2009). *H. gammarus*, also called 'Oosterschelde lobster' in the Netherlands, belongs to the subphylum Crustacea and the order Decapoda (National Lobster Hatchery, 2020). The European lobster and the Oosterschelde lobster are the same species, but it is called the 'Oosterschelde lobster' because the lobster fisheries in the Netherlands is mainly about the lobsters in the Oosterschelde, Zeeland. The Oosterschelde lobster is also fished in lake Grevelingen and lake Veerse Meer. The biology description below applies for both lobsters, differences in distribution is described separately.

3.1.1 Description Oosterschelde lobster

3.1.1.1 Age

Female *H. gammarus* can reach an average age of 54 years and males an average of 31 years (Sheehy, Bannister, Wickins, & Shelton, 1999). A female reaches sexual maturity in 5 to 7 years of age with a carapace size of around 80 mm and carries the eggs under the abdomen for 9 to 12 months (Stralen & Smeur, 2008).

3.1.1.2 Physical characteristics

In Figure 2, the exoskeleton of the lobster is shown. They have two large claws, which they use for crushing and slicing their prey. Males tend to have larger claws than females, but females have wider abdomens. The lobsters have ten legs, and pleopods, which are used for swimming. The exoskeleton is blue on the carapace and lighter underneath with an orange tinge. Their body length can be up to 60 cm and they can weigh up to 6 kg, although bigger individuals are not common. (Stralen & Smeur, 2008).

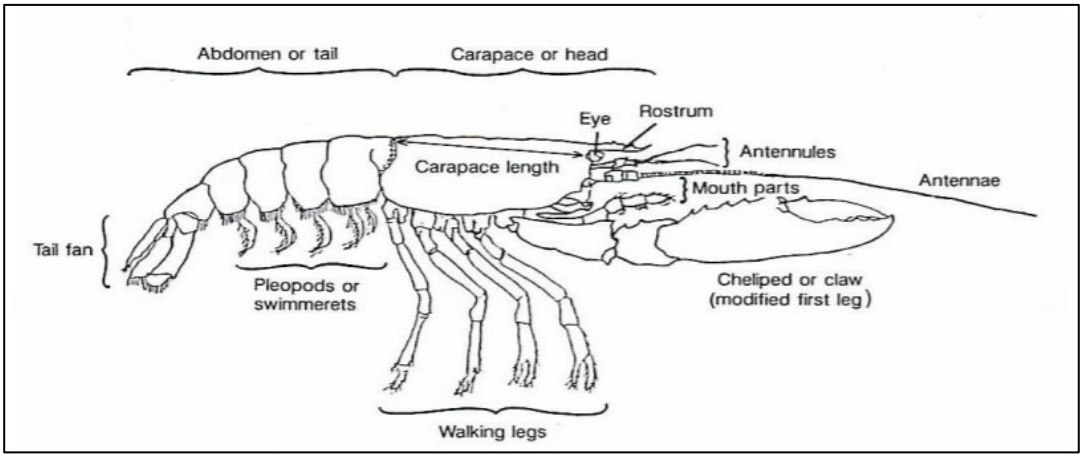

Figure 2 *External anatomy of a mature H. gammarus (National Lobster Hatchery, 2020).*

3.1.1.3 Diet

Lobsters have a habit of eating until saturated. They hide what is left over to consume later. The lobster is an opportunistic feeder, the foraging behaviour is in line with what food is available at that time (Rozemeijer & van de Wolfshaar, 2019). The lobsters hunt nocturnally on benthic invertebrates such as crabs, molluscs, starfish, and polychaete worms, but can also include fish, algae, and zooplankton (National Lobster Hatchery, 2020).

3.1.2 Distribution

3.1.2.1 Distribution European lobster

H. gammarus lives in coastal areas. They are distributed from the north-east Atlantic Ocean from Norway to the North Sea and from the south to the north African coast to the eastern Mediterranean. In the northern parts, they mainly occur in the fjords. More to the south, lobsters are less abundant and therefore only small populations live in the Mediterranean. (Rozemeijer & van de Wolfshaar, 2019)

3.1.2.2 Distribution Oosterschelde lobster

The figure below (3) shows the mean abundance of *H. gammarus* in the Oosterschelde, lake Grevelingen, and lake Veerse Meer in the period from 1994 to 2002. The average density is based on observations per research location, each yellow point being a research location. The densities are the highest towards the East. (Gmelig Meyling & de Bruyne, 2003)

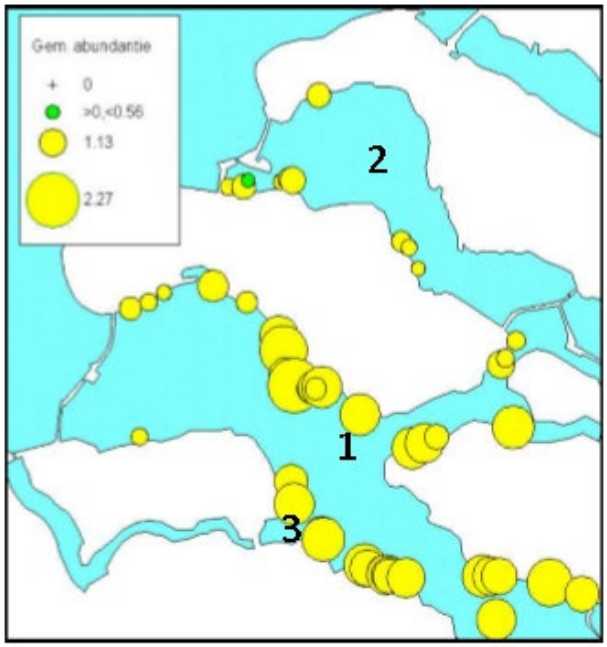

Figure 3 Mean abundance of *Homarus gammarus* (1994-2002) in the Oosterschelde (1), lake Grevelingen (2) and lake Veerse Meer (3) (Stralen & Smeur, 2008)

3.1.3 Biology and habitat

H. gammarus are located till depths of 165 m, but mostly live in depths of a maximum of 50 m. Older and larger lobsters show a preference for deeper regions. They are also sensitive to flow velocities and wave action, if this is higher than 0.6 m/s, they can be carried away by the flow. (Howard, 1988; Linley, Wilding, Hawkins, Black, & Mangi, 2007).

Adult lobsters choose their habitat based on food availability, sufficient oxygen levels, and shelters. They are mainly found on hard substrates such as stone, areas with soft substrate are used as a foraging area. At night the lobsters emerge from the holes and crevices where they live during the day to forage (Linley, Wilding, Hawkins, Black, & Mangi, 2007). These holes and crevices are especially important to protect them from predators and cannibalism. Young lobsters are very sensitive to this, which is why they are mainly located in holes and crevices, older animals live closer to the edge. These shelters must meet several criteria, such as multiple openings that count as escape routes, the size of the opening, length, oxygen levels, and it must have enough space for the lobster to move around. When the lobsters grow, they also move to larger shelters (Linley *et al.*, 2007).

The lobsters have a hard exoskeleton, like other crustaceans, they have to moult to grow further. This process is called ecdysis and occurs several times a year in young lobsters. The older animals only moult once or twice a year and adults only annually during the mating cycle (Phillips, 2013).

3.1.4 Reproduction

3.1.4.1 Mating

Depending on the water temperature, most lobsters reach maturity between 5 and 8 years old. The male lobsters reach sexual maturity earlier than the females. The lobsters are iteroparous, so they are able to reproduce often. The size of females when they start carrying eggs varies, presumably depending on temperature. The females can start carrying eggs when they reach a carapace length of 71mm (Phillips, 2013).

Dominant males with large claws are generally more successful in finding a female. When the males reach a carapace length of 45-50mm, the sperm is present in the vas deferens. The lobsters are polygynous, meaning they mate with multiple females (Phillips, 2013). Reproduction takes place in the summer around the months of June and July. In that time, most female lobsters are done moulting, shortly after the moulting they look for a partner to mate with. During mating, the male deposits a spermatophore in the seminal receptacle of the female, the female can store the sperm for a few years. The females keep the eggs on the pleopods for almost a year, the eggs hatch the summer after mating. Adult females with a carapace length bigger than 120mm usually spawn twice before moulting again (Phillips, 2013). The eggs are quite large and the clutch sizes relatively small. The clutches range from a few thousand to as many as 20,000 eggs, the amount of eggs increases with carapace length and age (Contarini, Perrella, Hickey, & Ballestrazzi, 2008).

3.1.4.2 Larval stage

When the eggs hatch, they enter a pelagic phase of about 10 to 18 days. During this period, they change from larva into a small lobster-like body (stage 1 to 3 in Figure 4). The body structure changes in that phase, the claws and tail move outwards from to the thorax and abdomen. This allows the larva to swim forward using its pleopods. When he has reached this phase, he looks for suitable substrate to settle in, this substrate consists of gravel or coarse sand (Jensen, Wickins, & Bannister, 2000).

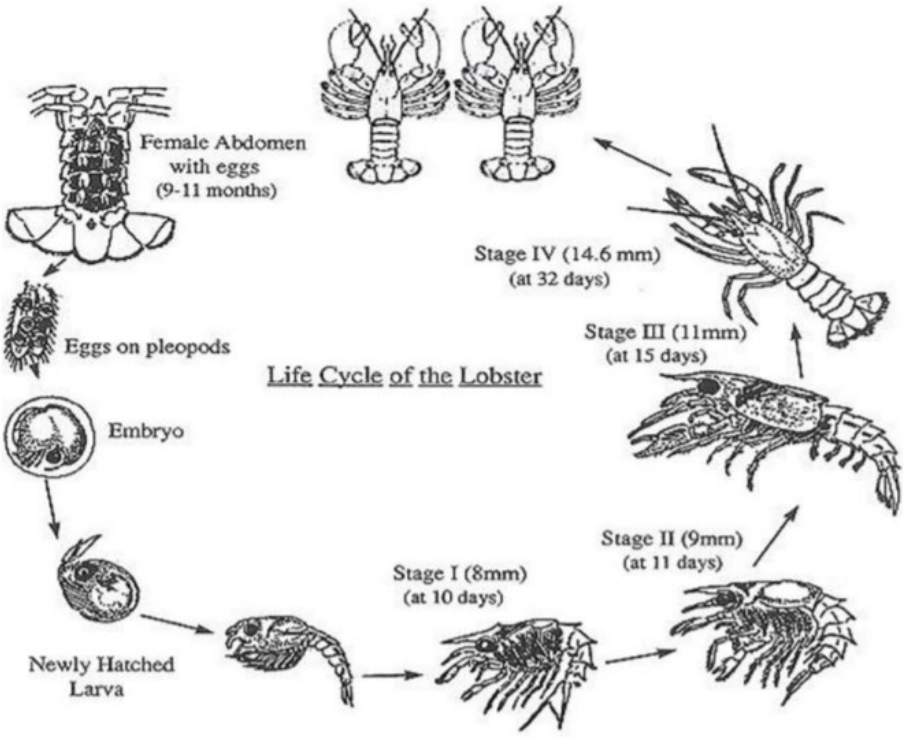

Figure 4 *The life cycle of the Lobster (Skerrit, 2014).*

The distribution of the larvae is mainly determined by currents. The availability of suitable substrate and benthic habitat determine where the lobsters settle. The planktonic phase is a crucial phase of the larva, only a very small part survives the transition from the planktonic phase to the benthic phase. (Phillips, 2013)

3.1.4.3 Settlement

After the transition from the planktonic phase to the benthic phase, the post larva will look for a suitable nursery habitat. Suitable substrate consists of gravel or coarse sand to hide in (Phillips, 2013). The right substrate is a crucial factor in survival rates of the post larva, they are very vulnerable to predation if they don't find the right substrate (Mercer, et al., 2002).

The lifecycle of juvenile lobsters consists of a period where they live in an environment with little shelter. After this period, the juvenile lobster hardly emerges from its hiding place. Subsequently, the phase begins in which they grow into an adult lobster and look for a suitable habitat. Young *H. gammarus* live underground for almost their entire first year of life. They burrow in lose substrate and feed on infauna. When the food reserves of the young lobsters are reduced, and they no longer have enough food around their hiding place, they come out to forage further away. When they reach a carapace length of about 15mm, they leave their burrows for a new shelter in rocky substrate. From that moment on, they feed themselves with other post-larval animals such as crabs and sea urchins, but also plankton. (Howard, 1988; Jensen *et al.*, 2000; Phillips, 2013)

Little is known about the early benthic phase (EBP) of *H. gammarus*, despite extensive research. Juvenile lobsters with a carapace length smaller than 45mm are barely found or caught. It is hard to tell if this is because there are not many, or because they may be in unexplored habitats. (Mercer, et al., 2002; Phillips, 2013)

3.1.5 Mobility and population dynamics

The mobility of *H. gammarus* consists of daily movements and migration movements. They can have a migration range ranging from 0 to 45 km. Once they have found a suitable shelter, they are known to remain at the shelter where they have settled. Around this shelter, the *H. gammarus* only makes some short daily movement. The range of this daily movement goes up to 125m, but can be influenced by factors such as competition for food, shelter and other lobsters. The lobster walks slowly, but with the help of its telson it can make a short powerful propulsion. (Lees, Mill, Skeritt, Robertson, & Fitzsimmons, 2018).

3.2 Management of lobster fisheries

How is the lobster fishery in the Oosterschelde currently managed? To get a good view on the lobster stock in the Oosterschelde, it is important to know what kind of fishing techniques are used and how lobster fisheries are managed, in the past and in the present.

3.2.1 Fishing techniques

Lobster fishers use different fishing techniques, and with some of these techniques other species are targeted in combination with the lobster. Down below the different techniques used in the Oosterschelde are shown.

3.2.1.1 Cages

Cages are the traditional fishing gear for lobster fisheries and still different kind of cages are used for lobster fisheries (Stralen & Smeur, 2008). It consists of a frame, covered with knotted mesh, with one or more openings. In the cage, bait is placed to attract the lobsters and once in the cages they are not able to get out. Cages and also traps are usually attached to a long line, and at the end of both sides of the line, buoys are placed to mark the location of the cages (Waddengoud, 2012). The cages are

less sensitive to damage and are firmer than traps, but the downside is that they take up a lot of space on board of the vessels (Vist ik het maar, 2020). In figure 5 and 6 lobster cages are shown.

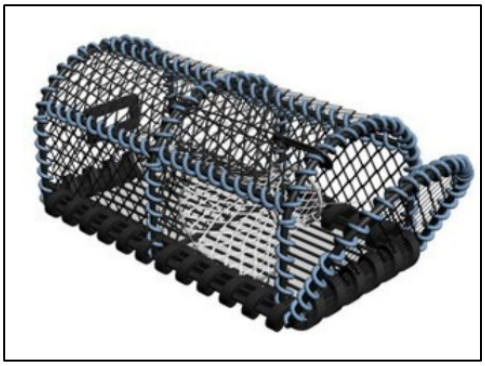

Figure 5 *Lobster cage (Seafish, 2016)* ***Figure 6*** *Lobster cages (Wijsman, 2020).*

3.2.1.2 Fykes

A fyke is a trap, which is made of a net that is fixed on the bottom. It has wings which guides the lobster (and often other animals) to the entrance of the fyke and once in the fyke, larger organisms are not able to get out. Fykes are commonly used in shallow coastal waters, as the Oosterschelde (FAO, 2020a). In Figure 7 a fyke is shown.

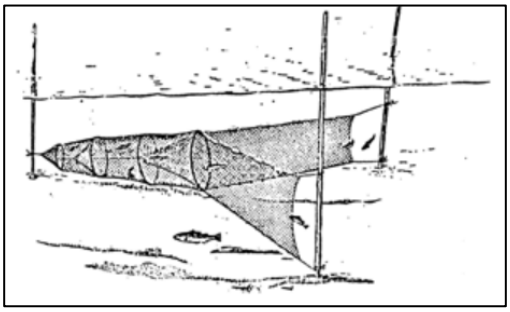

Figure 7 Fyke net (FAO, 2020a)

3.2.1.3 Traps

A trap is a small fyke with at least two openings, and are mostly placed in long lines (Goedevissers.nl, n.d.). A trap works the same as a fyke and the cage: the lobsters can get in but cannot get out. Bait is attached in the trap, to attract lobsters (Stralen & Smeur, 2008). In Figure 8 a vessel loaded with traps is shown.

Figure 8 *A vessel loaded with lobster traps (Uil, 2019).*

3.2.1.4 Gillnets

Gillnets are a vertical netting wall, with vertical single, double or triple netting walls, on the bottom. The lobsters and other target species get entangled in the net (FAO, 2020b). In Figure 9 a gillnet is shown. In 2008, around 20% of the lobster catch came from gillnets and dredges, according to (Stralen & Smeur, 2008).

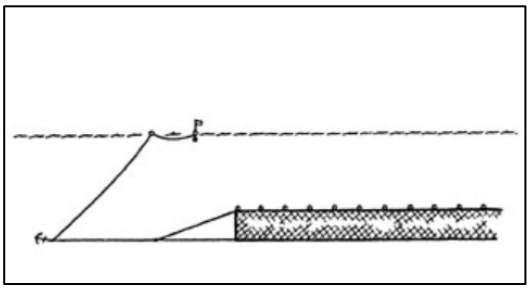

Figure 9 *Gillnet (FAO, 2020b).*

3.2.1.5 Trawl nets

A trawl net is fishing gear that is dragged along the bottom to catch benthic organisms (FAO, 2020c). In the Oosterschelde, fishers do not especially use a trawl net to catch lobster, but the hypothesis of OWV is that some trawl net and oyster fishers do accidentally catch lobster (OWV, personal communication, June 2020). It is not possible anymore to use tickler chains, because using them has a large impact on the seabed. Catching lobster with a trawl net is not beneficial, because fishing with it damages the lobsters making them less valuable on the market, dead lobsters have no economic value. In Figure 10 a trawl net is shown.

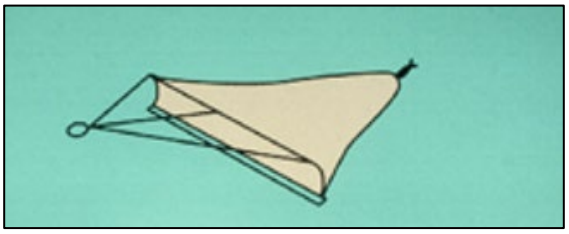

Figure 10 *Trawl net (FAO, 2020c)*

3.2.2 Management in the past

According the current policy officer on marine resources of the ministry of Agriculture, Nature and Food Quality (LNV), there is no policy specifically for the lobster fisheries (Ministry of Agriculture, Nature and Food Quality, personal communication, June 2020). There are, however, general fisheries policies that are applied for the lobster fisheries.

3.2.2.1 Structuurnota Zee- en Kustvisserij 1993-2003

The 'Structuurnota Zee- en Kustvisserij' was implemented in 1993, with regulations for the next ten years. This was for all coastal fisheries in the Netherlands, and was in consultation with stakeholders (Ministerie van LNV, 1998). In the Structuurnota, it was decided that sectors in the coastal fisheries can give their own interpretation to the long-term goals. Another goal was to minimalize the licenses for fixed fishing gear, but this was decided in a policy decision in 2002 called 'Vast en Zeker!'. This policy decision is still in effect and is discussed in chapter 4.3.

Around 1987, a lobster season was implemented, from the last Thursday of March to the 15th of July. Lobster fisheries is only allowed during this period, and lobsters caught before or after the season need to be discarded (Stralen & Smeur, 2008). Management policies by countries in Europe were taken as an example to implement a lobster season in the Netherlands. The motivations of these management policies differed. The decision to implement a shorter lobster season in the Netherlands

was based on the following reasons (Ministry of Agriculture, Nature and Food Quality, personal communication, June 2020):

- The larvae are produced during the summer months, but the female lobster carries the eggs with her until they hatch, so fishing should be closed in the summer;
- The lobster season closes before the summer holidays to minimize amateurs catching lobster;
- The fishing intensity on lobster is already lower in the winter, so the fishing on lobster can be closed anyways.

In addition to the lobster season, there is a provision that egg-bearing lobsters and lobsters that have just moulted need to be returned to the water (discarded). Also, there is a minimum size that the lobster needs to be before the lobster can be landed. The length between the backside of the eye and the backside of the exoskeleton of the head needs to be larger than 87 millimetres. This corresponds with an average of 24.6 centimetre total length (TL) and an average of 464 grams (Stralen & Smeur, 2008). If the lobster is smaller than that it needs to be discarded. Fishers need to registrate their catch for the Netherlands Food and Consumer Product Safety Authority (NVWA[2]) by reporting their daily catch (of lobsters) in kilos in a logbook.

From 1989, there was an increase in the number of license applications for fishing with fixed fishing gear and from 1991 onward, new applications were rejected. Initially, there were three different licenses that could be distinguished for all fixed fishing gear: traditional licenses, temporary licenses and recreational licenses. 108 traditional licenses, which were transferable, were issued in 1988. The traditional license holders also had the possibility to rent fixed fishing grounds, which are located close to the shore. Temporary licenses were issued to new applicants from mid-1989. In 2002 there were around 250 licenses, but in reality, a large part of these licenses was non-active. (Ministerie van LNV, 2002)

During the lobster season, it was possible for the lobster fishers to fish for lobster everywhere on the free fishing grounds. Where other fishing gear was placed, lobster fishers had to observe a radius of 50 meters. Around 2015 some fishers started placing fishing gear at locations where they would catch a lot of lobster to claim their spot before the lobster season started. This led to disagreement between fishers. That is why in 2017 it was decided that all fixed fishing gear needed to be out of the water at the so called 'lobster hotspots', to prevent that the best spots were claimed beforehand (Ministry of Agriculture, Nature and Food Quality, personal communication, June 2020). As a result, all the lobster fishers needed to race to the best lobster hotspot at the start of the season. This race came to be called the 'lobster race'. According to the Ministry of Agriculture, Nature & Food Quality and the fishers, this race led to dangerous situations. Also, it was unfair for the fishers who have a slower vessel (interviews, personal communication, June 2020). Only in 2017 and 2018 this lobster race took place. In 2019 a different way was used for dividing the lobster hotspots, and this is explained in chapter 3.2.3.2.

3.2.3 Current management and regulations

Currently, the lobster fishery is part of the fixed fishing gear regulation 'Vast en Zeker!' (Ministerie van LNV, 2002). Also, a Fishing Plan was written to improve management for the fishery sector.

3.2.3.1 Policy decision for fixed fishing gear 'Vast en zeker!'

The main objective of this decision was to make sure that the fishing with fixed fishing gear is sustainable and in balance with the ecological values of the coastal ecosystem and affects both professional and recreational fishers. The core of the policy can be described in the following points:

- Registration of catches for evaluation;
- Reducing the fishing pressure;
- Simplifying regulations by reducing the wide variety of license types to a standard license for the free fishing grounds;
- Appropriate Assessment against the Nature Conservation Act and Birds- and Habitat Directive;
- Encouraging a co-management regime comparable to that in other fishing sectors;

[2] In Dutch 'Nederlands Voedsel en Waren Autoriteit'

- Boost the stock management, by (for example) expanding fixed fishing grounds;
- Gaining insight into the ecological consequences of the gillnet fisheries;
- Monitoring the impacts of recreational fishing with fixed gears.

The policy decision 'Vast en Zeker' mainly led to changes in the license system. This decision aimed to eliminate the licenses that were not used by professional fishers. The traditional and temporary licenses were transformed to a 'standard license' in April 2003. Only if the fishers met certain requirements, the license could be transformed. The idea behind this was that only the active and 'professional' fishers could keep their license. All requirements can be read in the report of the policy decision (Ministerie van LNV, 2002).

To summarise, in 2002, the non-active licenses were eliminated and only 42 'standard licenses' were left. This is a lot less than the previous 250, but fishers still think the current 42 licenses are too much compared to the 16 that were active when the lobster fishery started.

In addition it still possible to rent fixed fishing grounds. In Figure 11 a map of the fixed fishing grounds of the Oosterschelde is shown. The fixed fishing grounds are shown in yellow.

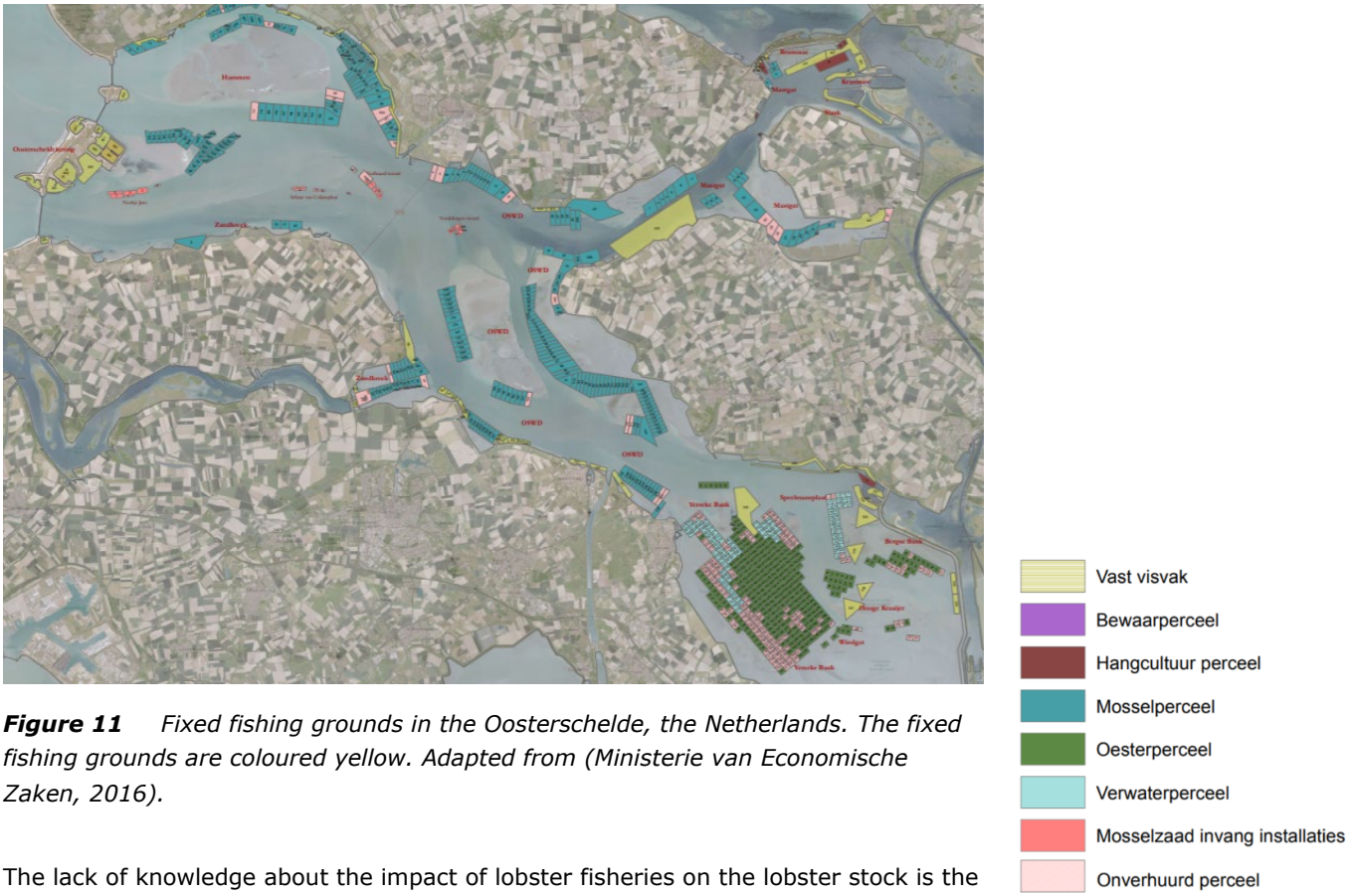

Figure 11 *Fixed fishing grounds in the Oosterschelde, the Netherlands. The fixed fishing grounds are coloured yellow. Adapted from (Ministerie van Economische Zaken, 2016).*

The lack of knowledge about the impact of lobster fisheries on the lobster stock is the main reason why management is limited to the current measures and there is no more targeted stock management.

3.2.3.2 Fishing plan

In 2018, the Fishing Plan was set up by the Association of OWV in cooperation with the Ministry of Agriculture, Nature and Food Quality. According to board members of OWV, the Chair and Secretary, in the current situation there are 42 licenses, given by the Ministry of Agriculture, Nature and Food Quality. Of those 42 licenses, 37 of those licenses are member of OWV and signed the new Fishing Plan. The licenses of the lottery lines are transferable, and so are the licenses of the fixed fishing grounds.

With implementation of the Fishing Plan, the lobster race was history. In the plan, so called lobster fishing hotspots were assigned on the free fishing grounds. These hotspots consist of lines, approximately 220 in total. In Figure 12 the map of Zeeland is shown, with Ouwerkerk encircled red.

In Figure 13 the fishing lines at the hotspot of Ouwerkerk is shown for the signatories of the Fishing plan. In Figure 14, the fishing ground at Ouwerkerk for the non-signatories is shown in red. The 5 non-signatories divide the appointed fishing spots between them.

Figure 12 *Location of Ouwerkerk in the Oosterschelde. Adapted from (Docukit, n.d.)*

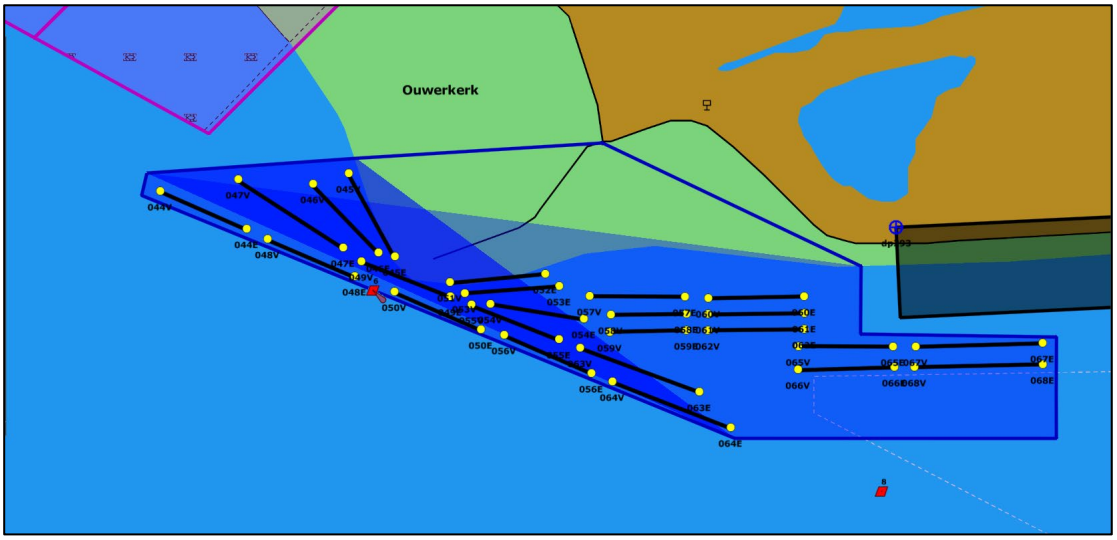

Figure 13 *Hotspot Ouwerkerk with fishing lines for the signatories (personal communication, 2020).*

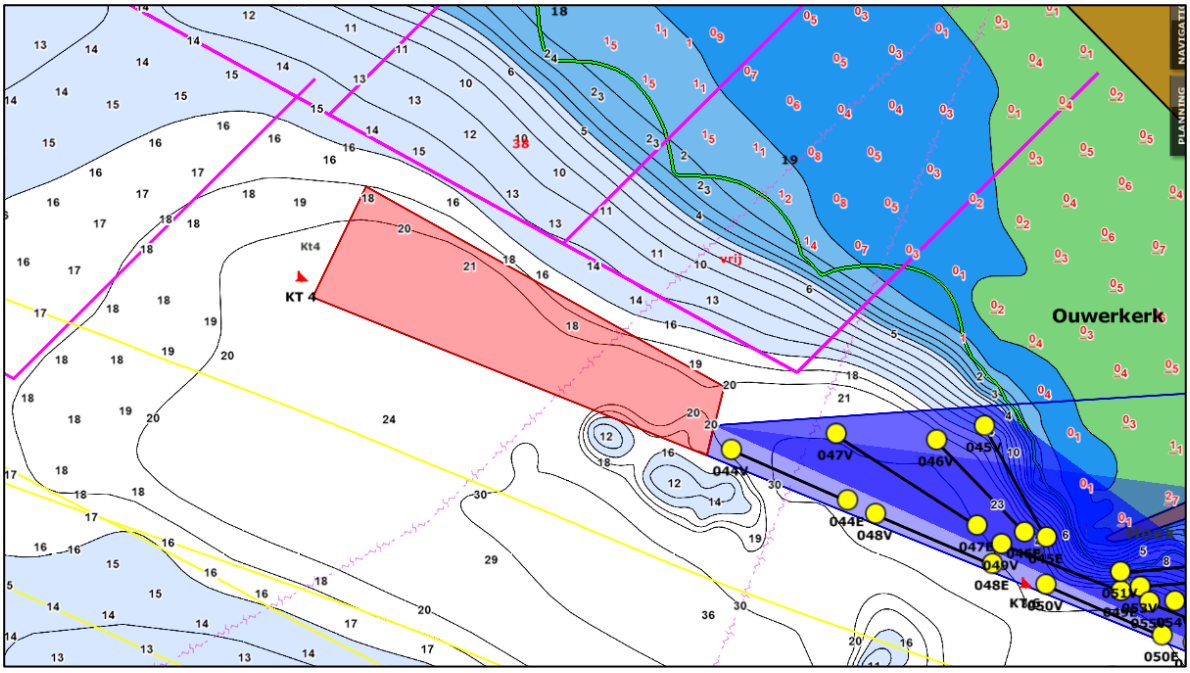

Figure 14 *Map of the fishing lines of Ouwerkerk for the non-signatories (OWV, personal communication, 2020)*

The maps of these fishing lines, that are available for the members of OWV, can be found in appendix III. In March, before the start of the lobster season, the hotspots are divided. The order in which the fishers can choose their fishing lines, is done by a 'lottery'. Every license has the right to fish at 5 or 6 lines. Every year the plan is evaluated with the sector (OWV, personal communication, May 2020).

In total, 5 fishers did not agree with the Fishing Plan. Those fishers do not participate in the lottery and have their own hotspots where they are allowed to fish for lobsters. The maps of these hotspots can be found in appendix IV.

The current regulations that are active are shown in Table 1.

Table 1

Current regulations concerning the lobster fishery

	Standard license	Fixed fishing ground
Fishing ground	Free fishing ground, lottery lines	Fixed fishing ground
Total allowed fishing gear per license	180 fykes or traps	Unlimited fykes, traps or cages 1x Gillnet
Season	Last Thursday of March– July 15th	Last Thursday of March– July 15th
Minimum landing size	24.6 cm (TL)	24.6 cm (TL)
Discards	Egg-bearing lobsters, scaled lobsters, under 24.6 cm	Egg-bearing lobsters, scaled lobsters, under 24.6 cm
Fishing ground	Free fishing ground, lottery lines	Fixed fishing ground
Total allowed fishing gear per license	180 fykes or traps	Unlimited fykes, traps or cages 1x Gillnet

3.2.4 Research on lobster fisheries

Not a lot of research has been done on the lobster fisheries in the Oosterschelde. As mentioned earlier, this may be because of lack of funding. In addition,, according to the Ministry of Agriculture, Nature and Food Quality, there is no direct reason to conduct research on the population. Because of the lobster season, it is not possible to fish for most of the year. The ministry is of the opinion that the lobster population is relatively stable and that there is no direct risk of stock collapse.

In 2008, the expertise centre of the Ministry of Agriculture, Nature and Food Quality wanted to check what knowledge was needed to implement the policy decision. This led to the research assignment concerning the European lobster that was given to IMARES (now Wageningen Marine Research) and AQUATERRA. IMARES delegated the assignment to research agency Marinx, leading to the research report of (Stralen & Smeur, 2008). Catch data from 2002 onwards was used, which the Ministry of Agriculture, Nature and Food Quality collects through the logbooks that the fishers had to fill in in the fishery registration system (VIRIS). In 2006 and 2007, additional data was acquired on board of fishing vessels. The research concluded that there were indications that the lobster stock declined in the past decades and that this could be linked to fishing activities. Regulating the fisheries through more fixed fishing grounds instead of free fishing grounds, could have a favourable effect on the development of the lobster stock. It would offer the fishers self-regulation on the fixed fishing grounds that are exclusively for them. If more measures need to be taken, measures that reduce bycatch could be the most effective (Stralen & Smeur, 2008).

3.2.5 Bottlenecks in current management and regulations

There are some bottlenecks in the current management and regulations. According to the interviewed fishers, there are too many licenses. Since the change from the so called 'lobster race' to the 'lottery', more licenses are active. This change was initiated by the lobster sector itself however, consulted by the ministry. The change to a lottery meant that every license could be used, and is used. This means that now there are more licenses active than previously, which leads to more active fishing. According to the interviewed fishers, there are too many licenses (interviews, personal communication, June 2020).

The government has tried, for multiple years (up to 2015), in consultation with the Province of Zeeland and the lobster fishers to find possibilities to reduce (by 50%) the number of licenses to fish for lobster in the Oosterschelde because there were complaints fishing for lobster was no longer economically viable. However, there was not enough ecological research or lobster stock assessments to carry the proposition through (Ministry of Agriculture, Nature and Food Quality, personal communication, June 2020).

Some interviewed fishers also pointed out that there is a lot of illegal fishing going on. People fish longer than the lobster season or with more fixed fishing gear than allowed. There is not enough control on illegal fisheries by the ministry according to several interviewed fishers.

3.3 Perception of lobster fishers

3.3.1 Available data on lobster fisheries in the Oosterschelde

Currently, there is insufficient information about the development of the stock over time. Stock assessment is not done, mostly due to the costs involved (Stralen & Smeur, 2008). An inventory on the found data that is available on lobster fisheries in the Oosterschelde is summarised in table 2.

Table 2
Available data on lobster fisheries

Who	What	When
United Fish Auctions (Colijnsplaat)	Data on yearly sales in kilos. Data on yearly suppliers. Prices per kilo per category. Auction process details.	Weekly auction on Thursdays within the season.
Fishers log's	Data on landings in kilos. Data on discards in numbers and/or kilos.	Every fishing day landing data and discard data is processed.
Association OWV	Contact details of lobster fishers. Maps of lottery lines and fixed fishing grounds. Hotspots for non-members of OWV. License reduction plan (2013).	

Who	What	When
	Yearly catch statistics 2010-2018. Fishing Plan signed by members of the OWV	
Ministry of Agriculture, Nature and Food Quality	Historical overview of lobster fisheries in the Oosterschelde. Current lobster policy and situation overview. Contact details of control authorities. Daily reported catch statistics.	
Research Marnix van Stralen	Lobster report about history, management, regulations and fishing gear.	2008
Centrum voor Visserijonderzoek	Demersal Fish Survey (trawl survey aimed at flatfish and shrimp in coastal waters; all catches of lobster and other benthic species are also recorded)	1970
Stichting Anemoon	Data on lobster are available for a large number of dive sites in the Oosterschelde since 1987. These are collected by volunteers of 'Stichting Anemoon' (Gmelig Meyling & de Bruyne, 2003). It was not further researched how data was collected and how reliable this data is.	From 1987 onwards
Policy decision 'Vast en Zeker!'	Regulations on fisheries in the Oosterschelde with fixed fishing gear as fykes, cages and traps. Information on licenses and how this changed.	2002

3.3.2 Private sales and the auction

Fishers that fish for lobster in the Oosterschelde have several options regarding selling their lobster. Lobster can be sold to individuals or restaurants directly. Another option is auctioning the lobster at the United Fish Auctions or bringing the lobster to a third party e.g. "Kreeftenpark Yerseke" that will distribute the lobster to restaurants and individuals. Whether the fishers sell their lobster to restaurants directly or via the auction, about 90% of the total caught Oosterschelde lobsters end up in restaurants (Visserijnieuws, 2020).

An advantage for fishers selling lobster directly to individuals or restaurants is the higher price per kilo they will get (up to 150%). Especially once the fishers have contacts and deals with nearby individuals and restaurant, selling the lobster this way is economically more rewarding than using the auction without being too time consuming (interviews, personal communication, June 2020).

Advantages of using the auction or Kreeftenpark Yerseke for a fisher are: (1) it is a very quick way of selling the lobster, (2) no time is lost in travelling to individuals or restaurants or contacting and discussing with possible buyers and (3) the auction or Kreeftenpark Yerseke are never fully saturated, so fishers are always able to sell their lobster there. This offers stability and reliability. Fishers have a weekly opportunity within the season to bring their lobster to the auction on Thursdays (United Fish Auctions, personal communication, June 2020).

The price of lobster differs per season and within season, however, depending on the abundance. In general, at the auction the price is higher in the beginning of the season than towards the end of the season. When fishers sell their lobster privately, they tend to try to keep a stable price throughout the season making less profit in the beginning of the season when prices at the auction are relatively high. But making more profit towards the end of the season due to the declining price of lobster at the auction (interviews, personal communication, June 2020).

The price is also dependent on the quality of the lobster as noted by one of the interviewed fishers "lobster caught with trawls are bruised and the price for which they are sold is very low". Sometimes lobster with only one leg or without legs are supplied by the fishers, this also influences the price negatively. Therefore, lobster brought to the auction are sorted into four different categories being: 1) Lobsters < 1.000 grams, 2) lobsters > 1.000 grams, 3) lobsters with one claw, and 4) lobsters without claws (United Fish Auctions, personal communication, June 2020). There are no further distinctions in price between sexes apparent. See Table 2 for average prices per kilo Oosterschelde lobster in 2019

per category sold via the United Fish Auctions in Colijnsplaat. Data about sales, landings and distribution of lobster was obtained by contacting the United Fish Auctions Colijnsplaat.

In 2018, 23 fishers used the auction point to sell their lobster. This was 19 in 2019 and 18 in 2020 respectively. The number of fishers that use the auction to sell their lobster has been relatively stable over the past five years according to the United Fish Auctions. There is a steeper decline in supplies in kilos of lobster to the auction in the past three years (15.956 kg in 2017, 12.138 kg in 2018 and 6.867 kg in 2019) than there is in fishers that use the auction. Some fishers bring all their lobster to the auction where others only bring what they are not able to sell privately. The percentage of fishers who sell lobster through the auction differs between 10% and 100% (interviews, personal communication, June 2020). Three of the interviewed fishers said they bring around 10% of their catch to the auction. Two other fishers said they bring about 95% to the auction or Kreeftenpark Yerseke and one has its own wholesale (interviews, personal communication, June 2020).

The main bycatch that is delivered to the auction are crabs (*Cancer pagurus*). Other bycatch mentioned by interviewed fishers are squid, eel and starfish.

Table 3

Average price per kilo Oosterschelde lobster in 2019 per category at United Fish Auctions (United Fish Auctions, personal communication, June 2020)

Lobster sales	Average price in 2019 per kilo
Lobster < 1.000 grams	€31,39
Lobster > 1.000 grams	€25.38
One-legged lobsters	€19.88
No-legged lobsters	€11.43
Lobster sales	Average price in 2019 per kilo

3.3.3 Lobster fishers and their perception of the Oosterschelde lobster fishery

In total six interviews of lobster fishers in the Oosterschelde were conducted in the first half of June 2020. Contact details of six fishers were given by the fishing association OWV, taking our criteria as mentioned in the Materials and Methods. Four of these fishers agreed to be interviewed. Later, three more contact details were given by the OWV. Two of these fishers agreed to be interviewed. Contact with the fishers was made by e-mail at first but after a lack of response, phone calls were made to agree upon time of the interviews.

The fishers were interviewed to get a better understanding on the following subjects:

- Fishing methods: what methods are mostly used, how often and how many cages/fykes/traps are released, where and when those are released; how many fishers practise trawling and gillnet fisheries;
- Fishing grounds: what is the distribution of the fishing grounds, who fishes where;
- Licenses: for the free fishing ground (lines) and fixed fishing grounds;
- Catch: general trend in lobster catches and sizes;
- Sales: where do the fishers sell the lobsters to, can we give an estimate of how much of the catch (%) goes via the auction and how much directly sold to restaurants;
- Thoughts and opinions: movement of lobster within their habitat, on limiting factors for growth of the lobster population, on lobster fisheries management and the current status of the lobster stock.

The six interviewed lobster fishers in general had the same view on the lobster fisheries in the Oosterschelde. According to them, there is no doubt that there is less lobster caught in the last three seasons compared to the seasons six to seven year ago. The yearly catch rates for some of the fishers in 2019 were around the 1.000 kilo mark while they were around the 2.000 kilo mark in 2013 to 2016 with the same fishing effort. The same is the case for fishers that used to catch 6.000-7.000 kilos and

now get to 4.000 kilos in a season. However, it was noted by one of the interviewees that the seasons 15 to 20 years ago were comparable with the last three seasons.

The increase in licenses and fishing effort is one of the main reasons for the downward trend according to the interviewees. A fisher that has fished in the Oosterschelde for a long period of time stated: the lobster sector warned the ministry before more licenses were issued that the lobster population would not be able to handle this increased fishing effort. Since the transition from "lobster race" to the "lottery system" also licenses that were issued but not used, suddenly were actively used (interviews, personal communication, June 2020). This increased the fishing effort further although none of the interviewed fishers use all of their fykes, cages and traps they are allowed to with their license. While the fishing effort for lobster in the Oosterschelde rose after the system change, all the interviewed fishers agreed that the lottery system is better than the lobster race (interviews, personal communication, June 2020). This system is fairer and gives fishers with small vessels the ability to earn their living.

None of the interviewed fishers think that the increase in licenses and fishing effort is the only cause. Several other possible natural and anthropogenic reasons were given for the declining lobster population in the Oosterschelde. See Table 4 for the natural possible causes and table 5 for the anthropogenic causes. Some of these possible causes are also highlighted by Stichting Anemoon (Stichting Anemoon, 2020).

Table 4

Natural causes named by fishers that possibly influence the lobster stock size in the Oosterschelde

Natural causes	
Increased seawater temperature	Increase in seawater temperature. Suspicion it has influence on the reproduction cycle of the lobster.
Increased North Sea crab population	Sometimes more crab than lobster in a fyke, cage or trap. When there is already a crab in the cage, lobsters are not eager to go in as well. Crab also compete for the same food sources.
Algal blooms	Extreme algae numbers the last years. Lobsters fishing may be hindered by this because it clogs the fishing gear.
Increased seal population	Seal population is growing. Seals eat lobster.

Table 5

Anthropogenic causes named by fishers that possibly influence the lobster stock size in the Oosterschelde

Anthropogenic causes	
Fisheries	Fishing for lobster decreases the lobster population
Destruction of natural habitat	Good lobster grounds are destroyed. For example, near sand suppletions.
Unfair fishing by other lobster fishers	Some fishers exceed the number of allowed fykes, cages and traps per license. Also, some fishers fish longer for lobster than is allowed up to September/October according to other fishers.
Toxic metals	Building of structures in the Oosterschelde including use of metals that may be toxic to the lobster.

Besides the downward trend in general, all fishers agree that the fisheries in the fixed fishing grounds generate similar or better results when compared to the free fishing grounds chosen in the lottery system. The main argument is that in the personal fixed fishing grounds more care is taken of the lobster population (interviews, personal communication, June 2020). For example: lobster that are legal to keep based on size are thrown back in order for them to grow larger to catch and harvest them next year. In the lines on free fishing grounds the fishers never know whether they will have the same lines next year again. If the small but legal lobsters are thrown back and they are not able to get the same lines, other fishers will reap the benefits of their practices. This directly addresses the

perception of fishers that lobster tend to stay at the same place. This was illustrated by two interviewees who mark the lobsters they throw back and catch them again in the near vicinity (interviews, personal communication, June 2020). Although two other fishers state the lobsters walk around when water temperatures rise in May/June. As described in paragraph 3.5, lobster once the lobster found a home, they have short daily movements. Possibly the daily movements are increasing in May/June because there is the need to find a mating partner.

The first weeks of the lobster fishing season are considered to be good; in this period mainly the so called "home lobster" is caught, more in the deeper waters. These lobsters do not move much. The middle period of the season is not as good. In this period many female lobsters that are carrying eggs are caught (and put back according to the regulations), same as for moulting lobsters with a soft shell. The last weeks of the season, a lot of lobster is caught again. Now more of the "moving lobsters" are caught in shallow waters, females are eggless again and most shells have become hard again. In total the interviewees make an estimated guess that between 50% and 80% is thrown back because of size limits, egg-bearing females and soft shells depending on the period of the year. The landings are all written down (obligatory) in kilos. What is thrown back is often counted in estimated numbers or kilos (interviews, personal communication, June 2020) and reported together with the landings.

Less small lobsters were caught two to three seasons ago compared to years before. Previous season and this season there seem to be more small lobsters again. Areas where no other fishers fish, or have fished hold way more small lobster according to one of the fishers. Also, the same areas seem to generate larger lobster because they have more time to grow before they are fished away (interviews, personal communication, June 2020).

Females used to be full of eggs in springtime. Several fishers note that "there are less females with eggs and the females that are egg-bearing are not full of eggs, but only half-full" and "I used to throw back all females without checking for eggs because they were always full of it, now I do check because there are quite a bit of females without eggs". A possible reason for this according to the fishers is the rising seawater temperature which influences the reproduction.

The fishing materials such as fykes, cages and traps are rarely lost. It can happen that passing vessels drag the lines away. According to the fishers, this happens less often than once a year. Once dragged away it is very hard to find them again. In contrast to the rare disappearance of fykes, cages and traps, fishers reported that damage to fishing material by divers occasionally happens. Although this seems to happen less often than it used to. This type of damage is place dependent, and seems to happen more often at dive sites. According to the interviewed fishers, divers also take lobster from the Oosterschelde increasing the landings without registration.

4 Conclusions and recommendations

4.1 Discussion

The European lobster is a species that has been fished since the end of the 19th century in the Oosterschelde. There have been fluctuations in the stock level due to natural causes, e.g. cold winters, and possibly anthropogenic causes, e.g. fisheries. The exact causes why the lobster population shows a downward trend the last years are not known. Likely it is a combination of factors described in Tables 4 and 5.compiled from six interviewed lobster fishers and information by Stichting Anemoon (Stichting Anemoon, 2020). Since the exact reasons for the declining lobster population are not known, no focused action or policy can be undertaken and made. Plans to reduce the number of licences in order to lessen fishing effort and increase the economic viability failed in 2015 after a process of ten years. The lack of a stock assessment as a basis for decision-making and insufficient support from the sector to carry out these changes , were the main reasons (Ministry of Agriculture, Nature and Food Quality, personal communication, June 2020). This situation resulted in a continuous and, according to the fishers, high fishing effort.

Fishing for Oosterschelde lobster is only allowed in the period between the last Thursday of March and medio July. The other eight and a half months there is no lobster fishing with fixed gear in the Oosterschelde, reducing the fishing effort for lobster by theoretically 100% in that time period. However, several interviewed fishers mentioned that there are illegal fisheries in the months after the lobster season ends. This implies an reduced but existing fishing pressure in the closed lobster season. According to some interviewed fishers, control authorities do not act adequately enough to stop the illegal fisheries. The Ministry noted that there are two boats controlling the Oosterschelde on illegal activities and, according to them, this should be sufficient to stop the illegal fisheries.

In the Oosterschelde there are 42 active licenses that fish for lobster within season. 37 licenses are connected to the OWV. Two years ago, the system changed from 'lobster race' to the lottery system, organised by the OWV, consulted by the government. All interviewed fishers agree that this system is an improvement compared to the lobster race. Small adjustments to further improve the system can be made after each season and implemented in the coming season.

Four out of six interviewed fishers agree that they fish differently on the fixed fishing grounds compared to the lottery grounds. They believe that lobsters tend to stay in the same place. In the fixed grounds, which they lease for a multitude of years, they discard lobster of smaller sizes so that they can fish them the following year when they have grown. This investment is hence more rewarding on fixed grounds compared to the lottery grounds to which access the following year is uncertain. Benefits from discarding lobsters that just meet the minimum landing size is also suggested from catch results which indicated slightly larger lobsters with a higher worth in the fixed fishing grounds compared to the lottery grounds (interviews, personal communication, June 2020). These qualitative findings indicate that differences in management in the fixed fishing grounds pay off, both ecologically (higher lobster biomass) as well as economically (higher economic benefits). However, it seems unlikely that the lottery grounds will be treated the same as the fixed fishing grounds, even though it would be in the sector's own interest.

About half of the lobster fishers in the Oosterschelde use the auction (partly) for their sales. The number of fishers using the auction has slightly decreased in the last three years but is relatively stable. The total weight of lobster supplied by fishers show a steeper decline over the last three years. This can be explained by reduced catches in more recent years. Furthermore, it is likely that fishers seek for alternatives (e.g. direct sales to restaurants) that give higher prices per kilo lobster compared to the auction. This way fishers can still make a living from lobster even if the yearly caught kilos are declining. In the long term, if the lobster catches keep declining, this strategy will no longer be a viable solution for fishers.

Fishers record their landings in kilos and are willing to share their information with research institutes as long as these records are kept strictly anonymous to avoid competition. The willingness of the fishers to share their knowledge and information suggest that they are open for discussion and working towards improving the Oosterschelde lobster fishery's management. Not much research on the Oosterschelde lobster has been conducted yet. The responsible ministry commented they have no immediate concerns about the lobster population in the Oosterschelde. To be able to explain why the lobster population or lobster catches are fluctuating and in more recent years seems to be declining, a much better understanding of natural and anthropogenic influences on the lobster population should be researched.

The process of getting contact details of lobster fishers in the Oosterschelde from the OWV to executing interviews with the fishers went smooth. The method of interviewing fishers instead of face to face interviews due to COVID-19 restrictions worked well and no limitations in willingness to talk were detected. There was no control over representativity of the interviewed fishers since contact details were given by the OWV. Due to time limitations, interviews with six fishers were conducted, which is a relatively low number. This could have had an influence on the representatives of this research. As more interviews were held the number in different opinions saturated, which means that the information collected on perceptions on the fishery and its management through the interviews can be considered indicative for the perceptions of the whole group (Dinklo, 2006).

4.2 Conclusion

The biology of the Oosterschelde lobster, *Homarus gammarus,* has been reviewed and described in chapter three. Lobster fisheries in the Oosterschelde are declining in recent years. Annual landings in 2019 were about half of what they were during the period 2013 to 2016 and this directly affected fishers and their income. There are both natural and anthropogenic possible causes for the decline and likely it is a combination of causes. The responsible ministry does not seem to share the concerns of fishers and Stichting Anemoon about the lobster population in the Oosterschelde. The Ministry of Agriculture, Nature and Food Quality is not as worried about the declining lobster population as the fishers or Stichting Anemoon. Beside financial reasons, this is the reason why no stock assessment of the Oosterschelde lobster is carried out by the ministry. The change from 'lobster race' to 'lottery system' initiated by the lobster sector in consultation with the ministry is an improvement for the sector. All fishers have a fair chance of catching lobster. By changing the system, the fishing effort, however, increased since passive licenses became active. Interviewed fishers note that, despite control, illegal fisheries continued, both with exceeding the allowed number of gear units and fishing outside the lobster season, occur. Table 2 summarizes the limited available data on lobster fisheries in the Oosterschelde. A stock assessment and further research are needed to know what the current lobster stock size in the Oosterschelde is and what factors the decline in the lobster population of the Oosterschelde cause. With gained knowledge, 'adapted' management can be formulated and implemented (if necessary) in order to promote a healthy lobster population in the Oosterschelde.

4.3 Recommendations

This research leads to four recommendations.

First of all, the early benthic phase (EBP) of the lobster is not feasible to use in a future stock assessment. Despite extensive research, juvenile lobsters with a carapace length smaller than 45 mm are barely found or caught. To create a reliable stock assessment, assessing larger individuals will give a more reliable view of the lobster population in the Oosterschelde.

Secondly, fishers and Stichting Anemoon have identified possible reasons for the declining lobster population in the Oosterschelde (Table 4 and 5). Further research should be carried out into what factors affect the lobster population and to what extent. Based on such research, management action can be undertaken.

Thirdly, we recommend conducting a survey among all lobster fishers. A survey makes it possible to gain more insight into the perceptions on stock development and management amongst the full population of lobster fishers, as well as their willingness to contribute to future data collection projects. This will inform the development of a stock assessment and research priorities.

Finally, we recommend working on an improved communication system between the fishers and the Ministry of Agriculture, Nature and Food Quality in relation to monitoring of (illegal) fishing activities.

5 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2015 certified quality management system. This certificate is valid until 15 December 2021. The organisation has been certified since 27 February 2001. The certification was issued by DNV GL.

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Justification

Report C075/20

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved: Dr. ir. Nathalie Steins
Project manager \ researcher

Signature: 

Date: 21st of August, 2020

Approved: Drs. J. Asjes
Manager Integration

Signature: 

Date: 21st of August, 2020

Annex 1 Interview script

Below the Dutch interview script used during the interviews with the lobster fishers is shown.

Interview script
Allereerst bedankt dat u wilt mee werken aan dit interview. Informatie wordt anoniem verwerkt. Is het oké als we dit gesprek opnemen? (slechts voor het doel voor ons om het gesprek nog eens terug te kunnen luisteren en de juiste informatie eruit halen) Daarna zal de opname verwijderd worden! (Als de data verwerkt is)

- Korte introductie van onszelf (waarom we graag een gesprek willen en waarvoor we hun informatie nodig hebben en gaan gebruiken). Ons onderzoek is een vooronderzoek van het onderzoek van Wageningen Marine Research om een bestandsschatting voor kreeft op te zetten. Dit onderzoek is in samenwerking met de visserijvereniging.
- Zou u zichzelf misschien ook even kort voor willen stellen (wat doen ze naast het kreeftvissen buiten het seizoen?)
- Hoe lang wordt er al op kreeft gevist in de familie? Hoe bent u (en/of uw familie) in deze branche belandt? Hoe lang vist u zelf al? Dit als de visser daar nog niet zelf over heeft gepraat.

Dan heb ik nu een paar vragen over het vissen zelf.
- Vist u het hele seizoen lang?
  En hoe ziet dat eruit (hoeveel uur per dag? Hoeveel dagen per week?).
  Waar precies? Alleen in de Oosterschelde of ook daarbuiten, e.g. Veerse Meer, Grevelingen, ect.
  Welk deel van het jaar vist u op die plekken?

- Met wat voor vistuig vist u?
- Is er iets veranderd in de manier waarop u vist in de laatste (5/10 jaar?) Zowel qua materiaal (wat voor materiaal wordt er nu gebruikt?), als qua schip;

Als de visser vist met fuiken of korven:
- Hoeveelheid fuiken en/of korven zet u uit?
- Is het makkelijk om die fuiken/korven te verliezen?
- Verliest u wel eens korven/fuiken? Hoe vaak dan ongeveer?
- Vind u ze gemakkelijk terug?

Dan heb ik nu een paar vragen over de vislocaties (vergunningen en vakken/lijnen).
- Wat voor vergunning (en hoeveel) heeft u (vrije vakken, vaste vakken, staand wand of sleepnet)? Sinds wanneer heeft u die vergunning al? Bent u overgestapt? (als er overgestapt is, wat is de reden?)

Als de visser in traditionele vakken en lotinglijnen vist:
- Hoeveel vist u naar schatting in de traditionele vakken en hoeveel in de vakken van de loting qua tijd?
- Gebruikt u alle lijnen?
- Welk percentage van de vangst komt uit de traditionele vakken?
- Is de visserij te vergelijken op beide plaatsen?
- Waar zit het grootste verschil in (vangsten)?
- Heeft u het idee dat dit iets van de laatste jaren is of speelt het al langer?
- Handelt u op dezelfde manier in de vrije als in de vaste vakken?

Als de visser mee doet aan de loterij lijnen:
- Wat vindt u van de verandering van de kreeftenrace naar de loterij? (als ze dit meegemaakt hebben) Anders: wat vindt u er van hoe het nu geregeld is?

Als de visser ook een sleepnetvergunning heeft:

- Hoeveel in percentage van de totale vangst van kreeft (dus inclusief de vakken) komt uit de sleepnetvisserij?
- Hoeveel tijd vist u in de vakken en hoeveel sleepnet?
- Hoe denkt u dat kreeften zich bewegen over de zeebodem (leggen ze afstanden af of zijn ze honk vast?) Zijn plekken waar kleine kreeften en kreeften met eitjes worden teruggezet plekken waar de jaren daarop meer kreeft zit?

Als de visser met fuiken vist:

- U gebruikt dus X aantal fuiken (klopt dit?)
- Hoe lang laat u deze fuiken liggen voordat u ze leegt (is dit ergens van afhankelijk?)?
- Gebruikt en leegt u alle fuiken per trip?
- Hoe lang duurt zo een trip dan ongeveer? En hoeveel trippen per seizoen maakt u ongeveer?
- Hoe lang liggen de fuiken in het water? En is het mogelijk om een gemiddelde te geven van hoeveel kreeft er in een fuik zit (per zoveel tijd)?
- Hoe groot of zwaar zijn de kreeften gemiddeld?
- Hoeveel kreeft wordt er gevangen in een goede trip?
- Hoeveel kreeften per trip vangen om uit de kosten te komen?

Dan hebben we ook een aantal vragen dat op meer detail ingaat over de vangsten.
Als ze die informatie niet in detail willen delen. Vragen over vangsten meer in relatieve termen stellen, dus vang je nu meer of minder dan 5 jaar geleden.

- Is het mogelijk om een gemiddeld aantal te geven van hoeveel kreeften er in een fuik zitten? Wat voor percentage wordt er meegenomen?
  Is er een duidelijke verdeling qua kleine kreeft, vrouwtjes (met eitjes) en mannetjes?
- Hoe heeft het kreeftenbestand zich naar uw idee ontwikkeld in de afgelopen 5 jaar in de Oosterschelde (en andere plekken als hij daar vist)? En vergeleken met 10 jaar geleden?
- Waar is dit van afhankelijk? Veranderen de groottes van de gevangen kreeften? (5/10 jaar?)
- Houdt u zelf een vangstregistratie bij? Welke dingen houdt u bij?
  Zo ja, mag ik vragen hoeveel kreeften u vorig jaar (2019) ongeveer heeft gevangen? Wellicht heeft u ook de nummers van andere jaren (per trip/seizoen)? Vangt u nu meer of minder kreeften dan afgelopen jaren?
- Zou u er in de toekomst voor open staan om jaarlijkse vangsten te delen (met bijvoorbeeld de vereniging of WMR?) voor onderzoek naar de ontwikkeling van de kreeftenstand.

Dan hebben we ook een aantal vragen over de verkoop van de kreeften.

- Als de kreeften gevangen zijn, waar verkoopt u ze dan? Horeca, particulieren of viswinkels? Waarom op deze manier?
- Verkoopt u 100% daar aan, of ook via horeca/particulieren/viswinkels. En welke percentage is dat dan? Deed u dat 5 jaar geleden ook al?
- Heeft u contact met andere vissers over de ontwikkeling van het kreeftenbestand? Wat is hun idee daarover?

Bedankt dat we u zoveel vragen hebben mogen stellen en dat u daar de tijd voor genomen heeft! Wij zullen een samenvatting maken van dit interview en deze anoniem opnemen in ons onderzoek. Wilt u deze eerst ontvangen zodat u dit kunt nalopen?

Annex 2 Format interviews

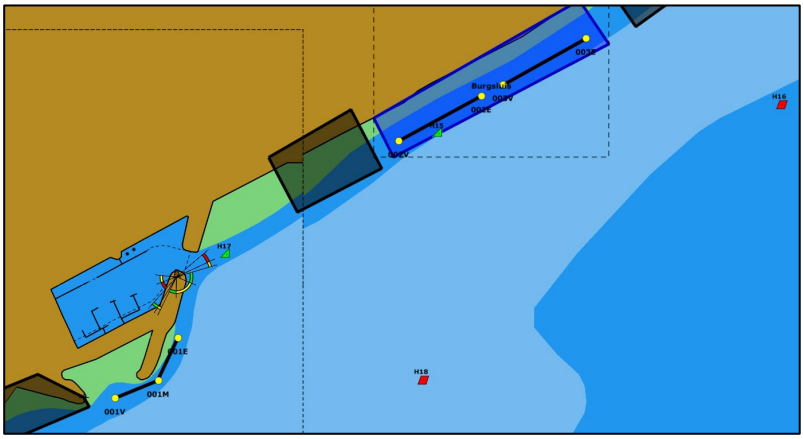
The letters A to F in the format represent the interviewed fishers. Answers on the questions, gathered in the interviews, were displayed in the column beneath A to F to aid a clear overview on their thoughts and experiences.

	A	B	C	D	E	F
Aantal jaar actief in de kreeftenvisserij						
Gemiddeld aantal trips per week						
Aantal vergunningen						
Aantal visvakken						
Aantal lijnen						
Aantal lijnen in gebruik						
Totaal aantal fuiken						
Totaal aantal kubben						
Totaal aantal korven						
Aantal fuiken/kubben/korven op visvak						
Aantal fuiken/kubben/korven op lijnen						
Aantal fuiken/kubben/korven geleegd per trip						
% van de vangst uit visvak						
% van de vangst uit lijnen						
% van de vangst uit staand want						
% van de vangst wat (ong.) wordt teruggegooid						
Ander gedrag op visvak dan op de lijnen						
Kijk op de verandering van race naar loterij						
Zijn kreeften honkvast?						
Kg kreeft in een goede trip						
Kg kreeft in een goed jaar						
Observatie bestand over de jaren d.m.v. vangst						
Mogelijke redenen						
Overige observaties						
Huidige verkoop van kreeft aan restaurant						
Huidige verkoop van kreeft aan particulieren						
Huidige verkoop van kreeft via de veiling						

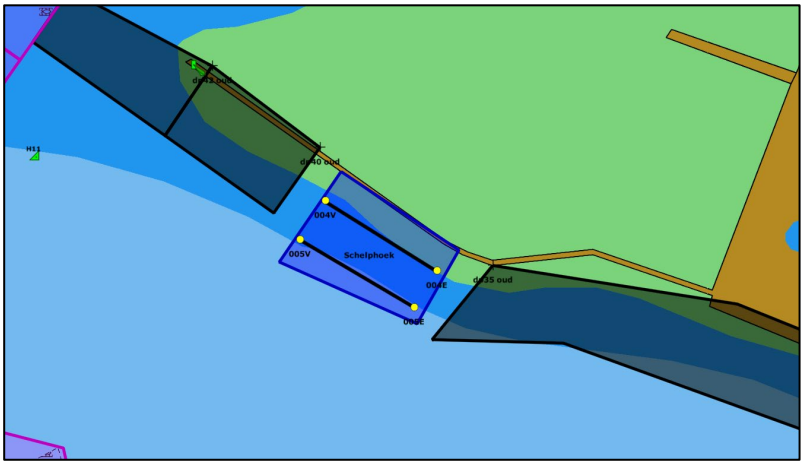
Annex 3 Maps of lobster fishing line plan

These maps were made by the association of OWV to show the fishing lines on the free fishing ground for the members of OWV. The lines between the yellow dots represent the lines on where lobster gear is attached.

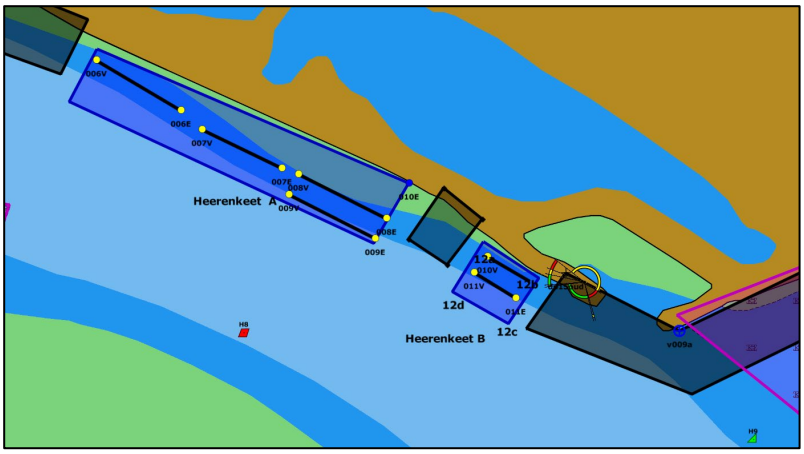
Burgsluis



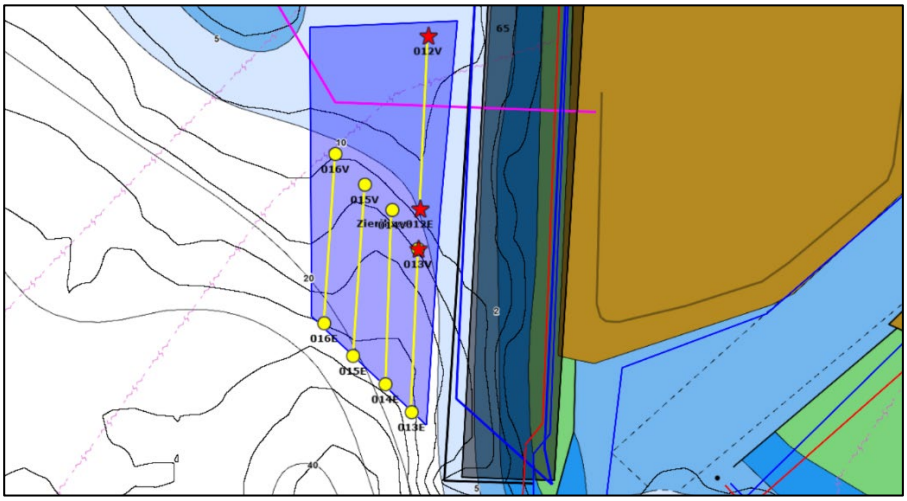
Schelphoek



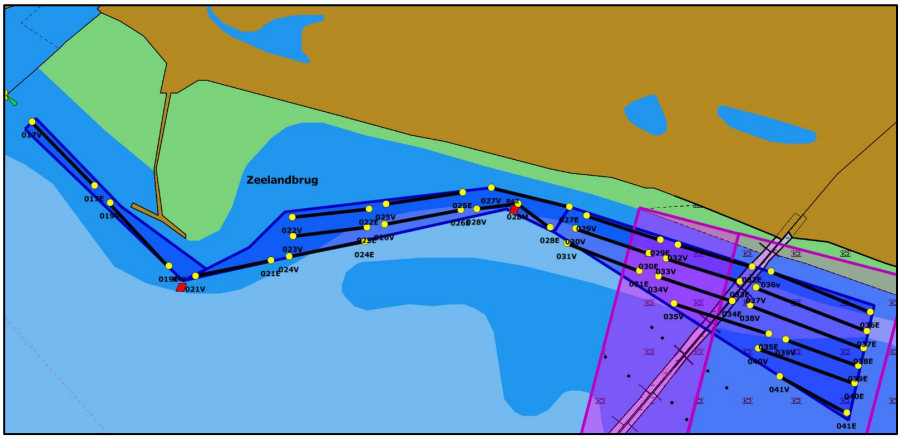
Heerenkeet



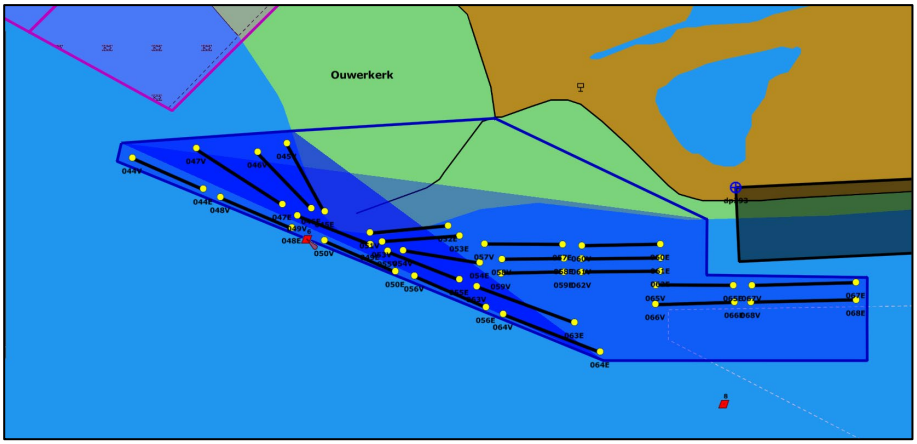
Zierikzee



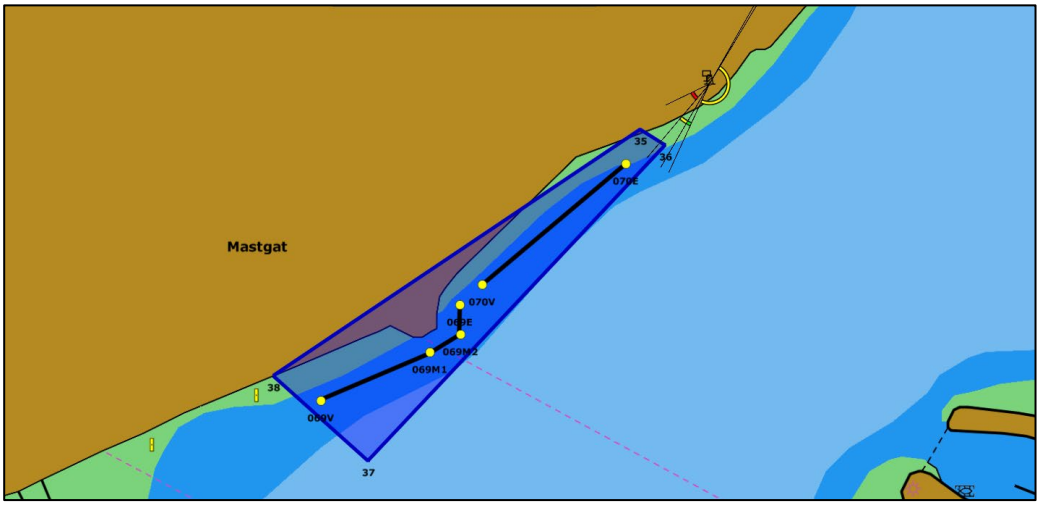
Zeelandbrug



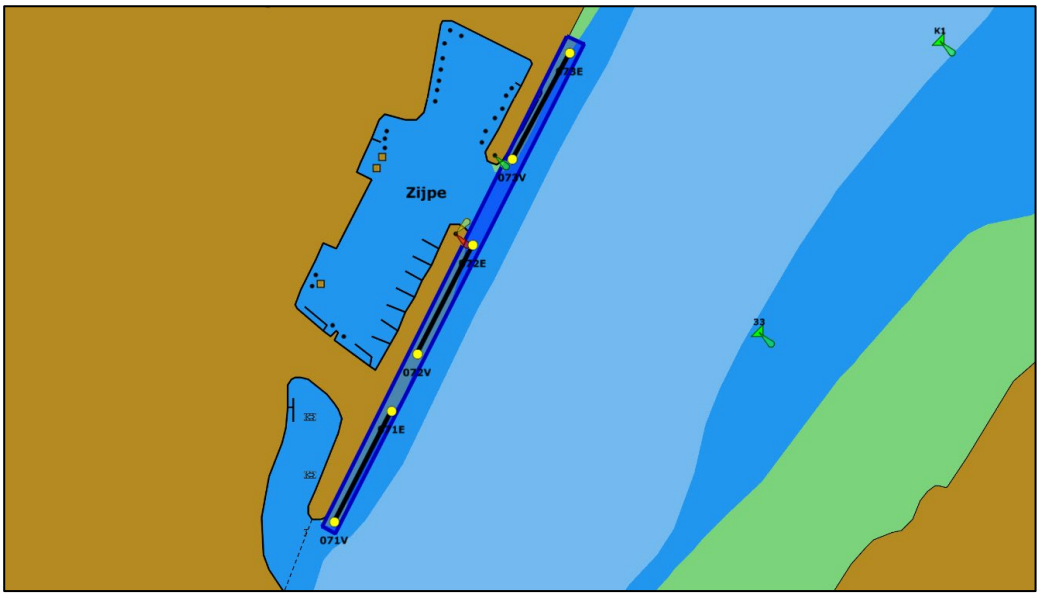
Ouwerkerk



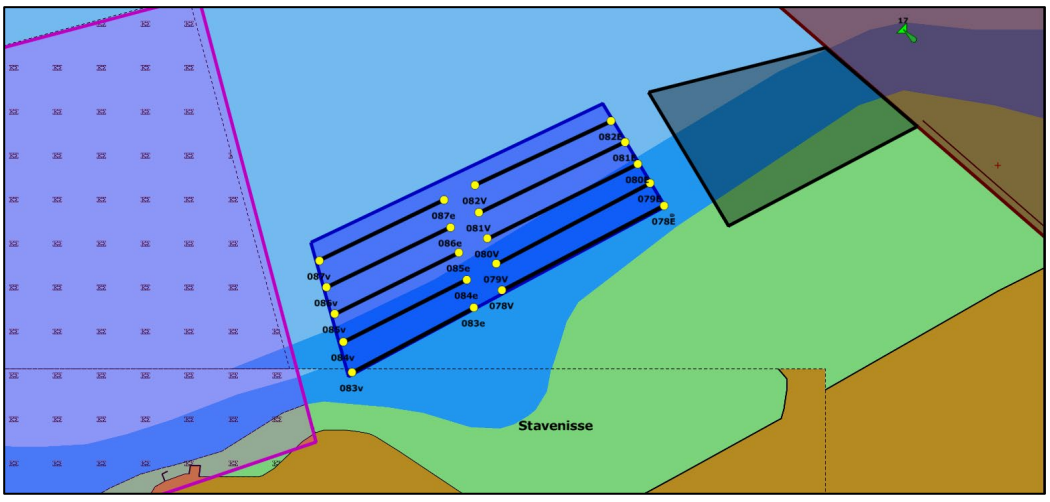
Mastgat



Zijpe



Stavenisse



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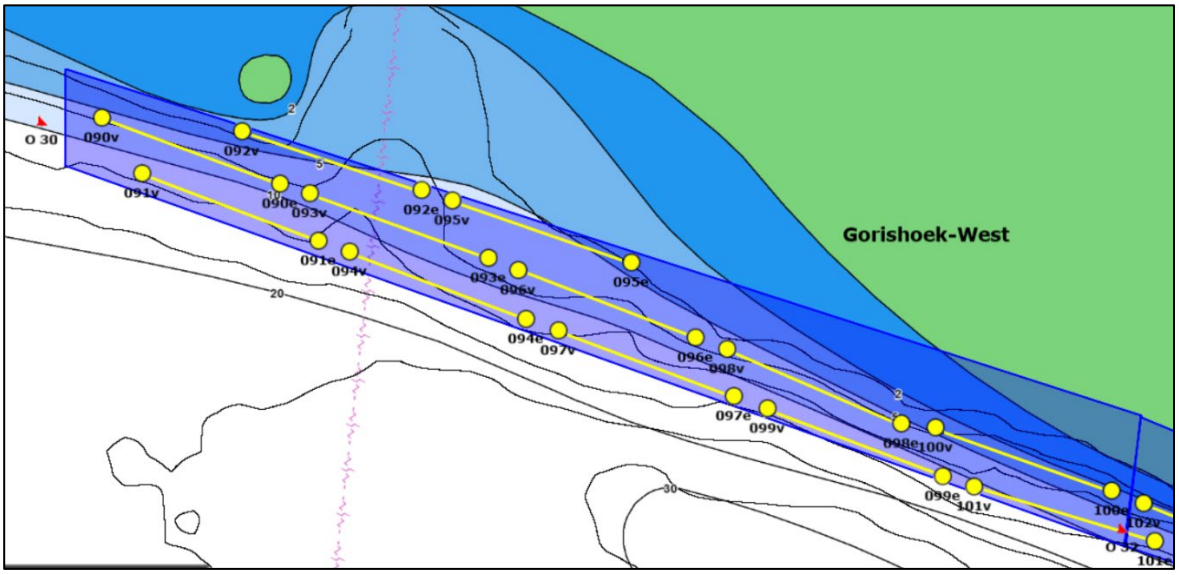

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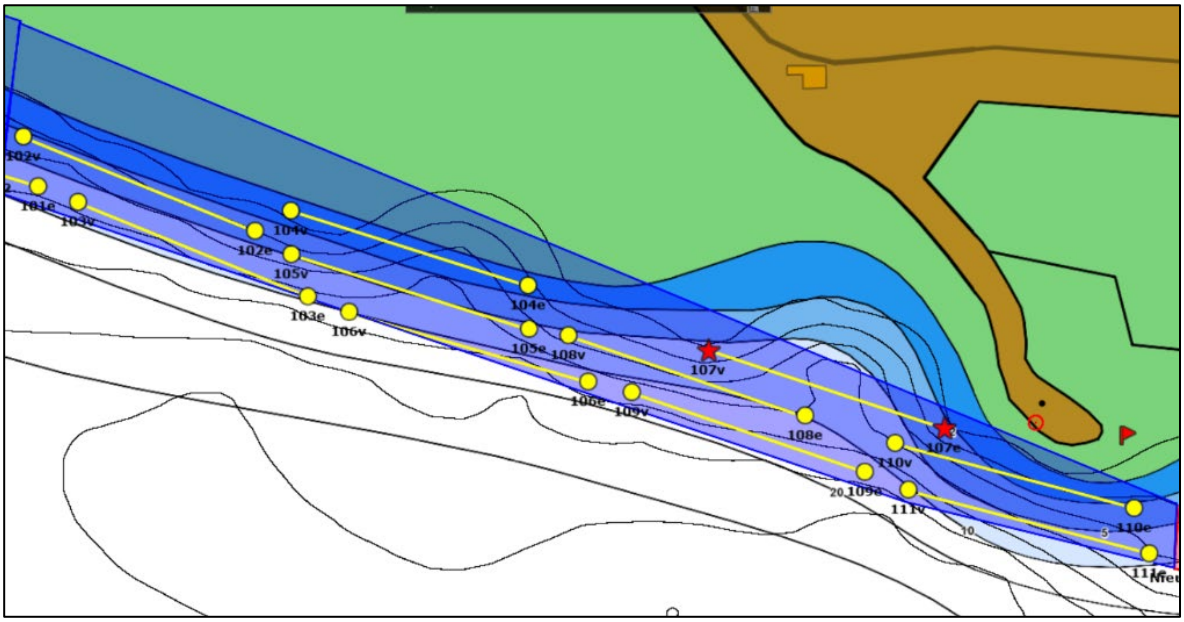

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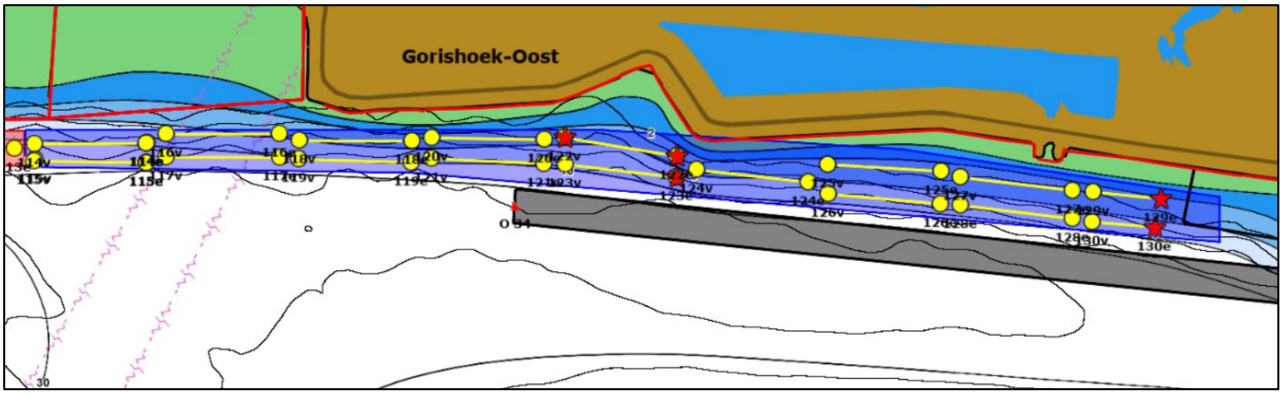

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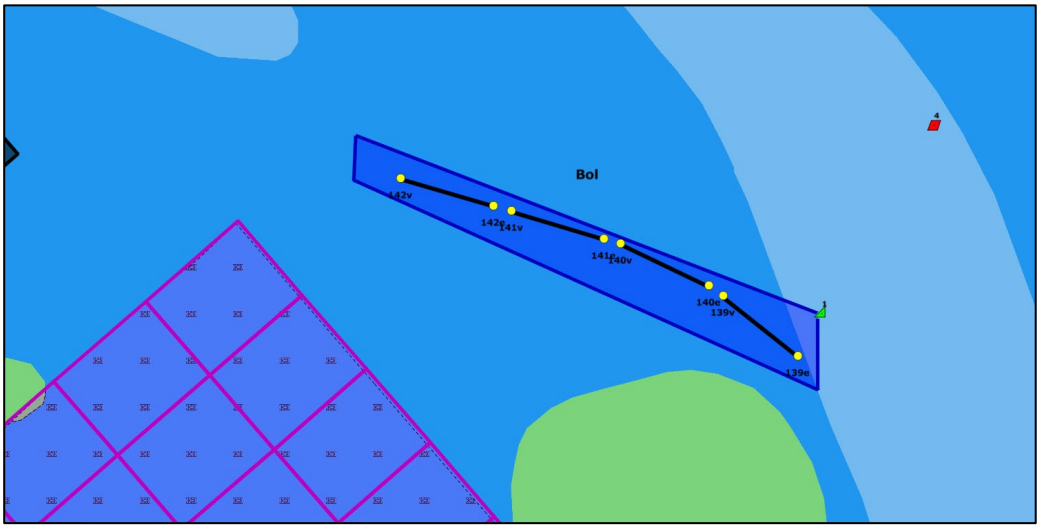

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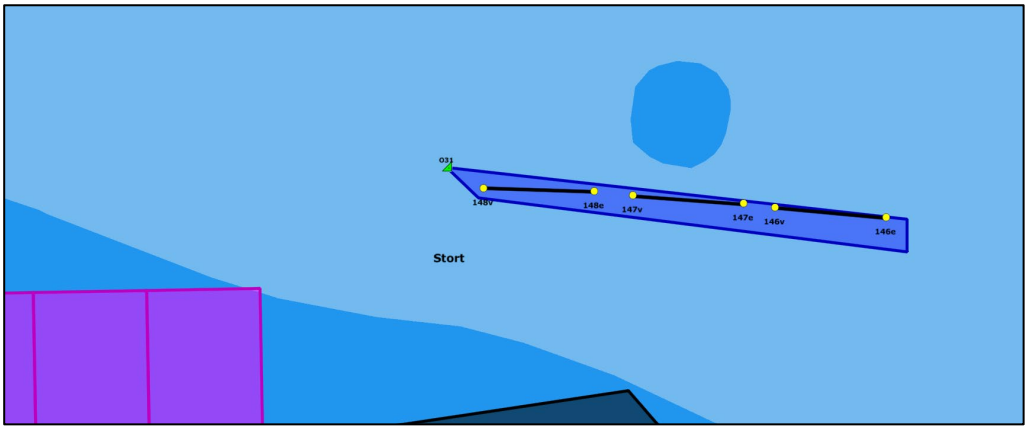

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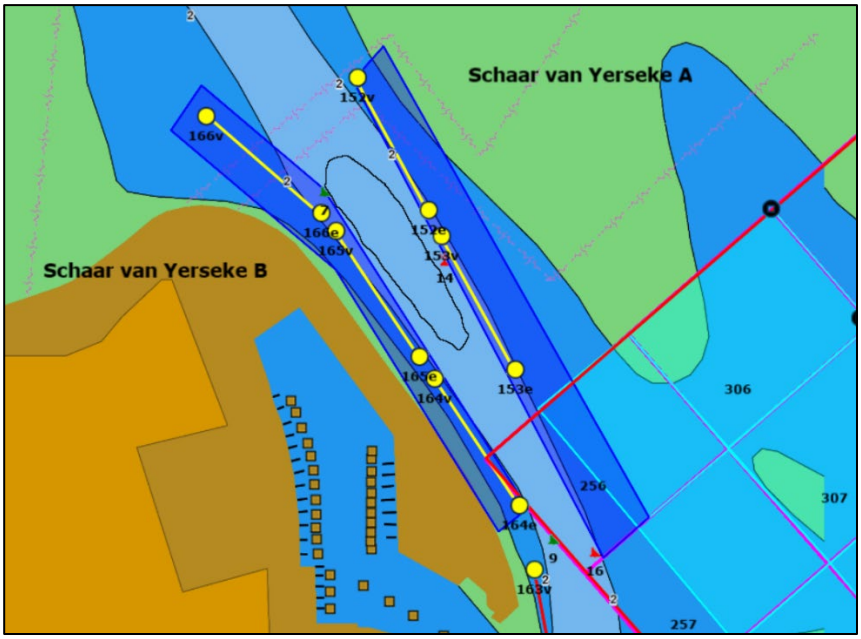

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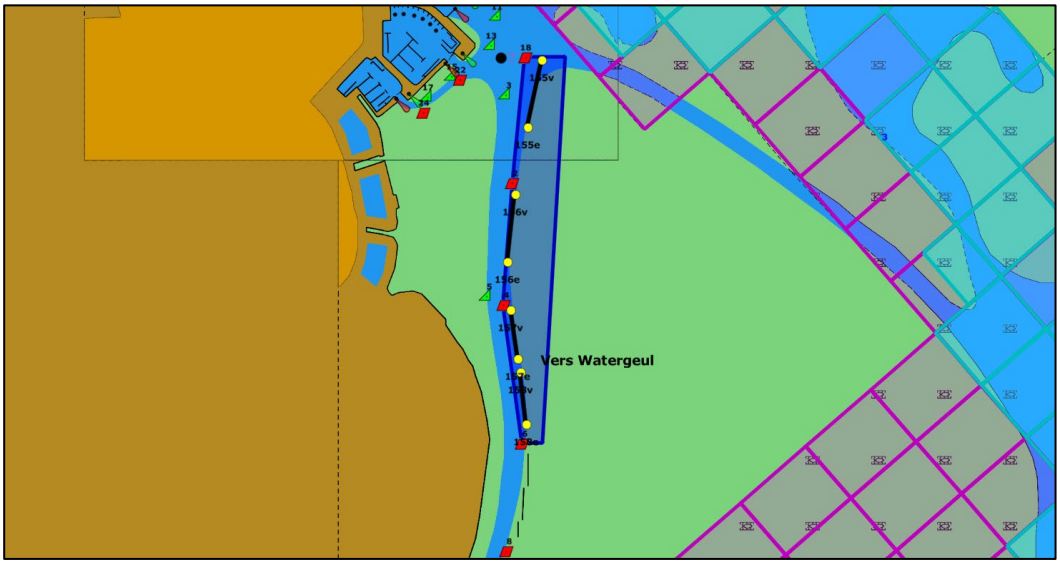

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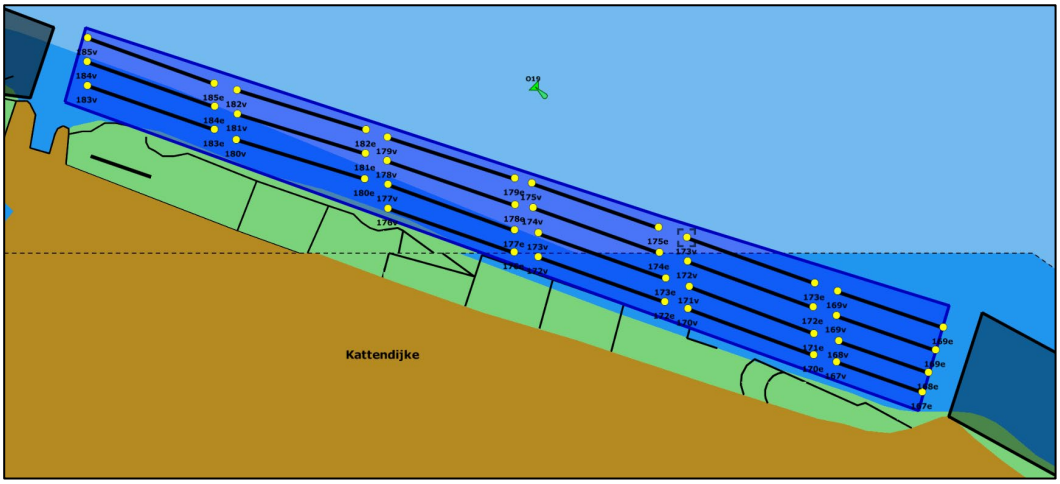

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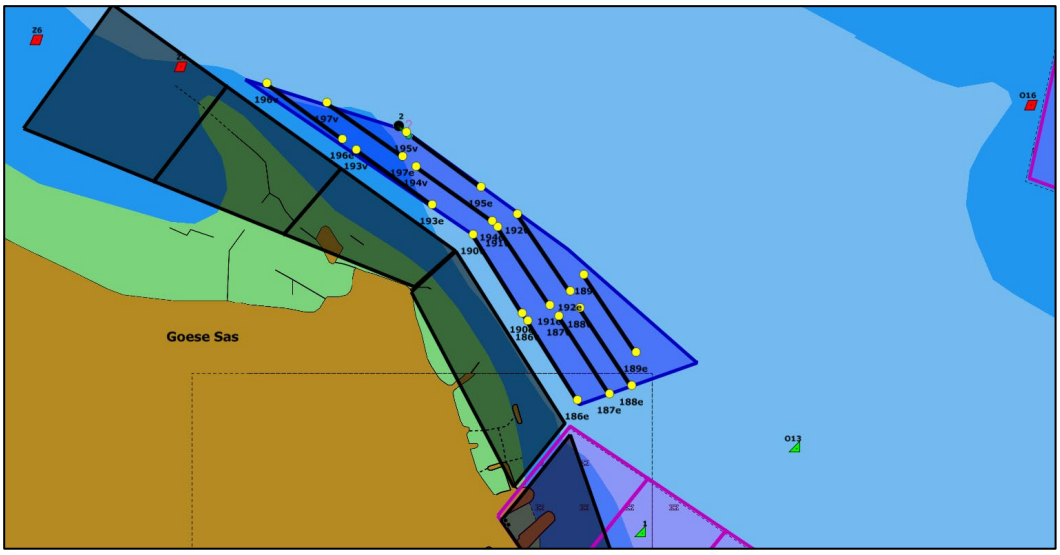

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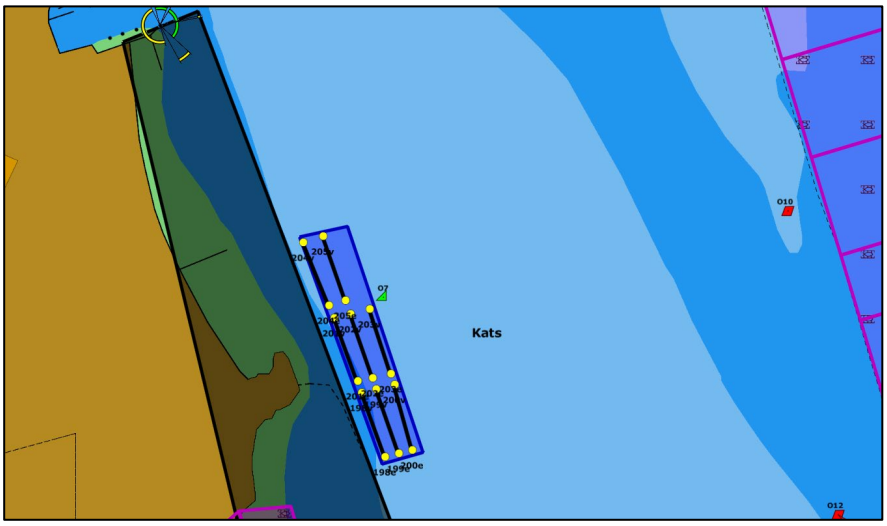

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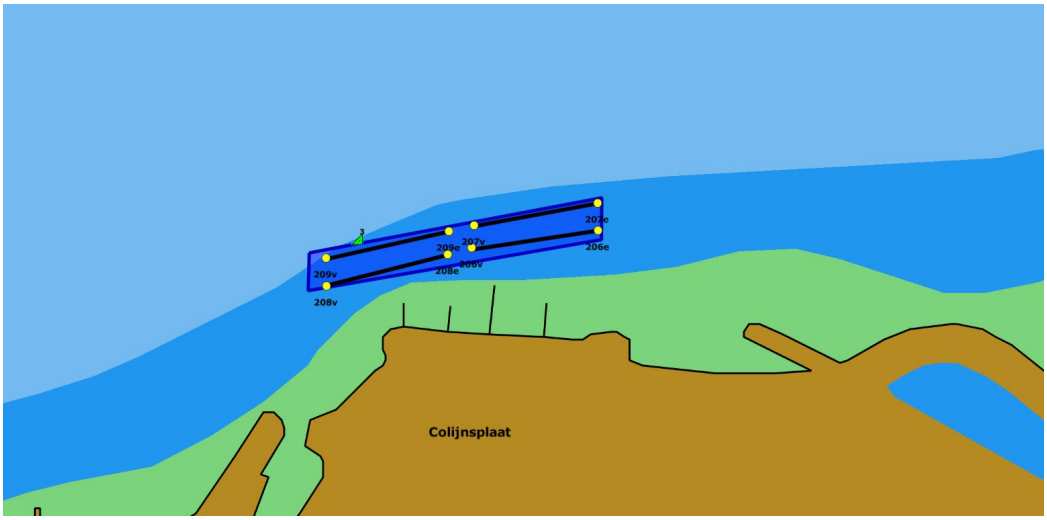

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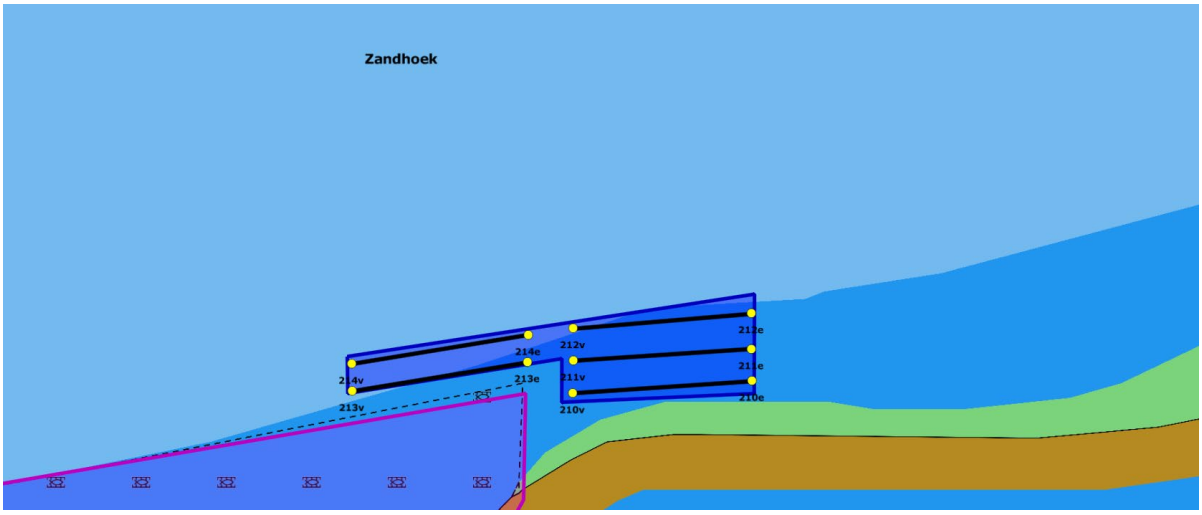

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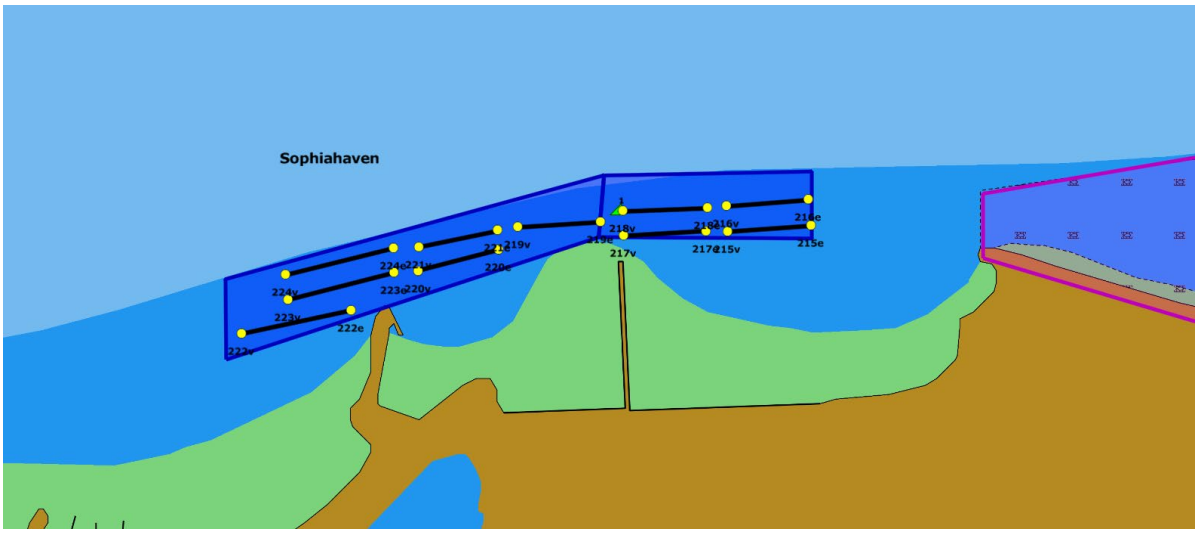
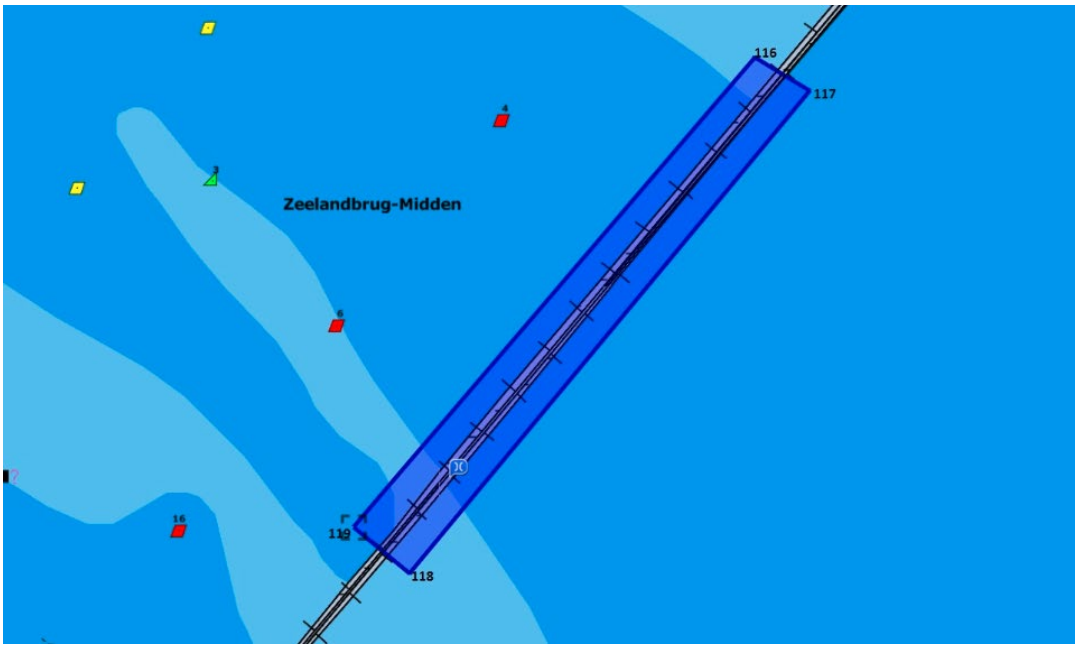


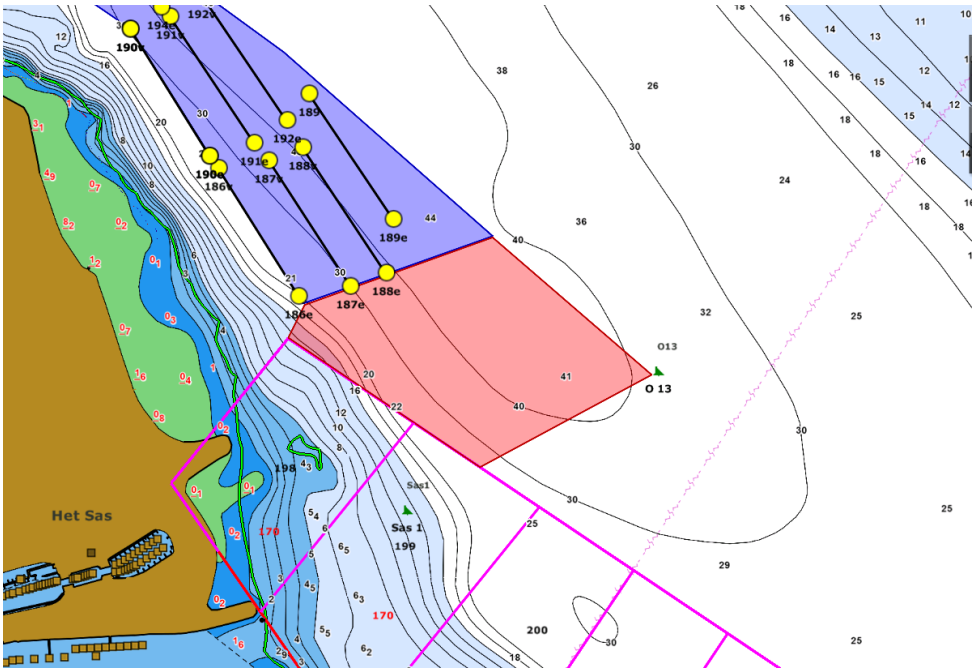
Zeelandbrug-Midden



Annex 4 Maps other fishing grounds

These maps were made by the association of OWV to show the fishing grounds for fishers who did not sign the Fishing plan. The red outlined boxes are the hotspots where these fishers are allowed to fish.

Goese Sas



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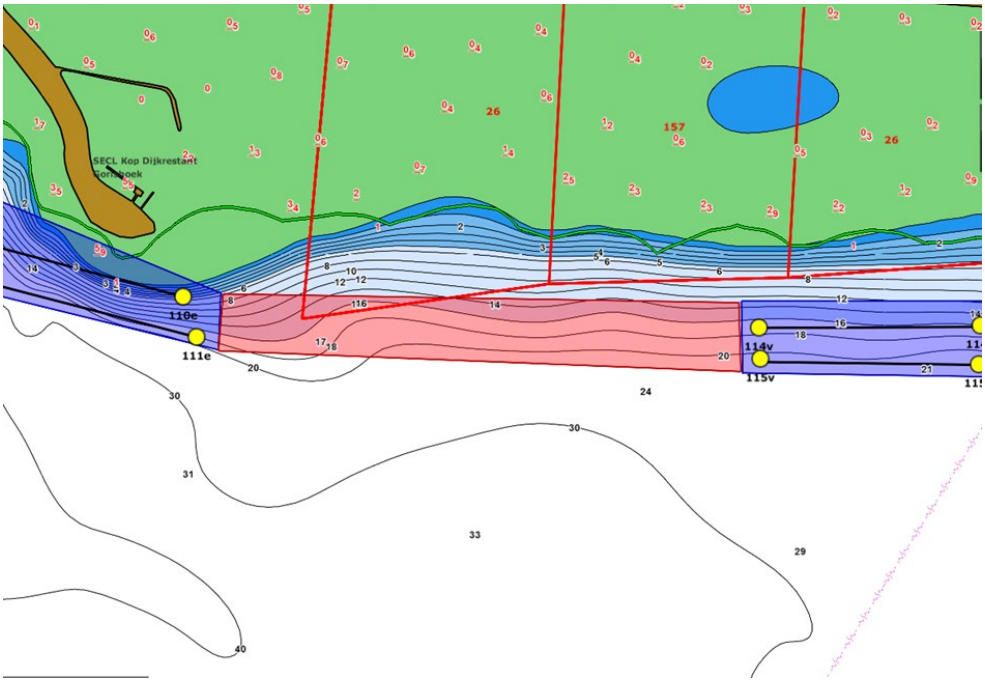

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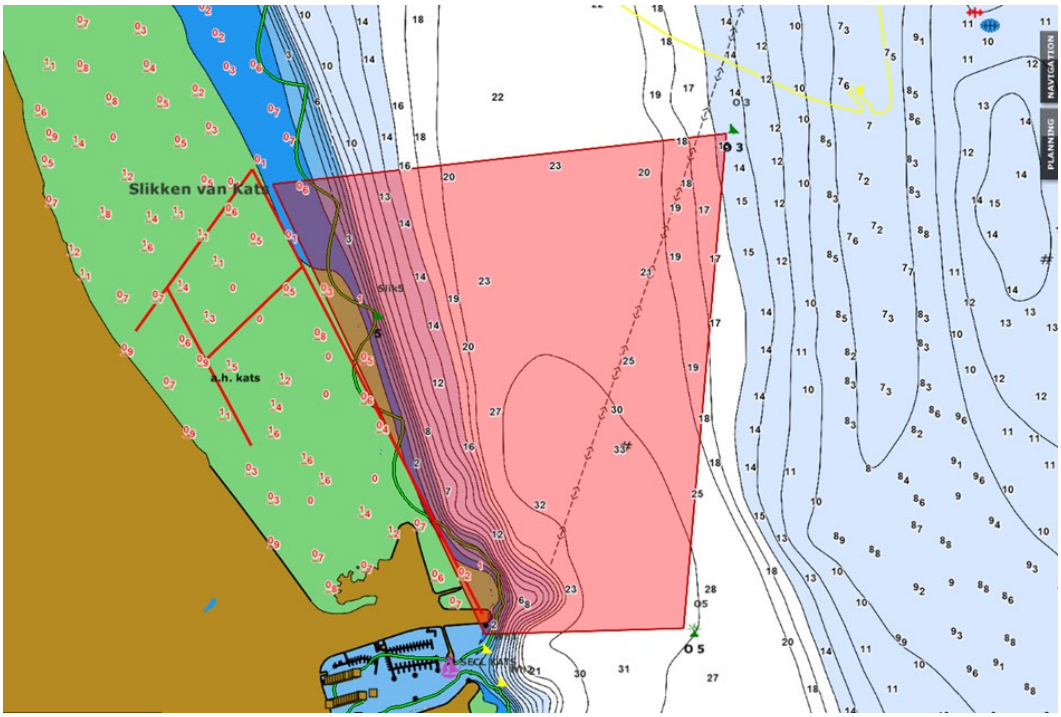

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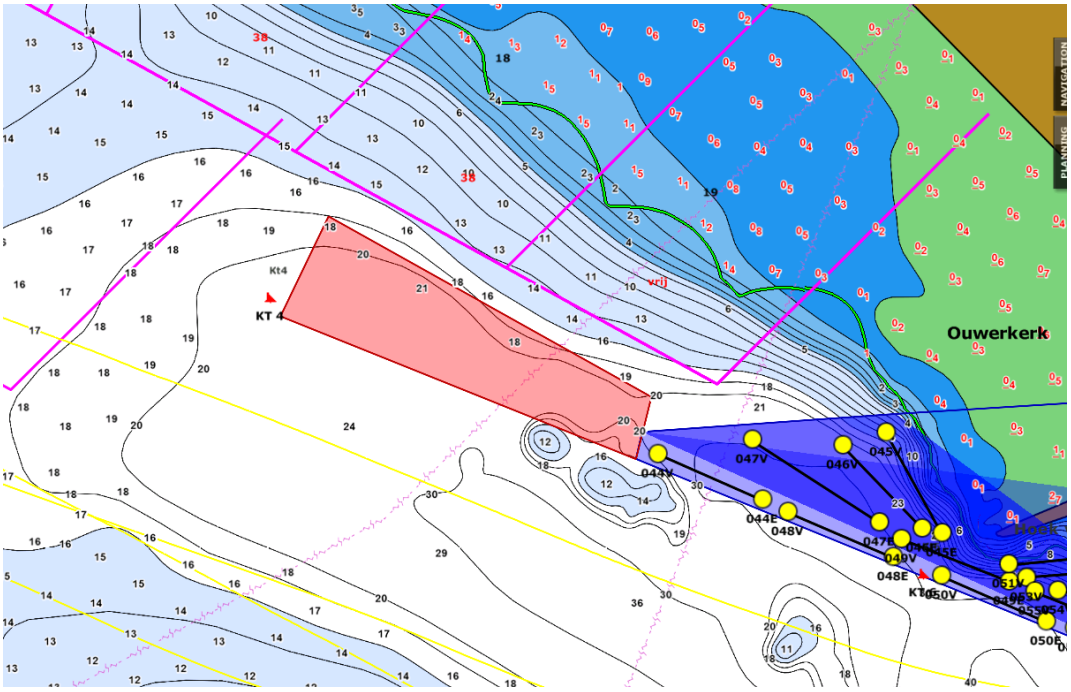

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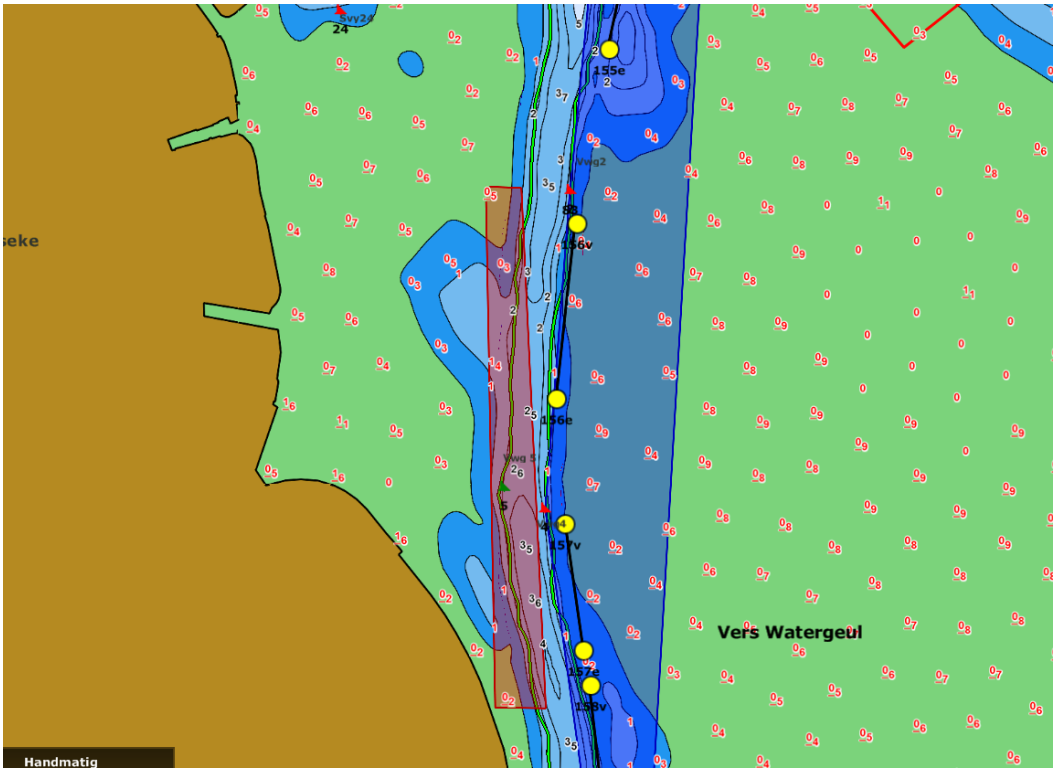

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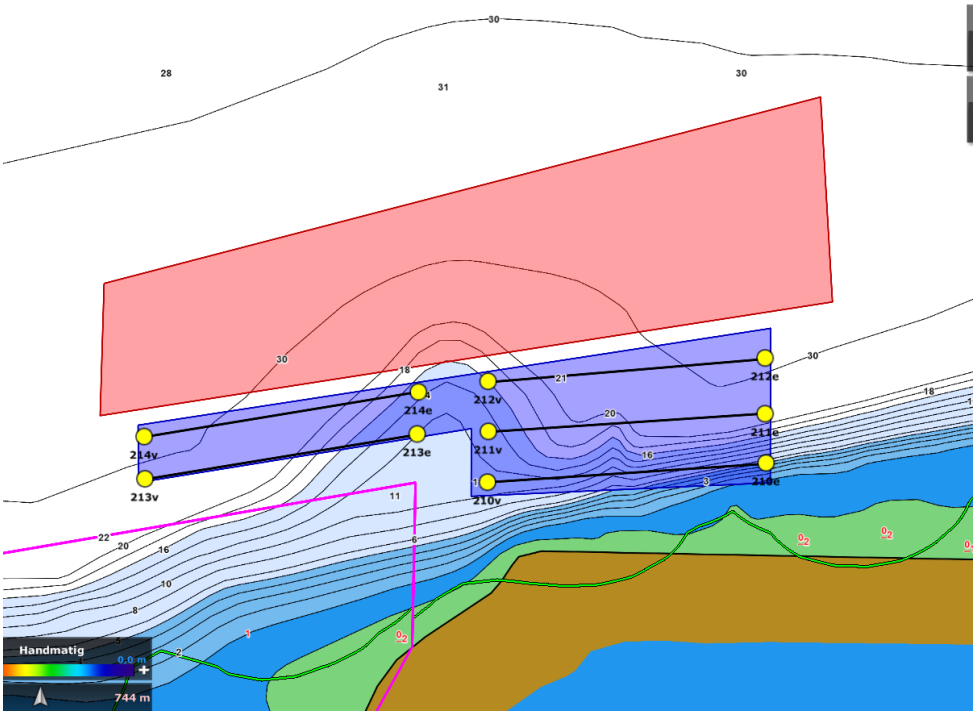
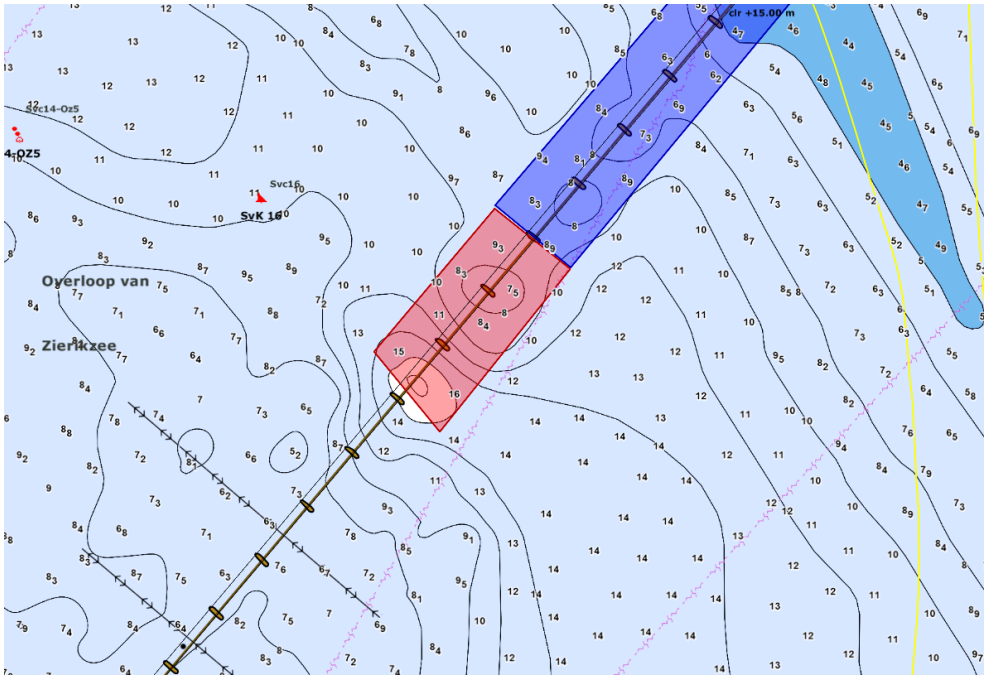


Zeelandbrug Midden



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