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Summary

Since January 2019 the Brown shrimp (*Crangon crangon*) fisheries (here in short called shrimp fishery) have been required to land commercial by-catch species under the landing obligation. In 2018 a *de-minimis* condition for the exemption to the landing obligation was put forward in the brown shrimp fishery for beam trawls fishing in the North Sea (ICES divisions 4b and 4c) (EU 2018/2035). According to this, member states with an interest in shrimp fisheries need to report bycatch of species subject to TAC (Total Allowable Catch). It was advised to organize the data collection as self-sampling by the fishery. The brown shrimp fisheries should deliver unsorted samples from their catches for determining yearly percentages of bycatch of TAC species relative to the yearly TACs of those species (EU 2019/2238, EU 2020/2014). The percentages should not exceed 7% in 2020 and 6% in 2021 and 2022, and 5% in 2023. Sampling programs in The Netherlands, Germany, and Denmark were initiated and the set-up was internationally coordinated by the respective National research institutes. The data analyses for the de-minimis exemption were made on a trilateral level to produce estimates of total yearly bycatch in the brown shrimp fisheries in the North Sea (Beier et al. 2023b).

Information and experiences from the previous Data Collection Framework (DCF) program as well as the IRC shrimp project were used in designing and implementing a co-sampling in a systematic and internationally coordinated way. In this project we use the terminology of "co-sampling" as, fishers took samples themselves (self-sampling), but the samples were sorted and analysed by scientific staff of Wageningen Marine Research (WMR). The Dutch DCF program for the shrimp fishery ran from 2008 until 2015, but had not been used for raising data from bycatch samples to total fleet bycatch, because of data insufficiency. Additional aim was to develop knowledge for an ecologically responsible management of shrimp fisheries in the North Sea in connection to the MSC certification of shrimp fisheries in 2017 (Acoura Marine Ltd. 2017). This motivated the International Research Collaboration (IRC) shrimp project, which was funded by the EU Maritime and Fisheries Fund, and which was set up as a collaboration between WMR and the sector organizations the Dutch Fishermen's Association (Nederlandse Vissersbond) and Coöperatie Kottervisserij Nederland (VisNed). In the IRC shrimp project, bycatch sampling of the shrimp fishery was carried out by an observer on board shrimp vessels.

The aim of this co-sampling program was to collect data on bycatch that are representative for the Dutch brown shrimp fishery, in order to be able to evaluate the "de minimis" conditions. Together with Dutch Fishers Producer Organisations (POs), it was the decided that 10% of the Dutch shrimp fleet should contribute to the sampling. Therefore, around 20 vessels were recruited and maintained as a reference fleet during the project period. Before setting up the sampling program as well as for maintaining it during the sampling period, information from the Nederlandse Vissersbond regarding how and where the shrimp fishery operates has been essential. The POs had a central role in communication with the fishery and participating vessels, for motivating participation and receiving information regarding how and where the shrimp fishery operates.

The sampling program was designed to perform about 200 co-sampling trips from July 2021 until June 2023, stratified over seasons and five distinct fishing areas in order to ensure representativeness. During a sampling trip, the fisher took two catch samples from two different hauls. For all hauls during the same trip, total catch and trawling time were recorded. The samples were frozen, landed and collected by WMR for analysis in the lab. The analysed quantity of bycatch of fish and benthos in the sample was then raised (extrapolated) to total catch level. Within this project, estimates where not raised to the national fleet level, but provided for the fleet level calculations on a trilateral level. This report discusses possibilities and their caveats of raising the data to the Dutch brown shrimp fleet using VMS and logbook data.

In total, 22 Dutch shrimp fishing vessels participated during the sampling period (October 2021-April 2023) and 275 hauls during 154 fishing trips were sampled. The major part of the sampling was carried out in 2022, when samples were collected during all months except in February due to unfavourable weather conditions. Most sampled trips were carried out in the Wadden Sea area (125) followed by the North Sea Coastal area (32). Based on all samples, the average total catch per haul (in weight) consisted of mainly fresh shrimp (marketable and undersized shrimp), followed by debris, benthos, TAC fish and non-TAC fish. The most frequently occurring TAC fish species were plaice (*Pleuronectes platessa*), herring (*Clupea harengus*), whiting (*Merlangius merlangus*), sprat (*Sprattus sprattus*), and sole (*Solea solea*). Regarding non-TAC fish, the group gobies (*Pomatoschistus sp*., *Aphia minuta*, and *Neogobius melanostomus* together) occurred most, in 97% of the sampled hauls. Other frequently occurring fish species were for example dab (*Limanda limanda*), smelt (*Osmerus eperlanus*), bull-rout (*Myoxocephalus scorpius*), hooknose (*Agonus cataphractus*), pipefishes (*Syngnathus* sp.), and flounder (*Platichthys flesus*). Fish species classified as 'ETP' (Endangered, Threatened, Protected) occurred in 0.4-1.1% of the sampled hauls with twaite shad (*Alosa fallax*), river lamprey (*Lampetra fluviatilis*), houting (*Coregonus oxyrinchus*), and thornback ray (*Raja clavata*) as ETP species. Regarding seasonal variability in catch compositionbycatch, plaice and sole were mainly caught during summer months, while whiting was mostly caught in the latter part of the year. Herring and sprat were mostly caught during the winter while benthos was caught mostly during summer.

For potential future raising efforts on a national level, a correlation analysis was performed. This correlation analysis shows that the bycatch composition (in units of weight per trawled hour) are most strongly associated with the total catch per haul and total catch per fishing hour. Total catch is therefore concluded to be a suitable, and best variable for raising bycatch to trip level. Fishing hours shows a negative relationship with total catch and total shrimp catch, as well as with the bycatch composition. This indicates that haul duration is relatively short when catches are large, assuming that the trawl is lifted when it is enough filled. As fishing hours per haul is negatively related to total catch per haul (and more weakly so to the bycatch fractions), bycatch may be overestimated if haul duration during sampled trips is used for raising bycatch to fleet level. Landed shrimp per haul or per trawled hour showed a positive but relatively weak relationship with the bycatch composition. If using landed shrimp during the trip for raising to total shrimp landings of the fleet, caution should be taken to the level of precision. It is concluded that raising the sample data to the Dutch total fleet bycatches should be done in a statistical model, considering multiple variables regarding the catch and effort, as well as seasonality.

For the success of the co-sampling, this project concludes that clear instructions in a sampling protocol are necessary with enough time to test and incorporate feedback from fishers and field personnel. Organizing a co-sampling program in combination with observer trips where personnel from a research institute participate in the sampling (such as the IRC program) would allow for comparison of the samplings, stimulate communication and exchange of knowledge and experiences. The sampling plan was challenged by the dynamic behaviour of the fishers (changing their decisions regarding when and where to go fishing) as well as from weather conditions, shrimp stock development and changes in the external situation (fisheries regulations, fuel prices) and close collaboration with the POs was essential to maintain a participating reference fleet.

Samenvatting

Sinds januari 2019 is de visserij op bruine garnalen (*Crangon crangon*) (hier garnalenvisserij genoemd) verplicht om commerciële bijvangstsoorten aan land te brengen onder de aanlandplicht. In 2018 werd een *de-minimis* voorwaarde voor de vrijstelling van de aanlandplicht voorgesteld voor de garnalenvissers met boomkornetten in de Noordzee (ICES-divisies 4b en 4c) (EU 2018/2035). Volgens deze voorwaarde moeten lidstaten met garnalenvisserij bijvangsten van soorten met een TAC (Total Allowable Catch) melden. Daarom werd geadviseerd om een zelfbemonsteringsprogramma voor de garnalenvisserij op te zetten, om meer te weten te komen over deze bijvangsten en hun hoeveelheden. De garnalenvissers moesten daarvoor ongesorteerde monsters leveren van hun vangsten om jaarlijkse percentages bijvangst van TAC-soorten te bepalen ten opzichte van de jaarlijkse TAC's van die soorten (EU 2019/2238, EU 2020/2014). De percentages mochten niet hoger zijn dan 7% in 2020, 6% in 2021 en 2022, en 5% in 2023. Bemonsteringsprogramma's in Nederland, Duitsland en Denemarken werden gestart en de opzet werd internationaal gecoördineerd door de respectieve nationale onderzoeksinstituten. De gegevensanalyses voor de *de-minimis* vrijstelling werden op trilateraal niveau uitgevoerd om schattingen te kunnen maken van de totale jaarlijkse bijvangst in de garnalenvisserij in de Noordzee (Beier et al. 2023b).

Informatie en ervaringen uit het vorige Data Collection Framework (DCF) programma en het IRC-garnalenproject werden gebruikt bij het ontwerpen en implementeren van een co-bemonstering op een systematische en internationaal gecoördineerde manier. In dit project gebruiken we de term "co-bemonstering" omdat vissers zelf monsters namen (zelfbemonstering), maar de monsters werden gesorteerd en geanalyseerd door wetenschappelijk personeel van Wageningen Marine Research (WMR). Het Nederlandse DCF-programma voor de garnalenvisserij liep van 2008 tot 2015, maar werd niet gebruikt om gegevens uit bijvangstmonsters op te werken naar de totale vangst van de vloot vanwege onvoldoende gegevens. Een aanvullend doel was het ontwikkelen van kennis voor een ecologisch verantwoord beheer van garnalenvisserij in de Noordzee in verband met de MSC-certificering van garnalenvisserij in 2017 (Acoura Marine Ltd. 2017). Dit motiveerde het International Research Collaboration (IRC) garnalenproject, dat werd gefinancierd door het Europees Fonds voor Maritieme Zaken en Visserij (EFMZV) en dat werd opgezet als een samenwerking tussen WMR en de sectororganisaties Nederlandse Vissersbond en Coöperatie Kottervisserij Nederland (VisNed). In het IRC garnalenproject werd de bijvangstbemonstering van de garnalenvisserij uitgevoerd door een waarnemer aan boord van garnalen schepen.

Het doel van dit huidige co-bemonsteringsprogramma was het verzamelen van gegevens over bijvangst die representatief zijn voor de Nederlandse garnalenvisserij, om de *de-minimis* voorwaarden te kunnen evalueren. Samen met Nederlandse Producenten Organisaties (PO's) werd besloten dat 10% van de Nederlandse garnalenvloot zou bijdragen aan de bemonstering. Daarom werden ongeveer 20 schepen geworven en onderhouden als referentievloot gedurende de projectperiode. Voor het opzetten van het bemonsteringsprogramma en het onderhouden ervan tijdens de bemonsteringsperiode was informatie van de Nederlandse Vissersbond essentieel over hoe en waar de garnalenvisserij op dat moment opereerde. De PO's hadden een centrale rol in de communicatie met de visserij en deelnemende schepen, om deelname te motiveren en informatie te verschaffen over hoe en waar de garnalenvisserij opereert.

Het bemonsteringsprogramma was ontworpen om ongeveer 200 co-bemonsteringsreizen te laten bemonsteren in de periode juli 2021 tot juni 2023, verdeeld over seizoenen en vijf verschillende visgebieden om representativiteit te waarborgen. Tijdens een bemonsteringsreis nam de visser twee vangstmonsters uit twee verschillende trekken. Voor alle trekken tijdens dezelfde reis werden de totale vangst en de trawltijd geregistreerd. De monsters werden bevroren, aangeland en opgehaald door onderzoekers van WMR voor analyse in het laboratorium. De geanalyseerde hoeveelheid bijvangst van vis en benthos in het monster werd vervolgens opgewerkt (geëxtrapoleerd) naar de totale vangst. In dit

project werden schattingen niet opgehoogd naar het nationale vlootniveau, maar op trilateraal niveau verstrekt voor de berekeningen op vlootniveau samen met lidstaten Duitsland en Denemarken. Dit rapport bespreekt daarom ook de mogelijkheden en hun beperkingen om de gegevens op te hogen naar de Nederlandse garnalenvloot met behulp van VMS- en logboekgegevens.

In totaal namen 22 Nederlandse garnalenvissersschepen deel tijdens de bemonsteringsperiode (oktober 2021 tot april 2023) en werden 275 trekken tijdens 154 visreizen bemonsterd. Het grootste deel van de bemonstering vond plaats in 2022, toen monsters werden verzameld in alle maanden, behalve in februari vanwege ongunstige weersomstandigheden. De meeste bemonsterde reizen werden uitgevoerd in het Waddenzeegebied (125), gevolgd door het Noordzeekustgebied (32). Op basis van alle monsters bestond de gemiddelde totale vangst per trek (in gewicht) voornamelijk uit verse garnalen (zowel marktwaardige als ondermaatse garnalen), gevolgd door tarra, benthos, TAC-vis en niet-TAC-vis. De meest voorkomende TAC-vissoorten waren schol (*Pleuronectes platessa*), haring (*Clupea harengus*), wijting (*Merlangius merlangus*), sprot (*Sprattus sprattus*) en tong (*Solea solea*). Wat betreft niet-TAC-vis, kwam de groep grondels (*Pomatoschistus sp., Aphia minuta* en *Neogobius melanostomus* samen) het meest voor, in 97% van de bemonsterde trekken. Andere veel voorkomende vissoorten waren bijvoorbeeld schar (*Limanda limanda*), spiering (*Osmerus eperlanus*), zeedonderpad (*Myoxocephalus scorpius*), harnasmannetje (*Agonus cataphractus*), zeenaalden (*Syngnathus sp*.) en bot (*Platichthys flesus*). Vissoorten geclassificeerd als 'ETP' (Endangered, Threathened and Protected) kwamen voor in 0,4-1,1% van de bemonsterde trekken, met fint (*Alosa fallax*), rivierprik (*Lampetra fluviatilis*), houting (*Coregonus oxyrinchus*) en stekelrog (*Raja clavata*) als ETP-soorten. Wat betreft seizoensgebonden variabiliteit in vangstsamenstelling, werden schol en tong voornamelijk gevangen tijdens de zomermaanden, terwijl wijting voornamelijk werd gevangen in het laatste deel van het jaar. Haring en spiering werden vooral gevangen in de winter, terwijl benthos voornamelijk in de zomer werd gevangen.

Voor mogelijke toekomstige inspanningen om de gegevens op nationaal niveau op te hogen, werd een correlatieanalyse uitgevoerd. Deze correlatieanalyse toont aan dat de samenstelling van bijvangst (in gewichtseenheden per gevangen uur) het sterkst geassocieerd is met de totale vangst per trek en de totale vangst per visuur. Daarom wordt geconcludeerd dat de totale vangst een geschikte en beste variabele is om bijvangst op reisniveau op te hogen. Het aantal visuren vertoont een negatieve relatie met de totale vangst en de totale garnalenvangst, evenals met de samenstelling van bijvangst. Dit duidt erop dat de trektijd relatief kort is wanneer de vangsten groot zijn, waarbij wordt aangenomen dat het net wordt opgehaald wanneer het voldoende is gevuld. Aangezien het aantal visuren per trek negatief gerelateerd zijn aan de totale vangst per trek (en in mindere mate aan de bijvangstfracties), kan de bijvangst worden overschat als de trektijd tijdens bemonsterde reizen wordt gebruikt om de bijvangst op vlootniveau op te hogen. Aangelande garnalen per trek of per gevangen uur vertoonden een positieve maar relatief zwakke relatie met de samenstelling van de bijvangst. Als gelande garnalen tijdens de reis worden gebruikt om op te extrapoleren naar de totale garnalenaanlandingen van de vloot, moet voorzichtigheid worden betracht met betrekking tot het precisieniveau. Er kan worden geconcludeerd dat het opwerken van de monsters naar de totale vlootbijvangst van Nederland moet worden gedaan in een statistisch model, waarbij rekening wordt gehouden met meerdere variabelen met betrekking tot de vangst en de inspanning, evenals de seizoensgebondenheid.

Voor het succes van de co-bemonstering kan geconcludeerd worden dat duidelijke instructies in een bemonsteringsprotocol noodzakelijk zijn, met voldoende tijd om feedback van vissers en veldpersoneel te testen en op te nemen. Het organiseren van een co-bemonsteringsprogramma in combinatie met observatiereizen waarbij personeel van een onderzoeksinstituut deelneemt aan de bemonstering (zoals het IRC-programma) zou vergelijking van de bemonsteringen mogelijk maken en tevens communicatie en uitwisseling van kennis en ervaringen stimuleren. Het bemonsteringsplan werd uitgedaagd door het dynamische gedrag van de vissers (veranderingen in hun beslissingen over wanneer en waar te gaan vissen), evenals door weersomstandigheden, de ontwikkeling van de garnalenstand en veranderingen in de externe situatie (visserijvoorschriften, brandstofprijzen), waarbij de nauwe samenwerking met de PO's essentieel bleek om de deelnemende referentievloot in stand te houden.

1 Introduction

1.1 Why is information from bycatch needed?

1.1.1 Discard ban and requirements for exemption

In the revision of the Common Fisheries Policy (CFP) it is stated that fisheries are obligated to land all catches of species subject to quotas, here named TAC (total allowable catch) species. Under this landing obligation, all discards of commercial species regulated by quotas must be landed (EU 1380/2013). The landing obligation was implemented in phases, and has been fully implemented since January 1, 2019. Exemptions such as a "*de minimis*" exemption to the landing obligation are possible. This applies to TAC species caught by certain fisheries where selective fishing (where little or no bycatch is expected) is no longer possible, or when costs of sorting and keeping TAC species on board is disproportionate (Neitzel et al. 2023).

Since January 2019, the brown shrimp (*Crangon crangon*) fisheries in the North Sea (ICES divisions 4b and 4c) fall under the landing obligation, but have been subject to a *de minimis* exemption (EU 2018/2035). The bycatch limit was 7% in 2019 and 2020 (as a percentage of the total allowable catch weight) and was further reduced to 6% in 2021 and 2022 and is now at 5% in 2023 (EU 2018, EU 2019, EU 2020: Commission Delegated Regulation). The exemption was granted on the condition that member states with an interest in shrimp fisheries (Germany, Denmark and the Netherlands) would report bycatches. The recommendations for data collection was to organize self-sampling programs. The Dutch Ministry of Agriculture, Nature and Food Quality (LNV) commissioned WMR to set up a self-sampling program, here defined as co-sampling, where samples were collected by fishers according to an agreed sampling design and WMR analysed and reported the collected data. The sampling program has been coordinated internationally with Germany and Denmark and the ICES brown shrimp group (WGCRAN) in order to establish a scientifically sound sampling program that allows to estimate the bycatch in the brown shrimp fishery for the de minimis exemption. Dutch data have also been used to investigate the disproportionate costs involved in implementing the landing obligation (Neitzel et al. 2023).

In the past, there have been several data collection programs for assessing bycatch in the Dutch shrimp fisheries. For example, from 2008 to 2015, Wageningen Marine Research (WMR) coordinated a sampling program within the Dutch shrimp fishery in the context of the Data Collection Regulation (DCF) of the European Commission (EC) (EU 2016/1701, EU 2016 /1251 and EU 2017/1004). Eight trips per year were on average sampled by WMR in this sampling program (Steenbergen et al. 2015b). The DCF program was discontinued after 2018 because it was no longer a legal obligation and therefore not prioritized. Furthermore the data collection was judged to be insufficient to raise (extrapolate) bycatch estimates to the total fleet, and thereby not meeting requirements for an exemption to the landing obligation (Steenbergen et al. 2015b).

1.1.2 IRC shrimp

The "International Research Cooperation Shrimp" (IRC shrimp) project started in 2019 initiated by WMR, the Dutch Fishermen's Association (Nederlandse Vissersbond) and Coöperatie Kottervisserij Nederland (VisNed), with the aim of developing knowledge for an ecologically responsible management of the shrimp fishery by setting up a structural, internationally coordinated and intersectoral cooperation. The MSC certification of shrimp fisheries (Acoura Marine Ltd. 2017) was also a motive for this project, as MSC requires information also on effects on the environment, including bycatch. IRC shrimp was funded by the

European Union from the European Maritime and Fisheries Fund and ran from July 2019 to September 2023. The sampling program within IRC shrimp consisted of observer trips where scientists go on board of Dutch shrimp vessels and sample the hauls during a fishing trip (i.e., take a sample of the bycatch, sort, measure and weigh it).

1.2 Co-sampling Dutch shrimp fishery

1.2.1 Sampling stratification

In 2021 the current shrimp bycatch sampling program started, called 'Self-sampling shrimp fisheries', where experiences from both the previous DCF program and the IRC shrimp project were used. During the initial phase of the IRC shrimp project, apart from compiling information from earlier monitoring of the shrimp fishery, information from the sector was obtained on when the shrimp fishery was operating in different areas along the Dutch coast (Beier et al. 2023a). The aim was setting up and implementing a systematic and internationally coordinated co-sampling program in the Dutch shrimp fishery in which bycatch data are collected that are representative for the Dutch shrimp fishery, to scientifically substantiate the "de minimis" conditions. In this report we use the terminology of "co-sampling" as fishers took samples themselves (self-sampling), but the samples were sorted and analysed by WMR. Chapter 2 describes the materials and methods used. Chapter 3 shows the results of this study and chapter 4 goes into detail on the discussion. Finally, chapter 5 describes the conclusions found and gives recommendations for further research.

The Dutch shrimp fishery is in general dynamic and variable, both regarding fishing areas and seasons, as it "follows the shrimp", i.e., fishes on marketable (>5cm) shrimp coming from two main yearly recruitment peaks. The growth of shrimp varies and is temperature dependent, so that the main peak after winter bearing females first reach marketable size in the south and later in areas in the North (Campos et al., 2009). The pattern of effort over the year in different areas is shown in Figure 1. For example, it can be seen that the landings in the South reach the autumn peak earlier compared to the West coast and the Dutch Wadden Sea (Figure 2).

These spatial differences point to the importance of designing a representative sampling of bycatch in the shrimp fisheries which reflects the fishing effort in the Dutch brown shrimp fishery over the year in different areas.

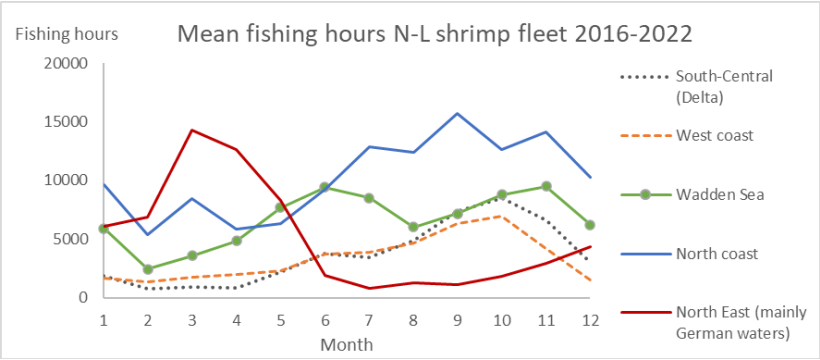

Figure 1 *- Average number of yearly fishing hours (2016-2022) in different months by the Dutch (N-L) brown shrimp fleet according to VMS data. For a map of divisions into areas, see section 2.2.*

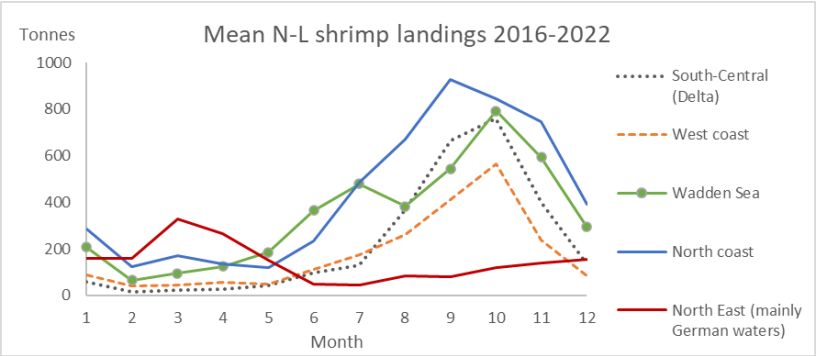

Figure 2 *- Average shrimp landings (2016-2022) caught in different areas during different months by the Dutch (N-L) brown shrimp fleet according to VMS data. For a map of divisions into areas, see section 2.2.*

2 Materials and methods

This chapter describes the materials and methods used in this research. The protocols and documents used for sampling on board, measuring the containers of the vessels and the laboratory protocols for sorting the samples are given in Appendix 1 to 7.

2.1 Reference fleet

2.1.1 The Dutch shrimp fleet & reference fleet

The Dutch brown shrimp fishing fleet has about 200 licences in total (2022) and in collaboration with the Dutch Fishers Producer Organisations (PO's), it was the decided that 10% of the entire fleet should contribute to the sampling program. Therefore, a total reference fleet of ~20 vessels was maintained throughout the project. The vessels for the reference fleet were recruited by telephone by a WMR employee, with preference given to fishing vessels where measurements of the catch container where known (i.e. the volume of the container). If positive, a WMR employee visited the vessel to jointly go through the sampling protocol (Appendix 1 Self-sampling protocol) with the skipper and the crew. During this visit, the skipper was also asked to sign the declaration of consent (Appendix 2 Declaration of Consent (Dutch only)). The fixed composition of the reference fleet was maintained throughout the project as much as possible, but with vessels changing from shrimp fishing to mixed flatfish fisheries in certain seasons, high fuel prices, maintenance, rules and regulations concerning nitrogen and remediation of a part of the fleet, some vessels left the reference fleet and others were added. This process was done in close cooperation with the Dutch Fishers PO Nederlandse Vissersbond (hereafter called the Dutch Fishers PO), who played an important role in recruiting new vessels, maintaining communication with the fishermen and financially compensating the fishers for their samples. For new vessels, the containers were first measured (Appendix 7 Measuring the container of the vessel) in order to determine the volume of the catch containers, needed for estimation of the total catch.

2.2 Sampling

2.2.1 Areas and sampling scheme

A description of which trip and which haul is sampled was determined at the beginning of the month. The preliminary sampling program indicated that a total of 200 sampling trips will be carried out in the period July 2021 to June 2023, stratified by season and areas (see Figure 3), representative for the Dutch brown shrimp fleet activity. The number of participating vessels and amount of samples to be collected was discussed and as far as possible aligned with the trilateral sampling, together with research institutes in Germany and Denmark (ICES 2022b; 2023). This resulted in planning in total 100 trips (200 samples) per year in the sampling period for the Netherlands. Based on the knowledge of the fishermen and Dutch Fishers PO, fishing patterns and ongoing and previous projects (Steenbergen et al. 2015a; Beier et al. 2023a), five different shrimp fishing areas In the North Sea were identified. This concerns four areas in the Dutch coastal zones and one in the German area "Sylt" covering six ICES rectangles and the two ICES areas 4b and 4c (Figure 3).

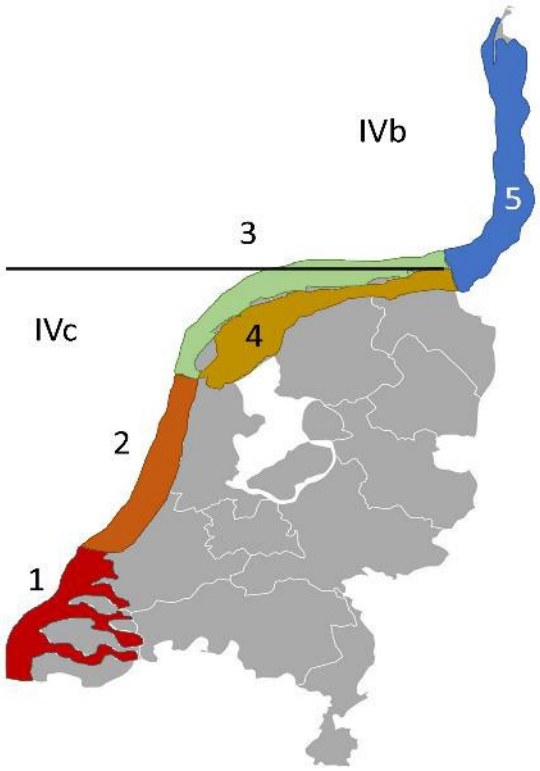

Figure 3 - *Sampling areas. In this project 5 areas were used (based on Steenbergen et al. 2015a). The defined subareas are 1: southern delta (S-C), 2: the west coast (WEST), 3: the Dutch Wadden Sea (WAD), 4: the North Sea coastal zone (NZKZ), and 5: the Sylt area (SYLT)). Most areas are in ICES area 4c, area 5 and part of area 3 lay in ICES area 4b.*

Each month, a sampling scheme was designed for each area from which the selected vessels should collect two samples in the allocated month. The realization of the sampling scheme depended on the cooperation of the shrimp fleet, weather and other circumstances like changing target species for certain months, maintenance on the vessel, fuel prices and capacity of the crew.

2.2.2 On-board sampling procedure

In order to relate the collected sample to the total amount of the catch in the haul, the total catch volume must be known. This requires the volume measurements of the container, which may convert the catch in the container (cm height) into volume. WMR measured container volumes and used measurements to map the container volume per cm height in order to calculate, from the measured height of the catch in the container using the ruler, the total volume of the catch in litres. Before the sampling started, WMR provided the reference fleet with the necessary equipment (buckets, rulers, bags, labels and a list to fill in haul information (called trawl list, see Appendix 3)). During a selected sampling trip, two total catch samples of 10 litres were taken from the unsorted catch from the container by the crew. The catch samples were taken from two different hauls spread out during the trip and preferably one haul sampled during day and the other during night, according to the WMR sampling protocol. A trawl list with information about all hauls (sampled and not sampled) during each co-sampling trip was also completed by the crew and shared with the researchers. The frozen samples were landed and handed over to WMR together with the associated trawl list. WMR ensured transport of the samples to the lab for further processing.

2.2.3 Sample analyses at WMR

In the lab, samples were mostly sorted, weighed and measured fresh (Figure 4). If that was not possible, samples were first stored in the freezer and thawed before sorting. First, the total amount (kg) of shrimps and waste in the sample was analysed. Then, all (remaining) species were identified and the length

frequencies of each registered. When having too many individuals of the same species in the sample, researchers sub-sampled according to common procedure (see also Appendix 5 Sub-sampling). Benthic species and other fractions (algae, stones, etc.) in the sample were only weighed. Afterwards all data were registered into the WMR database 'Billie', together with all data registered on the trawl list provided by the skipper. According to data quality and security routines, data were controlled before import to the Frisbe database at WMR where data is stored and maintained; and from there the data was extracted for compilation and analyses.

Figure 4 – *Sorting the samples by species in the lab. Photo: Wageningen Marine Research*

2.3 Raising of bycatch

Catch recorded in the collected samples were first raised to catch *fractions* per sampled haul, by relating the sample volume (in the bucket) to the total catch volume in the haul, as measured by catch height in the container of that haul (see Appendix 1 - Dutch sampling protocol).

For the trilateral reporting of bycatches of TAC species (STECF 2023; Beier et al. 2023b), bycatch fractions in the Dutch data from sampled hauls were then raised to bycatch fractions on trip level by using the total catch volume of the sampled hauls raised to the total catch volume of all hauls during each sampled trip. Bycatch components were then raised to quarters of the year first by summing up all active fishing hours (hours when a vessel actually performed fishing activity, meaning when the nets were fishing) during all sampled trips of that quarter, and then to the total fishing hours of the entire fleet as reported from official vessel monitoring system (VMS) and logbook data for the same quarter. All sampled trips were raised to the total Dutch brown shrimp fleet activity (effort) per quarter using all samples irrespective of the subarea. That is, because samples were not evenly distributed among subareas throughout the year due to

seasonally dependent fishing locations. The TAC-species to be reported for shrimp fisheries for de minimis requirement in the bycatch are shown in Table 1.

For details on calculations regarding the Dutch data, see below. Calculations made by Denmark and Germany were slightly different depending on their respective sampling protocols (ICES 2022b; 2023).

Table 1 *– TAC fish species reported in shrimp fisheries grouped for reporting in fractions.*

Group	English name	Scientific name	Dutch name
Flatfish	Plaice	*Pleuronectes platessa*	schol
	Sole	*Solea solea*	tong
	Turbot	*Scophthalmus maximus*	tarbot
	Brill	*Scophthalmus rhombus*	griet
	lemon sole	*Microstomus kitt*	tongschar
Roundfish	Whiting	*Merlangius merlangus*	wijting
	Cod	*Gadus morhua*	kabeljauw
Roundfish (pelagic)*	Herring	*Clupea harengus*	haring
	Sprat	*Sprattus sprattus*	sprot
	horse mackerel	*Trachurus trachurus*	horsmakreel
	mackerel**	*Scomber scombrus*	makreel
Sandeels	Sandeels	*Ammodytes sp.*	zandspieringen indet.
	Raitt's sand-eel	*Ammodytes marinus*	Noorse zandspiering
	lesser sand-eel	*Ammodytes tobianus*	kleine zandspiering
	greater sand-eel	*Hyperoplus lanceolatus*	smelt

** Pelagic species as a subgroup of "roundfish" (used in the Results section 4.2).*
*** Non-quota species in connection to shrimp fisheries, but reported here.*

List of variables used in the raising procedure:

variable	description
$W\_TACsps\_trip_t$	The bycatch weight of TAC species s during a sampled trip *t*
$total\ catch\ trip_t$	The total catch (sum of all hauls) during a sampled trip *t*
$total\ catch\ sampled\ hauls_t$	The total catch (sum of sampled hauls) during a sampled trip *t*
$W\_TACsp_s\_sampled\ hauls_t$	The bycatch weight (raised to hauls) of TAC species *s* from sampled hauls during a sampled trip *t*
$W\_TACsp_s\_Q_i$	The bycatch weight (raised) of TAC species *s* during quarter *j*
$total\_fleet\_fhr\_Q_i$	The total fishing hours of the shrimp fishing fleet during quarter *j*
$sampled\_trips\_total\_fhr\_Q_i$	The total fishing hours during the sampled trips during quarter *j*
$W\_TACsp_s\_sampled\_trips\_Q_i$	The bycatch weight (raised) of TAC species *s* during quarter *j*
$W\_TACsp_s\_Y_j$	The bycatch weight (raised) of TAC species *s* during year *y*
$total\_fleet\_fhr\_Qsampled_j$	The total fleet fishing hours during the same quarters as when trips were sampled in year *j*

Catch fractions in the two collected samples were first raised to catch fractions per sampled haul, by the total catch volume of the respective sampled haul (see A.2. - Dutch sampling protocol, results in this report). Catch fractions in sampled hauls were then raised to trip level by using the total catch volume of the (both) *sampled* hauls raised to the total catch volume of *all* hauls during each trip as reported by the fishers on the trawl list (results in Beier et al. 2023b). Raising from sample to trip:

$W\_TACsp_s\_trip_t$ = (total catch $trip_t$ / total catch sampled $hauls_t$) * W_TACsp_s_sampled $hauls_t$

To take seasonality into account, bycatch components were first raised to quarters of the year by the active fishing time during sampled trips during that quarter to the total (active) fishing hours of the entire Dutch brown shrimp fleet as reported from official VMS and logbook data for the same quarter. Obtaining bycatch estimates per quarter:

$W\_TACsp\_Q_i$ = (total_fleet_fhr_Q_i / sampled_trips_total_fhr_Q_i) * W_TACsp_sampled_trips_Q_i

The bycatch components for all quarters (weighted by fleet activity in each respective quarter) were then added to obtain bycatch components for the whole year *j*. If samples had not been collected for all four quarters, the available estimated bycatches raised to quarter were used for raising to the whole year. This was done by using the ratio of total fleet fishing hours during quarters where samples were collected to the total fleet fishing hours for the whole year:

$W\_TACsp\_Y_j$ = (total_fleet_fhr_Y_j/ sum(total_fleet_fhr_Qsampled $_j$) * sum($W\_TACsp\_Q_i$)

3 Results

3.1 Sampled trips

3.1.1 Sampled hauls per trip

In total 22 shrimp fishing vessels participated; 12 vessels in 2021, 21 in 2022 and 10 vessels in 2023. Participating vessels carried out sampling during on average 3-4 trips each during these years (range 1-9 sampling trips for participating vessels per year). The self-sampling program was tested in June 2021, and went on from October 2021 until April 2023 (Table 2).

Table 2 *- Number of hauls and number of trips (within brackets) per month and year when self-sampling was carried out by the shrimp fishery. According to the sampling protocol, two hauls per trip should be sampled, but for some trips this could not be realized or information was not complete, e.g., in June and July 2021.*

	2021		2022		2023	
Jan			16	(8)	16	(9)
Feb					8	(7)
Mar			20	(10)	19	(12)
Apr			10	(6)	19	(11)
May			12	(6)		
Jun	1	(1)	24	(12)		
Jul	1	(1)	6	(4)		
Aug			7	(4)		
Sep			12	(7)		
Oct	8	(4)	27	(16)		
Nov	14	(8)	25	(13)		
Dec	12	(6)	18	(9)		
Total	**36**	**(20)**	**177**	**(95)**	**62**	**(39)**

The resulting number of sampled hauls varied between subareas (Table 3). The area with the most collected samples was the Wadden Sea (WAD) followed by the North Sea coastal zone (NZKZ) and the south-central area (S-C). Apart from spatial distribution, the sampling was also temporally distributed depending on the general fishing activity of the fleet in different subareas during different quarters (Table 4).

Table 3 *- Number of sampled hauls and number of trips when sampling occurred (trips within brackets) per defined subarea (southern delta (S-C), the west coast (WEST), the Dutch Wadden Sea (WAD), the North Sea coastal zone (NZKZ), and the Sylt area (SYLT)) and year during the self-sampling program.*

Area	2021		2022		2023	
S-C	8	(4)	41	(23)	8	(4)
WEST	0	(0)	2	(1)	2	(2)
WAD	18	(10)	72	(39)	35	(20)
NZKZ	10	(6)	48	(24)	1	(2)
SYLT	0	(0)	14	(8)	16	(11)
Total	**36**	**(20)**	**177**	**(95)**	**62**	**(39)**

Table 4 *- Number of sampled hauls per quarter and year in the defined subareas during the self-sampling program.*

	S-C			WEST			WAD			NZKZ			SYLT		
QUARTER	2021	2022	2023	2021	2022	2023	2021	2022	2023	2021	2022	2023	2021	2022	2023
1			8			2		8	21		24	1		4	11
2		8					1	16	14		16			6	5
3		7					1	14			4				
4	8	26			2		16	34		10	4			4	

Normally two hauls were sampled during each trip, where one was taken during daytime and one during the night. The proportion of day- and night samples is in accordance to the proportion of day- and night hauls during the trips when samples were taken (Figure 5).

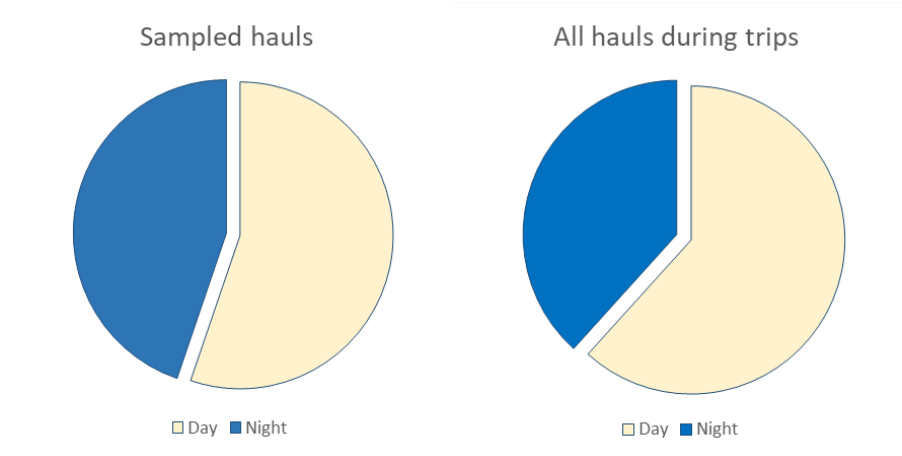

Figure 5 *- Proportion of hauls sampled during day and night, for sampled hauls (left) and for all hauls during trips when hauls were sampled.*

3.2 Bycatch

In 2021, a total of 36 samples were delivered from six ICES rectangles by 12 shrimp vessels during 19 trips in quarters 3 and 4. The estimated biomass of TAC species bycaught in 2021 was dominated by plaice *Pleuronectes platessa*, whiting *Merlangius merlangus* and sprat *Sprattus sprattus*. In 2022, a total of 175 samples were delivered from 17 ICES rectangles by 21 shrimp vessels during 88 trips in quarters 1, 2, 3 and 4. The number of sampled trips per quarter ranged from 18-34, with the lowest number in quarter 1. The estimated biomass of TAC species bycaught in 2022 was dominated by plaice *Pleuronectes platessa*, whiting *Merlangius merlangus* and herring *Clupea harengus*. The next paragraphs describe the bycatch in more detail.

3.2.1 TAC species

The most frequently occurring TAC species found in at least 20% in the sampled hauls were plaice (*Pleuronectes platessa*), herring (*Clupea harengus*), whiting (*Merlangius merlangus*), sprat (*Sprattus sprattus*), sole (*Solea solea*), and sandeels (*Ammodytes* sp. and *Hyperoplus lanceolatus* together). Other TAC species in the bycatch were lemon sole (*Microstomus kitt*), anchovy (*Engraulis encrasicolus*), mackerel (*Scomber scombrus*), turbot (*Scophthalmus maximus*), cod (*Gadus morhua*), horse mackerel, (*Trachurus trachurus*), and brill (*Scophthalmus rhombus*). For percentage occurrences, mean weights and numbers per hour trawling in hauls where TAC fish species occurred, see Appendix 8.

3.2.2 Other fish species

Apart from TAC species, 52 other fish species (a few of these are species groups) were noted, out of which gobies (*Pomatoschistus sp*., *Aphia minuta*, and *Neogobius melanostomus* together) were found in 97% of the sampled hauls. Found in 10-60% of sampled hauls were (in falling order of occurrence) dab (*Limanda limanda*), smelt (*Osmerus eperlanus*), bull-rout(*Myoxocephalus scorpius*), hooknose (*Agonus cataphractus*), pipefishes (*Syngnathus* sp.), flounder (*Platichthys flesus*), dragonet (*Callionymus lyra*), five-bearded rockling (*Ciliata mustela*), scaldfish (*Arnoglossus laterna*), solenette (*Buglossidium luteum*), and butterfish (*Pholis gunnellus*). Sea bass (*Dicentrarchus labrax*) occurred in 9.5% of the sampled hauls. For percentage occurrences, mean weights and numbers per hour trawling in hauls where other fish species occurred, see Appendix 8.

Four fish species classified as 'ETP' (Endangered, Threatened, Protected) were found in sampled hauls. These were twaite shad (*Alosa fallax*) and river lamprey (*Lampetra fluviatilis*), both caught in 1.1% of the sampled hauls, and houting (*Coregonus oxyrinchus*) and thornback ray (*Raja clavata*) which were both caught in 0.4% of the sampled hauls. The reasons behind classifying species as 'ETP' are listed in Appendix 8.

3.2.3 Benthos

The benthos occurring in sampled hauls were in total 77 species (some of these are species groups). The caught benthos is a varied collection of different organisms, which in Appendix 8 have been sorted into squids and cuttlefish, polychaetes, jellyfish, gastropods, echinoderms, crustaceans, bivalves, and ascidians. Among all benthos, the following were caught in more than 30% of sampled hauls:
starfish (*Asterias rubens*), common swimming crab (*Liocarcinus holsatus*), serpent star (*Ophiura ophiura*), green crab (*Carcinus maenas*), and Bernhard's hermit crab (*Pagurus bernhardus*). In hauls where they occurred, the following species exceeded 2000 specimens per trawled hour: common swimming crab (*Liocarcinus holsatus*), grey swimming crab (*Liocarcinus vernalis*), serpent star (*Ophiura ophiura*), and brittlestar *(Ophiura albida*). The commercially fished edible crab (*Cancer pagurus*) occurred in 0.7% of the sampled hauls.

3.3 Estimates of bycatch fractions

3.3.1 Selected fractions

In general, haul catches consisted of mainly fresh shrimp (all sizes), followed by bycatch divided into aggregated fractions 'TAC fish species', 'non-TAC fish species', and 'Benthos' (Figure 6, Table 5). When subtracting the aggregated bycatch fractions from the total catch, the remaining difference obtained was defined as 'debris', i.e., algae, sediment, empty shells, or other material.

Apart from considering species in *aggregated* fractions ('TAC fish species', 'non-TAC fish species', and 'Benthos'), the five most commonly occurring TAC species in the bycatches (plaice, herring, whiting, sprat, and sole) were also treated as *separate* fractions in analyses (Figures 7, 8; see also Appendix 8).

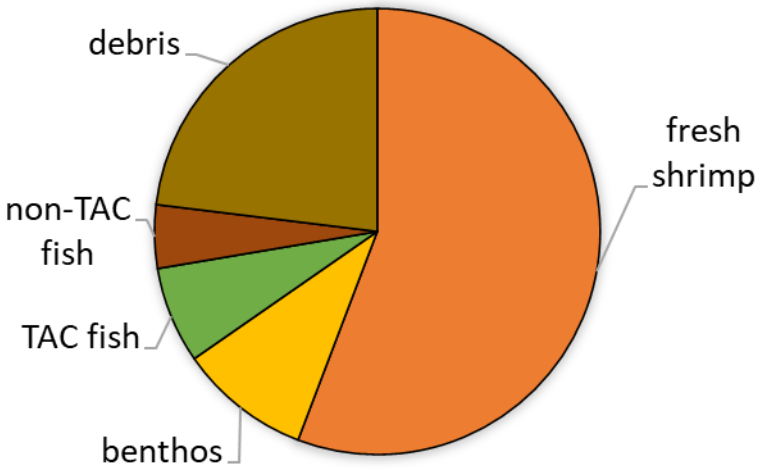

Figure 6 *– Average haul composition of all self-samples by weight, divided into fresh shrimp (all sizes, non-boiled), and the aggregated bycatch fractions: benthos, TAC fish species, non-TAC fish species, and debris. Note that the fraction of fresh shrimp considers shrimp of all sizes in the sample and thus marketable (landings) and non-marketable shrimp (discard).*

Table 5 *- Mean weights and standard error based on self-sampling data (274 hauls) of aggregated bycatch fractions as well as total catch per haul. Note that the fraction of fresh shrimp considers shrimp of all sizes in the sample and thus marketable (landings) and non-marketable shrimp (bycatch).*

	kg / haul	SE
fresh shrimp (all sizes)	238	14.4
benthos	41	2.5
TAC fish	30	1.8
non-TAC fish	20	1.2
debris	98	5.9
total catch	427	25.8

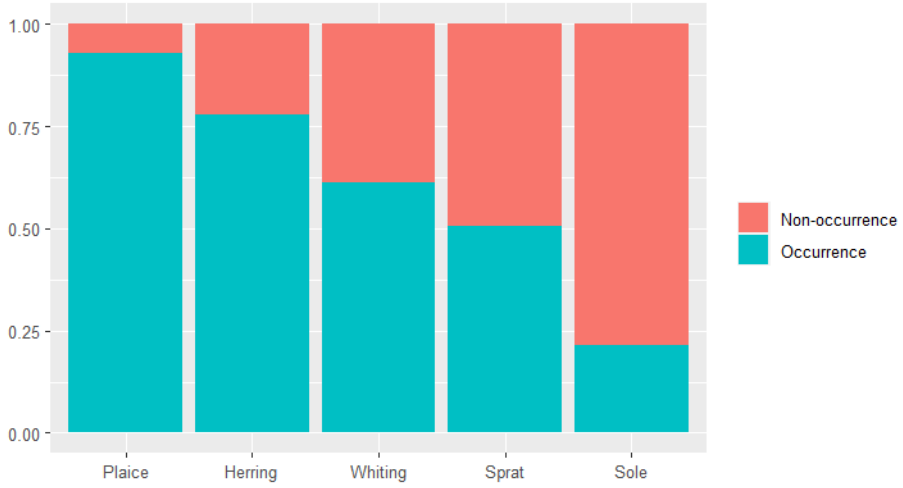

Figure 7 *- Fractions of occurrence versus non-occurrence in haul samples of five TAC species, in sampled hauls (n=274) in the self-sampling program.*

The bycatch of different fractions varied depending on the season (Figure 8). In general, the pelagic TAC species herring and sprat were mostly found in bycatches during the winter or early spring, while plaice was mostly caught during spring and summer. Adding all TAC species together, this bycatch fraction was comparatively larger during the second half of the year (June-December). The non-TAC fish, consisting of many different species (see Appendix 8), were as an aggregated fraction bycaught more evenly over the year, except for some months (winter and summer) where more or less non-TAC species were present in the samples. Benthos represented a comparatively large fraction which was most common in the summer months.

Figure 8 *- Mean weight (kg) per trawled hour in hauls where the respective fraction occurred, with 95% confidence limits for bycatch fractions of single species (for aggregated fractions means are calculated for all hauls), for different months, based on data from self-sampling 2021-2023 (in total 274 sampled hauls).*

3.3.2 Raising bycatch fractions to the total fleet

For raising bycatch fractions from samples to estimates of total for the whole fleet, so called offset variables are used, under the assumption that there is a relationship between a specific fraction and the offset variable. Raising to fleet level has been done on a trilateral level, in this project possibilities for future raising efforts are discussed. To illustrate relationships between offset variables and bycatch fractions, the offset variables a) fishing hours per haul (i.e., haul duration), b) total catch weight per haul, c) total catch per trawled hour, d) total amount of unsorted, fresh shrimps per haul, e) fresh shrimp per trawled hour,

f) landed shrimp per haul and g) landed shrimp per trawled hour were used in a correlation analysis, together with the bycatch fractions. Water depth was added as an example of a covariate which may be associated with bycatches and/or offset variables (Figure 9). Strong correlations were found between the offset variables total catch (both per haul b) and per trawled hour c)) and fresh shrimp (per haul d) as well as per trawled hour e)). The landed shrimp g) had comparatively weaker relationships with the other offset variables. Fishing hours per haul b) was negatively correlated to the other offset variables. This indicates that a shorter trawling time was used if total catch in the haul was large. Water depth did not show a relationship to the offset variables, although there was a weak positive relationship between fishing hours and water depth.

The relationships between aggregated bycatch fractions and offset variables shows that Benthos, TAC fish, and non-TAC fish were positively associated with the offset variables, especially with total catch, but not for fishing hours per haul. Fishing hours was weakly negatively correlated to the bycatch fractions. Furthermore, the single species fractions were positively correlated with the total TAC fish, with the exception of sole which is probably because it was comparatively rare in the bycatches. Plaice, in contrast being the most common TAC species in bycatches, showed a comparatively strong relationship with the offset variables.

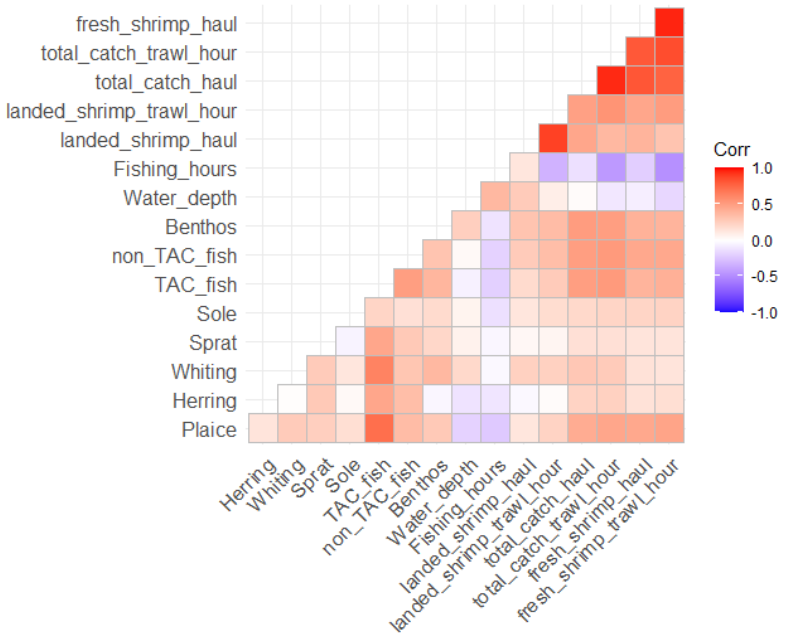

Figure 9 *- Correlation analysis (Pearson) between offset variables and bycatch fractions (weights per hour trawling) based on the collected self-sampling data. All variables were log-transformed prior to analyses, except Fishing hours which was square-root-transformed.*

For the trilateral reporting of bycatches in shrimp fisheries (STECF 2023), annual bycatch was expressed as percentage of the advised North Sea TAC for each species, based on the total sampling organized in all three countries (Denmark, Germany, the Netherlands). The results show that when bycatch is expressed as a percentage of the ICES advised TAC for the North Sea stock of four species dominating the amount of bycatch, one species (whiting) had more than 5% bycatch one year (2021) (Table 6). The status of the spawning stock biomass (SSB) influences the TAC advice and bycatch in the brown shrimp fishery is dominated by the young fish. Therefore, bycatches in coastal areas may change (increase or decrease) several years before this is visible as a development of the SSB. Whiting exceeding the bycatch percentage limit in 2021 is one example of this, and the TAC of whiting was indeed raised more than threefold in 2022 compared to 2021 (ICES 2022a).

***Table* 6 –** *Total bycatches of dominant TAC species in the brown shrimp fisheries of Germany, Denmark and the Netherland as % to the species specific quota for the North Sea. From Appendix to reported bycatches based on trilateral co-sampling programmes in Denmark, Germany, and the Netherlands (STECF 2023; Beier et al. 2023a).*

	2019	2020	2021	2022
Plaice *Pleuronectes platessa*	0.4%	0.3%	0.6%	1.3%
Herring *Clupea harengus*	0.1%	0.1%	0.2%	0.1%
Whiting *Merlangius merlangus*	1.8%	1.2%	6.3%	3.2%
Sprat *Sprattus sprattus*	0.1%	0.1%	0.1%	0.2%

4 Discussion

4.1 Implementing a self-sampling program

The original aim was to strive for a stable reference fleet during the project, and to distribute the samples taken according to the activity of the fleet covering different areas during different parts of the year. The goal for representativity of the self-sampling program was to engage 25 shrimp fishing vessels, which was close to being reached as 22 vessels in total participated. Sampling was planned according to the general activity of the shrimp fleet in different areas along the coast (pers. comm. Nederlandse Vissersbond). For practical reasons regarding communication and coordination of collecting samples from sieving stations to the lab, the number of vessels was limited. Because the shrimp fleet is to a large extent dynamic in where and when vessels go fishing, this involved considerable challenges to plan ahead. Vessels in the reference fleet sometimes went to other areas than originally aimed for. Furthermore, weather conditions were sometimes limiting, especially during winter months, causing planned trips to be cancelled on a short notice. Also, an experience from the project has been that in spite of reimbursement for extra costs, it is not self-evident that every vessel asked would be willing to participate and deliver haul samples, together with data on total catch, haul duration etc. for all hauls during the trip. However, with respect to quality and reliability of samples, voluntary participation is preferable.

The reliability in generally of self-sampling has been questioned, as fishers may consciously or sub-consciously collect samples which are not representative. To prevent bias or errors, clear instructions in a sampling protocol are necessary. Ideally, the sampling protocol should be tested in advance to obtain feedback from fishers or field personnel with experience from sampling on board fishing vessels. Furthermore, a self-sampling program might be organized in combination with observer trips where field personnel from a research institute participate. This allows for comparisons of samples collected by fishers and observers, and would stimulate communication and exchange of experiences regarding bycatch sampling (Beier et al. 2023a).

The self-sampling program in the Netherlands was set up in coordination with similar sampling programs in Germany and Denmark, with the goal to provide a basis for estimating total bycatches of TAC species in the shrimp fisheries on a trilateral level (Beier et al. 2023b). This is motivated by that the fishing fleets of the different countries overlap in their fishing waters along the North Sea coast. In line with earlier experiences (Steenbergen et al. 2015b), it proves difficult or impossible to obtain an identical sampling design using identical methods in all countries. This can be explained by that the fishery operates differently in different countries, where traditions and developed sampling methods are for many reasons not easily adjusted. If the objective is to obtain comparable data, it is essential to allow for international contacts and meetings before and during the sampling programs, and also when data are compiled and analysed. Therefore the authors participated in ICES working group 'WGCRAN' and were in close contact with researchers from institutes in other member states (Thünen Institute and DTU Aqua) to further discuss and align the self-sampling programs. The present project has in these respects been important both for the present goal, i.e., to provide basis for bycatch estimates on a trilateral scale, but also for future planning and design of sampling programs.

4.2 Representativeness of the sampling

The different bycatch fractions estimated from self-sampling data covered estimates from all quarters and the five defined fishing areas. As the North Sea coastal ecosystem is dynamic (e.g., Tulp et al., 2017),

bycatch in shrimp fisheries show a high spatial and temporal variability (Schellekens et al., 2014; Glorius et al., 2015; Steenbergen et al., 2015b, Quirijns et al., 2021). The sampling was set up to reflect the Dutch shrimp fishery, where fishing effort differs over the year and between subareas. Next to limitations regarding participating vessels and numbers of samples to be handled, changes in the planned fishing area of vessels and the fleet simply not fishing at all 5 areas throughout the year, not all subareas could be sampled during all months (Table 2). In contrast, other areas such as the Wadden Sea and Coastal Zone have been sampled more intensively. While a rather high number of sampled trips and samples has been achieved, changes in the sampling scheme might have altered the representativeness of the sampling to the actual fleet activity. To establish high and consistent representativeness of the reference fleet, one could compare for example fishing effort and landings of the reference fleet with that of the whole fleet (VMS data or PO information) and adjust the sampling scheme accordingly, provided that a broad range of (other) shrimp vessels are interested in participating. Without evaluating the representativeness, raising of the bycatch to the total fleet based on the collected data may become biased. A more extensive sampling with higher coverage of areas and quarters could give a more precise estimate of total bycatch and could enable taking differences in bycatches among subareas into account. Furthermore, between-year variability cannot be well estimated, as 2022 was the only year with samples collected in all months (except for February).

The sampling method of taking a bucket from the total catch of each haul in the container is a simple and straightforward method to sample bycatch, which can be easily explained and performed by the fishers themselves. The instructions to fishers to sample two hauls, one during the day and one during the night, turned out well as the proportion of day or night sampled hauls reflected the actual distribution of hauls during the trip (Figure 5). Estimation of the catch volume for each haul by the fishers worked well; the method of first measuring the catch containers on beforehand, and then using a ruler by the fisher to measure the height of catch in the container, did not disturb the normal fishing process onboard.

For raising data from bycatch samples to the whole fleet, results from the sampling show that both total catch and fresh shrimp weight may be suitable as to use so called offset variables. Estimates of all bycatch fractions to haul level have been obtained by using the total catch. The advantage of using total catch as an offset variable is that it has also been estimated for all (also non sampled) hauls during each trip where samples were taken. However, this method may also lead to imprecise estimates when for example the container is almost empty (small catch), or if the vessel is tilted to one side so that the catch is unevenly distributed, or if there are for example many jelly fish in the total catch volume which would not be well preserved until the sample in the bucket is analysed. Bearing possible uncertainties in mind, the estimates of bycatch fractions on haul level can be raised to trip level. In the next step when raising trips to fleet level for a defined time, e.g., month, estimates from trips may be used as well as an offset variable for that period. Available data to use as offset variables can be landed shrimp from logbook data, or fishing hours from VMS data, or possibly a combination. This was also discussed in the ICES working group 'WGCRAN' and agreed upon with the institutes from other member states. Data show that both landed shrimp and fishing hours may in certain respects disadvantageous to use. Landed shrimp shows a relatively weak positive correlation to the different bycatch fractions, and also to the total catch (Figure 9). This can be understood by the large variation in marketable shrimp (boiled and sieved on board) over the year, resulting from the seasonality in the shrimp population. Interestingly, trawling time ('fishing hours') was on haul level negatively related to total catch and fresh shrimp catch. If the trawl gets filled faster, it can be assumed that trawling time is then shortened, explaining the negative relationship. However, if trawling time during the trip is used to raise bycatches to fleet level during that particular period, e.g., month or year, by using fishing hours of the fleet, this may cause incorrect or biased estimates. It is suggested that a statistical model is developed incorporating different offset variables, when raising bycatch estimates from collected samples to fleet level. To obtain reliable, robust and representative bycatch estimates, results from this co-sampling project show that the respective sampling program needs to reflect the fleet in a representative way both regarding fishing areas and periods of the year.

5 Conclusions and recommendations

Before setting up the sampling program as well as for maintaining it during the sampling period, information from POs regarding how and where the shrimp fishery operates has been essential. POs have also had a central role in communication with the fishery and participating vessels, for motivating participation. For the success of the co-sampling, clear instructions in a sampling protocol are necessary and enough time and space needs to be given to test a draft protocol and obtain feedback from fishers and field personnel.

Challenges to plan the sampling may arise from the dynamic behaviour of the brown shrimp fleet and could be tackled by good communication with the POs, increasing the reference fleet and sampling effort and investigating representativeness of the reference fleet by comparison with the total fleet activity (VMS data, PO information). Organizing a self-sampling program in combination with observer trips where personnel from a research institute participate in the sampling would allow for comparisons of sampling, and would stimulate communication and exchange of knowledge and experiences.

It is concluded that an estimate of total fleet bycatches from sampling data should be made by including more than one offset variable, and in a statistical model where seasonal variability is also taken into account.

6 Acknowledgement

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7 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2015 certified quality management system. The organisation has been certified since 27 February 2001. The certification was issued by DNV.

The Chemical and Benthos laboratory has an EN-ISO/IEC 17025:2017 accreditation for test laboratories with number L097. This accreditation has been granted by the Dutch Accreditation Council. As a result, the Chemical and Benthos laboratory has demonstrated its ability to provide valid results in a technically competent manner and to work in accordance with the ISO17025 standard. The scope (L097) of de accredited analytical methods can be found at the website of the Council for Accreditation (www.rva.nl).

On the basis of this accreditation, the quality characteristic Q is awarded to the results of those components which are incorporated in the scope, provided they comply with all quality requirements. The quality characteristic Q is stated in the tables with the original research results.

The quality of the test methods is ensured in various ways. The accuracy of the analysis is regularly assessed by participation in proficiency tests.
In addition, a first-level control is performed for each series of measurements.

If desired, information regarding the performance characteristics of the analytical methods is available.

If the quality cannot be guaranteed, appropriate measures are taken.

References

Acoura Marine Ltd. 2017. Marine Stewardship Council Publication Certification Report for the North Sea Brown Shrimp Fishery, 428 pp.

Beier, U., Bleeker, K., Chen, C., Neitzel, S. & Winter, A. (2023a). Monitoring shrimp fisheries - the International Research Cooperation (IRC) shrimp project. Wageningen Marine Research - *Draft report, October 2023*.

Beier U., Chen C., Huenerlage K., Mosegaard H., Neitzel S.M., Nielsen A. & Pedersen EM. (2023b). Bycatch of TAC-species in the North Sea brown shrimp fishery. Results from trilateral co-sampling programmes. Appendix for the Scheveningen Group Brown Shrimp exemption report (March 2023).

Campos, J., Van der Veer, H.W., Freitas, V. & Kooijman, S.A.L.M. (2009). Contribution of different generations of the brown shrimp *Crangon crangon* (L.) in the Dutch Wadden Sea to commercial fisheries: A dynamic energy budget approach. Journal of Sea Research 62:106-113. https://doi.org/10.1016/j.seares.2009.07.007

EU (2013). REGULATION (EU) No 1380/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC.

EU (2018). Commission Delegated Regulation (EU) 2018/2035 of 18 October 2018 specifying details of implementation of the landing obligation for certain demersal fisheries in the North Sea for the period 2019-2021.

EU (2019). Commission Delegated Regulation (EU) 2019/2238 of 1 October 2019 specifying details of implementation of the landing obligation for certain demersal fisheries in the North Sea for the period 2020-2021.

EU (2020). Commission Delegated Regulation (EU) 2020/2014 of 21 August 2020 specifying details of implementation of the landing obligation for certain fisheries in the North Sea for the period 2020-2023.

Glorius, S., Craeymeersch, J., van der Hammen, T., Rippen, A., Cuperus, J., van der Weide, B., Steenbergen, J., Tulp, I. (2015). Effecten van garnalenvisserij in Natura 2000 gebieden. IMARES-rapport Rapport C013/15. https://edepot.wur.nl/332091

ICES. (2022a). Whiting (*Merlangius merlangus*) in Subarea 4 and Division 7.d (North Sea and eastern English Channel). In Report of the ICES Advisory Committee, 2022. ICES Advice 2022, whg.27.47d. https://doi.org/10.17895/ices.advice.19457411

ICES. (2022b). Working Group on Crangon Fisheries and Life History (WGCRAN; outputs from 2021 meeting). ICES Scientific Reports. 4:14. 77 pp. http://doi.org/10.17895/ices.pub.10056

ICES. (2023). Working Group on Crangon Fisheries and Life History (WGCRAN). ICES Scientific Reports. 5:93. 48 pp. https://doi.org/10.17895/ices.pub.24220471

Neitzel, S.M., Deetman, B., de Reus, B., Beier, U., Klok, A., & van Oostenbrugge, H. (2023). Implementing the landing obligation - what costs are involved for the shrimp fisheries sector? A brief overview. Wageningen Marine Research report; No. C020/23. Wageningen Marine Research. https://doi.org/10.18174/629723

Quirijns, F., Beier, U., Deetman, B., Hoekstra, G., Mol, A., & Zaalmink, W. 2021. Beschrijving garnalenvisserij: Huidige situatie, knelpunten en kansen. Wageningen Marine Research rapport; No. C049/21. Wageningen Marine Research. https://doi.org/10.18174/547410

Schellekens, T., V. Escaravage, P. C. Goudswaard, M. v. Asch, & J. A. M. Craeymeersch. 2014. Garnalenvisserij experiment Voordelta. Rapport / IMARES Wageningen UR : C154/15. 88 pp. https://edepot.wur.nl/328929

STECF (Scientific, Technical and Economic Committee for Fisheries). (2023). Evaluation of Joint Recommendations on the landing obligation and on Technical Measures Regulation (STECF-23-04 &

23-06), Rihan, D., Grati, F., Ligas, A., Doerner, H. and Vasilakopoulos, P. editors, Publications Office of the European Union, Luxembourg, 2023. https://stecf.jrc.ec.europa.eu/documents/43805/61703874/STECF+23-0406+-+Ev+JRs+LO.pdf/5cf75911-6a7f-4aa5-be7d-3f371440b2bd

Steenbergen, J., van Kooten, T., van de Wolfshaar, K.E., Trapman, B.K., & van der Reijden, K.J. (2015a). Management options for brown shrimp (*Crangon crangon*) fisheries in the North Sea. Report/IMARES No. C181/15. IMARES. https://edepot.wur.nl/366175

Steenbergen, J., J. Ulleweit, M. Machiels, R. Nijman, K. Panten, and E. van Helmond. (2015b). Discards Sampling of the Dutch and German Brown Shrimp Fisheries in 2009 – 2012. Stichting DLO Centre for Fisheries Research (CVO), IJmuiden. CVO Rep. 15.003, 40 pp. https://edepot.wur.nl/329757

Tulp, I., H. W. van der Veer, P. Walker, L. van Walraven, and L. J. Bolle. 2017. Can guild- or site-specific contrasts in trends or phenology explain the changed role of the Dutch Wadden Sea for fish? Journal of Sea Research 127:150-163.

Justification

Report C068/23
Project Number: 4311400045

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:	Anna-Marie Winter Researcher
Signature:	
Date:	26 October 2023

Approved:	Maarten Mouissie Management Team
Signature:	
Date:	26 October 2023

Appendix 1 Self-sampling protocol

Discards in shrimp fisheries – Protocol self-sampling

Version 4.0 **Last update: 15-03-2022**

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1.1 Background

An important element in the revision of the Common Fisheries Policy (CFP) is the introduction of the landing obligation. Under this landing obligation, all discards of commercial species that are regulated by quota must be landed (EU Regulation 1380/2013). The landing obligation has been introduced step by step and has been in full force since 1 January 2019. This means that fishermen must land all their catches of quota species. Current regulations include a number of exceptions to the landing obligation, such as the "*deminimis*" exception. This exception applies to fisheries where it has proven difficult to achieve greater selectivity, or where there are disproportionate costs involved in landing unwanted catches. All catches under a *deminimis* exemption may be returned to the sea up to a certain maximum.

Since 2018, a *deminimis* exemption has been in effect for the shrimp (*Crangon crangon*) fishery (EU 2018/2035). The exemption in question means that a maximum of 7% of the total catches of all species subject to catch limits may be discarded into the sea. This percentage will be reduced to 5% in the next 4 years. The *deminimis* exemption for shrimp fisheries has been granted on the condition that Member States with an interest in shrimp fisheries (i.e. Germany, Denmark and the Netherlands) set up and implement a self-sampling program to better understand the amount of by-catches in shrimp fisheries. The results of the program create a scientific basis for evaluating the bycatch of the Dutch shrimp fishery. For this purpose, WMR has designed a shrimp self-sampling program on behalf of the Ministry of Agriculture, Nature and Food Quality (LNV) that takes into account both the spatial and temporal pattern of the fishery.

1.2 Purpose

The aim of this project is to set up and implement a systematic and internationally coordinated self-sampling program in the Dutch shrimp fishery in which bycatch data are collected that are representative for the Dutch shrimp fishery in order to scientifically substantiate the *deminimis* conditions.

1.3 Intent

For this project, a reference fleet of approximately 15-25 vessels will be recruited within the Dutch shrimp fleet that will carry out self-sampling. The vessels of this reference fleet are requested to take catch samples on fishing trips, also known as self-sampling trips.

During a sampling trip, a catch sample of 10 liters is taken from the box (lastbak) by the crew (two different hauls according to the WMR sampling protocol). A trawl list is also completed by the crew for each self-sampling trip and shared with the researchers. The samples with the associated trawl list are landed and handed over to WMR. WMR ensures further processing of the samples.

A description of which trip and which trawl is sampled is determined at the beginning. The preliminary sampling program indicates that a total of 200 self-sampling trips will be carried out in the period July 2021 to June 2023, spread evenly over the seasons and areas (see Table 1, Figure 1). This concerns four areas in the Dutch coastal zones and one in the German area "Sylt" (Figure 1). The feasibility of the sampling plan will depend on the cooperation of the shrimp fleet, weather and other circumstances.

Table 1. *Provisional sampling plan 2021 to 2023, trips per area per month. For areas see Figure 1.*

2021															
	Aantal schepen	Aantal visreizen	Aantal monsters	Bemonsterde reizen per maand											
Gebied	25	67	134	jan	feb	maa	apr	mei	jun	jul	aug	sep	okt	nov	dec
S-C	5	15	30								4	4	3	2	2
Westkust	5	10	20							3	3	4			
Waddenzee	6	23	46							3	4	5	5	3	3
NZKZ	4	15	30							2	3	2	3	2	3
Sylt	5	4	8												4
2022															
	25	100	200	jan	feb	maa	apr	mei	jun	jul	aug	sep	okt	nov	dec
S-C	5	15	30								4	4	3	2	2
Westkust	5	10	20							3	3	4			
Waddenzee	6	30	60				2	3	2	3	4	5	5	3	3
NZKZ	4	30	60	2	3	2	3	2	3	2	3	2	3	2	3
Sylt	5	15	30	4	4	3									4
2023															
	15	33	66	jan	feb	maa	apr	mei	jun	jul	aug	sep	okt	nov	dec
S-C	0	0	0												
Westkust	0	0	0												
Waddenzee	6	7	14				2	3	2						
NZKZ	4	15	30	2	3	2	3	2	3						
Sylt	5	11	22	4	4	3									

Nr	IRC shrimp gebieden	Gebieden volgens Steenbergen et al. 2015
1	**Area S-C**	Dutch Delta
2	**Area Westkust**	Dutch Westcoast
3	**Area NZKZ**	Dutch North Coast
4	**Area Waddenzee**	Dutch Wadden Sea
5	**Area Sylt (DE)**	German North Coast
6		*German/Danish Wadden Sea*
7		German West Coast
8		Sylt
9		*Danish West Coast*

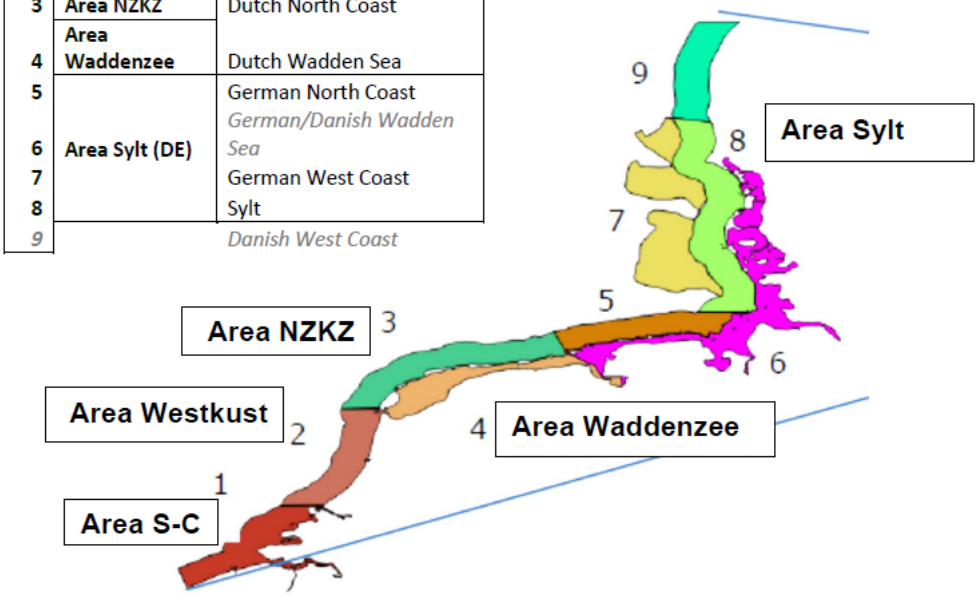


Figure 1. *IRC shrimp areas. In this project we use 5 areas (areas 5 to 9 have been merged into area 5). Steenbergen et al. 2015, figure 5.*

1.4 Preparations

1.4.1 Reference fleet

At the start of the project, the ships for the reference fleet were recruited by WMR. For this, the skippers of the ships whose boxes have already been measured were approached by telephone by a WMR employee. If positive, a WMR employee visited the ship to jointly go through the self-sampling protocol with the skipper and the crew. During this visit, the skipper is also asked to sign the declaration of consent (Appendix I).

In the course of the project, new ships can be added to the reference fleet if needed. For new ships, the boxes must be measured (Appendix VI) in order to determine the total catch.

1.4.2 Communication and coordination

Participants are planned in according to a schedule when a self-sampling trip (i.e. collecting samples and maintaining trawl list) is to be performed. In addition, the skipper is called, texted or e-mailed a week before the sampling as a reminder and it is checked whether the sampling can still take place according to plan. Employees of WMR collect the samples at the fish auction or the ship. Always check whether the trawl list is included and place a photo of it in the folder with the relevant month, week and ship on the W disk:

W:\IMARES\DATA\Shrimp_EgProg_202101006\4. Data and Analysis\Data

1.4.3 Selfsampling protocol for participants

During a self-sampling trip, various data will have to be collected by the ship's crew. Keeping track of the trawl list is one of the crew's most important tasks during the trip. This must be done right from the first haul.

In order to properly complete the trawl list, it is important to discuss all parts of the self-sampling protocol with the skipper and crew (Appendix V):

- Keeping a trawl list
- Measuring the unsorted total catch
- Taking an unsorted catch sample from two hauls, 10 liters per haul
- Keeping track of the amount of market-worthy catch

1.5 Sorting the samples in the lab

1.5.1 Step 1. Weighing and measuring the volume of the samples

Write down the ship number, trawl number and date. Use a separate sample_id and measurement list for each sample. Clean the labels of the bags, dry them and store them in airtight bags. Tare a bucket (with liter size) and weigh the total catch sample per haul. Read the volume and weight and record this on the measurement list.

1.5.2 Step 2. Sorting the sample

A number of basic principles apply to the processing of the sample:

- A sub-sample can be taken for measuring or counting from more than 100 individuals of a species. See **Appendix IV** for the sub-sample method.
- For a reliable and representative representation, **at least 50 individuals** are always counted or measured, unless of course there are no more in the sample.
- It is **very important to write down the sub-factor** when taking a sub-sample. Without the sub-factor it is impossible to analyze the data of the sub-sample (see also Appendix IV for more information about this).

Step-by-step plan for sorting a sample:

1. Put the sample on the sorting table
2. Remove all species with <100 individuals in the sample and sort them (by species) into trays.
3. When there are >100 individuals of a species in the monster, you can halve the monster and put half of the monster back in the bucket (don't throw it away just yet to be safe).
4. The remainder of step 3 is your **sub-sample**. Everything you get out of it now has a **subfactor** x2 (see also **Appendix IV**). Note the **subfactor** for the species you are now measuring/counting!
5. Now remove all species from the subsample of which are <100. For species >100 another sub-sample is taken. **Note the subfactor again**!
6. Repeat this until all species have been removed and trays with species, a fraction of shrimp and a fraction of 'waste' remains. Waste, also called miscellaneous (varia) in this study, means: plastic, empty shells, pieces of peat, wood, jellyfish and seaweed.

1.5.3 Step 3 Measuring, counting and weighing

When the sorting process has been completed, the shrimp fraction and the miscellaneous fraction (varia) can be weighed separately from each other. Record the weights on the measurement list.

Then the different species are measured or counted. **Table 2** presents an overview of the different methods (i.e. measuring, counting and/or weighing) per species. Length measurements of species with more than 5 individuals are counted on the measurement list. With 5 or less, there is a separate section for these species at the bottom of the measurement list (see also **Appendix III**).

Table 2. *Overview of the different methods of quantity determination per (sub)species.*

Measuring (cm, to the cm below) and weigh the total amount per species	**Measuring (mm) and weigh the total amount per species**	**Measuring (to 0,5 cm below) and weigh the total amount per species**	**Count and weigh the total amount per species** **Benthos**	**Only weighing**
All fish species (unless mentioned in other columns)	Commercial crab species: North Sea crabs and Chinese mitten crabs	Herring	Crabs (other)	Brown shrimp
ETP species		Sprat	Starfish and brittle stars	Trash/varia: - jellyfish - empty shells - wood, peat, etc. - dead or rotten fish
Squids	Other shrimp species		Shellfish (alive)	
			Hermit crabs	
			Anemones	
			(Rag)worms	
			European common squid	

***Table 3**. ETP species.*

Category	Family / Order	Dutch name	Scientific name	English
ETP-species	Lampreys	rivierprik	*Lampetra fluviatilis*	River Lamprey
		zeeprik	*Pertromyzon marinus*	Sea Lamprey
	Herrings	fint	*Alosa Fallax*	Twaite Shad
		elft	*Alosa alosa*	Allis Shad
	Salmon	houting	*Coregonus oxyrinchus*	Houting
	Sturgeons	Atlantische steur	*Acipenser sturio*	European Sea Sturgeon
	Sharks	haaien (meerdere soorten)	*Selachii*	Sharks
	Rays	roggen (meerdere soorten)	*Batoidea*	Rays and skates
	Eel	aal /paling	*Anguilla anguilla*	European eel
Commercial fish species	Gurnards	rode poon*	*Chelidonichthys lucerna**	tub gurnard*
	Cods	kabeljauw	*Gadus morhua*	Atlantic cod
		schelvis	*Melanogrammus aeglefinus*	haddock
		wijting	*Merlangius merlangus*	whiting
		zwarte koolvis	*Pollachius virens*	saithe / coalfish / coley
		kever	*Trisopterus esmarkii*	Norway pout
	Mackerels	zeebaars*	*Dicentrarchus labrax**	seabass*
		makreel	*Scomber scombrus*	mackerel
		horsmakreel	*Trachurus trachurus*	horse mackerel
*** non-commercial fish species (without quota)**	Sand eels	zandspieringen indet.	*Ammodytes sp.*	sandeels
		Noorse zandspiering	*Ammodytes marinus*	Raitt's sand-eel
		kleine zandspiering	*Ammodytes tobianus*	lesser sand-eel
		smelt	*Hyperoplus lanceolatus*	greater sand-eel
	Flatfish	schar*	*Limanda limanda**	dab*
		bot*	*Platichthys flesus**	European flounder*
		schol	*Pleuronectes platessa*	plaice
		tarbot	*Scophthalmus maximus*	turbot
		griet	*Scophthalmus rhombus*	brill
		tong	*Solea solea*	sole
	Salmon	zalm	*Salmo salar*	salmon
	Herrings	sprot	*Sprattus sprattus*	sprat
		haring	*Clupea harengus*	herring
	Anchovies	ansjovis	*Engraulis encrasicolus*	anchovy
	Crustaceans	Noorse kreeft (langoustine)	*Nephrops norvegicus*	Norway lobster
		Noordzeekrab*	*Cancer paugurus**	brown crab*

1.6 Data processing, entry and storage

After processing a sample, the files should be saved. Table 4 shows the locations where this is done.

Table 4. *Data and storing location(s).*

Data	Format	W: drive	S: drive
Measuring lists	Billie files	Yes	Yes
Trawl lists	Excel files	Yes	Yes (special trawl list)

All the above files will be saved in the folder on the drive after scanning and entering:

W:\IMARES\DATA\Garnalen_BijvProg_202101006\4. Data\1. Ruwe data.

Then choose the correct year and create a folder with the relevant ship number. When the data can be checked, the files must be copied to location:

S:\discran_ss*jaar**scheepsnaam.1*.

1.7 Calculations

Before entering the data in BillieTurf 8.2, some calculations have to be made.

1.7.1 Calculating total catch in kg

It is **important** that the crew smooth out the catch in the boxes of each haul and always measure the **depth of the catch** in the boxes at the same deepest point with a ruler (in cm) and record it on the trawl list. The WMR employee checks the trawl list for these measurements for each trip. As soon as these measurements are missing, the crew of the ship must be contacted so that this does not happen again on a subsequent trip.

INFORMATION ON RAISING METHOD
Because the total catch cannot be weighed, the bins (containers) are measured. In this way, for every cm in height measured with the ruler, the catch volume (Litres) can be calculated. The catch volume of all existing bins is added together.
The volume is then converted to an average weight over all hauls, by the ratio KG/L recorded for each sample. In this way, all species recorded in the sample are processed proportionally to the total catch in the bin.

The total volume of the catch is subsequently converted to kg using a conversion factor (see also Steps 1 to 3 below).

Step 1: determination of volume of total catch in litres
The volume of the total catch can be determined by means of the measurement of the depth of the catch (measured in cm with the ruler) and volumes per cm of height measured in front of the boxes. The volumes per cm of height can be found in:

W:\IMARES\DATA\Garnalen_BijvProg_202101006\4. Data en Analyse\last_bakken\alle_lastbakken.xlsx

In column a, select the measurement of the depth of the catch, and take the corresponding total liters (column d). Note, if the ship has several boxes, the total catch per box is entered and the volume per box is calculated. For example, box starboard: 23 cm = 313.73 l, box port side: 12 cm = 103.6 l 313.73 l + 103.6 l. = 417.33 l.

If the dimensions of the boxes are not yet known, they will first be measured and drawn by a WMR employee. Consult with the project coordinator if this is the case.

Step 2: calculation ratio kg/litre
For each sample, the weight (kg) and volume (litres) of the entire sample is recorded. This information is used to calculate a ratio.

- Add up the weight and volume of the samples. Then divide the total weight by the total volume to arrive at the kg/l ratio.

Step 3: calculate total catch in kg per haul

- Multiply the total liters (Step 1) per haul and per bucket by the kg/l ratio (Step 2) to calculate the total catch expressed in kg per haul.

1.7.2 Calculating bottomtrack

When making statements about the relative difference in catches between different trawls, it is important to know how great the fished distance ('bottom track') is.

Two key figures are used for this:
- Boat speed in knots
- 1 knot = 1 nautical mile p/hour
- 1 nautical mile = 1852 meters

- Trawling time in hours

The formula for calculating fishing distance in kilometers (bottom track):

BT= (S * D)*1.852

Whereby:

S = Speed in knots
D = Trawling time in hours

Step 1: calculation of trawling time in hours
- Calculate the difference between the time of setting and hauling the nets for each trawl in hours.

Step 2: multiply the number of pulling hours by the number of knots
- Take the trawling time in hours and multiply it by the number of knots.

Step 3: calculate back to kilometers
- Multiply (number of knots*hours) by 1.852 (the distance traveled in one hour on 1 knot).

1.8 Entering data in Billie

For the input into Billie, sample IDs are required for all trawls sampled. Ask the project coordinator about this. Now that all data is available, everything can be entered in Billie. The Billie files are saved as: DISCRAN_YEAR_SAMPLEID. Year is 4 digits and Sample ID is 7 digits.

On the S drive, the file location is S:\ discran_ss\year.

For storage: also look at already existing files and use the same format for folders/files.

1.8.1 Entering trawl-metadata

- Open Billie and fill in the fields as shown in **Figure 2**.

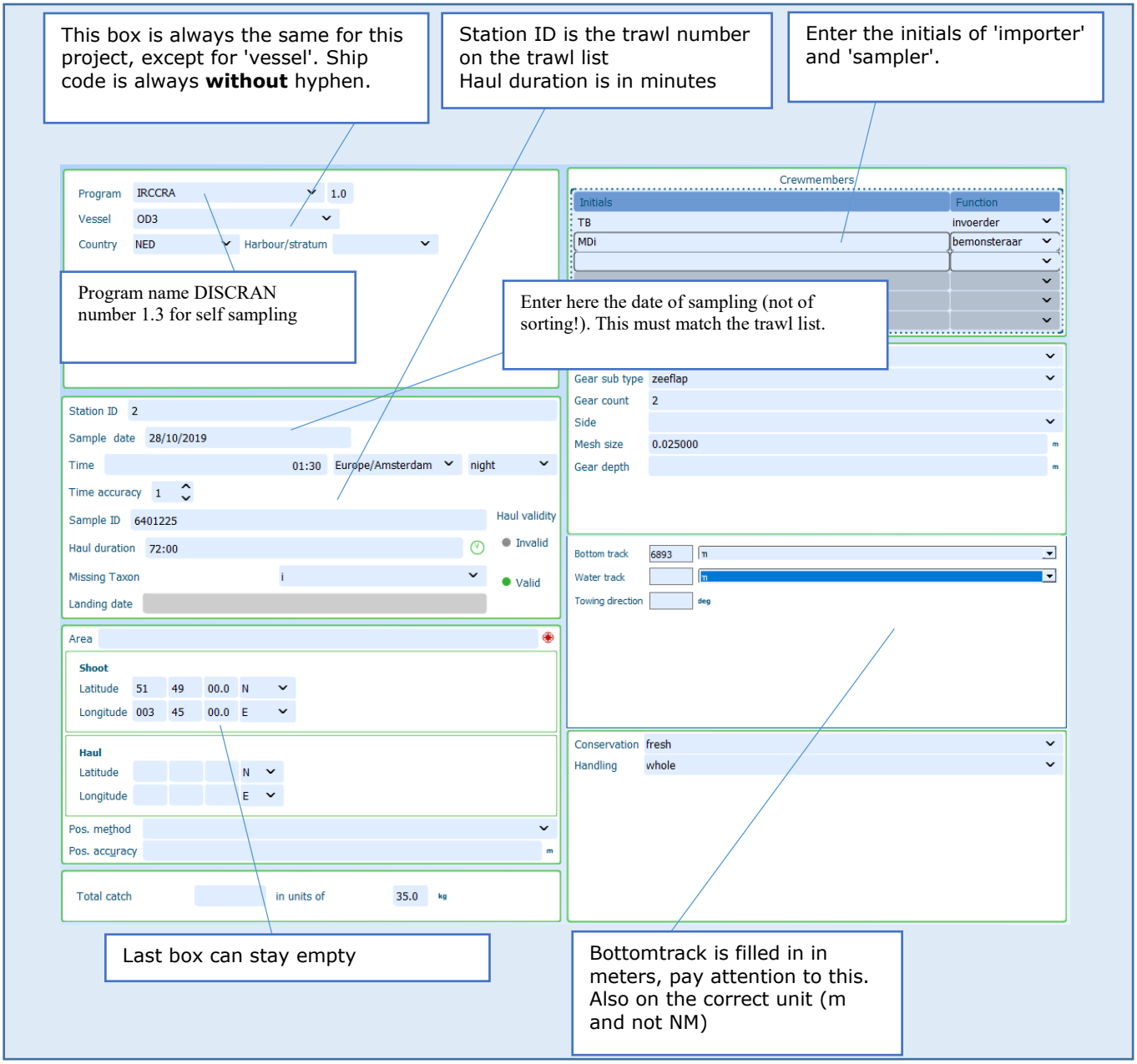


Figure 2. *Way of entering the first Billie page.* ***Note****: This is an example! For this project (Program = DISCRAN) we work with conservation = cooked.*

Click on the  button 'next page' to fill in the last parameters

On the next page, fishing depth, wind speed and direction are the only factors to be entered (**Figure 3**).

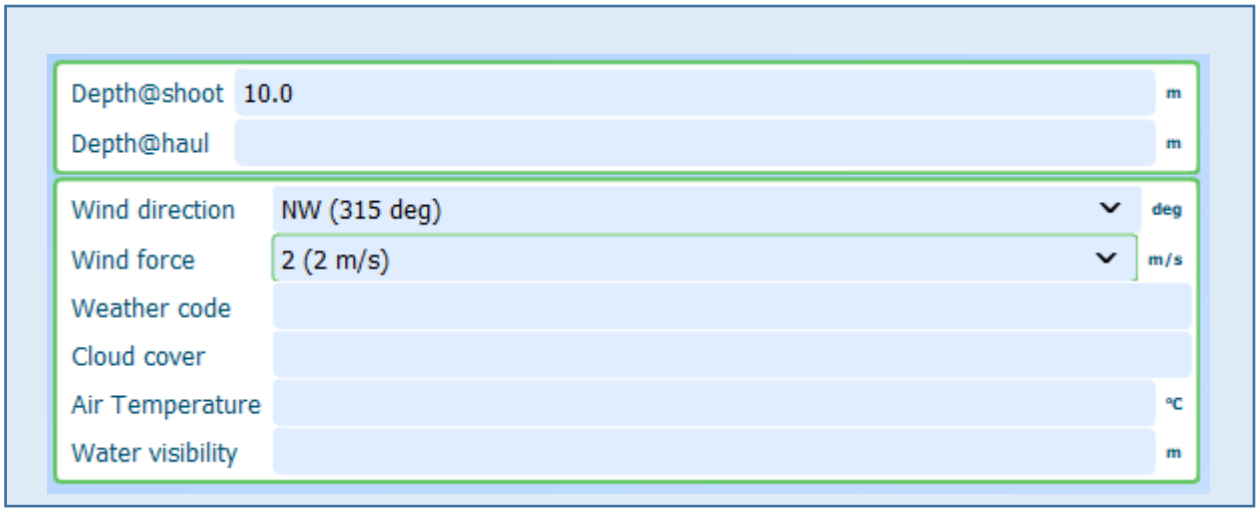


Figure 3. *Way of entering second Billie page*

- Note that the wind strength and direction are selected in the drop-down menu and not typed. Depth must be typed.

1.8.2 Entering measuring lists

- To enter length measurements, use the button 

- See **Figure 4** for instructions on how to enter the length measurements.

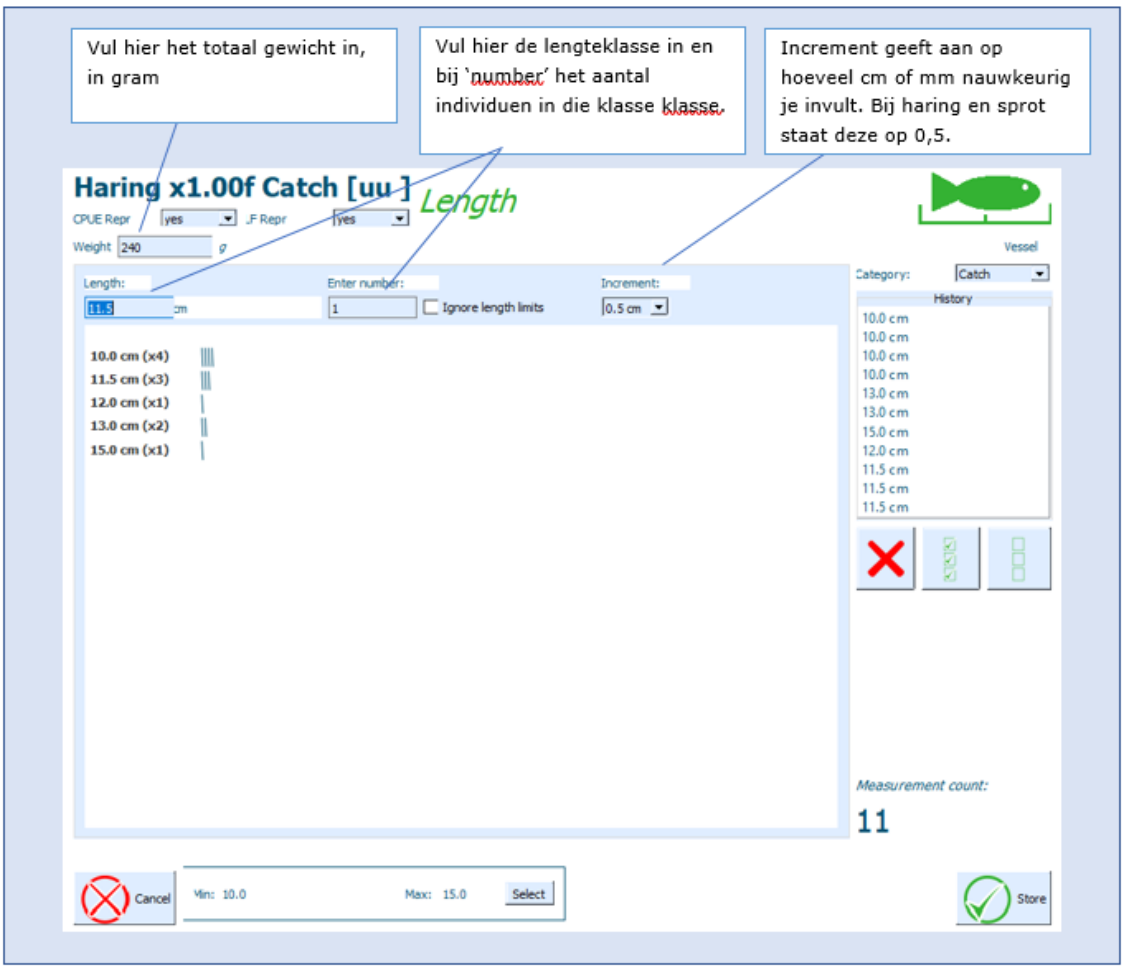


Figure 4. *Way of entering length measurements*

- To enter numbers, use the button 

- For input instructions, see **Figure 5**.

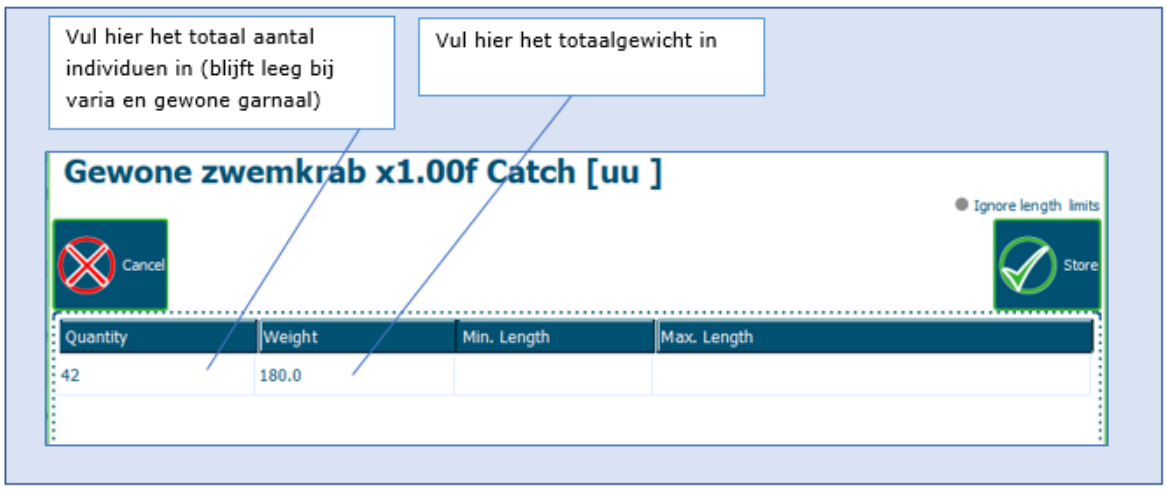


Figure 5. *Way of entering numbers + weights.*

- Enter the correct sub-factor for each species by clicking on the button. 

- See **Figure 6** for instructions.

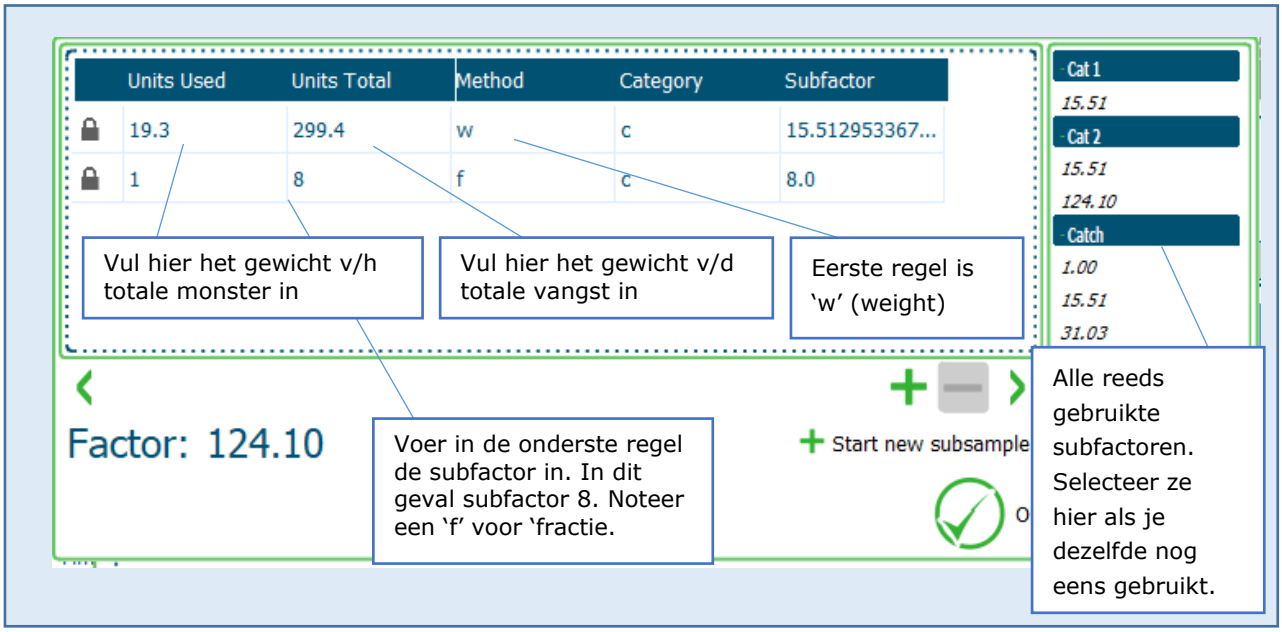
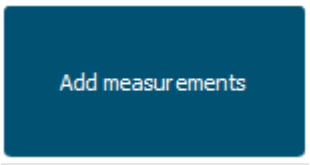


Figure 6. *Creating the right sub-factor.*

Note! When discards are entered, the total catch is entered for 'units used' and 'units total'. 'Category' then becomes 'd' for discard.

- After entering the subfactor, click 

to enter the numbers or length measurements, along with the weights.

Number of points for attention:

- Pipefishes and razor clams (ensis) may be entered by common name (Sp.). The rest must all be entered by species.
- Note that smelt defaults to mm increment. Adjust this to cm.
- Herring and sprat are filled in with an accuracy of 0.5 cm.

1.9 Trawl lists

As soon as you received a trawl list, take a picture of it and save it on the drive:

W:\IMARES\DATA\Garnalen_BijvProg_202101006\4. Data\2. Treklijsten.

Fill in the trawl list in Excel from the paper trawl list and save it in the correct folder on the W drive:

W:\IMARES\DATA\Garnalen_BijvProg_202101006\4. Data\1. Ruwe data.

Also save the trawl list in the correct folder here:

S:\discran_ss*jaar**scheepsnaam.*w*weeknummer.

When the Billie files and the trawl lists are saved and ready on the S disk, please let the project coordinator know.

1.10 Responsible use of data

Collected data is stored by WMR in the FRISBE database for further use within the self-sampling project and is treated according to the conditions as stated in the declaration of consent (Appendix I).

These conditions are:

- The data from the analysis are stored in the WMR database FRISBE. This database is not publicly accessible. This concerns data about: ship, hauls (position and time), types of fish and lengths per species.
- Research results are always presented anonymously, so they cannot be traced back to ship and/or skipper and crew.
- The owners of the participating ships agree that the data will remain available in the WMR FRISBE database after the event and may also be used for other (future) research.
- Further use of non-anonymised research data is only possible with the permission of the relevant skipper(s) and if the skipper is not the owner of the fishing vessel concerned, the owner.

These points will also be agreed with the skipper/owner of the participating ships in the declaration of consent (Appendix I). As mentioned earlier in this document, a WMR employee will have this signed by the skipper/owner (section 1.4.1).

Appendix 2 Declaration of Consent (Dutch only)

Onderzoek: Wetenschappelijke garnalen bijvangstsampling programma
Looptijd: 03 mei 2021 – 30 september 2023

Informatie:
In het Garnalen bijvangstsampling project wordt in samenwerking tussen Nederlandse Garnalenvissers en Stichting Wageningen Research, Wageningen Marine Research (WMR), een zelfbemonsteringsprogramma uitgevoerd. Het doel van dit programma is het verzamelen van bijvangstgegevens die representatief zijn voor de Nederlandse garnalenvisserij om de "de minimis" voorwaarden die in het kader van de aanlandplicht zijn opgesteld wetenschappelijk te evalueren.
In grote lijnen ziet het zelfbemonsteringsprogramma er als volgt uit: binnen de Nederlandse garnalenvloot wordt een referentievloot gekozen die representatief wordt geacht voor de gehele vloot. De schepen van deze referentievloot worden gevraagd om voor specifieke visreizen, ook wel bemonsteringreizen genoemd, ongesorteerde vangstmonsters te nemen. Tijdens een bemonsteringsreis wordt door de bemanning van twee trekken volgens het WMR bemonsteringsprotocol een vangstmonster van 10 liter genomen. Voor iedere bemonsteringsreis wordt tevens door de bemanning een treklijst ingevuld. Op de treklijst wordt per trek de vispositie, start- en eindtijd, waterdiepte, weersomstandigheden en commerciële vangstgegevens geregistreerd. Tevens wordt op de treklijst algemene reisinformatie, zoals type vistuig, haven etc. geregistreerd. De monsters met bijbehorende treklijst worden aangeland en aan WMR overgedragen. WMR zorgt voor de verdere verwerking van de monsters. Een beschrijving van welke reis en welke trek wordt bemonsterd, wordt aan het begin bepaald en staat in het WMR bemonsteringsprotocol.
Bij deelname aan het onderzoek gelden de volgende uitgangspunten:

- De bemonstering wordt uitgevoerd volgens het WMR bemonsteringsprotocol.
- De gegevens uit de analyse worden opgeslagen in de WMR database FRISBE. Deze database is niet publiek toegankelijk. Het betreft gegevens over: schip, trek (positie en tijdstip), soorten vis en lengtes per soort.
- Onderzoeksresultaten worden te allen tijde anoniem, dus niet herleidbaar tot schip en/of schipper en bemanning, gepresenteerd.
- De eigenaren van de deelnemende schepen zijn ermee akkoord dat de gegevens ook na afloop beschikbaar blijven in de WMR FRISBE-database en ook voor andere (toekomstige) onderzoeken mogen worden ingezet.
- Verder gebruik van niet-geanonimiseerde onderzoeksgegevens kan enkel na toestemming van de betreffende schipper(s) en in geval de schipper geen eigenaar van het betreffende visserijvaartuig is, de eigenaar.

Verklaring:
Ondergetekende verklaart geïnformeerd en akkoord te zijn over de opzet, het doel van het onderzoek en de omstandigheden waaronder dit wordt uitgevoerd, de inhoud van het WMR bemonsteringsprotocol, en verklaart deze informatie begrepen te hebben.
Ondergetekende geeft Wageningen Marine Research, onderdeel van de Stichting Wageningen Research, toestemming met de ondertekening van dit formulier de verzamelde gegevens te gebruiken voor de onderzoeksdoeleinden binnen het garnalen bijvangstsampling programma en toekomstige onderzoeken conform bovenstaande uitgangspunten.

Ondergetekende weet dat hij/zij de deelname aan het onderzoek en de regeling ook na ondertekening van deze verklaring op ieder moment zonder opgave van reden kan stoppen.

Datum:	
Schip:	
Naam van de schipper*:	
Naam van de eigenaar (indien anders dan de schipper)*	
Handtekening schipper*:	

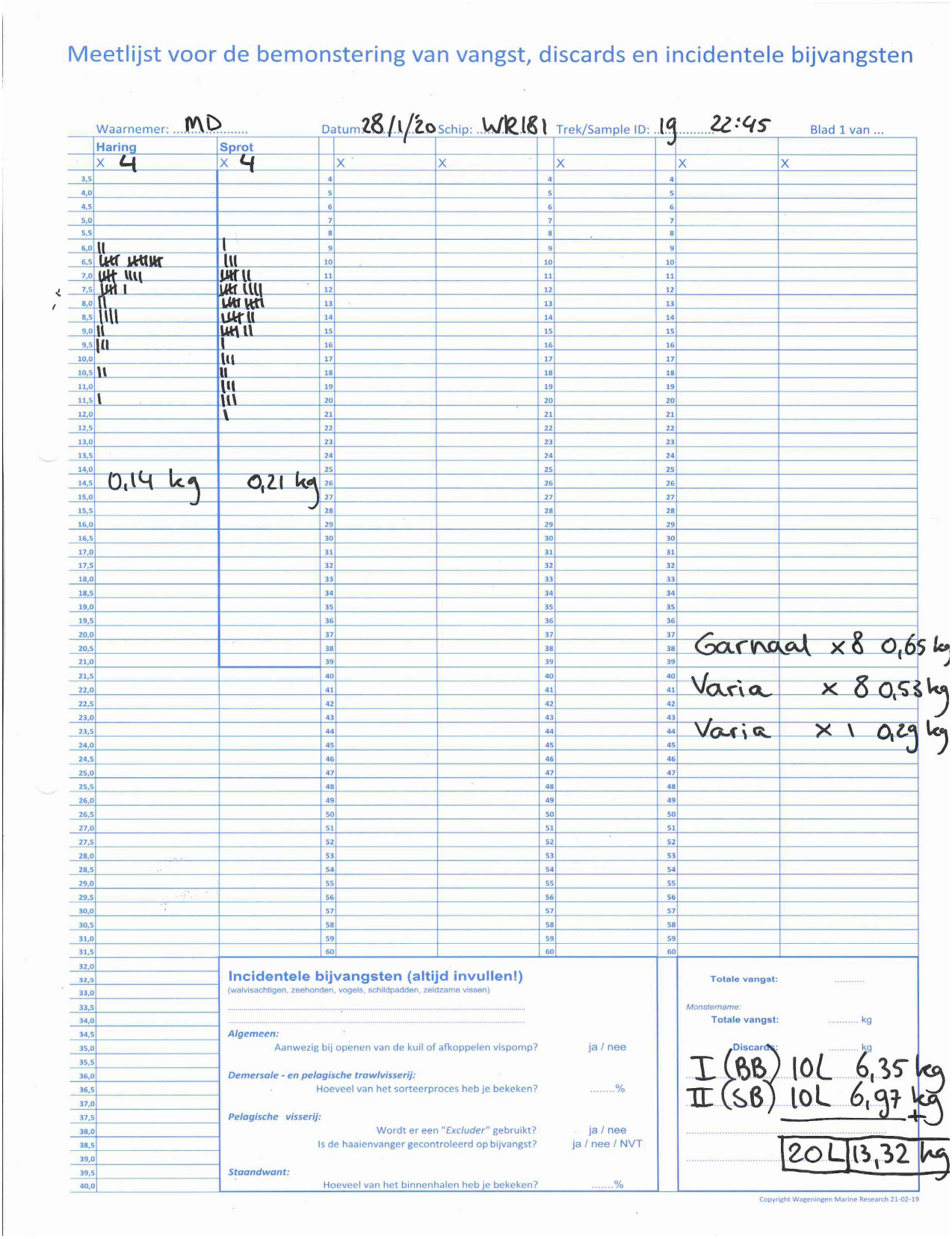
*Indien de schipper niet de eigenaar is, dienen zowel de schipper als de eigenaar te tekenen.

Trawl list

Schip	Zeeflap/ brievenbus	Maaswijdte	Haven uit		Haven in		Aanlandhaven	Visgebied	Aantal trekken
		Kuil Zeeflap	Datum	Tijd	Datum	Tijd			

Trek	Tijd zetten		Datum	Locatie zetten		Snelheid (knopen)	Wind		Water Temp (Celcius)	Tijd halen		Diepte (meter)	Volume LASTBAK (cm)	Volume LASTBAK (cm)	Totaal gekookte garnaal	Opmerkingen
	Uur	Minuut		Lat	Long		Richting	Kracht (bft)		Uur	Minuut		BB	SB	(kg)	

Appendix 4 Measuring list



Meetlijst voor de bemonstering van vangst, discards en incidentele bijvangsten

Waarnemer: MD Datum 28/1/20 Schip: WR181 Trek/Sample ID: 19 22:45 Blad 1 van ...

Haring x 4 | Sprot x 4

0,14 kg | 0,21 kg

Garnaal x8 0,65 kg
Varia x 8 0,53 kg
Varia x 1 0,29 kg

Incidentele bijvangsten (altijd invullen!)
(walvisachtigen, zeehonden, vogels, schildpadden, zeldzame vissen)

Algemeen:
Aanwezig bij openen van de kuil of afkoppelen vispomp? ja / nee

Demersale - en pelagische trawlvisserij:
Hoeveel van het sorteerproces heb je bekeken? .....%

Pelagische visserij:
Wordt er een "*Excluder*" gebruikt? ja / nee
Is de haaienvanger gecontroleerd op bijvangst? ja / nee / NVT

Staandwant:
Hoeveel van het binnenhalen heb je bekeken? .....%

Totale vangst: .....
Monstername:
Totale vangst: ..... kg
Discards: ..... kg

I (BB) 10L 6,35 kg
II (SB) 10L 6,97 kg +
20L 13,32 kg

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	Bot	Grondel
X	1	1
2		
3		
4		4
5		1
6	2	5
7	5	5
8	3	3
9	3	
10	3	
11	6	
12	2	
13	1	0,09 kg
14		
15		
16		
17	0,27 kg	
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
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53		
54		

Soorten waarvan er enkelen zijn gevangen

	Soort	cm	
x1	5 dr. meun	13/9/15	0,05 kg
x1	gew. zeedond. pad	9	0,01 kg
x1	zeenaald	11/12/17	X
x1	Smelt	14	0,01 kg
x1	koornaarsvis	8	0,01 kg
x1	Schol	6	X

Benthos - bemonstering

Soort	Aantal	X
Str. krab	15	1
kl. heremiet	6	1
gr. heremiet	6	1
Mesheft	1	1
zeester	1	1
Slangster	2	1

Soort	Aantal	X
0,25 kg		
0,01 kg		
0,01 kg		
0,01 kg		
X		
X		

Appendix 5 Sub-sampling

Because it is impossible to measure all individuals in the sample, a part of each species can be measured, this is called a subsample. A representative subsample consisting of a minimum of 50 individuals is taken as follows:

- Mix the total amount of the relevant type well in the measuring cup.
- Divide the mixture into 2 equal parts in two measuring cups.
- Discard 1 part.
- Mix the remaining part well and split into 2 equal parts.
- Continue until there are a workable number of individuals in the sample (but a **minimum of 50**).
- **Write down the sub-factor**: The sub-sample factor indicates how often the catch is split and is noted on the measurement list.

Number of times 'splitting'	**Subfactor**
1	2
2	4
3	8
4	16
etc.	etc.

Appendix 6 Self-sampling protocol on board

Trawl list

For the entire sampling trip, a form ("treklijst") is filled in for *every haul* during the fishing trip, not only those where samples are taken from. Below is a translation of the columns of that form. For every haul, note the total catch volume of each box (port side, starboard). This is done by first straightening the dry catch in the box, so the catch is equally distributed in the box. Then a measuring stick is being placed at the *deepest point* of the smoothened out and dry catch in the box. The volume (cm) is noted on the form.
It is very important that during this measurement:

- the boxes are closed
- the catch is still dry and no water has been added yet
- the catch has been smoothened out in the box as much as possible
- the measuring stick is placed at the deepest point of the catch in the box

After processing of the shrimps, please fill in the amount of shrimp landings (the weight (kg) of processed marketable shrimps) for *every haul*. In case of no scale available, give an estimation of the weight.

Please also note in the form if there are any irregularities that are good to know.

Translated column names of the "treklijst" (trawl list) to be filled in for the entire self-sampling trip.

vessel		sieve net/letterbox	mesh size		departure		arrival		harbour	fishing area	no. hauls
			sieve net	letterbox	date	time	date	time			

Translated column names of the "treklijst" (trawl list) to be filled in for the entire self-sampling trip (continued).

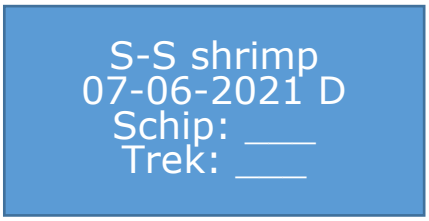
haul	time of setting haul	date	location	driving speed	wind	water temp	time of taking haul	depth	volume catch box (port side)	Volume catch box (starboard)	total volume cooked shrimps	notes

Taking samples

Choose 2 hauls during one self-sampling trip, 1 haul during day and 1 haul during night within the same area. This is done in the following way:

- Please take a 10 L sample per sampled haul of the unsorted, dry catch. With a 10 L bucket, the sample is scooped out of the catch box(s). If there is one box, 10 L are taken out from the one box. Are there more than one box, the sample is taken equally from each of the box (e.g. 5 L from the starboard, 5 L from the port side box). Please scoop out the sample from at least 3 different places in the box to ensure the sample is representative. Make sure that the bucket is completely filled; tap the bucket 10 times on the deck and fill it so that the bucket is completely full.

- The bucket is emptied into the delivered plastic bags and labelled with the date, vessel ID and haul number. Each sample is placed in a separate bag. Please label the bag with the delivered label and a *permanent marker* with project name, date, vessel and haul number (see graphic). The label is fixed on the bag with tie-wraps.



- Please store the bags in a box with ice and inform the WMR personnel via WhatsApp for pick-up of the sample.

For questions and remarks about the self-sampling, please contact:
Name Surname (mobile number, email address).

Appendix 7 Measuring the container of the vessel

This is done in case a new ship is added to the research fleet where the container ('lastbak') has not yet been measured. It is important that all sides, depths and edges of the box are measured. This will take some time and perhaps an extra pair of hands from a crew member.

Step 1: take pictures
Take photos from all angles, sides and the top view.

Step 2: outline the box
Make a sketch of each side (including the top) of the box. Try to draw in the course of the box as best as possible.

Step 3: measurements
Write the measurements in mm on the sketch made for each side. Sometimes it happens that several oblique surfaces are welded into the box with different depths. Try to measure this as best you can and write it down in your sketch.

Step 4: scan
Scan the sketches with measurements and put them together with the photos at the following location:

W:\IMARES\DATA\Shrimp_BijvProg_202101006\4. Data and Analysis\last_bakken

Step 5: communicate
Inform the project coordinator that this is ready.

Appendix 8 List of species in the bycatch

*Table 8.1 - Bycatch of registered species or species groups caught in the self-sampling program 2021-2023. Species are divided in categories and within these sorted by frequency of occurrence (high to low) in the sampled hauls (in total 274). *Mean weight per hour and numbers per hour are given for hauls where the species occurred.*

Category	Scientific name	English name	Dutch name	Occurrence %	Mean weight (g) per hour trawling*	Mean numbers per hour trawling*	National red list	N2000 species
TAC fish	*Pleuronectes platessa*	Plaice	Schol	93.8	7129.9	2032.9		
	Clupea harengus	Herring	Haring	79.6	4182.4	1408.6		
	Merlangius merlangus	Whiting	Wijting	62.0	9736.4	408.3		
	Sprattus sprattus	Sprat	Sprot	52.2	6582.0	731.4		
	Solea solea	Sole	Tong	21.2	2159.6	137.2		
	Ammodytes sp.	Sandeels	Zandspieringen indet.	16.4	334.3	113.6		
	Hyperoplus lanceolatus	Greater sand-eel	Smelt	8.4	1009.1	34.7		
	Microstomus kitt	Lemon sole	Tongschar	8.4	469.7	68.1		
	Engraulis encrasicolus	Anchovy	Ansjovis	2.2	668.0	45.2	VU	
	Scomber scombrus	Mackerel	Makreel	1.8	2631.3	31.6		
	Scophthalmus maximus	Turbot	Tarbot	1.8	294.7	27.0		
	Gadus morhua	Cod	Kabeljauw	1.1	5495.2	96.4		
	Trachurus trachurus	Horse mackerel	Horsmakreel	1.1	688.0	31.0		
	Scophthalmus rhombus	Brill	Griet	0.4	5.7	2.9		
Other fish (ETP)	*Alosa fallax*	Twaite shad	Fint	1.1	364.7	9.2	Disappeared as spawning species	H1103
	Lampetra fluviatilis	River lamprey	Rivierprik	1.1	466.7	8.3		H1099
	Coregonus oxyrinchus	Houting	Noordzeehouting	0.4	2109.8	49.1	NT	
	Raja clavata	Thornback ray	Stekelrog	0.4	267.5	17.8	VU	
Other fish - gobies	*Pomatoschistus sp.*	Goby lei	Grondels indet.	66.4	2918.3	1105.3		
	Pomatoschistus lozanoi/minutus	Sand goby complex	P. lozanoi/minutus	22.3	1531.7	607.0		
	Neogobius melanostomus	Round goby	Zwartbekgrondel	6.9	1473.7	175.1		
	Aphia minuta	Transparent goby	Glasgrondel	0.7	38.7	26.9		
	Pomatoschistus microps	Common goby	Brakwatergrondel	0.7	37.5	14.4		
Other fish	*Limanda limanda*	Dab	Schar	65.0	7452.2	502.5		
	Osmerus eperlanus	Smelt	Spiering	43.4	2828.8	644.9		
	Myoxocephalus scorpius	Bull-rout	Zeedonderpad	38.3	2791.3	242.0		
	Agonus cataphractus	Hooknose	Harnasmannetje	35.0	894.3	196.5		
	Platichthys flesus	Flounder	Bot	28.5	4122.0	210.0		
	Callionymus lyra	Dragonet	Pitvis	21.5	608.5	109.7		
	Ciliata mustela	Five-bearded rockling	Vijfdradige meun	21.5	1330.4	59.7		
	Syngnathus	Seaweed pipefishes	Zeenaalden indet.	18.6	125.2	169.3		

Category	Scientific name	English name	Dutch name	Occurrence %	Mean weight (g) per hour trawling*	Mean numbers per hour trawling*	National red list	N2000 species
Other fish (cont.)	*Arnoglossus laterna*	Scaldfish	Schurftvis	14.2	475.4	56.8		
	Syngnathus acus	Greater pipefish	Grote zeenaald	13.9	320.3	154.1		
	Buglossidium luteum	Solenette	Dwergtong	10.6	763.2	111.5		
	Pholis gunnellus	Butterfish	Botervis	9.9	286.7	36.9	VU	
	Dicentrarchus labrax	Sea bass	Zeebaars	9.5	869.1	91.7		
	Trisopterus luscus	Bib	Steenbolk	7.7	3603.9	273.9		
	Syngnathus rostellatus	Nilssons pipefish	Kleine zeenaald	7.3	42.5	63.5		
	Liparis liparis liparis	Sea-snail	Slakdolf	6.9	608.6	44.7		
	Callionymus reticulatus	Reticulated dragonet	Rasterpitvis	6.6	221.9	40.9		
	Zoarces viviparus	Viviparous blenny	Puitaal	5.1	2037.9	108.2		
	Gasterosteus aculeatus	Stickleback	Driedoornige stekelbaars	4.7	216.5	82.1		
	Atherina presbyter	Sand-smelt	Grote koornaarvis	3.3	531.2	68.9	EN	
	Atherina		Koornaarvissen indet.	2.2	446.5	48.6		
	Mullus surmuletus	Striped red mullet	Mul	2.2	1915.7	46.5		
	Chelidonichthys lucerna	Tub gurnard	Rode poon	1.1	1467.9	79.6		
	Echiichthys vipera	Lesser weever	Kleine pieterman	1.1	200.5	11.9		
	Eutrigla gurnardus	Grey gurnard	Grauwe poon	1.1	191.3	39.8		
	Sardina pilchardus	Pilchard	Pelser	1.5	6226.6	1101.3		
	Taurulus bubalis	Sea scorpion	Groene zeedonderpad	1.1	818.8	56.9		
	Gaidropsarus vulgaris	Three-bearded rockling	Driedradige meun	0.7	1590.3	77.6	VU	
	Gymnocephalus cernua	Ruffe	Pos	0.7	206.4	51.3		
	Liparis liparis	Shanny	Slijmvis	0.7	151.4	19.6		
	Perca fluviatilis	Perch	Baars	0.7	315.6	31.8		
	Anarhichas lupus	Wolffish	Zeewolf	0.4	83.4	27.8		
	Callionymus maculatus	Spotted dragonet	Gevlekte pitvis	0.4	152.3	15.2		
	Hippoglossoides platessoides	Long rough dab	Lange schar	0.4	34.0	34.0		
	Liza ramada	Thin-lipped grey mullet	Dunlipharder	0.4	5730.0	191.0		
	Rutilus rutilus	Roach	Blankvoorn	0.4	153.9	26.5		
Benthos – squids and cuttlefish	*Allateuthis subulata*	European common squid	Dwergpijlinktvis	8.8	858.0	116.4		
	Sepiola	Bobtail squid nei	Dwerginktvissen indet.	2.9	185.8	62.0		
	Sepiola atlantica	Atlantic bobtail squid	Dwerginktvis	1.8	220.2	189.6		
	Loligo vulgaris	European squid	Gewone pijlinktvis	1.5	3328.3	32.8		
	Sepia	Cuttlefish nei	Sepia	1.5	64.0	19.8		

Category	Scientific name	English name	Dutch name	Occurrence %	Mean weight (g) per hour trawling*	Mean numbers per hour trawling*	National red list	N2000 species
Benthos – squids and cuttlefish (cont.)	*Alloteuthis*	Common squids	Alloteuthis sp.	0.7	146.7	33.6		
	Loligo	Squid nei	Langvinpijlinktvissen indet.	0.4	112.6	64.4		
Benthos - polychaetes	*Alitta virens*	King ragworm	Zager	0.4		43.6		
	Aphrodita aculeata	Sea mouse	Fluwelen zeemuis	0.4		124.8		
	Lanice conchilega	Sand mason	Zandkokerworm	0.4		22.1		
Benthos - jellyfish	*Anthozoa*	Anthozoans	Zeeanemonen	12.0		364.9		
	Rhizostoma pulmo	Barrel jellyfish	Zeepaddestoel	1.5		59.6		
	Scyphozoa	Cup animals	Kwallen	1.1				
	Cyanea lamarckii	Blue jellyfish	Blauwe haarkwal	0.4				
	Pleurobrachiidae	Sea goosberry	Ribkwallen indet.	0.4				
Benthos - gastropods	*Euspira catena*	European necklace shell	Grote tepelhoorn	2.9		39.1		
	Nassarius reticulatus	Netted dog whelk	Gevlochten fuikhoorn	2.9		645.2		
	Euspira nitida	Alder's necklace shell	Glanzende tepelhoorn	1.1		14.6		
	Nassarius	Dog whelks	Fuikhoorns indet.	1.1		18.9		
	Crepidula fornicata	American slipper limpet	Muiltje	0.7		102.0		
	Nassarius nitidus	Nassa snail	Grof geribde fuikhoorn	0.7		112.4		
	Natica	Moon snail nei	Tepelhoorns indet.	0.7		16.8		
	Buccinum undatum	Whelk	Wulk	0.4		17.8		
Benthos - echinoderms	*Asterias rubens*	Starfish	Zeester	60.6		492.4		
	Ophiura ophiura	Serpent star	Slangster	56.6		3141.1		
	Ophiura albida	Brittlestar	Kleine slangster	18.2		2023.2		
	Psammechinus miliaris	Green sea urchin	Zeeappel	7.3		87.2		
	Astropecten irregularis	Sand star	Kamster	4.0		27.7		
	Echinocardium cordatum	Heart-urchin	Hartegel	1.5		75.1		
	Spatangus purpureus	Purple heart urchin	Purperen zeeklit	0.4		190.5		
Benthos - crustaceans	*Liocarcinus holsatus*	Common swimming crab	Gewone zwemkrab	58.0		5114.4		
	Carcinus maenas	Green crab	Strandkrab	51.1		898.7		
	Pagurus bernhardus	Bernhard's hermit crab	Gewone heremietkreeft	30.7		80.9		
	Diogenes pugilator	Roux's hermit crab	Kleine heremietkreeft	11.7		129.6		
	Pagurus	Hermit crab nei	Heremietkreeften indet.	0.4		40.7		

Category	Scientific name	English name	Dutch name	Occurrence %	Mean weight (g) per hour trawling*	Mean numbers per hour trawling*	National red list	N2000 species
Benthos – crustaceans (cont.)	*Liocarcinus vernalis*	Grey swimming crab	Grijze zwemkrab	8.4		3278.4		
	Macropodia rostrata	Long legged spider crab	Hooiwagenkrab	8.4		62.2		
	Liocarcinus	Swimming crab nei	Zwemkrabben indet.	6.9				
	Liocarcinus navigator	Arch-fronted swimming crab	Gewimperde zwemkrab	6.9		189.1		
	Liocarcinus depurator	Blue-leg swimcrab	Blauwpootzwemkrab	6.6		172.2		
	Corystes cassivelaunus	Helmet crab	Helmkrab	3.3		16.6		
	Liocarcinus marmoreus	Marbled swimming crab	Gemarmerde zwemkrab	2.2		456.3		
	Necora puber	Velvet swimcrab	Fluwelen zwemkrab	1.8		96.4		
	Cancer pagurus	Edible crab	Noordzeekrab	0.7	130.6	19.6		
	Hemigrapsus penicillatus	Common Japanese intertidal crab	Penseelkrab	0.7		29.0		
	Callinectes sapidus	Blue crab	Blauwe zwemkrab	0.4		18.7		
	Cladocera	Cladocerans	Watervlooien	0.4		19.8		
	Inachus	Anemone spider crab	Langpootspinkrab	0.4		77.1		
	Thia scutellata	Polished crab	Nagelkrab	0.4		55.0		
Benthos - bivalves	*Mytilus edulis*	Common mussel	Mossel	14.2		1343.1		
	Spisula subtruncata	Cut surfclam	Halfgeknotte strandschelp	11.7		784.5		
	Ensis	Razor shell	Zwaardschedes indet.	11.3		861.4		
	Limecola balthica	Baltic macoma	Nonnetje	4.4		1150.7		
	Spisula	Surf clams	Strandschelpen indet.	4.0		258.5		
	Cerastoderma edule	Common cockle	Kokkel	3.6		264.5		
	Abra alba	White abra	Witte dunschaal	3.3		117.5		
	Ensis siliqua	Giant razor clam	Tafelmesheft	1.8		15.4		
	Mactra stultorum	Rayed trough clam	Grote strandschelp	1.5		28.3		
	Venerupis corrugata	Pullet carpet shell	Tapijtschelp	1.5		24.7		
	Petricolaria pholadiformis	American piddock	Amerikaanse boormossel	1.1		140.3		
	Chamelea striatula	Striped venus	Venusschelp	0.7		100.0		
	Donax vittatus	Banded donax	Zaagje	0.7		28.9		
	Ensis leei	Atlantic jackknife clam	Amerikaanse zwaardschede	0.7		93.1		
	Fabulina fabula	Bean-like tellin	Rechtsgestreepte platschelp	0.7		30.5		

Category	Scientific name	English name	Dutch name	Occurrence %	Mean weight (g) per hour trawling*	Mean numbers per hour trawling*	National red list	N2000 species
Benthos – bivalves (cont.)	*Macomangulus tenuis*	Petal tellin	Tere platschelp	0.7		18.5		
	Spisula solida	Solid surf clam	Stevige strandschelp	0.7		16.1		
	Barnea candida	White piddock	Witte boormossel	0.4		16.1		
	Crassostrea gigas	Giant cupped oyster	Japanse Oester	0.4		8.8		
	Donax	Wedge shell	Donax	0.4		18.7		
	Lutraria lutraria	Common otter clam	Otterschelp	0.4		77.1		
	Pholadidae	Piddocks	Boormossels indet.	0.4		53.7		
	Ascidiacea	Sea squirts	Zakpijp	1.8		164.6		

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With knowledge, independent scientific research and advice, **Wageningen Marine Research** substantially contributes to more sustainable and more careful management, use and protection of natural riches in marine, coastal and freshwater areas.