Full Catch Monitoring in the Dutch Norway lobster fishery (2018-2020)

Results of a science-industry partnership to improve information for *Nephrops norvegicus* stock assessment

Author(s): Katinka Bleeker[1], Tom Bangma[1], Harriet van Overzee[1], Chun Chen[1], Wouter van Broekhoven[2], David Ras[2], Emma de Boer[3], Brita Trapman[3], Nathalie A. Steins[1]

Wageningen University & Research report C044/21

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Wageningen Marine Research
Yerseke, April 21, 2021

Wageningen Marine Research report C044/21

WAGENINGEN
UNIVERSITY & RESEARCH

Keywords: *Nephrops norvegicus*, Norway lobster, North Sea, catch monitoring, science-industry research collaboration, North Sea, fisheries management

Date April 21, 2021

Client: Rijksdienst voor Ondernemend Nederland
Attn.: A.P.M. Vaessen
Postbus 93144
2509, AC Den Haag

European Union, European Maritime and Fisheries Fund (EMFF)

This report can be downloaded for free from https://doi.org/10.18174/545755
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Photo cover: Pieke Molenaar

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Acknowledgements

We would like to thank the skippers, owners and crews of the participating fishing vessels for their active participation in the project. Installation of equipment, self-sampling, measuring nephrops and keeping trip records had to be done on top of regular fishing activities. We also thank staff of "Visserijbedrijf Van Malsen", "VOF Gebroeders Kaij" and Wageningen Marine Research, who contributed to data collection and data management. In particular we would like to credit former Wageningen Marine Research colleagues Ruben Verkempynck, who was instrumental in setting up this project, and Pieke Molenaar for technical assistance on discards valves and load cells. "Pat Kruger BV", supplier of the load cells, provided good customer support. We thank the civil servants who granted the necessary derogations to make the data collection programme possible. We thank ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) for their feedback throughout the duration of the project.

This project was funded under a science-fisheries partnership grant (*Partnerschappen Wetenschap en Visserij*) under the Dutch Operational Programme of the European Maritime and Fisheries Fund.

Summary

The full catch monitoring in the Dutch Norway lobster fishery was part of a science-industry research collaboration project (*Onderzoekssamenwerking 2.0*) and aimed to improve data for the stock assessments of Norway lobster stocks. The International Council for the Exploration of the Seas (ICES) has divided the discrete patches of mud Norway lobster inhabit into so-called Functional Units (FUs). The Dutch fishery for Norway lobster mainly takes place in FU5, FU33 and outside FUs (outFU). The ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) has expressed concerns about data limitations, including lack of representative discards data in FU33. This project was set up to address these issues. To improve data for Norway lobster stock assessments, the project comprised of three phases: 1. Development of a Fully Catch-Monitored system (FCM), 2. Implementation of the FCM scheme by a reference fleet and 3. Data analysis and reporting including data sharing with ICES WGNSSK.

The FCM system comprised of so-called load cells, installed to measure the total catch of a haul. In addition, the reference fleet participates in a self-sampling scheme in which discard samples 80 kg are taken from two hauls during a fishing trip. A sample of approximately 5 kg of Norway lobster landings is taken from these same hauls for length measurements. The self-sampling scheme is validated with observer trips.

The reference fleet (2018-2020) consisted of three vessels. In 2019 two observer trips were executed and one in 2020. Due to COVID-19 restrictions, more observer trips were not possible. A total of 34 self-sampling trips have been carried out (12 in 2019 and 22 in 2020). The collected data provides valuable insight in catch composition, including in the length-frequency distribution, and fishing effort of the reference fleet in regard to the FUs. WGNSSK has raised some concerns about how representative participating vessels are for Dutch fishing effort on nephrops, as they are Dutch owned but foreign flagged. While skippers believe that in a 'regular year' (no COVID-19, no temporary Brexit quota) there are no differences, the question whether or not the current reference fleet is a good representation of the Dutch Norway lobster fishing fleet warrants further investigation. The full catch monitoring in the Dutch Norway lobster fishery will be continued in a follow-up programme in which outcomes of the current project will be taken into consideration. This includes expansion of the current reference fleet with three Dutch registered vessels.

The research collaboration also provides an opportunity for improved exchanges with nephrops fishers on developments in the fishery and how these affect landings. This is of particular importance to current assessments as they rely heavily on landings data. The skippers pointed out that fishing effort on nephrops, and hence catch composition and landings in 2020 was influenced by COVID-19 and by the temporary Brexit quota allocations.

This project was funded under a science-fisheries partnership grant (*Partnerschappen Wetenschap en Visserij*) under the Dutch Operational Programme of the European Maritime and Fisheries Fund.

Samenvatting

Het project vangstmonitoring in de Nederlandse Noorse kreeft visserij was onderdeel van het wetenschaps-industrie onderzoekssamenwerking project (*Onderzoekssamenwerking 2.0*) en had als doel het verbeteren van bestandsschattingen van Noorse kreeft populaties. De Internationale Raad voor het Onderzoek van de zee (ICES) heeft de discrete modder patches welke Noorse kreeft bewonen ingedeeld in zogenoemde 'Functional Units' (FUs). Hoewel ICES een apart advies geeft over de visserij in deze FUs, worden ze gemanaged als één stock en is er één totaal toegestane vangst (TAC) voor alle FUs samen. De Nederlandse visserij op Noorse kreeft vindt voornamelijk plaats in FU5, FU33 en buiten deze FUs (outFU). De ICES werkgroep Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) heeft bezorgdheid geuit over het ontbreken van representatieve gegevens over discards, met name in FU33. Dit project is gericht op het verbeteren van de Noorse kreeft bestandschattingen en bestond uit drie fases: 1. Ontwikkeling van een vangstmonitoring system (FCM), 2. Implementatie van het FCM-systeem door een referentie vloot, en 3. Data analyse en rapportage, inclusief het aanleveren van deze data aan WGNSSK.

Het FCM-systeem bestond uit zogenaamde loadcellen, die werden geïnstalleerd om de totale vangst van een trek te meten. Daarnaast neemt de referentievloot deel aan een zelf-bemonstering programma waarbij zij van twee trekken een discardmonster nemen van 80 kg en een monster van ongeveer 5 kg van de Noorse kreeft aanvoer waarvan lengte gegevens worden gemeten. Het zelf-bemonsteringsprogramma wordt gevalideerd aan de hand van waarnemersreizen.

De referentievloot (2018-2020) bestond uit drie schepen. In 2019 zijn er twee waarnemersreizen uitgevoerd en in 2020 één. Vanwege COVID-19 maatregelen was het niet mogelijk om in 2020 meer waarnemersreizen uit te voeren. In totaal zijn er 34 zelf-bemonsteringsreizen geweest (12 in 2019 en 22 in 2020). The verzamelde gegevens geven een waardevol inzicht in de vangstsamenstelling, onder meer in de lengte-frequentie verdeling en de visserij-inspanning van de referentievloot met betrekking tot de verschillende FUs. WGNSSK heeft enige bezorgdheid geuit over de representativiteit van de referentievloot voor de Nederlandse Noorse kreeft visserij, aangezien de referentievloot bestaat uit Nederlandse schippers met buitenlands gevlagde schepen. Hoewel de schippers menen dat er in een 'regulier jaar' (geen COVID-19, geen tijdelijk Brexit-quotum) geen verschillen zijn, is er meer onderzoek nodig om te bepalen of de referentievloot een goede weergave is van de Nederlandse Noorse kreeft vloot. Het vangstmonitoring project van de Nederlandse Noorse kreeft visserij zal worden voortgezet in een vervolgproject waarin de uitkomsten van het huidige project worden meegewogen. Dit is inclusief een uitbreiding van de huidige referentievloot met drie Nederlands gevlagde schepen.

De onderzoekssamenwerking biedt ook de mogelijkheid voor betere uitwisselingen met Noorse kreeft vissers over ontwikkelingen in de visserij en hoe deze de aanvoer beïnvloeden. Dit is met name van belang voor de huidige bestandschattingen, aangezien deze sterk afhankelijk zijn van aanvoer data. De schippers wezen erop dat de visserij-inspanning op Noorse kreeft, en daarmee de vangsamenstelling en aanvoer in 2020 werd beïnvloed door COVID-19 en door de tijdelijke Brexit-quota.

Dit project werd gefinancierd door een samenwerkingssubsidie tussen wetenschape en visserij (Partnerschappen Wetenschap en Visserij) in het kader van het Nederlandse operationele programma van het Europees Fonds voor Maritieme Zaken en Visserij

1 Introduction

1.1 Background

The marine decapod crustacean Norway lobster (*Nephrops norvegicus*) is becoming of increasing importance to the Dutch demersal North Sea fleet. The species distribution is limited to muddy habitats as they require specific sediment compositions (silt and clay content) to excavate their burrows. As such, the sediment distribution in the North Sea determines the distribution of Norway lobster. The International Council for the Exploration of the Seas (ICES) has divided the discrete patches of mud Norway lobster inhabit into so-called Functional Units (FUs) (Figure 1).

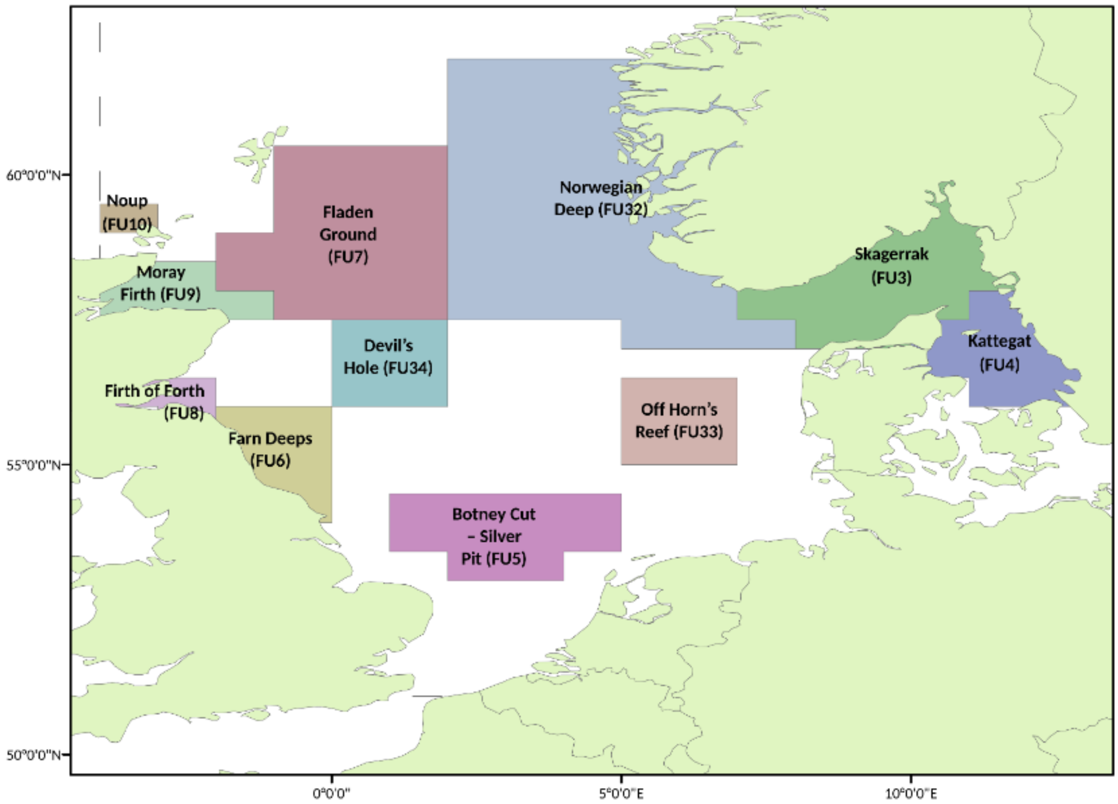

Figure 1: *Norway lobster Functional Units (FUs) in the Greater North Sea Ecoregion. Areas outside these FUs are defined as outFU. Source: ICES, 2018a.*

The Dutch fishery for Norway lobster mainly takes place in FU5 and FU33, and outside FUs (outFU). In the ICES stock assessments, Norway lobster stocks in FU5 and FU33 are currently classified as a data limited stock (DLS) in accordance with ICES category 4 stocks (ICES , 2018a; ICES, 2018b). This means that the stock assessment is based on landings data (total and average weights per length class). Consequently, ICES provides advice for these FUs based on the precautionary principle.
The ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) has expressed concerns about data limitations, including lack of representative discards data in FU33 (ICES, 2018b).

While ICES provides advice on fishing opportunities for each FU separately with the objective of sustainable stock exploitation, all Norway lobster stocks in the North Sea are managed as one, i.e., there is one Total Allowable Catch (TAC) for all FUs combined. This allows fishers to offset the fishing options for a Norway lobster stock from a FU that is in worse shape with a stock from another FU that is doing better. However, it should not be ruled out that in the future Norway lobster stocks might be managed separately. In order to achieve better management of Norway lobster stocks in FUs 5, FU 33 and outFU, improvements of the knowledge base and the stock assessments are needed. Therefore, within this project a consortium of Wageningen Marine Research (WMR) and the Dutch science-industry Norway lobster partnership set out to improve data collection in these FUs by developing a state-of-the-art full catch monitoring system.

1.2 The Dutch fishery for Norway lobster

The Dutch Norway lobster fishery is relatively young and geographically concentrated compared to the traditional flatfish fishery. Fishing activities mainly take place in FU5 (Botney Cut), FU33 (Off Horn's Reef) and outside the FUs in the North Sea (outFU) (Figure 1). The targeted Dutch fishery for Norway lobster developed from the early 2000s. Approximately 20 Dutch registered vessels target Norway lobster using otter-trawls, deploying either 4 nets (quadrig) or 6 nets (multi-rig) (Molenaar et al., 2016). In addition, a number of Dutch owned foreign flagged (so-called flag vessels) target Norway lobster. Furthermore, Norway lobster is a commercial by-catch in the flatfish fishery.

The Norway lobster fishery shows a seasonal pattern, with the majority of catches landed in the months July to September (Van der Hammen & Steenbergen, 2011). By-catches of Norway lobster in the other (non-targeted) fleet segments can, however, be significant. The European minimum conservation reference size (MCRS) for Norway lobster is 25 mm carapace length. Because of quota limitations, and with the objectives of sustainable management and preventing early closures of the fishery, the joint Dutch producer organizations (POs) agreed that landing and selling of Norway lobster of over 35 individuals per kilo was prohibited for PO members. In effect, this implied that the landing size in the fishery under Dutch registration increased to approximately 32 mm carapace length (Molenaar *et al.*, 2016a). This larger "PO market size" resulted in higher discard ratios of Norway lobster. Following the introduction of the European landing obligation in 2016, this PO market measure is no longer applicable. As a result, a discontinuity in the trends for the catch data of the fleet under Dutch registration - more specifically in the discard data - has become visible since the introduction of the landing obligation. In addition, adjustments have recently been made to incentivise selectivity and reduce discards in the fishing fleet. In this context, a better understanding of Norway lobster landings and discards in the segments of fleet that catch this species (targeted and as by-catch) is urgently needed. This is also advised by ICES (ICES, 2018b).

1.3 Dutch science-industry partnership Norway lobster

In 2018, we successfully submitted a science-industry research collaboration project proposal (*Onderzoekssamenwerking 2.0*) under the European Fund for Maritime Affairs and Fisheries (EMFF). The project consortium comprises Wageningen Marine Research (WMR), the main fisheries organisations (Nederlandse Vissersbond, VisNed, Redersvereniging voor de Zeevisserij), the environmental NGO Stichting de Noordzee, and the educational NGO ProSea. This partnership included the development of a catch monitoring system for Norway lobster to improve data for the stock assessments of FU5, FU33 and outFU.

The Norway lobster science-industry partnership comprised of three phases:

1. Development of a Fully Catch-Monitored System (FCM): designing a sound monitoring scheme (self-sampling with validation by scientific on-board observers), developing and selecting equipment that makes it possible to measure the different catch fractions (i.e. total catch, landings, and discards) on board , and selection of vessels for the reference fleet.

2. Implementation FCM scheme by a reference fleet: research license application, training of crew, coordination of self-sampling, analysis of samples, validation, and data base management.
3. Data analysis and reporting including data sharing with ICES Working Group on the Assessment of demersal stocks in the North Sea and Skagerrak (WGNSSK).

This report presents the results of the Dutch Norway lobster science-fishery partnership (2018-2020). The partnership is currently continued in a follow-up project (*OSW 2.2 Noorse kreeft*).

2 Methods

2.1 Introduction

The Dutch Norway lobster science-industry partnership (2018-2020) has three phases:

1. Development of a Fully Catch-Monitored System (FCM).
2. Implementation FCM scheme by a reference fleet.
3. Data analysis and reporting.

In this chapter, we present information on all three stages. For stage 3, we present the methodology for data analysis and feedback from reporting to the ICES Working Group on the Assessment of demersal stocks in the North Sea and Skagerrak (WGNSSK). We present the results of the analysis in Chapter 3.

2.2 Phase 1: Development of a FCM system

2.2.1 Selection of equipment

The initial objective of phase 1 was to develop a FCM system based on a combination of so-called discards valves and load cells. A discard valve automatically and accurately weighs all discard quantities falling through the discarding chute on board of a vessel (Molenaar et al., 2016b), while a load cell is a weighing system measuring the weight of the cod-end before the catch is released for processing (see 2.2.2). Using a discard valve system results in more accurate measurements of discard amounts in the demersal fisheries. In combination with a load cell measuring device, and the landings data of the vessels, discards ratios can be accurately determined.

The installation of discards valves on Norway lobster vessels proved, however, to be difficult. Set up of the conveyer belt and discarding chute differs (chutes are too small for discard valves) from those on the larger flatfish vessels for which the discards valves prototypes were developed (Molenaar et al., 2016). Furthermore, while the prototypes worked in the lab, practical operation on board the larger flatfish vessels proved to be a considerable challenge and required a longer development period than anticipated. It was decided not to pursue the use of discards valves as part of the Norway lobster FCM system, but focus on discards self-sampling (see 2.2.3) in combination with load cells for measuring weight of the total catch (see 2.2.2).

2.2.2 Description of the load cell system

Load cells were implemented to measure the total catch of a haul. The weight of the total catch measured by the load cells minus the weight of the landed catch gives an estimate of the total discards weight, including non-organic materials such as water, stones and sand.

The load cell weighing system has been developed by the firm “Pat Kruger” to perform vessel motion-compensated weight measurements at sea on board of fishing vessels. The system consists of two stainless steel traction load cells, a swell compensator and a control console installed on the bridge. After installation on board, each load cell was calibrated by "Pat Kruger" with a water bag filled with 2000 litres water. The load cells have a weighing capacity up to 7 tons. If weights greater than 7 tons are applied, the system needs to be recalibrated because the measuring elastic material in the load cell can be stretched, causing deviating measurements. In this project, weights have not exceeded 7 tons and recalibration of the system has not been necessary.

Figure 4: *Load cell with safety plates mounted between mast and jumper block. Photo: Tom Bangma*

Figure 2: *Console with pre selection "portside" before weighing. Photo: Tom Bangma*

Figure 3: *Load cells with safety plates. Photo: Pat Kruger*

The load cells are mounted between the jumper block and the mast at each side (Figure 2). When the cod-end is attached to the jumper rope, it is lifted up from the water through the jumper block. This results in the full weight of the cod-end hanging under the loadcell. When the cod-end hangs free above the load box, the weighing can be started. To carry out a weighing, the skipper selects the side before activating the weighing (Figure 3).

The weighing takes 10-15 seconds. In this period the system takes several measurements and compensates for the sea swells and partially for the water running out of the cod-end. Performing this process while the cod-end is hanging free under the load cell is critical to ensure an accurate weighing. The total catch measurement will be compensated afterwards by subtracting the "wet" weight of the cod-end itself. All measurements performed are stored on an internal hard drive that can be read by a pre-installed USB device.

During the trials with the initial system, we experienced some safety problems with the load cells. Therefore, in order to ensure safety onboard, the load cells were secured by mounting extra safety plates on each side (Figure 4). All load cells are checked and tested with a traction force of 7 tons. Before installing with safety plates, all plates are checked and delivered with test reports to ensure safety. In addition to the safety plates, the software was adjusted to take automatic measurements when the system detects a higher force than 5 tons.

2.2.3 Self-sampling procedure

Self-sampling by the participating vessels covers three activities: (1) Collecting operational- and catch data per haul, (2) taking discards samples of two separate hauls for further analysis onshore, and (3) from those same hauls, taking a sample of Norway lobster landings (approximately 5 kg per haul) for measuring carapace length for both sexes.

During a self-sampling trip, the skipper registers the following operational data of each haul: (a) the total weight of unsorted catch (measured by the load cells), (b) the weight in kilograms of marketable fish per species (landings), (c) geographical position data, (d) fishing time, and (e) environmental variables such as wind direction and force.

The skipper selects two separate hauls (one during daytime and one during night-time) from which a discards sample of 80 kilograms is taken. The discards are collected at the discards chute situated at the end of the conveyer belt where the discards are released overboard after the crew sorted all of the marketable catch. At the start of catch processing, species composition on the conveyer belt is different than towards the end of the processing; when processing starts relatively more larger fish are found on the conveyer belt then towards the end (Aarts *et al.,* 2009). To account for this, the sample is collected in four separate bags of ± 20 kg discards, distributed over the time required for catch processing. These bags are labelled and kept in the cold store (± 7ºC). This sampling procedure is to a large extent similar to the procedure used in the Dutch demersal discards self-sampling programme that is carried out under the European Data Collection Framework (DCF) (van Overzee *et al.,* 2020). In addition, 5 kg of unsorted marketable Norway lobsters are collected randomly from the conveyer belt and up to 50 individuals of each sex are measured for carapace length (Figure 5) and weighed. The landings samples are taken from the same hauls as the discard samples. Back at port, the collected discard samples are promptly collected by WMR staff and taken to the laboratory for further analysis. All participants received a protocol with a detailed description of the self-sampling procedure.

All vessels receive a remuneration for samples that are supplied in accordance with the protocol.

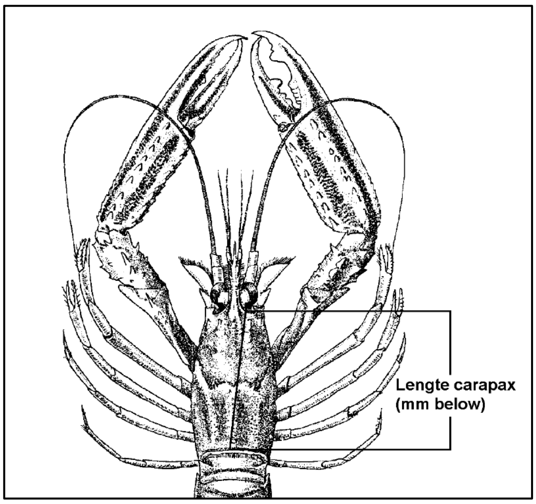

Figure 5: *Outline of length carapace*

2.2.4 Self-sampling scheme

Based on Norway lobster data collected in the Dutch demersal discards self-sampling programme (DCF), we carried out a power analysis to design a sampling scheme for the current programme (OSW 2.0). We used this power analysis to examine the number of ships, trips and hauls to be sampled per trip to get an estimate of Norway lobster discards and landings with an appropriate acceptable coefficient of variation (CV). We used a CV of 40% for discards and 20% for landings. Due to our project being bounded to purchasing and deploying the load cells the number of participating vessels was limited to three. The power analysis showed two options: 1) Each vessel samples four hauls per trip and a total of three trips per quarter, or 2) each vessel samples two hauls per trip and a total of five trips per quarter. Option 2 was chosen to optimize the coverage of sampled trips in both space and time.

2.2.5 Validation of self-sampling

To validate the data from the self-sampling programme scientific observer trips were carried out. This is similar to the validation procedure used in the Dutch discards self-sampling programme under the European DCF.

During an observer trip, trained scientific observers join the fishing vessel to sample as many hauls as possible during a fishing trip. The fishing crew will perform self-sampling during this trip, following the same procedure as during the regular self-sampling trips. The observer and self-sampling data are compared in order to validate the accuracy of the self-sampling data. Experiences in the DCF programme show that these trips are also important for training and motivating crew members in sampling discards (van Overzee *et al.,* 2020) and measuring Norway lobster landings.
A total of 8 observer trips were planned over the period 2019-2020. Due delays in the start of sampling and the COVID-19 pandemic, In practice, we could only carry out 2 observer trips in 2019 and 1 observer trip in 2020. At the start of the pandemic observers from WMR were not allowed to join any commercial fishing vessel. Since then, WMR developed COVID-19 protocols. In practice, however, the relatively small Norway lobster vessels do not meet the criteria that are set in the WMR COVID-19 protocol for commercial vessels, which include private sleeping quarters for observers. Consequently, we have not been able to carry out observer trips onboard the participating vessels since the outbreak of the pandemic and the extent to which the self-sampling data can be validated is currently restricted to the 3 trips carried out. COVID-19 notwithstanding, we plan to intensify observer trips as part of data collection in the follow-up project *OSW 2.2* (2021-2023).

2.2.6 Selection of participating vessels

We used 7 criteria to select the Norway lobster vessels participating in this project:

1. Vessel targets Norway lobster fulltime.
2. Vessel fishes in FU5 and FU33.
3. It is physically possible to install the load cells onboard the vessel.
4. Crew of the vessel is motivated to carry out the self-sampling and measurements of Norway lobster.
5. VMS data of the vessel are available.
6. Skipper and crew of the vessel are willing to carry out the work based on the available budget for reimbursement.
7. Skipper or crew of the vessel are willing to participate in project meetings with the science team.

These criteria resulted in a shortlist of seven vessels. Two vessels were eliminated as they participated in other WMR projects (one vessel participates in DCF discards self-sampling, and another in a Fully Document Fisheries pilot). Two other vessels had, in hindsight, no interest in participating. The resulting 3 Dutch-owned, foreign flagged vessels were recruited for this project.

2.3 Phase 2: Implementation FCM

2.3.1 Communication with participating vessels

Once the participating vessels were identified, we held a kick-off meeting with the skippers and owners of the vessels (1 March 2019). For one vessel also the crew members were present . During the meeting we explained the background and objective of the project and answered any questions of the participants We also explained the self-sampling protocol. Following queries from the skippers during the meeting, who observed differences in catches during day and night, clarifications to the final protocol were made.

At the time of the kick-off meeting was held, the load cell measuring device was already installed on board one of the participating vessels for testing. The initial experiences were shared during the meeting and led to some changes in the weighting procedure (multiple measurements before the cod-end is opened to allow for seawater not to be included in the catch weight).

Following the kick-off meeting, it was decided to continue the installation of the load cells onboard the remaining two participating vessels, and to set up meetings with the crew of all participating vessels to hand over the materials for self-sampling and carapace length measurements and to instruct the crews on the protocols. A contract with the skippers on data use and the research license (derogations) applications was also agreed upon (see 2.3.2).

Throughout the duration of the project we communicated with the skippers and crews on an individual basis. Because of the COVID-19 pandemic no group meetings could be planned. Communications typically took place prior to the week of sampling. In consultation with the skipper it was decided whether the selected week was suitable for self-sampling. This often depended on the number of crewmembers available for the selected trip, the weather conditions and possible planned maintenance of the ship. The project coordinator of WMR was always standby to support and answer questions of the skippers about the sampling programme or specific technical problems during a self-sampling trip. The project coordinator could also be contacted for less urgent problems (e.g. shortage of materials).

2.3.2 Contracts and licenses

Each vessel owner signed a contract with WMR. The contract captures the conditions of use of the data including privacy stipulations, and the conditions for eligibility of the renumeration.

The fishing associations contacted the relevant Member States for the required derogations under the European landing obligation to allow the participants to keep undersized fish for which an MCRS but no catch limitation applied on board during the weeks of self-sampling. The derogation requests were all granted. However, the derogation requests could only be granted for one calendar year and could sometimes only be processed after the start of a calendar year. As a result, the planned start of the sampling programme could be delayed.

2.3.3 Analysis of self-samples

The companies "Visserijbedrijf Van Malsen" and "Gebroeders Kaij" analysed all discards samples collected by the vessels. Analysis included species determination, weight and length measurements and weight of non-living material. Both companies are experienced in conducting this work and have demonstrated to meet the quality assurance standards which WMR uses for all its personnel in relation to species sampling and determination. Only personnel or external parties that meet these standards (annual test), are allowed to carry out this work without supervision.

2.3.4 Data management

All data were entered in the WMR in-house software package Billie Turf. After data entry, data were checked for completeness and outliers of numerical variables (i.e. haul duration, distance towed, fish length, fish weight, fish age, including length-weight and age-length relationships, fishing positions) and for completeness and consistency of text variables (i.e. station coding, ship names, fishing gear). The quality control checks have been carried out using standardised SAS scripts, full version of scrips available via WMR upon request.

After quality control and -if needed- data correction, the data were imported into the WMR database FRISBE. This Oracle based relational database contains information from all fisheries-related sampling types carried out within WMR projects. The database contains a number of quality assurance checks, such as consistency of species coding, ship coding, gear coding, on top of format checks for all fields.

2.4 Phase 3: Data analysis and reporting

2.4.1 Data-analysis self-sampling and validation

Numbers (at length) were registered for all species and multiplied with the weight ratio between the discard sample and total discards (total catch from load cells minus landings) to estimate total numbers (at length) within each sampled haul. For each species, the total weight within the discard sample was recorded. The numbers (at length) and weights were summed for the two hauls. It is assumed that the species composition in the sampled hauls are representative for all other hauls within that trip.
The numbers at length for Norway lobster were used to visualize the length-frequency distribution of both discards and landings.

2.4.2 Statistical analysis raising parameters catch data

The numbers (at length) and weight of discarded species from the sampled hauls were raised to trip level by multiplying numbers (at length) and weight with the ratio between the total discards weight of all hauls and the total discards weight of the two sampled hauls. For future use in ICES stock assessments, these numbers could be raised to the entire Dutch Norway lobster fleet by using the ratio of fishing effort within the reference fleet and fishing effort of the entire fleet as is done for the majority of assessed stocks. In this report the collected discard samples have not been raised to fleet level and only the data from the self-sampling trips are presented.

2.4.3 Feedback WGNSSK

The Norway lobster catch monitoring programme was presented at the ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) in 2019 and 2020. This working group are the end-users of the data, and the programme was set up in response to concerns about data limitations, including lack of representative discards data in FU33 (ICES, 2018b).

2.4.3.1 WGNNSK 2019

At the 2019 WGNSSK meeting, we introduced the Norway lobster catch monitoring programme.

The sampling design that was based on a power analysis, using three vessels, 5 trips per quarter, and 2 hauls per trip (see section 2.2.4) was presented. In the power analysis each of these variables (i.e. number of vessels, number of trips, and number of hauls) was varied to arrive at the optimum configuration. The assessment experts at WGNSSK (ICES, 2019) agreed that the analysis showed that adding vessels was likely to be the most potent way of expanding the power of the programme. The group pointed out that the 40% Coefficient of Variance (CV) target, used for discards in the power analysis, should be reduced if trends are to be detected over time. The corresponding 20% CV used for landings was deemed more appropriate. The combined CV for total catch was unknown at the time of the presentation.

WGNSSK recommended that the first phase of the programme should be expanded in order to achieve the stated aims because the CV’s mentioned relate to the full area and not to the individual FU’s. In order for trends to be detected at FU level more vessels would need to be added to the programme. It was agreed that in order to determine the required scale of expansion of the sampling programme, the first data produced by the programme should be used to refine the analysis. It was noted that representativeness of the reference fleet’s expected catch composition for the entire Nephrops-targeting fleet should be given consideration when recruiting additional vessels.

2.4.3.2 WGNNSK 2020

At the 2020 WGNSSK meeting, we presented a status update of the programme to WGNSSK. In response to the presentation, WGNSSK 2020 raised the following points.

First, the potential fit of the programme's data into the assessment in future should be considered (ICES, 2020). In relation to FU33, it was decided to explore options for the collection of additional data during the follow-up programme, with the aim of raising the assessment category status to a higher level. This could take the form of additional length measurements but is to be investigated in further detail.

Secondly, critical remarks were made in relation to the reliability of data based on self-sampling (ICES, 2020). It was pointed out that the Norway lobster catch monitoring programme is to a great extent similar to the sampling procedure used in the Dutch demersal discards self-programme that is carried out under the DCF; data from this scheme are being used in several ICES stock assessments.

Finally, the question was raised whether or not the data collection by Dutch flag cutters under German and Belgian flag is representative for the nephrops fleet under Dutch flag, because of different quota portfolios and management.

We will revisit this WGNSSK input in chapter 3 and 4.

2.4.4 Communication with participating vessels

The COVID-19 outbreak meant we had more limited live interactions with skippers and crew than anticipated. Also delays in resolving data management issues meant that WMR could only send anticipated quarterly reports to individual skippers of catch composition at the end of the project. The individual vessel catch composition reports are not publicly available as this would not be in accordance with privacy law.

We held an online meeting with the participating skippers in April 2020, prior to the WGNSSK 2021 meeting. The skippers of the Dutch vessels that will be added to the reference fleet in the follow-up project ("OSW 2.2") were also present. The 2019-2020 results were presented, and feedback was asked, including on the WGNSSK questions on comparability of flag vessels' fishing activities for *Nephrops* compared to Dutch vessels. Their feedback is presented in chapter 3.

3 Results self-sampling

3.1 Introduction

Delays to the start of monitoring activities were incurred in 2019 due to safety issues with the load cells. Safety modification were made after an extensive review and adapted load cells were fitted to the participating vessels. Subsequently in Q3 of 2019, Brexit-related market conditions resulted in a temporary move away from targeting *Nephrops,* resulting in further delays. Ultimately, 2 of the 3 participating vessels were able to conduct monitoring activities on 6 trips in 2019, with the third vessel commencing monitoring in 2020.

A total of 8 observer trips was planned for the period 2019-2020. However, only 2 observer trips were executed in 2019 (due to the delays in the start of the monitoring) and 1 observer trip was executed in 2020 (due to COVID-19 restrictions). Because of the low number of observer trips, the self-sampling data could not be validated with observer data. Therefore, only the self-sampling data for Norway lobster catches are presented.

3.2 Self-sampling trips

A total of 12 and 22 self-sampling trips were carried out in 2019 and 2020, respectively. Table 1 presents a summary of the self-sampling trips by year and quarter. Average catch (tonnes) is derived from the total catch measured with the load cells (see 2.2.2.).

Table 1: Overview of self-sampling trips with the number of hauls, sampled hauls and the average catch per trip in 2019 and 2020

Year	*Quarter*	*Total number of trips*	*Total number of hauls*	*Total number of sampled hauls*	*Average catch per trip (tonnes)*
2019	2	2	44	4	40.7
	3	6	135	12	40.1
	4	4	85	8	26.8
2020	1	7	150	14	31.3
	2	5	98	10	41.0
	3	5	79	10	36.0
	4	5	93	10	34.6

Table 2: Overview of the total number of hauls of the self-sampling trips per FU in 2019 and 2020

Year	*Quarter*	*Total number of trips*	*Hauls in FU5*	*Hauls in FU33*	*Hauls in outFU*
2019	2	2	44	0	0
	3	6	83	13	39
	4	4	56	3	26
2020	1	7	32	99	19
	2	5	72	17	9
	3	5	77	0	2
	4	5	70	23	0

Table 2 shows the number of hauls per quarter and year in the three FUs (FU5, FU33 and outFU). During the majority of self-sampling trips, fishing activities took place in FU5 in both 2019 and 2020. Maps with the locations of only sampled hauls for each year and quarter with the FUs outlined can be found in Annex 1.

3.3 Norway lobster catch composition

Based on the length measurements of discards and landings, the relative length-frequency is calculated for each length class and presents the ratio of the number of times a certain length class is present within the total numbers of individuals of all length classes per year and quarter. The relative length-frequency shows how the different length classes contribute to both discards and landings (Figures 6 and7). In 2019, self-sampling trips were carried out in quarters 2, 3 and 4. Some overlap is visible in the length-frequency distribution between discards (Figure 6a; range 1.7 and 5.1 cm) and landings (Figure 6b; range 2.8 and 7.4 cm). The length classes in which Norway lobster have relatively highest frequencies in landings is between 3.5 and 4.5 cm. These patterns are similar within all quarters in 2019. The length-frequency distribution for 2020 shows similar patterns (Figure 7a; range 1.8 and 5.2 cm). However in all quarters, more larger length classes are being landed in 2020 (Figure 7; range 2.6 and 6.4 cm) compared to 2019. Figures of the length-distribution of landings and discards combined can be found in Annex 2.

Table 3 presents an overview of the average amount of Norway lobster landings and the average percentage of discards within Norway lobster catches (landings + discards). Average Norway lobster discards percentage range from 31.2 – 70.7 % and the respective standard deviations also show variation.

Table 3: Average total Norway lobster landings (tonnes) and average discards (% of catch) with corresponding standard deviation (SD) for 2019 and 2020.

Year	*Quarter*	*Number of trips*	*Average Norway lobster landings (tonnes)*	*Average Norway lobster discards ± SD (% of Norway lobster catch)*
2019	2	2	4.93	48.8 ± 23.0
	3	6	4.74	61.8 ± 28.3
	4	4	2.19	31.2 ± 3.9
2020	1	7	3.07	50.9 ± 14.5
	2	5	1.78	70.7 ± 16.7
	3	5	3.58	62.7 ± 21.5
	4	5	3.21	42.4 ± 8.5

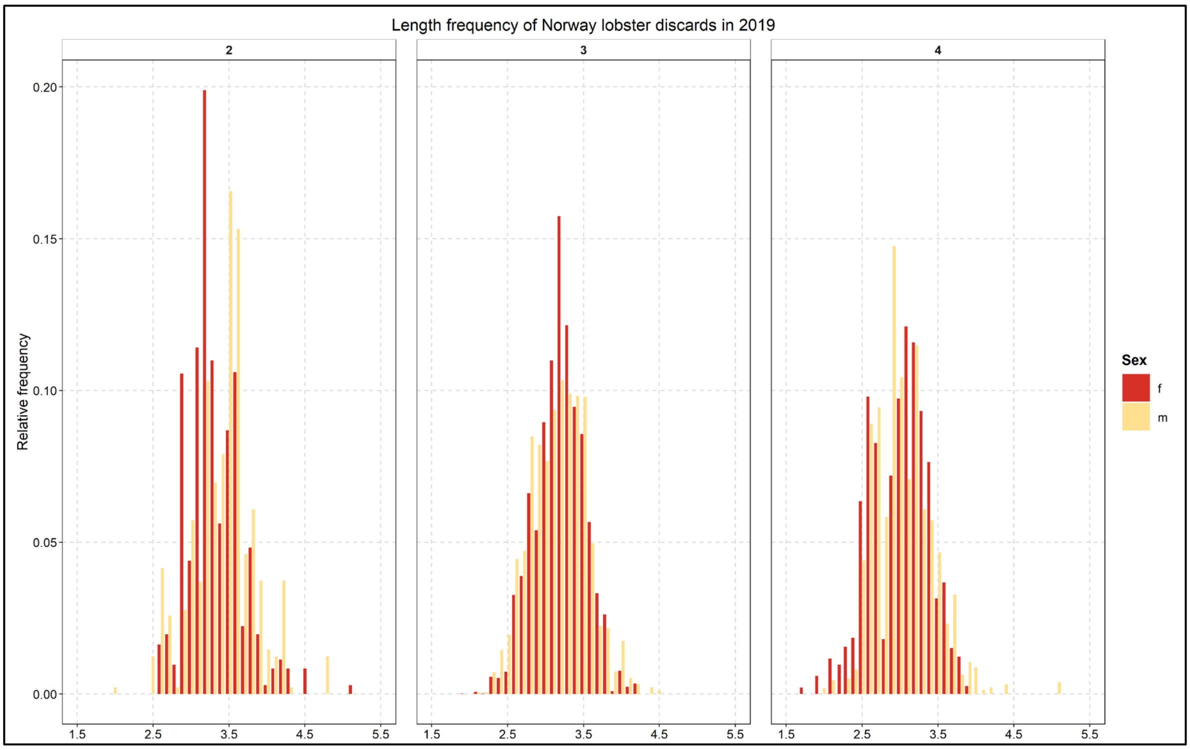

Figure 6a: *Relative length-frequency distribution of Norway lobster discards in 2019 per quarter and sex (f = female, m = male).*

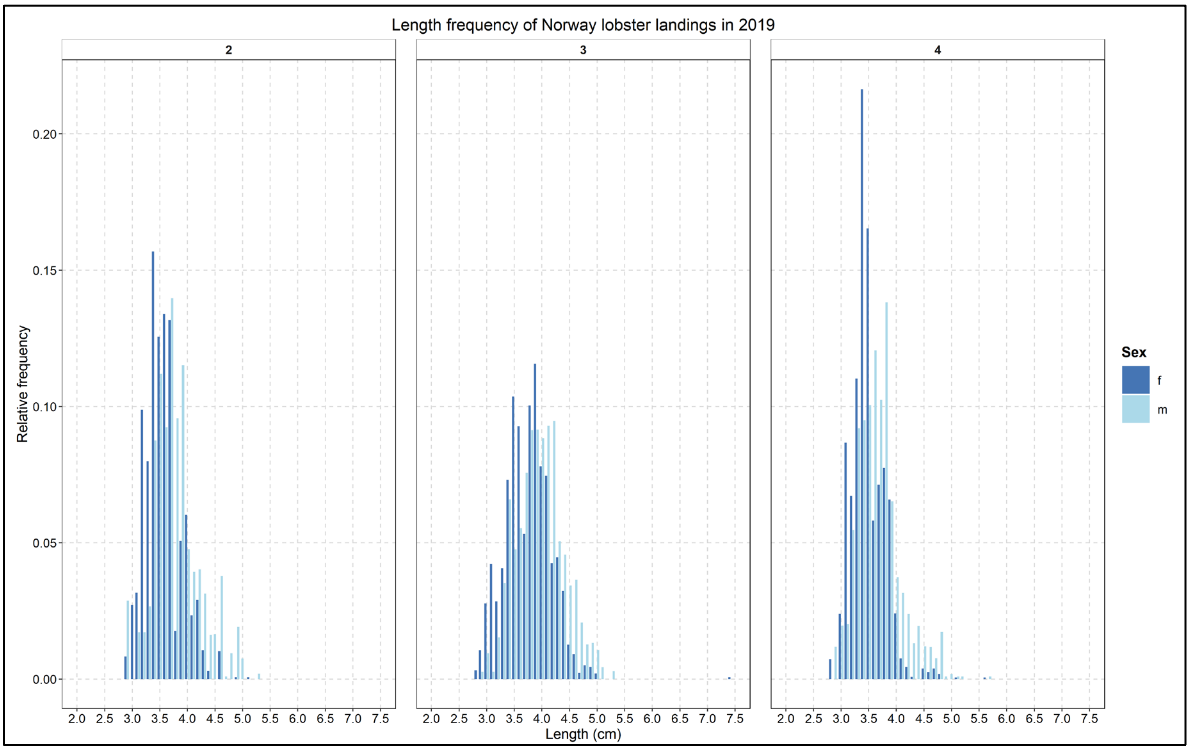

Figure 6b: *Relative length-frequency distribution of Norway lobster landings in 2019 per quarter and sex (f = female, m = male).*

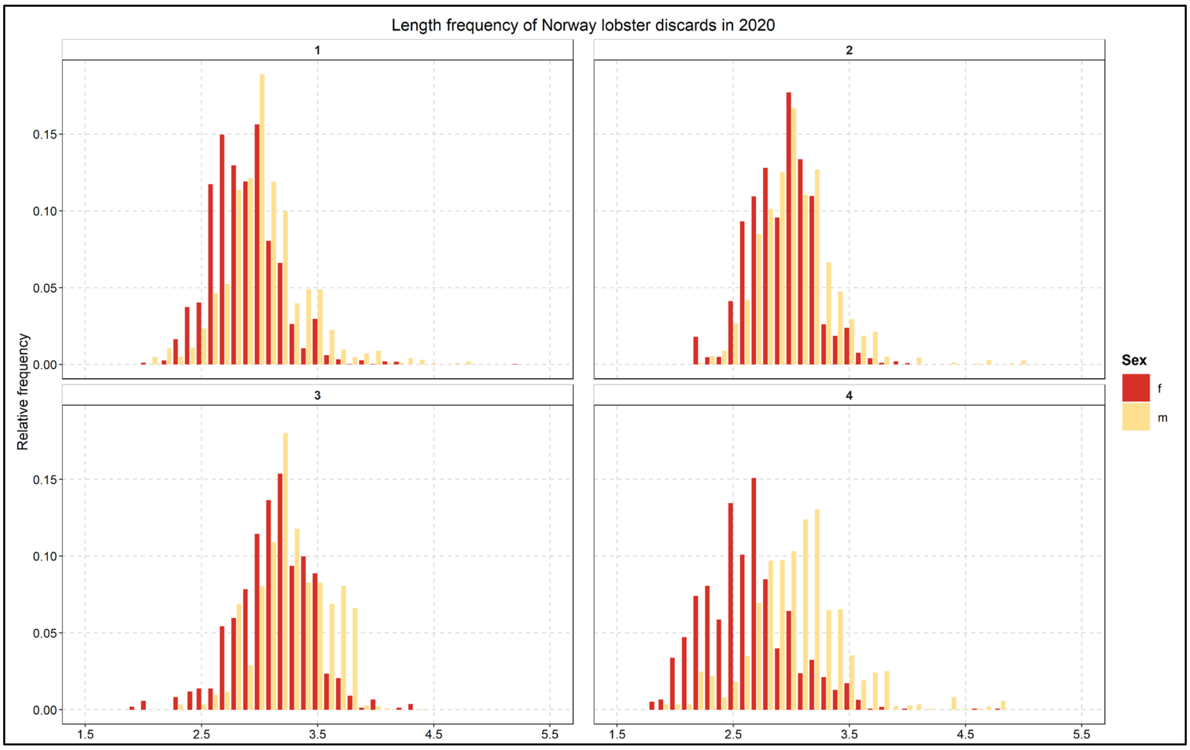

Figure 7a: *Relative length-frequency distribution of Norway lobster discards in 2020 per quarter and sex (f = female, m = male).*

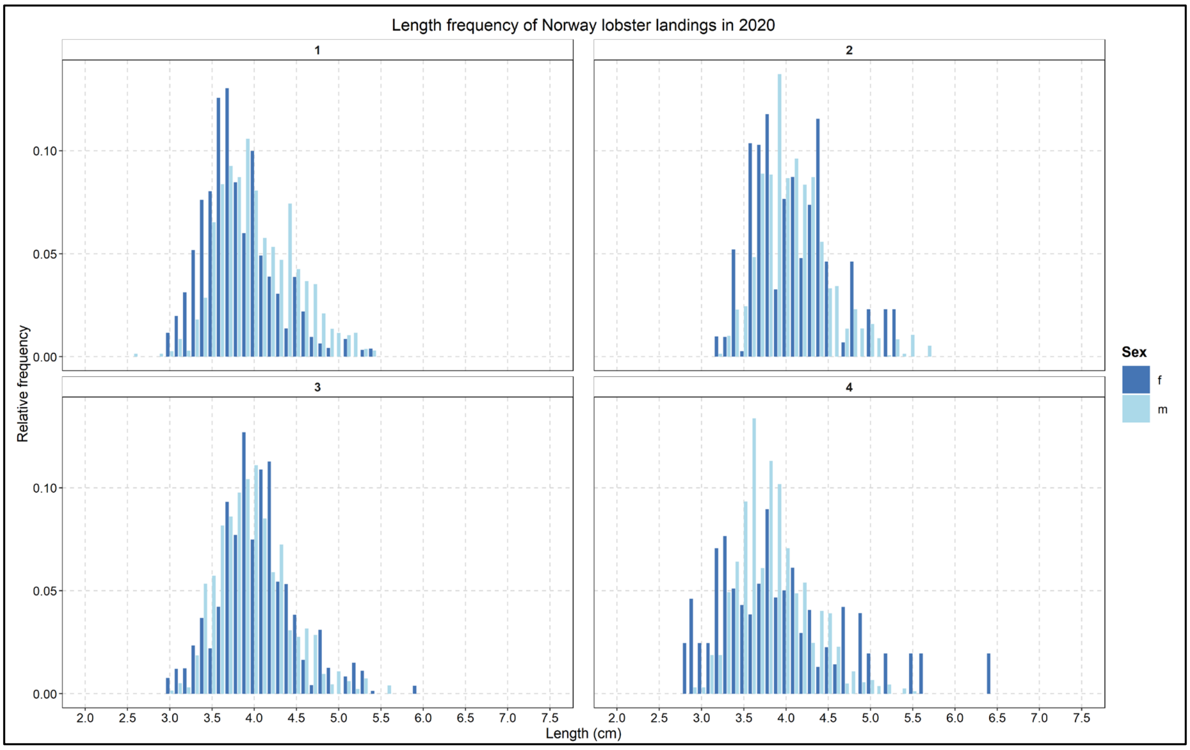

Figure 7b: *Relative length-frequency distribution of Norway lobster landings in 2019 per quarter and sex (f = female, m = male).*

3.4 Feedback from the participating skippers

The results on catch composition from the self-sampling trips was presented to the skippers of the participating vessels (German and Belgian registration) and the skippers of the vessels that will join the reference fleet in 2021 (Dutch registration). In this presentation, also the non-validated results of discards of other species were included.

The skippers confirmed the results, noting that these reflect their own observations and experiences. The shift in the length-frequency distribution between males and females in the fourth quarter (Figure 7b) is well-known from fisheries practice. The skippers also noted that while in quarter 3 most landings will be from FU5 (Botney Cut), in quarter 4, there is only limited fishing activity in this FU.

The skippers also noted that there are significant changes in growth rates between the FUs, with better growth in the more northern areas. They suggested that management per FU would be more appropriate as opposed to one TAC for the whole North Sea.

The ICES WGNSSK's question on whether the catch pattern of the Belgian and German flag vessels is comparable to that of Dutch vessels, as each country has a different quota regime (section 2.4.3.2) was discussed. The skippers were in agreement that in a 'normal year' there are no differences in fishing or catch patterns. They pointed out that in 2021, the temporary Brexit quota allocation, will have an impact. Dutch vessels have a limited *Nephrops* quota for the first quarter; German vessels did not get any quota. Once the final quota for 2021 are allocated, landings in the remainder of the year will look differently compared to earlier in the year or compared to other years.

Nephrops catches and catch patterns were also discussed in relation to the COVID-19 pandemic. The skippers pointed out that prices had dropped by half since the start of the pandemic. This also affects catches. Fishers either decide not to go to sea, even if they have *Nephrops* quota, or decide to target other species using different nets in the same gear category. In the latter case, they may still catch some *Nephrops* as commercial by-catch. The skippers expressed concerns that the reduced landings of *Nephrops* due to COVID-19 or 'Brexit quota restrictions' would be shown in the ICES stock assessments as evidence for decreasing stock levels. They highlighted that "impacts of the pandemic and temporary Brexit quota on catches does not mean that the *Nephrops* are not there; we just do not go after them".

Another impact on catch composition from 2021 onwards are the increasing mesh sizes in FUs that are in British waters. In the British waters, mesh size has been increased to 95mm. Some *Nephrops* fishers fish in both the UK and EU waters during the same week. This also will affect catch composition and landings.

It was agreed the self-sampling protocol would be updated, so that fishers will indicate whether self-sampling was done on a target *Nephrops* trip or a targeted flatfish trip. Mesh size is already accounted for in the information they provide.

Finally the skippers noted that the catch monitoring worked well and was easy to implement.

4 Discussion and recommendations

4.1 Norway lobster catch monitoring

Within this project a FCM system has been successfully developed (phase 1) and implemented (phase 2) into a reference fleet. The FCM system is, once installed, easy to use by the fishing crew. It provides valuable information about the total catch and enables more accurate discard estimates as compared to other previously employed methods (e.g. estimation of total catch through visual judgement by skipper or observer). However, installing the FCM system on board takes around two days (installation of equipment, calibration of load cells), and it is difficult to move the system from one vessel to another. Furthermore, the equipment and installation is expensive.

The collected data provides valuable insight in catch composition and fishing effort of the reference fleet in regard to the FUs. FU5, FU33 and outFU are data-limited. At present, no discard data is used in the ICES stock assessments for FU33 and outFU. Though discard data is used for FU5, there are concerns about the representativeness of the discards time series (ICES, 2018b).

The FCM project was set up in response to concerns about data limitations, including lack of representative discards data in FU33, expressed by ICES (ICES, 2018b). Therefore, we involved WGNSSK, the end-users of the data, from the beginning of the project. The WGNSSK raised some concerns which we will address below.

The current reference fleet consists of Dutch owned, foreign flagged vessels. These vessels have a different portfolio of quota for commercial (fish) species compared to Dutch flagged vessels and as a result may make different choices affecting fishing behaviour. WGNSSK wondered whether or not the current reference fleet is a good representation of the Dutch Norway lobster fishing fleet. We discussed this question with fishers and their representatives. They believe this is not an issue in a 'normal year'. However, there will be differences in 2021 when temporary 'Brexit quota' have been allocated (or not). The temporary Brexit quota regime will not only result in changes in fishing patterns between the fleets of different nationality but also within country of registration. Also, fishers and representatives stressed that the COVID-19 pandemic (lower prices) will have influenced fishing effort for *Nephrops* by all fleets.

The question on if different country of registration results in different fishing patterns merits further investigation. This could be done by a comparison of spatial fishing effort and the catch composition of Dutch Norway lobster vessels with the effort of the reference fleet (three participating vessels), using VMS data. WMR has no access to the VMS-data of the participating vessels as they are foreign flagged. Another option would be to include Dutch vessels in the programme.

Including Dutch vessels in the programme would also address issues raised by WGNSSK in relation to the 40% CV target in the current programme (considered high) and the potential fit of data in future assessments, particularly for FU33 which is insufficiently covered. The input from WGNSSK on these issues has led to the development of a follow-up programme ("OSW2.2"), expanding the number of participating vessels from 3 to 6, testing alternative methods to raise from the discards sample to haul level and from haul to the trip level, and exploring methods to scale up monitoring to a broader set of vessels and spatial coverage. The load cell currently used in the programme works reliably but it cannot be easily transferred to other vessels and thereby hinders the ambitions to scale up the monitoring activities to a broader set of vessels. In terms of alternative raising methods to be explored in this follow-up programme include: (i) using the proportion of discarded to landed Nephrops, considering that landings of each haul are already recorded as part of the practice of commercial fishing; (ii) using volume rather than weight of the sample and of the total catch, a) by visual estimation, and b) through the use of 3D-imaging using a smartphone application with image processing on land; and (iii) developing a mobile version of the load cell that can be fitted to a vessel for an individual fishing trip.

WGNSSK also made critical remarks in relation to the reliability of data based on self-sampling (ICES, 2020). We point out that this is a concern with any kind of self-sampling. Furthermore, this concern is not unique to data collected by industry: scientific observer programmes are also known to have biases or insufficient coverage (Benoit *et al.*, 2009; Liggins *et al.*, 1997; Kraan *et al.*, 2013; Suuronen *et al.*, 2020). To address concerns about representativeness and reliability, the Norway lobster catch monitoring programme is to a great extent similar to the sampling procedure used in the Dutch demersal discards self-programme that is carried out under the DCF. In this DCF programme, ten observer trips are carried out annually to verify the accuracy and objectivity of the self-sampling. Since 2011, total discard data from DCF self-sampling programme fleet have been used in several ICES working groups for the assessment of stocks in the North Sea, such as plaice, sole, and Norway lobster. The introduction of a specific Norway lobster self-sampling programme results in an increase in the spatial and temporal sampling coverage of the Norway lobster fleet.

Our experiences with the self-sampling programme for nephrops show that it proves to be a valuable tool. While the FCM programme is work in progress, it already provided insight in the length-frequency distribution of both landings and discards. It also provides an opportunity for improved exchanges with nephrops fishers on developments in the fishery and how these affect landings. This is of particular importance to current assessments as they rely heavily on landings data. The Norway lobster self-sampling and validation procedures is to a great extent similar to those used in the Dutch demersal discards self-programme under the DCF, used in various North Sea stock assessments since 2011. Due to the low number of observer trips (delays in start of programme followed by COVID-19) we have not been able to carry out all trips for validation of the Norway lobster self-sampling scheme. We plan to start observer trips at intensified level once COVID-19 measures permit. These will be conducted as part of the follow-up project ("OSW 2.2").

4.2 Science-industry research collaboration

WMR has a long history of collaborating with the Dutch demersal North Sea fleet. Over the years, this research collaboration evolved to include a focus on improving the knowledge base for data-limited species and fishers experiential knowledge. Another change was the employment of scientists by some of the fisheries associations (Steins *et al.,* 2020). The Norway lobster science-industry partnership fits well in this tradition. It demonstrates the fishing industry's understanding of the importance of good quality information in support of fisheries management. Particularly in the case of data-limited stocks, where assessments often rely on catch data only – as is the case for Norway lobster in FU5, FU33 and outFu –, reliable data on catch composition is essential. This project showed the industry's preparedness to work towards an appropriate catch monitoring scheme. Despite initial technical difficulties with the load cells and the significant additional labour during the self-sampling, skippers and crews remained motivated throughout the project.

In science industry research collaboration, communication with participating fishers throughout all phases of the project is key (Johnson and Van Densen, 2007; Steins *et al.,* 2020). We mainly communicated with the skippers and crew using telephone and WhatsApp. COVID-19 restrictions made regular group meetings difficult. An online group meeting was held to discuss results at the end of the project. The skippers expressed that results were in line with their own observations and experiences. They also provided input on the interpretation of results, particularly in relation to changes in the fishery due to economic and regulatory factors that affected catches (Section 3.4). The planned regular individual vessel reports were not implemented until the end of the project. It is also important to inform the non-participating fleet. To this end, we published short articles about the project in the newsletters of the fisheries associations and the Dutch Fishing News (*Visserijnieuws*).

We also made an infographic about the FCM scheme (Figure 8). All communications are also available on the online educational platform for prospective and active fishers, www.vistikhetmaar.nl

Figure 8: *Infographic Norway lobster catch monitoring*

4.3 Recommendations

The pilot project to set up a FCM system for Norway lobster results in the following recommendations. Most of these recommendations are being addressed in the follow-up project "OSW2.2", from 2021 onwards.

1. The development of alternative weighing systems would increase scope for participation of vessels who target Norway lobsters only during part of the year. The current weighing system is fixed on board. This means it cannot easily (and cheaply) be removed and reinstalled on other vessels. Such alternative weighing systems may include loads cell that can easily be installed for a single trips; other methods of estimating the volume or weight of the total contents of the cod-end (e.g., 3D volumetric determinations from digital images); or even developing raising methods that do not require cod-end content estimates at all.
2. Self-sampling data need to be validated against data from observer trips. Additional validation effort through observer trips in the follow-up project, pending COVID-19 restrictions, is recommended.
3. The question whether or not the three participating Dutch-owned foreign flagged vessels are representative for the Norway lobster fishery under the Dutch flag. This can be done based on a comparison of spatial fishing effort and catch composition using VMS data, but would require participation of German and Belgian institutes. Ideally expansion of the reference fleet should focus on Dutch-flagged vessels.
4. Providing feedback to participating vessels about the data they collected is very important to keep skippers and crew motivated. The (confidential) data overview letter to the individual vessels has only been introduced towards the end of the project. The scrutiny in the data

management system is a source of delay (quarterly data entry, followed by data checks that take time). Providing quarterly provisional vessel data using unchecked data (including a disclaimer) with a 6-monthly or annual final vessel may be a way forward. Options should be discussed with the skippers.

5. Currently a derogation is needed for the participating fishing vessels in order to be allowed to keep on board undersized species in the samples for which an MCRS but no catch limitation applies. When no catch limitation applies, no landing obligation applies and in that case species under the minimum conservation reference size have to be released back into the sea as soon as possible after they have been caught. As a result no complete samples can be landed for further analysis. It is important that the project group timely requests these derogations and stays in good contact with the relevant authorities to facilitate that the derogations are granted as soon as possible for the continuity of the data collection.

5 Quality Assurance

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

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Justification

Report C044/21
Project Number: 4311400012

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

Approved: Dr. J. Batsleer
Fisheries researcher

Signature:

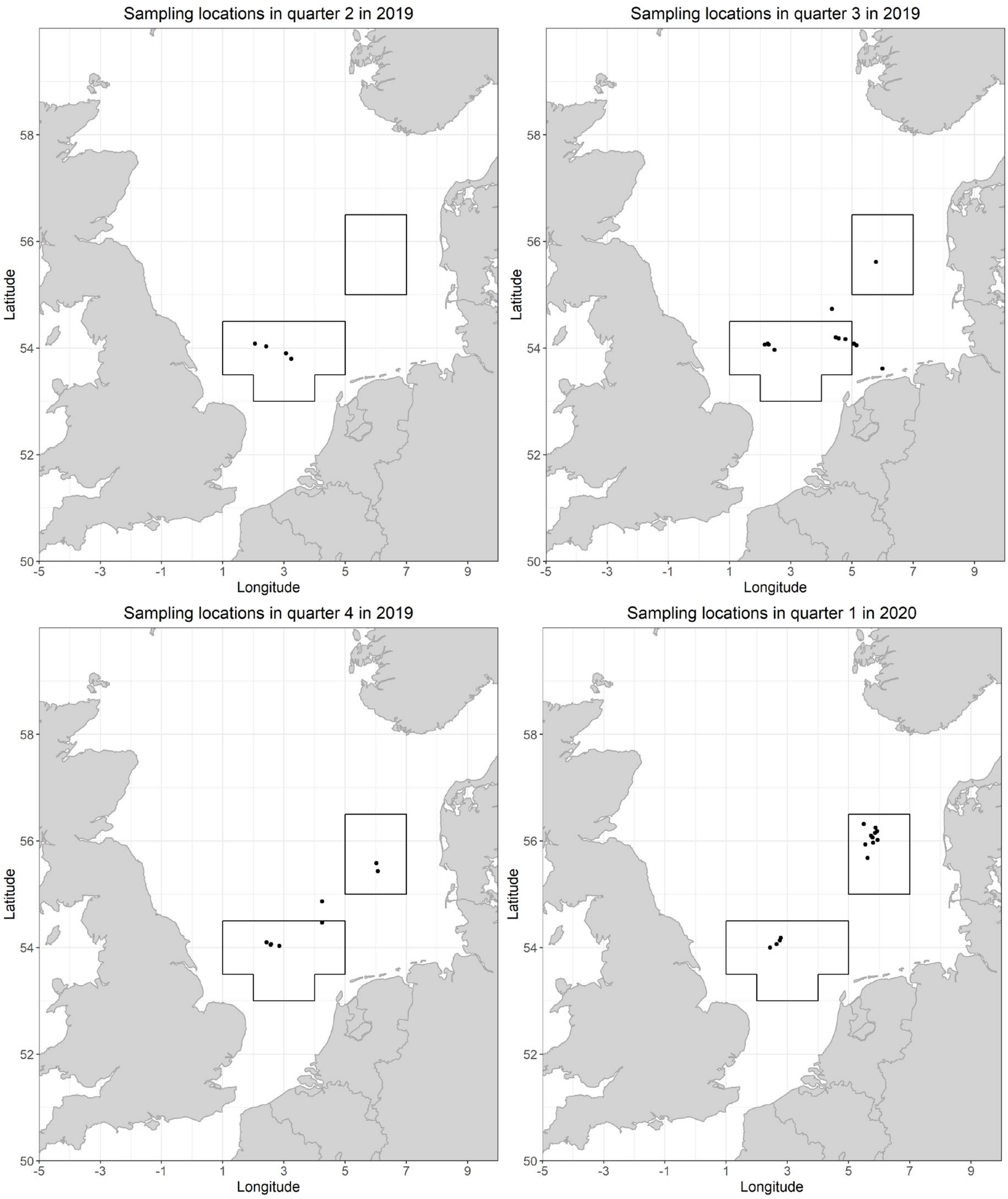
Date: April 21, 2021

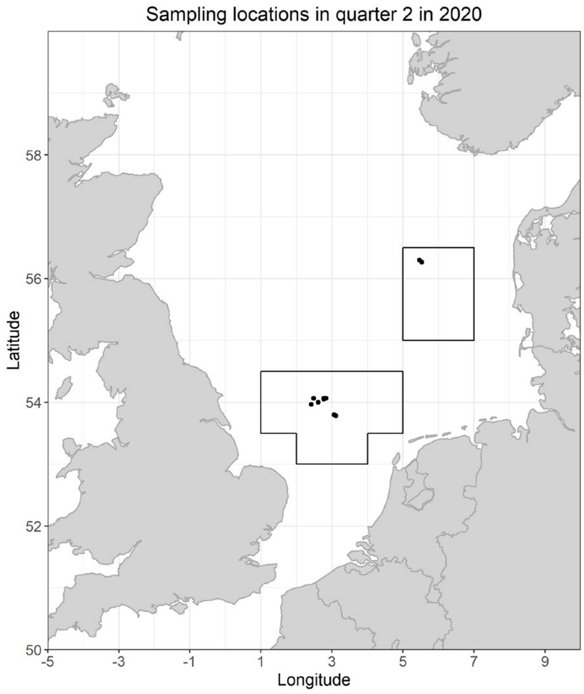
Approved: Dr. Ir. T.P. Bult
Director

Signature:

Date: April 21, 2021

Annex 1: Sampled hauls locations




Sampling locations in quarter 2 in 2020
Latitude
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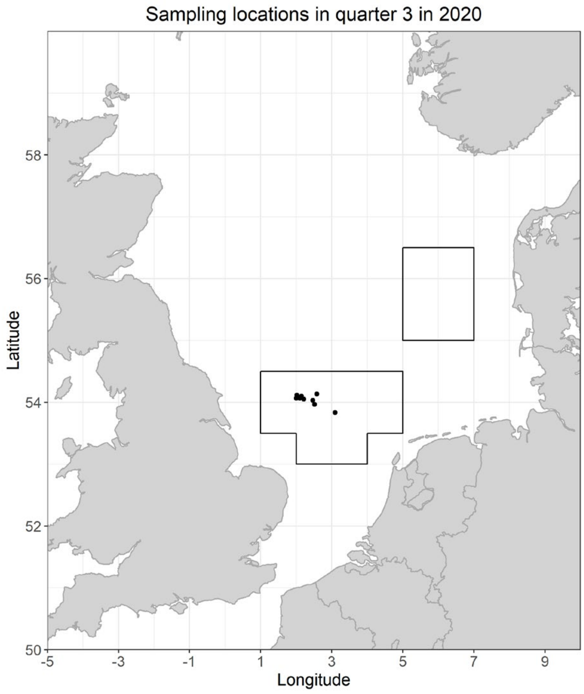
52
50
-5
-3
-1
1
3
5
7
9
Longitude


Sampling locations in quarter 3 in 2020
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-5
-3
-1
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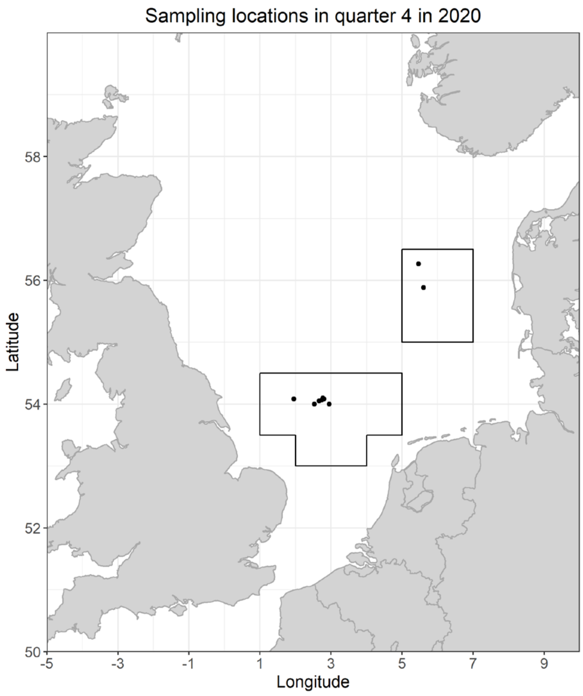
3
5
7
9
Longitude


Sampling locations in quarter 4 in 2020
Latitude
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-5
-3
-1
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Longitude

Annex 2: Length-frequency distribution of landings and discards

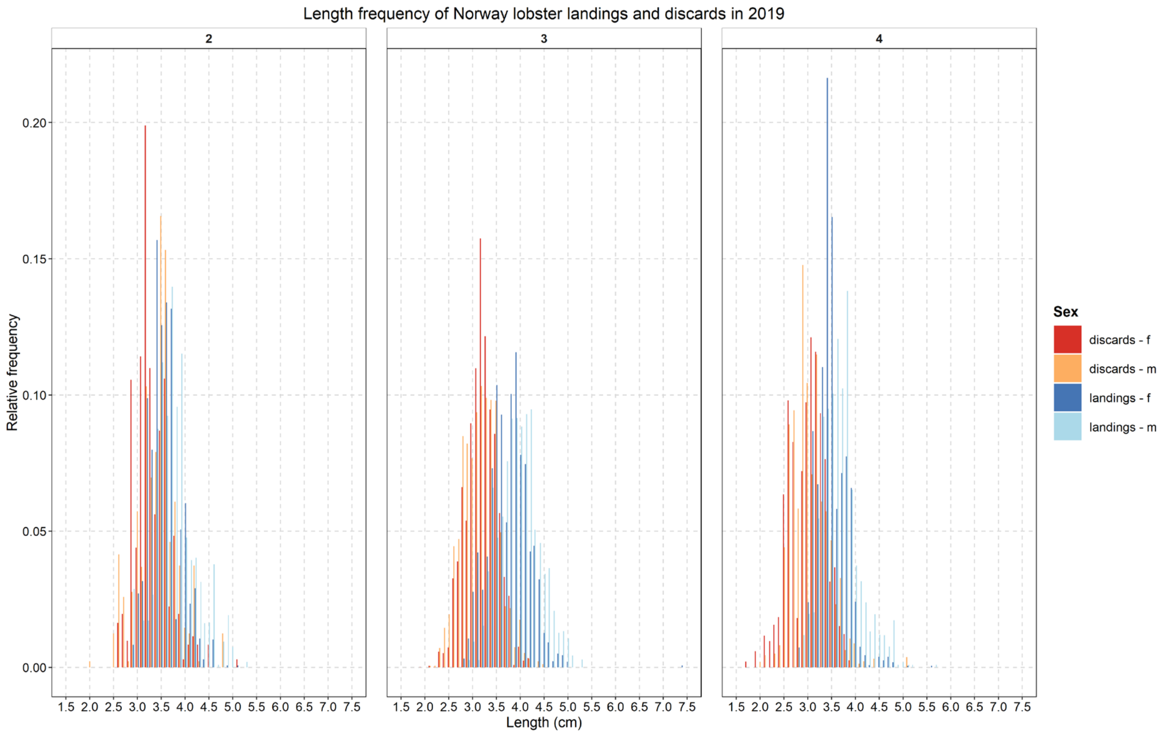
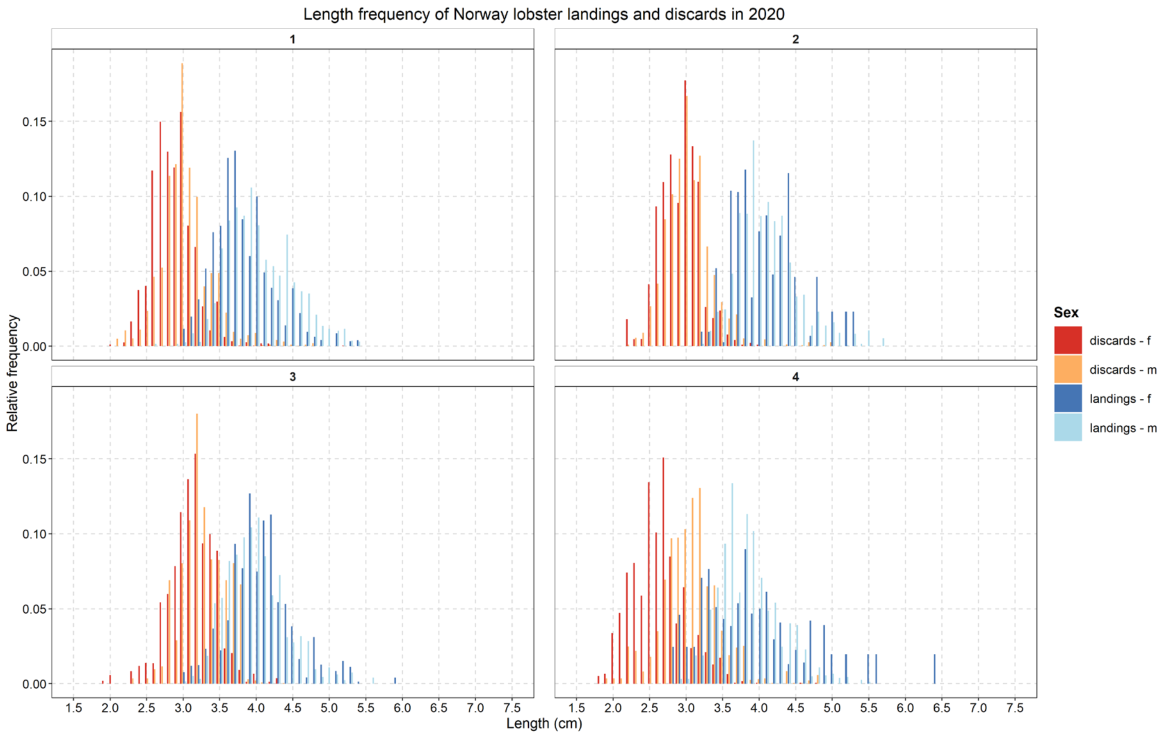


Figure 5a: Relative length-frequency distribution of Norway lobster landings and discards in 2019 per quarter and sex (f = female, m = male).

Figure 5b: Relative length-frequency distribution of Norway lobster landings and discards in 2020 per



quarter and sex (f = female, m = male).

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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.

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