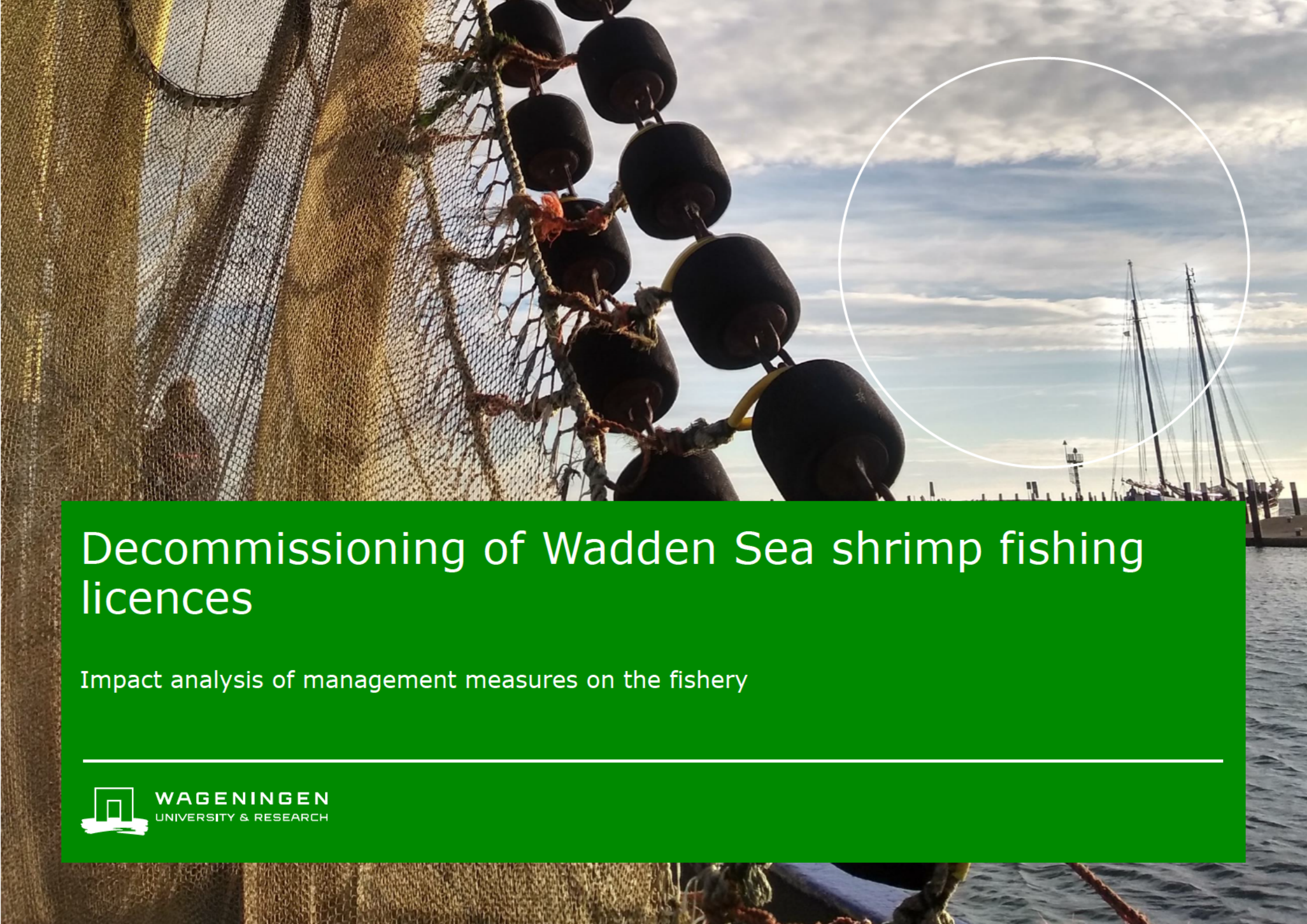

Decommissioning of Wadden Sea shrimp fishing licences

Impact analysis of management measures on the fishery

WAGENINGEN
UNIVERSITY & RESEARCH

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1 Wageningen Economic Research
2 Wageningen Marine Research

Deze studie is een deelonderzoek van de overkoepelende sociaal-economische impactanalyse visserij. De centrale onderzoeksvraag is: Wat zijn de economische effecten van de 2021 saneringsregeling op de Waddenzee-garnalenvisserijvergunningen op het visserijcluster geweest? Door met kwantitatieve en kwalitatieve data-analyse en modellering te kijken naar het kortetermijneffect, is er weinig economisch effect van de sanering op het visserij cluster geobserveerd. Door een verhoogde inzet van de resterende vloot, is de inspanning op de Waddenzee niet significant veranderd en werden lagere vangsten door goede garnalenprijzen gecompenseerd met als gevolg een positief economisch resultaat in het jaar na de sanering. Op de lange termijn is de visserij nu beperkt met een aantal vergunningen dat rond de 20% lager is qua aantal actieve schepen, zonder mogelijkheid om het aantal te laten groeien.

This study is part of the overarching socio-economic impact analysis of fisheries project. The central research question is: What have been the economic impacts of the 2021 decommissioning scheme on Wadden Sea shrimp fishing licenses on the fishing cluster. By looking at the short-term effect with quantitative and qualitative data analysis and modelling, little economic effect of the decommissioning scheme on the fishing cluster has been observed. By increasing the effort of the remaining fleet, the effort on the Wadden Sea did not change significantly, lower catches were compensated by good shrimp prices with as a result a positive economic result in the year after the decommissioning. In the long term, the fishery is now limited with a number of licences around 20% lower than the prior number of active vessels, with no possibility of increasing again.

Key words: shrimp, decommissioning, Wadden Sea, fishery

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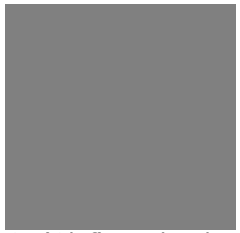
Preface

Dutch fisheries have been increasingly restricted in their activities in recent years by developments in (fisheries) policy in the North Sea. The socio-economic consequences of these developments are only partially clear for the Dutch fishery. Furthermore, it is unknown how these changes in policy and Dutch fisheries translate into socioeconomic effects on the chain and fishing regions.

Policy decisions, such as the North Sea Agreement, the Wadden Agenda, the Cutter Vision and the Brexit, including area closures and restrictions in the use of space by offshore wind farms, nitrogen legislation and nature reserves, have major consequences for Dutch fisheries. The adopted motions Lodders and Von Martels asked from the Lower House for an impact analysis of these policy decisions for the Dutch fishery, the fish chain (including fish processing industry) and the economy of regions of which the North Sea fishery is an important part.

A part of this impact analysis is to look at the economic impacts of the 2021 decommissioning scheme on the Wadden Sea shrimp fishing licences. The decommissioning scheme was fully implemented in September 2021 and we performed a retrospective analysis of its short-term (one year) socio-economic effects on the Dutch fishery, chain and local communities. In this report, we look at i) the fishing capacity that was removed by the decommissioning using past data, ii) the short-term effect on the remaining fleet using quantitative and qualitative data and iii) the impact on the fishery cluster.

We wish to thank the participants to the regional workshops for their participation and the insights they shared with us. We would also like to thank the fishers who participated in the focus group in Lauwersoog for their time and the experiential knowledge they shared with us. It helped us improve the model.



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Samenvatting

S.1 Kernvraag

Wat zijn de economische effecten van de sanering van de Waddenzee-garnalenvisserijvergunningen op het visserijcluster? De sanering vond plaats in augustus 2021 en een jaar later zijn de economische effecten ervan onderzocht door te kijken naar i) de oorspronkelijke visserijactiviteiten van de schepen waarvan de vergunning is gesaneerd, ii) de activiteiten van de schepen die met één van de resterende Waddenzee-garnalenvergunningen vissen en iii) de veranderingen in de aanvoer en in actieve schepen om het effect op het land in te schatten.

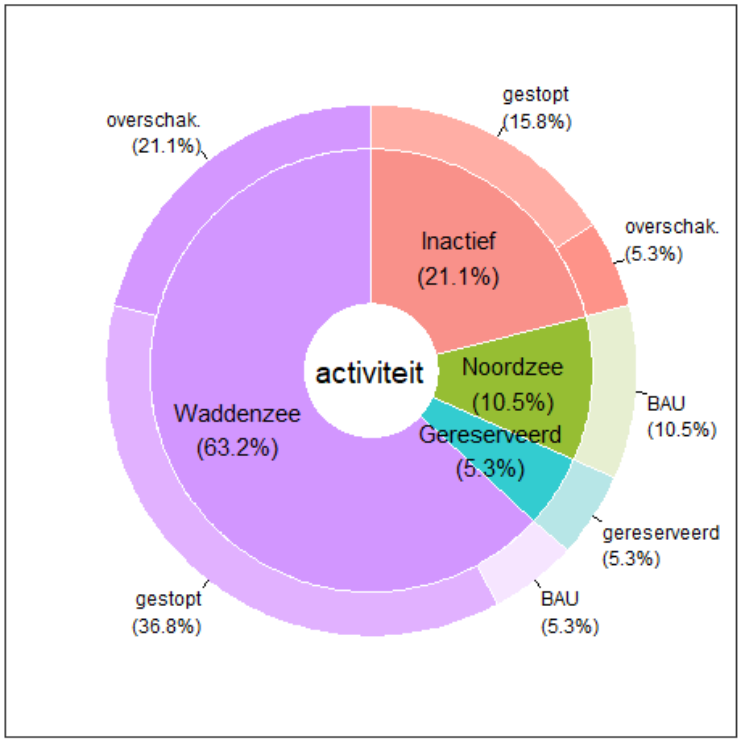
S.2 Op korte termijn is het verlies aan visserijactiviteit van de Waddenzeegarnalenvisserij beperkt als gevolg van de sanering in augustus 2021 van 19 GK-vergunningen

Bijna een derde (zes) van de vergunningen was het jaar voorafgaand aan de sanering al inactief op de Waddenzee

Van de 19 gesaneerde vergunningen waren er zes al sinds 2020 inactief op de Waddenzee (Figuur S.1): één vergunning was gereserveerd (niet toegekend aan een vissersvaartuig), drie waren toegekend aan vaartuigen die in 2019 voor het laatst actief waren en twee waren toegekend aan vaartuigen die in de vier jaar voorafgaand aan de sanering niet actief op de Waddenzee visten. Hierdoor vertegenwoordigden de 19 vergunningen weliswaar meer dan 20% van de beschikbare GK-vergunningen, maar de schepen waaraan ze waren toegekend vertegenwoordigden slechts 12% van de aanvoer en 16% van de inspanning van de Nederlandse garnalenvisserij in de Waddenzee.

Vijf vaartuigen zijn na de sanering blijven vissen op garnalen (vier buiten de Waddenzee, één met een gereactiveerde vergunning).

Van de 16 vergunningen die werden gebruikt door vaartuigen die in de periode voorafgaand aan de sanering actief waren in de Waddenzee (Waddenzee en inactief op Figuur S.1), zijn er na augustus 2021 tien helemaal gestopt met vissen, vijf hebben hun activiteiten aangepast (vier zijn overgestapt op het volledig vangen van garnalen buiten de Waddenzee en één is overgestapt op het vissen met passief vistuig binnen de Waddenzee) en het laatste vaartuig heeft een andere vergunning toegekend aan het vaartuig om in de Waddenzee op garnalen te blijven vissen.



Figuur S.1 *Beschrijving van de activiteit van vaartuigen waaraan de vergunning is opgekocht in de sanering in 2021. Deze vaartuigen hadden als activiteit vóór de sanering (binnenste cirkel): vissen op de Waddenzee, alleen op de Noordzee, helemaal niet vissen (inactief) of niet gekoppeld aan een vaartuig (gereserveerd) en na de sanering (buitenste cirkel): business as usual (BAU), overschakelen op ander vistuig of ander gebied (overschak.), of helemaal gestopt met vissen*

In het jaar na de sanering heeft de overblijvende vloot haar inspanning verhoogd; dit compenseert de daling van het aantal vergunningen.

Vijfenzestig procent van de overblijvende vaartuigen heeft hun activiteit sinds september 2021 verhoogd ten opzichte van de vier jaar daarvoor

Gemiddeld hebben de vaartuigen die in 2021 en/of 2022 op de Waddenzee op garnalen visten hun inspanning sinds september 2021 met 12% verhoogd ten opzichte van hun gemiddelde jaarlijkse inspanning in de vier jaar voorafgaand aan de sanering.

Modelsimulaties voorspellen geen significant kortetermijneffect van de sanering op de garnaleninspanning

Omdat de externe factoren in de periode na de sanering zijn veranderd, is het moeilijk de situatie voor en na de sanering te vergelijken. Met behulp van een statistisch model waarin seizoensinvloeden, mogelijke alternatieve activiteiten, type vissers, brutotonnage en garnalen- en brandstofprijzen worden gebruikt om de visserij-inspanning van een vaartuig per maand te bepalen, konden wij aantonen dat de voorspelde inspanning zonder de sanering niet significant verschilde van wat werkelijk werd waargenomen.

Goede prijzen voor garnalen leidden tot een winstgevende visserij in het jaar na de sanering.

De resterende vaartuigen visten meer (totaal visdagen bleef stabiel met gemiddeld +27% visdagen per vaartuig ten opzichte van de vloot vóór de sanering, dus inclusief de gesaneerde vergunningen, tabel S.1) in de Waddenzee met als gevolg iets meer vangst (+11% per vaartuig) maar vooral veel meer inkomen (+39% per vaartuig) door gunstige garnalenprijzen.

Tabel S.1 *Overzichtstabel van de garnalenactiviteit vóór (september 2017-augustus 2021) en na (september 2021-augustus 2022) de sanering in termen van aantal beschikbare vergunningen, aantal actieve vaartuigen (die ten minste 1 visdag per maand actief zijn), inspanning, aanvoer en waarde van de aanvoer. Voor de Waddenzee activiteit van vaartuigen die het laatst met een gesaneerde vergunning hebben gevist, de totale garnalenvisserij in de Waddenzee en de totale Nederlandse garnalenvisserij*

	Vaartuigen gesaneerde vergunningen Garnalenvisserij Waddenzee		Totaal Nederlandse garnalenvisserij Waddenzee		Totaal Nederlandse garnalenvisserij	
	4 jaar voor	1 jaar na	4 jaar voor	1 jaar na	4 jaar voor	1 jaar na
Aantal vergunningen	19	1	89	70	215	196
Gemiddeld per jaar						
Aantal actieve vaartuigen	16	1	85	68	195	174
Inspanning (visdagen)	469	48	3,160	3,215	14,030	13,254
Aanvoer (ton)	553	54	4,777	4,255	18,997	14,055
Waarde van de aanvoer ('000 euro)	1,711	192	14,806	16,344	57,264	53,118
Gemiddelde per actief vaartuig per jaar						
Inspanning (visdagen)	31	48	37	47	72	76
Aanvoer (ton)	36	54	56	63	97	81
Waarde van de aanvoer ('000 euro)	112	192	173	240	293	305

De sanering van de vergunningen had een beperkt effect op de visserijcluster.

Verbindingen met de visserijcluster aan land via de waardeketen voor garnalen (forward linkage, voorwaarts) en de toeleveringsketen voor de visserij (backward linkage, achterwaarts)
Er zijn twee wegen van de garnalenvisserij naar het viscluster, via de aanvoer van garnalen (voorwaarts) en de levering van goederen en diensten voor de actieve vaartuigen (achterwaarts). De aanvoer van de bij de sanering betrokken schepen vertegenwoordigde 3% van de totale Nederlandse garnalenaanvoer, wat lager is dan de interjaarlijkse variabiliteit van de Nederlandse garnalenvangst. Daarom kan worden gesteld dat de waardeketen voor garnalen niet door de sanering is beïnvloed.

De levering van goederen en diensten (backward linkages) aan de garnalenvloot zijn niet specifiek voor de garnalenvisserij en staan ook ten dienste van andere vissersvloten. Daarom vertegenwoordigen de tien vaartuigen (zeven waren nog actief in het jaar vóór de sanering en drie waren al gestopt met vissen, zie ook figuur S.1) die als gevolg van de sanering daadwerkelijk uit de visserij verdwijnen, slechts een klein deel van de Nederlandse vloot.

Geen verandering in de verdeling van de aanvoer van garnalen over de aanvoerhavens
De totale aanvoer van garnalen uit de Waddenzee is ongewijzigd gebleven en ook de verdeling ervan over de aanvoerhavens is stabiel gebleven, waarbij Harlingen, Wieringen en Lauwersoog het grootste deel van de aanvoer in stabiele verhoudingen voor hun rekening nemen.

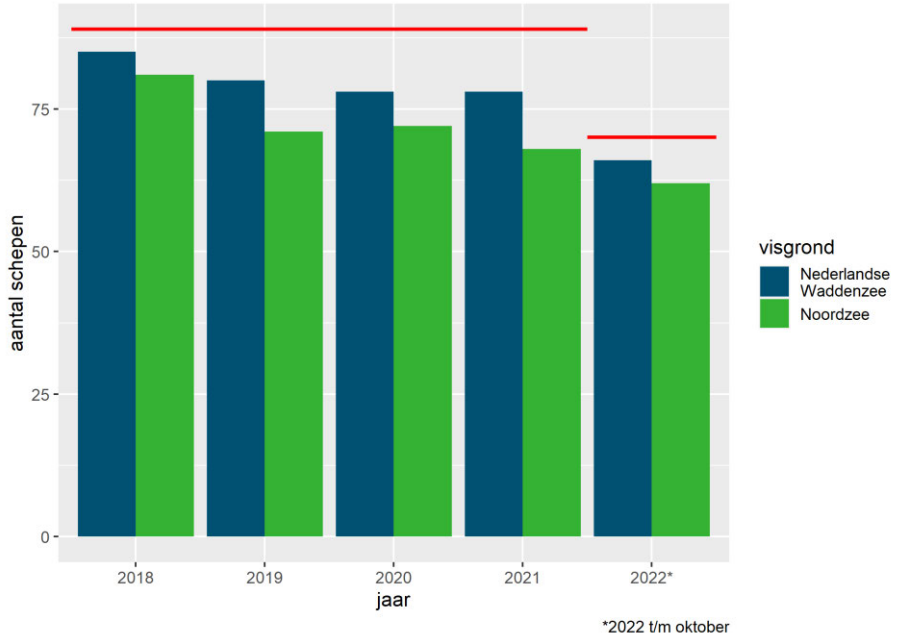
Acht havens verloren garnalenschepen aan de sanering
Van de acht geregistreerde havens die als gevolg van de sanering schepen hebben verloren, hadden er vijf vijf of minder actieve schepen in de vier jaar voorafgaand aan de sanering; voor deze havens vertegenwoordigde het verlies 20 tot 100% van hun actieve vloot. Twee havens met ongeveer 10 actieve vaartuigen verloren 10% van hun vloot en Wieringen, met ongeveer 50 actieve vaartuigen, verloor slechts 2% van zijn vloot.

Op lange termijn ligt de vangstcapaciteit van de garnalenvisserij op de Waddenzee nu 21% lager dan voorheen.

De sanering heeft geleid tot een lager aantal beschikbare vergunningen voor de garnalenvisserij op de Waddenzee dan voorheen.
De sanering had tot doel de langetermijncapaciteit van de garnalenvisserij op de Waddenzee te verminderen. Dit is bereikt omdat het aantal vergunningen (70) aanzienlijk lager is dan de 85 actieve garnalenkotters die in de vier jaar voorafgaand aan de sanering jaarlijks in de Waddenzee actief waren

(Figuur S.2 en Tabel S.1). In feite wordt de capaciteit van de Waddenzeevisserijvloot nu 21% lager afgetopt dan voorheen.

De vissers verwachten dat een volgende sanering veel grotere gevolgen zal hebben.
Omdat de minder actieve vissers uit de visserij zijn gehaald, verwachten de vissers met wie wij hebben gesprokken dat wanneer een nieuwe saneringronde zou plaatsvinden, deze een veel groter effect zal hebben op de afname van de garnalenvisserij op de Waddenzee. Op dit moment is daar overigens geen zicht op.



Figuur S.2 *Aantal schepen met een actieve GK-vergunning (gedefinieerd als minimaal 24 visuren per jaar in het gebied) in de Nederlandse Waddenzee en in het overig deel van de Noordzee tussen 2018 en 2022 (gegevens voor 2022 omvatten informatie tot oktober). De rode lijnen geven het aantal beschikbare GK-vergunningen voor en na de sanering*

S.3 Methodologie

In deze studie hebben we gecombineerde kwantitatieve en kwalitatieve methoden gebruikt om inzicht te krijgen in de veranderingen die hebben plaatsgevonden sinds de uitvoering van de sanering.

Analyse van de recente activiteit met gesaneerde vergunningen
Om de recente activiteit van de gesaneerde vergunningen te bekijken, hebben wij gebruikgemaakt van de lijst van vaartuigen die bij die vergunningen horen, logboekgegevens met informatie over de aanvoer en de inspanning per visreis en VMS-gegevens (satellietvolgsysteem voor vissersvaartuigen) met om de twee uur de GPS-coördinaten van de vaartuigen. De VMS-gegevens zijn gebruikt om het aandeel van de inspanning en de aanvoer van vaartuigen in de Nederlandse Waddenzee te schatten. We hebben gekeken naar de vier jaar voorafgaand aan de sanering en het activiteitenniveau van de schepen met een later gesaneerde vergunning vergeleken met de rest van de Nederlandse garnalenvisserij in de Waddenzee en de totale Nederlandse visserij in termen van inspanning, aanvoer en waarde van de aanvoer.

We hebben ook gebruikgemaakt van relevante inzichten die zijn verzameld tijdens regionale bijeenkomsten in juni 2022 in de verschillende visserijregio's in Nederland en tijdens een focusgroep met op de Waddenzee vissende garnalenvissers in november 2022. Deze bijeenkomsten zijn gebruikt om ons te helpen bij onze analyses, ervoor te zorgen dat we de tijdens de regionale bijeenkomsten gestelde vragen konden beantwoorden en te checken of de tijdens de bijeenkomsten en de focusgroep geuite percepties daadwerkelijk zijn waargenomen.

Analyse van de activiteiten van de vaartuigen waaraan resterende vergunningen zijn toegekend
De activiteiten van de vaartuigen met resterende vergunningen is onderzocht aan de hand van logboek- en VMS-gegevens. Om inzicht te krijgen in de verandering in activiteiten van de vaartuigen met resterende vergunningen, is gekeken naar hun activiteiten in termen van inspanning, aanvoer en waarde van de aanvoer in de vier jaar vóór de sanering en in het jaar na de sanering. Omdat de activiteit in de garnalenvisserij zeer variabel is en een eenvoudige vergelijking van de activiteit voor en na de sanering niet aangaf of de

waargenomen veranderingen significant waren, is een statistisch model ontwikkeld om het inspanningsniveau in de visserij te schatten op basis van een aantal factoren.

Het statistische model is ontwikkeld in een co-creatieproces. Het is eerst geparametriseerd aan de hand van literatuuronderzoek en input vanuit de regionale bijeenkomsten. Vervolgens is het voorgelegd aan de focusgroep van garnalenvissers en gecorrigeerd op basis van hun aanbevelingen.

Het model schat in twee stappen de hoeveelheid inspanning in de garnalenvisserij op de Waddenzee die in een maand per vaartuig wordt gebruikt. In de eerste stap schat het model in of de visser in die maand wel of niet vist. Is het antwoord op die eerste stap ja, dan wordt in de tweede stap geschat hoeveel inspanning dan wordt gebruikt. Het model bevat als verklarende variabelen vaartuigkenmerken, visserijspecifieke factoren, de maanden van het jaar en de volgende factoren:

- De vaartuigkenmerken: het motorvermogen, de tonnage van het vaartuig en de leeftijd van het vaartuig.
- De visserijspecifieke factoren: het type visser (ofwel een visser die zijn inkomsten probeert te maximaliseren door zoveel mogelijk te vissen, bekend als 'urenvisser', ofwel een visser die tevreden is met een bepaald activiteitsniveau, niet noodzakelijk het hoogste niveau, bekend als 'kennisvisser') en of de visser ook actief was in andere visserijtakken.
- De economische factoren: de gemiddelde maandelijkse brandstof- en garnalenprijzen.

Het model is gebruikt om de verwachte inspanning voor een aantal jaren vóór en een jaar na de sanering met en zonder sanering van de vergunningen te schatten. Het effect van de sanering wordt vervolgens beoordeeld door de data van de vloot te vergelijken met de simulatieresultaten en de simulatieresultaten met en zonder sanering met elkaar te vergelijken.

Schatting van de effecten op het land door veranderingen in de aanvoer en in het aantal actieve vaartuigen

De effecten op land in het visserijcluster worden vooruit in de keten geschat door te kijken naar de verandering in de aanvoer van garnalen in de regio (niet alleen van de Waddenzee - maar van de hele Nederlandse garnalenvisserij).

De effecten op land worden ook kwalitatief achterwaarts (op de toeleveringsketen) geschat door te kijken naar het aantal actieve schepen dat in de havens is geregistreerd.

Summary

S.1 Key question

What are the economic impacts of the decommissioning scheme on the Wadden Sea shrimp fishing licences on the fishery cluster ? The decommissioning scheme happened in August 2021 and a year later its economic impacts were investigated by looking at i) the fishing activity of the decommissioned licences prior to the scheme, ii) the activity of the vessels with remaining licences and by looking at iii) changes in landings and in active vessels to estimate the impact on land.

S.2 On the short-term, limited loss of fishing activity on the Wadden Sea shrimp fishery due to the August 2021 decommissioning of 19 GK licences

Almost a third (six) of the licences were already inactive in the Wadden Sea the year prior to the scheme

Out of the 19 licences decommissioned six were already inactive in the Wadden Sea since 2020 (Figure S.1): one was inactive (not assigned to a fishing vessel or 'reserved'), three were assigned to vessels that were last active in 2019 and two were not actively fishing in the Wadden Sea in the four years prior to the decommissioning scheme. Because of this, although the 19 licences represented more than 20% of the available GK licences, the vessels operating them only represented 12% of the landings and 16% of the effort of the Dutch shrimp fishery in the Wadden Sea.

Five vessels kept fishing for shrimps (four outside the Wadden Sea, one with a reactivated licence)

Of the 16 licences used by vessels active in the Wadden Sea in the period prior to the decommissioning, ten stopped fishing altogether after August 2021, five modified their activities (four moved to fully catching shrimp outside the Wadden Sea and one switched to fishing with passive gear inside the Wadden Sea) and the last vessel repurposed a licence to keep fishing for shrimp in the Wadden sea.

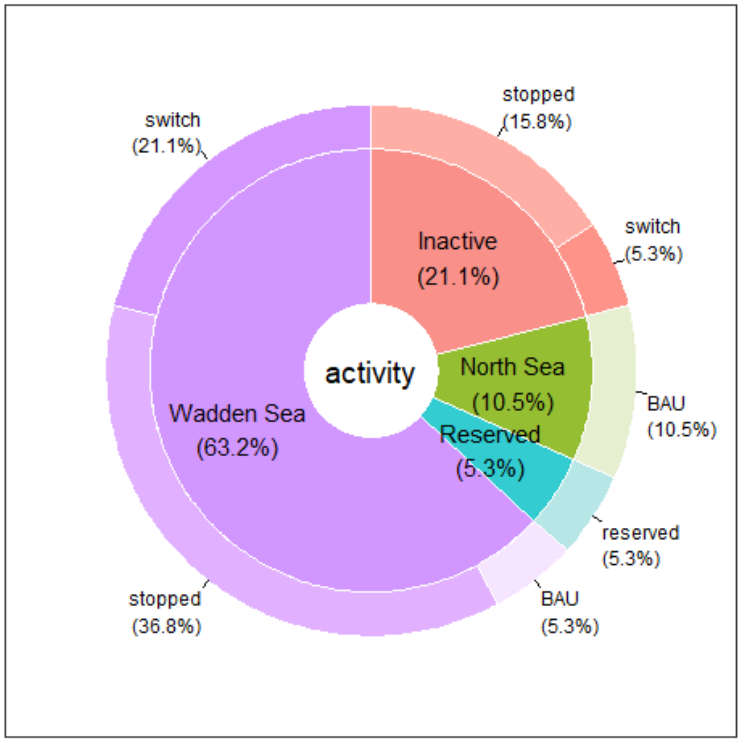


Figure S.1 *Description of the activity of vessels linked to the decommissioned licences in 2021 before the decommissioning (inner circle): fishing in the Wadden Sea, only in the North Sea, not fishing at all (inactive) or not linked to a vessel (reserved) and the activity of the vessels in the year after the decommissioning (outer circle): business as usual (BAU), switch gear or area, or stopped fishing all together*

In the year following the decommissioning scheme, the remaining fleet increased their effort, compensating the decrease in licences

Sixty-five per cent of the remaining vessels increased their activity since September 2021 compared to the four years prior

On average, the vessels fishing for shrimp in the Wadden Sea in 2021 and/or 2022 increased their effort by 12% since September 2021 compared to their average annual effort of the four years prior to the scheme.

Model projections forecast no significant short-effect of the decommissioning scheme on shrimp effort

Because external factors have changed in the period after the decommissioning, it is difficult to compare the situation before and after. Using a statistical model using seasonal factors, possible alternative activities, type of fishers, gross tonnage and shrimp and fuel prices to determine the fishing effort of a fisher per month, we were able to show that the effort forecasted without the decommissioning scheme was not significantly different from what was actually observed.

Good shrimp prices led to a profitable fishery in the year after the decommissioning scheme

The remaining vessels fished harder (resulting in a stable total effort and +27% fishing days per vessel on average compared to the fleet prior to the decommissioning, i.e. including decommissioned licences, Table S.1) in the Wadden Sea resulting in slightly higher catch (+11% per vessel) but especially much higher income (+39% per vessel) due to favourable shrimp prices.

Table S.1 *Summary table of the shrimp activity before (September 2017-August 2021) and after (September 2021-August 2022) the decommissioning scheme in terms of number of available licences, number of active vessels (operating at least 1 fishing day in a month), effort, landings and value of landings. For the Wadden Sea activity of vessels that last operated with a decommissioned licence, the total shrimp fishery in the Wadden Sea and the total Dutch shrimp fishery*

	Decommissioned Vessels shrimp Wadden Sea fishery		Total Dutch shrimp Wadden Sea fishery		Total Dutch shrimp fishery	
	4 y before	1 y after	4 y before	1 y after	4 y before	1 y after
Number of licences	19	1	89	70	215	196
Average per year						
Number of active vessels	16	1	85	68	195	174
Effort (fishing days)	469	48	3,160	3,215	14,030	13,254
Landings (tonnes)	553	54	4,777	4,255	18,997	14,055
Value of landings ('000 euro)	1,711	192	14,806	16,344	57,264	53,118
Average per active vessel per year						
Effort (fishing days)	31	48	37	47	72	76
Landings (tonnes)	36	54	56	63	97	81
Value of landings ('000 euro)	112	192	173	240	293	305

The decommissioning of licences had a limited impact on the fishery cluster

Links with on-land fishery cluster through the shrimp value chain (forward linkage) and the supply chain for the fishery (backward linkage)
There are two paths from the shrimp fishery to the fish cluster, through the landings of shrimps (forward) and the provision of goods and services for the active vessels (backward). The landings of the vessels involved in the decommissioning scheme represented 3% of the total Dutch landings which is lower than the interannual variability of Dutch shrimp catch. It is therefore safe to say that the shrimp value chain was unaffected by the decommissioning scheme.

The provision of goods and services (backward linkages) to the shrimp fleet are not specific to the shrimp fishery and also service other fishing fleets. Because of this the ten vessels (seven were still active in the year prior to the decommissioning and three had already stopped fishing see also Figure S.1) effectively exiting the fishery as a result of the scheme only represent and minor part of the Dutch fleet.

No change in landing distribution of shrimp to landings harbours
The total landings of shrimp from the Wadden Sea remained unchanged, and in addition, their distribution to landing harbours also remained stable with Harlingen, Wieringen and Lauwersoog concentrating the majority of the landings in stable proportions.

Eight harbours lost shrimp vessels to the decommissioning scheme
Of the eight registration harbours that lost shrimp vessels due to the decommissioning scheme, five had five or less active vessels in the four years leading to the scheme, for those the loss represented 20 to 100% of their active fleet. Two harbours with about 10 active vessels lost 10% of their fleet and Wieringen, with about 50 active vessels lost only 2% of its fleet.

On the long-term, the fishing capacity in the Wadden Sea is now capped 21% lower than before

The decommissioning scheme led to a number of available licences for shrimp fishing in the Wadden Sea lower than earlier fleet
The decommissioning scheme had a goal of reducing the long term capacity of the shrimp fishery in the Wadden Sea. This is now achieved with a resulting number of licences (70) being substantially lower than the 85 active shrimp vessels in the Wadden Sea annually in the four years prior to the scheme (Figure S.2 and Table S.1). In effect, the capacity of the Wadden Sea fishing fleet is now capped 21% lower than its previous capacity.

Fishers expect a subsequent decommissioning to reach much higher impacts
Because less active fishers have been taken out of the fishery, fishers expect that if a new decommissioning scheme would happen, it would have a much higher impact in decreasing the shrimp fishing activity in the Wadden Sea. There are no current plan for a new decommissioning scheme.

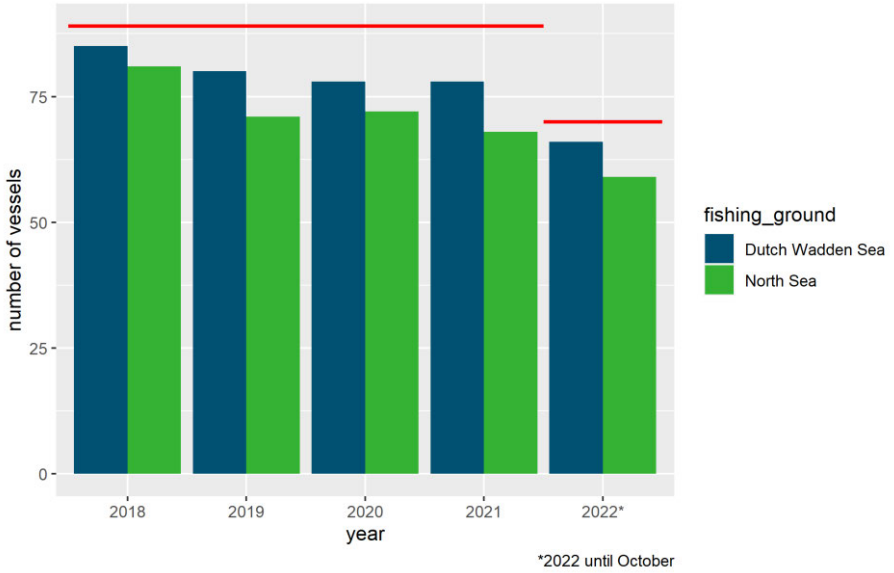


Figure S.2 *number of vessels with a GK licence active (defined as minimum 24 fishing hours per year in the area) in the Dutch Wadden Sea and in other part of the North Sea between 2018 and 2022 (data for 2022 includes information until October). The red lines represent the number of available GK licences before and after the decommissioning scheme*

S.3 Methodology

In this study we used combined quantitative and qualitative methods to understand the changes that happened since the implementation of the decommissioning.

Analysis of the recent activity with decommissioned licences
To look at the recent activity of decommissioned licences, we used the list of the vessels associated with said licences, logbook data containing information of landings and effort per fishing trip and VMS data (vessel monitoring system) containing the GPS coordinates of vessels every two hours. The VMS data were used to estimate the share of effort and landings of vessels happening in the Dutch Wadden Sea. We looked at the four years prior to the decommissioning scheme and compare the level of activity of the vessels operating with a later decommissioned licence, with the rest of the Dutch Wadden Sea shrimp fishery and the total Dutch fishery in terms of effort, landings and value of landings.

We also used relevant insights collected in regional meetings held in June 2022 in the differents fishing regions of the Netherlands and in a focus group with shrimp fishers fishing in the Wadden Sea held in November 2022. Those were used to help guide our analysis, make sure we could answer the questions identified in the regional meetings and assess whether the perceptions expressed during the meetings and the focus group were actually observed.

Analysis of activity of the vessels with remaining licences
The activity of vessels operating with remaining licences was also investigated with logbook and VMS data. To understand the change in activity of the vessels operating with a remaining licence, we looked at their activity in terms of effort, landings and value of landings during the four years prior to the decommissioning scheme and in the year after the decommissioning scheme. Because the activity in the shrimp fishery is highly variable, simply comparing activity before and after the decommissioning scheme could not inform us on whether changes observed were siginificant, we developed a statistical model to estimate the level of effort in the fishery based on a number of factors.

The statistical model was developed in a co-creation process. It was first parameterised using literature insights and input from the regional meetings. Then it was presented to the focus group of shrimp fishers and was corrected based on their recommendations.

The model estimates the amount of effort in the Wadden Sea shrimp fishery used in a month per vessel in two steps. In the first step the model estimates whether the fisher would be fishing or not in that month. If the answer to that first step is yes, then the second step is used to estimate how much effort is then used. The model includes as explanatory variables vessel characteristics, fisher specific factors, the months of the year, and economic factors:

- The vessel characteristics are engine power, vessel tonnage and age of vessel.
- The fisher specific factors are the type of fisher (either a fisher that try to maximise their revenue by fishing as much as they can, known as 'hour fisher', or a fisher satisfied with a given level of activity, not necessarily the

highest level, known as 'knowledge fisher') and whether the fisher also operated in alternative fisheries.
- The economic factors include average monthly fuel and shrimp prices.

The model was used to estimate the amount of expected effort for a number of years before and a year after the decommissioning scheme with and without the decommissioning of the licences. The effect of the decommissioning is then assessed by comparing the observed data with the simulation results and the simulation results with and without decommissioning.

Estimation of the impacts on land through changes in landings and in number of active vessels

The impacts on land in the fishery cluster is estimated forward in the chain by looking at the change in landings of shrimp in the region (not only from the Wadden Sea but from the whole Dutch shrimp fishery). The impacts on land are also qualitatively estimated backward (on the supply chain) by looking at the number of active vessels registered in harbours.

Glossary

- **Fishing region** = the regions with a clearly present fishing cluster, fishing ports with upstream industry and trade and processing, and associated fishing municipalities and communities. The following six fishing regions are defined in this study called 'Impact analysis of policy measures on the chain of Dutch fishing regions' (Quirijns et al., 2019):
  - Wadden coast (provinces of Friesland and Groningen)
  - Kop van Noord Holland (including Den Helder, Texel, Den Oever, Wieringen)
  - IJmuiden
  - Katwijk/Scheveningen
  - Southwest Netherlands (including Stellendam, Ouddorp, Goedereede, Vlissingen, Arnemuiden, Breskens)
  - Urk
- **Fishery cluster** also **called fishing cluster =** the fishing industry, the supply industry (shipbuilding, energy, etc.), and the processing industry (auctions, transport, processing, trade).
- **Logbook data** of landings per fishing trip including identifier of vessels, gear used, species caught.
- **VMS data** GPS coordinates of fishing vessels with vessel identifier, speed and direction of the vessel.

1 Decommissioning of Dutch Wadden Sea shrimp fishing licenses

1.1 Background and objective

The Dutch fishing industry has been increasingly constrained in recent years by developments in fisheries policy and North Sea policy. The economic consequences of these developments for the fishing industry are not clear, nor is it clear how these changes in policy and the fishing industry translate into socio-economic effects on the fish chain and in fishing regions. In response to two motions from the House of Representatives, this study aims to answer the question: what are the socio-economic effects of policy on the fisheries sector, the fish chain and fishing regions?

The Lodders and Von Martels motions (House of representatives Dossiers number 33450/84 and 33450/93 [in Dutch]) call for an impact analysis of the North Sea Agreement, the Wadden Agenda, the Cutter Vision and the Brexit, including area closures/restrictions due to offshore wind farms and nature reserves, for the fishing industry, the fish chain (including fish processing industry) and the economy of regions where North Sea fishery is an important sector (hereafter referred to as fishing regions). The motions request the government to report on this in May 2022 and May 2023. Following these motions, the Ministry of LNV asked Wageningen Economic Research to carry out this socio-economic impact analysis.

Within this impact analysis project, several socio-economic studies are planned to analyse the effects of policy. A total of three studies were planned in the first phase of this research project. The following reports are planned within this two-year impact analysis (2022/2023):

- Zero measurement of fish cluster structure and dependencies: How large are the regional fish clusters and how do they depend on the fishing sector? (Hoekstra and de Valk, 2023)
- Impact of a smaller active fishing fleet on the social and cultural capital of fishing communities: What are the socio-cultural effects of changes in fishing? (Kraan et al., In prep)
- Impact analysis of the decommissioning schemes on the cutter and shrimp fisheries: What are the economic effects of the two decommissioning schemes on the fishing cluster?

This report presents the results of our study to determine the retrospective socio-economic effects of the 2021 decommissioning scheme on the Wadden Sea shrimp fishing licences in terms of change in fishing capacity in the Wadden Sea and the impact for the fishery, chain and local communities. Because the vessels stopping due to the decommissioning scheme of the cutter fleet were still not fully known when this report was written, this report solely focuses on the decommissioning of the shrimp fishing licences in the Wadden Sea. The impact analysis of the decommissioning for the Dutch cutter fleet will be analysed in a later report. However, the shrimp fleet and cutter fleet are not completely independent from each other and the larger decommissioning scheme of the cutter fleet will also likely have impact on the shrimp fishery.

1.2 Decommissioning scheme in the Dutch shrimp fishery

Two types of shrimp fishing licences

The Dutch shrimp fishery in the North Sea and Wadden Sea is operated by relatively small vessels with a maximal length of 24 metres. The majority of those vessels focus exclusively on shrimp but some vessels are also equipped to operate in other fisheries such has the beam-trawl flatfish fishery or nephrops fishery (see Quirijns et al. 2021 [in Dutch] for further details on the Dutch shrimp fishery). To be allowed to fish for shrimp, Dutch fishers a shrimp licence. There are two types of licences: the coastal waters licence (GK) and fishing zone licence (GV). The coastal water licence (GK) allows shrimp fishing

in the 'fishing zone'[1] and in the waters designated as sea area and coastal waters by Decree Designating Sea Area and Coastal Waters 1970,[2] except for the Oosterschelde and the Eems estuary. The fishing zone licence (GV) allows shrimp fishing in the 'fishing zone'. Only the vessels with a GK licence have access to the Wadden Sea (see Figure 1.1 for the position of the Dutch Wadden Sea). Fishing with a trawl in the Wadden Sea also requires written permission from the owner of the water, in this case the Dutch government. A shrimp vessel that fishes in the Wadden Sea must have been granted a GK license and a written permission. In the policy regarding shrimp fishery, the Ministry of Agriculture, Nature and Food Quality stipulates that no new licenses will be issued. Licences are transferable.

Goal of the decommissioning scheme for the GK licences was to decrease the impact of the shrimp fishery on the Wadden Sea
In the Viswad Covenant,[3] agreements have been made to manage the impact of the shrimp fishery. Components of those agreements include closure of areas to shrimp fishing, gradual buy-out of fishing licences and technical and management measures to improve to reduce the amount of bycatch and improve the survival rate of bycatch. In 2021, the Wadden Fund reserved €10 million to buy out GK licences. A tender scheme was opened in April 2021 (see details of the tender scheme in Appendix 1). The condition for the scheme to go through is that at least 10 GK licences must be taken out of the market. While the overall goal of the Viswad covenant is to halve the fishing pressure of the shrimp fishery in the Wadden Sea compared to 2014, the specific objective targeted through this scheme was to reduce the number of licences by 20 to 30%. By mid-May 2021, 19 of the 89 GK licences had been registered for decommissioning.

In complement to the decommissioning scheme, two zones[4] of the Wadden Sea have been closed to shrimp fishing since 2022. Most vessels lost access to those areas from 1 January 2022 while about 10 fishers with recent written permissions were allowed to continue fishing until 30 September 2022.

1.3 Sub-questions and key question

The key question of this study is:
What are the economic impacts of the decommissioning scheme on the Wadden Sea shrimp fishing licences on the fishery cluster?

The decommissioning carried out in 2021 had an impact on both the fishing industry itself and possibly also the processing industry and fishing communities. Based on the information on the decommissioned licences, the regional impact of the decommissioning is estimated. To identify these impacts, the following analyses have been carried out:

[1] The 'fishing zone' is defined as the Dutch EEZ and other countries EEZ in which Dutch fisheries are allowed https://wetten.overheid.nl/BWBR0003110/1977-07-02
[2] Including the Wadden Sea, focus of this study https://wetten.overheid.nl/BWBR0002703/1994-06-29
[3] In 2014, shrimp fishers, nature organisations, the Wadden Sea provinces and the Ministry of LNV created the covenant 'Transition Shrimp Fisheries and Nature Ambition Rich Wadden Sea' (VISWAD for short). With the covenant parties committed to aim for the most natural possible development of the Wadden Sea in combination with sustainable shrimp fishery. https://rijkewaddenzee.nl/wp-content/uploads/2016/03/transitie-garnalenvisserij-natuurambitie-rijke-waddenzee.pdf
[4] The Eierlandse Gat in the western Wadden Sea and around the Rottums in the eastern part of the Wadden Sea https://open.overheid.nl/repository/ronl-be6e0074-cafa-4d01-9f44-8f6e484765ab/1/pdf/lnv-informatieblad-sluiting-gebieden-waddenzee.pdf

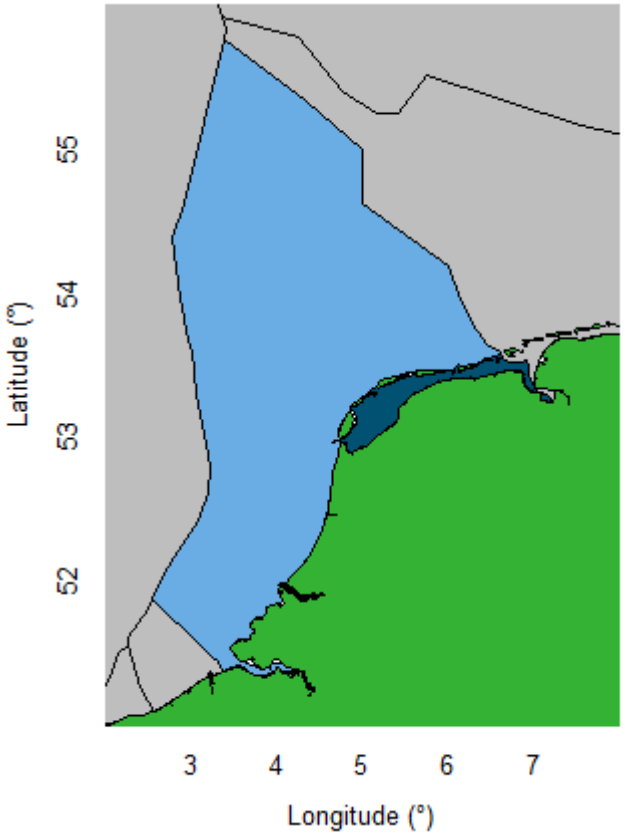


Figure 1.1 *Dutch EEZ (light blue) and Dutch part of the Wadden Sea (dark blue)*

1. An analysis of the short-term loss of fishing capacity based on the historical fishing activity of the affected vessels.
2. An analysis of the response in the fishing patterns of the remaining fleet and the resulting economic performance of the fishery. This analysis is based on a quantitative analysis of catch and effort patterns from logbook data, model projections, cost and earnings analysis, as well as an inventory of fishers' opinions on their reactions to the decommissioning. The latter was done in a focus group.
3. Based on the results of this analysis and the dependencies found in the other sectors (see report Zero measurement of fish cluster structure and dependencies, Hoekstra et al., in review), the effects on the other parts of the regional fish clusters and regions is qualitatively estimated.

1.4 Approach

The analysis of the economic impacts of the decommissioning of GK licences was done using a combination of mixed qualitative and quantitative methods. For the different steps of the analysis, the Essington model was used of collaborative analysis (Figure 1.2 and Essington et al. 2017). In an iterative process, we first used input from the Dutch Ministry of Agriculture, Nature and Food Quality (in the writing of the proposal, the approach proposed, from empirical literature studies about the Dutch shrimp fishery (Steenbergen et al. 2015 and Quirijns et al. 2021) and from regional meetings with the fishery (see Appendix 2). Based on those insights and the analysis of logbook and VMS (vessel monitoring system) data, a first version of the quantitative analysis and model were developed (see Appendix 3). Those results were then presented in a focus group (see Appendix 2) with active shrimp fishers in the Wadden Sea and the model and analysis were revised based on their feedback. Only the final results are presented here.

The static analysis of the withdrawn fishing capacity (sub-question 1) was done using insights from the fishery collected in regional meetings between June and August 2022 (see Appendix 2) and a quantitative analysis of the previous activity of the vessels operating with one of the decommissioned licences. In a first step, the past activity is analysed for the four years prior to the implementation of the decommissioning scheme (September 2017 to August 2021) and for the year since the implementation (September 2021 to August 2022). The quantitative analysis and the perceptions of the fishers in regional meetings and the focus group organised in November 2022 were compared to identify agreements and inconsistencies between the analyses.

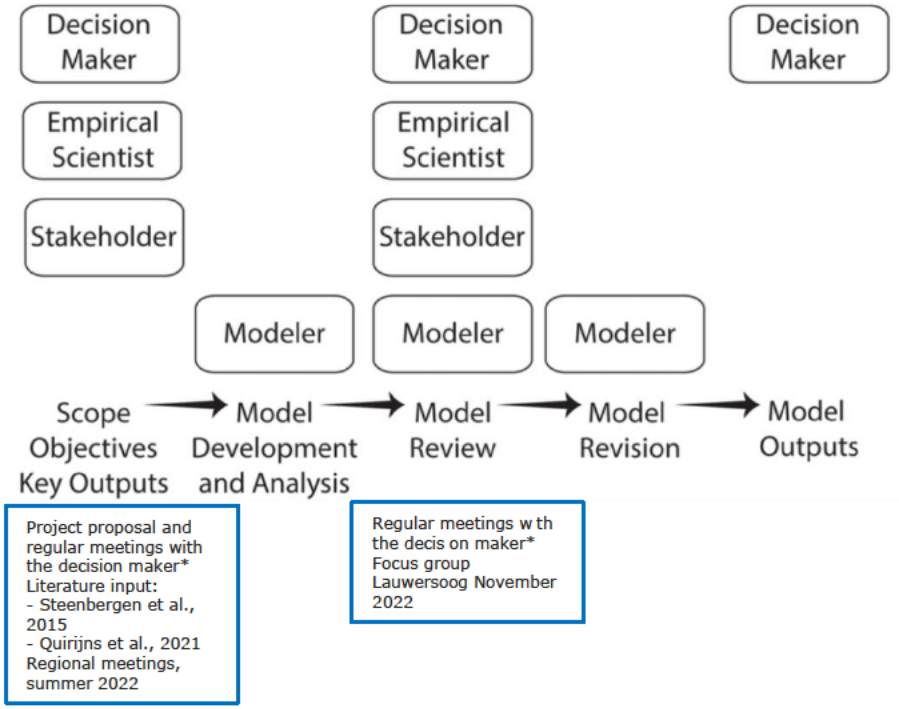


Figure 1.2 *Collaborative approach to stakeholder participation to modelling, typically proceeds by 1) defining scope, objectives, and key outputs with stakeholders, then 2) model development and analysis, 3) possibly model review with stakeholder feedback, and 4) revision before 5) model outputs are delivered. In the blue frame, our inputs from stakeholders are described. Adapted from Essington et al. 2017. *The decision maker is the Dutch Ministry of Agriculture, Nature and Food Quality*

The analysis of the response in the fishing patterns of the remaining fleet (sub-question 2) was done using a model developed to predict the level of fishing effort in the Wadden sea based on factors identified by Steenbergen et al. 2015 and during regional meetings (Appendix 2). The model developed was presented to fishers in a focus group where they commented both on the factors used and on the expected relationships between the factors and the individual effort of fishers. The feedback received was then used to correct the model.

The effects on the other parts of the regional fish clusters and regions is estimated (sub-question 3) using observations of the changes in the fishery between the situation before the decommissioning scheme and the current situation (in terms of landings and number of active vessels) and insights from the regional meetings and the focus group.

The results of the three analyses are shown in the next three sections, the detailed methodology is described in Appendices 2 and 3.

2 Limited loss of short-term fishing capacity on the Wadden Sea shrimp fishery due to the decommissioning

2.1 Description of the Wadden Sea fishery

About 40% of the available Dutch shrimp licences provide access to the Wadden Sea and about 40% of the total active Dutch shrimp fleet is active in the Wadden Sea (Table 2.1). However, only 23% of the total Dutch shrimp effort was deployed in the Wadden sea in the four years before the decommissioning (24% after) resulting in 25% of the Dutch shrimp landings in weight and 26% in value (respectively 30% in weight and 31% in value after the decommissioning). The fishery is strongly seasonal and show highly variable activity patterns over the years (Figure 2.1).

Table 2.1 *Summary table of the shrimp activity before (September 2017-August 2021) and after (September 2021-August 2022) the decommissioning scheme in terms of number of available licences, number of active vessels (operating at least 1 fishing day in a month), effort, landings and value of landings. For the Wadden Sea activity of vessels that last operated with a decommissioned licence, the total shrimp fishery in the Wadden Sea and the total Dutch shrimp fishery*

	Decommissioned Vessels shrimp Wadden Sea fishery		Total Dutch shrimp Wadden Sea fishery		Total Dutch shrimp fishery	
	4 y before	1 y after	4 y before	1 y after	4 y before	1 y after
Number of licences	19	1	89	70	215	196
Average per year						
Number of active vessels	16	1	85	68	195	174
Effort (fishing days)	469	48	3,160	3,215	14,030	13,254
Landings (tonnes)	553	54	4,777	4,255	18,997	14,055
Value of landings ('000 euro)	1,711	192	14,806	16,344	57,264	53,118
Average per active vessel per year						
Effort (fishing days)	31	48	37	47	72	76
Landings (tonnes)	36	54	56	63	97	81
Value of landings ('000 euro)	112	192	173	240	293	305

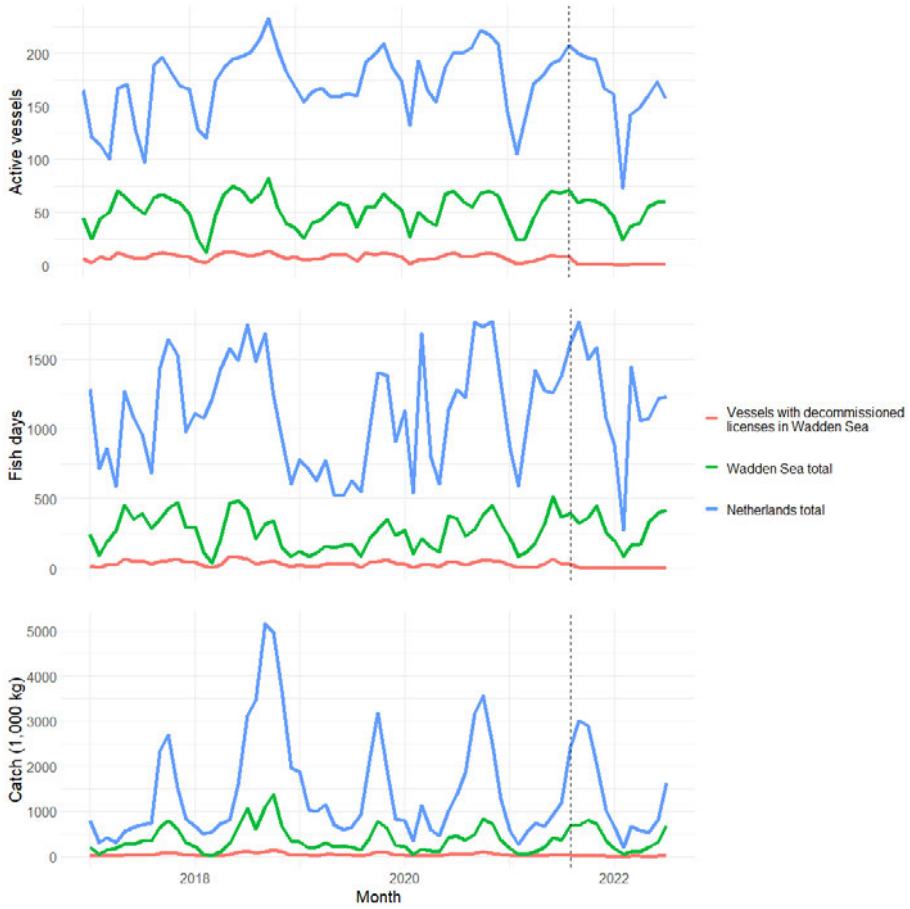


Figure 2.1 *Number of active vessels, effort in fishing days and catch in tonnes for the Dutch shrimp fishery shown for the total fishery (blue), the Wadden Sea (green) and the vessels with a decommissioned licence in the Wadden Sea. The vertical dotted line represent the decommissioning scheme*

2.2 Only 12 of the 19 decommissioned licences were recently active in the Wadden Sea representing 12% of landings and 16% of effort of the shrimp Wadden Sea fishery

The 2021 decommissioning scheme resulted in the removal of 19 GK licences from the Dutch fishery. To evaluate the potential loss of fishing capacity due to the removal of those 19 licences, we looked at their fishing activity in the four previous years (between September 2017 until the date of the implementation of the decommissioning scheme in August 2021). The analysis was done using logbook and VMS data (see Appendix 3). In total the 19 licences represented 21% of the available GK licences (19 out of 89, see Table 2.1), but only 15% of the fishing effort of the shrimp fishery in the Wadden Sea (469 out of 3,160 fishing days) and 12% of the Wadden Sea shrimp landings (553 out of 4,777 tonnes) in the four years before the implementation of the decommissioning scheme (see Table 2.1). Of the 19 licences decommissioned only 16 were on average active in the Wadden sea in the four years prior to decommissioning (Table 2.1). In addition, the fishers operating with those licences were on average less active than the rest of the GK fishers with about 31 fishing days in the Wadden sea for the active fishers compared to 38 for the total Wadden Sea shrimp fishery.

Of those 19 licences, six were not active in the Wadden Sea in 2021 (see inner circle Figure 2.2). One was 'reserved' (i.e. the licence was not allocated to a vessel), four were inactive and two were only fishing shrimp outside of the Wadden Sea. The other 12 licences were all fishing for shrimp in the Wadden Sea and eight of them almost exclusively (the other four caught shrimp mainly outside of the Wadden Sea).

2.3 Since September 2021, vessels have either stopped fishing, fully moved to an alternative activity or kept fishing as before

Three types of behaviour of individual fishers previously operating with one of the decommissioned licence have been observed since September 2021. By looking at the logbook and VMS data between September 2021 and October 2022, we identified the following activities for the 18 vessels linked to decommissioned licences (one licence being 'reserved', no vessel was linked to it, see outer circle Figure 2.2):

- Ten stopped all fishing activity and have not been active since September 2021. Three of those were already inactive in 2021.
- Five have modified their activity. Four of them already fished in the North Sea and moved their shrimp fishing fully outside the Wadden Sea, and one (who was inactive in 2021) switched to passive gears to continue fishing in the Wadden Sea but for other species.
- Three kept fishing as they used to. Two kept fishing exclusively for shrimp in the North Sea, and one repurposed an available licence and kept fishing for shrimp in the Wadden Sea.

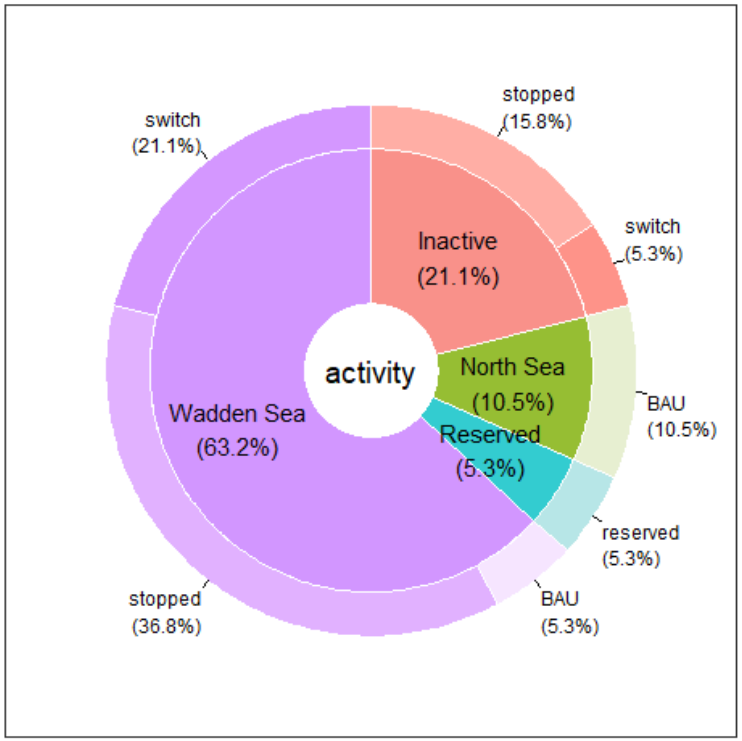


Figure 2.2 *Description of the activity of vessels linked to decommissioned licences in 2021 before the decommissioning (inner circle): fishing in the Wadden Sea, only in the North Sea, not fishing at all (inactive) or not linked to a vessel (reserved) and their activity in the year after the decommissioning (outer circle): business as usual (BAU), switch gear or area, or stopped fishing all together*

2.4 The potential fishing capacity decreased by 21%

The potential shrimp fishing capacity in the Wadden Sea is represented by the number of available licences. The 19 licences that were bought out in the decommissioning scheme represented 21% of the available GK licences.

Although those licences were on average less actively used than the ones that remained active, the total number of active vessels in the Dutch Wadden Sea has decreased as a result of the decommissioning scheme (Figure 2.3). In the four years prior to the decommissioning, the number of active vessels in the Wadden Sea was higher than the current limit on licences.

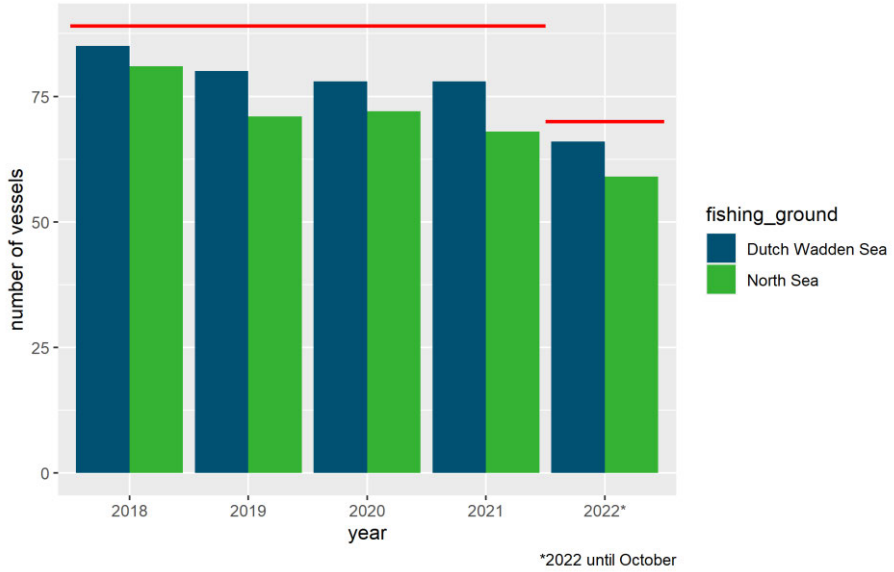


Figure 2.3 *Number of vessels with a GK licence active (defined as minimum 24 fishing hours per year in the area) in the Dutch Wadden Sea and in other part of the North Sea between 2018 and 2022 (data for 2022 includes information until October). The red lines represent the number of available GK licences before and after the decommissioning scheme*

2.5 Fishers anticipate little effect from this decommissioning scheme and expect that a new decommissioning scheme would really decrease the fishing pressure on the Wadden Sea

In summer 2022, Wageningen Economic Research scientists organised a series of regional meetings to present the project approach and collect information about the current situation of the Dutch fishing sector and the fish chain (see Appendix 2 for a description of the regional meetings and their analysis). During some of those meetings, the participants also provided feedback on the shrimp fishery and the Wadden Sea licences decommissioning scheme. In November 2022, an additional stakeholder engagement activity was organised, namely a focus group in Lauwersoog with seven active shrimp fishers from Harlingen, Oostdongeradeel, Westdongeradeel, Usquert and Zoutkamp (see Appendix 2 for a description of the focus group and its analysis).

The initial feedback of the fishers of regional meetings and our workshop was that they expected the impact of the decommissioning to be low. It turns out some fishers were under the impression that only inactive licences were taken out in the scheme:

'With the buyout in the shrimp fishery, only fishers who already were no longer fishing were bought out. And yet areas are closed.' Regional meeting Den Helder, June 2022.

⇨ This is incorrect as 16 vessels were still actively fishing in the Wadden Sea over the four years prior to the decommissioning and 13 were still active in 2021.

The fishers attending the focus group in Lauwersoog also indicated that some of the fishers who have been decommissioned were not fishing in the Wadden Sea before the decommissioning. Some of them were inactive, and others were also fishing outside of the Wadden Sea.

⇨This is correct, only 9 vessels had the Wadden Sea as main fishing ground.

They recognise that since these licences have now been decommissioned, no new fishers can make use of these licences, but to notice a real effect of the decommissioning, they say, there would have to be another round of decommissioning.

⇨ This is likely correct. Given that the number of available licences is now lower that the number of vessels previously active in the Wadden Sea shrimp fishery, the number of active vessels can never go back to the levels seen before the decommissioning scheme.

Also, some of them were in favour of further reduction of the shrimp fleet fishing in the Wadden Sea as it would allow the remaining fleet to perform better.

'With a smaller fleet we are going to earn again. If 50 percent goes out we have more catch and a healthier system. There's also just growth overfishing. They just go ahead [to fish] on smaller shrimp. They say, you have to be there on Monday or you won't catch any more. But there are just too many fishers. In the 70s and 80s there were 3 vessels fishing at Ameland, now there are 15.' Regional meeting Lauwersoog, June 2022.

⇨ This could already be true, since the decommissioning, Wadden sea effort, landings and value per vessel have gone up. However, it is difficult to determine whether those changes are related to the decommissioning scheme.

Fishers in the Lauwersoog workshop argued that the decommissioning had gone hand in hand with the closure of areas, meaning that *de facto* fishing pressure in the open areas did not decrease. Only a few weeks before the focus group was organised, the last areas of the Wadden Sea were closed, so the effects of this could not yet be properly noticed.

⇨ This is correct. The total effort on the Wadden Sea observed in the year after the decommissioning is similar to the level of effort observed on average in the four years before. The closures were not yet fully implemented during the study period so nothing could be said about the effort when closures were implemented.

3 Good shrimp prices led the remaining fleet to increase their effort, compensating the decrease in licences

3.1 Sixty-five per cent of the remaining vessels increased their activity since September 2021

The average annual shrimp effort per active vessel in the Wadden Sea increased by about 27% between the 4 year period before the decommissioning and in the one year after (from 37 fishing days per year to 47, see Table 2.1). Figure 3.1 shows the average annual shrimp effort after the decommissioning relative to the average annual shrimp effort before the decommissioning on the x-axis for these vessels operating in the Wadden Sea. Each dot (fishing vessel) above the black line indicates that their annual effort after the decommissioning is higher than the average of the five years before. About 65% of the remaining fishers increased their shrimp fishing effort in the Wadden Sea after 1 September 2021 compared to the 5-year period before.

Note that there is one vessel previously operating one of the decommissioned licence that continued to fish in the Wadden Sea and also increased their effort since the decommissioning scheme (the one blue dot above the line).

3.2 A model to understanding the drivers of effort

To assess the effect of the 2021 shrimp fisheries decommissioning scheme in the Wadden sea on the total shrimp effort (number of fish days), it is not possible to simply compare the total effort during the period following the decommissioning scheme to the effort in the period prior to this policy intervention. The fishing effort for shrimp is highly variable (Figure 2.1). The reason is that many other factors influence of the effort on the Wadden Sea. Some of these factors are described in Steenbergen et al. (2015). Take for example the North Sea shrimp price and oil price shown in Figure 3.2. Both prices are highly unstable and could have a major influence on the Wadden Sea shrimp effort. Simply comparing the period and after with the period before the policy intervention could mistakenly yield results that are mainly due to other external factors like these. Ideally, the total shrimp effort in the Wadden Sea from the moment the decommissioning scheme took place would be compared to a 'what if' scenario, where the realised total effort can be compared to a scenario in which the decommissioning scheme did not take place.

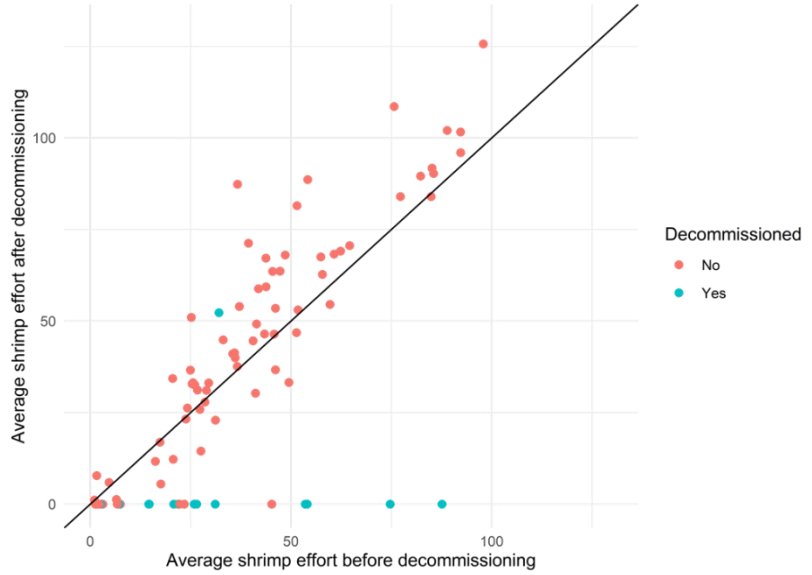


Figure 3.1 *Scatter plot of average annual shrimp effort in fishing days (24h) per year in the Wadden sea during the period from 1 September 2016 until the decommissioning (x-axis) and the period after the decommissioning scheme up until 31 August 2022 (y-axis)*

Assuming that the drivers of effort in the period prior to the policy intervention (1 January 2012 to 31 August 2021) are the same as in the period following the policy intervention (1 September 2021 to 31 August 2022), except for the decommissioning scheme itself, the effort can be estimated and used to forecast the period from 1 September 2021 to 31 July 2022, this forecast can subsequently be compared with the realised effort in order to estimate its impact.

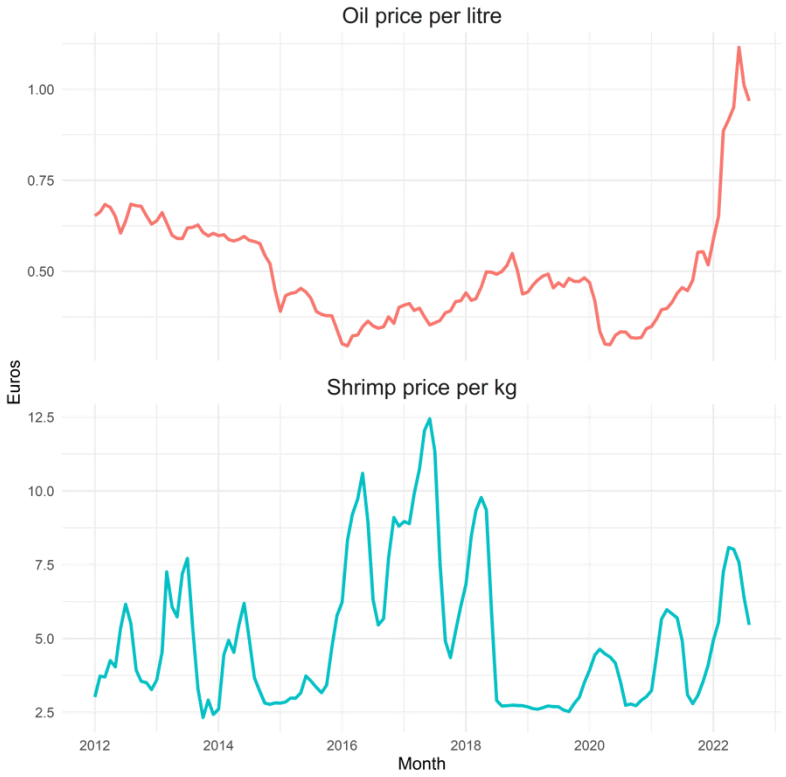


Figure 3.2 *Monthly oil price per litre (top; source: Wageningen Economic Research) and shrimp price per kg (bottom; source: CBS) from 2012 until August 2022*

3.3 Many factors drive the level of the shrimp fishing activity in the Wadden Sea

Steenbergen et al. (2015) identified drivers of shrimp effort. There are seasonal variation and variation linked to the type of vessel or skipper. Subsequently the first forecasting model we used for this analysis incorporated the following explanatory variables:

- Month
- Possibility for switching fishing gear type
- Possibility for fishing in North Sea
- Monthly North Sea shrimp price per kg
- Monthly oil price per litre
- Type of fisher (hours fisher vs knowledge fisher) See cluster analysis in Appendix 3
- Length of vessel

Most of these explanatory variables are already in our data set as described in the previous chapter. However, the variable *type of* fisher is not yet included in our data. This is because there is no data on whether a fisher is an *hours fisher* or a *knowledge fisher*. However, using the definition as described by Steenbergen et al. (2015), a cluster analysis can be used to estimate which vessel-year combinations are hours fishers and which are knowledge fishers. Vessel-year combinations are used because fishers can use different vessels, however, here we assume that fishers do not switch vessels more than once a year. The variables used for this cluster analysis are *kW*, *age of vessel*, *gross tonnage of* vessel and *average maximum effort* ratio (which is described in Appendix 3).

After discussing the model with stakeholders in the Lauwersoog focus group (see Appendix 2), we received some feedback on the chosen explanatory variables. Table 3.1 provides an overview of the overarching factors, the chosen explanatory variables, the reason why we chose them, an explanation of the stakeholders on the mechanisms that the factors could influence their fishing effort and lastly a suggestion for model adaptations. The season, price of shrimp, possibility to operate in an alternative fishery, and the type of fisher (hour vs knowledge fisher) all significantly affected the level of effort in the Wadden Sea.

Table 3.1 *List of factors included in the analysis, including data source, our rational for choosing them, their statistical significance, the insights of fishers about it and their suggestions for adaptation of the model*

Factor	Category	Source	Researchers' rational	Model effect and significance	Explanation given by fishers	Modelling suggestions by fishers
Season effect	Per month		Catch per day and weather conditions have a strong seasonal component. *Source: Steenbergen et al 2015 & regional meetings*[5]	Significant seasonal effects Negative in February/March Positive from May to November	Besides seasonal effects, fishers indicated that the Wadden Sea cannot be seen as one area, but instead must be seen as three different areas. In these three areas, the Wadden Sea behaves differently and therefore influences the behaviour of fishers as well.	The Wadden Sea could be divided in three different regions (not taken into account as the areas would need to be better defined).
Alternative options fishery	Otter trawls (OTT/OTB)	VMS/logbook	If a fisher can also carry out another fishery it influences how much they fish for shrimps on the Wadden Sea. *Source Steenbergen et al 2015*	Negative effects, only significant in the first stage.	Fishers wondered whether this was of that much importance for the Wadden Sea as there are, according to them, only fishers that solely fish on shrimps: 'if this applies to the Wadden Sea then I do not see it that way. On the Wadden Sea there are only 100% shrimp fishers, there are no alternatives. This story comes from the North Sea cost.'	
	Flatfish beam trawl (TBB/SUM/PUL)	VMS/logbook		Significantly negative		
	shrimp beam trawl (TBS outside Wadden Sea)	VMS/logbook		Too few observations in order to take it in to account		
External economic factors	Price of oil	WEcR	Higher oil price increases the costs to fish (and steaming). *Source: regional meetings*[6]	unsignificant effects.	Fishers indicated that a higher oil price causes fishers to move less between different areas. They indicated that a higher oil price causes fishers to return to the port sooner, even if they do not have the quantity of shrimps they would like to have. Others instead said that the time a fisher stays on the Wadden Sea does not have anything to do with the oil price but instead with where the shrimps are located.	
	Price of shrimps	CBS	Higher shrimp price makes shrimp fishing more financially attractive. *Source: expert knowledge*	Significantly positive.	The fishers indicated that indeed a higher shrimp price can compensate for other costs: '[when the shrimp price is higher] you indeed stay longer and do not consider the oil [you are using].'	
Characteristics vessel/fisher	Hours fisher (compared with knowledge fisher)	Outcome of cluster analysis (Appendix 3)	Here, an hours fisher is statistically defined as a fisher who fishes on average more, with a newer, larger vessel. *Source: Steenbergen et al 2015*	Hours fishers have significantly more fish days than knowledge fishers and are more likely to go fishing.	The fishers that were present at the focus group see themselves as knowledge fishers. They fish for as long as needed to be satisfied which is different to the way hours fishers fish as they were labelled as more fanatic and 'hard' fishers.	
	Yearly average catch per fish day (individual fisher)	VIRIS	Fishers who are 'more efficient' need to less time at sea to fish the same amount. *Source: expert knowledge*	Removed	This is an artifact from the data as the least active vessels are more likely to be active when the catch rates are high	remove
	Length vessel[7]	Wageningen Economic Research	Related to number of crew members. *Source: expert knowledge*	Removed	the length of the vessel does not necessarily relate to the number of crew members. Instead, the tonnage of the vessel should be considered as a category	replace by tonnage
	Gross tonnage[8]	Wageningen Economic Research	Added after the focus group. *Source: Focus group*	Significantly negative	Related to number of crew members	

[5] *'In the winter you have "sinks" This means shrimp go away from the Wadden Sea'* Regional meeting Lauwersoog, June 2022.

[6] 'The high diesel prices have less effect on the shrimp fishery than in the cutter fishery. But if prices continue like this or rise even further, that will also become a problem.' Regional meeting Lauwersoog, June 2022.

[7] Removed from model based on feedback from fishers.

[8] Added to the model after feedback from fishers.

Besides the used factors, fishers argued that the quality of the shrimps also affects how long fishers stay fishing. When shrimps are smaller, fishers will go to other places even though they catch less shrimps. Unfortunately, there is no available data on the quality of shrimp and this factor could not be included in the analysis. After revision of the model and incorporating the stakeholder feedback, *length of vessel* has been substituted by *gross tonnage of vessel* as an explanatory variable.

3.4 No significant effect of decommissioning scheme on shrimp effort

Using the two-step modelling approach described earlier, a forecast was made on shrimp effort in the Wadden Sea for each shrimp vessel. The forecast was done using 1,000 Monte Carlo Simulations as described by (Whiteside II et al. 2008). Figure 3.3 shows this forecast in green with its corresponding 95% confidence interval in grey. The red line shows the realised trend, while the blue line shows the expected trend after the decommissioning scheme, if the only thing that changes was that the decommissioned vessels stopped fishing in the Wadden Sea and there were no further changes.

Figure 3.3 shows that the forecasted effort is actually somewhat lower than the realised effort, although mainly still within the 95% confidence region. This indicates that the decommissioning did not have a significant effect on the total shrimp effort in the Wadden Sea. The expected effect from the period from 1 September 2021 until 31 July 2022 was a decrease of about 295 days in shrimp effort, or about 10%. However, when comparing the realised shrimp effort with the forecasted shrimp effort in the Wadden Sea, an increase of about 240 days in shrimp effort is observed, which is an increase of about 8%. Note, however, that the forecast does contain some uncertainty and the realised trend is well within the 95% confidence bounds. Therefore, it is only possible to conclude, using this modelling approach, that the decommissioning did not have a significant effect on the shrimp effort in the Wadden Sea during the period following the decommissioning until 31 July 2022.

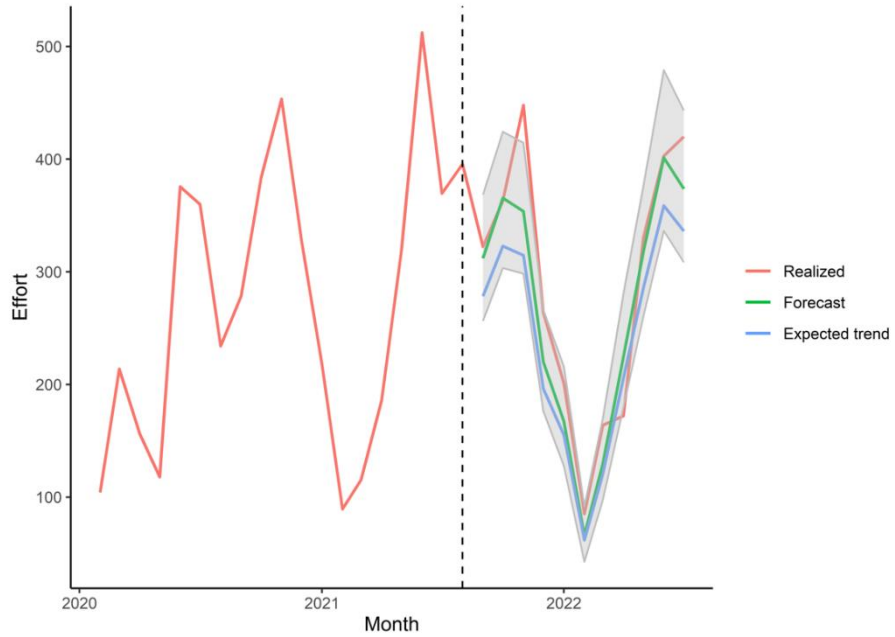


Figure 3.3 *Monthly shrimp effort in fishing days in the Wadden Sea including the realised trend (in red), forecasted trend if decommissioning had not occurred (green), 95% confidence interval of forecast (grey area) and expected trend if decommissioning had occurred (blue)*

3.5 Economic performance of the remaining fleet improved due to higher shrimp prices

The increase in the price of shrimp in 2022 compared to the previous years (Figure 3.2) has led to a shrimp revenue originating from the Wadden Sea 39% higher per vessel in the year after the decommissioning than in the four years before (Table 2.1). In the meantime the individual effort in the Wadden Sea has 'only' increased by 27%. Despite the higher fuel price, this led to a higher profitability for the fleet.

4 The decommissioning of licences hardly impacted the fishery cluster

4.1 Links with on-land fishery cluster through the shrimp value chain and the supply chain for the fishery

The shrimp fishery is linked to land-based activities and businesses through the landings of shrimp in auctions (described in Figure 4.1) and other supply industries linked to vessels being active (not shown here). The Dutch shrimp value chain starts with the landings of shrimp in Dutch or other European harbours and ends with the consumer. As seen on the figure the shrimp value chain is only partially dependent on the Dutch landings (about 60% according to Quirijns et al. 2021). Of those 60% only about a quarter of the shrimp comes from the Dutch Wadden Sea (see Table 2.1) corresponding to about 15% of the total landings weight entering the Dutch value chain.

The landings of the vessels affected by the decommissioning of the licences represented only about 3% of the total Dutch shrimp landings (Table 2.1). This is much lower than the interannual variability of shrimp landings (as seen on Figure 2.1).

Fishers experience a decrease in some activities such as sorting shrimp at the port, while other activities are increasing, like transporting shrimp between ports (focus group, 2022 see Appendix 2). They, however, do not see a direct relationship between these developments and the 2021 decommissioning scheme.

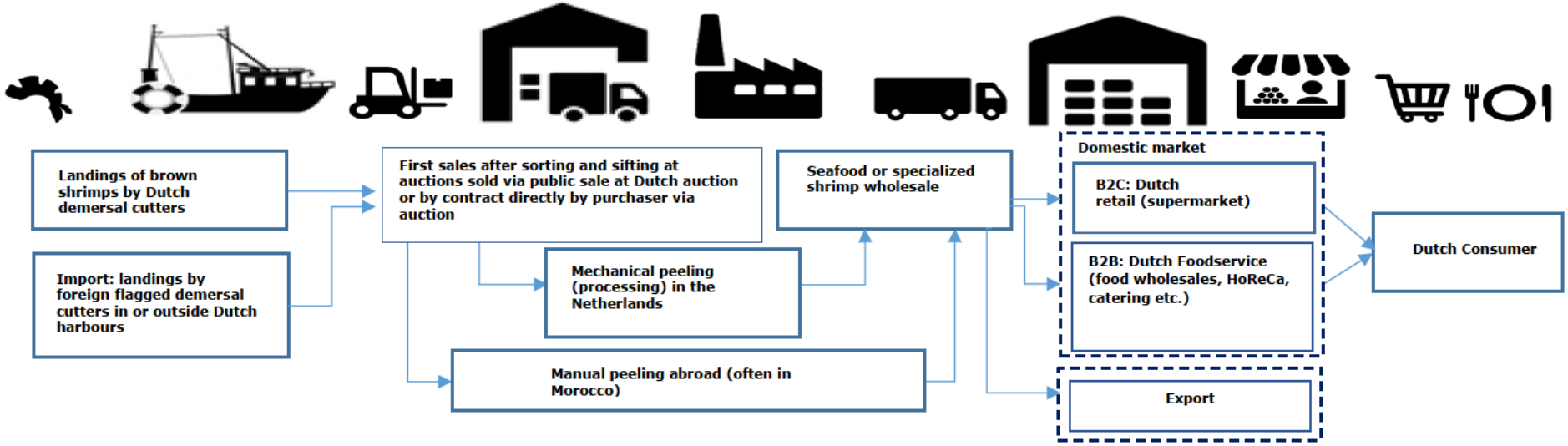


Figure 4.1 *Description of the Dutch logistic chain of the North Sea brown shrimp. B2B means Business to business and B2C means business to consumer. Translated from Quirijns et al. 2021*

4.2 No change in landing distribution of Wadden Sea shrimp to harbours

There are four main landings harbours in the Netherlands where the annual shrimp landings exceed a thousand tonnes: Lauwersoog, Wieringen, Harlingen and Den Helder (see Table 4.1). The shrimp fished in the Wadden Sea are mainly landed in three harbours: Harlingen, Wieringen and Lauwersoog. Those three harbours represented 87% of the Wadden Sea shrimp landings since 2017. Before the implementation of the decommissioning scheme (September 2017-August 2021), the vessels operating with decommissioned licences landed in all harbours and represented about 8% of the total Dutch shrimp landings in Wieringen, 6% in Harlingen and 2% in Lauwersoog. The one vessel who remained actively fishing for shrimp in the Wadden Sea has mainly landed in Lauwersoog after the implementation of the scheme. The overall distribution of shrimp landings to the different harbours does not seem to have been impacted by the decommissioning scheme and has remained comparable after the decommissioning compared to before, with about 25% of total Dutch shrimp landings in Lauwersoog, and 17% in Wieringen and Harlingen (Table 4.1).

Table 4.1 *Shrimp landings in tonnes per landing harbour before (September 2017-August 2021) and after (September 2021-August 2022) the decommissioning scheme for the Wadden Sea activity of vessels that last operated with a decommissioned licence, the total shrimp fishery in the Wadden Sea and the total Dutch shrimp fishery*

Landing harbour	Decommissioned Vessels shrimp Wadden Sea fishery		Total Dutch shrimp Wadden Sea fishery		Total Dutch shrimp fishery	
	4 y before	1 y after	4 y before	1 y after	4 y before	1 y after
Lauwersoog	96	52	1,035	811	4,540	3,686
Wieringen	215	-	1,345	1,394	2,937	2,506
Harlingen	170	2	1,809	1,521	3,201	2,492
Den Helder	26	-	169	152	1,596	986
Other	46	-	419	377	6,723	4,385
Total	553	54	4,777	4,255	18,997	14,055

4.3 Eight harbours lost shrimp vessels to the decommissioning scheme

As a result of the decommissioning scheme, ten vessels stopped their activity. Those represent about 2% of the active Dutch fishing fleet in 2021 (STECF, 2022) or 5% of the 195 active Dutch shrimp fishing vessels (Table 2.1) and are not expected to lead to major changes in the Dutch supply industry. However, when looking at the distribution of those vessels by registration port we see for example that the vessel from Workum (WK) that stopped fishing was the last active vessel registered in that village (Table 4.2). There are eight other home-harbours of vessels that stopped as a result of decommissioned licences: Harlingen (1 stopped out of the average of 10 active vessels over the period 2017-2021 or 10% of the capacity), Harderwijk (1 stopped out of 4 active vessels or 25% of the capacity), Lauwersoog (1 stopped out of 10 vessels or 11% of the capacity), Terschelling (1 stopped out of 5 active vessels or 20% of the capacity), Usquert (2 stopped out of 5 vessels or 40% of the capacity), Wonseradeel (1 stopped out of 3 vessels or 33% of the capacity), Wieringen (1 stopped out of 50 vessels or about 2% of the capacity).

In some villages in which traditionally many fishers live, fishers see the number of potential successors decreasing like in many other fishing communities (Focus group Lauwersoog, 2022). By contrast, there are still some villages with enthusiastic young people who are very eager to start fishing. It is important for both current fishers and potential new recruits that fishers have a perspective for the future.

Table 4.2 *Number of active vessels registered per harbour for all harbours affected by the decommissioning scheme. Average annual number of active vessels before (September 2017-August 2021) and after (September 2021-August 2022) the decommissioning scheme. As total for the harbour of vessels that last operated with a decommissioned licence, and the total Dutch shrimp fishery*

	Vessels operating with decommissioned licences in the 'before' period		Total Dutch vessels	
Registration harbour	4 y before	1 y after	4 y before	1 y after
Harlingen	1	-	10	8
Harderwijk	3	2	4	5
Lauwersoog	1	-	10	7
Stellendam	1	1	6	7
Terschelling	1	-	5	3
Texel	1	1	16	16
Usquert	2	-	5	2
Workum	1	-	1	-
Westdongeradeel	1	1	12	10
Wonseradeel	1	-	3	2
Wieringen	3	2	50	45
Zoutkamp	2	2	25	22

5 Discussion

Modelling limits and uncertainties and measures to mitigate these

Comparing the realised shrimp effort trend in the Wadden Sea with the forecast can give some insight into the effectiveness of the decommissioning, however it is important to note that there is a lot uncertainty surrounding the model used for the forecast. The model has been validated using the methods described in Appendix 3 subsection *Model performance*. However, as shown in the out-of-sample predictions in Figure A3.4, there are differences between the predicted values of shrimp effort in the Wadden Sea and the realised values. This suggests, that in reality the true data generating process deviates from the estimated model in this report. Subsequently, besides uncertainty shown in Figure 3.3, there is some additional model uncertainty, that cannot be explained by the variance in the model. The difference between the real data generating process and the predictions are possibly to be due to omitted variables (such as shrimp quality, or management measures) or nonlinear relations (the models in this report only include linear relations), not included in the model that are of influence on the shrimp effort in the Wadden Sea. To include as many relevant factors as possible, stakeholder discussions were held, and feedback was given on the factors included in the model.

Furthermore, no auto-correlation effects were taken into account when establishing the model, due to time limitations. This means that beyond the annual seasonal patterns, short term knowledge of catch rates of shrimp or effort in the Wadden Sea in the previous month have not been used to predict effort. Adding such effects in panel data models could yield potential estimation biases.

High natural variability

The natural variability of the North Sea shrimp stock and variability of the fishery and shrimp market have not been taken into account in the study. It is therefore difficult to assess what the effort and catch of the fishery would have been without decommissioning scheme. The modelling attempt took some of the drivers of fishing effort into consideration but some uncertainty remain.

Missing input van Wieringers

Seven fishers attended the focus group in Lauwersoog. They came from Harlingen, Oostdongeradeel, Westdongeradeel, Usquert and Zoutkamp. As the fishers themselves indicated during the focus group, these fishers do not represent the diversity of Dutch shrimp fishers on the Wadden Sea. There is also a large group of shrimp fishers from Wieringen active on the Wadden Sea. As the fishers present in the focus group argued, Wieringers have a different mentality and fishing style compared to fishers from the more eastern villages such as Zoutkamp. They generally invest in relatively larger and newer vessels which leads them to fish more to pay off the vessels. Unfortunately, none of the invited fishers from Wieringen were able to accept the invitation. Our results from the focus group might therefore be biased.

Limited short-term effect due to removing inactive or little active licences

This report focuses on the decommissioning scheme as it happened. The licences that were taken out were not selected randomly, nor were they amongst the most active in the Wadden Sea. On average the vessels operating with the decommissioned licences were less active in the Wadden Sea than the total fleet. In addition, one of the fishers could decommission an active licence and after the implementation of the decommissioning scheme and use another licence to keep fishing as usual (or even slightly harder than before, see Figure 3.1). For the ten vessels that completely stopped their activity after the decommissioning, it is unclear whether they would have remained active without the scheme. As noted by one of the focus group participant in Lauwersoog in November 2022 *'Did you also look at who went out? It could also be that those were people who were about to retire, or had no succession? It has a bearing on whether someone has eight or 20 more years to work.'* However, by reducing the capacity with a decommissioning scheme, one makes sure that those licences never become active again.

Extraordinary context since the decommissioning with record high fuel price

The fuel price increase has been observed since the end of 2021 and particularly since February/March 2022. The 2022 prices have been far above the range observed during the model calibration period (2012-August 2022). During that period, the effect of fuel price did not significantly affect the choice of fishing in the Wadden Sea within a month or not nor the level of effort when fishing. This was already mentioned in Steenbergen et al. (2015), however during the regional meeting in Lauwersoog in June 2022, it was mentioned that the fuel prices would become a problem for the fleet if they remained at the level of the time or increased.

Decommissioning is part of a bigger management plan (also area closures) with expected longer-term effects

This decommissioning scheme is part of a larger plan from the VisWad covenant to reduce the fishing impact in the Wadden sea. As mentioned in the introduction, the decommissioning goes hand in hand with the closure of areas to shrimp fishing. The latest areas of the Wadden Sea were closed only a few weeks before we spoke with the fishers (1 October 2022). This study has been performed relatively shortly after the decommissioning. For the fishers it was hard to notice the effects of this already. Some of the effects of the management (decommissioning + closures) might not be clear at the moment when the study was performed. One fisher who attended the Lauwersoog focus group said that 'the time horizon is too short, we have to look 20 years ahead. (…) After the decommissioning, the Wadden Sea has yet to prosper'.

The dynamics in the Wadden Sea shrimp fishery also depends on the shrimp fishery North of the Wadden Sea

In this research, we looked at decommissioning for the Wadden Sea solely. However, the Wadden Sea is not a physically demarcated area, and shrimps swim outside of the Wadden Sea to the North Sea as well. These two areas and the activities happening in these areas are in strong connection with each other. Shrimps, some of the fishers said, 'have to come from the outside to the inside' (focus group, Lauwersoog November 2022). With this he meant that shrimps have to come from the North Sea to the Wadden Sea. When other fishers fish for shrimps on the North Sea coastal area, this decreases the number of shrimps that arrives on the Wadden Sea. Fishers pointed out that when there are a few shrimps 'in front of the hole' (where the North Sea flows into the Wadden Sea), many shrimp fishers that fish outside the Wadden Sea are also going to that area to fish for these shrimps. This leaves less shrimps for the fishers on the Wadden Sea. By considering both the activities that happen on the Wadden Sea as the activities that happen on the North Sea, one could get a more complete picture of the activities related to shrimp fishing that are happening in this area.

Fish clusters unaffected by this decommissioning scheme will be impacted by the cutters' one

This decommissioning may not have had effects on the fish auctions and the supply industry around the fishery but the cutter decommissioning scheme implemented in 2022 is expected to have negative impacts on land. Those impacts will also influence the shrimp fishery. If fish auctions, cooperatives (selling fuel in harbours) and other good and service industries also supplying the shrimp fishing fleet close, this could have a strong impact on how shrimp fishers can operate. Having to go further for supplies or to sell their catch would mean extra labour and extra costs, without mentioning the existing personal relationships leading to trust between fishers and their on-land business partners that would have to be recreated.

6 Conclusions

Limited loss of short-term fishing activity on the Wadden Sea shrimp fishery due to the August 2021 decommissioning of 19 GK licences

Almost a third (six) of the licences were already inactive in the Wadden Sea the year prior to the scheme

Out of the 19 licences decommissioned six were already inactive in the Wadden Sea since 2020: one was inactive (not assigned to a fishing vessel or 'reserved'), three were assigned to vessels that were last active in 2019 and two were not actively fishing in the Wadden Sea in the four years prior to the decommissioning scheme. Because of this, although the 19 licences represented more than 20% of the available GK licences, the vessels operating them only represented 12% of the landings and 16% of the effort of the Dutch shrimp fishery in the Wadden Sea.

Five vessels kept fishing for shrimps (four outside the Wadden Sea, one with a reactivated licence)

Of the 13 licences used by vessels active in the Wadden Sea in the period prior to the decommissioning, seven stopped fishing altogether after August 2021, five modified their activities (four moved to fully catching shrimp outside the Wadden Sea and one switched to fishing with passive gear inside the Wadden Sea) and the last vessel repurposed a licence to keep fishing for shrimp in the Wadden sea.

In the year following the decommissioning scheme, the remaining fleet compensated the decrease in licences

Sixty-five per cent of the remaining vessels increased their activity since September 2021 compared to the four years prior

On average, the vessels fishing for shrimp in the Wadden Sea in 2021 and/or 2022 increased their effort by 12% since September 2021 compared to their average annual effort of the four years prior to the scheme.

Model projections forecast no significant short-effect of the decommissioning scheme on shrimp effort

Because external factors have changed in the period after the decommissioning, it is difficult to compare the situation before and after. Using a statistical model using seasonal factors, possible alternative activities, type of fishers, gross tonnage and shrimp and fuel prices to determine the fishing effort of a fisher per month, we were able to show that the effort forecasted without the decommissioning scheme was not significantly different from what was actually observed.

Good shrimp prices led to a profitable fishery in the year after the decommissioning scheme

The remaining vessels fished harder (+27% fishing days per vessel on average compared to the fleet prior to the decommissioning, i.e. including decommissioned licences) in the Wadden Sea resulting in slightly higher catch (+11% per vessel) but especially much higher income (+39% per vessel) due to favourable shrimp prices.

The decommissioning of licences hardly impacted the fishery cluster

Links with on-land fishery cluster through the shrimp value chain (forward linkage) and the supply chain for the fishery (backward linkage)

There are two paths from the shrimp fishery to the fish cluster, through the landings of shrimps (forward) and the provision of goods and services for the active vessels (backward). The landings of the vessels involved in the decommissioning scheme represented 3% of the total Dutch landings which is lower than the interannual variability of Dutch shrimp catch. It is therefore safe to say that the shrimp value chain was unaffected by the decommissioning scheme.

The provision of goods and services (backward linkages) to the shrimp fleet are not specific to the shrimp fishery and also service other fishing fleets.

Because of this the ten vessels (seven were still active in the year prior to the decommissioning and three had already stopped fishing see also **Figure 2.2**) effectively exiting the fishery as a result of the scheme only represent and minor part of the Dutch fleet.

No change in landing distribution of shrimp to landings harbours
The total landings of shrimp from the Wadden Sea remained unchanged, and in addition, their distribution to landing harbours also remained stable with Harlingen, Wieringen and Lauwersoog concentrating the majority of the landings in stable proportions.

Eight harbours lost shrimp vessels to the decommissioning scheme
Of the eight registration harbours that lost shrimp vessels due to the decommissioning scheme, five had five or less active vessels in the four years leading to the scheme, for those the loss represented 20 to 100% of their active fleet. Two harbours with about 10 active vessels lost 10% of their fleet and Wieringen, with about 50 active vessels lost only 2% of its fleet.

Long-term fishing capacity now capped 21% lower

The decommissioning scheme led to a number of available licences for shrimp fishing in the Wadden Sea lower than earlier fleet
The decommissioning scheme had a goal of reducing the long term capacity of the shrimp fishery in the Wadden Sea. This is now achieved with a resulting number of licences (70) being substantially lower than the 85 active shrimp vessels in the Wadden Sea annually in the four years prior to the scheme. In effect, the capacity of the Wadden Sea fishing fleet is now capped 21% lower than its previous capacity.

Fishers expect a subsequent decommissioning to reach much higher impacts
Because less active fishers have been taken out of the fishery, fishers expect that a new decommissioning scheme would have a much higher impact in decreasing the shrimp fishing activity in the Wadden Sea.

References

Bishop, C.M., and N.M. Nasrabadi. 2006. Pattern Recognition and Machine Learning. Vol. 4. 4. Springer.

Chow, G.C. 1960. 'Tests of Equality Between Sets of Coefficients in Two Linear Regressions.' Econometrica, 591–605.

Davidian, M., and A.R. Gallant. 1993. 'The Nonlinear Mixed Effects Model with a Smooth Random Effects Density.' Biometrika 80 (3): 475–88.

Fletcher, D., D. MacKenzie, and E. Villouta. 2005. 'Modelling Skewed Data with Many Zeros: A Simple Approach Combining Ordinary and Logistic Regression.' Environmental and Ecological Statistics 12 (1): 45–54.

Essington, T.E., L. Ciannelli, S.S. Heppell, et al. 2017. Empiricism and Modeling for Marine Fisheries: Advancing an Interdisciplinary Science. Ecosystems 20, 237–244. https://doi.org/10.1007/s10021-016-0073-0

Hastie, T. 2009. Elements of Statistical Learning.

Hausman, J.A. 1978. 'Specification Tests in Econometrics.' Econometrica 46: 1251–71.

Held, L., and D. Sabanés Bové. 2014. Applied Statistical Inference. Springer, Berlin Heidelberg. Springer.

Hintzen, N.T., A. Coers, and K. Hamon. 2013. "A Collaborative Approach to Mapping Value of Fisheries Resources in the North Sea (Part 1: Methodology)." IMARES Wageningen UR. IMARES Wageningen UR.

Hoekstra, F.F., Y. de Valk. 2023. Visclusters in Nederland (nulmeting): omvang en afhankelijkheden voor de keten en toeleverende industrie van Noordzeevisserij. Wageningen, Wageningen Economic Research, Rapport.

Honda, Y. 1985. 'Testing the Error Components Model with Non-Normal Disturbances.' The Review of Economic Studies 52 (4): 681–90.

Kraan, M.L., N. Steins, X. Verschuur, O. van der Valk, D. van Wonderen B. Deetman. In prep. Sociale en culturele waarde van visserij voor de visserijgemeenschap en gevolgen van beleidswijzigingen. Wageningen, Wageningen Economic Research, Rapport

Pesaran, M.H. 2015. Time Series and Panel Data Econometrics. Oxford University Press.

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

Stammann, A., F. Heiss, and D. McFadden. 2016. 'Estimating Fixed Effects Logit Models with Large Panel Data.'

STECF, 2022.

Steenbergen, J., T. van Kooten, K. van de Wolfshaar, B. Trapman, and K. van der Reijden. 2015. 'Management Options for Brown Shrimp (Crangon Crangon) Fisheries in the North Sea.'

Stock, J.H., M.W. Watson et al. 2003. Introduction to Econometrics. Vol. 104. Addison Wesley Boston.

Whiteside II, J.D. et al. 2008. 'A Practical Application of Monte Carlo Simulation in Forecasting.' AACE International Transactions, 17–21.

Wooldridge, J.M. 2015. Introductory Econometrics: A Modern Approach. Cengage Learning.

Zhang, H., N. Lu, C. Feng, S.W. Thurston, Y. Xia, L. Zhu, and X.M Tu. 2011. 'On Fitting Generalized Linear Mixed-Effects Models for Binary Responses Using Different Statistical Packages.' Statistics in Medicine 30 (20): 2562–72.

Appendix 1 Rules of the GK licences decommissioning

The Wadden Fund decommissioning scheme was officially published on 12 March 2021[9]. Here is a summary this tender scheme.

Background information

The shrimp fishery is an important economic activity in the Dutch Wadden Sea. In order to achieve sustainable fishing while preserving nature, the Covenant Viswad was signed in 2014 by the State Secretary of Economic Affairs, the Executive Councils of Groningen, Friesland, and North Holland, parties united in the Coalition Wadden Natuurlijk, the Netherlands cutter fishery association and the Association Co-operative Producers Organization Dutch Fishers' Union U.A.. In this covenant it was agreed that all parties will strive for the most natural possible development of the Wadden Sea in combination with a sustainably operating shrimp fishery. The joint ambition is to halve the fishery impact of shrimp fishery in the Wadden Sea by 2020. The Implementation Program of the Covenant describes several measures that will contribute to achieving this goal.

One of the measures is to close certain fishing areas. This is already underway. In addition, a sustainable operating and profitable shrimp sector must be developed. The direct consequence of closing shrimp fishing areas is a possible increase in fish pressure in the areas that are not closed. To prevent this, the Covenant agreed to work on the recovery of the Wadden system by reducing the negative effects of fishing. As part of the Covenant's total package of measures, the purpose of this tender scheme is to withdraw shrimp fishing licenses in the Wadden Sea (hereafter: GK licenses) from the market by giving shrimp fishers the opportunity to voluntarily relinquish their GK licenses. The participating fishers will receive financial compensation for this. This tender scheme is explicitly part of the established Viswad Covenant.

Agreements have been made between the Wadden Fund and the Ministry of LNV or Economic Affairs that the Ministry will no longer issue GK licenses and will delete the surrendered GK licenses and the corresponding written permission.

Purpose of the tender scheme

The purpose of this scheme is to reduce the impact of shrimp fishing in the Wadden Sea by giving fishers the opportunity, on a voluntary basis, to relinquish their GK license as well as the associated engine power and written permission, for which they will receive financial compensation. In return for taking GK licenses, the protected areas in the Wadden Sea will be scaled up. The covenant sets the goal of reducing the number of permits by 20-30% by 2020.

Rules and conditions of the tender scheme

In total €10 million were made available for this decommissioning scheme. The distribution of the amount is based on a ranking of the applications. This is based on the amount of subsidy requested per application (from low to high). The ranking is based on the number of kilowatts attached to the GK license. The registration concerns an amount per kW with a maximum per kW of € 3114. This amount was arrived at by dividing the maximum per GK license (€ 688,194) by the maximum power of a shrimp cutter on the Wadden Sea (221 kW). This means that the applicant who turns out to ask for the lowest amount per kW at registration will be the first to be considered for subsidy. The applicant requesting the highest grant will be the last to be considered for grant funding. Distribution of the budget will take place as far as the budget allows. However, a minimum of 10 licenses and/or a minimum of 1900 kW will be subsidised and a maximum of 30 GK licenses will be subsidised.

[9] https://zoek.officielebekendmakingen.nl/bgr-2021-211.pdf [in Dutch]

Based on the Fisheries Law, the GK license is required to fish for shrimp. The GK license is in the name of the license holder and is mandatorily linked to a fishing vessel. A separate GK license is required for each fishing vessel. If the GK license is not linked to a fishing vessel, it is what is called 'reserved'. A licence could be reserved for up to two years before the decommissioning scheme.

Appendix 2 Qualitative Methods

Regional meetings

Between June and August 2022 twelve regional meetings were held in Den Helder, Lauwersoog, Urk, Ijmuiden, Scheveningen and Stellendam to present the approach taken of the Impact Analysis Project and to collect information about the current situation of the Dutch fishing sector, looking at the impact of policy measures on the fishery, the fish chain and the fishing communities. Both economic impacts as well as social and cultural impacts were discussed. Separate meetings were organised for stakeholders related to fishing and for those related to the fish chain (trade, auction, processing but also supply industries). Of the fisheries meetings, one meeting focused on the pelagic subsector and one meeting on the small scale coastal fleet. The rest of the fisher meetings were a mix but with a strong focus on the cutter fleet. It was made sure that a wide variety of stakeholders were present, but the groups were kept relatively small to allow for discussion. The world cafe method was used to make sure that everyone would have the opportunity to respond to all the questions. With the world cafe method groups are made even smaller (between 2-5 people in this case) to avoid that discussions are dominated by a small nr of people.

During the meetings the project was explained and the data that Wageningen Economic Research had available was shared and discussed. During and after the presentation, there was ample time for questions and discussion. This time was always used and gave a clear insight in the mix of feelings felt by many: concern, anger, distrust and disappointment were most prevalent. Concern about the situation they were in, the lack of perspective and disappointment about the role of the government in the crisis. The meetings were often the first physical meeting in years, in which a lot had happened. Due to covid many meetings had been cancelled or postponed. Also the meetings were held in a time that the Dutch fleet was suffering from the high oil price, due to the war in Ukraine and was awaiting a long promised announcement of the decommissioning scheme for cutters (which make up the majority of the fleet). This first part of the meeting was followed by discussing different sets of questions in the world cafe format. All the feedback that was received was documented and analysed after coding the data in Atlas.ti, a qualitative coding software. In this programme, texts can be analysed by attaching codes or memos on the text. Codes can be seen as labels existing of one or multiple words. By attaching codes to a specific part of the text, it becomes visible when a certain topic is discussed. For analysis purposes all quotes belonging to a certain code can be easily extracted. This data is available for the different parts of the project. For this report the codes *'garnalen'* [shrimp] and *'sanering'* (decommissioning) were used. Most of the shrimp quotes came from the regional workshops held in Lauwersoog and Den Helder. Most of the decommissioning quotes were about the expected scheme for cutters, but some were also about the shrimp licence decommissioning scheme.

Focus group

A focus group was organised in November 2022, in Lauwersoog with seven active shrimp fishers from Harlingen, Oostdongeradeel, Westdongeradeel, Usquert and Zoutkamp. These fishers were a sample taken from the total number of 70 shrimp fishers fishing on the Wadden Sea. The sample was defined by fishers fishing between 10 and 100 percent on the Waddensea and to be relatively easily contacted through our own database (being linked to different POs) or via the largest shrimp producer organisation (Vissersbond), resulting in a list of 29 fishers. From that group a purposeful sample of 17 fishers was taken, by making sure a mix of different registration numbers was taken, making sure that fishers would come from different harbours and communities. Of those fishers invited, 7 came to the focus group. Unfortunately we did not manage to have fishers from Wieringen in the group. We later realised that by organising the focus group in Lauwersoog we had unintentionally made it more difficult for them to come (more than 2 hours driving for a 2-hour meeting is quite a burden). It would have been better to have organised it in Harlingen, which is approximately within one hour drive for all the invited fishers.

A focus group takes form of a workshop in which by means of a semi-structured discussion, feedback from a small group of participants is requested. The goal of this focus group was to verify the model that was created and ask the fishers if they thought the correct factors were used in creating this model and if the statistical coefficient estimated made sense. Besides that, the fishers were also asked whether (and if so, how) they thought their behaviour after the decommissioning changed and if they could explain certain results that the researchers thought were outstanding. Three researchers were involved in this workshop; one economist/modeller who presented the research and the model, one anthropologist who guided the conversation and one anthropologist who took notes.

After the meeting, the notes were processed into a report. A specific focus hereby was on the remarks the fishers had on the model and its outcomes. After this workshop report was finished, the document was coded in Atlas.ti. For the analysis of the data of this focus group, the three researchers that were present at the workshop pre-created a list with codes before the coding was done. This list was completed with a more inductive approach during the actual coding of the document in which more codes that seemed important were added as well. Codes were also grouped according to the theme they represented. After the report was coded, one could see very clearly in which parts certain topics were discussed by looking at the codes and code groups. This made the analysis and processing of the workshop report clearer.

Table A2.1 *Overview of codes used in Atlas.ti to code report focus group Lauwersoog*

Code group	Code	Grounded
Model	Adaptations model	5
	Confirmation model	1
	Explanation by outcome model	1
Presence of shrimps	Number of shrimps on Wadden Sea	12
	Quality / size of shrimps	2
	Siftsel	4
Use of the Wadden Sea	Closed areas	5
	Too many fishers for the space	5
	Hour slot	2
	Other use of Wadden Sea	2
Way of fishing	Number of crew members	4
	Number of fishing days	3
	Way of fishing	7
	Fish more/harder	4
	Fish more/less	2
	Less switching between areas	3
	Design vessels	2
	Piggy banks	2
	Hours fishers / knowledge fishers	2
	Fish for other kinds of fish	1
Social/cultural aspects	Presence of successors / young recruits	2
	Mentality fishers	7
	Perspective for fishers	4
	Fisher community	3
Economic aspects	Fuel price	12
	Shrimp price	1
	Investments	2
	Costs (besides fuel)	3
	Revenue	2
Natural aspects	How clean is the water?	3
	Natural effects	4
	Differences per month	3
	Silting	7
	Rising of sea level	1
Permits and rules	Current decommissioning	7
	New decommissioning	3
	Previous decommissioning schemes	2
	Perspectives on decommissioning	3
	MSC-certification label	3
	Permits/rules from the government	7
Other	Activities on fish auction and port	3
	Cooperations	1
	Separation Wadden Sea	3

Appendix 3 Quantitative Methods

Logbook-VMS data

The logbook data records landings and effort at the ICES rectangle level. However, to be able to identify the amount of fishing allocated to the Wadden Sea, a finer scale of analysis is needed. We use the Vessel Monitoring System (VMS) data coupled to the logbook data as described in Hintzen et al. (2013). The landings of a trip are assigned to the different pings proportionally to the duration of a ping (time between two VMS points). The pings are then overlapped with the polygon of the Dutch Wadden Sea to identify fishing pings inside/outside the Dutch part of the Wadden Sea.

One problem arises when using the methods described in Hintzen et al. (2013) in order to estimate when a vessel is fishing or not. Vessels are assumed to be fishing while maintaining a speed between two threshold values. However, it could be that a vessel is estimated to be fishing when in fact it is not. This could cause monthly shrimp effort in the Wadden Sea for a fisher to be above zero during a given month, when in reality the fisher has not fished for shrimp in the Wadden Sea that month. If these errors are small and unbiased, this would not be major problem for reporting, as these errors could be both positive as well as negative. However, for our logistic regression model (see below), it could yield some problems, as the outcome variable changes from a zero (fisher is not fishing for shrimp in the Wadden Sea) to a one (fisher is fishing for shrimp in the Wadden Sea). In order to solve this problem, a minimum monthly effort threshold has been set. In order for a vessel-month observation to count as actually fishing, the number of fish days should be at least one whole fish day in a given month. This approach should not influence our model results, unless errors arising from estimating the fish days are differently distributed across the period before and after the decommissioning scheme, which we assume not to be the case.

Modelling approach

The approach that is used in this study is to divide the model in to two different modelling stages. The first stage will consist of a model with a binary outcome variable predicting whether or not a vessel is setting out to fish in a given month. The second model, subsequently, predicts the effort for a vessel in a given month, in case the outcome for the first model is true. Since the model in the first stage is one with a binary outcome, a logistic regression model will be used, while for the second stage, a linear regression model is used. See Figure A3.1 for a graphical overview of this approach.

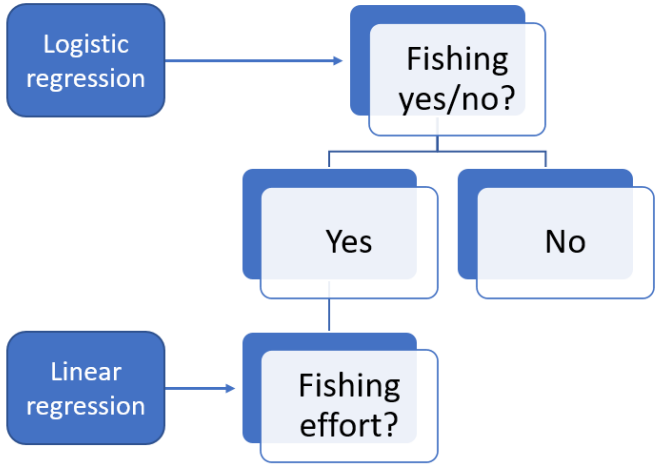


Figure A3.1 *Two-step modelling approach*

To accurately forecast the hypothetical trend for the period following the decommissioning, we aim to estimate a model that describes the data generating process best. Therefore, some form of out of sample validation of our modelling approach is required. Validation is done by back testing the models on 5 different subsets of the data from January 1st 2012 to August 31st 2021 keeping subsets of the data outside of the training data.

For the modelling stage a mixed effects logistic regression is used as described by Davidian & Gallant (1993). For the linear regression model, a fixed effects estimation approach has been used as described by Wooldridge (2015, pp. 484-84). Tables A3.2 and A3.3 show the estimated coefficients and their respective standard errors for each modelling stage respectively.

Cluster Analysis

One of the explanatory variables, described in Steenbergen et al. (2015), is whether or not the fishers on the vessel are hours fishers or knowledge fishers. In order to divide fishers across hour fishers and knowledge fishers, a k-means clustering algorithm is used, $k = 2$ as described in Hastie (2009), pp. 509-510. The way this clustering algorithm works is that it starts off with taking an initial guess at the center of each cluster. Subsequently, for each observation the Euclidean distance to the center is computed and the closest center is identified. For each cluster, a new cluster center is established. This process is repeated until convergence.

As previously stated, the following variables will be used for the cluster analysis, in order to compute a new variable, representing whether the vessel-year combination was an hours fisher or a knowledge fisher: *KW*, *Age of vessel, Gross tonnage of vessel*, *Average maximum effort ratio*. The age of the vessel can be calculated by subtracting the current year by the hull year variable for each vessel. The average maximum effort ratio variable however, will require some additional computations. This variable is based on the annual average effort divided by the maximum effort for a vessel's specific size class. The maximum effort is determined by dividing the numeric variable gross tonnage into 3 different size classes, using the k-means clustering algorithm described above, but using only gross tonnage in order to calculate the distances. Effort does not limit itself to only shrimp fishing on the Wadden Sea, but also includes other types of fish and fishing in the North Sea. The size classes are subsequently divided according to Figure A3.2. The maximum effort for each size class-month combination can subsequently be derived by taking the 99^{th} percentile of the effort for each size class-month combination. The mean effort ratio can then be calculated by dividing each annual average effort of a certain vessel by the maximum effort. One problem with this approach is that for some vessels there are no fish days recording in a given year. For those year-vessel combinations, mean imputation on a vessel level is used.

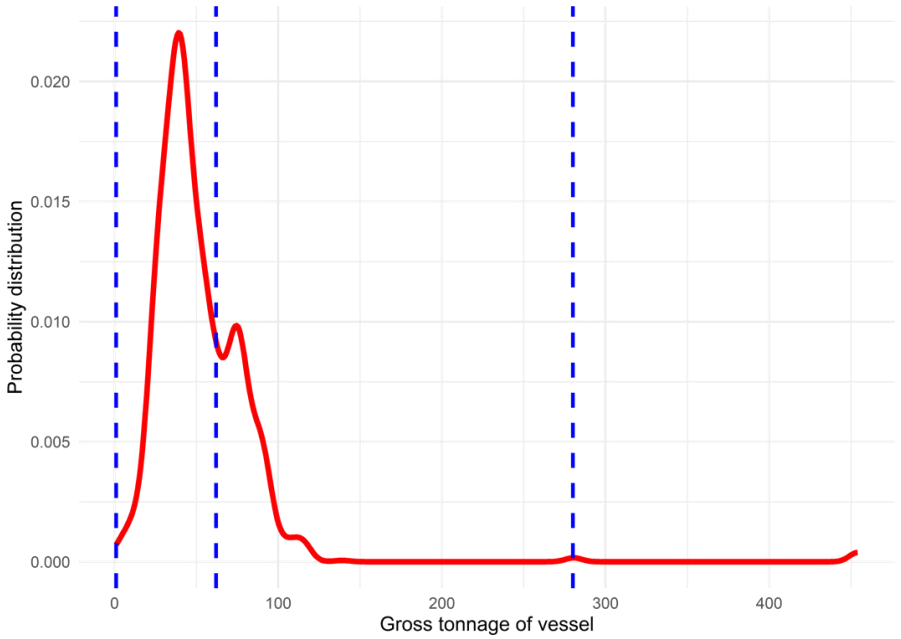


Figure A3.2 *Distribution of gross tonnage across vessel-year combinations (in red), with division of size classes (blue dashed lines)*

Now that all required variables for the cluster analysis have been computed, it is time to move on to the actual clustering. Recall that each vessel-year combination receives a binary cluster outcome, based on its features. Figure A3.3 shows relations between each variable used for the cluster analysis and their densities, while the colors indicate the estimated type of fisher.

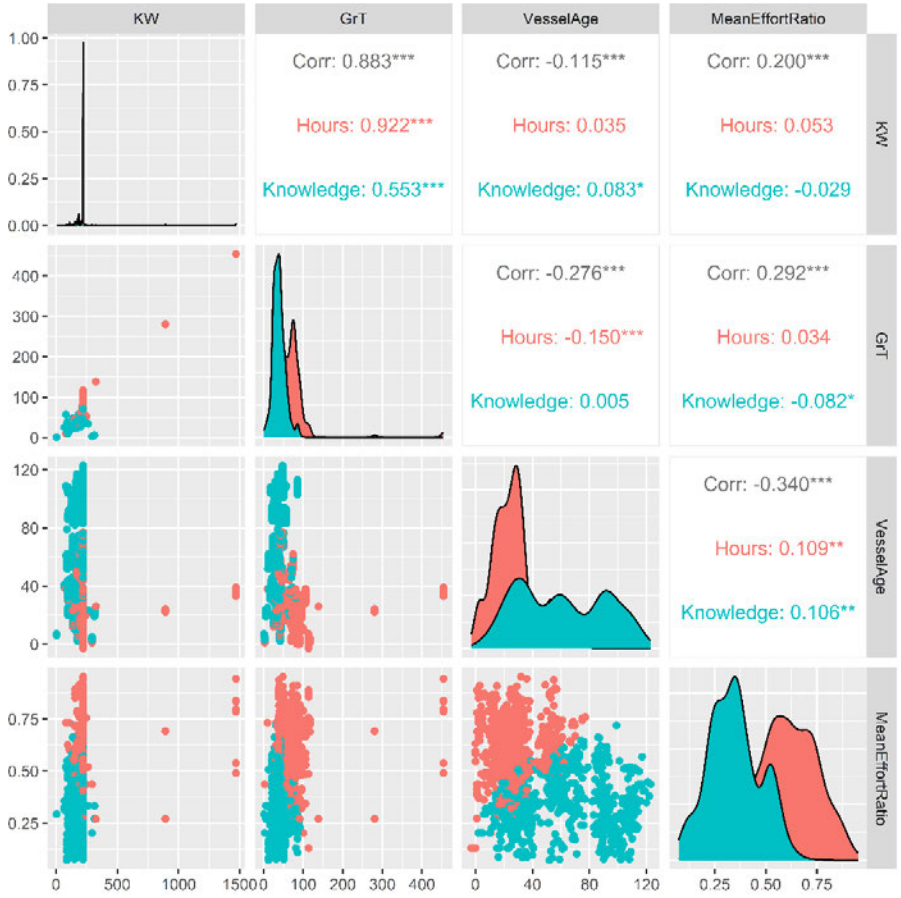


Figure A3.3 *Correlation plots of KW, gross tonnage, vessel age and mean effort ratio on the lower diagonal, density plots on the main diagonal and Pearson correlation coefficients on the upper diagonal, coloured by whether the vessel-year combination is estimated to be an hours fisher (red) or a knowledge fisher (blue)*

Logistic regression model

The first stage of the modeling approach considers predicting whether or not a fisher i will go shrimp fishing in the Wadden sea in a given month. In this case, the target variable is a binary response variable and therefore we are interested in a model that describes the fishing probability conditioned on the explanatory variables. This can be achieved by estimating a logistic regression, also known as a logit model (Nasradi, 2006, p. 197). The logistic regression is estimated using maximum likelihood. However, due to the nonlinear log likelihood function, the iteratively reweighted least squares (IRWLS) is used in order to estimate the model coefficients (Hastie, 2009, pp. 119-22).

However, estimating regression model in a panel data setting without controlling for individual fixed effects could cause an omitted variable bias to occur (Stock, Watson, et al. 2003, 104:403). Estimating an individual fixed effects model for logistic regression can be tricky as it requires estimating nonlinear individual effects. One approach described by Stammann, Heiss, and McFadden (2016) uses a pseudo-demeaning method in order to control for fixed effects in logit models. When using a linear regression model, testing for fixed effects can be done using the Chow test (Chow 1960). However, since we are dealing with a nonlinear regression model, which is estimated using maximum likelihood a likelihood ratio test can be used as described by Held & Savanés Bové (2014, pp.146-48). Computing the likelihood ratio test statistics, we obtain $W = 2.904$ and under a chi-square distribution ($\chi^2(10)$) we obtain a p-value of $p = 0.016$. Therefore, the null hypothesis of no significant fixed effects is rejected, subsequently, we should use the fixed effects logistic model over the pooled logistic model.

Suppose that the individual fixed effects are uncorrelated with each explanatory variable for all time periods, then using a transformation in order to eliminate the individual fixed effects is inefficient (Wooldridge 2015, 492). An alternative approach is then to use a generalised linear mixed model (GLMM) approach, where inter-individual variation is accounted for by inclusion of a separate, random parameter for each individual. In order to test for the consistency of the GLMM estimators, a specification test is used as described in Hausman (1978). After computing the Hausman specification test, we obtain $H = 15.102$, where under the null hypothesis of consistent estimators for the mixed effects model $H \sim \chi^2(10)$. Therefore the p-value for the Hausman specification test is $p = 0.128$ and the null hypothesis can be accepted. We conclude that for this model, the mixed effects estimator is consistent. The model estimates of the GLMM approach are shown in Table A3.1.

Table A3.1 *Outcomes logistic GLMM, with binary response outcome variable: whether or not a fisher will go shrimp fishing in the Wadden Sea in a given month. (D) indicates that the variable is computed as a dummy variable*

Variable	Estimate	Std. Error
Intercept	-0 7896***	0 2101
kW of vessel	-0 0226	0 1432
Gross tonnage	0 0844	0 1513
Vessel year	-0 3707***	0 1006
Oil price	0 0006	0 0372
Shrimp price	0 1510***	0 0293
OTT/OTB (D)	-0 1176***	0 0331
TBB/SUM/PUL (D)	-0 0817***	0 0302
North Sea (D)	1 5727***	0 0467
Trend	0 0822**	0 0364
Hours Fisher (D)	0 1070**	0 0488
February (D)	-0 3750***	0 0350
March (D)	-0 1377***	0 0326
April (D)	0 1062***	0 0318
May (D)	0 3316***	0 0323
June (D)	0 4373***	0 0326
July (D)	0 4413***	0 0323
August (D)	0 3797***	0 0318
September (D)	0 3957***	0 0313
October (D)	0 5022***	0 0318
November (D)	0 4588***	0 0315
December (D)	0 2472***	0 0308

Regression model

The second stage of the modeling approach is that of linear regression. This stage is used to predict the number of fishing days that a fishing vessel i is actually fishing going fishing in a given month t. The first model that will be looked at is the pooled Ordinary Least Squares regression model as described by Pesaran (2015), pp. 636-39.

The pooled OLS model, however, does not control for unobserved heterogeneous individual specific effects. In order to do this, the fixed effects specification can be used as described by Wooldridge (2015), pp. 484-486. In order to control for individual fixed effects using the fixed effects transformation, all the variables in the model can be entity-demeaned which yields a new regression equation that can be solved using OLS. In order to test for individual specific fixed effects, the Chow test can be used (Chow 1960). After computing the Chow test, we obtain the test statistic $C = 17.64$, where under the null hypothesis of no fixed effects the test statistic follows an F-distribution, $C \sim F(125,6062)$. The corresponding p-value is then $p = < 0.001$. Subsequently, the null hypothesis is rejected, therefore, we prefer the fixed effects regression model over the pooled regression model.

Similar to the binary mixed effects model explained earlier, it might be more efficient to estimate a regression model in which the individual fixed effects are not eliminated. This can be done by using the random effects approach (Wooldridge 2015, 492). An important assumption when estimating this random effects model is that the unobserved individual fixed effects follow a normal distribution with mean 0 and fixed variance σ^2. In order to test for this, a Lagrange multiplier test can be used (Honda 1985). For testing the consistency of the random effects estimator, a specification test is applied (Hausman 1978). Computing the Lagrange multiplier test for the regression model yields a test statistic of $L = 94.715$. Under the null hypothesis, the test statistic follows a standard normal distribution, $L \sim N(0,1)$, subsequently $p = < 0.001$. Therefore, the null hypothesis can be rejected and it cannot be assumed that the individual fixed effects follow a normal distribution with mean 0 and constant variance σ^2. Furthermore, the Hausman specification test yields a test statistic of $H = 338.138$. Under the null hypothesis $H \sim \chi^2(21)$, subsequently $p = < 0.001$. Therefore the null hypothesis is rejected and the fixed effects is chosen as the preferred model. Table A3.2 shows the estimated coefficients and its corresponding standard errors for the fixed effects modelling approach.

Table A3.2 *Outcomes fixed effects regression model with continuous outcome variable: total shrimp effort in the Wadden Sea for a fisher in a given month. (D) indicates that the variable is computed as a dummy variable*

Variable	Estimate	Std. Error
KW of vessel	-0 0123	0 0293
Gross tonnage	-0 0666*	0 0376
Vessel year	-0 1562**	0 0530
Oil price	-0 0063	0 0101
Shrimp price	0 1266***	0 0083
OTT/OTB (D)	-0 0068	0 0074
TBB/SUM/PUL (D)	-0 0220***	0 0072
North Sea (D)	0 0432***	0 0119
Trend	-0 0262**	0 0106
Hours Fisher (D)	0 0826***	0 0173
February (D)	-0 0757***	0 0080
March (D)	-0 0524***	0 0087
April (D)	-0 0099	0 0094
May (D)	0 0306***	0 0101
June (D)	0 0899***	0 0103
July (D)	0 0879***	0 0102
August (D)	0 0465***	0 0099
September (D)	0 0833***	0 0098
October (D)	0 1046***	0 0100
November (D)	0 0946***	0 0099
December (D)	-0 0024	0 0094

Model performance

Validation of the modelling approach is done by dividing the time window from before the decommissioning scheme into 5 different subsets. Subsequently, the shrimp effort is predicted on a vessel-month level for each of these subsets, using the methods described above, only on the data located outside the subset. Table A3.3 shows the out of sample performance of both modeling stages. The first modelling stage's performance is measured using the out-of-sample Area Under the Curve (AUC) measure, it describes the area under the ROC curve. For the second modelling stage, the out-of-sample R^2 is shown, indicating the correlation between the predicted values and the realised values. A graphical depiction of the comparison of the out-of-sample predictions with the realised values are shown in Figure A3.4.

Table A3.3 *Model performance across validation subsets*

Subset	Logistic regression model out-of-sample AUC	Regression model out-of-sample R^2
1	0.862	0.579
2	0.884	0.615
3	0.903	0.623
4	0.885	0.515
5	0.871	0.552

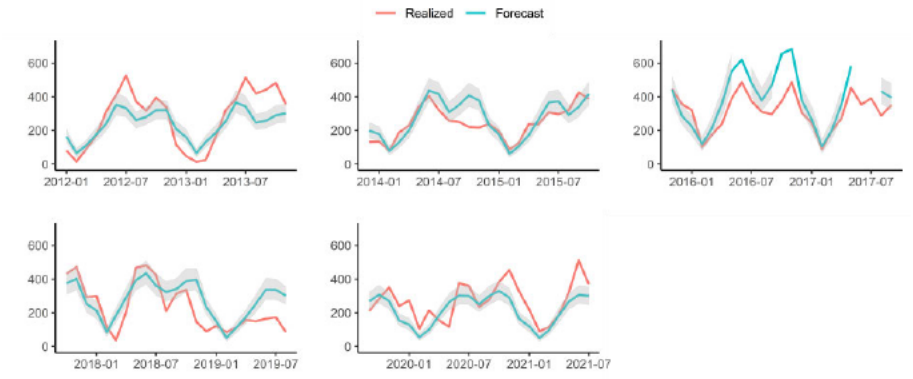


Figure A3.4 *Out of sample predictions of two-step modelling approach on shrimp effort in the Wadden Sea (shown in blue) and their corresponding 95% confidence interval (shown in grey), compared with the realised shrimp effort in the Wadden Sea (shown in red)*

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