Declining catch rates of small scale fishers in the southern North Sea in relation to the pulse transition in the beam trawl fleet

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Contents

Abstract

This report analyses the complaints of gillnet and handline fishers working in the coastal waters of Belgium and the Netherlands about declining catches which they relate to the arrival of pulse trawlers. The testimonies are compared to (i) trends in the catch rate of sole, cod and seabass estimated for the beam trawl fisheries in six different areas of the southern North Sea and (ii) trends in the spawning stock biomass of these species estimated by ICES. It is shown that the catch rate of sole in the beam trawl fishery increased between 2009 and 2016. Therefore it is unlikely that the decline in the catch of sole in gillnets is due to a decline in the biomass of sole in the southern North Sea. It is more likely that the decline is due to the competition with pulse trawlers which are more efficient in catching sole than traditional beam trawlers. The decline in cod catches in gillnet and handline fisheries matched the declining catch rate of beam trawlers between spring and autumn suggesting that the decline is related to a decline in stock size in the southern North Sea. For seabass the decline in catch rates of the small scale fishers is likely related to the decrease in stock size.

1 Introduction

The transition in Dutch fleet fishing for sole (80mm codend mesh) underwent a transition from using tickler chain beam trawls or Sumwing to using Pulsewing or Delmeco pulse beam trawl. At present 78 Dutch and 11 flag vessels are fishing with the pulse for sole (ICES, 2018). During the transition, the distribution pattern of pulse trawlers shifted to the southern North Sea (Turenhout et al., 2016). Anecdotal information from the fisheries indicate that pulse trawlers are able to deploy their gear on softer grounds than when fishing with the traditional beam trawl. The increase in pulse trawling in the southern North Sea gave rise to complaints from other fishers, such as gill netters and hand-liners, about possible adverse effects. A report summarises the complaints of a number of small scale fishers voiced at a meeting on 1 September 2017 (Anon, 2017). There was a general consensus among small scale fishers on declining catches in recent years coinciding with the increase in pulse trawl activities in the area. In a meeting in March 2018 in IJmuiden similar concerns were expressed (Steijns et al., 2018).

In this report, changes in fishing effort and corresponding landings of sole, cod and seabass are analysed in the southern North Sea.

The objective of this study is to

- analyse the complaints made in the light of the species, areas and gear groups involved,
- analyse the time trend in the removal of fish species by the pulse trawl fleet
- map the changes in fishing effort distribution of the beam trawl fleet and the pulse trawl fleet
- discuss the possible effects of the recent increase in pulse trawling on the catch rate of small scale fishers

2 Materials and Methods

2.1 Catch and effort data

Catch and effort data by fishing trip (landings by species, hours at sea, rectangle, gear, mesh size, vessel ID, landing date) were extracted from the VISSTAT data base for the vessels that have obtained a pulse license to fish for sole. These vessels represents today's pulse license holders that have switched from the traditional beam trawl with tickler chains (beam trawl or sumwing) to the pulse trawl (pulswing or delmeco pulse trawl).

Because the VISSTAT data base does not distinguish between the tickler chain and pulse trawl, fishing trips were assigned to the pulse trawl based on the reported mesh size (70-99mm) in combination with the estimated towing speed during fishing (VMS recordings) and the start date of the pulse license reported in the vessel register (data LNV).

Vessels may be engaged in different fisheries (metiers). The large vessels with an engine power exceeding 221 kW target sole with the traditional beam trawl (TBB_SOL) or a pulse trawl (PUL_SOL) using a mesh size of 80mm (reported mesh size 70-99mm), or target plaice using a mesh size of at least 100mm (TBB_PLE). The smaller vessels (Euro cutters) with an engine power of <=221 kW, can be engaged in the above metiers and in addition target brown shrimps (TBB_CRG) using a small mesh size, or fish for nephrops or demersal fish with an otter (twin) trawl. Trips in which vessels have landed brown shrimps were assigned as shrimp fishing.

For the small scale fishers, catch and effort data were extracted for the static gears (codes) and hand lines (codes) and for the species sole, cod and seabass. Recreational fisheries are not included in this report.

2.2 Analysis

2.2.1 Catch rate

If catching opportunities for the small scale fisheries indeed declined, we expect to find a decline in catch rates throughout the study period. Changes in catch rate (landings per fishing hour) were analysed taking account of the variation caused by gear type, engine power, season, area and year. We used a generalised additive mixed effect model [1] (*gamm*) of the ' mgcv" library in R (Wood, 2016):

$$\ln(CPUE_{ij}) = \beta_0 + \beta_1 G_{ij} + \beta_2 A_{ij} + \beta_3 E_{ij} + s(T_{ij}; A_{ij}) + \epsilon_{ij}$$

$$Vessel_i \sim N(0,\sigma)$$

with G_{ij} = gear type (beam trawl or pulse trawl), A_{ij} = area (area 2, 3, 3a, 4, 5, 5a), E_{ij} = engine power, $s(T_{ij}:A_{ij})$ = smooth term of time to allow for fitting both the seasonality as well as the changes over years for each area separately, and ε_{ij} is the error term with a quasipoisson distribution to allow for overdispersion. Vessel identity was included as random effect to take account of the dependency of the observations within each vessel.

[1] gamm(cpue.sol ~ as.factor(gear) + as.factor(area) + ln(VE_KW) + s(decimal.year, by=as.factor(area), k=20), random=list(VE_REF=~1), method="REML", data=dat2, family="quasipoisson")

The southern North Sea was subdivided in 6 areas representing the western and eastern parts between 52° and 53° N (Figure 1): area 2 = rectangles 33F2+34F2; area 3 = rectangles 33F3+34F3 (outside 12 nm zone); area 3a = rectangles 33F3+34F3 (inside 12 nm zone)) and between 51°N and 52°N: area 4 = 31F1+32F1; area 5 = rectangles 31F2+32F2+31F3+32F3 (outside 12 nm zone); area 5a = rectangles 31F2+32F2+ 31F3+32F3 (inside 12 nm zone). We assumed landings and effort of vessels <=221 kW in area 3 and 5 took place within the 12 zone and these were assigned to area 3a and 5a accordingly.

In some instance, the *gamm* model gave conversion problems, likely caused by the large number of zero observations for some of the vessels. To obtain an estimate of the changes in catch rate during the study period, the above model was simplified by omitting the random vessel effect. For the species for which the random effect model converged, the simplified model yielded similar estimates of the changes in catch rate. The main difference between the two model approaches was the wider confidence intervals around the estimated catch rate when including a random vessel effect.

2.2.2 VMS

Trawling intensity (swept area ratio) was estimated by 1x1 minute latitude and longitude of the beam trawlers and the pulse trawlers interpolating trawl tracks according (Hintzen et al., 2010).

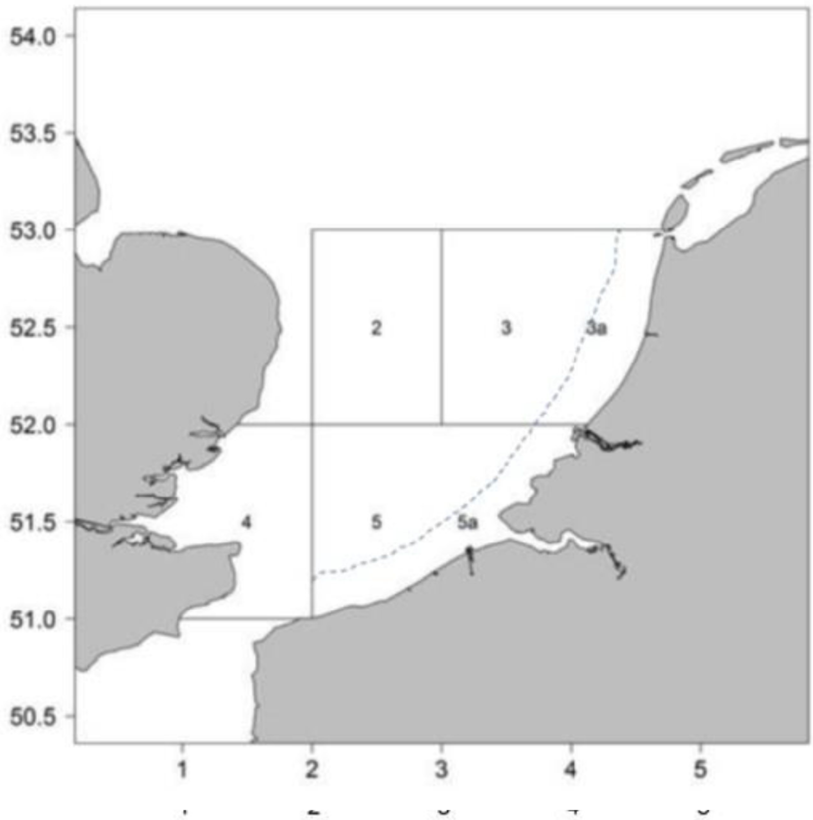


Figure 1. Map with the areas distinguished in this study to analyse the trends in catch rate (CPUE).

3 Results

3.1 Testimonies

The testimonies refer to commercial fishers operating in the coastal waters of the southern North Sea, in particular off the Belgium coast, deploying a variety of fishing gears (Table 1). In total testimonies of 11 small scale fishers were available fishing for sole, seabass, cod or pollack

Table 1. Fishing method, number of testimonies and fish species with declining catch.

Fishing method	Number	Species			
		Sole	Seabass	Cod	Pollack
Handline	5	(x)	x	x	
Charter	3		x	x	x
Trammel	2	x			
Shrimp trawl	1	x			

3.2 Effort and landings

The reported fishing effort of small scale fishers in the southern North Sea (between 51-53°N) declined during the study period. Coinciding with the drop in effort, the reported landings of sole, cod and seabass decreased as well (Table 2). Gillnet effort dropped from a level between 2400 and 3200 hours in 2009-2012 to less than 580 hours in 2013 and to zero in 2014 and following years. Reported hand-line effort already ceased in 2012. The landings by beam trawl vessels (<=221kW) do not show a decreasing trend for sole, but for cod and seabass the landings decreased substantially.

Table 2. Annual landings (1000 kg) of cod, seabass and sole reported by fishing method by Dutch vessels (<=221kW) in the southern North Sea. Fishing methods are gillnets (GN, GNS, GTR), hand lines (LHM, LHH) and beam trawl (TBB, Pulse trawl).

small vessels <=221kW

Year	Gillnet			Handlines			Beam trawl (traditional + pulse trawl)		
	cod	seabass	sole	cod	seabass	sole	cod	seabass	sole
2009	14.7	1.7	17.3	0.5	0.9	0.0	200.4	2.9	953
2010	9.1	0.3	8.7	0.7	0.4	0.0	116.4	2.2	806
2011	12.1	1.4	12.1	0.0	0.0	0.0	81.4	4.5	1014
2012	4.1	1.3	26.2	0.0	0.0	0.0	54.2	4.0	1267
2013	0.0	0.0	9.4	0.0	0.0	0.0	35.3	2.5	1424
2014	0.0	0.0	7.9	0.0	0.0	0.0	32.2	0.6	1117
2015	0.0	0.0	0.0	0.0	0.0	0.0	49.5	1.9	1300
2016	0.0	0.0	0.0	0.0	0.0	0.0	32.0	0.5	1524
2017	0.0	0.0	0.0	0.0	0.0	0.0	6.5	1.4	1214

3.3 Effort and landings today's pulse license holders

In the analysis we focussed on the fleet of vessels that have switched to pulse fishing since 2009 (today' s pulse license holders). Following the incremental deployment of pulse licenses, pulse fishing effort increased since 2009, while the fishing effort of traditional beam trawls targeting sole (TBB_SOL) decreased (Figure 2). During the transition period the total effort of large vessels remained constant (all), but the percentage of effort targeting sole (SOL) decreased from 95% in 2009 to 87% in 2017, while the percentage effort targeting plaice increased. The increase in the percentage effort targeting plaice is due to some of the pulse vessels that switched back to the tickler chain beam trawl to utilise their plaice quota during part of the year. Total fishing effort of the Euro cutter license holders showed a slight increase until 2013 and then decreased to the level at the start of the study period. The proportion of effort allocated in the sole fishery was around 70% without a trend and is not affected by the introduction of the pulse trawl.

The fleet of today's pulse license holders contributed to 75% of the Dutch sole landings in 2009 and their contribution increased to about 95% after the transition to pulse fishing (Figure 3). After the transition to pulse trawling, these vessels were using the pulse trawl to target sole (PUL_SOL) with a codend mesh of 80mm, but also deployed other gears during part of the year. Large vessels (>221 kW) used conventional beam trawls with a mesh size of >100 mm during part of the year to target plaice (TBB_PLE), while small vessels (<=221 kW) used conventional shrimp beam trawls with bobbins to target shrimps (TBB_CRG) or used otter (twin) trawls to target other demersal fish or Nephrops (OTHER).

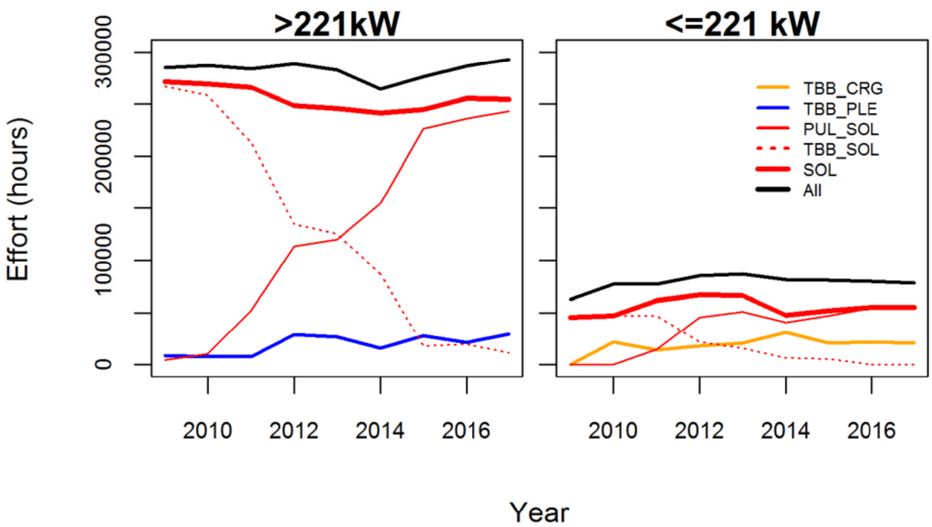


Figure 2. Effort by metier of today's pulse license holders of large (left) and small vessels (right). PUL_SOL = pulse trawl fishery targeting sole (80 mm mesh size); TBB_SOL = beam trawl fishery with tickler chains targeting sole (80mm mesh size); TBB_PLE = beam trawl fishery targeting plaice (mesh size >=100mm); TBB_CRG = beam trawl fishery for shrimps. SOL represents the total effort in the sole fishery (TBB_SOL + PUL_SOL). All represents the total fishing effort of the todays pulse license holders.

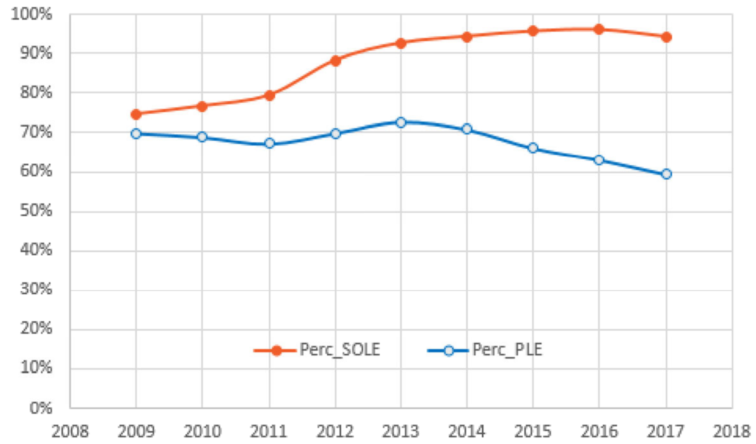


Figure 3. Contribution of the fleet of today's pulse license holders to the total landings of sole and plaice by Dutch vessels. These vessels used the traditional beam trawl before they switched to pulse trawling.

3.4 Changes in effort and landings in the southern North Sea

The spatial distribution of the pulse license holders targeting sole (80mm mesh size) shows a change towards fishing grounds in the southern North Sea south of 53°30′N (Figure 4). The maps show the average distribution patterns over the period 2009-2017. Hot spots of pulse trawling are apparent on the Norfolk Sandbanks and off the Thames estuary. Absolute fishing effort has decreased over large parts of the fishing area in the German Bight and remained relatively stable in the other areas. In the southern North Sea, both sole fishing effort and sole landings have increased during the transition from the traditional beam trawl to the pulse trawl, while the effort and landings in the area north of 53°N have decreased (Figure 5). The changes in the annual fishing effort and landings by rectangle are presented in appendix 1 and 2, respectively. Fishing effort increased in some of the rectangles for instance in the rectangle off the Thames Estuary (32F1) and to a lesser degree in 32F2 off the Belgium coast. No increase in fishing effort was observed on the Norfolk Sandbanks (34F1, 34F2).

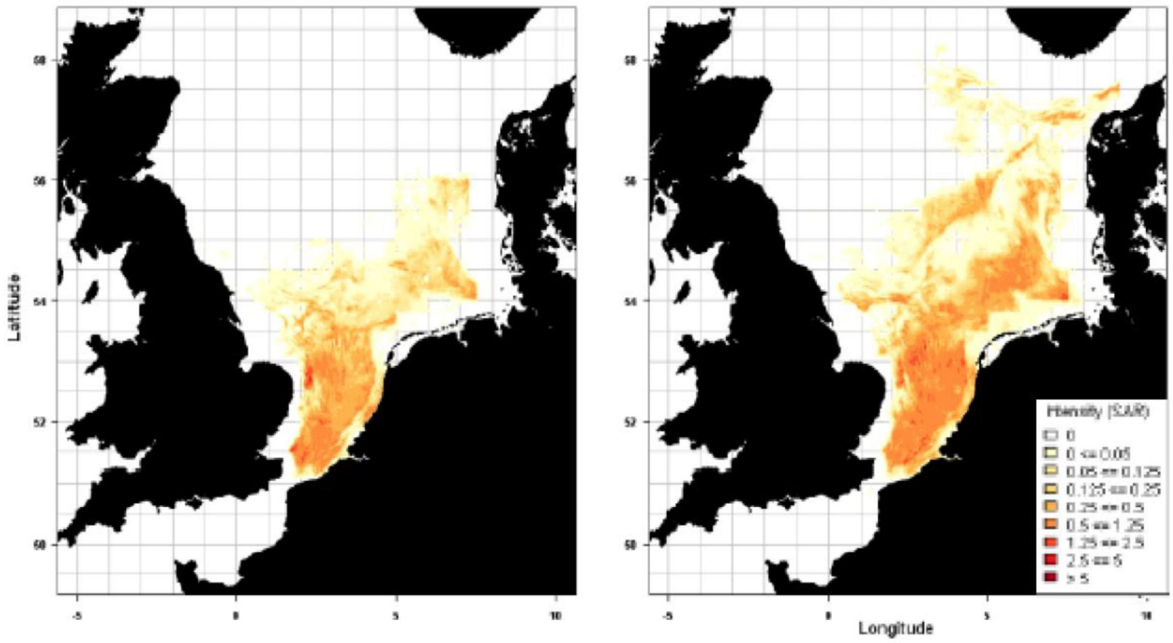
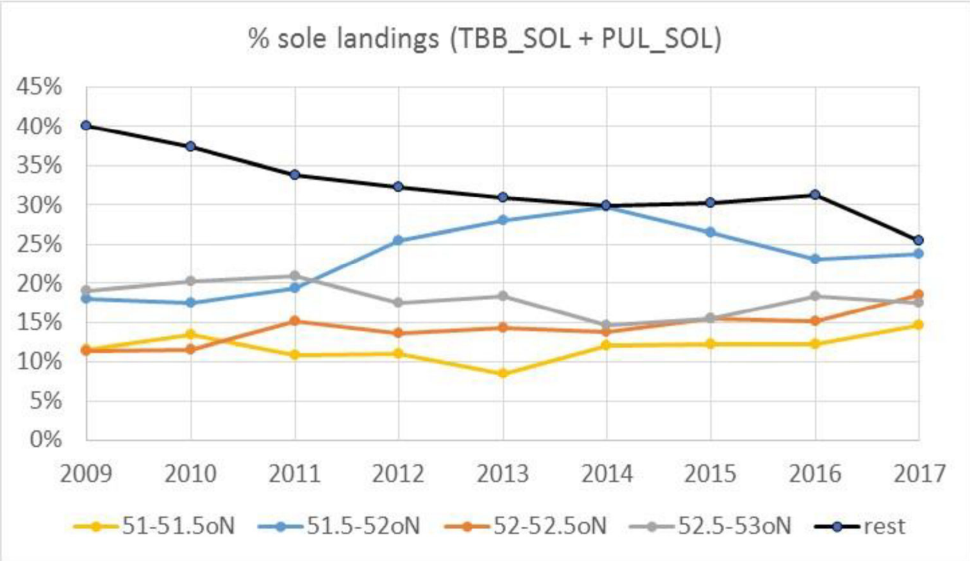


Figure 4. Average annual trawling intensity (swept area ratio of 1x1 minute grid cells) of the pulse trawls (left: PUL_SOL) and traditional beam trawl (right: TBB_SOL) in the period 2009 – 2017.



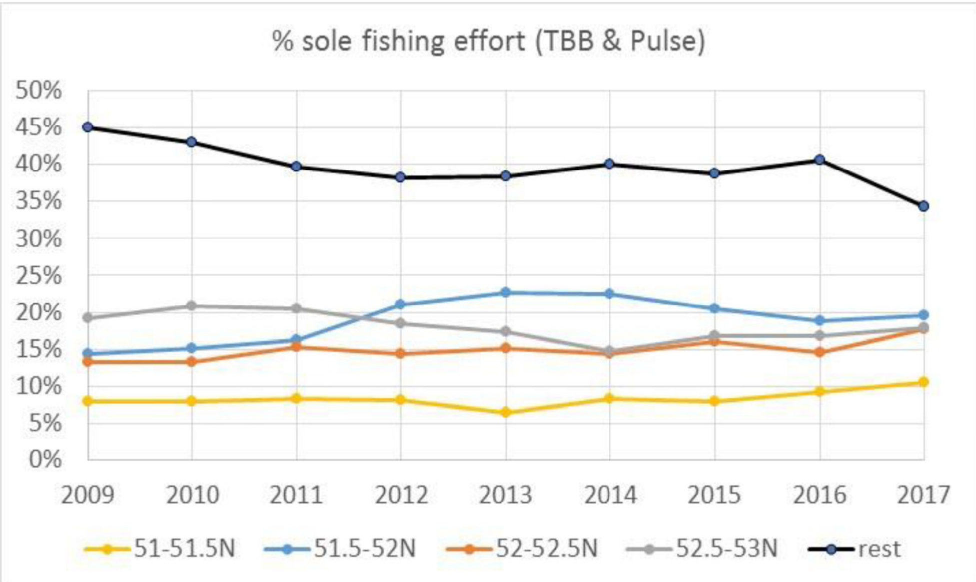


Figure 5. Sole fishing effort (bottom) and sole landings (top) of today's pulse license holders (% of total effort or landings) allocated to different latitudinal zones in the southern North Sea by year in the period 2009 - 2017. Rest refers to the fishing area north of 53ºN.

3.5 Changes in catch rate in the southern North Sea

3.5.1 Sole

Throughout the study period the catch rate of sole of today's pulse license holders in the southern North Sea (south of 53˚N) was higher than in more northern areas. This is shown by the higher proportion of landings as compared to the proportion of effort. For instance, in 2017 75% of the sole landings were taken between 51º and 53ºN with 65% of the fishing effort, while in the area north of 53ºN, 25% of the sole was taken in 35% of the fishing effort (Figure 5).

The estimated CPUE of sole shows a clear seasonality in area 2, 5 and 5a, but not in area 4 (Figure 6). The seasonality in area 3 is only apparent in some of the years. The seasonality in area 5 and area 5a seem to have an opposite pattern which may be related to the coastal migration of sole during the spawning period which increases their catchability within the 12 nm zone and reduces their catchability outside the 12 nm zone.

The CPUE of sole varied between years with relative low values in 2010-2012 and relative high values in 2013-2017. The analysis further suggests that in 2017, the CPUE of sole within the 12 nm zones decreased. No changes in CPUE are suggested in the offshore areas or in the western areas.

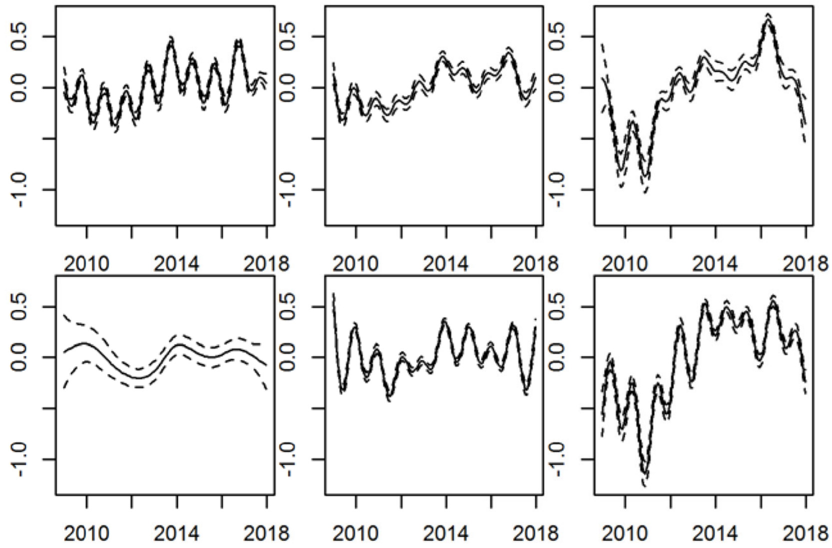


Figure 6. Sole: changes in relative CPUE and the 95% confidence interval in the southern North Sea estimated by the mixed effect gam model. Upper panels from left to right: area 2; area 3 outside 12 miles zone; area 3 inside 12 miles zone. Lower panels from left to right: area 4; area 5 outside 12 miles zone; area 5 inside 12 miles zone.

3.5.2 Cod

The CPUE of cod show a clear seasonality with a high value in winter and a low value in summer. The results further suggest that the amplitude of the seasonal pattern increased over time coinciding with a gradual decline in all study areas (Figure 7).

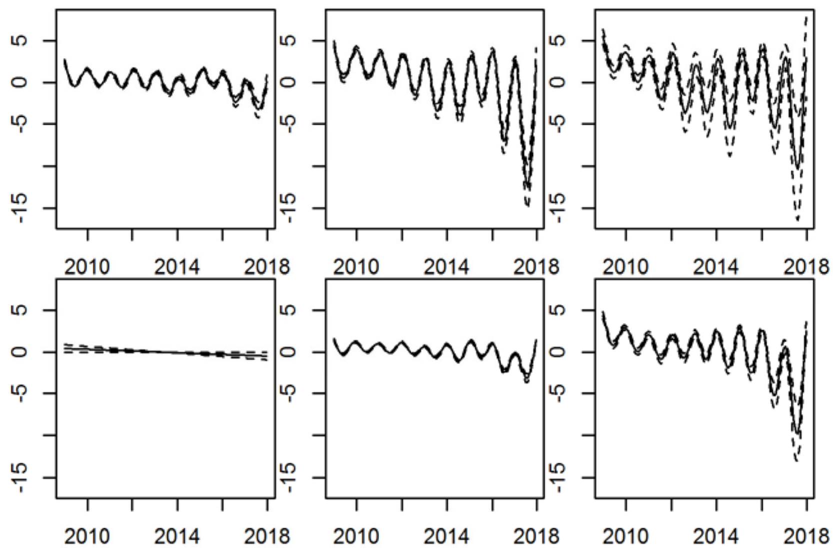


Figure 7. Cod: changes in relative CPUE and the 95% confidence interval in the southern North Sea estimated by the mixed effect gam model. Upper panels from left to right: area 2; area 3 outside 12 miles zone; area 3 inside 12 miles zone. Lower panels from left to right: area 4; area 5 outside 12 miles zone; area 5 inside 12 miles zone.

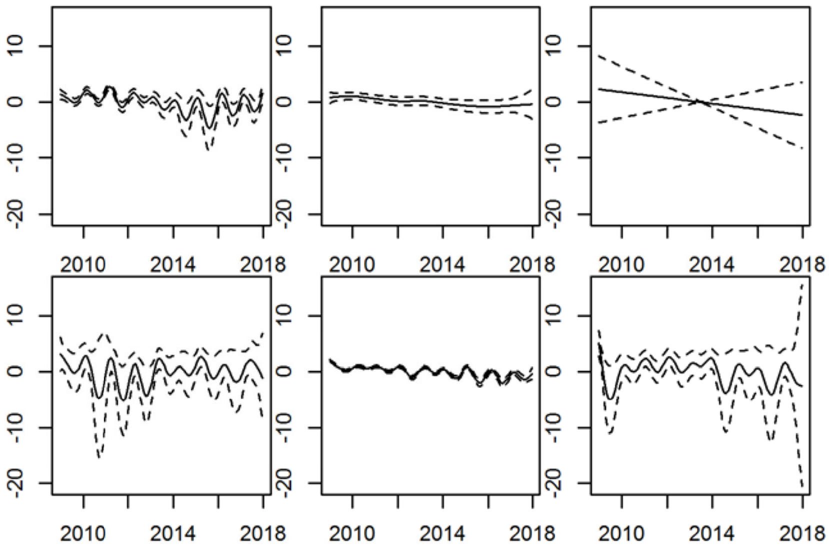


Figure 8. Seabass: changes in relative catch rate and the 95% confidence interval in the southern North Sea estimated by the simplified gam model ignoring the random effect of vessels. Upper panels from left to right: area 2; area 3 outside 12 miles zone; area 3 inside 12 n miles m zone. Lower panels from left to right: area 4; area 5 outside 12 miles zone; area 5 inside 12 miles zone.

3.5.3 Seabass

The analysis of the CPUE of seabass failed due to convergence problems when including vessel as random effect. Simplifying the model by ignoring the random effect provided an estimate of the changes in seabass CPUE during the study period (Figure 8). The results indicate that seabass CPUE in area 3 and 5 decreased. For areas 3a, 4 and area 5a, the confidence bands are too wide to indicate a significant trend in time.

3.5.4 All fish

The catch rate of all fish species together show a clear seasonality with a high value in winter and a low value in summer. The results further suggests that the amplitude of the seasonal pattern has decreased over time in most areas, while the catch rate in the most recent year has reduced substantially as compared to previous years, in particular within the 12 miles zone off Belgium and the Netherlands and in the northern section of the study area (Figure 9).

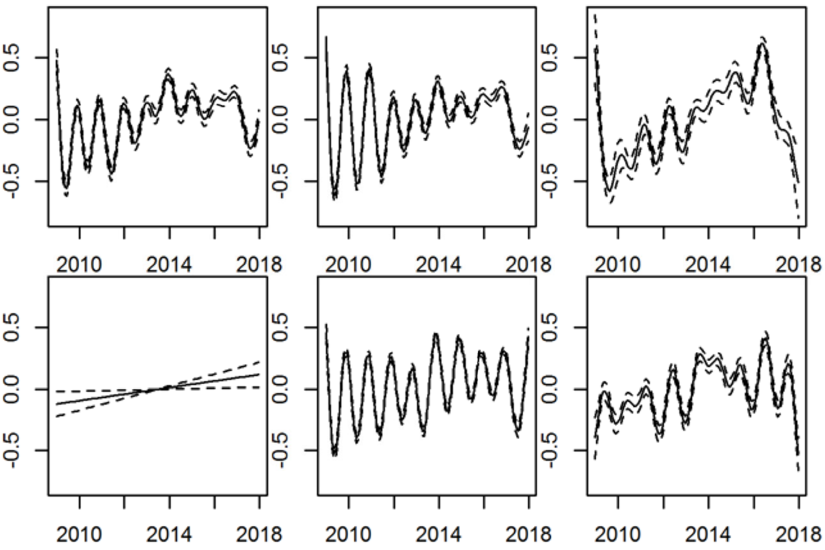


Figure 9. All fish species: changes in relative CPUE and the 95% confidence interval in the southern North Sea estimated by the mixed effect gam model. Upper panels from left to right: area 2; area 3 outside 12 miles zone; area 3 inside 12 miles zone. Lower panels from left to right: area 4; area 5 outside 12 miles zone; area 5 inside 12 miles zone.

3.6 Catch efficiency of pulse trawl and beam trawl

The statistical analysis of the CPUE also provides an estimate of the catch rate of the traditional beam trawl relative to the pulse trawl (Table 3). The analysis shows that the traditional beam trawl catches 16% (95%CL: 14%-18%) less sole as compared to the pulse trawl, while it catches 55% (95%CL: 50%-61%) more plaice. For the total landings of fish, the catch efficiency of the traditional beam trawl is 24% (95%CL: 21%-26%) higher. Also for cod and seabass the catch efficiency of the traditional beam trawl is higher than of the pulse trawl.

Table 3. Catch efficiency of the traditional beam trawl relative to the pulse trawl estimated with the mixed effect gam model for sole, plaice, cod and for the landings of all fish species (total fish landings).

Species	Estimate	SE	Catch efficiency traditional beam trawl relative to pulse trawl		
			lower CL	estimate	upper CL
Sole	-0.1706	0.0121	0.82	0.84	0.86
Plaice	0.4399	0.0192	1.50	1.55	1.61
Cod	0.8981	0.0489	2.23	2.45	2.70
Seabass[1)]	1.1751	0.1037	2.64	3.24	3.97
Total fish landings	0.2112	0.0109	1.21	1.24	1.26

[1)]estimated with a gam model excluding a random vessel effect

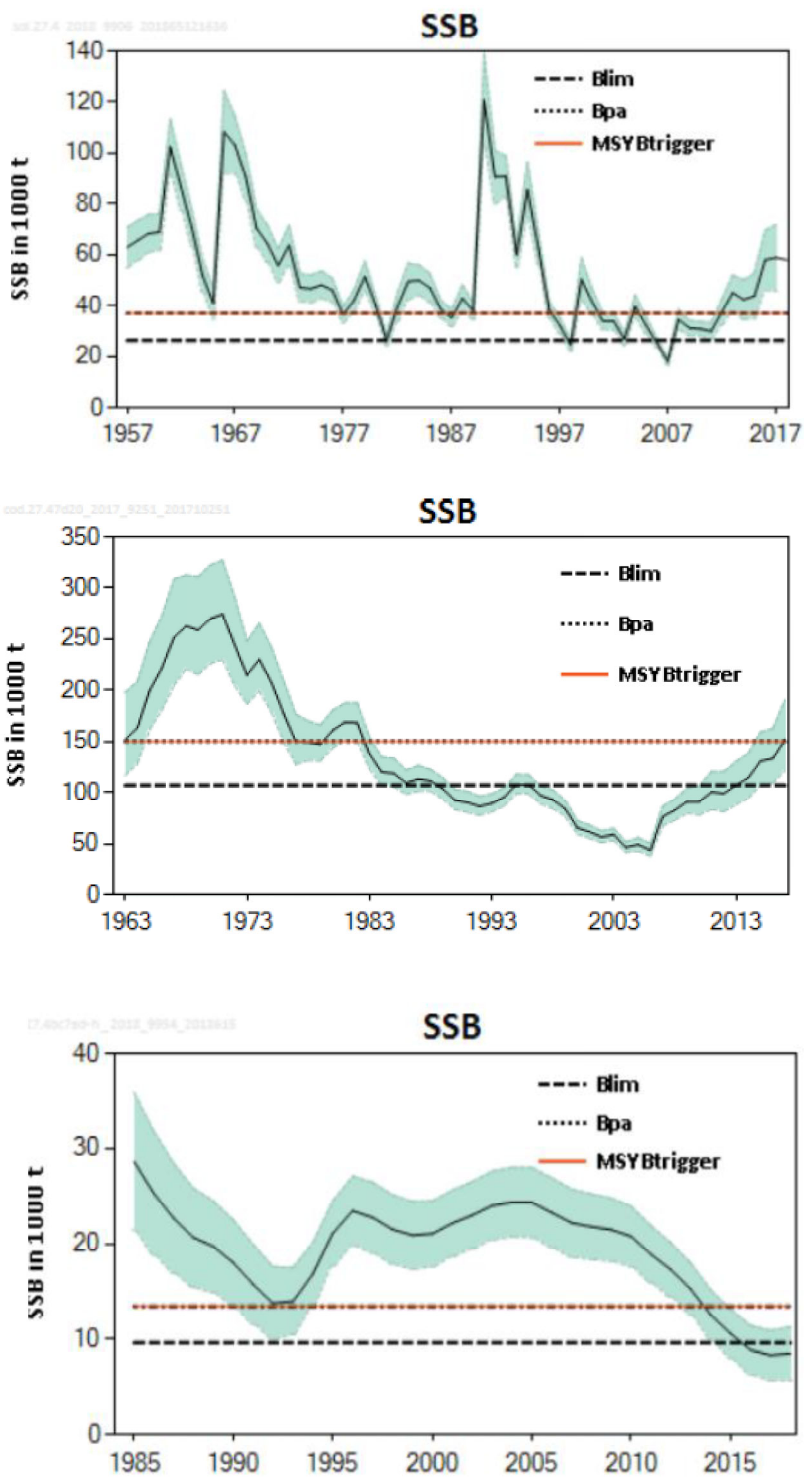


Figure 10. Trends in spawning stock biomass of North Sea sole[2] (upper panel), cod[3] (middle panel) and seabass[4] (lower panel) estimated by ICES. The blue band shows the 95% confidence limits of the SSB estimate. Blim, Bpa and MSYBtrigger are the reference levels used by ICES to assess the sustainability of the fisheries.

[2] http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/sol.27.4.pdf
[3] http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/cod.27.47d20.pdf
[4] http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/bss.27.4bc7ad-h.pdf

4 Discussion

The testimonies of small scale fishers about the decline in the catch opportunities in the southern North Sea is in agreement with the reported landings of the fishing vessels deploying either gill nets or hand-lines. There are several possible causes for the observed reduction in landings of small-scale fishers of their main target species sole, cod and seabass. Below we will discuss the possible causes.

The decrease in catch opportunities of small scale fishers may due to a decrease in the biomass of the target species, or due to a decrease in the catchability, or both. The spawning stock biomass (SSB) of target species (Figure 10), as estimated by ICES, does only partly match the pattern in landings of small-scale fishers.

The decrease in catch opportunities of sole for small scale fishers does not match the trends in SSB estimated by ICES. Sole SSB increased during the study period and is estimated in 2017 to be twice the SSB in 2009. This increase in SSB is reflected in the CPUE trend of beam trawl vessels in the southern North Sea which showed relatively high values in the period 2012-2016. The sharp decline in the CPUE in 2017, however, is not reflected in the SSB. The decline may be due to two incoming year classes – 1 year olds in 2016 and 2017 – which are below average size. The reduced catch of sole of small scale fishers is therefore unlikely due to the lack of sole on the fishing grounds. It is more likely due to a reduced catchability - fish may still be around on the fishing grounds but harder to catch for gill nets and hand-lines. This reduction in catchability may be caused by an increased competition with the pulse trawl fleet. Sys et al., (2016) showed that the catch rate of Belgian beam trawlers were reduced during weekdays when they competed with Dutch pulse trawl vessels but not during the weekends when the Dutch fleet was in the harbour.

The decrease in catch opportunities of cod for small scale fishers does not match the overall trend in cod SSB which gradually increased during the study period. The increase in the cod SSB in the total North Sea is also not reflected in the beam trawl CPUE in the southern North Sea which remained stable during the winter period and decreased during summer. This indicates that the recovery of the North Sea cod stock mainly occurs in the northern parts of the North Sea. This inference is supported by the trend in cod abundance in the international bottom trawl surveys (ICES Advice 2018 cod.27.47d20.pdf). The CPUE of beam trawlers may have become biased since the transition to the pulse trawl because fishers may discard part of the catch that developed a spinal injury and associated haemorrhage (van Marlen et al., 2014; de Haan et al., 2016; ICES, 2018). This may also have affected the estimated catch efficiency of the pulse trawl for cod.

The decrease in the catch opportunities of seabass for small scale fishers is consistent with the decrease in SSB estimated by ICES and the decrease in CPUE of the beam trawl fishery in the southern North Sea. It is unlikely that the transition to pulse trawling will have contributed to the decline in seabass SSB. Beam trawls only contribute a small proportion of the total international catches of seabass (about 1%) and the catch efficiency of the pulse trawls is substantially lower than of the traditional beam trawl. The catch opportunities may be influenced by the response of seabass to the electric fields of pulse trawls. It has been suggested that seabass may avoid areas where pulse trawlers are working but no information on this potential process is available.

Pulse trawls are more efficient in catching sole, but less efficient in catching plaice, cod or other fish in general. The estimated increase in efficiency for sole for the pulse trawl in this report (representative for all beam trawl vessels irrespective of their engine power) is slightly less than the estimate of Poos which applied to large beam trawlers only (ICES, 2018).

The increase in fishing effort in combination with the improved catch efficiency of the pulse vessels in the southern North Sea resulted in an increase in fishing pressure on the sole stock in the southern North Sea. The consequences of this shift in distribution of fishing pressure will depend on the structure of local sole stocks within the North Sea and the movement of sole. Tagging experiments and the analysis of the micro-chemistry of otoliths have revealed that sole juveniles don’t migrate between different nursery grounds and will likely recruit to the local spawning stock (Cuveliers, 2011). Hence, an increase in fishing pressure in coastal waters may reduce the recruitment to the local sole stock. How the increase in fishing pressure on the adult sole affects the dynamics of the local stock is unknown.

Changes in fishing opportunities in the coastal waters may also be influenced by changes in ecosystem productivity or changes in environmental conditions. In the 1980s, high fish biomass levels were recorded in the waters along the Dutch coast in the annual fish survey, which coincided with the peak nutrients (Tulp et al., 2008; Philippart et al., 2007). Since then nutrients and fish biomass have decreased. Survey data showed that in the recent decade, fish biomass of large fish (31-50cm) has decreased (Tulp et al., 2017). In addition to the decline in nutrients, the change may also be influenced by the increase in temperature in coastal waters. Poleward shifts in distribution have been reported in relation to temperature (Perry et al., 2005), as well as to deeper (cooler) waters (Dulvy et al., 2008; Perry et al., 2005; van Hal et al., 2016; van Keeken et al., 2007).

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6 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2008 certified quality management system (certificate number: 187378-2015-AQ-NLD-RvA). This certificate is valid until 15 September 2018. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V.

Justification

Report C051/18
Project Number: 4318200032

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

Approved: Dr. Ingrid Tulp
Senior Researcher

Signature: 

Date: 14-08-2018

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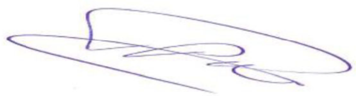
Signature: 

Date: 14-08-2018

7 Appendices

Appendix 1. Fishing effort (hours) of the pulse license holders fishing with the traditional beam trawl (TBB_SOL) or with the pulse trawl (PUL_SOL) by ICES rectangle in the southern North Sea. The total effort gives the annual effort in the North Sea.

Large beam trawlers (TBB_SOL + PUL_SOL)

	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total effort	270999	269032	265607	248550	245723	241418	244867	255760	254707
31F1	95	458	196	932	457	187	460	733	720
31F2	13544	14291	12779	13367	11822	13350	12871	16099	14461
31F3	979	805	0	0	98	39	0	32	100
32F1	229	0	2675	5768	4939	4011	4111	3761	2950
32F2	24518	23544	28588	34754	28803	32289	31671	28394	30479
32F3	7821	6450	4535	4765	8350	8397	4159	6939	6512
32F4	0	0	84	0	0	0	0	91	18
33F1	0	0	103	0	0	0	103	0	100
33F2	13392	11919	11834	11580	11227	8034	11294	12716	18832
33F3	17595	18192	19424	15608	16992	18535	20201	15483	20560
33F4	852	2025	1182	914	985	1305	2329	1941	2085
34F1	0	0	97	162	104	0	99	0	0
34F2	29578	27758	29856	23795	27513	25031	23684	23698	28124
34F3	17161	19400	16198	17497	18126	11618	15735	17512	19051
34F4	7317	10268	9243	4869	3612	4317	5188	4392	5120

Small beam trawlers (TBB_SOL + PUL_SOL)

Total effort	45524	47394	61962	67165	66422	47522	52231	55198	55482
31F1	174	426	462	279	187	307	0	89	41
31F2	9571	7871	11776	10511	6503	9344	9078	10287	14404
31F3	1051	1007	1994	809	1334	585	1013	1259	2714
31F4	0	0	74	90	0	0	0	0	154
32F1	0	186	388	93	497	195	16	88	0
32F2	3995	6839	7314	10846	16224	10736	9605	11514	7307
32F3	8874	10466	9261	9489	10788	9123	9703	7875	11545
32F4	95	224	194	310	1309	243	1730	104	1621
33F1	0	0	153	0	0	0	0	0	0
33F2	398	558	2052	922	370	151	0	285	2037
33F3	1540	2326	1875	2516	3949	4364	3717	978	2419
33F4	8365	7193	13297	13647	13377	9297	9978	13726	8787
34F2	452	0	339	289	210	0	0	0	78
34F3	1561	841	2054	2555	762	171	1304	1567	591
34F4	4901	7525	9625	9021	3752	1514	4188	5327	2781

All vessels (TBB_SOL + PUL_SOL)

Total effort	316523	316426	327569	315715	312144	288940	297098	310958	310189
31F1	269	883	658	1211	643	494	460	822	761
31F2	23115	22162	24555	23879	18325	22694	21950	26387	28865
31F3	2030	1812	1994	809	1432	624	1013	1291	2814
31F4	229	0	2749	5858	4939	4011	4111	3761	3104
32F1	24518	23730	28976	34847	29301	32484	31688	28482	30479
32F2	11816	13289	11849	15611	24574	19133	13764	18453	13819
32F3	8874	10466	9345	9489	10788	9123	9703	7965	11564
32F4	95	224	297	310	1309	243	1833	104	1721
33F1	13392	11919	11987	11580	11227	8034	11294	12716	18832
33F2	17993	18750	21476	16529	17362	18687	20201	15767	22597
33F3	2392	4352	3057	3431	4934	5670	6047	2919	4505
33F4	8365	7193	13394	13809	13482	9297	10078	13726	8787
34F2	30030	27758	30195	24084	27723	25031	23684	23698	28202
34F3	18722	20241	18253	20052	18888	11788	17039	19079	19642
34F4	12218	17793	18868	13890	7364	5831	9377	9719	7901

Appendix 2. Landings of sole (10^3 kg) of the Dutch pulse license holders fishing with the traditional beam trawl (TBB_SOL) or with the pulse trawl (PUL_SOL) by ICES rectangles in the southern North Sea

	2009	2010	2011	2012	2013	2014	2015	2016	2017
TBB_SOL + PUL_SOL									
31F1	5	30	15	32	20	14	23	30	32
31F2	739	769	602	765	671	949	959	1104	1097
31F3	19	20	35	20	42	16	25	41	66
32F1	7	3	91	167	185	163	145	168	100
32F2	916	825	860	1421	1676	1748	1613	1534	1363
32F3	272	244	202	292	513	501	367	497	451
32F4	0	2	3	4	32	8	50	6	32
33F1	0	0	4	0	0	0	3	0	4
33F2	311	258	312	321	400	261	369	479	681
33F3	338	351	369	388	501	638	640	493	601
33F4	102	102	211	298	326	224	261	475	222
34F1	0	0	1	5	3	0	3	0	0
34F2	746	606	656	637	933	793	705	871	805
34F3	324	387	318	386	468	265	368	576	456
34F4	188	249	268	267	176	127	201	302	171
TBB_SOL									
31F1	5	30	10	4	12	0	0	0	4
31F2	739	769	588	369	237	132	0	0	6
31F3	19	20	15	14	3	2	0	0	0
32F1	7	3	0	0	2	0	0	0	0
32F2	916	825	818	524	327	146	7	0	4
32F3	272	244	142	111	225	205	28	2	0
32F4	0	2	1	1	0	0	0	0	0
33F1	0	0	3	0	0	0	0	0	0
33F2	311	258	268	154	133	15	7	1	0
33F3	336	351	314	302	352	360	8	12	6
33F4	102	102	102	33	79	30	19	3	7
34F1	0	0	1	0	0	0	0	0	0
34F2	690	440	221	135	251	92	56	1	8
34F3	323	346	240	204	272	111	8	10	19
34F4	181	249	215	149	111	43	15	17	12
PUL_SOL									
	2009	2010	2011	2012	2013	2014	2015	2016	2017
31F1	0	0	5	28	8	14	23	30	28
31F2	0	0	14	395	433	818	959	1104	1091
31F3	0	0	20	6	40	15	25	41	66
32F1	0	0	90	167	183	163	145	168	100
32F2	0	0	42	897	1349	1602	1606	1534	1360
32F3	0	0	61	181	288	297	340	495	451
32F4	0	0	2	3	32	8	50	6	32

33F1	0	0	2	0	0	0	3	0	4
33F2	0	0	44	167	267	245	361	478	681
33F3	2	0	56	86	149	278	633	481	595
33F4	0	0	109	266	247	195	242	472	215
34F1	0	0	0	5	3	0	3	0	0
34F2	56	166	435	502	681	701	649	870	797
34F3	1	41	78	182	197	154	360	566	437
34F4	7	0	52	118	64	84	186	285	158

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is specialised in the domain of healthy food and living environment.

The Wageningen Marine Research vision
'To explore the potential of marine nature to improve the quality of life'

The Wageningen Marine Research mission

- To conduct research with the aim of acquiring knowledge and offering advice on the sustainable management and use of marine and coastal areas.
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