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Report
Cruise SB 737 of FRV „SOLEA“
21.07. – 09.08.2017

Chief scientists: Dr. Vanessa Stelzenmüller & Jens Ulleweit

Objectives

1. Participation in the German Small-Scale Bottom Trawl Survey (GSBTS) to monitor the fish fauna in 6 out of 12 small areas (boxes),

2. Investigation of the hydrographical conditions within the boxes (vertical distribution of temperature, salinity and turbidity).

3. Experimental fisheries in the vicinity of an offshore windpark

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Narrative

FRV "Solea" left Cuxhaven on the 21st of July 2017 and started its scientific program the following day in Box N (see Figure 1). In general, the scientific program consisted of three days with 7 hauls per day within each box. Each day at least two CTD casts were deployed. The scheduled personnel exchange was carried out around noon of the 30th of July in Esbjerg. The scientific program continued from the 31st of July until the 8th of August. The vessel returned to Cuxhaven on the 9th of August 2017.

During this year's survey a total of 110 hauls with the cod hopper trawl net and an additional 42 accompanying CTD casts were conducted in the six boxes of the GSBTS assigned to FRV "Solea" and the additional experimental box W. The actual sequence of sampling in the boxes was: Box N (German EEZ; 2 days), Box W (German EEZ; 2 days), Box H (British EEZ; 2 days), Box K (Danish EEZ; 3 days), Box P (German EEZ; 2 days), Box E (Dutch EEZ; 2 days), and Box F (British EEZ; 2 days) (Figure 1). A summary of the activities during SB737 within each box is given in Table 1 and a summary of the total sampling effort within the GSBTS survey program by box and year for the cod hopper is presented in Table 2.

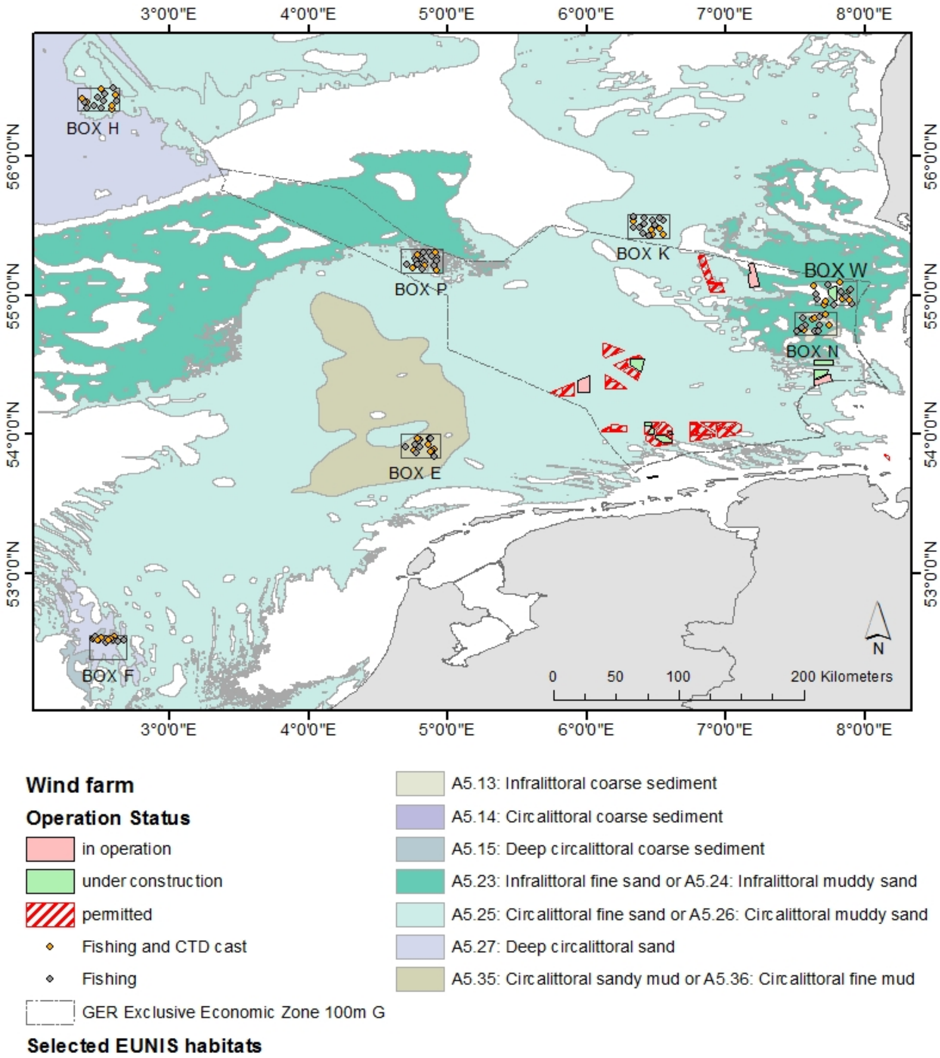


Figure 1: Positions of German small scale bottom trawl survey "boxes" (10 x 10 nm) monitored by the research vessel „Solea" during cruise no. 737 and sampling stations as mid positions indicating fishing activity (grey dot) or fishing in combination with a CTD cast (orange dot) per GSBTS box with intersecting EUNIS habitats categories.

Table 1. Total number of valid cod hopper (KJH) hauls and CTD casts during SB 737.

Box	KJH hauls	CTDs
BOX E	15	6
BOX F	14	6
BOX H	15	6
BOX K	17	6
BOX N	16	6
BOX P	18	5
BOX W	15	7
Total	110	42

Table 2. Total sampling effort (cod hopper hauls) in the standard GSBTS boxes per survey year.

Year	BOX P	BOX H	BOX N	BOX K	BOX E	BOX F	Total
1990	-	-	-	-	8	28	36
1991	-	27	-	24	28	28	107
1992	-	23	-	19	28	21	91
1993	-	25	-	27	27	23	102
1995	-	26	-	24	21	25	96
1996	-	17	-	28	28	26	99
1997	-	25	-	26	6	18	75
1998	-	25	-	23	17	20	85
1999	-	17	-	30	10	27	84
2000	-	-	8	-	-	-	8
2002	-	17	-	9	15	17	58
2003	24	23	-	24	15	24	110
2004	16	23	15	17	19	17	107
2005	14	20	20	14	14	16	98
2006	-	16	19	24	-	-	59
2007	16	24	21	12	23	22	118
2008	18	21	21	18	21	22	121
2009	16	21	22	15	24	22	120
2010	14	21	21	16	21	21	114
2011	21	21	21	7	10	-	80
2012	18	21	21	7	21	-	88
2013	18	21	23	21	21	21	125
2014	24	23	17	18	21	21	124
2015	18	21	17	21	22	23	122
2016	18	21	16	14	12	12	93
2017	18	15	16	17	15	14	95
Total	253	514	278	455	447	468	2415

Results

Trawl durations were constantly close to 30 min and the trawl speed ranged around 3.5 kn across all valid hauls (Table 3). Box F forms an exception since the fishing gear deployed differed due to different habitat conditions.

Table 3. Summary of mean catch depth (m), mean distance between trawl doors (m), mean vertical net opening (m), mean length of trawl warp (m), mean trawl duration (min) and min trawl speed (kn) of all valid hauls per box.

Box	mean depth (m)	mean distance trawl doors (m)	mean vertical net opening (m)	mean length trawl warp (m)	mean trawl duration (min)	mean trawling speed (kn)
BOX E	41.11	59.80	3.29	250.73	30.07	3.59
BOX F	48.74	58.54	--	269.43	28.50	3.52
BOX H	73.47	63.09	3.79	373.53	30.00	3.57
BOX K	41.83	60.11	3.28	261.00	30.00	3.62
BOX N	21.37	46.98	3.43	149.31	30.31	3.61
BOX P	47.18	58.10	3.29	269.39	30.06	3.67
BOX W	20.38	52.34	3.35	152.60	30.00	3.61

In Figure 2 the total catches in kg 30min^{-1} are shown for each GSBTS box. Overall the total catches were in the respective average range for all boxes. Overall an upwards trend in total catches can be observed in boxes F, N and H.

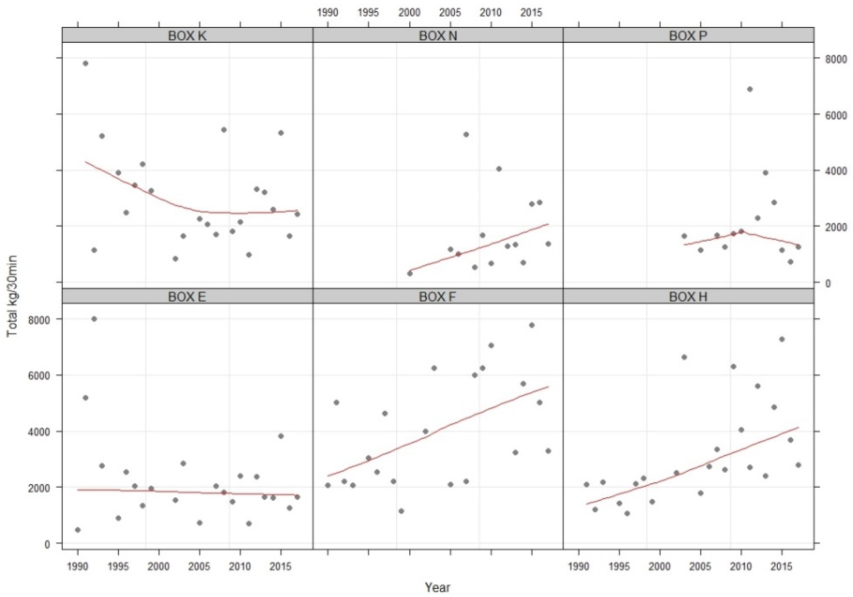


Figure 2: Trend in total catches as CPUE (kg 30 min^{-1}) for each GSBTS box.

In Figures 3 to 8 for each GSBTS box the annual catches (kg 30min^{-1}) of the species contributing at least 0.5% to the cumulative total catch across all sampling years are displayed. Between nine and 13 species contributed the most to the overall biomass caught in the respective GSBTS boxes. Compared to the long-term trend some differences in 2017 are noticeable:

- Catches in Box P (Fig. 3 top and bottom) were lowest for cod (*Gadus morhua*) and highest for Lemon sole (*Microstomus kitt*) compared to all previous years. Dab dominated the catch composition
- In Box H (Fig. 4 top and bottom) highest CPUE values were detected for dab (*Limanda limanda*) and the upward trend of whiting (*Merlangius merlangus*) CPUE continued. The downwards trend in haddock (*Melanogrammus aeglefinus*) catches continued.
- Box N (Fig.5 top and bottom) had highest CPUE of dab and the catches of tub gurnad (*Trigla lucerna*) dropped clearly in comparison to 2016. Catches were dominated by dab and Atlantic mackerel (*Scomber scombrus*).
- In Box K (Fig. 6 top and bottom) the catches of dab were highest, while CPUEs of herring and American plaice (*Hippoglossoides platessoides*) showed lowest values for the respective time series. Over the last three years the species composition has changed from herring (*Clupea harengus*) dominated catches to dab dominated.

- In Box E (Fig. 7 top and bottom) CPUE of herring dropped to the lowest values of the time series and dab showed highest catches. The CPUEs of whiting remained at levels higher than the long-term median.
- In Box F (Fig. 8 top and bottom) we found the lowest CPUEs of Atlantic horse mackerel (*Trachurus trachurus*) and Atlantic mackerel over the past 22 years. Whiting dominated the catch composition more than in all years before.

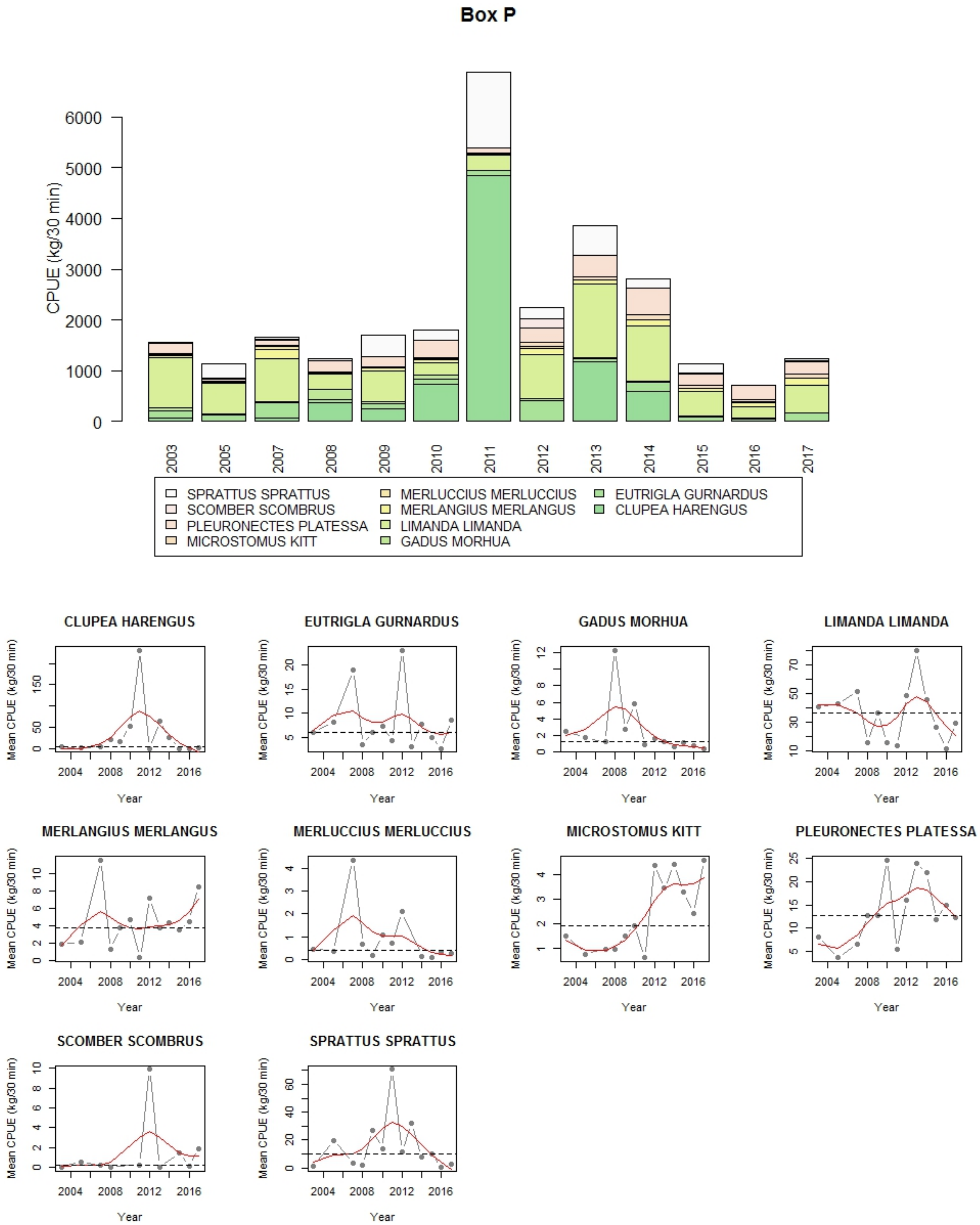


Figure 3: Summed CPUE (kg 30 min^{-1}) of the species contributing to 99.5% of the cumulative biomass in Box P. Bottom: Long-term trends in mean CPUE per haul (kg 30 min^{-1}) of the selected species in Box P, with indicated median CPUE per haul value over all sampling years (dashed line).

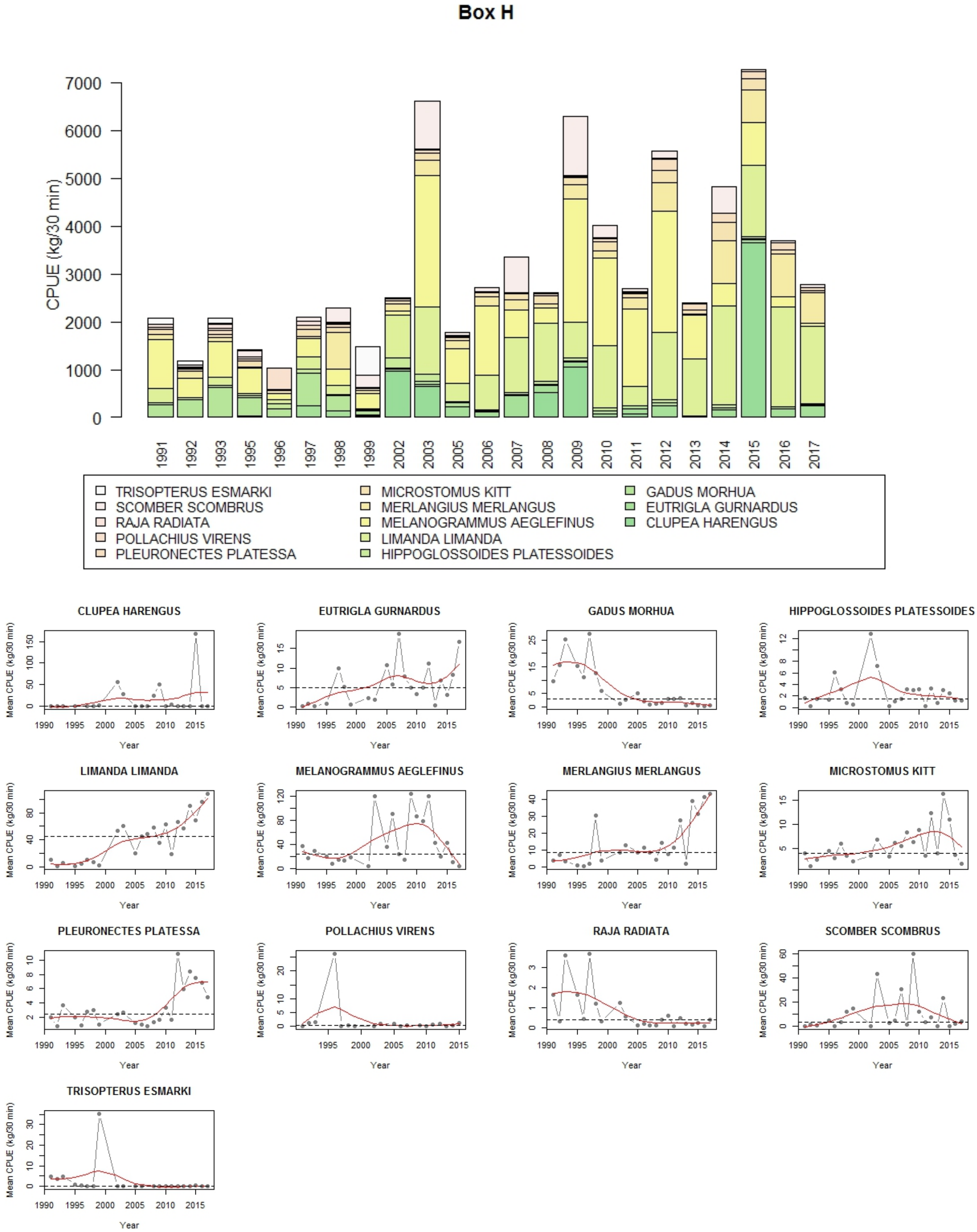
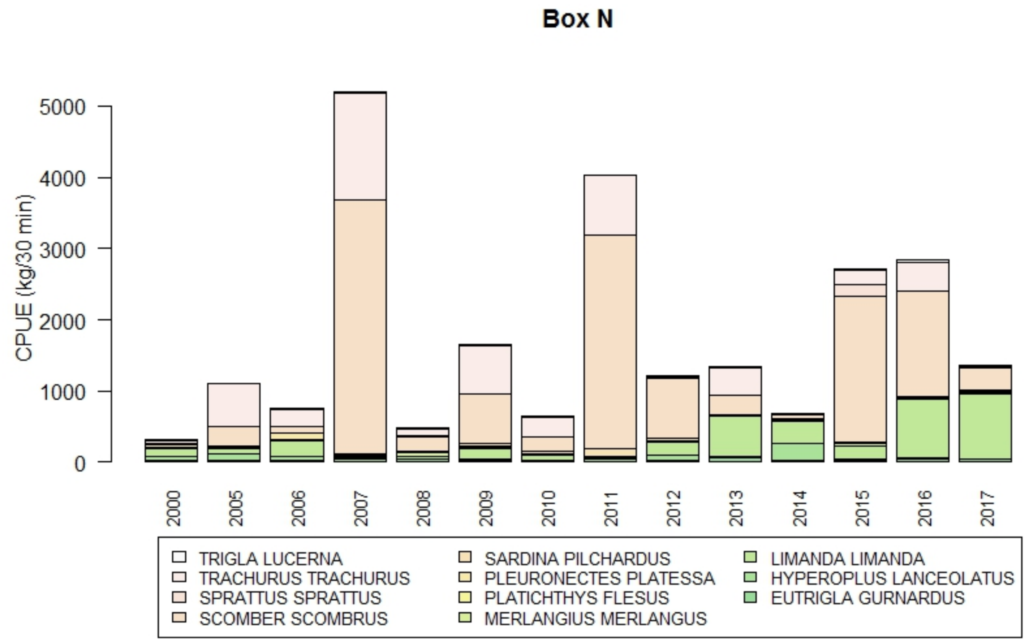


Figure 4: Top: Summed CPUE (kg 30 min^{-1}) of the species contributing to 99.5% of the cumulative biomass in Box H. Bottom: Long-term trends in mean CPUE per haul (kg 30 min^{-1}) of the selected species in Box H, with indicated median CPUE per haul value over all sampling years (dashed line).



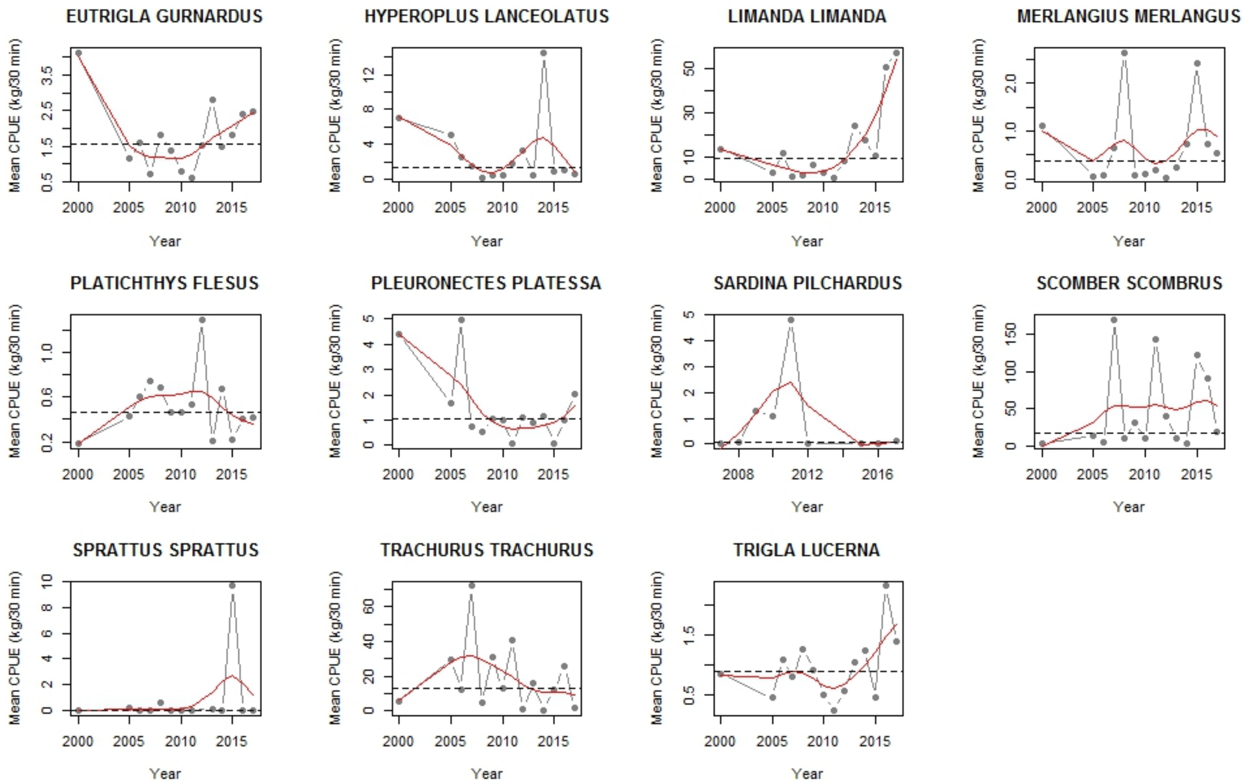


Figure 5: Top: Summed CPUE (kg 30 min^{-1}) of the species contributing to 99.5% of the cumulative biomass in Box N. Bottom: Long-term trends in mean CPUE per haul (kg 30 min^{-1}) of the selected species in Box N, with indicated median CPUE per haul value over all sampling years (dashed line).

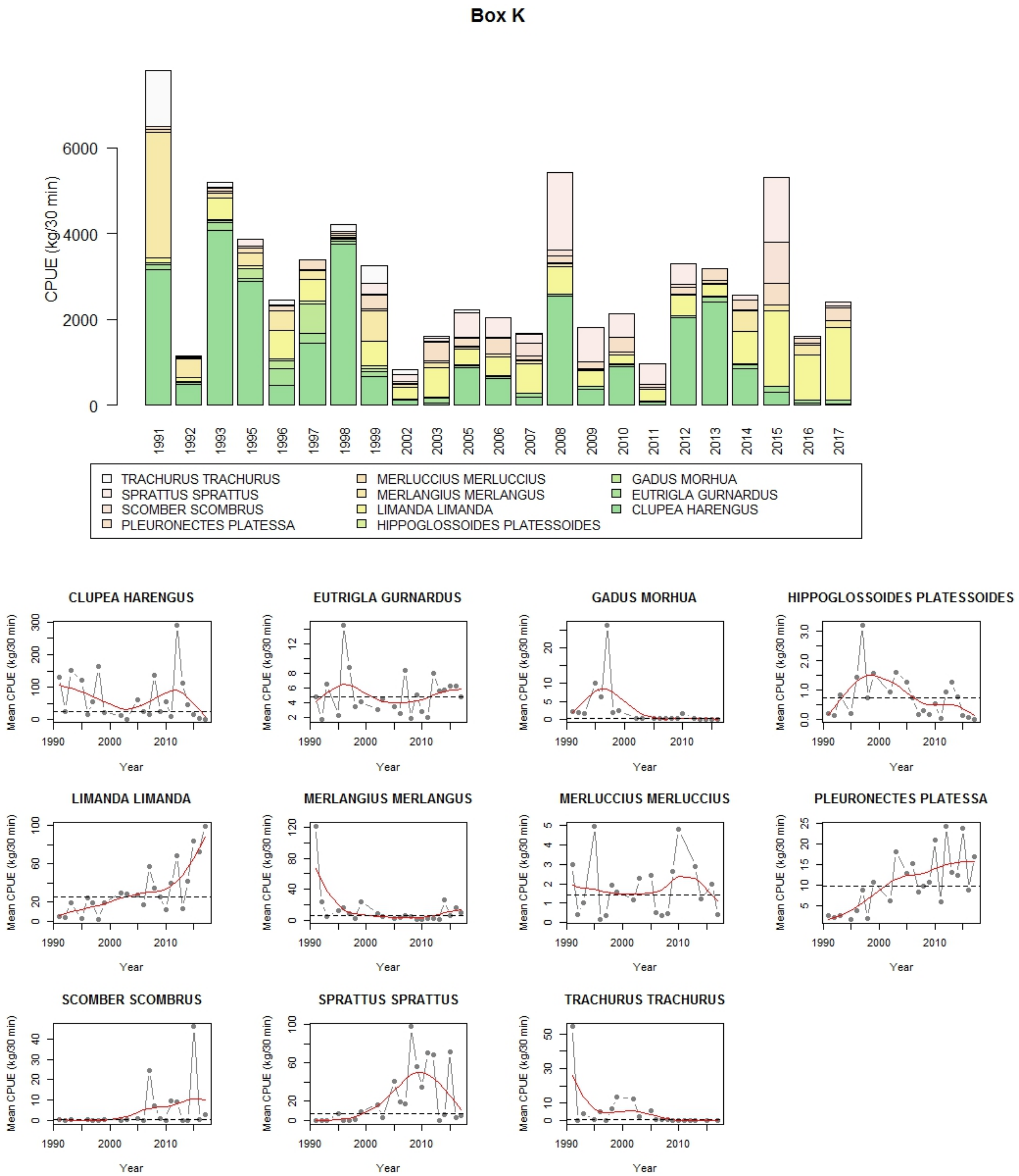
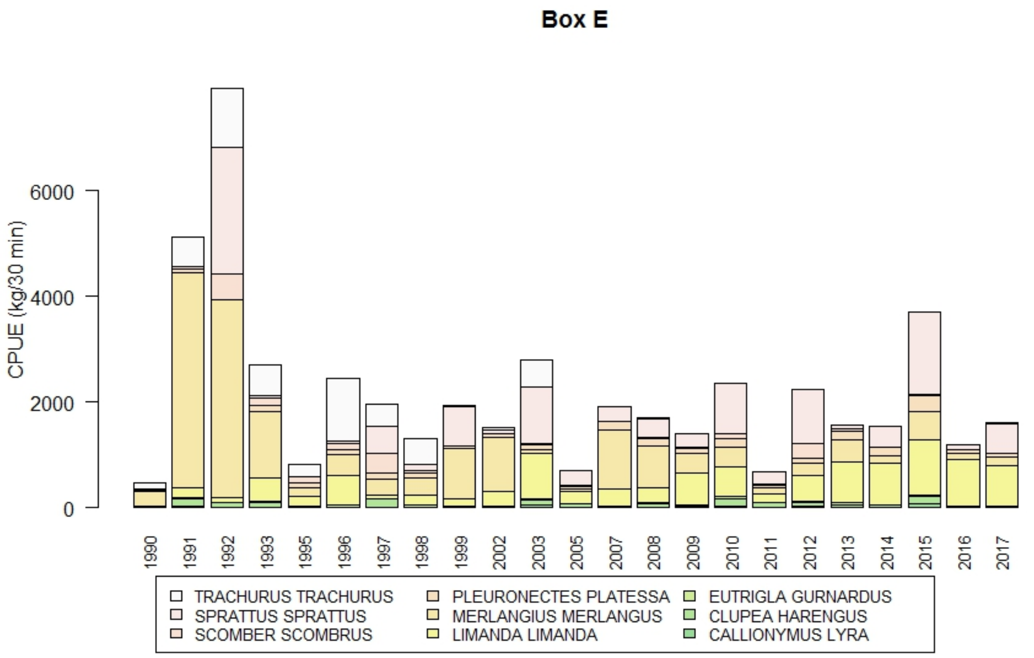


Figure 6: Top: Summed CPUE (kg 30 min^{-1}) of the species contributing to 99.5% of the cumulative biomass in Box K. Bottom: Long-term trends in mean CPUE per haul (kg 30 min^{-1}) of the selected species in Box K, with indicated median CPUE per haul value over all sampling years (dashed line).



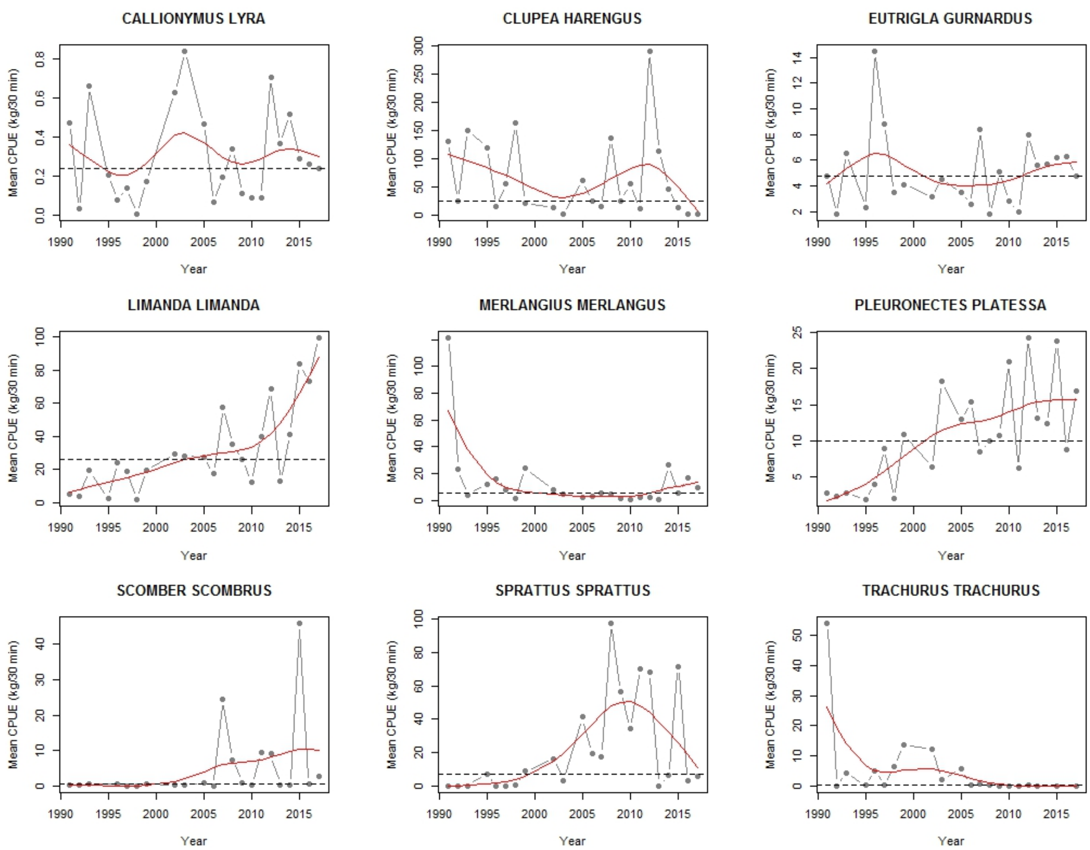


Figure 7: Top: Summed CPUE (kg 30 min^{-1}) of the species contributing to 99.5% of the cumulative biomass in Box E. Bottom: Long-term trends in mean CPUE per haul (kg 30 min^{-1}) of the selected species in Box E, with indicated median CPUE per haul value over all sampling years (dashed line).

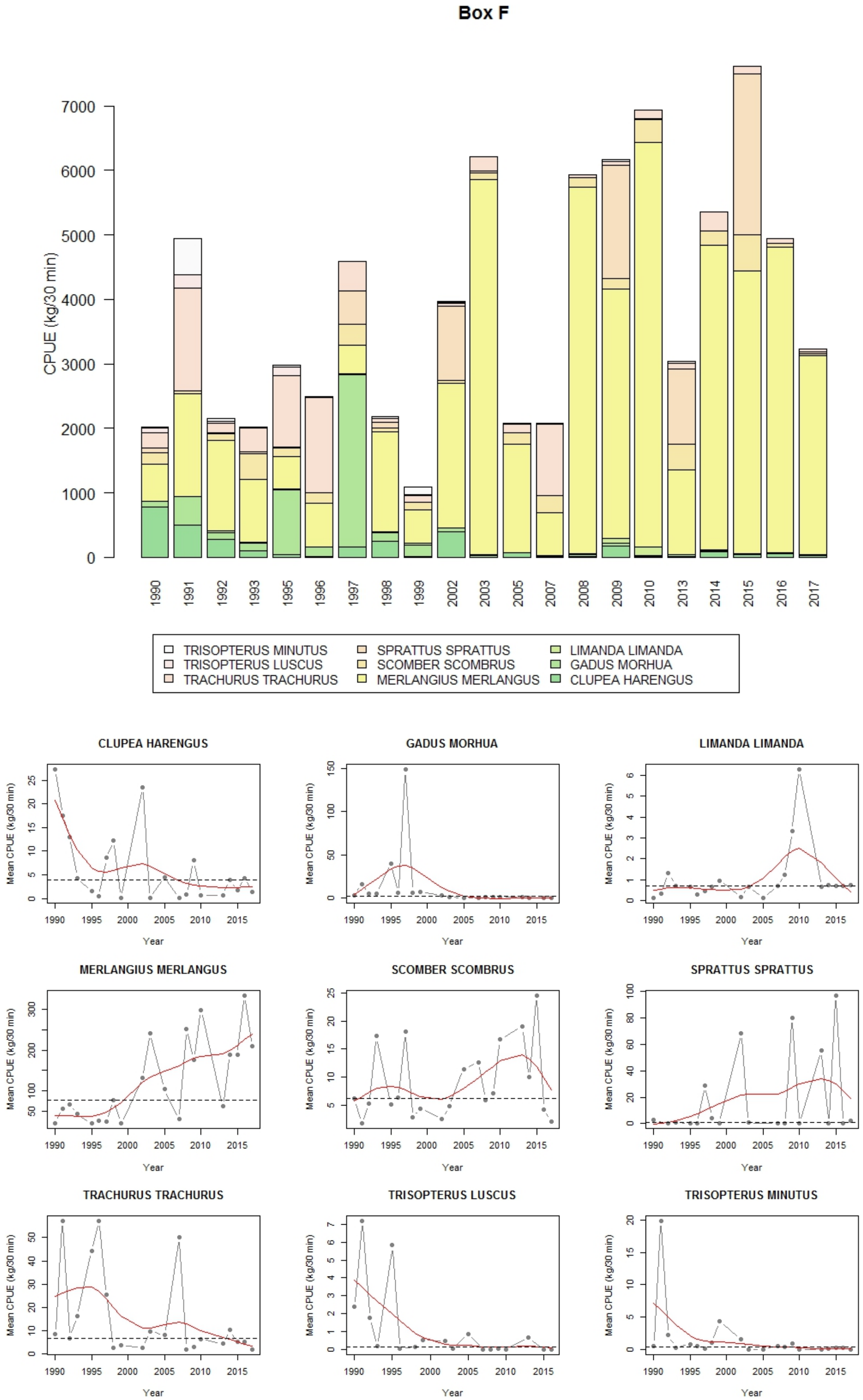


Figure 8: Top: Summed CPUE (kg 30 min^{-1}) of the species contributing to 99.5% of the cumulative biomass in Box F. Bottom: Long-term trends in mean CPUE per haul (kg 30 min^{-1}) of the selected species in Box F, with indicated median CPUE per haul value over all sampling years (dashed line).

Catches of elasmobranchs for all years and GSBTS boxes are displayed in Figure 9. An overview of the total elasmobranch catches in 2017 as kg per 30 min and numbers per 30 min for each box are given in Table 4. Overall most elasmobranchs are generally caught in box F. While over the years more lesser spotted dogfish (*Scyliorhinus canicula*) were caught in box F, the catches of the spotted ray (*Raja montagui*) decreased continuously. Since the early 2000´s the starry smooth-hound (*Mustelus asterias)* is caught every year with a slight upward trend in CPUEs. Spiny spurdog (*Squalus acanthias*), which was found in box H in the 2014 survey in exceptionally high numbers, was not caught in this year.

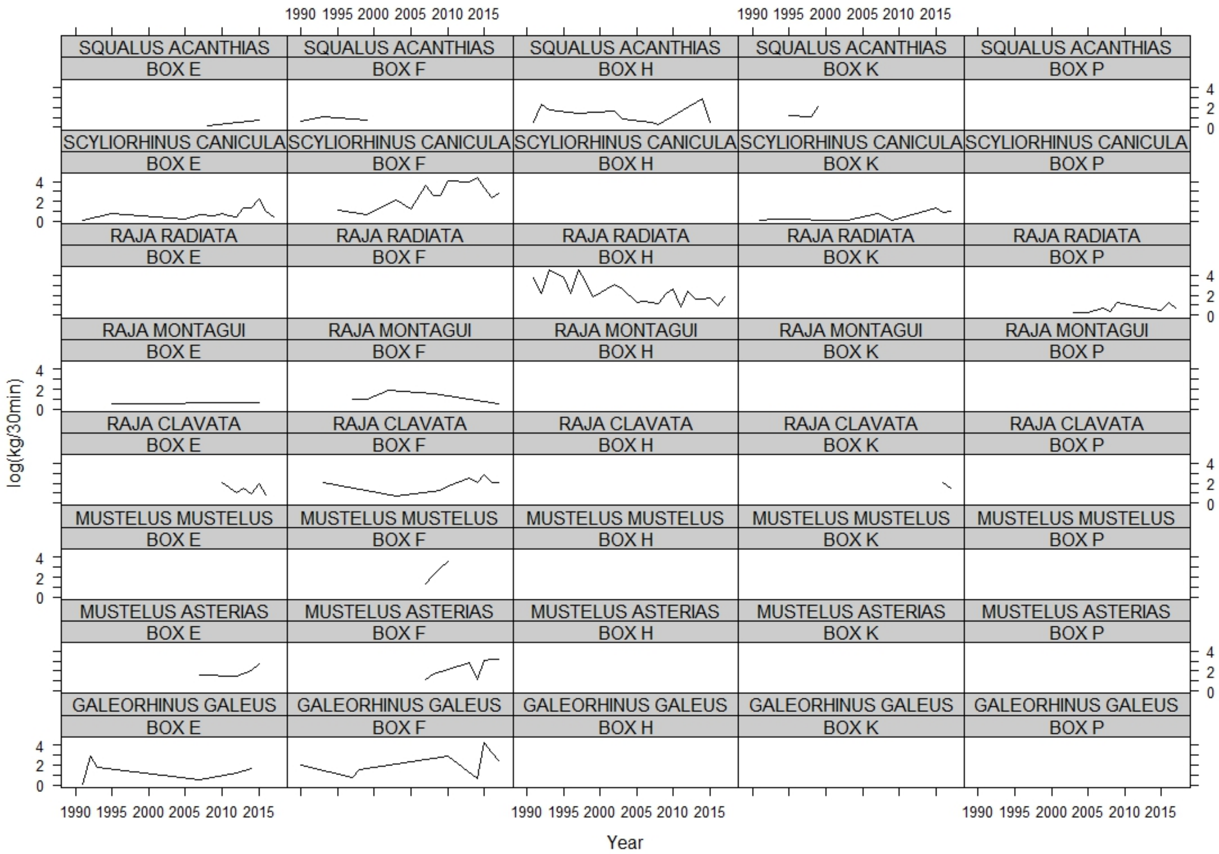


Figure 9: Long-term trend in total elasmobranches catches (log-transformed kg 30 min^{-1}) for each GSBTS box.

Table 4. Overview of elasmobranch catches in the 2017 GSBTS.

Box	Species	Total catch (kg)	Total catch (n)
BOX E	*Scyliorhinus canicula*	0.52	1
BOX F	*Galeorhinus galeus*	11.08	3
BOX F	*Mustelus asterias*	22.30	15
BOX F	*Raja clavata*	6.82	3
BOX F	*Raja montagui*	0.76	1
BOX F	*Scyliorhinus canicula*	14.80	37
BOX H	*Raja radiata*	5.66	13
BOX K	*Raja clavata*	3.27	1
BOX K	*Raja montagui*	1.19	1
BOX K	*Scyliorhinus canicula*	1.71	2
BOX P	*Raja clavata*	1.38	1
BOX P	*Raja radiata*	0.98	2

This year's GSBTS sampling was modified by introducing an additional experimental box W (see Figure 1). Box W is similar in size of all the other standard GSBTS boxes and represents similar habitat conditions as box N. However, box W is enclosing the offshore windfarm Butendiek, which is in operation since summer 2015. As shown in table 1 a total number of 15 hauls were carried out in box W and the sampling procedure followed the GSBTS standard protocol. The setting positions were defined prior to allow for a homogenous distribution of the sampling stations across the habitat classes. Since fishing activities are less frequent in the area the trawling direction was decided on a case by case basis. In general, a distance of 500 m has to be kept to the boundary of any windfarm area. The key question was if catches do significantly differ in composition, weight and numbers in the vicinity of the windfarm compared to box N. For the subsequent analysis each trawling track was reconstructed with the help of the gear parameters and the area swept was calculated in km^2. The exact area of each sediment class swept was also calculated. Thus each sampled station in Box N (2000 to 2017) and in Box W (only 2017) was associated to a relative habitat proportion which reflects the proportion of sand to muddy sand to coarse sediment with values ranging between 0 and 1 (with 1= sand and 0= coarse sediment. An analysis of variances (ANOVA) for the time series (2000 to 2017) of N $30min^{-1}$ per species sampled in Box N revealed that the catches of nine species differed significantly across the habitat proportions swept (Table 5). European flounder (*Platichthys flesus*) could be more associated to coarser sediment, while plaice, dragonet (*Callionymus lyra*) and tub gurnard (*Trigla lucerna*) preferred sand to muddy sand.

Table 5: ANOVA results of the nine species for which the habitat proportion had a significant effect on the catches (N 30min-1) in Box N (2000-2017).

Species	Df	MeanSq	ErrorVar	F ratio	p-value
AMMODYTES MARINUS	66	23.85	4.28	5.57	0.02
CALLIONYMUS LYRA	130	2.34	0.58	4.07	0.05
HYPEROPLUS LANCEOLATUS	173	25.38	3.82	6.65	0.01
LIMANDA LIMANDA	201	20.92	2.08	10.05	0.00
PLATICHTHYS FLESUS	148	3.19	0.50	6.36	0.01
PLEURONECTES PLATESSA	188	11.82	1.16	10.20	0.00
SPRATTUS SPRATTUS	53	25.03	4.69	5.34	0.02
TRACHURUS TRACHURUS	188	25.04	3.32	7.53	0.01
TRIGLA LUCERNA	168	2.10	0.54	3.90	0.05

Table 6: ANOVA results of the seventeen species which were commonly caught in boxes N and W during SB 737, where significant results are highlighted in bold.

Species	Df	MeanSq	ErrorVar	F ratio	p-value
AMMODYTES TOBIANUS	14	18.01	1495.84	0.01	0.91
ARNOGLOSSUS LATERNA	7	0.89	0.10	9.33	**0.02**
CALLIONYMUS LYRA	13	2.52	0.86	2.92	0.11
CANCER PAGURUS	15	2.64	0.37	7.06	**0.02**
CLUPEA HARENGUS	1	0.17	0.50	0.33	0.67
ECHIICHTHYS VIPERA	6	782.04	375.14	2.08	0.20
EUTRIGLA GURNARDUS	29	391.19	573.40	0.68	0.42
HYPEROPLUS LANCEOLATUS	19	94918.68	80368.65	1.18	0.29
LIMANDA LIMANDA	29	1403629.10	306876.75	4.57	**0.04**
MERLANGIUS MERLANGUS	29	632.92	102.52	6.17	**0.02**
PLATICHTHYS FLESUS	25	1020.17	52.77	19.33	**0.00**
PLEURONECTES PLATESSA	29	1794.59	633.36	2.83	0.10
SARDINA PILCHARDUS	8	18.15	19.34	0.94	0.36
SCOMBER SCOMBRUS	29	75158.68	90671.75	0.83	0.37
SPRATTUS SPRATTUS	6	0.38	0.08	4.50	0.08
TRACHURUS TRACHURUS	16	9363.60	8339.68	1.12	0.31
TRIGLA LUCERNA	26	30.79	57.52	0.54	0.47

For the GSBTS (SB 737) the catches of seventeen species which have been commonly caught in both areas have been compared. ANOVA results showed that the factor "Box" was significant for five species, thus catches (N $30min^{-1}$) differed significantly ($p < 0.05$) between the boxes N and W. While significantly more edible crab (*Cancer pagurus*) and European flounder was caught in box W, numbers of whiting, dab and scaldfish (*Arnoglossus laterna*) were significantly higher in box N (see Figure 10). The habitat type swept is shown for each sampling station in box N and W in Figure 11 (top left). Figure 11 shows also a fairly homogenous distribution of sampling stations across habitat types. Examples of the the spatial distribution of the number of individuals caught are shown for edible crab, dab, whiting and European flounder (Figure 11). In general, European flounder prefers muddy substrates and is a migrating species of international commercial relevance.

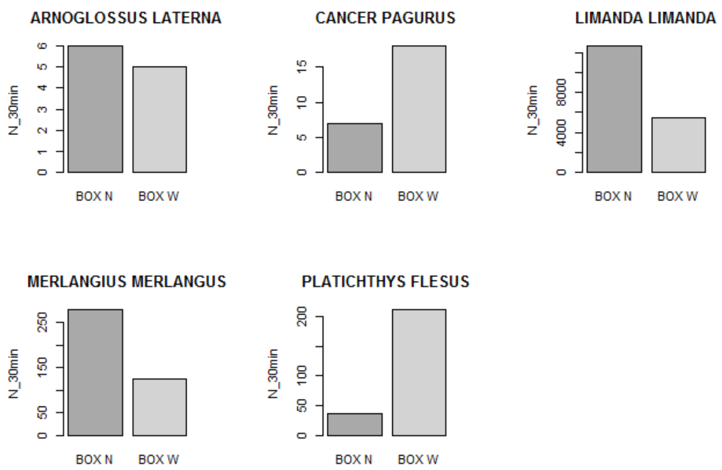


Figure 10: Comparison of the total catch in numbers per 30 min for the five species identified by the ANOVA analysis.

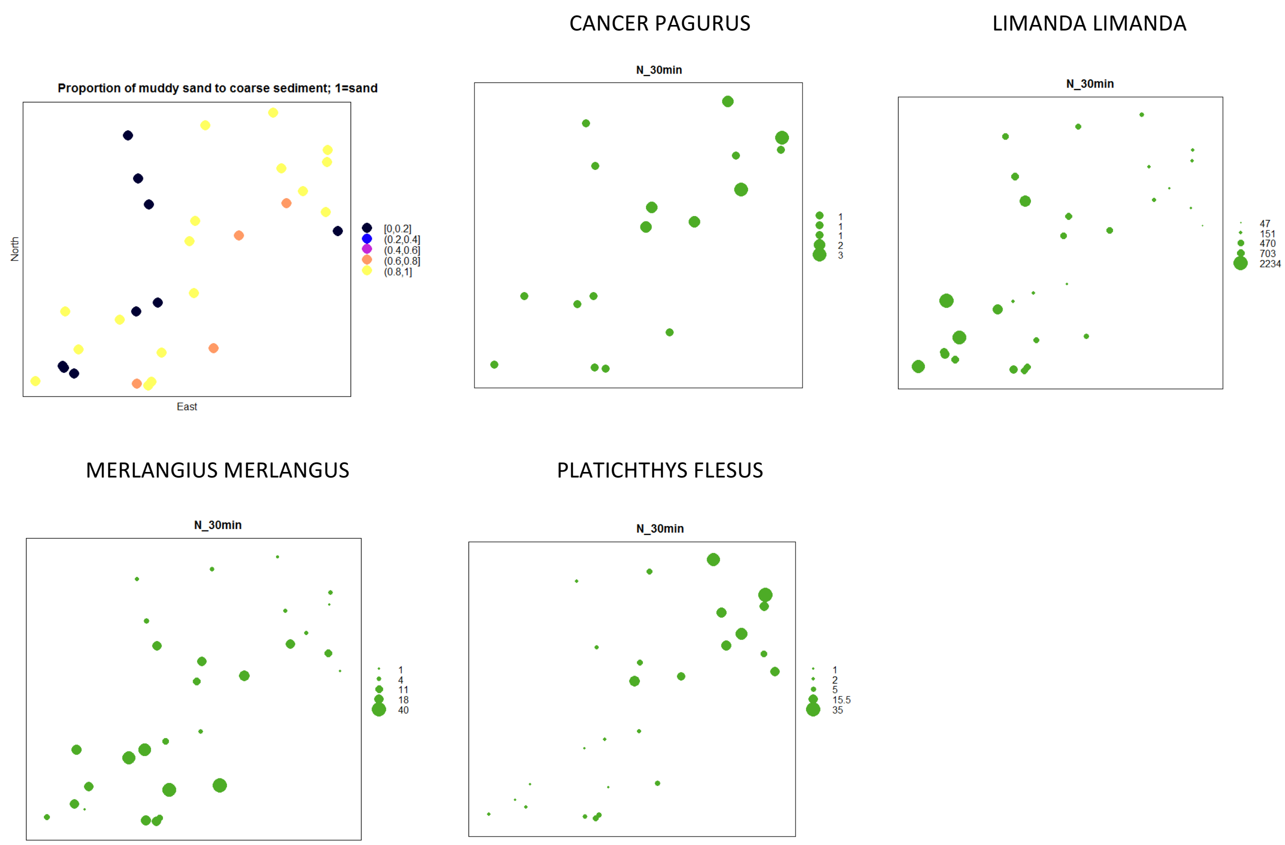


Figure 11: Top left: Mid positions of the hauls sampled in boxes W and N (see Figure 1 for their relative location to the wind farm Butendiek) with the associated proportion of swept habitat (1= sand to muddy and 0 = coarse sediment); bubble plots of the mid position of the hauls with the relative bubble size reflecting the numbers of edible crab, dab, whiting and European flounder caught in box N and box W.

For each mid position of the stations sampled in boxes N and W the distance (m) to the nearest wind turbine was calculated in the GIS (DistTurb). Adjacent to the north-eastern corner of Butendiek a field with boulders is located. Since this is a unique habitat feature which could also attract the aggregation of fish, the nearest distance to the boulders field (DistBoulders) was also calculated for each trawling mid-position. In Figure 12 the log-transformed catches (N 30 min^{-1}) of 13 more abundant species which were commonly caught in boxes N and W were plotted against the distances to the nearest wind turbine and the boulder field. Some trends could be observed in relation to the proximity to the sampling stations to the two spatial features. Decreasing trends in catches from box W to box N can be observed for Atlantic horse mackerel, European flounder, dragonet and edible crab. A clear increase in catches from box W to box N was computed for dab and Lesser weever (*Echiichthys vipera*).

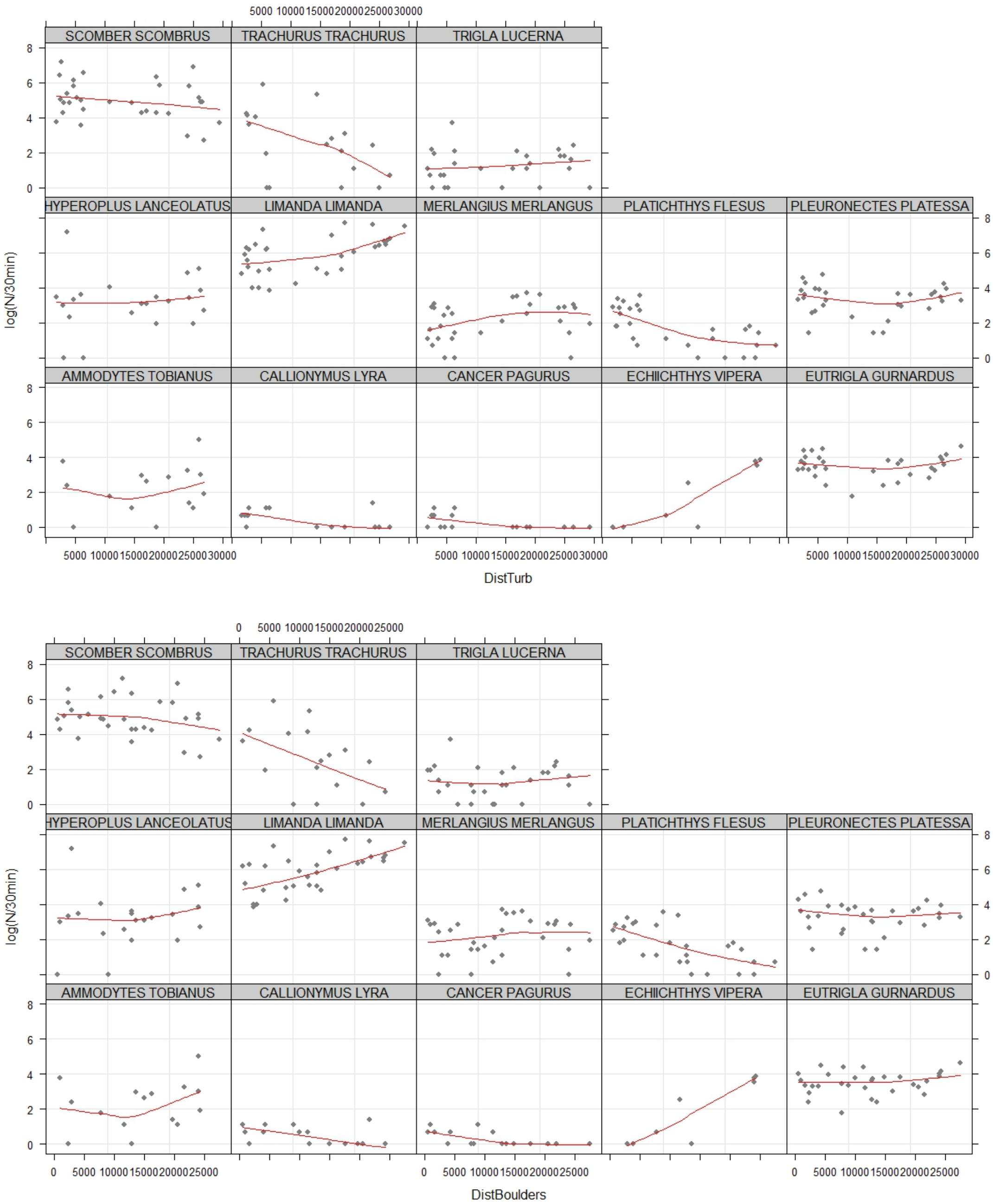


Figure 12: Trends in catches of the more abundant species commonly caught in box W and N with increasing distance (m) to the nearest wind turbine of Butendiek (DistTurb; top) and to the field with boulders (DistBoulders; bottom).

Finally, only the catches of the more abundant species caught in box W were plotted against the distances to the respective spatial features (Figure 13). Distances to the boulder field ranged from 500 m to 15000 m, while the distances to the nearest wind turbine ranged between 500 m to 6500 m. A slight decrease in numbers with increasing distance to the boulder field was observed for tub gurnard, Atlantic horse mackerel and whiting (Figure 13; bottom). With the exception of Atlantic horse mackerel those trends could not be observed with increasing distances to the nearest wind turbine (Figure 13; top).

In summary, the experimental fishing in box W revealed some clear differences in catches between boxes W and N besides similar substrate in both boxes. For some species such as edible crab and European flounder catches were clearly increased in box W. The results for European flounder and Atlantic horse mackerel are especially interesting since the habitat features are almost identical across the sampled stations in both boxes. The increased numbers of edible crab in the proximity of the wind park and the boulders are not surprising since hard substrates can provide shelter.

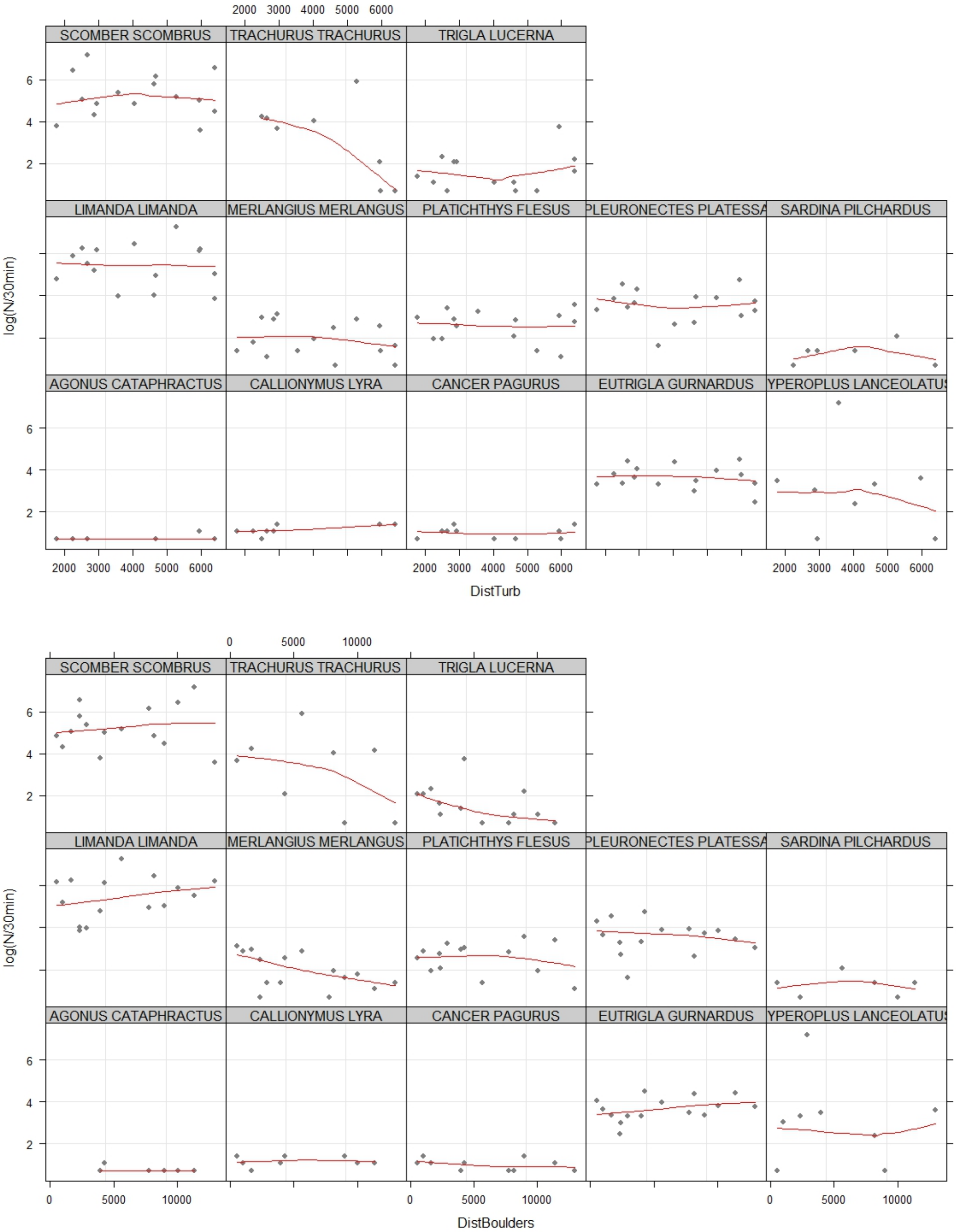


Figure 13: Trends in catches of the more abundant species caught in box W with increasing distance (m) to the nearest wind turbine of Butendiek (DistTurb; top) and to the field with boulders (DistBoulders; bottom).

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Acknowledgements

We thank Captain Volker Koops as well as the crew of FRV "Solea" and all members of the scientific team for their cooperation and commitment that allowed the successful accomplishment of the survey.

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