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THÜNEN

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Cruise Report
SO 751 of FRV „SOLEA"
25.07. –14.08.2018

Cruise Leaders: Dr. Vanessa Stelzenmüller & Dr. Antje Gimpel

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 (box W)

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Narrative

FRV "Solea" left Cuxhaven on the 25nd of July 2018 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 4th of August in Esbjerg. The scientific program continued from the 5th of July until the 13th of August. The vessel returned to Cuxhaven on the 14th of August 2018.

During this year's survey a total of 107 hauls with the cod hopper trawl net and an additional 46 accompanying CTD casts were conducted in five boxes of the GSBTS assigned to FRV "Solea" and the additional experimental box W. Every year the actual sequence of sampling in the boxes was adapted to the prevailing weather conditions (Box N (German EEZ; 3 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) and Box E (Dutch EEZ; 2 days) (Figure 1). Due to bad weather box F could not be sampled. A summary of the activities during SB751 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. Since 2017 the GSBTS sampling comprises the 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. 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 homogenously distributed across the main habitat types. In general, a distance of 500 m had to be kept to the windfarm boundary. The key question was if catches do significantly differ in composition, weight and numbers in the vicinity of the windfarm compared to box N. In addition, within box W and E a total of three experimental edible crab (*Cancer pagurus*) fisheries using crab pots have been conducted. Emphasis was on testing the catchability of pots, the gear set up and handling on board FRV "Solea."

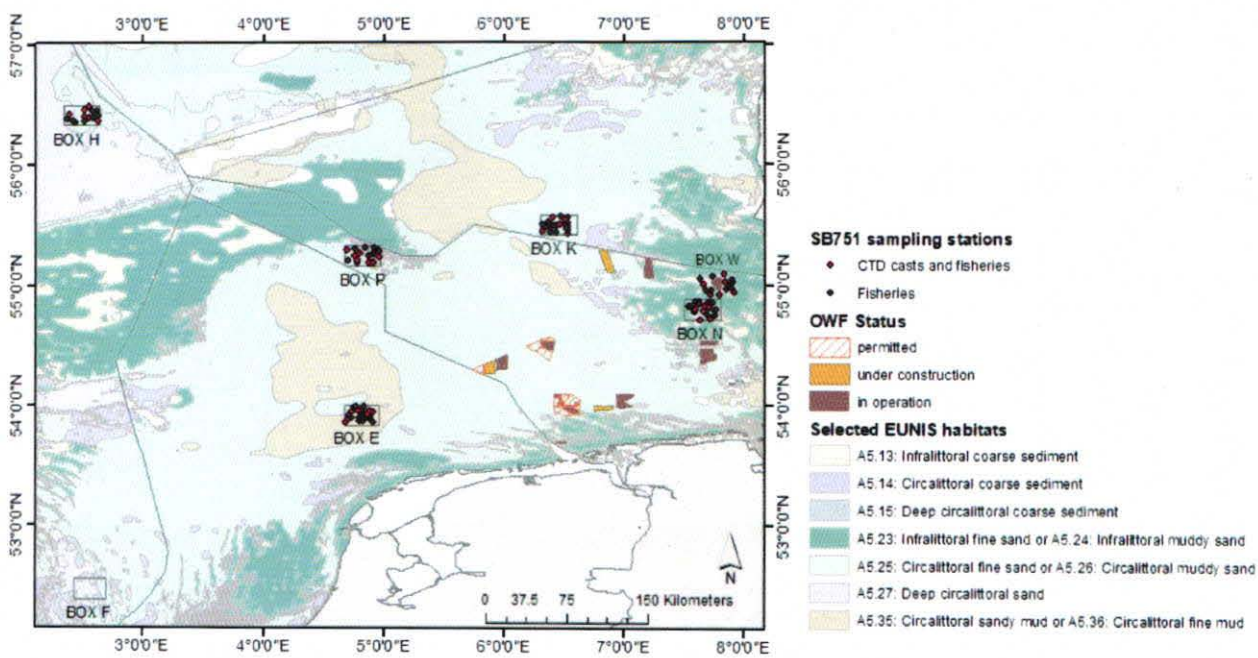


Figure 1: Positions of German small scale bottom trawl survey "boxes" (10 x 10 nm) monitored by the research vessel „Solea" during cruise no. 751 and sampling stations as mid positions indicating fishing activity (black dot) or fishing in combination with a CTD cast (red dot) per GSBTS box with intersecting EUNIS habitats categories.

Table 1. Total number of valid cod hopper (KJN) hauls and CTD casts during SO 751.

Box	KJH hauls	CTDs
BOX E	21	8
BOX F	-	
BOX H	14	6
BOX K	21	9
BOX N	21	9
BOX P	15	7
BOX W	15	7
Total	**107**	**46**

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
2018	15	14	21	21	21	-	92
Total	268	528	299	476	468	468	2507

Results

Long-term trends in catch compositions

Trawl durations were constantly close to 30 min and the trawl speed ranged around 3.5 kn across all valid hols (Table 3). Mean depth between sampled boxes varies between 19.8 and 71.7 m.

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

Box	mean depth (m)	mean vertical net opening (m)	mean trawl duration (min)	mean trawling speed (kn)	mean length trawl warp (m)	mean distance trawl doors (m)
BOX E	41.1	3.64	30	3.51	225.10	48.4
BOX H	71.7	3.95	30	3.52	350.21	59.4
BOX K	42.2	4.66	30	3.52	225.14	52.9
BOX N	20.6	4.49	30	3.48	123.86	46.0
BOX P	46.2	4.06	30	3.53	240.07	56.5
BOX W	19.8	4.93	30	3.50	115.07	46.1

In Figure 2 the total catches in kg 30min^{-1} weighted by the total number of stations sampled per box 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 N and H, while total catches declined in box P.

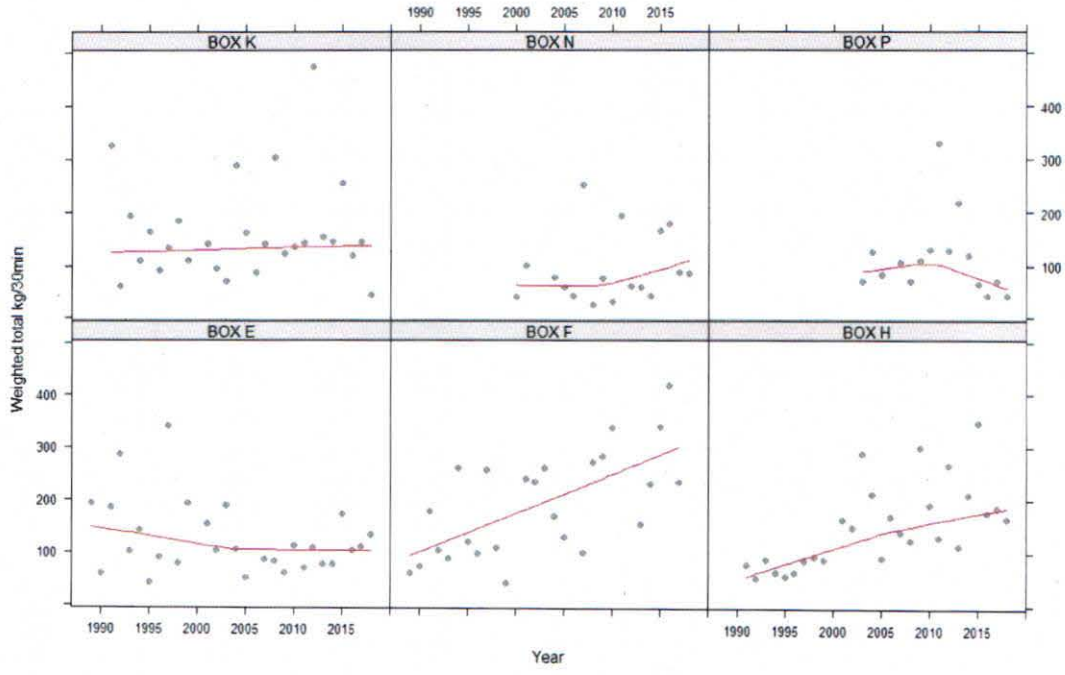


Figure 2: Trends in total catches as CPUE (kg 30 min^{-1}) weighted by the number of stations sampled in each GSBTS box. Box F was not sampled in 2018.

In Figures 3 to 7 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 a number of ten and twelve species contributed the most to the overall biomass caught in the respective GSBTS boxes.

- Although catches in Box P (Fig. 3 top and bottom) were highest in numbers and weights for dab (*Limanda limanda*) and European sprat (*Sprattus sprattus*), compared to all previous years the mean cpue's were well below the median of the respective time series. Only one individual for each species was caught for Cuckoo ray (*Raja naevus*), ling (*Molva molva*), Atlantic wolffish (*Anarhichas lupus*), and European hake (*Merluccius merluccius*). Catches of plaice (*Pleuronectes platessa*) continued to decrease over the last five years. The caught Cuckoo ray was the first one ever recorded across all boxes
- In Box H (Fig. 4 top and bottom) highest cupe values were detected for dab and whiting (*Merlangius merlangus) both exceeding by far median values of the time series.* Only one individual for each species was caught for Norway pout (*Trisopterus esmarki*) and red gurnard (*Aspitrigla cuculus*). *Catches of haddock (Melanogrammus aeglefinus*) were *comparably low continuing the observed downward trend.*
- In Box N (Fig.5 top and bottom) cpue values were highest for dab and Atlantic mackerel (*Scomber scombrus*). The upward trend of catches continued in 2018 for dab and grey gurnard (*Eutrigla gurnadus*). In contrast, catches of Atlantic horse mackerel (*Trachurus trachurus*) continued to decrease. Only on individual was caught for solenette (*Buglossidium luteum*), snake pipefish (*Entelurus aequoreus*), European anchovy (*Engraulis encrasicolus*), brill (*Scophthalmus rhombus*), and common sole (*Solea vulgaris*).
- In Box K (Fig. 6 top and bottom) the catches of dab were highest in weight and numbers, while compared to previous years' catches dropped below the median of the time series. Grey gurnard was the second abundant species in numbers and plaice had second highest cupe values. Only one individual per species was caught for Lesser weever (*Echiichthys vipera*), poor cod (*Trisopterus minutus*), Four-bearded rockling (*Rhinonemus cimbrius*), brill, and starry smooth-hound (*Mustelus asterias*).
- In Box E (Fig. 7 top and bottom) catches were highest in numbers and weight for dab and European sprat. In 2018 dab catches the highest ones recorded by the respective time series. In contrast, only one individual per species was caught for lamprey (*Lampetra fluviatilis*), European flounder (*Platichthys flesus*), and starry smooth-hound.

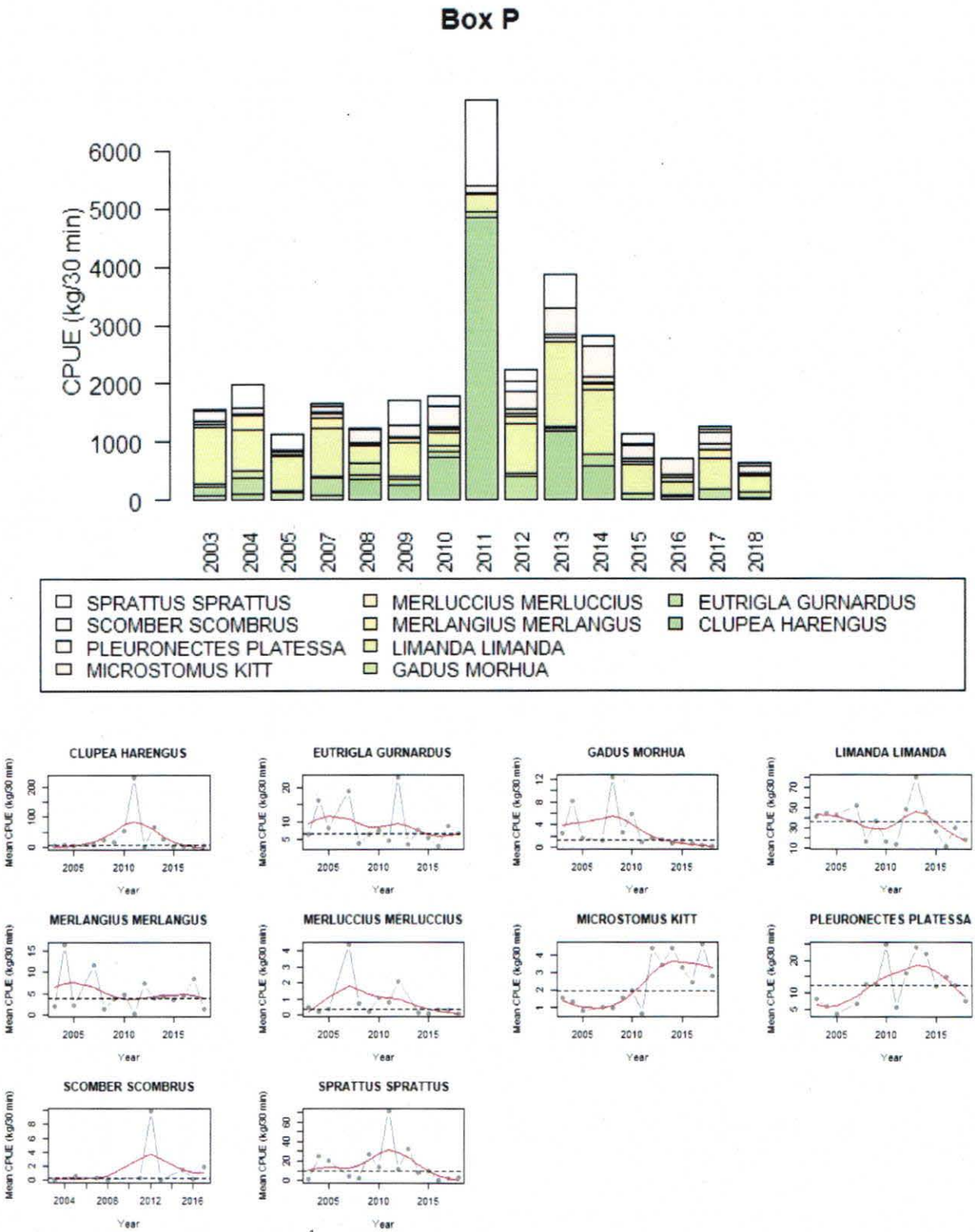


Figure 3: Summed CPUE (kg 30 min^{-1}) of the species contributing to least 99.5% to the cumulative biomass in Box P. Bottom: Long-term trends in mean CPUE per haul (kg 30 min^{-1}) of the selected species in Box P, with indicated median CPUE per haul value over all sampling years (dashed line).

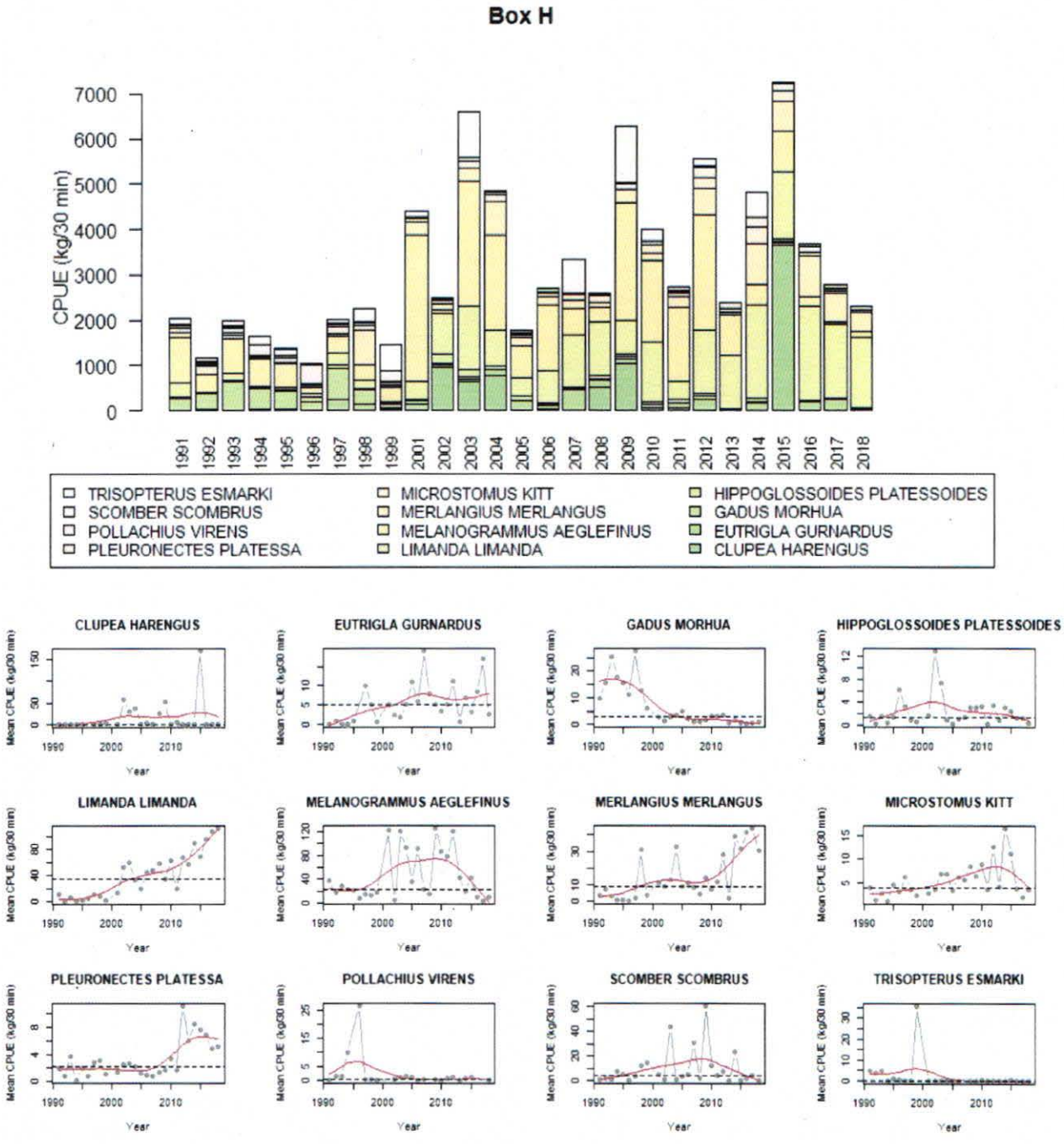


Figure 4: Top: Summed CPUE (kg 30 min^{-1}) of the species contributing to least 99.5% to the cumulative biomass in Box H. Bottom: Long-term trends in mean CPUE per haul (kg 30 min^{-1}) of the selected species in Box H, with indicated median CPUE per haul value over all sampling years (dashed line).

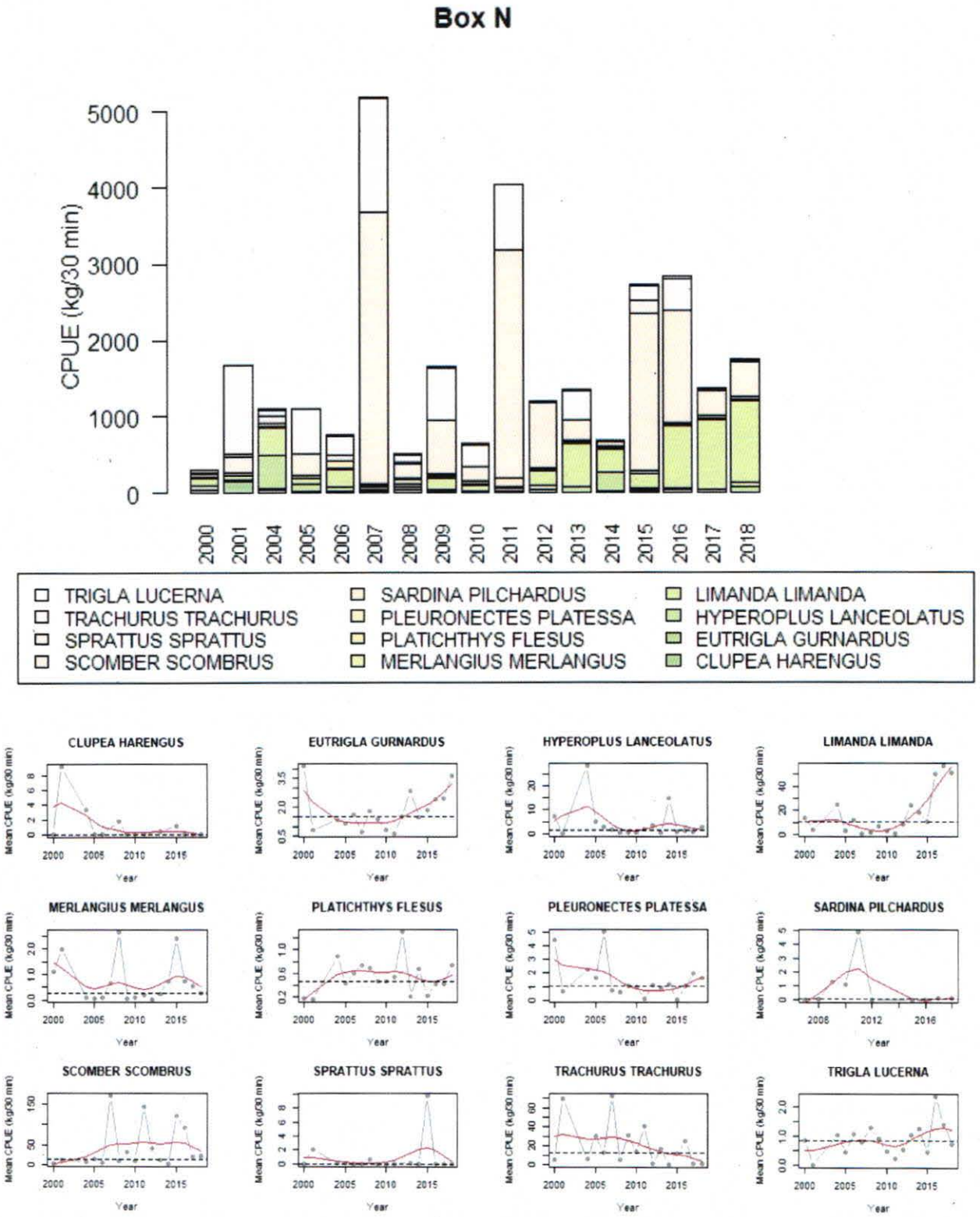


Figure 5: Top: Summed CPUE (kg 30 min^{-1}) of the species contributing to least 99.5% to the cumulative biomass in Box N. Bottom: Long-term trends in mean CPUE per haul (kg 30 min^{-1}) of the selected species in Box N, with indicated median CPUE per haul value over all sampling years (dashed line).

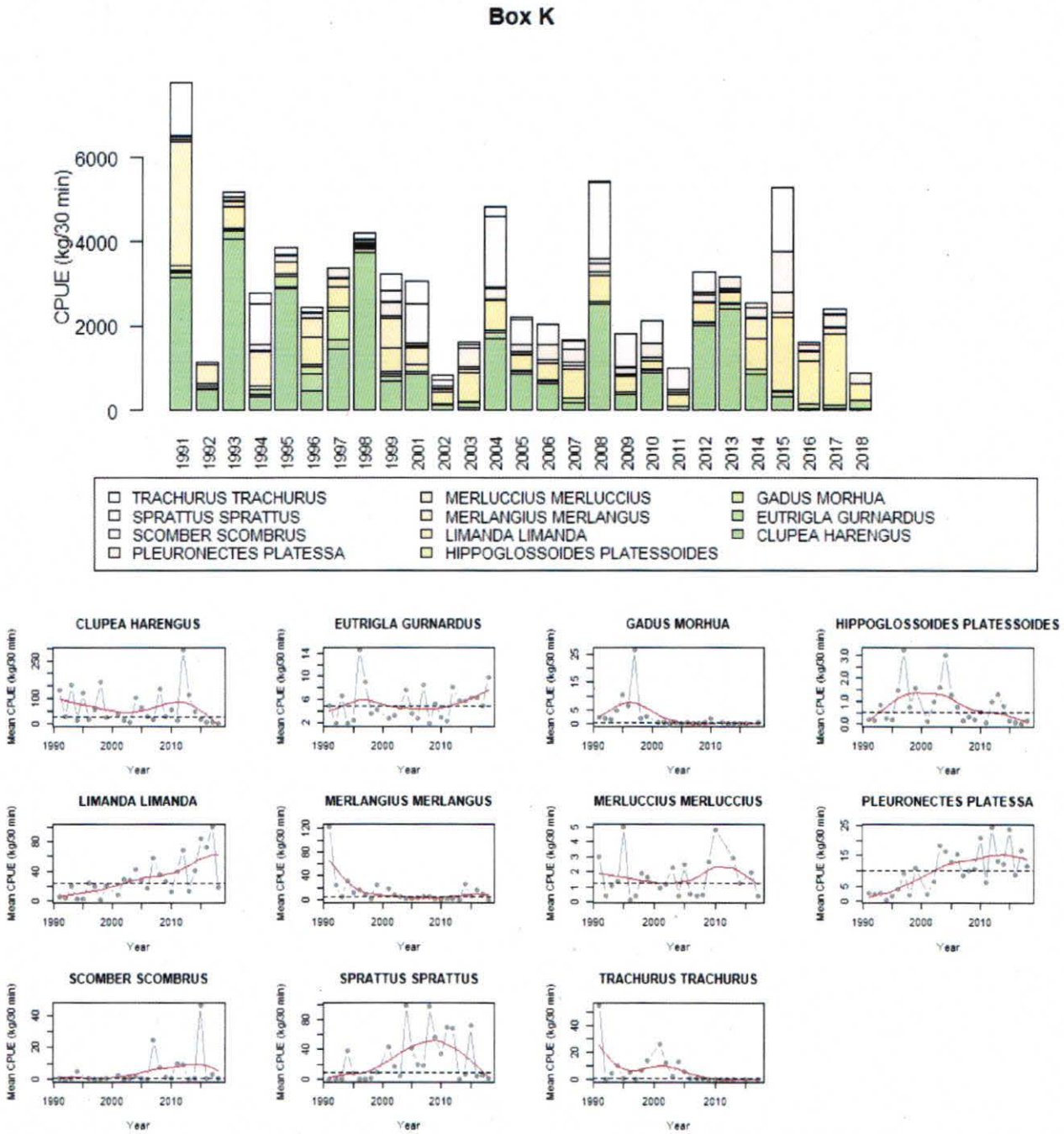


Figure 6: Top: Summed CPUE (kg 30 min^{-1}) of the species contributing to least 99.5% to the cumulative biomass in Box K. Bottom: Long-term trends in mean CPUE per haul (kg 30 min^{-1}) of the selected species in Box K, with indicated median CPUE per haul value over all sampling years (dashed line).

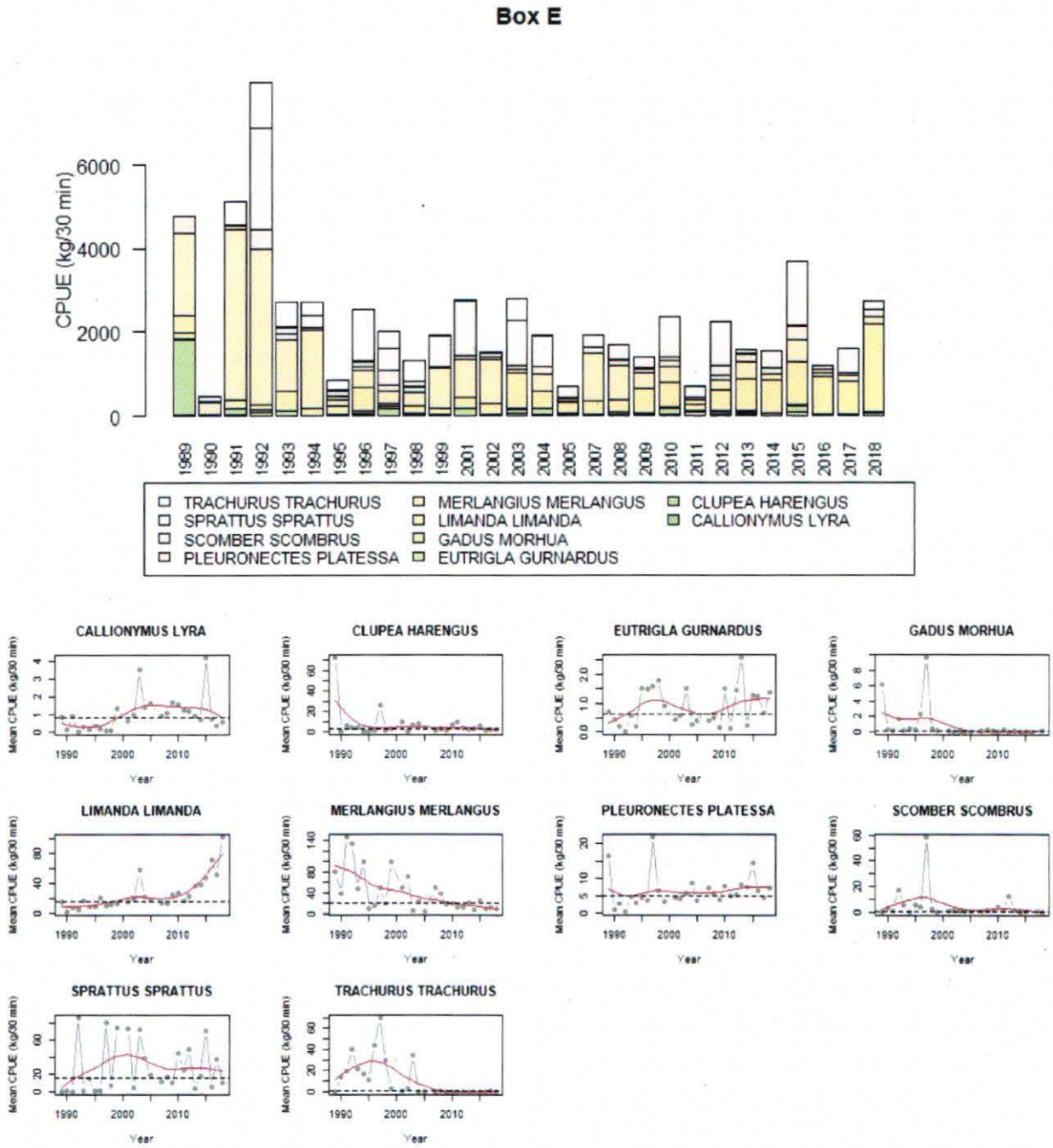


Figure 7: Top: Summed CPUE (kg 30 min^{-1}) of the species contributing to least 99.5% to the cumulative biomass in Box E. Bottom: Long-term trends in mean CPUE per haul (kg 30 min^{-1}) of the selected species in Box E, with indicated median CPUE per haul value over all sampling years (dashed line).

Long-term trends in elasmobranch catches

An overview of the total elasmobranch catches in 2018 as kg per 30 min and numbers per 30 min for each box are given in Table 4. Overall most elasmobranches are generally caught in box F. In Figure 8 the decreasing trend of catches of thorny skate is shown for box H. While in box E the catches of lesser spotted dogfish seem to slightly increase over the last decade.

Table 4. Overview of elasmobranch catches in the 2018 GSBTS.

Box	Species	Total catch (kg)	Total catch (n)
BOX E	MUSTELUS ASTERIAS	0.64	1
BOX E	RAJA CLAVATA	4.6	2
BOX E	RAJA MONTAGUI	4.2	4
BOX E	SCYLIORHINUS CANICULA	7.24	11
BOX H	RAJA RADIATA	1.63	4
BOX K	MUSTELUS ASTERIAS	3.07	1
BOX K	SCYLIORHINUS CANICULA	0.82	2
BOX P	RAJA NAEVUS	0.89	1

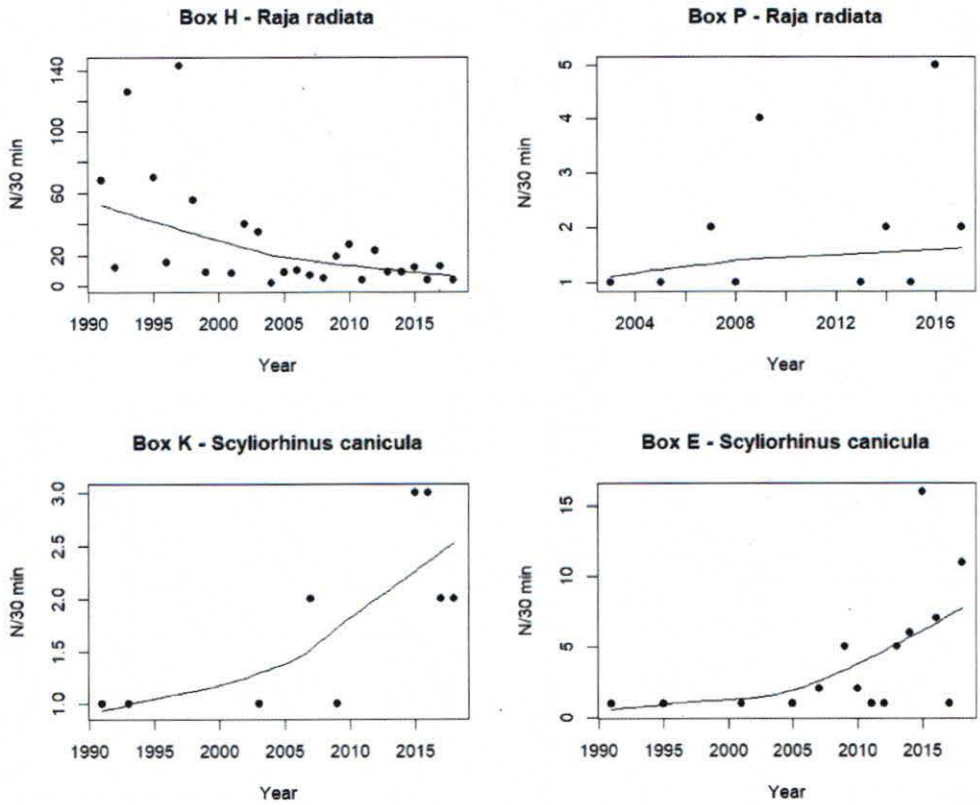


Figure 8: Examples of long-term trends of the two more frequently caught elasmobranchii thorny skate (*Raja radiata*) and lesser spotted dogfish (*Scyliorhinus canicula*) as total numbers 30 min^{-1}.

Experimental fisheries in the vicinity of an offshore windpark

In 2018 the 15 stations sampled in 2017 have been replicated. Thus, trawl tracks have been identical for the two subsequent years. In 2017 and 2018 (GSBTS 737 and 751) a number of twenty species have been commonly caught in the GSBTS boxes N and W (see Table 5). ANOVA results (Table 6) showed that the factor "Box" was only significant for European flounder (*Platichthys flesus*), with significant more catches (N 30min^{-1}) in box W. In general, European flounder prefers muddy substrates and is a migrating species of international commercial relevance. In both years dab dominated the catches in the two boxes and striped red mullet was only caught in box N.

Table 5: Overview of species catches (N 30min^{-1}) in boxes N and W in 2017 and 2018.

	2017		2018	
Species	**BOX N**	**BOX W**	**BOX N**	**BOX W**
AGONUS CATAPHRACTUS	1.00	1.17	1.17	1.00
AMMODYTES MARINUS		3.00		
AMMODYTES TOBIANUS	21.38	18.67	99.45	104.14

ARNOGLOSSUS LATERNA	1.00	1.67	1.89	1.50
BUGLOSSIDIUM LUTEUM			1.00	
CALLIONYMUS LYRA	1.43	2.25	2.33	1.64
CANCER PAGURUS	1.00	1.80	1.69	1.56
CLUPEA HARENGUS	1.50	1.00	1.60	1.33
ECHIICHTHYS VIPERA	23.83	1.00	4.00	2.33
ENGRAULIS ENCRASICOLUS			1.00	1.00
ENTELURUS AEQUOREUS			1.00	1.00
EUTRIGLA GURNARDUS	36.63	43.73	60.62	131.33
GADUS MORHUA				1.00
HYPEROPLUS LANCEOLATUS	43.31	181.75	209.40	185.33
LIMANDA LIMANDA	789.06	363.27	735.52	551.53
MERLANGIUS MERLANGUS	17.38	8.33	62.19	9.86
MULLUS SURMULETUS	4.00		1.75	
MYOXOCEPHALUS SCORPIUS	1.00	1.00	1.50	1.00
PLATICHTHYS FLESUS	2.77	15.07	4.53	8.57
PLEURONECTES PLATESSA	27.38	42.60	32.29	37.00
PSETTA MAXIMA	1.00	1.00	1.00	1.50
SARDINA PILCHARDUS	5.75	3.00	5.25	
SCOMBER SCOMBRUS	205.94	304.47	227.19	155.00
SCOPHTHALMUS RHOMBUS	1.00		1.00	
SPRATTUS SPRATTUS	1.00	1.50	1.50	3.00
TRACHURUS TRACHURUS	28.10	74.00	29.57	6.31
TRIGLA LUCERNA	4.67	6.77	3.18	2.10

Table 6: ANOVA results of twenty species which were commonly caught in boxes N and W during GSBTS 737 and 751, where significant results are highlighted in bold.

Species	Df	MeanSq	ErrorVar	F ratio	p-value
AGONUS CATAPHRACTUS	17	0.01	0.10	0.05	0.82
AMMODYTES TOBIANUS	32	3212.55	15906.06	0.20	0.66
ARNOGLOSSUS LATERNA	22	0.00	1.36	0.00	0.96
CALLIONYMUS LYRA	39	0.23	1.56	0.15	0.70
CANCER PAGURUS	37	0.53	0.46	1.16	0.29
CLUPEA HARENGUS	9	0.26	0.50	0.53	0.49
ECHIICHTHYS VIPERA	20	327.02	202.24	1.62	0.22
EUTRIGLA GURNARDUS	65	23037.48	9792.77	2.35	0.13
HYPEROPLUS LANCEOLATUS	43	27904.05	75903.39	0.37	0.55
LIMANDA LIMANDA	65	1503752.33	390674.39	3.85	0.05
MERLANGIUS MERLANGUS	64	18509.45	6612.87	2.80	0.10
MYOXOCEPHALUS SCORPIUS	6	0.30	0.53	0.56	0.48
PLATICHTHYS FLESUS	**56**	**939.63**	**38.13**	**24.64**	**0.00**
PLEURONECTES PLATESSA	65	1538.89	636.03	2.42	0.12
PSETTA MAXIMA	4	0.17	0.17	1.00	0.37
SARDINA PILCHARDUS	12	21.43	19.67	1.09	0.32
SCOMBER SCOMBRUS	65	2280.82	84732.83	0.03	0.87

For each mid positions of the stations sampled in boxes N and W the distance (m; DistTurb) to the nearest wind turbine of the Butendiek windfarm was calculated. Adjacent to the north-eastern corner of Butendiek an area with glacial boulders is located. Traditionally fishing activities around these boulders are limited due to an increased risk of fishing gear loss. Since this is a unique habitat feature which could also attract the aggregation of fish, the nearest distance (m; DistBoulders) to this area was also calculated for each trawling mid-position. In Figure 9 the log-transformed cpues (N 30 min^{-1}) of 18 in box W abundant species (2017 and 2018) were plotted against both the log transformed distances to the nearest wind turbine of Butendiek and the area with glacial boulders. In box W distances to the area with boulders ranged from 500 m to 15000 m, while the distances to the nearest wind turbine ranged between 500 m to 6500 m. Overall no clear linear trends of increasing or decreasing abundances in the close proximity of Butendiek and the boulders could be observed.
A comparison of the catches between the boxes N and W in relation to the distance to the two spatial features is shown in Figure 10. Thus, the log transformed cpues (2017 and 2018) of both boxes are plotted against log transformed distances to the nearest wind turbine of Butendiek and the area with boulders. In box W and N distances to the nearest wind turbine and area with boulders ranged from 500 m to 28000 m. Figure 10 shows on this lager spatial scale the significant differences of catches of European flounder between box N and W. Also it seems that plaice catches were slightly increased close to the glacial boulders where fishing activities are limited. In box N and therefore with greatest distances to the two spatial features catches of dab were clearly increased. In Figure 11 the log-transformed mean length (cm) of 18 abundant species in box W and N (2017 and 2018) were plotted against the log-transformed distances to the nearest wind turbine of Butendiek. Again there were no clear trends in the relationship between mean sizes and the distances to the spatial features observed.
In summary, the experimental fishing in box W revealed some differences in catches between boxes W and N besides similar substrates in both boxes. For some species such European flounder catches were clearly increased in box W, while habitat features were almost identical across the sampled stations in both boxes.

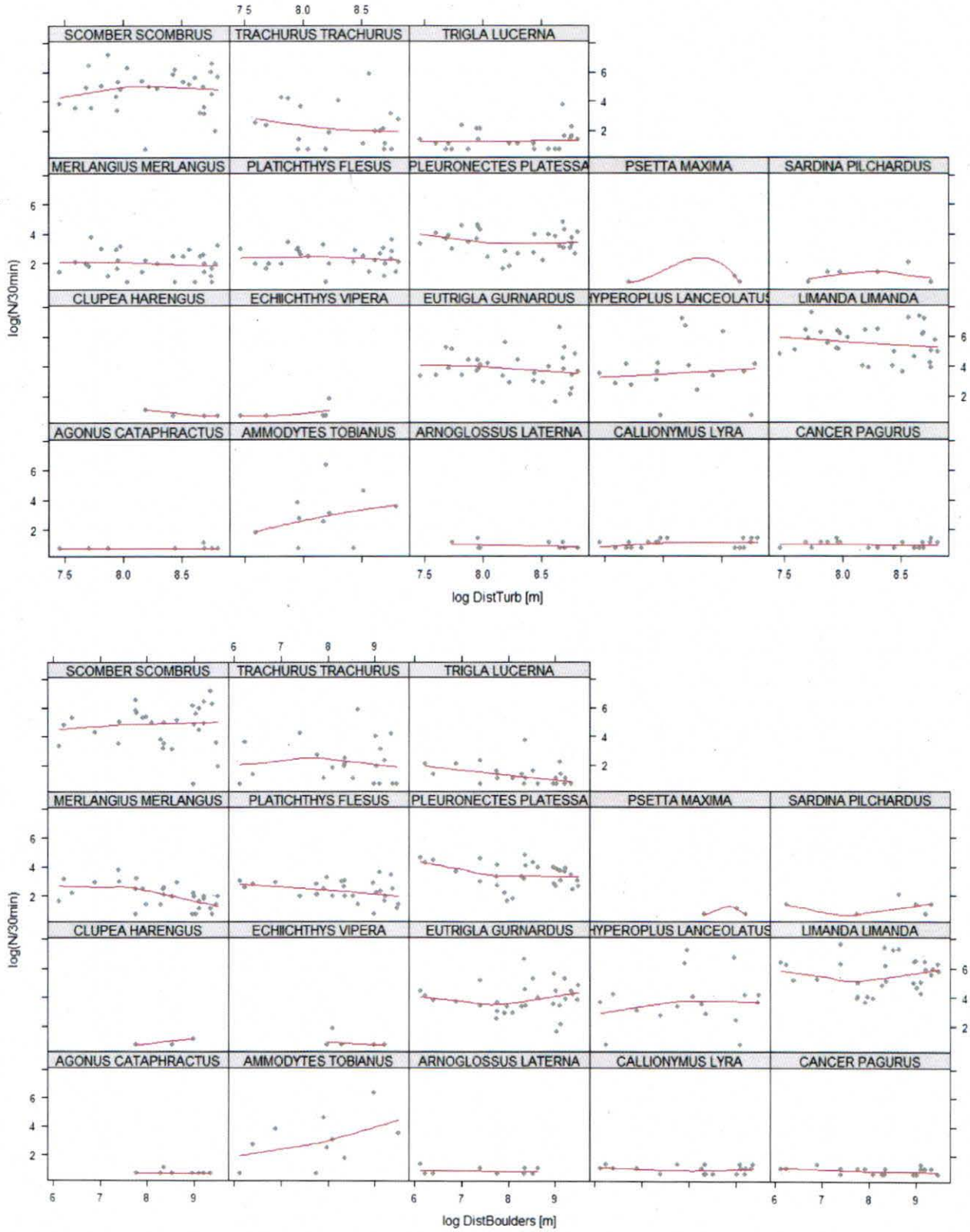
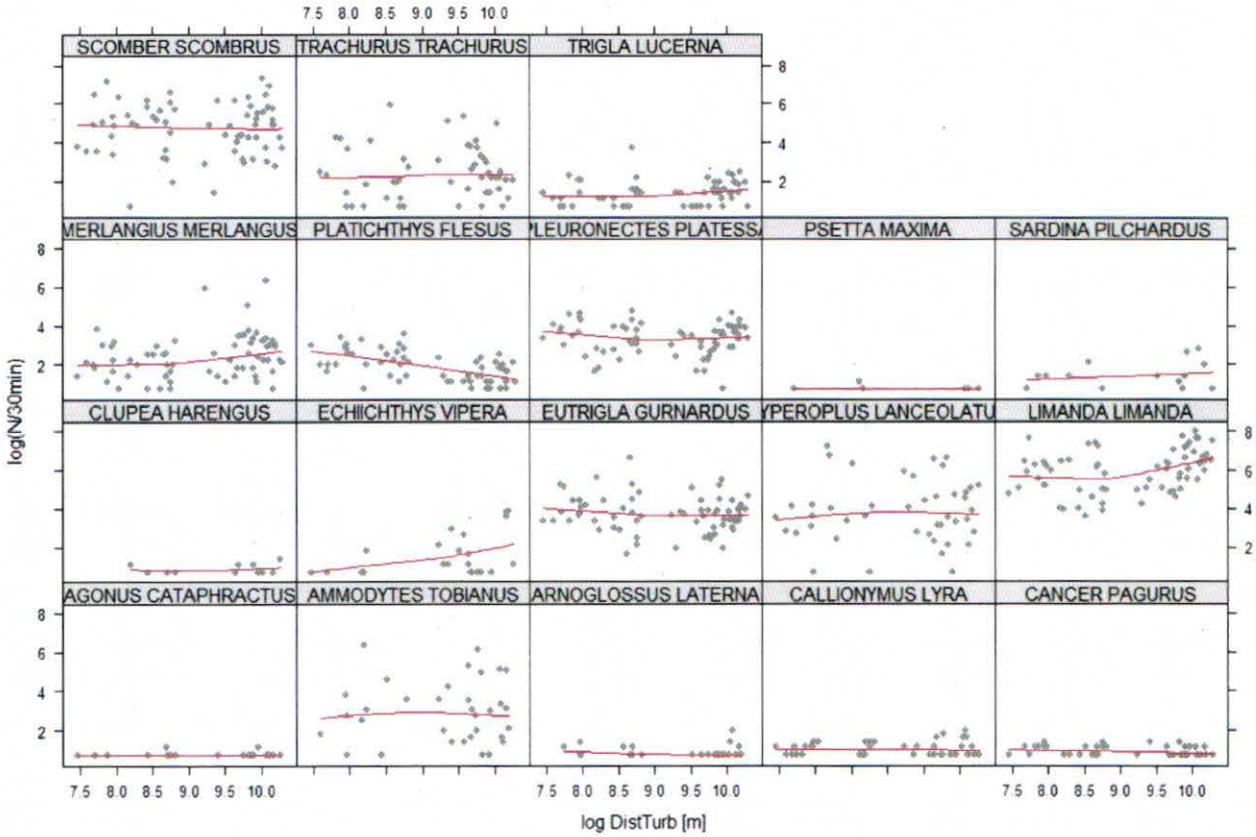


Figure 9: Trends in catches of 18 more abundant species caught in 2017 and 2018 in box W with increasing log transformed distances (m) to the nearest wind turbine of Butendiek (DistTurb; top) and to the area containing boulders (DistBoulders; bottom).


SCOMBER SCOMBRUS
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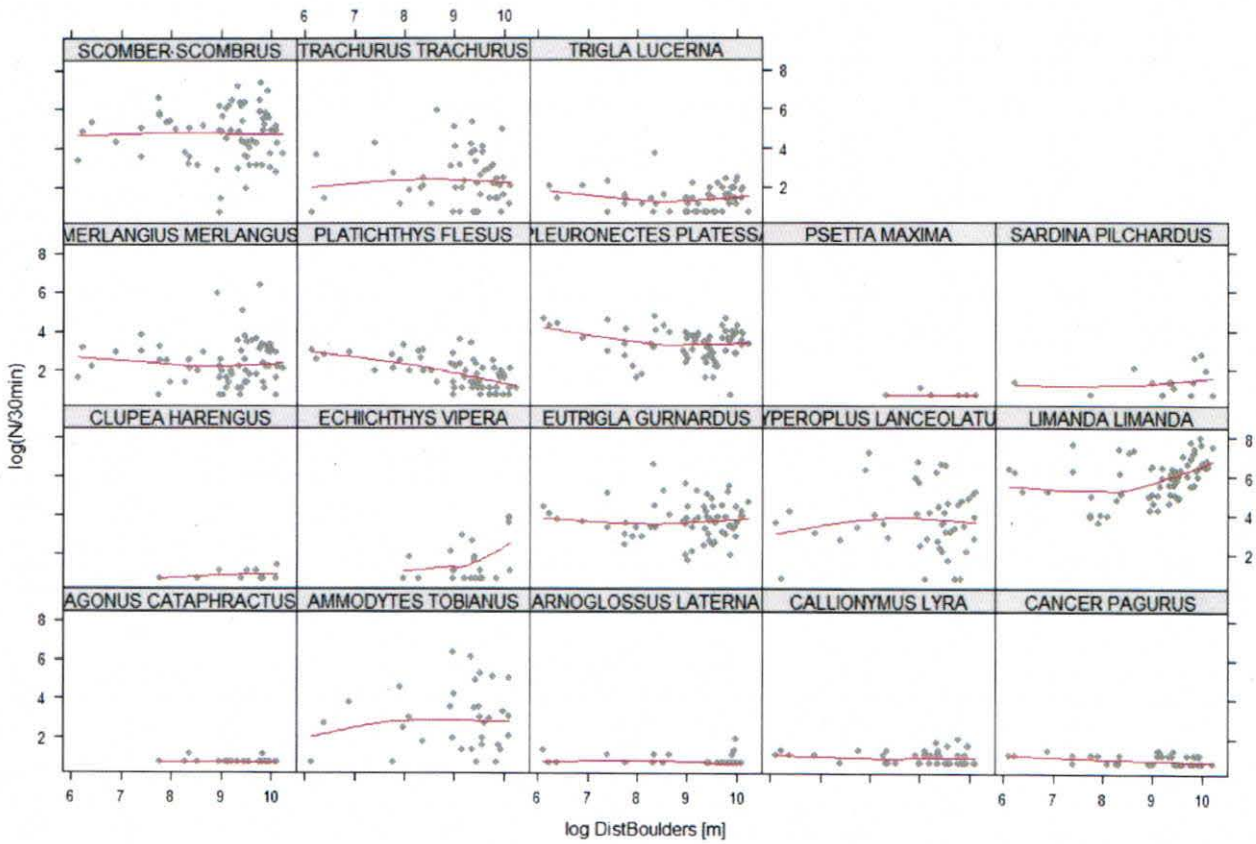
SARDINA PILCHARDUS
CLUPEA HARENGUS
ECHIICHTHYS VIPERA
EUTRIGLA GURNARDUS
YPEROPLUS LANCEOLATU
LIMANDA LIMANDA
AGONUS CATAPHRACTUS
AMMODYTES TOBIANUS
ARNOGLOSSUS LATERNA
CALLIONYMUS LYRA
CANCER PAGURUS
log(N/30min)
log DistTurb [m]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LIMANDA LIMANDA
AGONUS CATAPHRACTUS
AMMODYTES TOBIANUS
ARNOGLOSSUS LATERNA
CALLIONYMUS LYRA
CANCER PAGURUS
log(N/30min)
log DistBoulders [m]

Figure 10: Trends in log transformed catches and the mean length (cm) of the 18 more abundant species caught in box W and N (2017 and 2018) with increasing log transformed distances (m) to the nearest wind turbine of Butendiek (DistTurb; top) and to the area with boulders (DistBoulders; bottom).

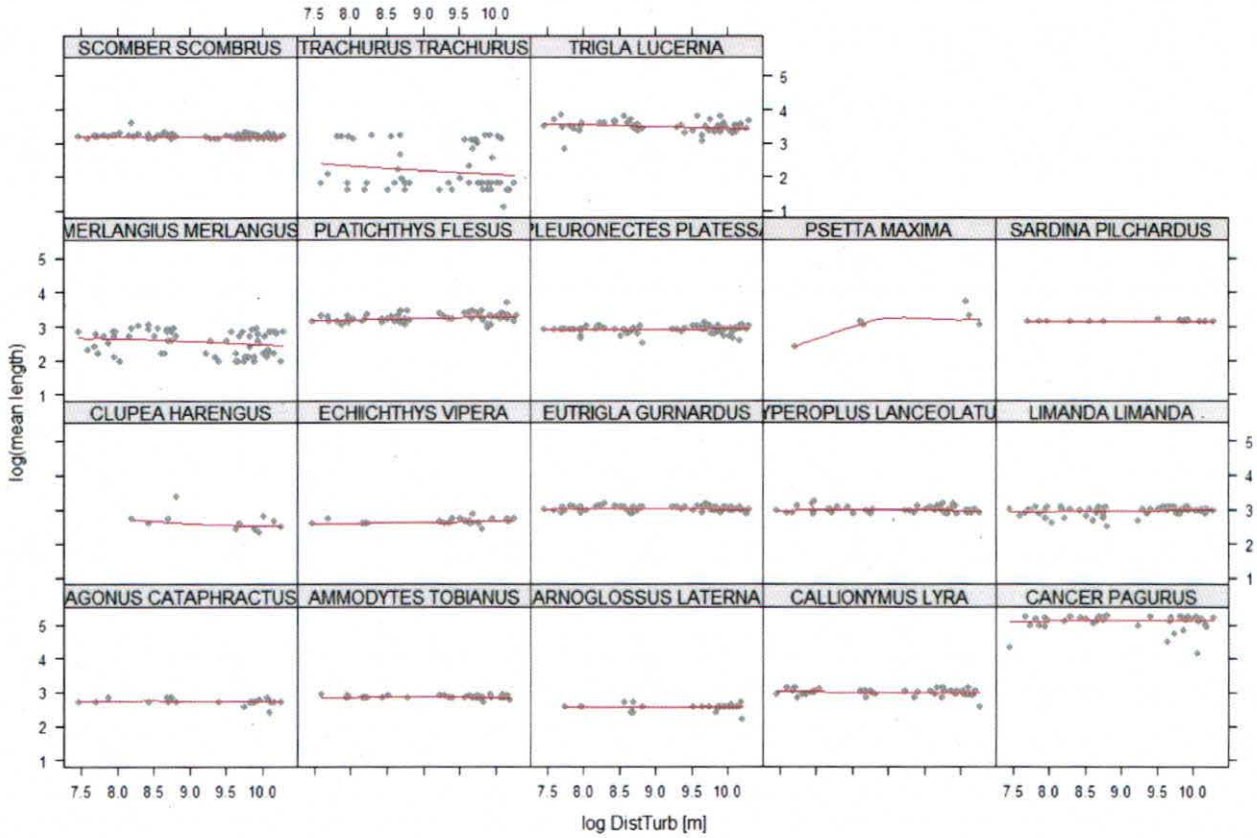

Figure 11: Trends in log transformed mean length (cm) of the 18 more abundant species caught in box W and N (2017 and 2018) with increasing log-transformed distances (m) to the nearest wind turbine of Butendiek (DistTurb).

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Dr. Antje Gimpel