Institut für Seefischerei (TI-SF)

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Report
Cruise SO 852 of FRV „SOLEA“
28.07. – 16.08.2025

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Verteiler:

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1. Narrative

The FRV Solea left the port of Cuxhaven on 28.07.2025 and commenced fishing on the 29.07.2025. Prevailing weather conditions led to the decision to start trawling in Box E, which, however, had to be left on the same day to find shelter in the lee side of Heligoland. There five trawls were conducted on the 01. & 02.08.2025, before the FRV "Solea" was forced to return to the port of Cuxhaven. The vessel remained there until the 06.08.2025 to weather off storm and waves, while in the meantime members of the scientific crew were exchanged. In the turn of the 06.08.2025 the weather calmed down and the FRV "Solea" left the port of Cuxhaven again to head out for the offshore wind farm (OWF) "Meerwind Süd/Ost". Upcoming storms forced the FRV "Solea" to return to port on the evening of the 15.08.2025. The cruise SO852 was thereby completed on the 16.08.2025. An overview on all activities per day are found in Table 1.1.1.

Table 1.1.1 Time line of station activities during S0 852. KJN refers to trawling with a demersal ground trawl (cod hopper trawl), eDNA to sampling of environmental DNA.

Date	KJN	eDNA	Plankton	Pots	Brown crab juvenile collectors	Hydro
28.07.2025	Departure from Cuxhaven					
29.07.2025	7					2
30.07.2025	No operations due to wind & waves					
31.07.2025	No operations due to wind & waves					
01.08.2025	3	2	1			3
02.08.2025	2		3			2
03.08.2025	Arrival in Cuxhaven, departure of scientific crew members					
04.08.2025	In port					
05.08.2025	In port					
06.08.2025	In port, arrival of scientific crew members					
07.08.2025	Departure from Cuxhaven					
07.08.2025			5			2
08.08.2025	6	4				2
09.08.2025	6	2	2			3
10.08.2025	7		2			2
11.08.2025	6		2			2
12.08.2025				6 setting		
13.08.2025				6 heaving	4 (Deployment)	
14.08.2025	7	2	2			2
15.08.2025	6		3			2
16.08.2025			Arrival in Cuxhaven			
Sum	**43**	**10**	**20**	**6**	**4**	**22**

2. Overview on activities

From 08.08.2025 until 11.08.2025 FRV "Solea" conducted 25 trawls in Box P within the new and old box layout (Figure 2.1.1).
From 14.-15.08.2025 13 trawls in Box K were conducted.
From 12.-13.08.2025 five chains of crab pots were set on the southern and Eastern edge of the offshore windfarm "Meerwind Süd/Ost".
On the 13.08.2025 four collector baskets for juvenile brown crab were deployed in the AWI research field within the OWF "Meerwind Süd/Ost".
Samples of environmental DNA (eDNA) were taken on the 01.08.2025 in the vicinity of Heligoland, on the 08. & 09.08.2025 in Box P/PX and on the 14.08.2025 in Box K.
Table 2.1.2 gives an overview on the trawl sampling effort of the GSBTS from 1989 until 2025. The number of sampled boxes and the number of hauls per box have decreased since 2021, partly as a result of the COVID pandemic, but also due to restricted access to Boxes H & N, which (in part) have become marine protected

areas. Due to limited survey time and the associated long steaming time, Box F has been not sampled since 2017.

Table 2.1.2. Total sampling effort (cod hopper hauls) in the standard GSBTS boxes per survey year.

JAHR	BOX E	BOX F	BOX H	BOX K	BOX N	BOX P
1989	25	24	0	0	0	0
1990	8	28	0	0	0	0
1991	28	28	27	24	0	0
1992	28	21	23	19	0	0
1993	27	23	25	27	0	0
1994	19	25	27	26	0	0
1995	21	25	26	24	0	0
1996	28	26	17	28	0	0
1997	6	18	25	26	0	0
1998	17	20	25	23	0	0
1999	10	27	17	30	0	0
2000	0	0	0	0	8	0
2001	18	24	27	22	17	0
2002	15	17	17	9	0	0
2003	15	24	23	24	0	24
2004	19	17	24	18	16	16
2005	14	16	20	14	38	14
2006	0	0	16	24	28	0
2007	23	22	24	12	33	16
2008	21	22	21	18	21	18
2009	24	22	21	15	22	16
2010	21	21	21	16	21	14
2011	10	0	21	7	21	21
2012	21	0	21	7	21	18
2013	21	21	21	21	23	18
2014	21	21	23	18	17	24
2015	22	23	21	21	17	18
2016	12	12	21	14	16	18
2017	15	14	15	17	16	18
2018	21	0	14	21	21	15
2019	0	0	16	21	20	16
2020	20	0	21	16	17	17
2022	0	0	0	18	0	0
2023	0	0	0	0	18	0
2024	3	0	0	0	0	0
2025	7	0	0	13	0	25

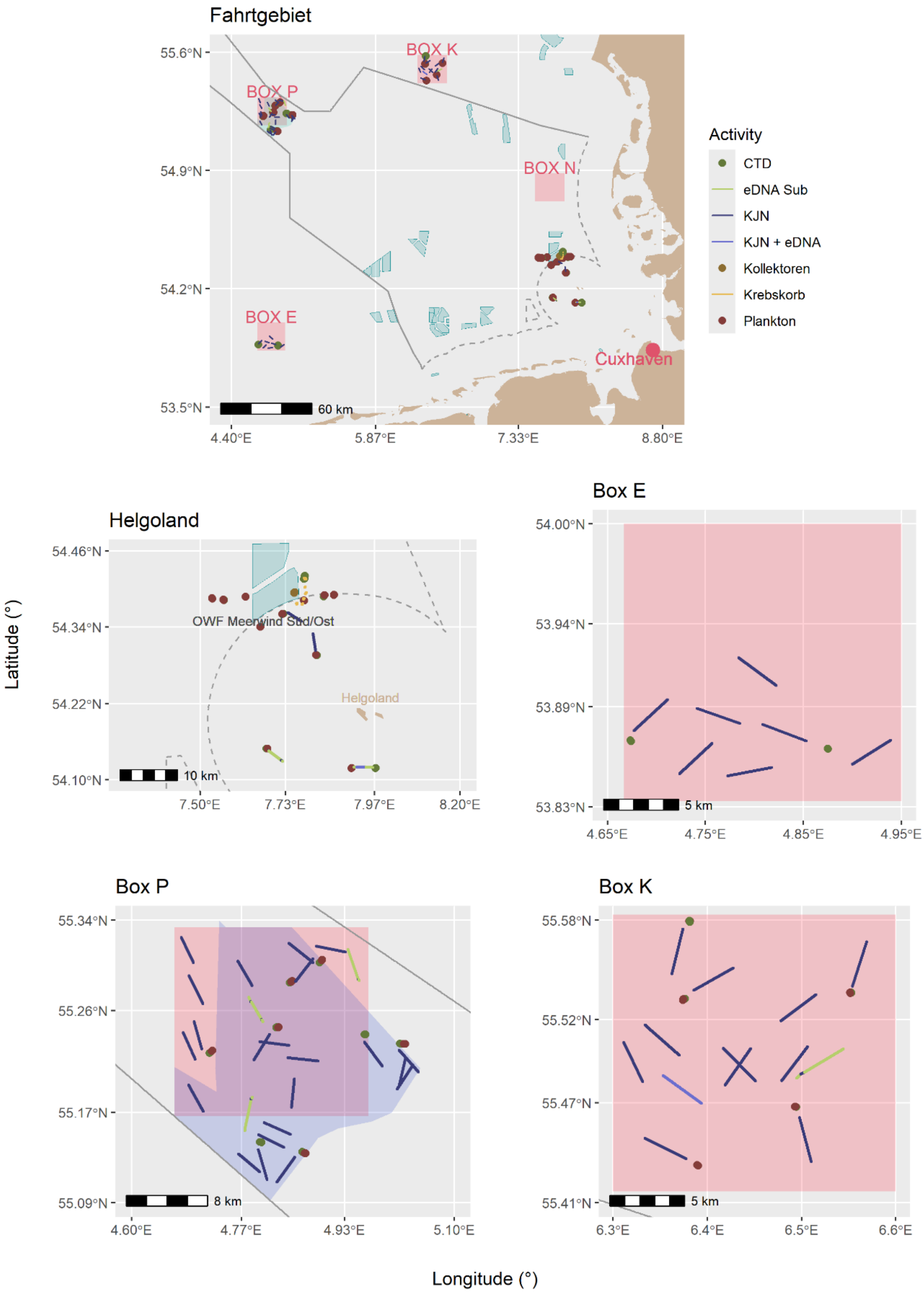

Figure 2.1.1. Overview on activities of SO852 in 2025. CTD = hydrological stations, KJN = trawling with cod hopper, Kollektoren = collectors for brown crab juveniles, Krebskorb = crab pots, KJN + eDNA = trawl with eDNA-cod end samplers, eDNA sub = eDNA tow body (“yellow submarine”, for the both see section 2.5),

3. Results

3.1. Community analysis in Box P

Due to the expansion of offshore renewables, Box P was suggested to be reshaped from a straight square to an asymmetric polygon by the Federal Maritime and Hydrographic Agency (BSH; Figure 3.1.1). This reshaped sampling area would accommodate the designated site development plan of the BSH for the offshore area of the German exclusive economic zone (EEZ). The Thünen-Institute was mandated to test, whether a new shape of Box P and the resulting difference in available trawl area would alter the results of scientific trawling with regards to fish community composition.

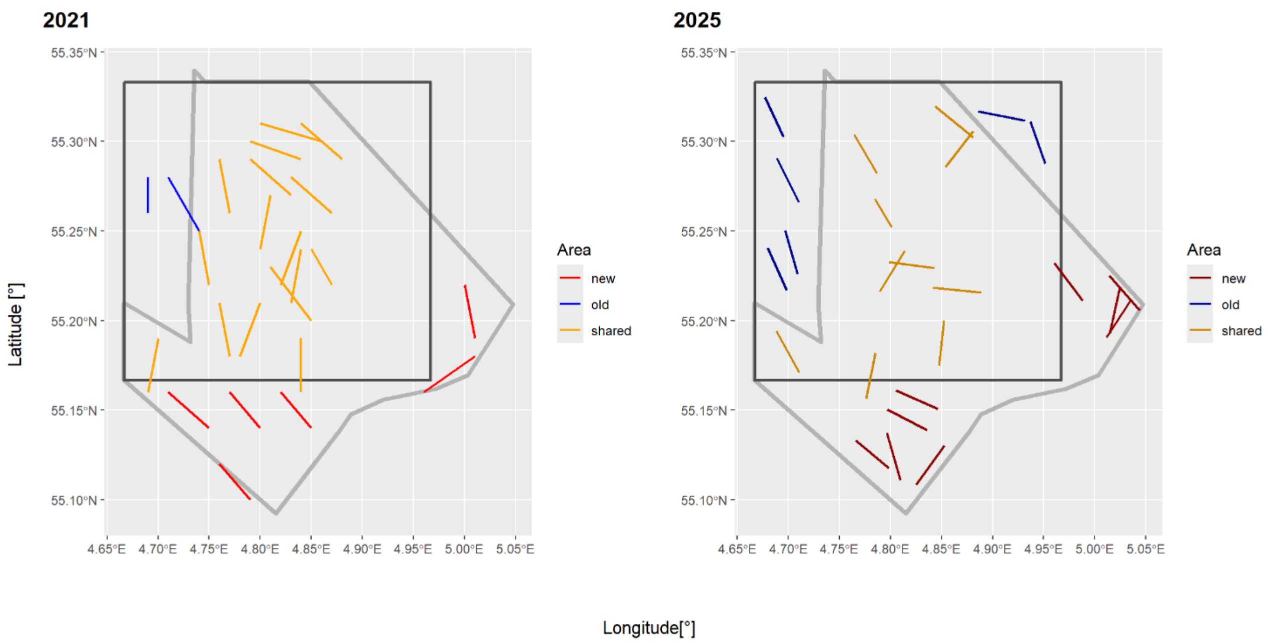

Figure 3.1.1. Overview on locations of hauls for the community comparison of hauls in Box P. Dark grey = old shape of Box P, light grey = new shape of Box P as suggested by BSH.

To this end, 25 trawls were conducted in 2025 and combined them with data from 24 trawls from 2021 (SO795) to analyse similarity of the catch composition between years and areas of Box P (Figure 3.1.1). The catches (as biomass) of hauls within the new, old and shared areas of Box P were compared by nonmetric-multidimensional scaling (nMDS) using “Bray-Curtis” distances and the default settings of the R-vegan package.

The community composition of these areas differed more between years than between sites with the year-effect accounting for ~ 20 % of the observed variation (permutational multivariate analysis of variance ADONIS, Figure 3.1.2 & Table 3.1.1). However, a site effect also accounted for ~ 10 % of the observed variation ($R^2 = 0.105$, $p = 0.002$), indicating a consistent and significant difference in community composition between old, shared and new areas in Box P.

In a second ADONIS, shared sites of Box P were combined with the old and new sites, respectively thereby comparing shared and old sites vs. shared and new sites in each year. This type of comparison mirrored the actual sampling scheme that would be applied when shifting from the old shape of Box P to the new shape. In the second ADONIS-analysis, the site effect was not statistically significant ($R^2 = 0.012$, $p = 0.331$, Table 3.1.2) and communities differed only by year.

The results of these analyses imply that the reshaping of Box P will allocate survey effort to previously unsampled areas with a slightly different community composition as opposed to the existing (i.e., old) Box P. However, these marginal differences are not expected to result in significant bias in the comparability of the long-term data series when the new areas of Box P will be sampled together with the shared sites.

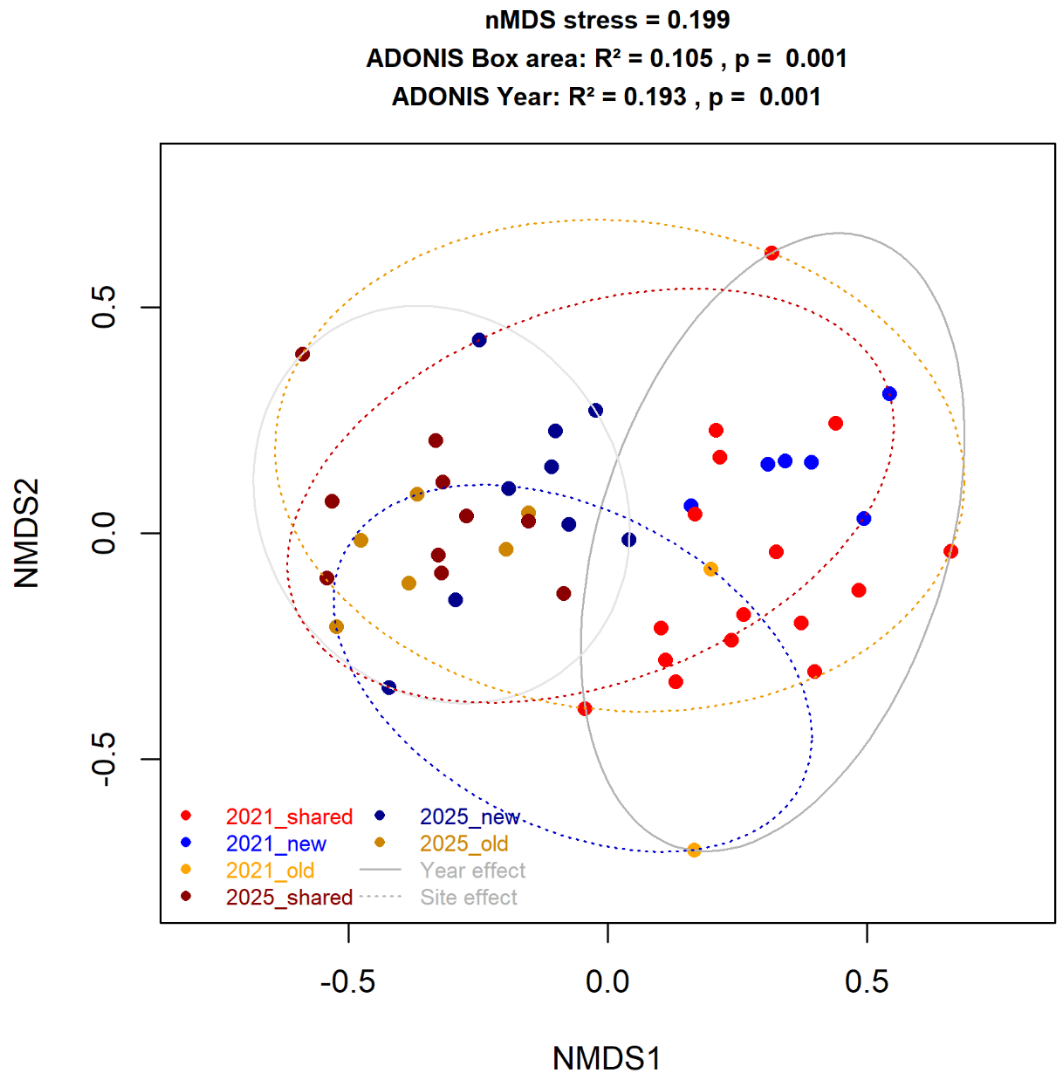

Figure 3.1.2. Non-metric multidimensional scaling (nMDS) of community composition from 49 hauls conducted in 2021 and 2025 in different areas of the old, shared and new shapes of Box P. The ellipses indicate the year (solid lines) and site effect (dashed lines). The higher the overlap of the ellipses, the more similar are the communities of the samples.

Table 3.1.1. Results of permutational multivariate analysis of variance (ADONIS) comparing three areas in Box P (old, new, shared, for reference see Figure 2.1).

Predictor	Df	SumOfSqs	R^2	F	Pr(>F)
Year	1	1.484	0.193	14.649	*0.001*
Area	2	0.810	0.105	3.998	*0.002*
Year * area	2	1.044	0.136	5.150	*0.001*
Residual	43	4.357	0.566		
Total	48	7.696	1.000		

Table 3.1.2 Results of ADONIS analysis comparing two groups of samples (shared + old areas vs. shared + new areas) within Box P.

Predictor	Df	SumOfSqs	R2	F	Pr(>F)

Year	1	1.984	0.169	15.073	0.001
Area	1	0.144	0.012	1.092	0.331
Year* area	1	0.240	0.020	1.821	0.098
Residual	71	9.345	0.798		
Total	74	11.713	1.000		

3.2. Trawl catches

The most frequently caught species throughout the time series of the GSBTS in Boxes E, K & P were herring *Clupea harengus*, grey gurnard *Eutrigla gurnardus*, Atlantic cod *Gadus morhua*, *dab Limanda limanda*, haddock *Melanogrammus aeglefinus*, whiting *Merlangius merlangus*, lemon sole *Microstomus kitt*, starry smooth-hound *Mustelus asterias*, plaice *Pleuronectes platessa*, mackerel *Scomber scombrus*, sprat *Sprattus sprattus* and horse mackerel *Trachurus trachurus* (Figure 3.2.1). There was an increase in mean biomass for whiting in Box E and Box P, and for plaice in Box E. On the contrary, the biomass of Atlantic cod and herring decreased in all three boxes (Figure 3.2.1).

Table 3.2.1. Summary of catches in the vicinity of Heligoland from four valid trawls.

Species	Mean biomass [kg 30 min^{-1}]	Mean abundance [N 30 min^{-1}]
Sprattus sprattus	42.892	3,989
Trachurus trachurus	29.970	1,150
Merlangius merlangus	13.334	511
Limanda limanda	12.476	194
Clupea harengus	9.218	1,288
Homarus gammarus	8.720	10
Mustelus asterias	3.667	1
Cancer pagurus	1.753	3
Platichthys flesus	1.114	6
Scomber scombrus	1.048	6
Eutrigla gurnardus	0.855	8
Pleuronectes platessa	0.602	10
Callionymus lyra	0.600	18
Gadus morhua	0.560	1
Chelidonichthys lucerna	0.502	1
Echiichthys vipera	0.430	10
Mullus surmuletus	0.320	4
Loligo forbesii	0.283	1
Hyperoplus lancoelatus	0.280	7
Illex coindetii	0.185	2
Alloteuthis spp.	0.120	16
Myoxycephalus scorpius	0.085	1
Melanogrammus aeglefinus	0.060	2

The decline of herring and cod was also evident when looking at single species time series (Figure 3.2.2). On the contrary, several elasmobranchs such as thornback ray *Raja clavata*, spotted ray *Raja montagui*, lesser-spotted dog fish *Scyliorhinus canicula* and starry smooth hound showed a strong increasing trend in abundance. Notably, in 2025 catches of starry smooth hound were the highest ever recorded in Boxes E.

Catches from four valid hauls around Heligoland (see Figure 3.1.1) and the offshore wind park “Meerwind Süd/Ost” were dominated by sprat, horse mackerel and whiting (Table 3.2.1). Also notably, in these trawls 10 European lobsters were caught, coinciding with the recent increase of lobster in the German Bight.

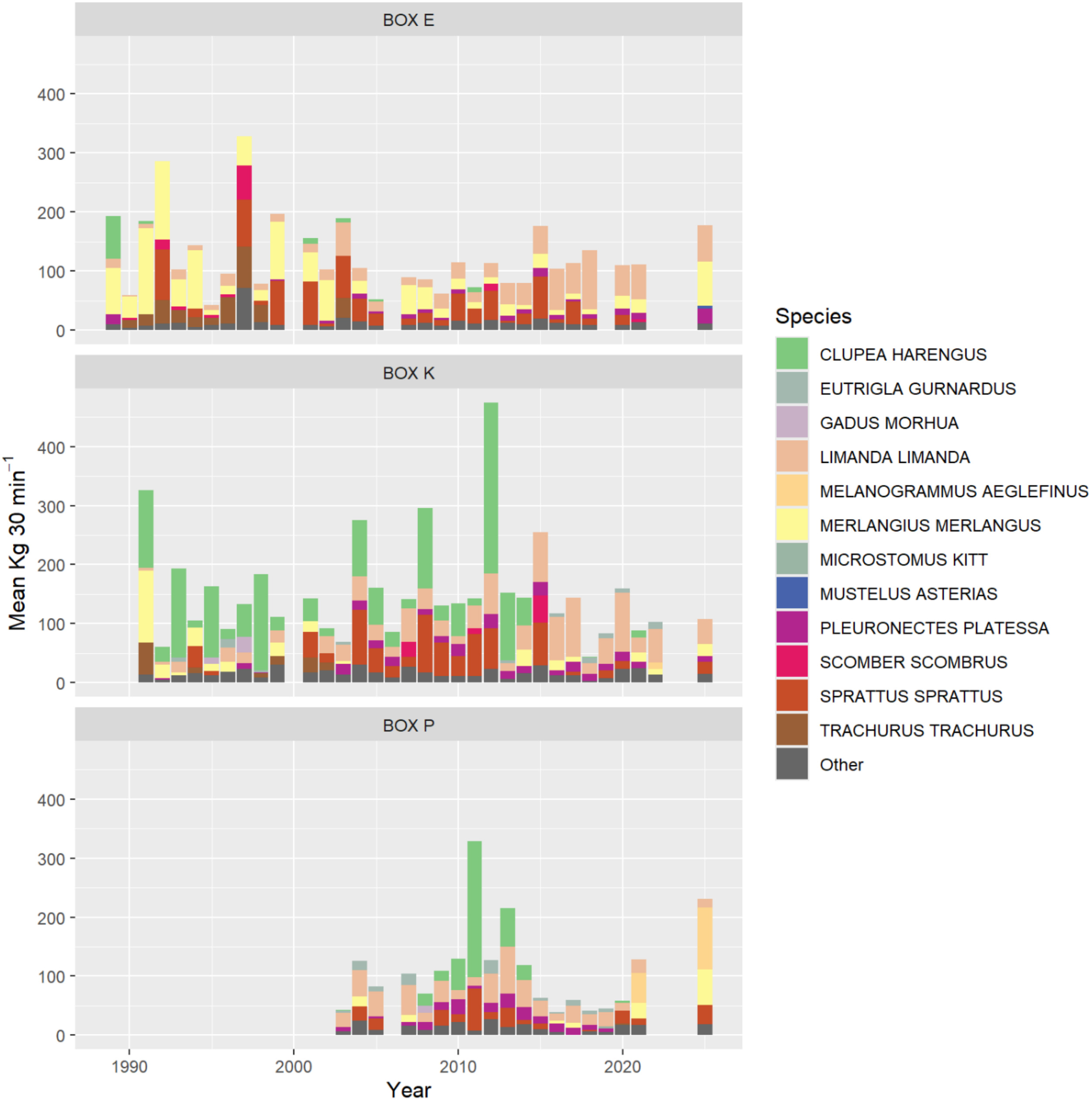

Figure 3.2.1. Time series of catches of the most abundant (by biomass) four species each year in Boxes E, K & P.

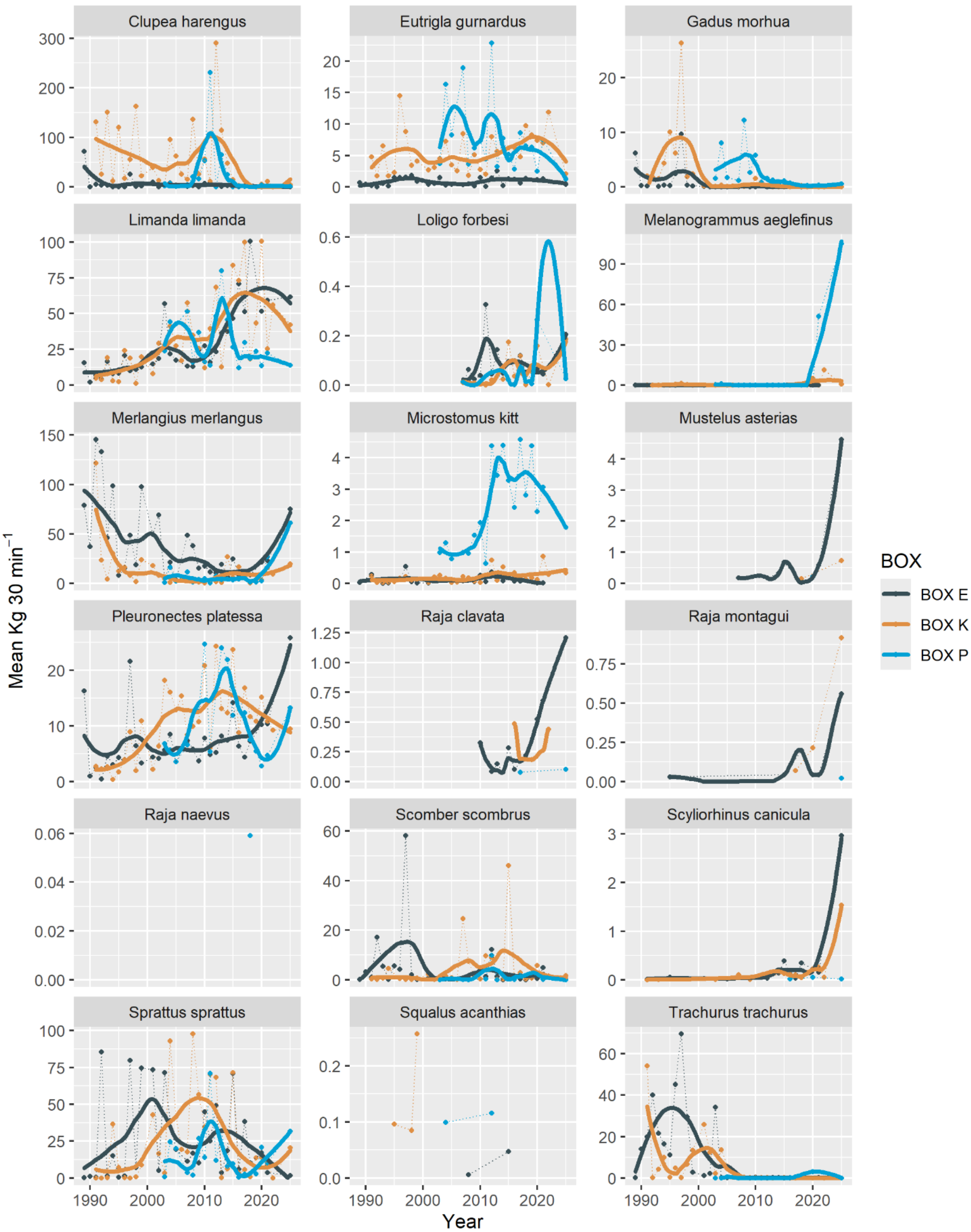

Figure 3.2.2. Time series of most common and selected species (i.e. commercial species and elasmobranchs).

3.3. Crab pot fishing

During the 2025 GSBT, 6 stations with 5 pots each set for ~ 24 h caught a total of 25 brown crab *Cancer pagurus* and two European lobster *Homarus gammarus* (Table 3.3.1). These catches indicated a lower brown crap CPUE than in previous years (Figure 3.3.1).

Table 3.3.1. Catches in crab pots from 2018 until 2025 taken during cruises of the GSBTS.

Year	Site	Total soak time [h]	Species	Total kg	Total N	CPUE [kg h^{-1}]
2018	OWF Butendiek	62.6	*C. pagurus*	2.1	4	0.033
2019	OWF Meerwind S/O	481.4	*C. pagurus*	160.4	298	0.333
2020	OWF Borkum Riffgrund	236.0	*C. pagurus*	35.0	86	0.148
2020	OWF Riffgatt	279.6	*C. pagurus*	7.7	20	0.028
2021	OWF Meerwind S/O	122.2	*C. pagurus*	59.6	99	0.488
2022	OWF Sanbank	356.1	*C. pagurus*	201.9	279	0.567
2023	OWF Meerwind S/O	854.4	*C. pagurus*	235.3	434	0.275
2024	N of Heligoland	501.7	*Asterias rubens*	0.3	9	0.001
2024	N of Heligoland	501.7	*Cancer pagurus*	164.9	338	0.329
2024	N of Heligoland	501.7	*Homarus gammarus*	13.2	14	0.026
2024	N of Heligoland	501.7	*Macropipus depurator*	0.1	5	0.000
2024	N of Heligoland	501.7	*Macropipus holsatus*	0.1	5	0.000
2024	N of Heligoland	501.7	*Macropipus puber*	0.7	5	0.001
2024	N of Heligoland	501.7	*Myoxocephalus scorpius*	0.1	1	0.000
2024	N of Heligoland	501.7	*Ophiura ophiura*	0.01	3	0.000
2024	N of Heligoland	501.7	*Pholis gunnellus*	0.01	1	0.000
2024	OWF Nordsee One	123.5	*Asterias rubens*	0.4	24	0.004
2024	OWF Nordsee One	123.5	*C. pagurus*	12.8	31	0.103
2024	OWF Nordsee One	123.5	*H. gammarus*	1.6	1	0.013
2024	OWF Nordsee One	123.5	*Macropipus depurator*	0.1	5	0.001
2024	OWF Nordsee One	123.5	*Macropipus holsatus*	0.1	2	0.000
2024	OWF Nordsee One	123.5	*Macropipus puber*	0.3	4	0.003
2024	OWF Nordsee One	123.5	*Pagurus bernhardus*	0.2	2	0.001
2025	OWF Meerwind S/O	149.4	*C. pagurus*	10.7	25	0.072
2025	OWF Meerwind S/O	149.4	*H. gammarus*	2.0	2	0.013

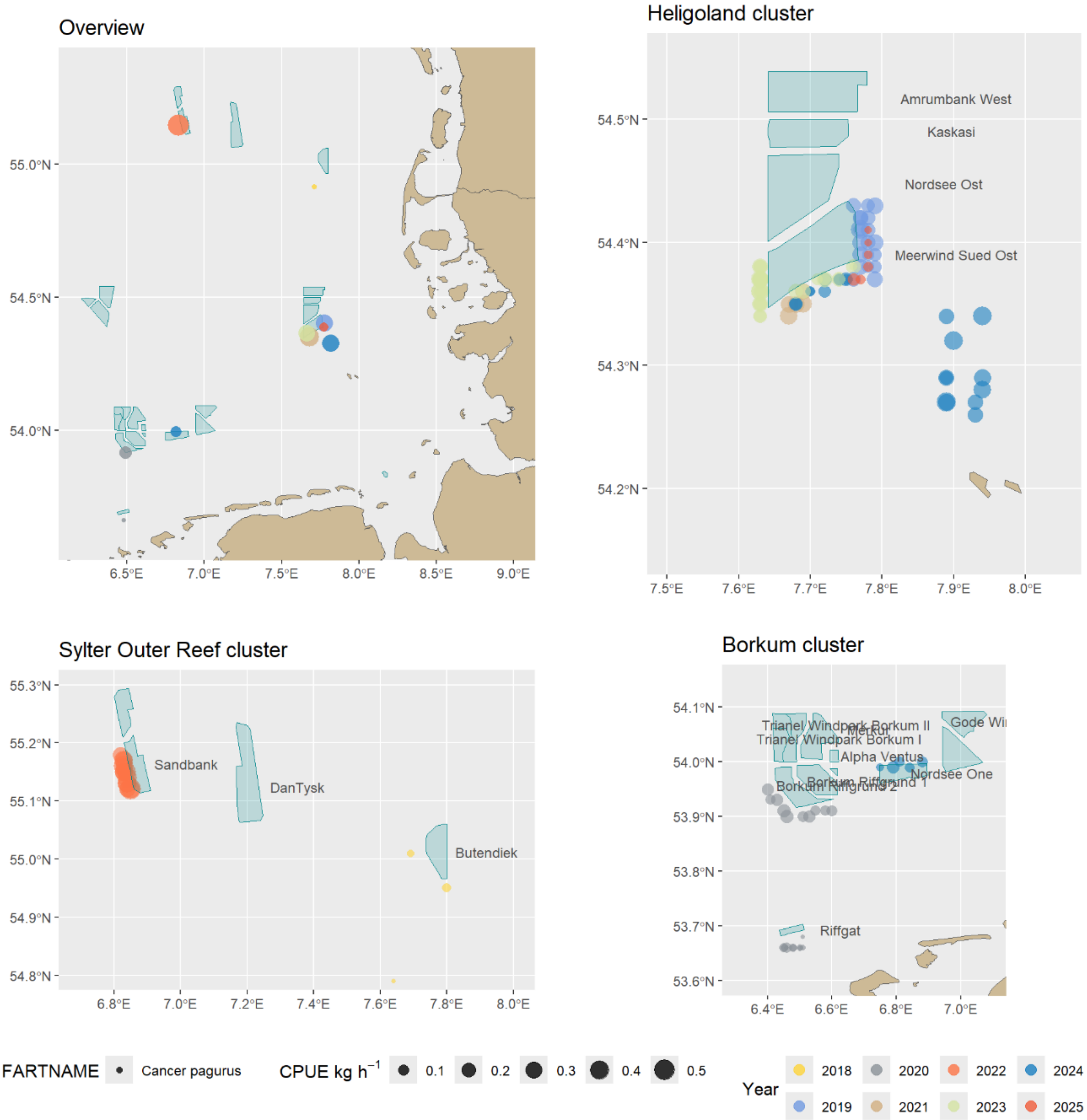

Figure 3.3.1. Overview and details on crab pot activities from 2018 until 2025.

3.4. Sampling of brown crab larvae and juveniles

Vertical zooplankton hauls were conducted in boxes K & P as well as around the eastern, southern and western edge of OWF “Meerwind Süd/Ost” to obtain information on abundance and duration of the larval period of brown crab. The vertical hauls were conducted with an Indian Ocean plankton net with a mesh size of 500 µm.

For the same purpose, four crab collectors were deployed within an experimental research field within the OWF “Meerwind Süd/Ost” (Figure 2.4.1). The aim of the collectors is to attract settling brown crab juveniles after their metamorphosis from the planktonic larval stage. The collectors were retrieved on a subsequent research cruise (S0 853).

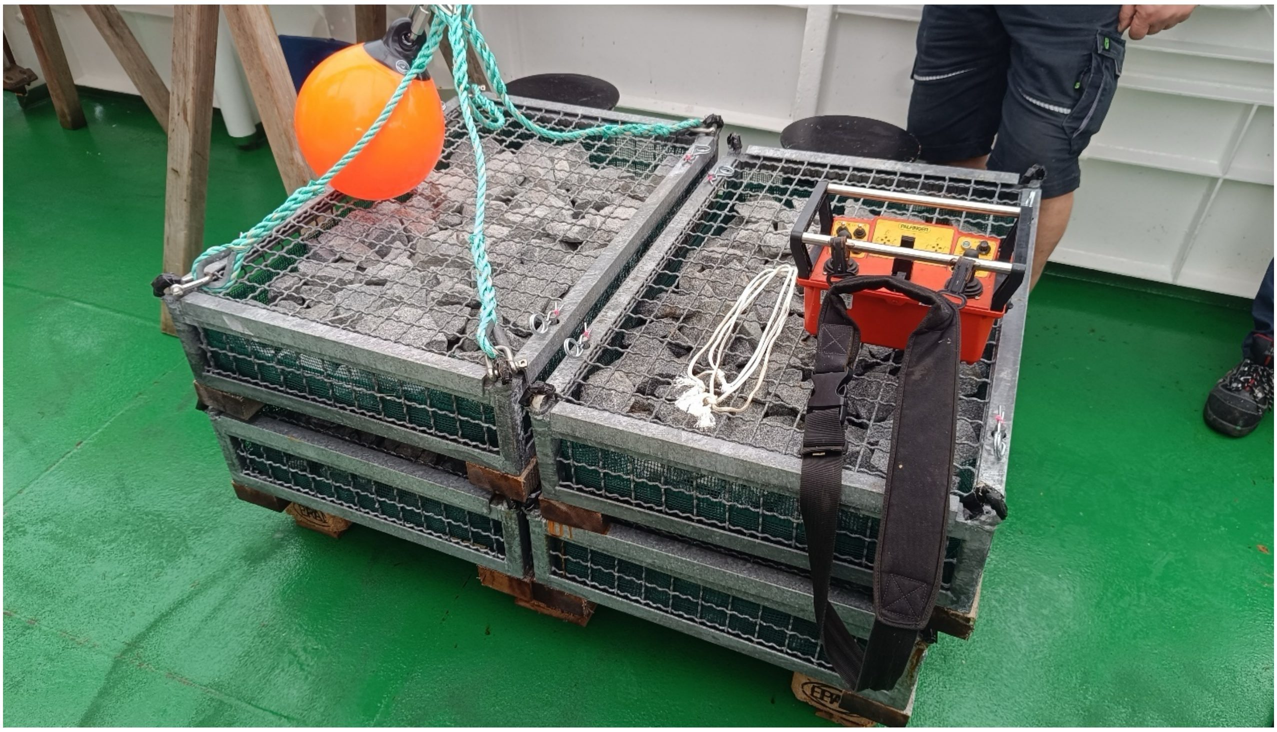

Figure 3.4.1. Collector baskets for brown crab juveniles deployed in the OWF “Meerwind Süd/Ost”.

3.5. eDNA sampling

SO852 applied eDNA sampling for the first time to test the potential of this new, non-invasive monitoring method. Non-invasive monitoring will become increasingly relevant in areas which will become inaccessible to trawl net fishing in the future, i.e. OWF and marine protected areas (MPA), in which more and more areas will or (already have) banned mobile bottom contacting fishing gears, including trawling for scientific purposes.

At the time of writing this report, the detailed results from the eDNA samples were not yet fully analysed. A first inspection of the results indicated that many teleost fish taxa could be identified in the eDNA samples, whereas elasmobranchs were absent. One bottom sample at station 55 indicated the presence of minke whale *Balaenoptera acutorostrata*. In the following, however, this report focuses on describing the sampling scheme and some first-handling experiences.

The aim of the SO852 eDNA-program was to test and apply two eDNA sampling devices from SEQUENCH Ltd. This first device essentially is a 3D-printed tow body (“yellow submarine”) which allows to attach three eDNA filters simultaneously in a 10 – 20 min haul (Figures 3.5.1 & 3.5.4). The yellow submarine filters more water within shorter time with less handling effort than water sampling schemes based on pumps or Niskin bottles, which increases efficiency and ease of sampling. The yellow submarine was towed behind the FRV “Solea” in two depth strata (surface and ~ 5 - 10 m above the bottom) at a towing speed of 6 kts (Table 3.5.1). With an average tow distance of ~ 2,800 m and a tow body opening area of 0.003 m², the filtered water volume amounted to ~ 8 m³. An overview on the eDNA samplings in Boxes P and K are given in Table 1.1.1 and Figure 2.1.1.

To validate the tow depth, a STARODDI depth logger was attached to the eDNA-sampler to measure the actual towing depth. Accordingly, the applied cable lengths of 46, 112 and 120 m resulted in towing depths of 16, 33 and 36 m, respectively. This suggest that the towing depth corresponds to 1/3 of the cable length (Figure 3.5.2).

As second eDNA sampling device a cod end sampler was applied (Figures 3.5.3 & 3.5.4) on three trawls, of which one was invalid due to high waves. In the first tow (Station 8), cod end samplers were attached first close to the cod end (N=3), where one sampler got damaged. In a second trial, the remaining two cod end samplers were attached to the upper net ~ 1m behind the net opening. These first trials indicated that the 3D-printed material might be too fragile for the mechanical stress occurring during the handling on board of FRS Solea.

On each day when eDNA sampling on board of FRS “Solea” took place, one control sample was taken to test for contamination through the handling procedures on board. This resulted in a total number of four control samples. Control samples were treated similar to the towed samples, i.e. filter caps were treated the same way as regular sample filters, e.g. taken through the lab on deck of the vessel by one crew member and subsequently stored in the sealed sample bag.

Figure 3.5.1. Application of the 3D-printed eDNA-sampling towing device from SEQUENCH Ltd. Three nanopore filters are attached to the tow body and secured with a latch, which, however, showed to be sensitive to mechanical stress. As a consequence, one replicate got lost on stations 25, 27 & 55. To make the yellow submarine sink towards the bottom a V-fin depressor of 15 kg weight was attached.

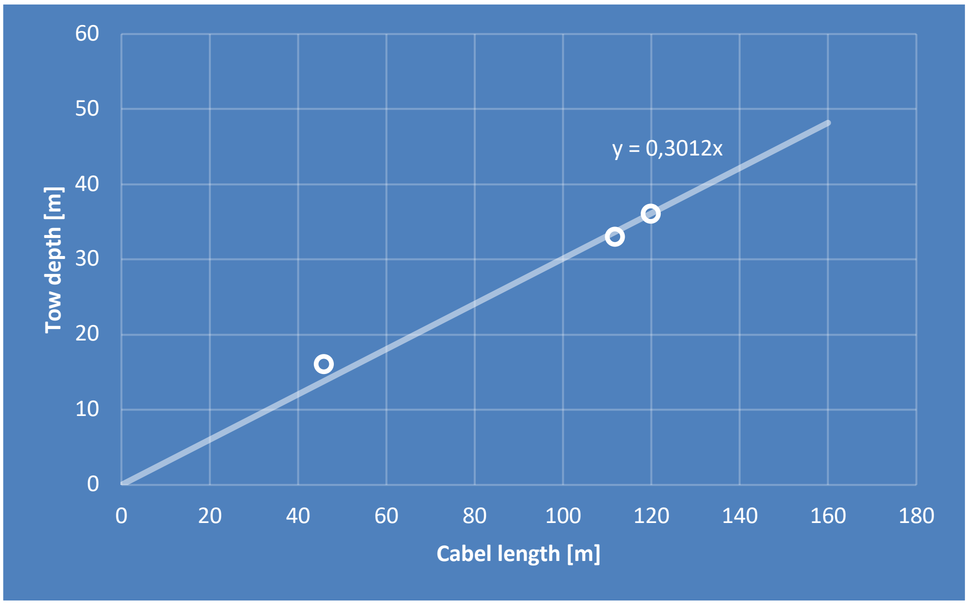

Figure 3.5.2. Empirical relationship between cable length and to depth.

Figure 3.5.3. Cod end sampler ready for the attachment to the trawl net with cable ties, hose clamps and carabines.

Table 2.5.1. Overview on eDNA sampling activities. Note: The trawl haul on station 10 was not valid (due to waves > 2 m wave height) and hence is also not shown in Figure 1.1.1.

Station	Device	Replicates	Tow depth [m]	Date	Towed distance [m]	Tow duration [min]
8	Yellow sub	3	0 [surface]	01.08.2025	1649	9
8	Yellow sub	3	16	01.08.2025	2572	14
8	Cod end	3	34	01.08.2025	2720	30
9	Yellow sub	3	0 [surface]	01.08.2025	2821	15
9	Yellow sub	3	16	01.08.2025	3010	16
10	Cod end	2	33	01.08.2025	2637	30
10	Yellow sub	3	0 [surface]	01.08.2025	2207	12
10	Yellow sub	3	33	01.08.2025	2983	16
21	Yellow sub	3	0 [surface]	08.08.2025	3150	17
21	Yellow sub	3	36	08.08.2025	3150	17
25	Yellow sub	3	0 [surface]	08.08.2025	2769	15
25	Yellow sub	2	36	08.08.2025	3145	17
27	Yellow sub	3	0 [surface]	09.08.2025	2534	14
27	Yellow sub	2	36	09.08.2025	2715	15
55	Yellow sub	3	0 [surface]	14.08.2025	3151	17
55	Yellow sub	2	33	14.08.2025	3506	19
58	Cod end	2	37	14.08.2025	3089	30

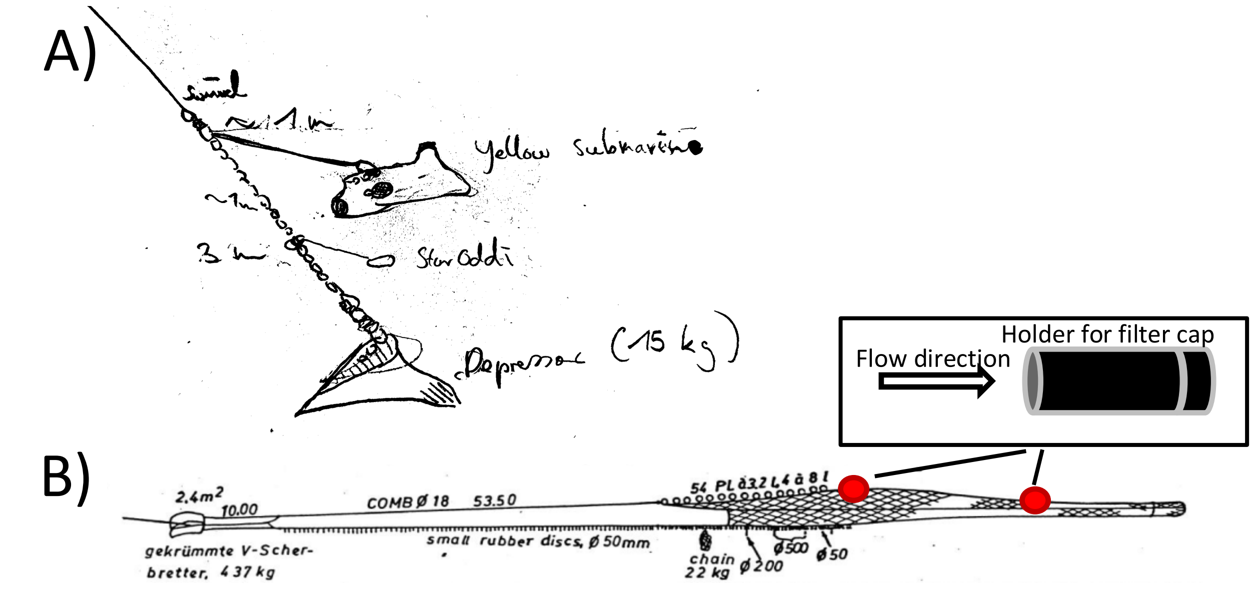

Figure 3.5.4. Sketch of setup for A) the tow body ("yellow submarine") and B) the cod end samplers by SEQUENCH Ltd. Red dots mark locations of attachment, where the location in the upper net mesh panel proved to be less susceptible to mechanical stress.

4. Personnel

Name	Role	Affiliation
Dr. Vanessa Stelzenmüller (1st PT)	Scientist in charge/Hydrology	TI - SF
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Dr. Wolfgang Nikolaus Probst **Dr. Vanessa Stelzenmüller**