CRUISE REPORT HYWIND TAMPEN 13 TO 28 MARCH 2023

Cruise no. 2023001004 G.O. Sars

Cruise leader(s): Anne Christine Utne Palm (IMR)

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Summary (English):

There is very little knowledge related to how floating windfarms effect the marine environment as this is such a new "product". Thus, the data that we gathered on this cruise will be novel in that sense. The aim of the cruise was to look at possible effects of the windfarm on the marine environment. Based on limited cruise time and tough weather conditions around Hywind Tampen we had to be selective related to topics for this first cruise, and we choose to focus on the following: 1) Measuring ***noise*** from the turbine. This we did by deploying a hydrophone mooring within the windfarm. 2) Measuring ***current*** to track possible changes in current and wake effect. We did this by deploying ADCP's within and around the windfarm, and by conducting CTD transects around and within the windfarm. 3) Look at possible effects on pelagic ***fish distribution***, by conducting acoustics transects with RV G.O. Sars's multi-frequency acoustics, within and around the windfarm. As the RV G.O. Sars is not allowed closer then 500m to the turbines, we conducted acoustic transects with an acoustic kayak-drone within the 500 m range to the wind turbines. The kayak being allowed as close as 15-20m to the turbines. To able ground truthing of acoustic findings we trawled with an open trawl equipped with a camera (**DeepVision)** and we took **eDNA** samples along the transects. 4) Effect of bottom structure on the benthic fauna. This was studied by ROV transects filming fauna around 3 suction anchors and the adjacent chains connecting the turbines to the anchor. ROV control transects were conducted from the very same suction anchors, but on a line moving away from the windfarm. This cruise was conducted in collaboration with the NFR-funded WindSys project.

Content

1 Background

1.1 Hywind Tampen windfarm

Hywind Tampen is the first floating windfarm in Norwegian waters. It is owned by Equinor and is built to support Gullfaks and Snorre with renewable energy. With its seven turbines and four more to come it is the biggest, floating wind farm in the world. The plan is to finish the construction of the windfarm by the end of this year, with 11 turbines in total. There are two other floating windfarms in North Sea. The others being Kincardine Offshore Windfarm outside Scotland (2 turbines) and Hywind Scotland (5 turbines) the later also owned by Equinor. In addition, there is one turbine located at the test location at Karmøy: Unitech Zefiros (Previously Hywind Demo).

1.2 The Hywind Tampen turbine structure

(text and figures taken from Equinor report: Hywind Tampen PUD del II – Konsekvensutredning).

The wind turbines are a standard offshore wind turbines placed on a floating concrete base (*Figure 1*). The blades are produced in fiberglass/epoxy. The turbines have a total height of approximately 190 meters from the bottom of the chassis to the centre of the nacelle. The distance between the sea surface and the blade tip is approx. 23 meters. The rotor has a diameter of 167 metres.

Each wind turbine is anchored to the seabed with three anchor lines consisting of steel wire and chain (138 mm). Each of the anchor lines extend approximately 800 meters from the installations and is moored to suction anchors on the seabed. A total of 19 suction anchors of which 9 act as common anchors for 2 or 3 turbines.

The wind turbines are linked together with power cables that run between the turbines (internal cables). The power cables hit the seabed 400 - 500 meters from the turbine. Where the power cables hit the seabed, a small anchor will be installed to hold the cables in place. The internal cables that link two wind turbines together will be around 2 km long. The export cables are static cables that are buried.

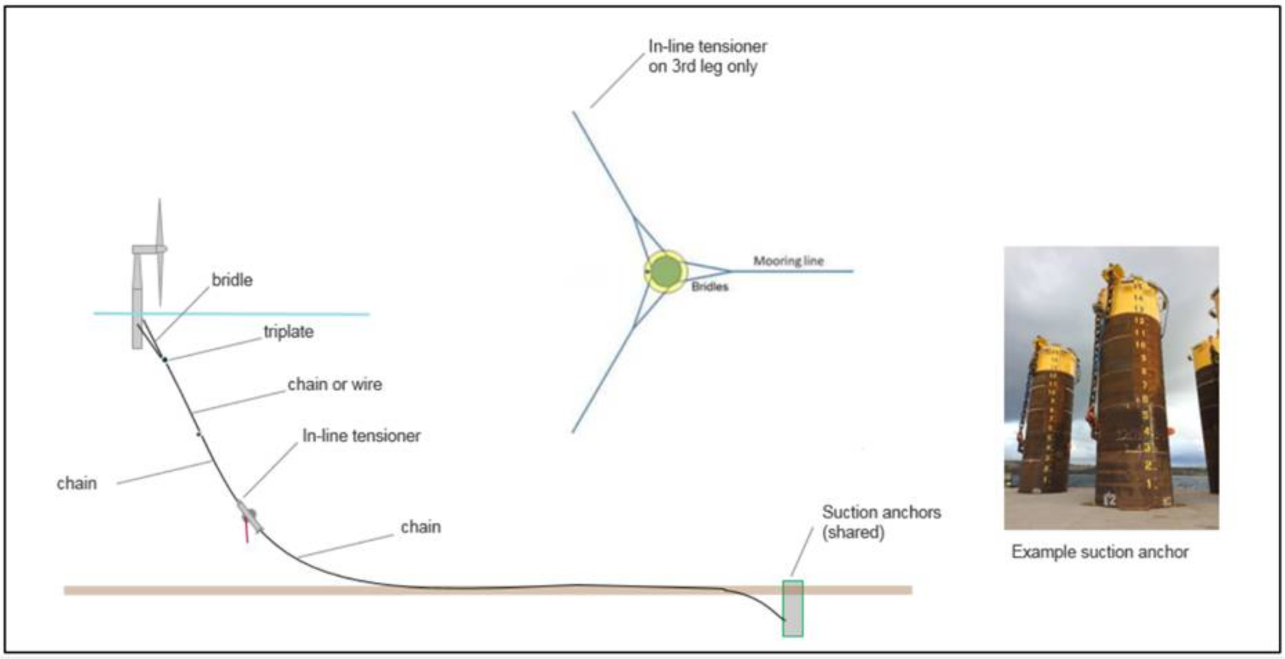


Figure 1: Illustration of anchoring of Hywind Tampen turbine copied from Equinor report: Hywind Tampen PUD del II – Konsekvensutredning 2019.

Table 1: Overview of the dimensions of the different design parameters of Hywind Tampen windfarm, copied (and translated) from Equinor report: Hywind Tampen PUD del II – Konsekvensutredning 2019.

Component	Design parameter	Size
Wind-farm	Area above surface	~ 11 km^2
	Area below surface	~ 22 km^2
	Number of turbines	11
	Expected annual production	~ 383 GWh
	Distance between the turbines	~ 1.5 km
	Distance to shore	~ 140 km
	Lifespan	20 years (25 years technical lifespan)
Wind- turbine	Effect	8 MW
	Total height from sea level to tip of rotor	~ 190 m
	Rotor dimension	~ 167 m
	Thorn height (from sea level to narcelle)	~ 105-107 m
	Concrete undercarriage diameter bottom/top	~ 18 m/ 9 m
	Distance between sea surface and rotor tip	~ 22-23 m
	Volume of concrete undercarriage	~ 3000 m^3
	Weight of concrete undercarriage	8-9000 t
	Solid ballast (Olivin)	~ 10000 t
	Water ballast	~ 500 t
	Total weigt turbine + undercarriage	~ 22500 t
	Subsurface depth	~ 90 m
	Total weight (deplacement)	~ 22600 t
Anchoring system	Number of anchor lines per turbine	3
	Length of anchoring line	~ 900 m
	Diameter of anchor chain	~ 138 mm
	Number of anchors	19-33
Internal cables	Number	11
	Length	~ 2km
	Diameter	150-200 mm
	Voltage transfer capacity	36 kV / 50 MVA

2 Cruise Timeline

Research crew and equipment was loaded from 08:00 13th of March, field full and returned to the harbour, to wait for the last equipment for the ROV arriving Bergen in the morning on the 14th of March. We left Bergen harbour 10:30 (Norwegian time).

On our way out Herdlefjorden, we tested the pelagic trawl (Harstadtrawl) and DeepVision. We also did a test dive with the ROV to make sure that the HIPAP worked.

15th of March - Arriving at Hywind Tampen at 00:30 – conducting the following.

- Checking coordinate system Equinor contra G.O. Sars.
- Deploying five ADCP moorings and one hydrophone mooring.
- Had our first daily 08:30 meeting with Equinor.
- ROV did the two chain transects on suction anchor 6 (SA06), a CTD vas taken to get the right density value for the acoustic HIPAP contact between the vessel and the ROV.
- Acoustic fisheries transect line, from 500m to 19 nm from the windfarm on our way to Lerwick, Shetland.

16th of March ca 08:00 – Arriving in Lerwick, Shetland where we spend 24 hours in shelter of a storm.

17th of March ca 08:00 – Leaving Lerwick, Shetland.

- On our way back to Hywind Tampen we conducted the acoustic fisheries transect. On which we had seven double CTD stations with water samples one for eDNA and one for nutrients (14 CTD stations). This transect was finished on the 18th of March.

18th of March –Started on the acoustic “ flower -transect” and CTD transects around the windfarm.

- Acoustic transect in a flower shape around the windfarm, going in and out from the safety zone (500-860 m) to 5.4 nm from the turbines. During this transect we trawled with DeepVision when we saw something of interest on the acoustics. In total we conducted five trawl hauls during the flower transect.
- CTD transect lines going from turbine HY06, HY04 and HY01, each consisting of five double CTD stations with water samples eDNA and nutrients. The CTD stations were at 500m, 0.54 nm, 1.08 nm, 2.70 nm og 5.4 nm from the three turbines. The flower transect was finished on the 20th of March.

19th of March – Continuing on the flower- transect with double CTD stations (see above) and ROV.

- ROV, finishing suction anchor 6 (SA06) doing the two control lines. Further we did the entire survey on suction anchor 9 (SA09).

20th of March – Finished the flower transect with the double CTD stations. Acoustic transect with the KayakDrone, and ROV transects suction anchor.

- The weather became much better, allowing us to conduct the acoustic transect within the windfarm with the KayakDrone, passing turbine HY11, HY10, HY09, HY08, HY07 on a 15-30 m distance. The KayakDrone holds a EK80 transducer.
- ROV, conducting the entire survey on suction anchor 12 (SA12).

21st of March – Transect and CTD samples within the windfarm.

- Trawling with DeepVision on the transect line – going between the two turbine lines.
- Conducting three double CTD stations with eDNA and nutrients along the transect line.
- Conducting three acoustic transect lines.

Redoing the fisheries transect this time with three trawl stations with DeepVision.

22nd of March – CTD transects.

- Conducting three CTD transect lines of 8nm with 8 CTD stations each (1nm apart).

23rd of March – CTD transect and retrieving moorings.

- CTD transect.
- Retrieving ADCP and hydrophone moorings.

24th of March - Leaving Hywind Tampen.

- Ca 07:30 Picking up glider, Slocum, for University of Bergen on our way back.
- 22:00 Returning to Bergen harbour.

A full overview of the different activities (stations) in terms of date, time, location (longitude and latitude), water depth, speed of vessel and weather conditions are given in Appendix (section 6).

To facilitate communication between G.O. Sars, Equinor operation room and service vessels on field, an Equinor Liaison Officer, Leonard Oliver Kielland; was mobilized onboard G.O. Sars for the entirety of the cruise. The responsibilities of the Liaison Officer consisted of preparing work permits for the different G.O. Sars operations within the vicinity of Hywind Tampen field, establishing communication with Sandsli Control room & other vessels, and to help plan G.O. Sars activities with other ongoing marine operations.

3 Activity

The first thing we did when we arrived at Hywind Tampen (HT) was to compare the coordinate system used by HT or Equinor with G.O. Sars system. To make sure that the positions we had on the Olex charting computer on G.O. Sars is comparable to Equinor’s system. G.O. Sars is using GWS 84, often referred to as «EPSG 4326» Units are in degrees Latitude and Longitude. Bridge personal prefers the DM-format, with degrees and decimal-minutes.

Following we will deploy the five ADCP and the hydrophone moorings. Three of the ADCP´s outside the windfarm and two ADCP´s and the hydrophone within the windfarm, see positions in the map Figure 2 and Table 2 .

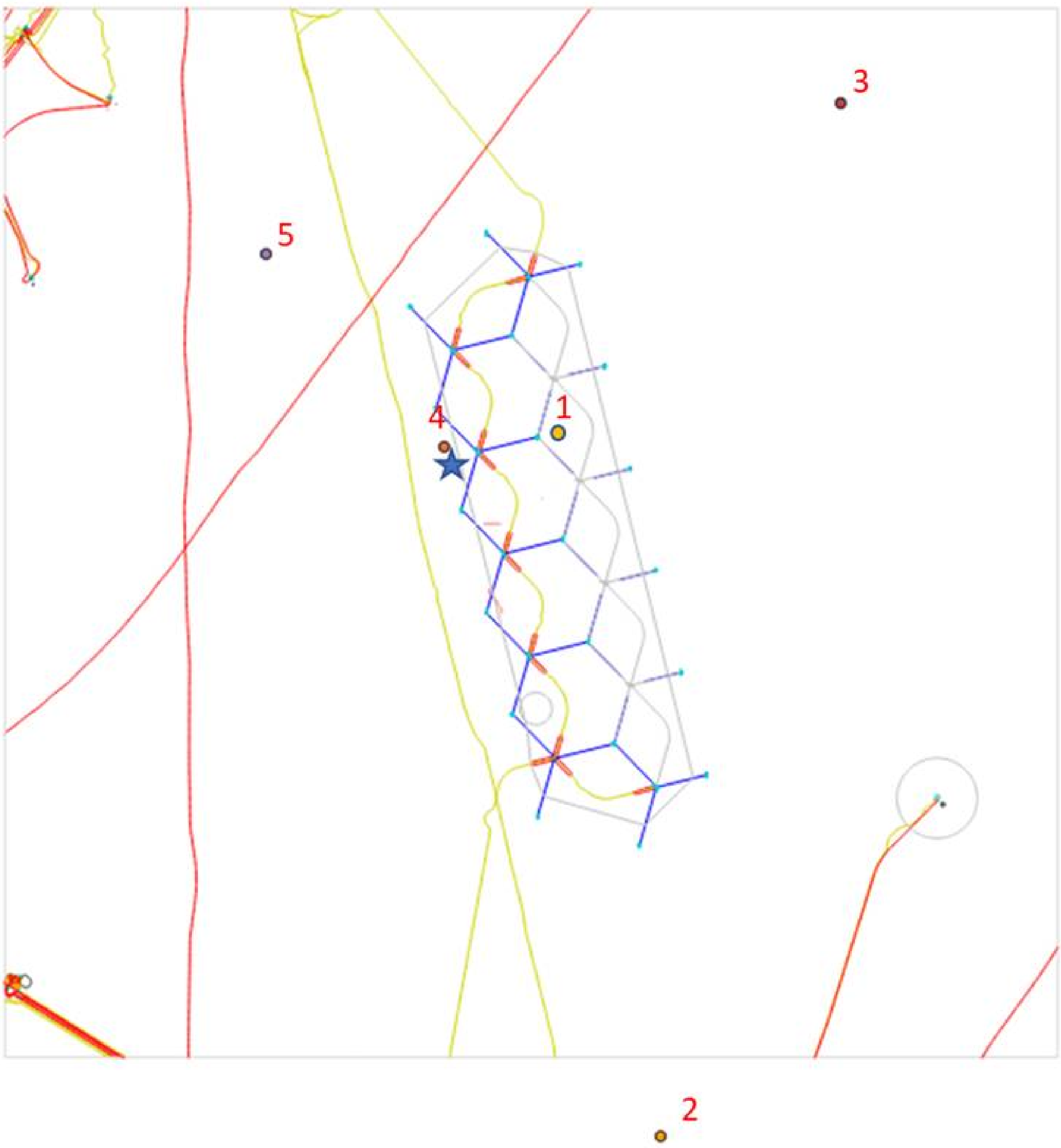


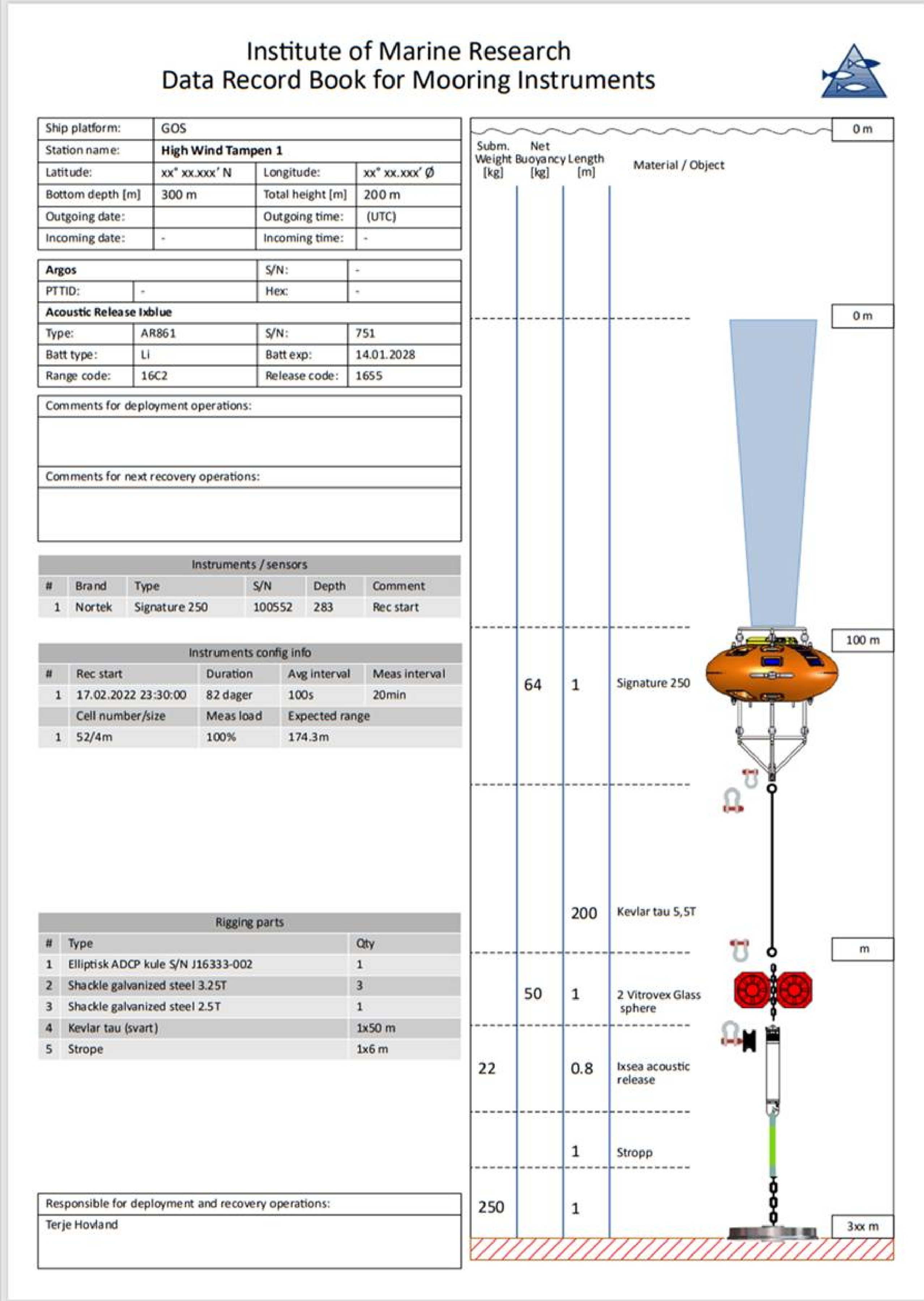
Figure 2. Map showing the positions where we deployed moorings at Hywind Tampen. The positions of the 5 ADCPs are marked with number 1 to 5, and the hydrophone marked with a blue star. The coordinates of the moorings are given in Table 2. Hywind Tampen windfarm: yellow line is cable, blue lines are anchor-chains. Turbines are positioned in the middle of three anchor-chains.

3.1 Wind-driven circulation patterns in and around Hywind Tampen

Our aim was to investigate the impact of the modification of the wind field by wind energy extraction on ocean current speed and direction and potential implications for up- and downwelling. This is highly relevant for distribution of nutrients and planktonic organisms which form the base of the marine ecosystem. Model studies looking at impact of wind-wake effects from larger bottom mounted OWF in the shallow southern part of the North Sea has suggested large scale changes in annual primary production and bottom sedimentation (Christiansen et al. 2022; Daewel et al. 2022). However, whether these anthropogenically induced wind-wake causing abrupt changes in upwelling and downwelling are significantly different from the natural variability is still not clear (Floeter et al. 2022). There are so far no studies of current and wake-effects around deepwater floating wind farms. Thus, any data on this will be novel. We deployed five bottom-anchored moorings two in and three around the Hywind Tampen to collect observations of upper ocean currents in the area.

ADCP Mooring design, deployment and recovery

The moorings consisted of a Signature250 ADCP mounted in a float and attached by rope to an acoustic release which is attached by chain to a bottom anchor in form of train wheels (see Figure 3). ADCP1, 2, 3 and 5 had a CTD on their mooring, clamped onto the rope below the ADCP.



Institute of Marine Research
Data Record Book for Mooring Instruments

Ship platform:	GOS		
Station name:	**High Wind Tampen 1**		
Latitude:	xx° xx.xxx' N	Longitude:	xx° xx.xxx' Ø
Bottom depth [m]	300 m	Total height [m]	200 m
Outgoing date:		Outgoing time:	(UTC)
Incoming date:	-	Incoming time:	-

Argos		S/N:	-
PTTID:	-	Hex:	-
Acoustic Release Ixblue			
Type:	AR861	S/N:	751
Batt type:	Li	Batt exp:	14.01.2028
Range code:	16C2	Release code:	1655

Comments for deployment operations:

Comments for next recovery operations:

Instruments / sensors

#	Brand	Type	S/N	Depth	Comment
1	Nortek	Signature 250	100552	283	Rec start

Instruments config info

#	Rec start	Duration	Avg interval	Meas interval
1	17.02.2022 23:30:00	82 dager	100s	20min
	Cell number/size	Meas load	Expected range	
1	52/4m	100%	174.3m	

Rigging parts

#	Type	Qty
1	Elliptisk ADCP kule S/N J16333-002	1
2	Shackle galvanized steel 3.25T	3
3	Shackle galvanized steel 2.5T	1
4	Kevlar tau (svart)	1x50 m
5	Strope	1x6 m

Responsible for deployment and recovery operations:
Terje Hovland

Figure 3. Drawing of the ADCP mooring and instrument information.

Deployment from G.O. Sars was done anchor-first to maximize control over position of the mooring and minimize risk of drift, following well-established procedures. For recovery we used the ROV to clamp a rope to the recovery hook on the top float, allowing us to winch in the mooring with anchor.

The moorings were deployed first day at Hywind Tampen (15th of march) and recovered at the end of the cruise on the 23rd of March.

Table 2. Position of the ADCP and hydrophone moorings in and around Hywind Tampen. Coordinates are given in GWS 84, (often referred to as «EPSG 4326») in DM-format, with degrees and decimal-minutes. For numbering of turbines see Figure 13.

Mooring	Latitude	Longitude	Approx. bottom depth (m)	Comment
ADCP1	61° 20.789'N	2° 15.610'E	292	Close to suction-anchor nr. 7 (SA07)
ADCP2	61° 15.384'N	2° 17.351'E	250	5km south of turbine nr 6 (HY06)
ADCP3	61° 23.367'N	2° 20.045'E	315	5km east/north-east of turbine nr. 1 (HY01)
ADCP4	61° 20.747'N	2° 13.7579'E	285	
ADCP5	61° 22.132'N	2° 10.892'E	290	3km north-west of turbine nr. 11 (HY11)
Hydrophone	61° 20.559'N	2 13.664'E	285	Ca 500 m from turbine nr 10 (HY10)

CTD transects

To get a better understanding of the water composition in the Hywind Tampen area, we conducted a three lined transects across the shelf (Figure 4 black lines is transect with red triangles showing waypoints, coordinates for the waypoints are given in Table 3). We started on a fourth line with CTD stations, but after 3 stations bad weather conditions and bad weather forecasts made us stop the transect, and head for Bergen harbour. Each of the lines were going in south-west and north-eat direction, they were 21 nm long and had 8 CTD stations with 3 nm between stations (8 station in each line x 3 transect lines 24 CTD stations).

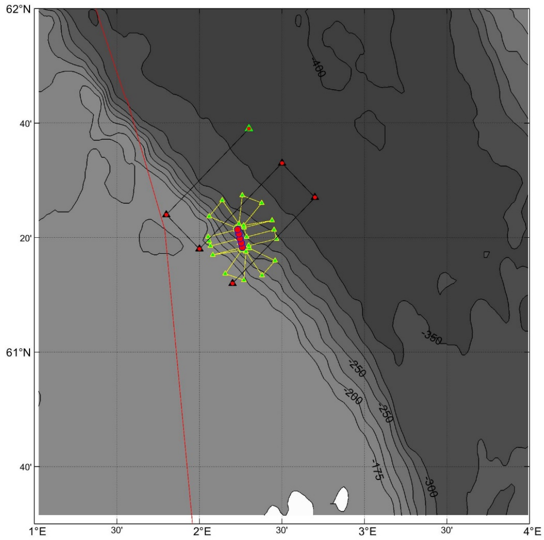


Figure 4. This map shows two of the CTD transect line studies runed on this cruise. The black lines with the red triangles (waypoints) shows the CTD transect going from the Tampen shelf across the drop to the Norwegian-trench. The green going in a flower like pattern, is the acoustic flower transect around the windfarm (see also Figure 15).

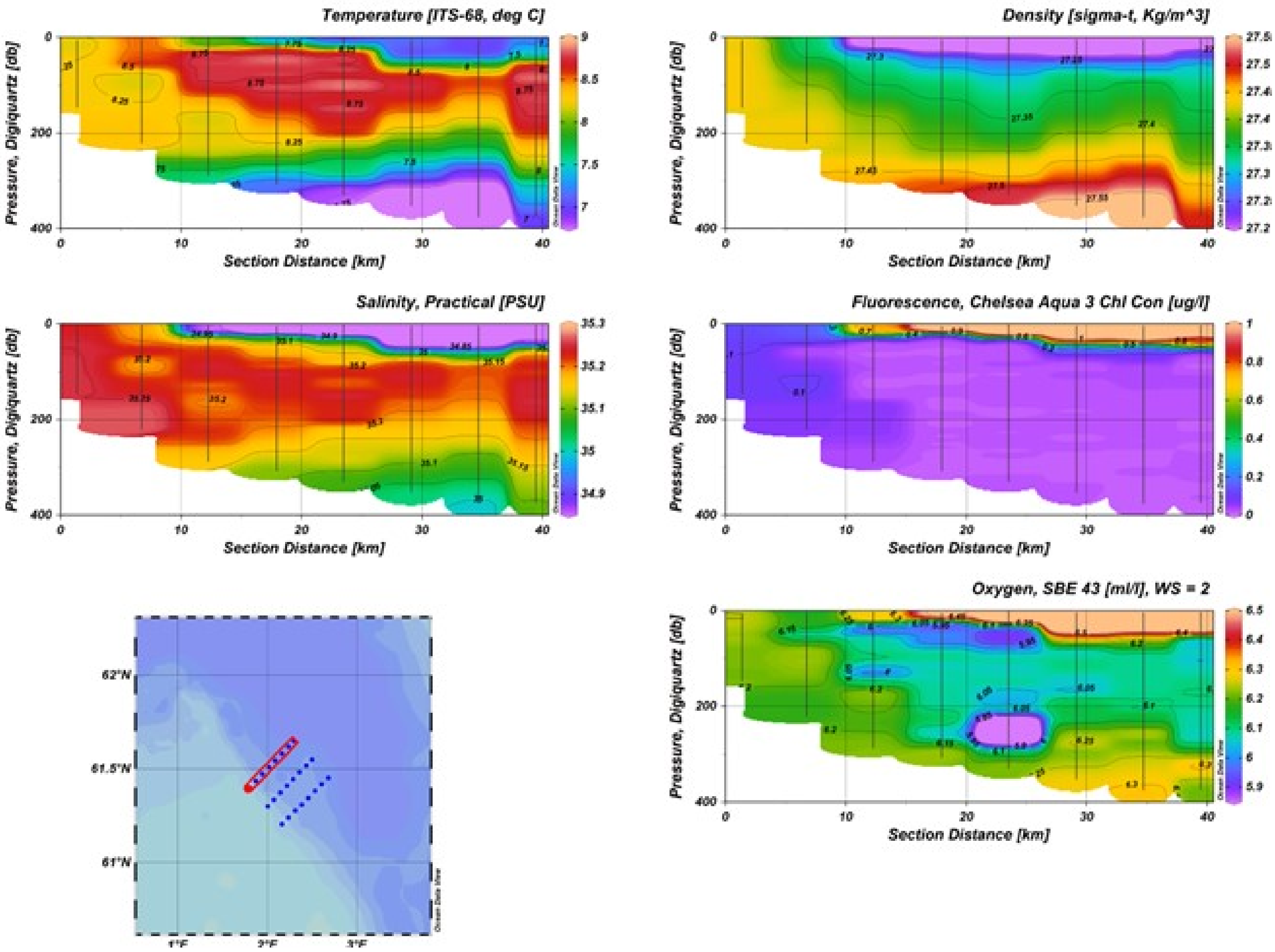
Table 3. Coordinates for the waypoints in the CTD transect.

Waypoint	Latitude		Longitude		Depth [m]
Start Northern line	N61°	24.03’	E001°	48.17’	154
Stop Northern line	N61°	38.94’	E002°	17.83’	378
Start Central line	N61°	32.98’	E002°	29.91’	373
Stop Central line	N61°	18.01’	E002°	00.13’	147
Start Southern line	N61 °	12.32’	E002°	09.72’	139
Stop Southern line	N61°	27.08’	E002°	40.91’	376

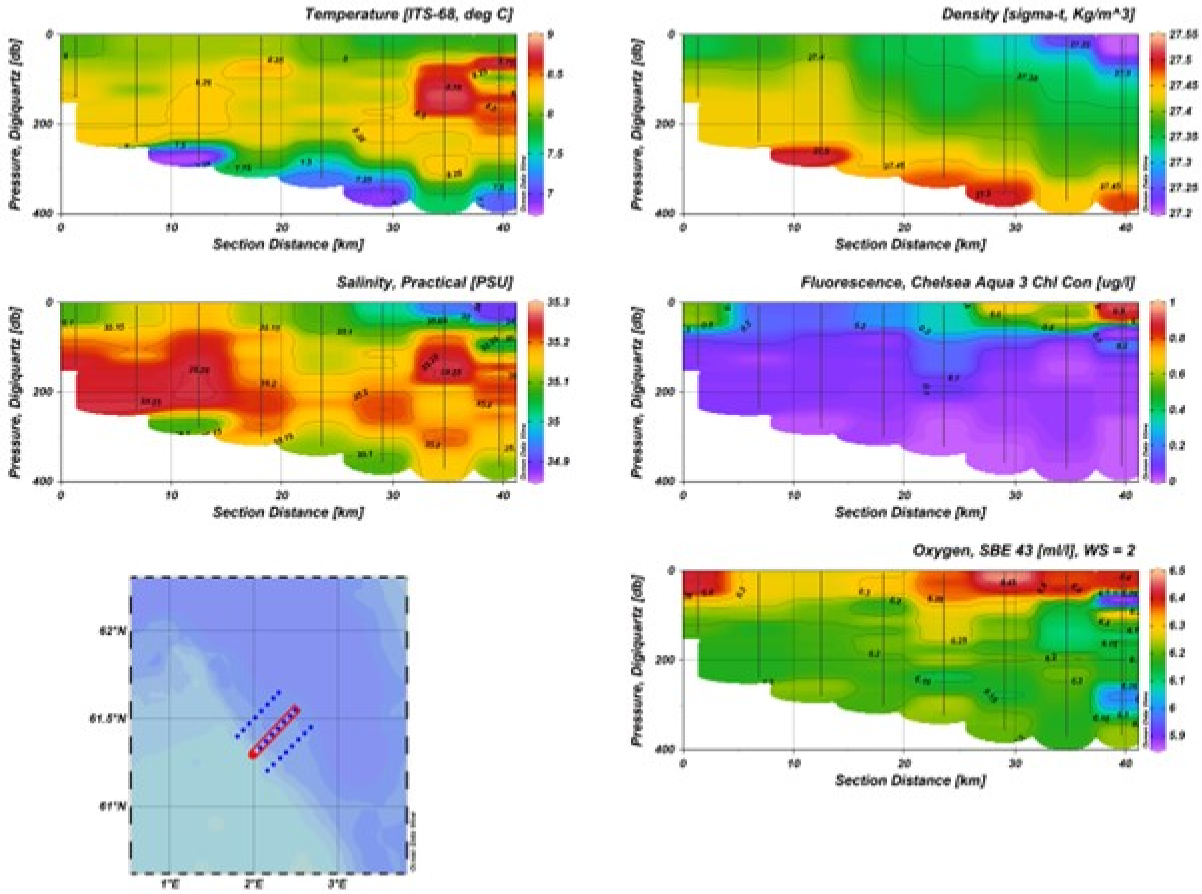
Preliminary results from CTD transects

(by Henrik Søiland)

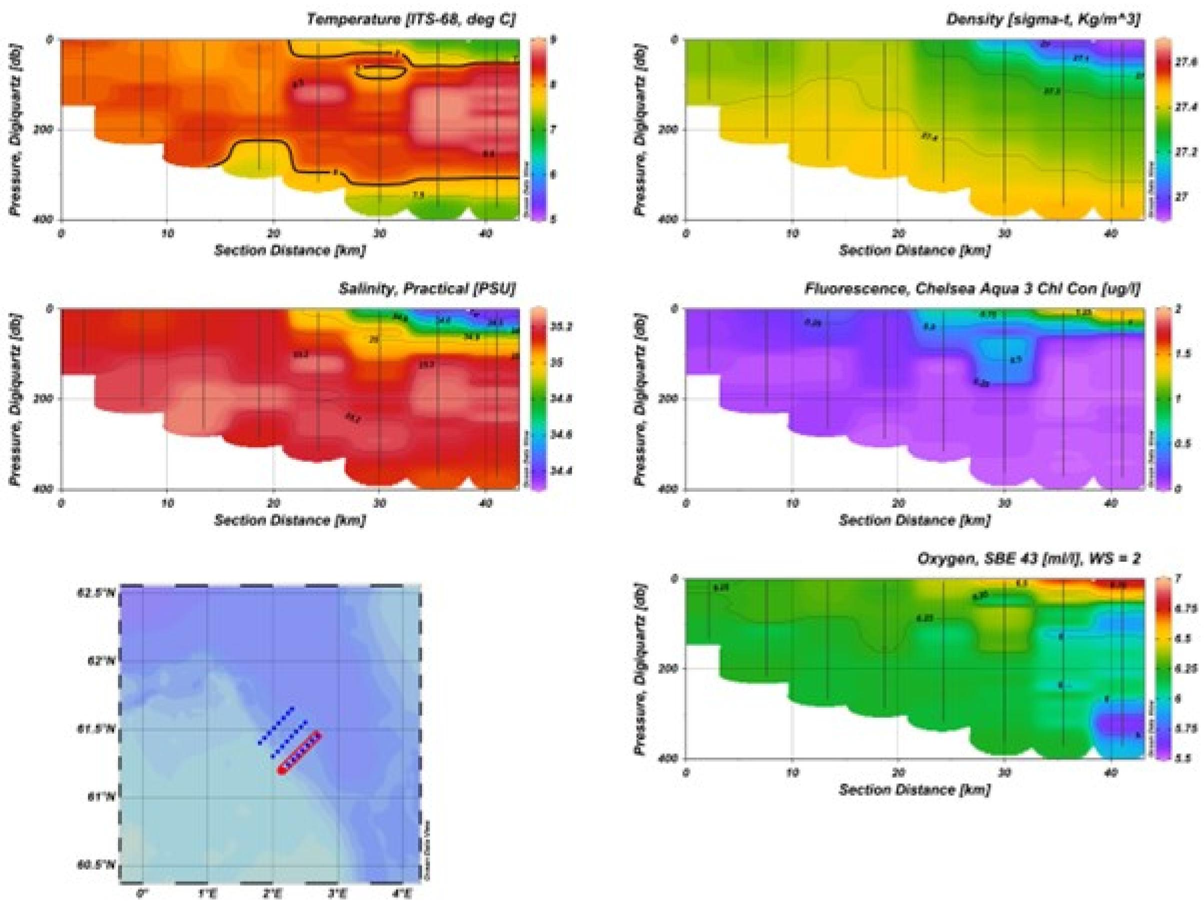
Results from the CTD transect is given in Figure 5 below


Temperature [ITS-68, deg C]
Density [sigma-t, Kg/m^3]
Salinity, Practical [PSU]
Fluorescence, Chelsea Aqua 3 Chl Con [ug/l]
Oxygen, SBE 43 [ml/l], WS = 2
Pressure, Digiquartz [db]
Section Distance [km]
62°N
61.5°N
61°N

a)


Temperature [ITS-68, deg C]
Density [sigma-t, Kg/m^3]
Salinity, Practical [PSU]
Fluorescence, Chelsea Aqua 3 Chl Con [ug/l]
Oxygen, SBE 43 [ml/l], WS = 2
Pressure, Digiquartz [db]
Section Distance [km]
62°N
61.5°N
61°N
1°E
2°E
3°E

b)



c)

Figure 5. The three CTD transect line going from shallow Tampen shelf across the drop to the Norwegian-trench. a) shows temperature, density, salinity, fluorescence and oxygen results from the northern transect, b) the central and c) the southern transect.

Nutrients

On all CTD stations, except for the across shelf CTD transect, we also took water samples to look at nutrients. We used IMR's standard sampling depths: 5, 10, 20, 30, 50, 75, 100, 125, 150, 200, 250 og 300 m. In total 295 nutrient samples.

3.2 Operational noise and wind climatology

Noise and in particular continues noise is known to influence fish and other marine organisms' behavior, physiology, and, in extreme cases, survival (Duarte et al 2021). Wind turbines produce continues noise when running. The noise depends on the turbine type and the fundament construction. Hywind Scotland's turbine are made of steel, while the turbines at Hywind Tampen are made of concrete. Thus, we expect the turbines at Tampen to be less noisy, as concrete has a lower propagation of sound. A sound source characterisation study has been conducted at Hywind Scotland (Burns et al 2022), but not yet at Hywind Tampen.

Numerical studies suggest that turbine-induced modulation of wind forcing affects upper ocean thermal stratification and current locally around each individual turbine. How much this influences the directionality of near-surface sound propagation, specifically from the floating (direct-drive) wind turbines, needs to be studied. Meanwhile impacts of tides, precipitation and in general any variation of surface climate in the presence of turbines can play important role in near surface (sea-side) propagation of sound and spatial homogeneity of sound field. For example, tidal fluctuations cause vibration of equipment or the hydrophone beside the operating structure vibration. The directionality may change depending on type of foundation, farm layout, and frequency of noise (for example it is possible that in cross-wind direction and within the windfarm area, we get high SPL. Noise propagation can then have either omni-directional [1] or directional behaviour (Figure 6).

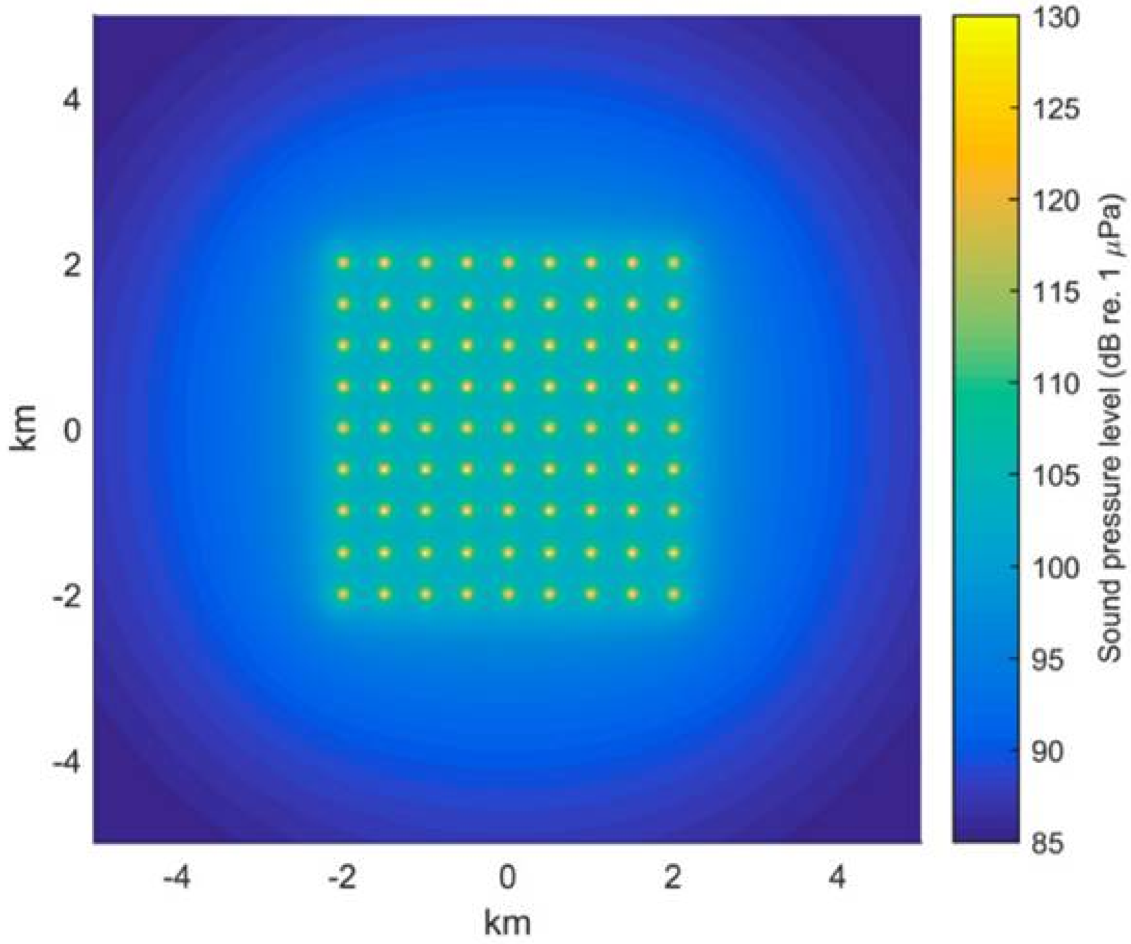


Figure 6. Operational noise for a 9 x 9 turbine offshore wind farm and park layout is given as [1] (Tougard et al 2020)

Regarding measurement of turbine-induced noise, vicinity to the turbine is a key factor. We expect very subtle sound (at a low level) from turbines even in distances less than 50-100m, during non-transient event conditions. The noise level reduces rapidly with distance (more than what is expected from simple spherical spreading – say more than 20dB/decade for a distance around 50m). Ship may generate a wide-band noise ranging from 25Hz to 1kHz (overlapping with low frequency turbine-emitted noise). It is therefore a concern that so much ship activity was going on in the near field to HY10 where the hydrophone mooring was located during the deployment period. As maintenance of this and the other turbines was conducted daily over the deployment period, except for the night and during 16th to 17th of March due to bad weather conditions.

Wind climatology

Figure 7 shows 11 years timeseries of wind speed and direction. It suggests the dominant annual wind is coming from South (or slightly southwest). Changes in wind speed/direction and resulting wind stress change for a certain climatological condition can affect both stratification (then soundscape) and upper ocean current. In such condition, we have directionality that its strength depends on wind farm layout and other factors. Time series of wind speed and direction show, however, complex variability with a pronounced south-westerly wind. In this deployment, we assumed the sound propagation to be omni-directional and according to the wind direction we should get better noise recording inside the windfarm. As the park so far have only 7 turbines all on one long string, the hydrophone was placed close to one of the central turbines (HY10) in the chain of turbines (blue star in Figure 2).

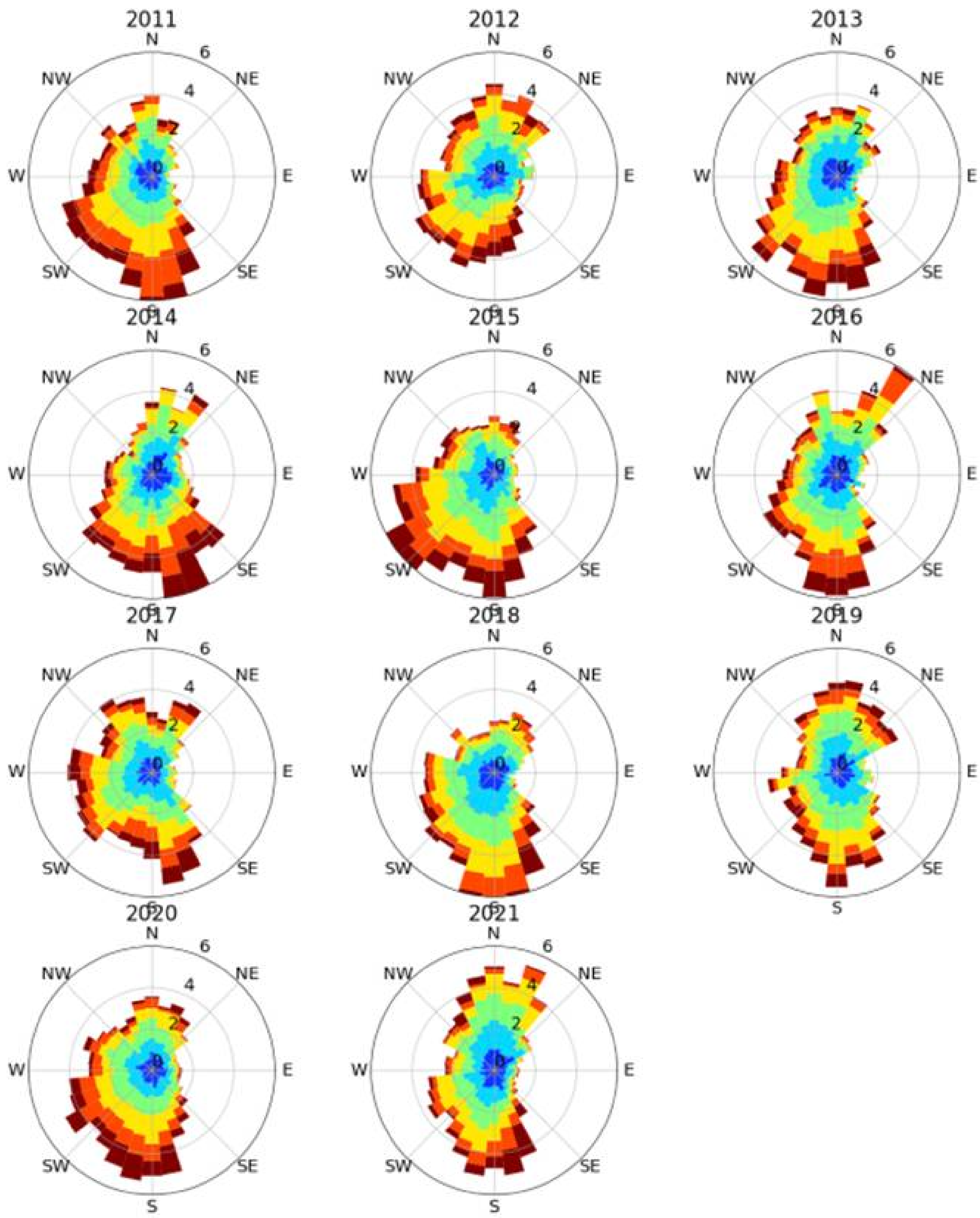


Figure 7. Rose plot of wind speeds and directions between 2011 and 2021.

Hydrophone mooring design

The hydrophone mooring consisted of three hydrophones and CTD mounted in a float and attached by rope to an acoustic release which is attached by chain to a bottom anchor in form of two train wheels (see Figure 8). The hydrophones were two SoundTrap 300 HF (Oceaninstruments.co.nz) hydrophones, and a RTSYS hydrophone. The two Sound traps were clamped on the mooring rope, one at 45 m and one at 35 m below surface. The RTSYS Hydrophone was positioned at 25 m, and the buoy at 15-16 m depth.

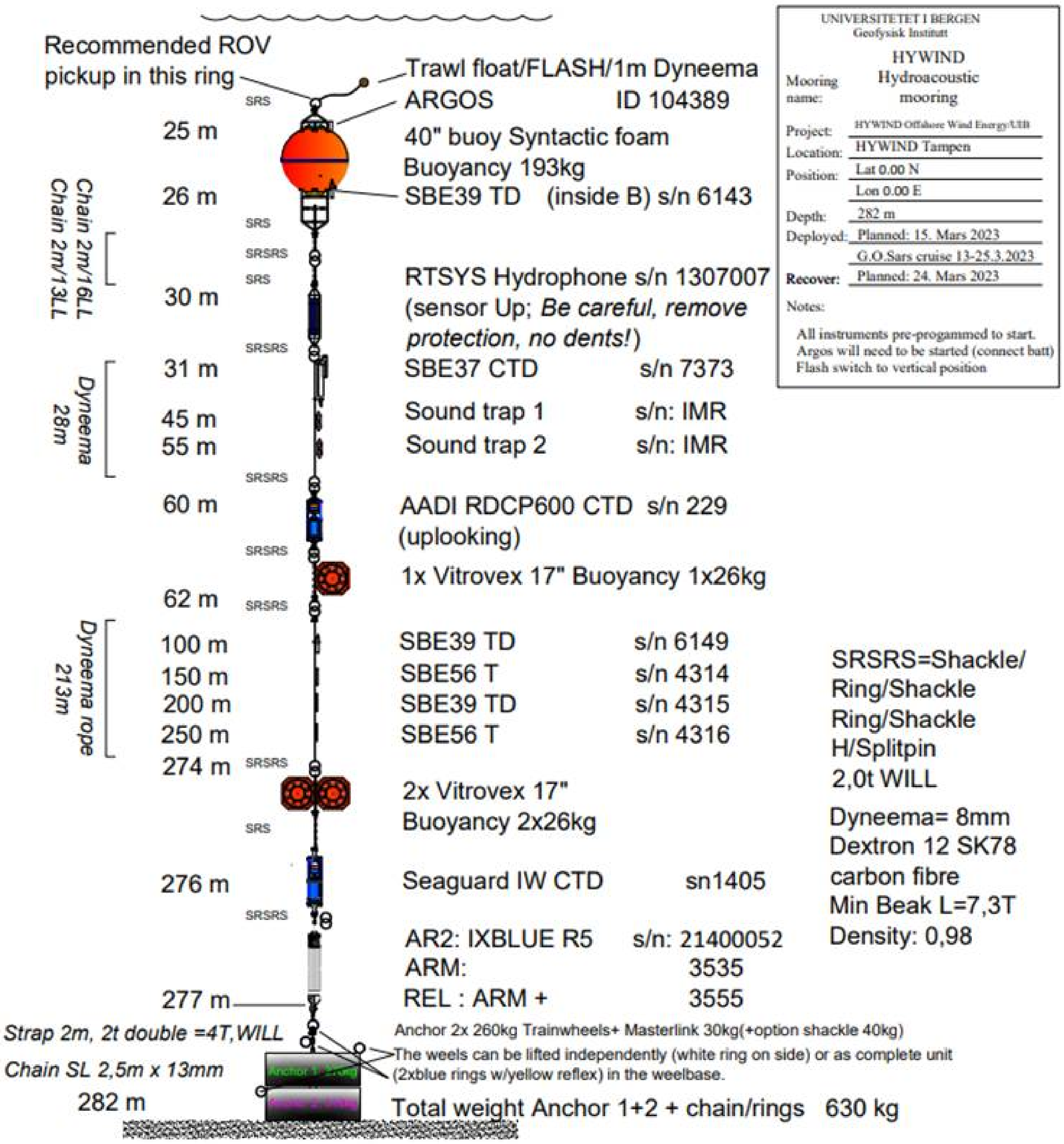


Figure 8. The hydrophone mooring design and instrument information.

Positioning of the hydrophone

We deployed the hydrophone moorings anchor first from the ship hangar traverse beam block winch. Lifting the instruments off deck and overboard in order to avoid twist/stress from contact with the ship at any part of the operation. Recovery was done using the ROV to clamp a rope to the steel frame under the buoy and pulling the mooring (including anchor) up.

Recorder configuration

For all hydrophones the recording was autonomous for the record dates between 13 and 23 of March. For the duration of campaign, we use 1 sampling channel, duty cycle 50 min on and 10 min off every hour. Sampling rate was 5000 kHz. We used 18 Li-SOCl2 batteries covering the recording period.

The two SoundTraps were sampling continuously, with a sampling rate of 48 kHz.

The hydrophone data has not yet been analysed.

Preliminary results from the sound measurements

(by Karen de Jong)

Preliminary results from a representative 10s recording from one of the SoundTrap hydrophones (Figure 9) shows two broadband noise bands, one between ~200Hz – 1000 Hz and an additional broadband band around 1500 Hz. In addition, we see several transient tones, the lowest frequency tone was at around 800Hz. Important to note: At this preliminary stage we can't be shore that these sounds are from the wind-turbines.

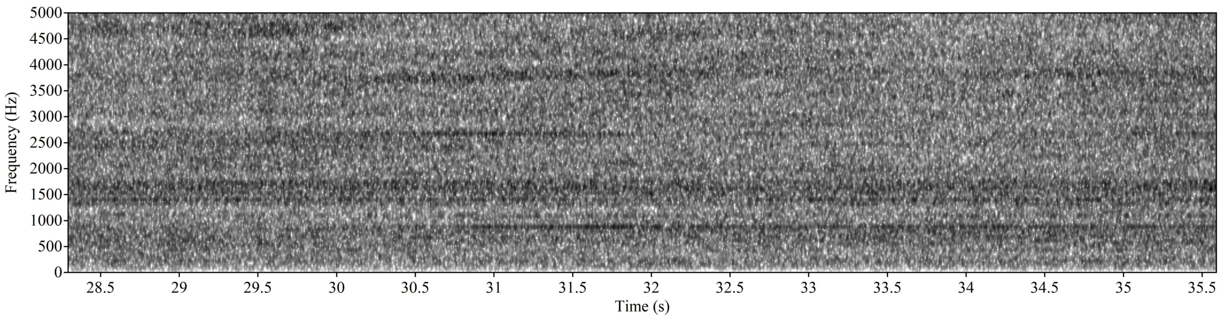


Figure 9. Spectrogram from a representative 10s recorded with one of the SoundTraps.

3.3 Acoustic study of pelagic fish

Hywind Tampen might attract fish due to all the added hard structure (called *Reef-effect*) or it might scare fish away by noise and activity. Likewise, are floating structures used to aggregate pelagic fish in fisheries, a device called *FAD* (Fish Aggregation Device). We, therefore, wanted to look at any possible attraction or avoidance effect of fish by conducting multi-frequency acoustic transect, within and around the windfarm using G.O. Sars. The acoustic transects were: 1) from Hywind Tampen safety zone (500 m) to a distance of 5.4 nm from the farm, in all directions (*flower transect* , see Figure 15), 2) from the safety zone on the west side of the farm to 19 nm in a south-west direction (*fisheries cruise transect,* see Figure 11), 3) *through the windfarm* (see Figure 13), 4) KayakDrone transect close to the turbines (Figure 18).

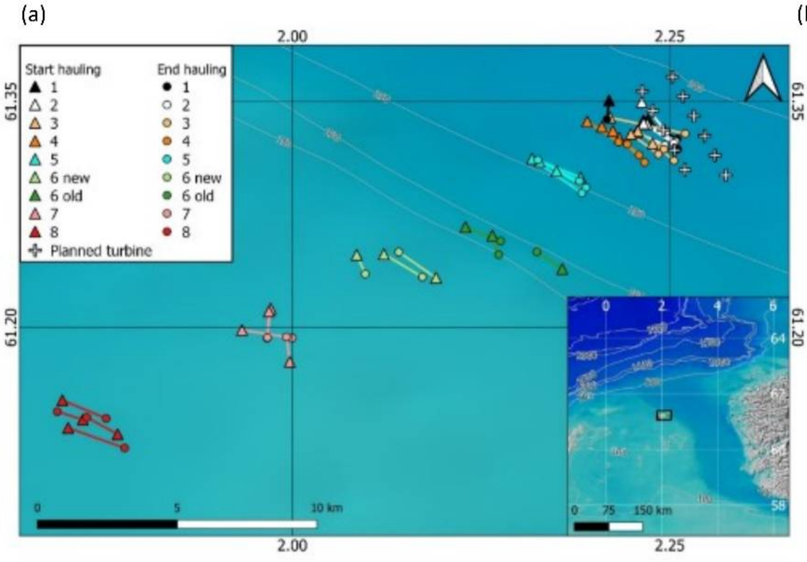
To ground truth what we saw on the acoustics we took pelagic trawl samples using an open-ended pelagic Harstad trawl with a camera unit called Deep Vision. The later takes pictures of the catch as it passes through the trawl (DeepVision Figure 10). In addition to trawling with DeepVision on the line of the acoustic transect, were eDNA samples taken at given CTD stations along the acoustic transect (see section 3.5 on eDNA).

Figure 10. Deep vision is an open trawl where the catch goes through a camera tunnel before it goes through the open cod end of the trawl. It is used in research to document what is in the different acoustic layers without having to catch the fish. It is developed by Scantrol in collaboration with IMR.

Fishery cruise transect

We conducted an acoustics transect following the fisheries surveys gill-net station lines going from the windfarm towards south-west, stopping at the U.K. bordar, starting at ca 500 m from Hywind Tampen to ca 19 nm (from station 2 to station 8 in Figure 11). This acoustic transect was repeated 3 times during the cruise.

(a)



(b)

Station	Distance (nm)	Distance (m)
1	0.05	100
2	0.27	500
3	0.54	1000
4	1.08	2000
5	2.70	5000
6	5.40	10000
7	10.80	20000
8	18.90	35000

Figure 11. (a) The hauling positions of gillnets from the 2022 cruise and the planned stations for the fishery survey cruise in 2023, with excaption of station 1 (100 m off the turbines). This figure is copied from IMR cruise report (Toktrapport 2022-15). We positioned our acoustic transect stations a bit to the north of the gill-net lines on the map.

In the same position as the gillnet stations in the fisheries cruise 2022 we took CTD and water samples to get nutrients and eDNA (Table 4).

Table 4. Showing position of gillnet stations 2 to 8 in the fisheries cruise, that also corresponds to our CTD and water sample stations for eDNA and nutrients. Given in degrees (D) and minutes (MIN)

Station	Latitude	D	min	longitude	D	min
2		61	19,630		2	14,330
3		61	19,4474		2	14,08997
4		61	19,4638		2	12,97851
5		61	18,1175		2	10,70873
6		61	14,4884		2	04,0351
7		61	11,7862		1	59,23628
8		61	08,118		1	51,7036

Preliminary results from DeepVision during the fisheries cruise transect

We sampled different sound scattering layers (SSL) three times during the fisheries transect using DeepVision (Figure 12). This revealed that there was jelly in the SSL layers furthest away from the windfarm (station 58 and 59 in Figure 12), while there were mesopelagic fish (pearl sider, *Maurolicus muelleri*) in the SSL layer as we got closer to the farm (station 60 in Figure 12).

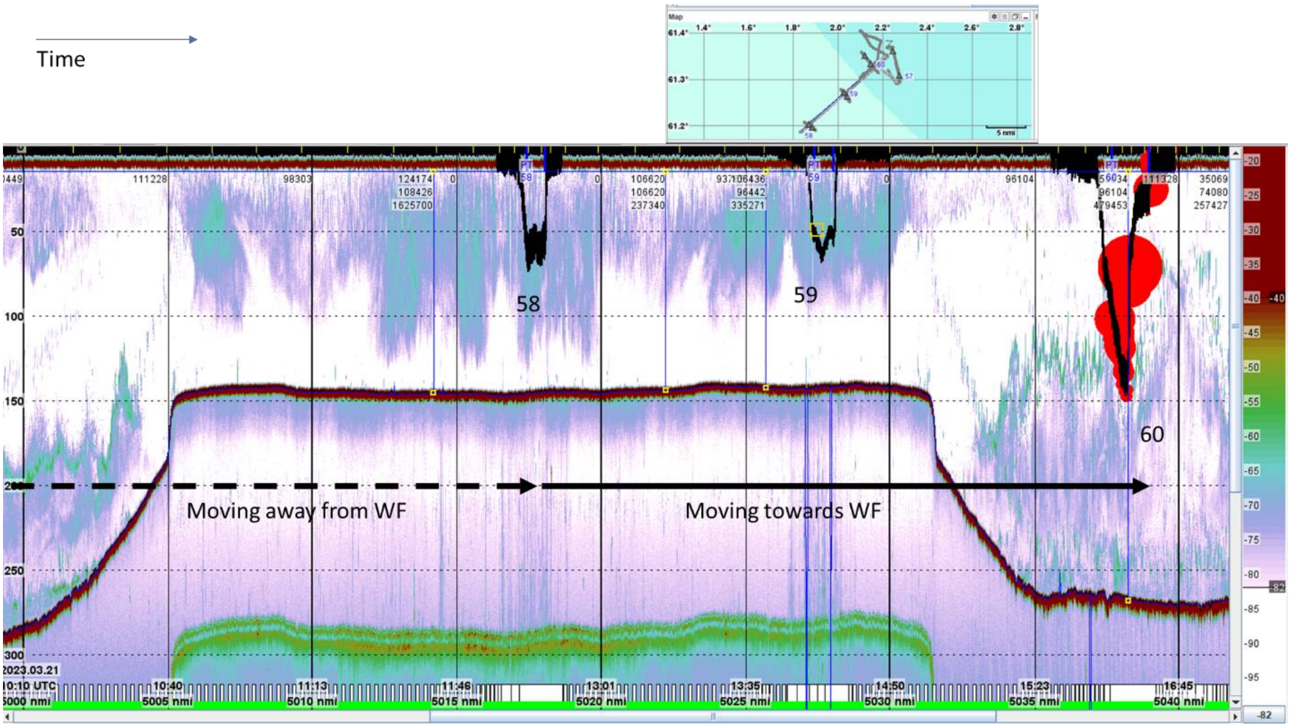


Figure 12. Showing the acoustic fisheries transect going from the windfarm to 19 nm and returning to the windfarm (windfarm is in the deep), making 3 DeepVision hauls on the way back to the park. The results are displayed in LSSS. Jelly was seen in station 58 and 59, while mesopelagic fish was seen in station 60.

Acoustic transects within the windfarm

We conduct four transect within Hywind Tampen. The acoustic transects went through the windfarm following the red arrow in Figure 13 , using the trawl only in safe places related to 500 m to turbines, anchor-chains and our own moorings (maximum depth 50 m depth). The transect lines were on the western side of central row of suction anchors. Here we stayed within a distance of 200 m from the suction anchors. The trawl was at surface or close to surface when entering and leaving the windfarm. Do to mostly poor weather conditions we only got a chance to trawl trough the windfarm once, and that was during the night.

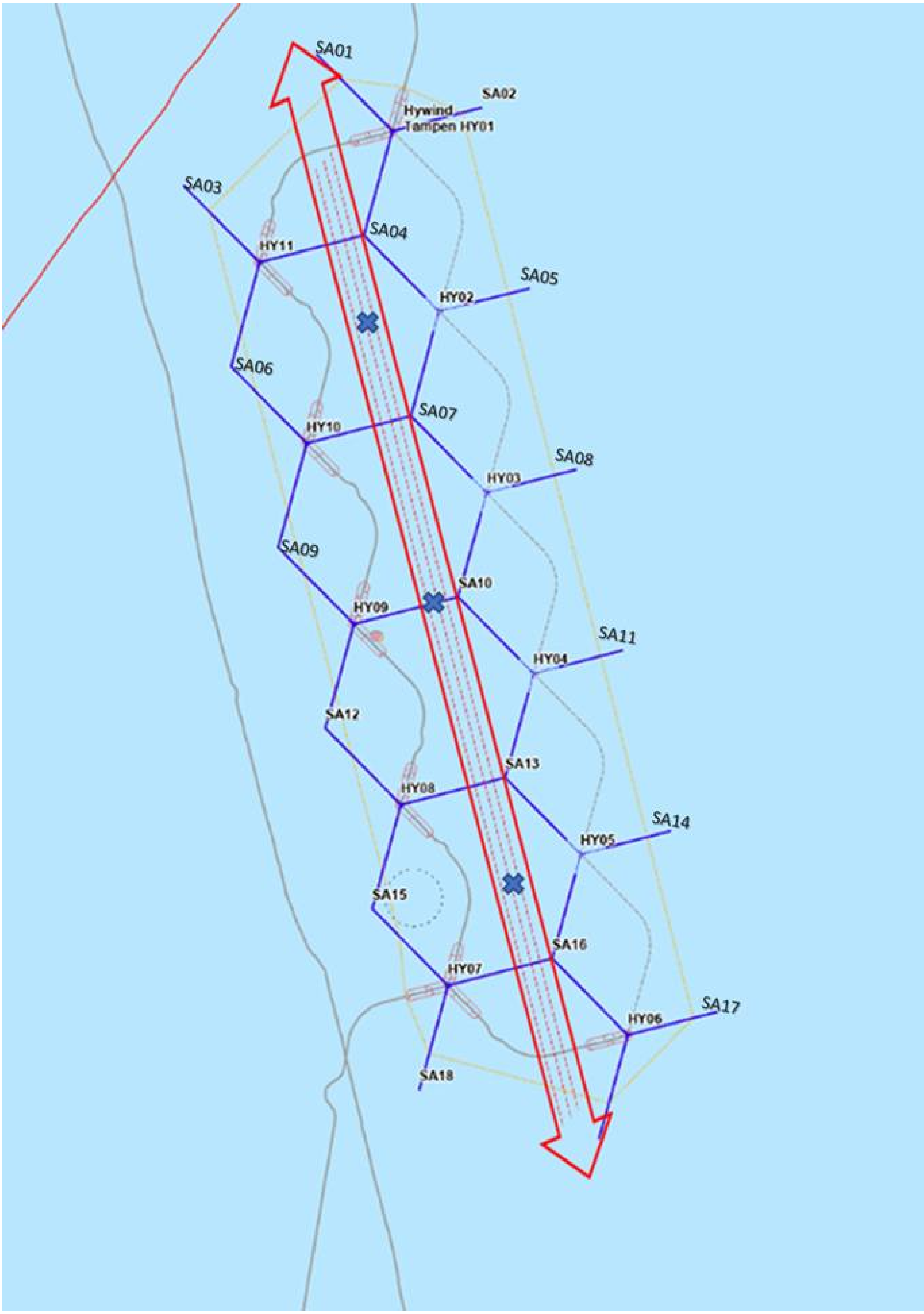


Figure 13. Drawing shows the transects conducted by G.O. Sars trough the Hywind Tampen, where pelagic trawl was used. The blue

X marks the position of the CTD -, eDNA - and nutrient stations within the windfarm.

Prelimenary results from DeepVision during transect inside the windfarm

DeepVision showed that we had pelagic fish (herring and mackerel) in the upper 200 m (Figure 14). CTD stations, with water samples for collecting nutrients an eDNA were also taken inside the windfarm (stations marked with X in Figure 13).

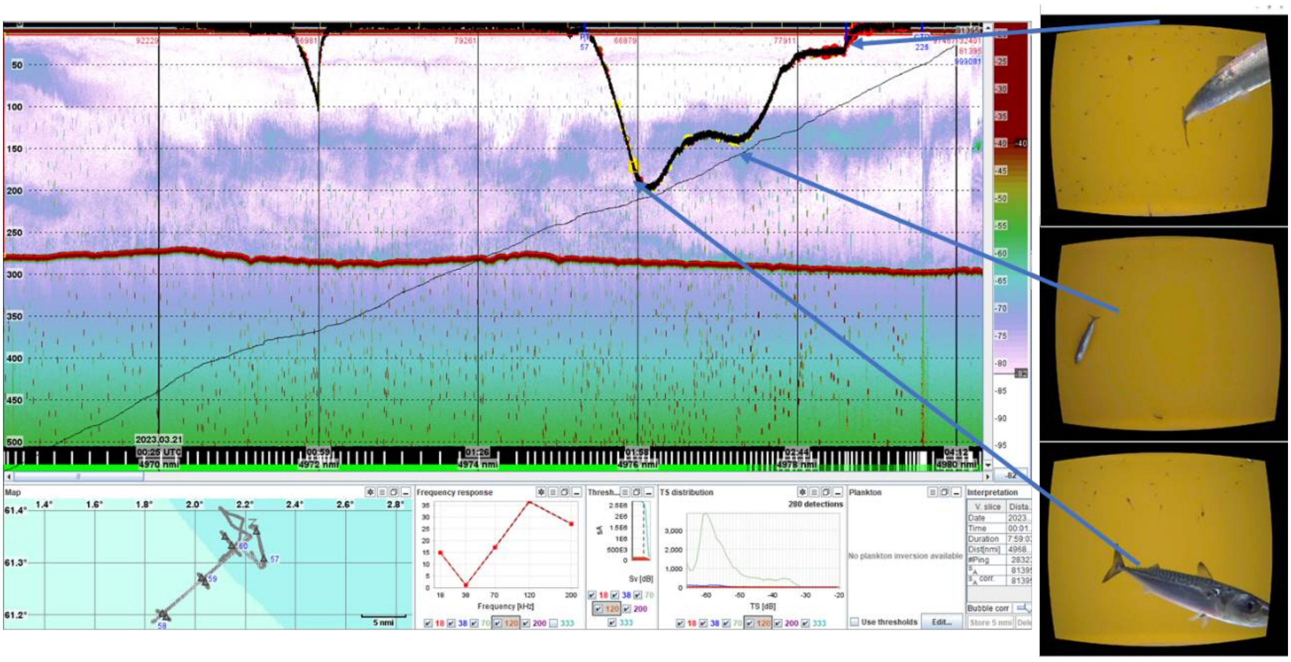


Figure 14. Showing the DeepVision results being displayed in LSSS. This from a transect inside the windfarm. Where we "caught" herring (Clupea harengus) and mackerel (Scomber scombrus) in the upper 200 m during night-time.

Acoustic transect around Hywind Tampen, flower transect

We started our flower transect at 500 m distance to the turbines and conduct transects outwards to 5.4 nm from Hywind Tampen. Also here, we trawled pelagic with a Harstad trawl equipped with DeepVision, to ground truth what we saw on the acoustics. In addition to trawling, we took CTD, nutrients and eDNA samples at given distance to the north, east and south of the wind farm (stations marked with red crosses on the transect lines in Figure 15), vest was covered by the CTD, nutrient and eDNA stations taken along the fisheries transect (Figure 11).

The transect design is a compromise between design for quantity calculation (more or less homogeneous coverage) and gradient study from the windfarm. Total length of transect is ca 105 nm (Figure 15).

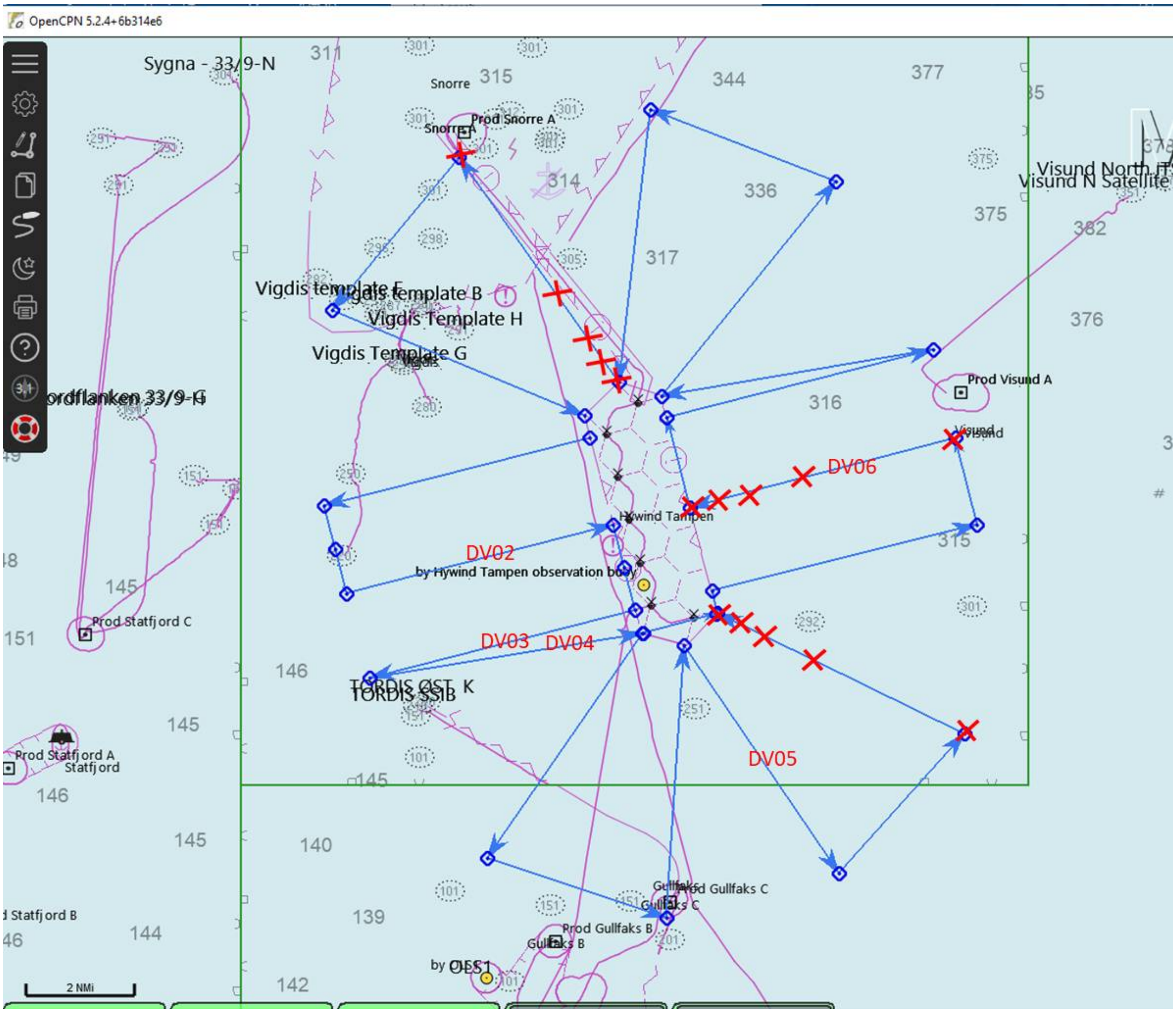


Figure 15. The acoustic transect around Hywind Tampen, conducted by G.O. Sars using broadband acoustics. Transect goes from 500 m off the turbines to 5.4 nm off the turbines. X marks the positions for CTD, eDNA and nutrient samples. The position of DeepVision trawl stations are marked with trawl station number (DV02 to DV06) on the transect line were the trawling was conducted.

Preliminary results from DeepVision during flower transect

All five DeepVision trawl stations (DV02 to DV06) showed mesopelagic fish present in the sound scattering layers (SSL's) from 200m and up around Hywind Tampen (Figure 16)

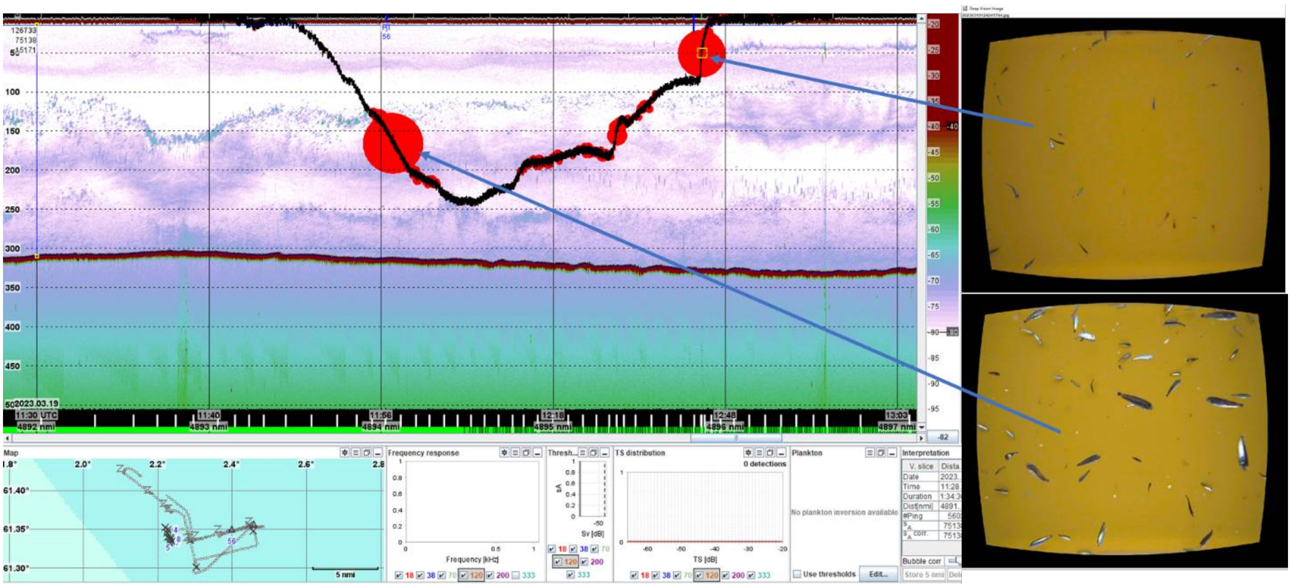


Figure 16. Showing the DeepVision results being displayed in LSSS. This from a transect around the windfarm (flower transect). Where we “caught” mesopelagic fish pearl sider, Maurolicus muelleri, in the upper 200m during day and evening.

Acoustic KayakDrone transects

We used an acoustic KayakDrone (Figure 17) for acoustic sampling close to the turbines. Previous research has shown that structure in the water has a *reef-effect* , and that this effect is seen close to the structure (<20 m from the turbines Methratta and Dardick 2019, < 50–150 m from oil installations Løkkeborg et al. 2002, Vold Soldal et al. 2002). Fish are attracted as they find food and shelter around the structure and in the current wake behind structure. Likewise floating structure is used in fisheries to aggregate fish (the so-called FAD, Fish Aggregation Devise). Both the reef - and FAD effect is seen in the near range to the structure, and with G.O. Sars we were not allowed closer than 500 m to the turbine. We therefore used an acoustic KayakDrone to look at fish abundance as close as possible to the turbines. The KayakDrone moves in a pre-set rout. It has an electrical outboard engine that makes it silent, and it holds a EK80 200 kHz transducer.

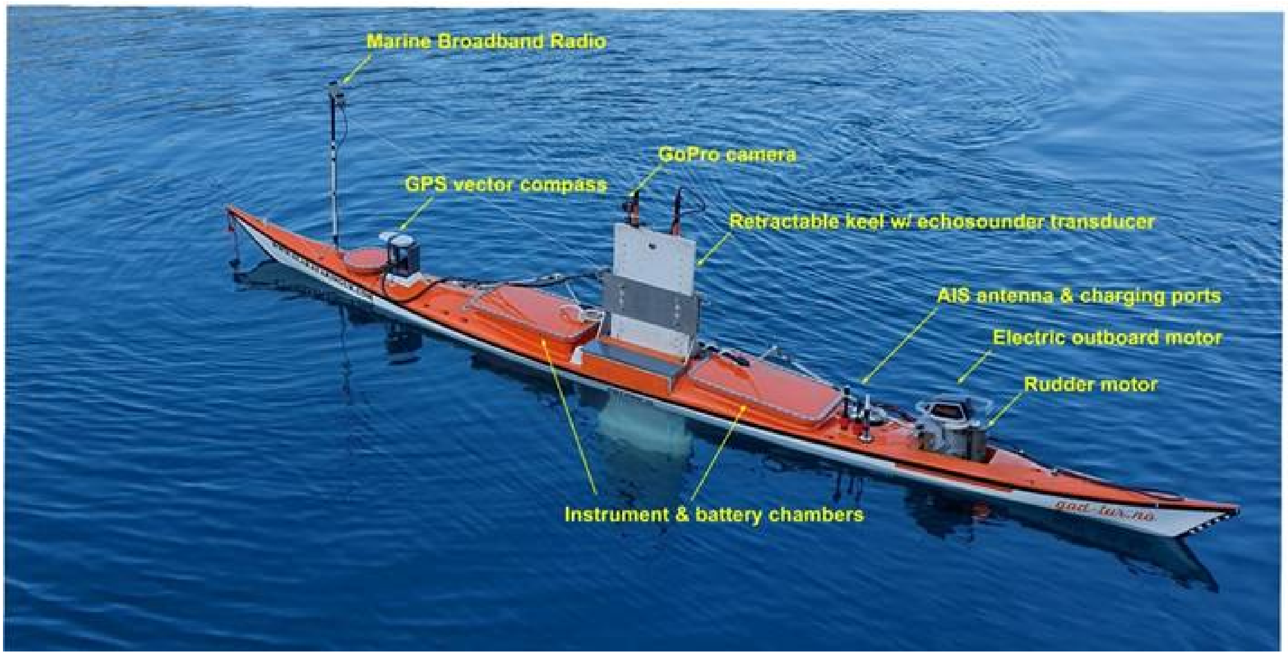


Figure 17. The kayakDrone. Made by IMR (Totlan and Johnsen 2022). It is 700 cm long and weighs 300 kg. It holds an EK80 200 kHz transducer on its retractable keel. Further it has a GPS vector compass and an AIS. It has an electrical outboard engine.

KayakDrone transect design

The design is based on the fact that in this experiment the FAD is not a single point (which is most common), but rather a cluster of FADs in an area. It is therefore likely that the fish aggregation effect of one turbine is not independent or unaffected by the surrounding wind turbines.

The design involves the passage of five turbines, and on two sides, with a distance of 30 meters from the centre of the turbine. The turbines are 10 m in diameter. Wind and current can offset the turbines position by ca 10 m, which gives a passing distance of 15 to 25 metres.

When making the rout for the KayakDrone we entered a waypoint (WP) just before arriving at a turbine (see Figure 18). This was done as wind and drift can cause the kayak to move in a bent line from one WP to the next, especially if there is a long distance between WPs. The extra WPs ensure that the kayak is on the correct track just before it passes the turbine. Further to reduce the damage if something goes wrong and there is a collision, we reduced the speed of the kayak from 5 to 2 knots when passing a turbine.

When picking up the KayakDrone we needed to use the mob-boat of G.O. Sars, given that to get the kayak back on board we needed to get the lifting hook connected to the kayak, and this could only be done from the mob-boat. We therefor needed good weather conditions to use the KayakDrone, something we were blessed with on the 20th of March (Figure 19).

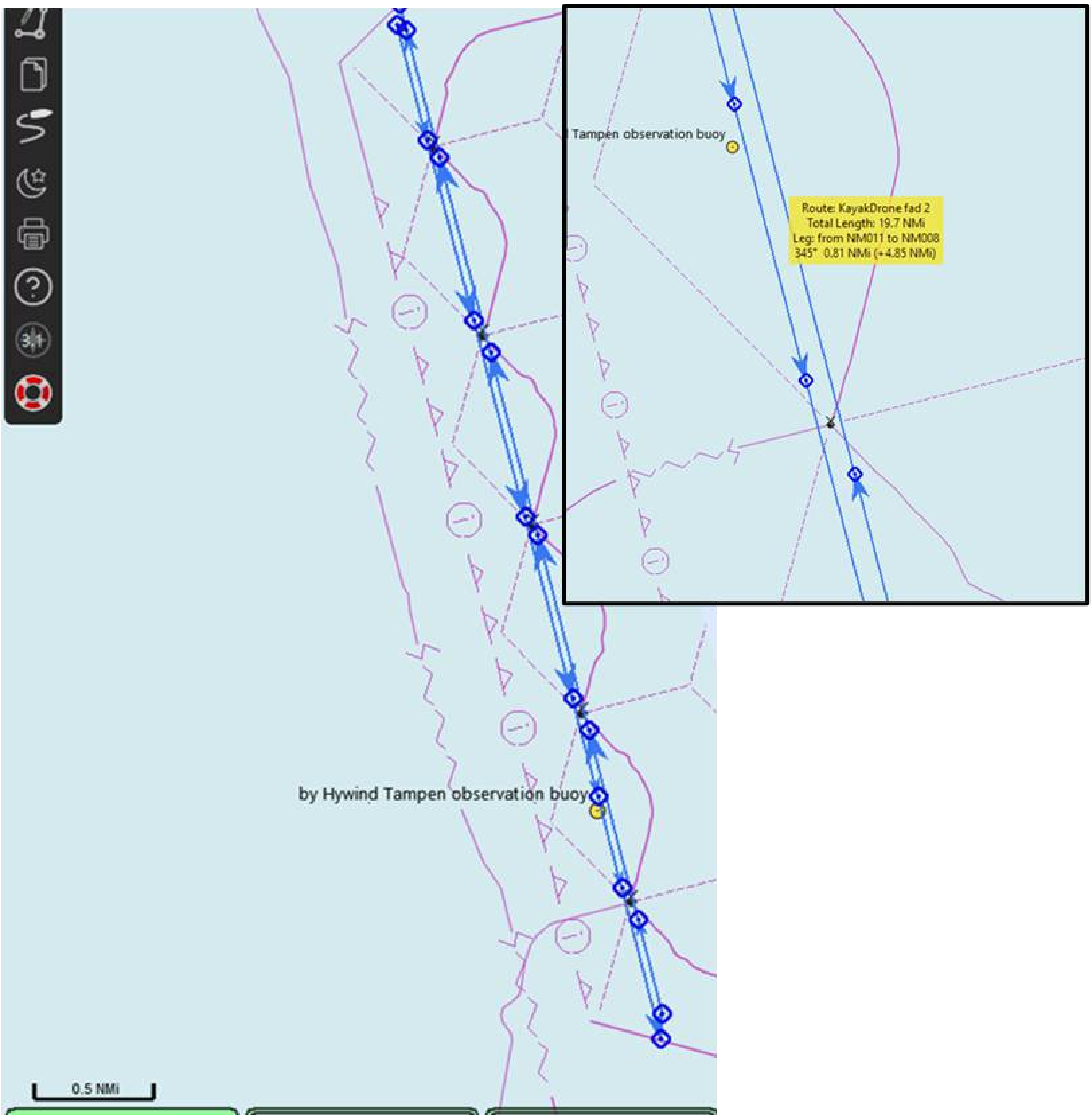


Figure 18. The KayakDrone's acoustic transect, survey design. Where the KayakDrone is to move between and passe by turbine: HY07, HY08, HY09, HY10, and HY11 all standing in one strait line. To the right: A close-up view of the KayakDrone's acoustic transect of the survey design. Blue circles are waypoint where the KayakDrone is repositioning related to the given coordinates in the transect.

Figure 19. Shows the KayakDrone in front of one of the turbines at Hywind Tampen as it is passing ca ca 20 m from the turbine. The KayakDrone is 7 m long so that gives one an idea of how huge these turbines are.

3.4 Bottom studies in Hywind-Tampen

The aim was to gain more knowledge about the effects of floating offshore wind farms on the bottom environment. The wind turbines at Hywind Tampen are secured /strapped to the soft bottom by suction anchors and chains. The anchors, chains and the 90 m deep submerged concrete part of the wind-turbines facilitate a new type of habitat in this softbottom area. A habitat that we expect will be colonised by hard bottom species, resulting in an additional food sources and shelter for higher tropic levels (Lindboom et al 2011) *reef effect* . Causing aggregation and colonisation of species close to the novel substrate. Studies have shown that ecosystem processes and properties can be sensitive to changes generated by OWF installations (Burkhard et al., 2011) and thus alter food webs.

Microbial community and pollutants can be an issue in OWF (Wang et al., 2023). We therefore took core samples at our ROV stations.

ROV activities

Suction anchors and anchor chains: We used a ROV (Figure 20) to study the area around three suction anchors and along their anchor chains for a length of 500 m, if possible, from the anchor position. Correspondingly, we mapped the same distance away from the wind farm area as a control. This was done at three anchor sites: SA06, SA09, SA12 (Figure 21 , for transect coordinates see Table 5). The investigations include video filming of the bottom outside and rounded the three suction anchors and their anchor chains. The area where the chain is mowing on and off the bottom is of particular interest. A sample of the bottom sediment was taken with a small corer from the ROV at each site. We also planned to do a video transect along some pockmarks next to SA12 (line id 13 in Table 5), however, lack of time with good weather conditions limited our ROV study. We chose to prioritise the chain and chain control transects. Furthermore, there was a request for additional 63 ROV stations randomly placed around the wider area to be completed if there was time and with lower priority, but again due to weather conditions these could not be completed.

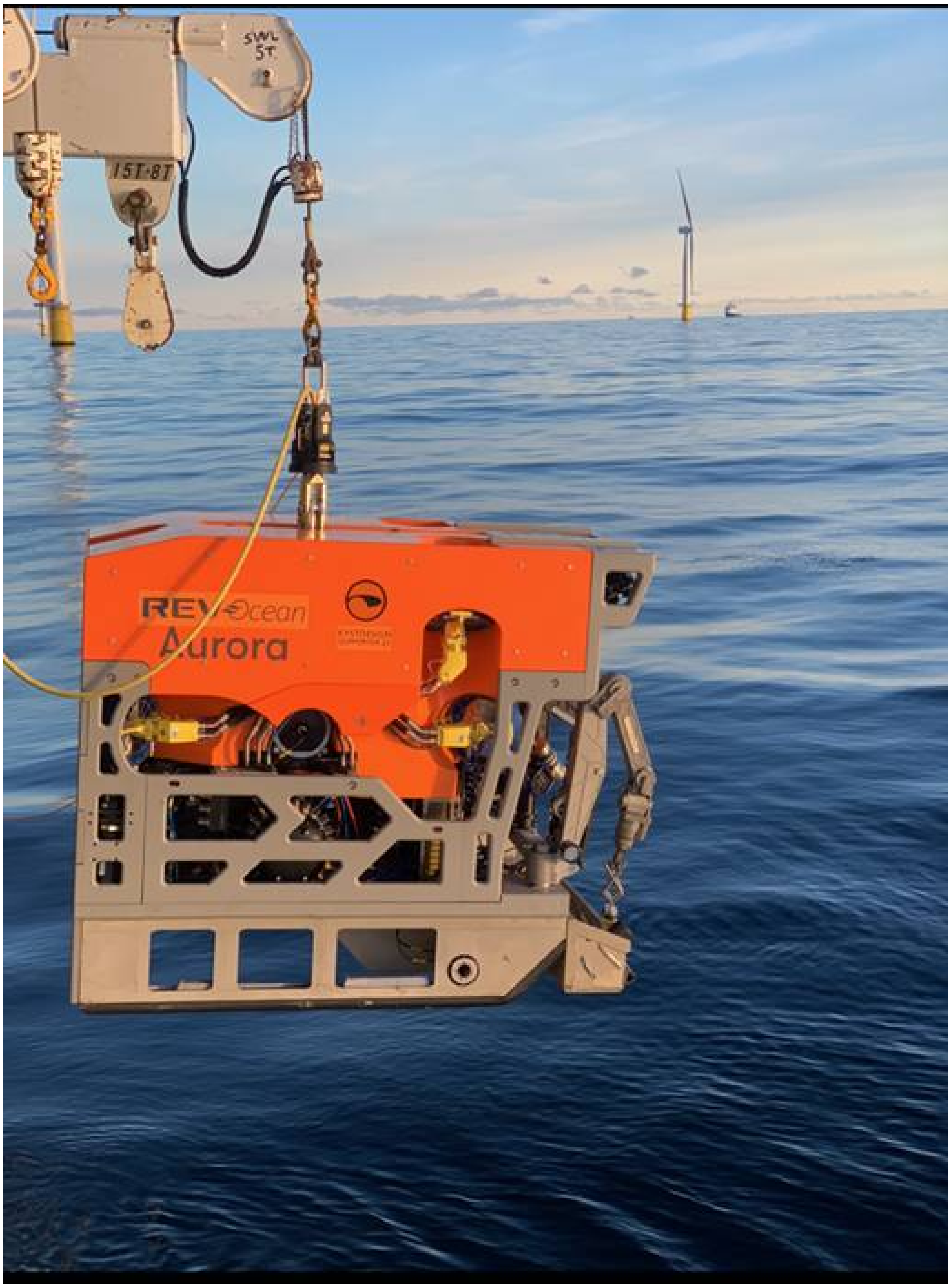


Figure 20. On this survey we used ROV, Aurora, owned and operated by REV Ocean.

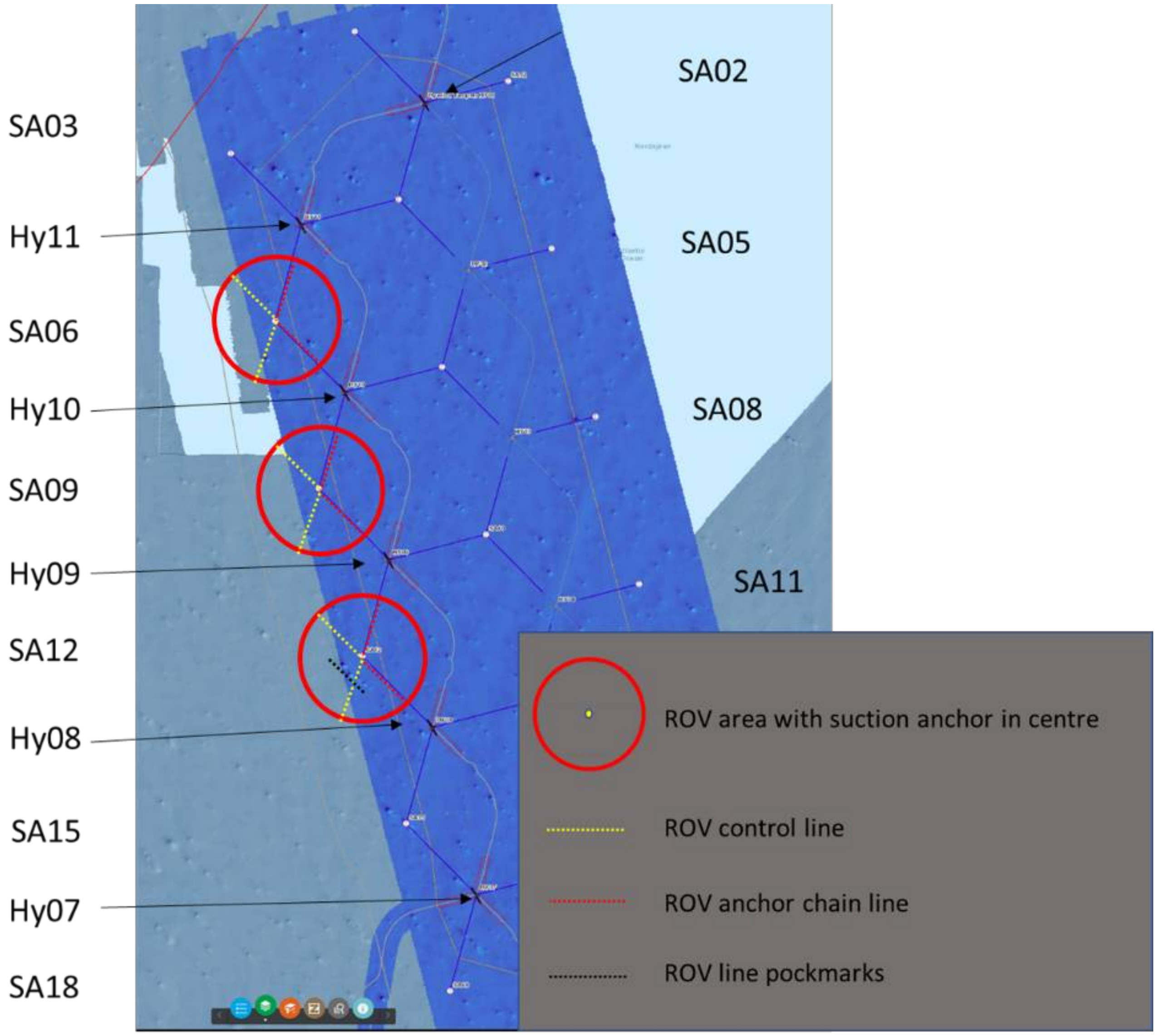


Figure 21. Map of the area. ROV investigations are marked with a red circles and dashed red lines are video lines along the anchor chains. Dashed yellow lines are video control lines. Red ring is 500m in radius. Dashed black line is a video line along some pockmarks.

Table 5. Positions of the ROV stations. Station or line id 13 was across a pockmark, this study was not conducted.

id	Lat	Long	Type	line_id	comments	Lat_Deg	Lat_Decmin	Long_Deg	Long_Decmin
1	61.35263473	2.2208763	ROV line end point	1	accurate enough	61	21.1580838	2	13.252578
2	61.34944191	2.2274465	ROV line end point	1	accurate enough	61	20.9665146	2	13.64679
3	61.35375949	2.2299206	ROV line end point	2	accurate enough	61	21.2255694	2	13.795236
4	61.34942927	2.2274593	ROV line end point	2	accurate enough	61	20.9657562	2	13.647558

id	Lat	Long	Type	line_id	comments	Lat_Deg	Lat_Decmin	Long_Deg	Long_Decmin
5	61.34504478	2.2250276	ROV line end point	3	accurate enough	61	20.7026868	2	13.501656
6	61.34938577	2.2274723	ROV line end point	3	accurate enough	61	20.9631462	2	13.648338
7	61.34619263	2.2340412	ROV line end point	4	accurate enough	61	20.7715578	2	14.042472
8	61.34937505	2.2274882	ROV line end point	4	accurate enough	61	20.962503	2	13.649292
9	61.33957884	2.2279873	ROV line end point	5	accurate enough	61	20.3747304	2	13.679238
10	61.33637235	2.2345517	ROV line end point	5	accurate enough	61	20.182341	2	14.073102
11	61.34070092	2.2370246	ROV line end point	6	accurate enough	61	20.4420552	2	14.221476
12	61.33638374	2.23455	ROV line end point	6	accurate enough	61	20.1830244	2	14.073
13	61.33198798	2.23212	ROV line end point	7	accurate enough	61	19.9192788	2	13.9272
14	61.3363166	2.2345923	ROV line end point	7	accurate enough	61	20.178996	2	14.075538
15	61.3331341	2.2411412	ROV line end point	8	accurate enough	61	19.988046	2	14.468472
16	61.33632953	2.2345799	ROV line end point	8	accurate enough	61	20.1797718	2	14.074794
17	61.32651995	2.2350869	ROV line end point	9	accurate enough	61	19.591197	2	14.105214
18	61.32331441	2.2416445	ROV line end point	9	accurate enough	61	19.3988646	2	14.49867
19	61.32764222	2.2441221	ROV line end point	10	accurate enough	61	19.6585332	2	14.647326
20	61.32332517	2.2416476	ROV line end point	10	accurate enough	61	19.3995102	2	14.498856
21	61.31893016	2.2392128	ROV line end point	11	accurate enough	61	19.1358096	2	14.352768
22	61.32327029	2.241676	ROV line end point	11	accurate enough	61	19.3962174	2	14.50056
23	61.32007517	2.2482353	ROV line end point	12	accurate enough	61	19.2045102	2	14.894118
24	61.32325802	2.2416898	ROV line end point	12	accurate enough	61	19.3954812	2	14.501388
25	61.32070743	2.2431306	ROV line end point	13	intends to cross pockmarks!!	61	19.2424458	2	14.587836

Preliminary results from ROV studies of anchor chains and suction anchors in Hywind Tampen wind farm

(by Anne Kari Sveistrup)

ROV station HT01 (15.03.23 kl 15:17)

Going 500m South-East from SA06 towards HY10, on the anchor chain. The chain never rises from the sea floor, but more traces of chain movement at the last part of the transect. Push core was taken close to the suction anchor (core sample CHT01).

Not much epifauna are seen on the suction anchor.

Gracilechinus (sea urchin) dominating the first part of the transect, with *Spatangus purpureus* (sea urchin), *Parastichopus tremulus* (sea cucumber), *Paguridae* (hermit crab) and *Ditrupa arietina common* (Polychaeta). *Asteroids* (starfish) partly buried in sediment, and species like *Leptasterias muelleri* (starfish) are living on the chain.

Of fishes were Norway pout (*Trisopterus esmarkii*) and silver cod (*Gadiculus argenteus*) most common, but also ling (*Molva molva*), tusk (*Brosme brosme*), saithe (*Pollachius virens*), cod (*Gadus morhua*), greater forkbeard (*Physis blennoides*), bluemouth (*Helicolenus dactylopterus*) and various flatfish were recorded.

Litter, like plastic strips was seen on top of sediment that covered anchor chain.

ROV station HT02 (15.03.23 kl 17:29)

Going North-East from SA06 along the suction anchor chain for only 375m of expected 500, due to chain movements, suspended sediments and low visibility. Push core taken at the end of 375m where sea floor was disturbed by the chain (core sample CHT02). Muddy sand.

At the first part of the transect, we followed the depression from the chain. The chain is visible, and gradually ascending from the sediments a way into the transect. Crustaceans like hermit crabs (*Paguridae*), squat lobsters (*Munida* sp.), and crabs (*Brachyura*) together with tusk (*Brosme brosme*) and ling (*Molva molva*) are hiding in and under the chain. Different starfish and a few gastropods are living on the chain. Around in the sediments small echinoids/sea urchin (*Gracilechinus acutus*) and hermit crabs are most common. Both hermit crabs living in empty gastropod shells (*Pagurus pubescens* and *P. alatus*) and in *Suberites* sp. sponge (*Pagurus bernhardus*) were observed. For a part of the transect there was a clear difference in numbers of small sea urchins (*Gracilechinus* sp.) on each side of the chain, with the highest number on the western side. Buried starfish, brittle stars, sea urchin (*Spatangus purpureus*) and sea cucumbers (*Parastichopus tremulus*, *Bathyplotes natans* and *Mesothuria intestinalis*) were seen along the transect.

Norway pout (*Trisopterus esmarkii*), silver cod (*Gadiculus argenteus*), greater forkbeard (*Phycis blennoides*), tusk (*Brosme brosme*) and ling (*Molva molva*) and various flatfish are spotted throughout the transect. Saithe (*Pollachius virens*) were following and feeding in the light from the ROV.

Fucus fragments were lying in the depression from the chain, so were plastic strips.

ROV station HT03 (19.03.23 kl 15:06)

Control transect starting from suction anchor SA06, going North-West for 500m off the chain. The first 50 m we were a bit off the line. Flat area.

Muddy sand with some burrows. Small sea urchin of genus *Gracilechinus* sp. dominating the whole line, but also some *Spatangus purpureus* (sea urchin) here and there. Various *Asteroidea* (starfish) including *Luidia sarsii*, *Pontaster tenuispinus* and *Pseudarchaster parelii*. *Paguridae* (hermit crabs), *Parastichopus tremulus* (sea cucumber), *Ditrupa arietina* (“sjøtann”, Polychaeta), and a few polychaeta tubes were also spotted on the way.

Dogfish (*Galeus melastomus*), ling and tusk around suction anchor. Flatfish (*Glyptocephalus*), Norway pout (*Trisopterus esmarkii*), silver cod (*Gadiculus argenteus*), were common along the transect. Three dogfish (*Galeus melastomus*) seen in total. A few saith (*Pollachius virens*) attracted by light, but mostly following behind us, also that in the light.

Taking a core (core sample CHT03) and picking up an Asteroidea at the end of the line, later identified as *Pseudarchaster parelii* up on deck.

Going back to suction anchor for next control transect.

ROV station HT 04 (19.03.23 kl 17:28)

Control transect, a 500 m transect going from suction anchor, SA06 South West off the chain.

We are hanging and filming the anchor before taking the transect. A tusk (*Brosme brosme*) has the tail of a shark hanging out its mouth. Ling (*Molva molva*) and saith (*Pollachius virens*) also moving around at the anchor site. Hydrozoa, Gastropoda, Asteroidea including *Porania pulvillus* and *Leptasterias muelleri*, living on the anchor.

Muddy sand mostly. Area with some gravel on muddy sand in the middle of the transect.

Small sea urchins (*Gracilechinus*) dominating, with *Spatangus purpureus* regularly. Various *Asteroidea* (starfish), *Paguridae* (hermit crabs), sea cucumber (*Parastichopus tremulus*), polychaeta (*Ditrupa arietina*) were also common.

A shoal of saith (*Pollachius virens*) followed the ROV, stirring up sediment and disturbing the vision.

Ling (*Molva molva*), tusk (*Brosme brosme*), blue mouth (*Helicolenus dactylopterus*), flatfish (*Glyptocephalus synoglossus*) were some of the fish species recorded.

No core sample.

Moving to HT 05, passing the Hydrophone.

ROV station HT05 (19,03.23 kl 19:20)

Control transect, starting in North West moving South East 500m off the chain towards the suction anchor, SA09.

Muddy sand with some burrows.

Small sea urchins (*Gracilechinus* sp.) dominating the transect with some *Spatangus purpureus* here and there. Shoal of saith (*Pollachius virens*) following and stirring up sediments disturbing the vision. A ling (*Molva molva*) forage together with saithe.

Along the transect we observe sea cucumber (*Parastichopus tremulus*), hermit crab (*Pagurus* sp.), polychaeta (*Ditrupa arietina*), ray-finned flatfish (*Pleuronectiformes*), various Asteroidea, gastropod (*Neptunea antigua*) and a couple of blue mouth (*Helicolenus dactylopterus*).

Filming a still sequence at the suction anchor. Many ling (*Molva molva*) and tusk (*Brosme brosme*) hiding in the anchor and swimming around it. Hydrozoans growing on the anchor.

Core is taken at anchor site (core sample CHT05).

ROV station HT06 (19.03.23 kl 20:17)

Starting from the suction anchor SA09, continuing South-East on the anchor chain.

Filming the suction anchor. Ling (*Molva molva*), tusk (*Brosme brosme*) and saithe (*Pollachius virens*) swimming around. Muddy sand.

The shoal of saithe (*Pollachius virens*) following is smaller here compared to last transect off the chain. Sea urchins (*Gracilechinus* sp. and *Spatangus purpureus*), sea cucumber (*Parastichopus tremulus*) and hermit crabs (*Pagurus* sp.) are common. Forkbeard (*Phycis blennoides*), hermit crabs (*Paguridae*), squat lobsters (*Munida* sp.) living under the chain, *Leptasterias* sp. and other asteroids living on the chain as well.

Stopping the transect at 447 into the line since chain rises from the sea floor. Not safe for the ROV to move on. No core sample.

ROV station HT07 (19.03.23 kl 21:50)

Control transect in North-East direction 500 m off chain towards suction anchor SA09.

A big Shoal of saithe (*Pollachius virens*) following ROV, stirring up sediments and disturbing the vision.

Bottom depression in the beginning of the transect. Main sediment type - muddy sand. Some shell fragments, pebbles, lots of burrows. Flat bottom. Not much variety. Small sea urchins (*Gracilechinus* sp.) dominating.

Fish species observed along the transect; saithe (*Pollachius virens*), pearlfish (*Echiodon drummondi*), blue mouth (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*), witch flounder (*Glyptocephalus cynoglossus*). Sea cucumber (*Parastichopus tremulus*), shrimp (*Caridea*), starfish (*Asteroidea*), polychaeta (*Ditrupa arietina*), hermit crabs (*Paguridae*).

Suction anchor at the end of the transect, with ling (Molva molva) around and on the anchor.

No core sample.

ROV station HT08 (19.03.23 kl 22:30)

Transect from suction anchor, SA09, 460 m on chain North-East direction towards Hy10. Transect was stopped where chain rises from the sea floor. We then moved back a few meters, at safe distance from rising chain, for taking a push core (core sample CHT08). Sandy sediments disturbed by whipping chain makes it hard to push down the core, with just a few cm sediments in the core as a result. Muddy sand.

Along the transect, saithe (*Pollachius virens*) seem to keep a distance to the chain as we go, especially at the first part of the transect. Then foraging more eagerly at the last part.

Life is more diverse and abundant in and on the chain, compared to the transect off the chain, with species of squat lobster (*Munida* sp.), hermit crab (*Pagurus* sp.), crab (*Brachyura*), various Asteroidea, Gastropoda (*Prosobranchia*) and fishes like ling (*Molva molva*), greater forkbeard (*Phycis blennoides*) and tusk (*Brosme brosme*).

Sea urchin (*Gracilechinus* sp. and *Spatangus purpureus*), polychaeta (*Ditrupa arietina*), sea cucumber (*Mesothuria intestinalis* and *Parastichopus tremulus*) and starfish *Porania* sp. are spotted in the sand. Various flatfish, “vassild” smelt (*Argentina silus*) and Norway pout (*Trisopterus esmarkii*) are also recorded.

ROV station HT09 (20.03.23 kl 17:43)

Transect 500 m on chain in South-East direction from anchor SA12. Muddy sand over whole transect. Some shell fragments. Push core CHT09 is taken at the beginning and HT09b at the end of the transect. Core

CHT09b - harder sediments, sand mostly. The transect is stopped 470 meters from the suction anchor. Core CHT09b was drained at the surface, not kept – but sediment frozen if later examining is of interest. Fine sand with a small proportion of mud.

“Kolmule” blue whiting (*Micromesistius poutassou*) was observed before recording was started. (Recorded in backup). Ling (*Molva molva*) and tusk (*Brosme brosme*) around suction anchor. “Rur” barnacles (*Balanoidea*) and Hydroidea are epifauna on anchor. Brittle star (*Ophiuroidea*) was collected by the ROV manipulator and identified as Ophiura albida later on deck.

Diversity is higher at first half of the transect. A smaller shoal of saithe (*Pollachius virens*), especially in the beginning. Foraminifera sand amoeba, polychaeta (*Ditrupa arietina*), crustacean amphipod (*Siphonoecetes* sp.), bivalve (*Astarte* sp. and *Abra* sp.) empty shells. Sea urchin (*Gracilechinus* sp.) along the whole transect, *Spatangus* sp., *Ophiuroidea* sp., *Pseudarchaster* sp., *Pontaster* sp. as well as other different Asteroidea species. Fish observed were ling (*Molva molva*) and tusk (*Brosme brosme*) from time to time along the whole transect, greater forkbeard (*Phycis blennoides*), blue mouth (*Helicolenus dactylopterus*), ray-finned flatfish (*Pleuronectiformes* sp.), silver cod (*Gadiculus argenteus*), Norway pout (*Trisopterus esmarkii*). Hermit crab, (*Pagurus* sp.), with houses of sponges (*Suberites* sp.), sea cucumber (*Parastichopus tremulus*), squat lobster (*Munida* sp.), gastropod (*Colus* sp.), shrimp (*Caridea*), sea anemone (*Bolocera tuediae*).

We stopped to film an anglerfish (*Lophius* sp.) that was lying on the side of the chain, fishing for prey. As well as a long, fish / dolphin skeleton.

ROV station HT10 (20.03.23 kl 20:02)

Control transect starting from suction anchor going North-West for 500 meters off the chain.

Ling (*Molva molva*) and tusk (*Brosme brosme*) close to anchor, outnumbered by saithe (*Pollachius virens*) as we start moving. A big shoal of saithe following throughout the transect, stirring up the sediments.

Sea urchins (*Gracilechinus* sp)., polychaeta (*Ditrupa arietina*) and brittle stars (*Ophiuroidea*) dominating, with sea urchin (*Spatangus* sp.), sea cucumber (*Parastichopus tremulus*), hermit crabs (*Paguridae*), shrimps, gastropods and various Ateroidea less abundant.

Flounder (*Glyptocephalus cynoglossus*), smelt (*Argentina* sp.) and ling (*Molva molva*) also along the transect. Dogfish (*Galeus melastomus*) was close to being eaten by saithe.

Taking a core in North-West, 500 meters away from suction anchor SA12 (corer sample CHT10).

ROV station HT11 (20.03.23 kl 22:08)

Control transect, starting in South-West, going 500 meters towards suction anchor SA12, North East direction off chain. Muddy sand with some shell fragments and burrows.

Shoal of saithe (*Pollachius virens*) messing the sediments swimming in front of the ROV. Ling (*Molva molva*), tusk (*Brosme brosme*), sea urchin (*Spatangus* sp. and *Gracilechinus* sp.), different starfish (*Asteroidea*), brittle stars (*Ophiuroidea*), polychaeta (*Ditrupa arietina*), shrimp (*Caridea*) and sea cucumber (*Parastichopus tremulus*). Poor diversity transect.

ROV station HT12 (20.03.23 kl 22:44)

Starting from suction anchor SA12 going North-East for 442 meters on chain, till the chain were rising from the sea floor.

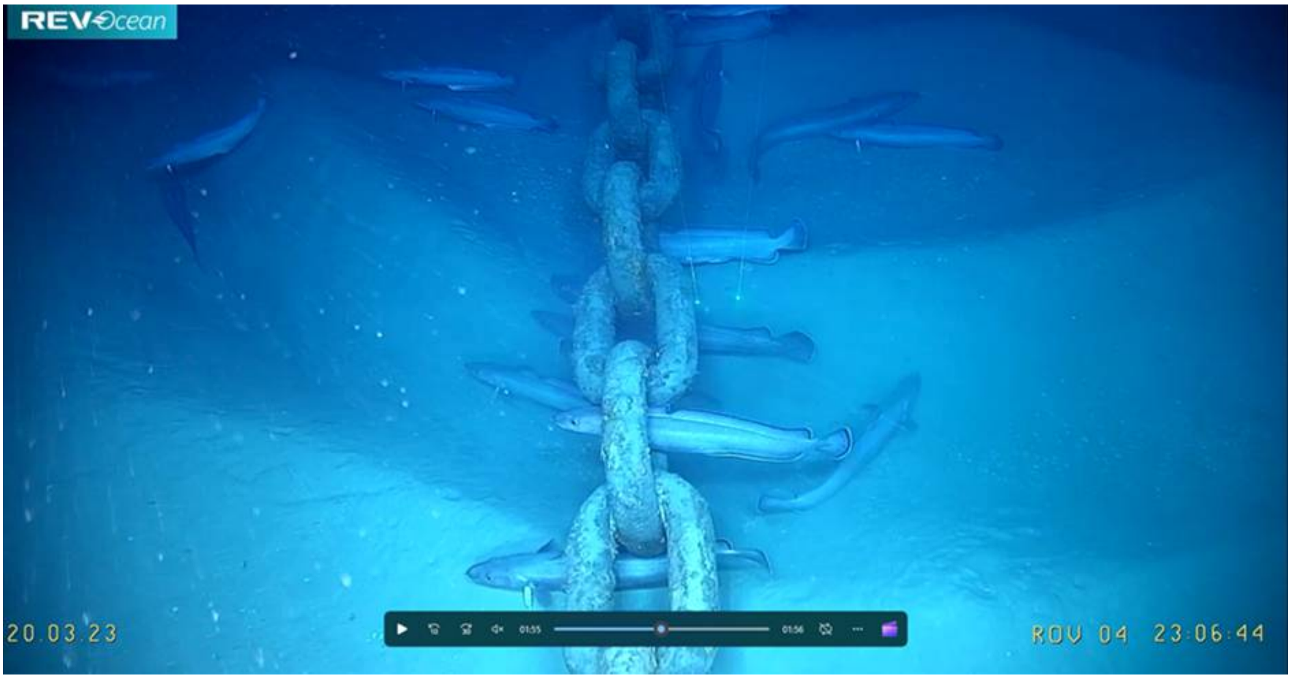
Saithe (*Pollachius virens*) slowly get fewer and disappear along the chain. Dense aggregation of ling (*Molva*

molva) in the middle of transect, where many of them lay under, on the side or inside the chain.

Trace of something under sediments with tracks around it - old trawl mark or traces from chain.

Sea urchin (*Gracilechinus* sp.) and various starfish (*Asteroidea*) very common both in the sediments and on the chain. “Rur” barnacles (*Balanoidea*) growing on the chain. Hermit crabs (*Paguridae*), squat lobster (*Munida* sp.), sea cucumber (*Parastichopus tremulus*) and shrimps (*Caridea*) common.

Inside the safety zone, 500m from the turbine, whipping marks from the chain get stronger and epibenthos less abundant. Transect stopped where the chain rises from the bottom. Various litter.



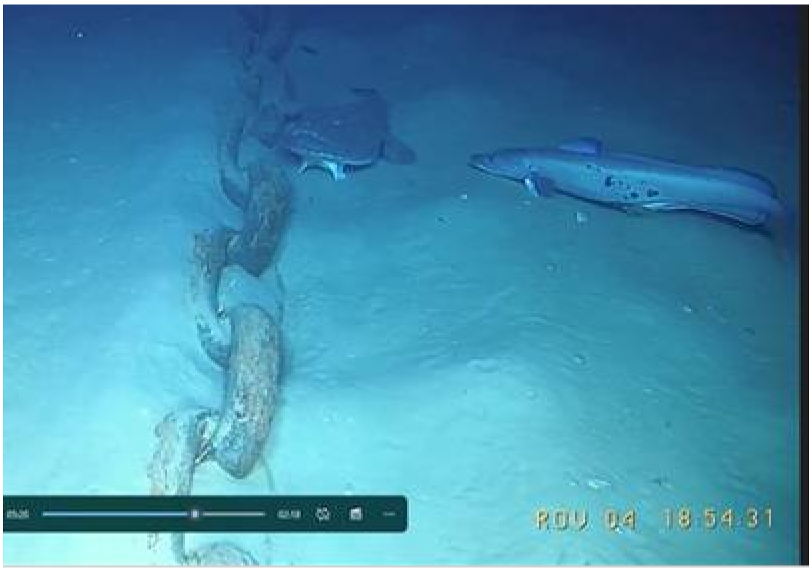


Figure 22. Ling, Molva molva. Top: picture taken from ROV video showing ling "hiding" in the anchor chain. Two pictures at the bottom: examples of ling with black spots, unknown to us what this is.

Total area

It appears to be sandier sediments in the south compared to northern anchor – not confirmed. Several sea cucumbers (*Parastichopus tremulus*) in the area were seen in bad condition, partly colored black. Many l ing (*Mova molva*) were also observed with black spots (Figure 22). Next time we need to take tissue samples from these ling to find out what it is.

Core samples

I addition to the transects ten Push core samples were taken during the inspection of the anchors and chains.

Table 6. Push Core samples taken during the 12 ROV transects. No core was taken on transect HT04, HT06 or HT07. Two corers were taken on HT09 (CHT09a and CHT09b). For positions are given in the campodlogger.

Core on transect #	Core sample #	Saple location
HT01	CHT01	at suction anchor SA6
HT02	CHT02	375m north-east of SA06 on chain
HT03	CHT03	500m north-west of SA06 off chain
HT05	CHT05	at suction anchor SA09
HT08	CHT08	460 m north-east of SA09 on chain
HY09	CHT09a	suction anchor SA12

Core on transect #	Core sample #	Saple location
HY09	CHT09b	470m south-east of SA12 on chain – drained, some sediments frozen in alu. foil
HT10	CHT10	500m north-west of SA12 off chain

3.5 eDNA

A simple way of sampling what animals are present in an area is by extracting eDNA from water samples. First, we sampled the location of the 7 gillnet stations from the fisheries survey cruise conducted in March 2022 and 2023 (Figure 11). Sampling locations were a bit north of the gillnet fishing locations, but at the same distance to the windfarm (0.27, 0.54, 1.08, 2.27, 5.4, 10.8 and 18.9 nm from turbines in a South-West direction to the U.K. border).

From each station, we sampled 2x 5 litre water from three depths: surface, pycnocline and bottom. Depth of the surface sample ca. 10 m, bottom sample ca. 10 m above the bottom. Before sampling water, we took a CTD haul to find the pycnocline. In total for the fisheries transect we took 42 samples (7 stations 6 samples).

In between every station we took a air control sample (control). Air control sample was done by pumping just the air after sampling, and pumping some of the fresh water that is used to flush the buckets.

Further we sampled eDNA at the 15 CTD stations in the acoustic flower transect around the windfarm (Figure 15). Here we took only eDNA at the pycnocline, to save some samples. While for the three CTD stations inside the park (Figure 13), we took eDNA et surface pycnocline and at 30 m above bottom. Due to windfarm structure on the bottom we were not allowed to sample closer than 30 m to the seafloor.

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5 Abbreviation and word explanation

ADCP: is an Acoustic Doppler Current Profiler. It is a hydroacoustic current meter similar to a sonar, used to measure water current velocities over a depth range using the Doppler effect of sound waves scattered back from particles within the water column.

Acoustic releaser: is for the deployment and subsequent recovery of instrumentation from the sea floor, in which the recovery is triggered remotely by an acoustic command signal.

CTD: is an oceanography instrument used to measure the electrical conductivity, temperature, and pressure of seawater. Conductivity is used to determine salinity and depth is calculated from pressure.

eDNA or Environmental DNA is DNA that is collected from a variety of environmental samples such as soil, seawater, snow or air, rather than directly sampled from an individual organism. As various organisms interact with the environment, DNA is expelled and accumulates in their surroundings.

Hydrophone: is a microphone designed to be used underwater for recording or listening to underwater sound. Most hydrophones are based on a piezoelectric transducer that generates an electric potential when subjected to a pressure change, such as a sound wave.

LSSS: Large Scale Survey System (LSSS) (pronounced "L-triple-S"). A software product for the interpretation of data from multi-frequency echo sounders. For more details see: https://www.kongsberg.com/maritime/products/ocean-science/ocean-science/scientific-post-processing-applications/large-scale-survey-system-lsss/

Multi-frequency echosounder: Recent research has shown that simultaneous use of several discrete echo sounder frequencies (multifrequency) not only improves fish stock estimates but can also be used to identify species. This is because each specie has a unique acoustic frequency response. This new and growing understanding greatly improves the value of hydroacoustics to obtain information about marine resources. For more information see: https://www.kongsberg.com/maritime/support/themes/simrad-content-s/scientific-applications/multifrequency-echo-sounder-operation/

ROV: stands for remote operating vehicle. ROVs are unmanned, highly manoeuvrable underwater machines that can be used to explore ocean depths while being operated by someone at the water surface. For more details see: https://www.revocean.org/vessel/rov/

DeepVision: is a camera system that is mounted at the cod-end entrance of the trawl. Here it takes pictures of the catch as it passes through the trawl. It is used to sample fish without having to land or injure the fish, as the fish passes through the open trawl cod-end. For more details see: https://www.deepvision.no/deep-vision-for-marine-research

6 Appendix

Table of all activities (station type) during the cruise. Giving date time location, station number, water depth speed of vessel, water temperature (Celsius), wind speed (m/s) and - direction and air temperature (Celsisus).

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
Pelagic trawl start - test	14.mar	12:17:32	51	6038.390271 N	00453.062923 E	219,16	2,8	6,6	
Pelagic trawl stop - test	14.mar	12:24:43	51	6038.675625 N	00452.684602 E	171,79	3	6,7	10,
ADCP2	14.mar	23:59:39	8	6115.384594 N	00217.350361 E	255,41	0,1	6,9	4,7
ADCP3	15.mar	01:26:53	9	6123.367720 N	00220.045226 E	317,21	0,3	6,5	5,9
ADCP5	15.mar	02:37:13	10	6122.133859 N	00210.887600 E	289,66	0	6,5	10
ADCP4	15.mar	03:55:06	11	6120.734480 N	00213.610215 E	288,42	0	6,5	8,4
Hydrophone	15.mar	06:28:27	12	6120.559786 N	00213.665359 E	286,31	0,1	6,5	5,7
ADCP1	15.mar	09:02:00	13	6120.788888 N	00215.610641 E	292,52	0	6,5	3,4
CTD start (to get desity measures for acoustic contact (HIPAP))	15.mar	13:01:53	175	6120.837544 N	00213.902110 E	288,51	0	6,7	5,4
CTD stop	15.mar	13:14:03	175	6120.836933 N	00213.901548 E	288,71	0,1	6,7	5,4

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
ROV SA06 chain mot HY11 station start	15.mar	15:14:37	1	6120.961592 N	00213.652568 E	287,49	0	6,7	5,8
ROV SA06 chain mot HY11 station stop	15.mar	16:27:48	1	6120.832271 N	00213.880689 E	289,15	0,1	6,8	6,7
ROV SA06 chain mot HY10 station start	15.mar	17:27:12	2	6120.954294 N	00213.615696 E	289,67	0,1	6,8	
ROV SA06 chain mot HY10 station stop	15.mar	18:09:26	2	6121.137264 N	00213.712688 E	289,81	0	6,8	9,5
CTD fisheries transect eDNA with watersample start	17.mar	19:58:28	176	6108.118027 N	00151.703662 E	141,89	0,3	7,9	10,
CTD fisheries transect eDNA with watersample stop	17.mar	20:15:27	176	6108.118308 N	00151.705917 E	141,97	0	7,9	11,
CTD fisheries transect nutrients with watersample start	17.mar	20:15:59	177	6108.119281 N	00151.705251 E	142,17	0,1	7,9	12

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD fisheries transect nutrients with watersample stop	17.mar	20:23:15	177	6108.119938 N	00151.706716 E	142,11	0,1	7,9	10,
Course change	17.mar	20:50:10	14	6111.109933 N	00149.573986 E	146	6,7	8,1	7,5
Course change	17.mar	21:19:19	15	6113.794628 N	00156.147007 E	144,9	8	8,2	11
CTD fisheries transect eDNA with watersample start	17.mar	22:27:25	178	6112.054326 N	00159.364024 E	142,47	0	8,1	6,8
CTD fisheries transect eDNA with watersample stop	17.mar	22:36:59	178	6112.054064 N	00159.365539 E	142,58	0	8,1	7,8
CTD fisheries transect nutrients with watersample start	17.mar	22:42:51	179	6112.052574 N	00159.366970 E	142,87	0,2	8,1	7,2
CTD fisheries transect nutrients with watersample stop	17.mar	22:50:08	179	6112.054332 N	00159.364997 E	142,37	0	8,1	8,2

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
Course change	17.mar	23:20:04	16	6113.804285 N	00156.161666 E	144,62	5,2	8,3	7,7
Course change	18.mar	00:01:37	17	6115.803830 N	00200.897931 E	142,45	4,3	7,8	7,7
CTD fisheries transect eDNA with watersample start	18.mar	00:32:28	180	6113.987372 N	00203.139694 E	139,82	0	8,3	9,7
CTD fisheries transect eDNA with watersample stop	18.mar	00:40:58	180	6113.987273 N	00203.139979 E	140,23	0	8,3	8,6
CTD fisheries transect nutrients with watersample start	18.mar	00:48:28	181	6113.995137 N	00203.176828 E	140,55	0,1	8,2	7,7
CTD fisheries transect nutrients with watersample stop	18.mar	00:56:20	181	6113.995978 N	00203.177807 E	139,91	0,1	8,3	7
Course change	18.mar	01:25:03	18	6115.775937 N	00200.845707 E	142,18	3,1	7,8	9,8
Course change	18.mar	02:13:53	19	6119.043006 N	00208.700660 E	256,24	7,2	7,2	9,5

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD fisheries transect eDNA with watersample start	18.mar	02:35:02	182	6117.907580 N	00210.877270 E	252,49	0	7,2	8,1
CTD fisheries transect eDNA with watersample stop	18.mar	02:47:08	182	6117.907995 N	00210.876245 E	253,47	0,1	7,1	7
CTD fisheries transect nutrients with watersample start	18.mar	02:55:18	183	6117.906673 N	00210.877657 E	252,49	0	7,1	8,5
CTD fisheries transect nutrients with watersample stop	18.mar	03:06:45	183	6117.908910 N	00210.878116 E	253,06	0	7,1	5,6
Course change	18.mar	03:22:27	20	6119.037658 N	00208.608589 E	257,37	4,8	7,2	7,9
Course change	18.mar	03:36:45	21	6120.132640 N	00211.292464 E	281,58	7,6	7,2	7,2
CTD fisheries transect eDNA with watersample start	18.mar	04:00:18	184	6119.070333 N	00213.199505 E	278,02	0,2	6,9	8,3

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD fisheries transect eDNA with watersample stop	18.mar	04:14:03	184	6119.070709 N	00213.200761 E	277,61	0,2	6,9	9,7
CTD fisheries transect nutrients with watersample start	18.mar	04:24:55	185	6119.070351 N	00213.200284 E	277,49	0,1	6,9	6,9
CTD fisheries transect nutrients with watersample stop	18.mar	04:36:31	185	6119.069946 N	00213.199586 E	277,33	0,1	6,9	7,1
CTD fisheries transect eDNA with watersample start	18.mar	05:11:21	186	6119.456174 N	00213.975773 E	281,23	0	7	8,7
CTD fisheries transect eDNA with watersample stop	18.mar	05:23:56	186	6119.456634 N	00213.974355 E	280,66	0,1	7	9,8
CTD fisheries transect nutrients with watersample start	18.mar	05:34:07	187	6119.456058 N	00213.975964 E	280,89	0	7	6,6

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD fisheries transect nutrients with watersample stop	18.mar	05:45:49	187	6119.456673 N	00213.975967 E	281,32	0	7	7,4
CTD fisheries transect eDNA with watersample start	18.mar	06:21:37	188	6119.634717 N	00214.336195 E	283,97	0	6,8	8,5
CTD fisheries transect eDNA with watersample stop	18.mar	06:34:15	188	6119.634552 N	00214.334925 E	283,59	0	6,8	8,8
CTD fisheries transect nutrients with watersample start	18.mar	07:22:39	189	6119.634913 N	00214.335148 E	283,72	0,1	6,8	9,5
CTD fisheries transect nutrients with watersample stop	18.mar	07:35:35	189	6119.633954 N	00214.335273 E	283,41	0,1	6,8	9,9
Course change	18.mar	09:11:56	22	6121.275744 N	00212.016649 E	287,9	7,5	6,9	8,4
Pelagic trawl start - flower	18.mar	11:00:22	52	6118.906938 N	00209.461550 E	257,9	2,8	7,1	9,6

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
Pelagic trawl stop - flower	18.mar	11:15:41	52	6118.468899 N	00210.531427 E	259,8	2,7	7,2	
Pelagic trawl start - flower	18.mar	12:46:14	53	6118.856754 N	00210.853541 E	264,36	2,7	7,2	6,7
Pelagic trawl stop - flower	18.mar	13:03:16	53	6118.140940 N	00211.248739 E	257,83	2,1	7,3	6,5
Pelagic trawl start - flower	18.mar	14:47:06	54	6118.547661 N	00210.852752 E	260,63	2,2	7,3	8,6
Pelagic trawl stop - flower	18.mar	15:02:09	54	6117.934260 N	00211.049154 E	253,14	2,4	7,4	7
Pelagic trawl start - flower	18.mar	17:53:15	55	6115.504060 N	00219.667006 E	265,43	2,6	7,4	11,
Pelagic trawl stop - flower	18.mar	18:08:19	55	6114.970377 N	00220.485965 E	265,45	2,6	7,4	10,
CTD eDNA transekt HY06 with watersample start	18.mar	20:18:57	190	6114.772582 N	00226.166298 E	281,82	0,6	6,9	9,4
CTD eDNA transekt HY06 with watersample stop	18.mar	20:29:43	190	6114.774618 N	00226.175016 E	281,74	0	6,9	7,2
CTD nutrient transekt HY06 with watersample start	18.mar	20:32:50	191	6114.774381 N	00226.175745 E	281,9	0	6,9	7,4

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD nutrient transekt HY06 with watersample stop	18.mar	20:44:26	191	6114.774863 N	00226.176016 E	282,01	0	6,9	6,7
CTD eDNA transekt HY06 with watersample start	18.mar	21:15:14	192	6116.458066 N	00221.675233 E	280,01	0,1	7,1	5,6
CTD eDNA transekt HY06 with watersample stop	18.mar	21:22:53	192	6116.459365 N	00221.674389 E	279,72	0	7,1	6,2
CTD nutrient transekt HY06 with watersample start	18.mar	21:28:48	193	6116.459778 N	00221.674130 E	280,03	0,1	7,1	5,8
CTD nutrient transekt HY06 with watersample stop	18.mar	21:40:47	193	6116.458926 N	00221.674133 E	279,96	0	7,1	5,7
CTD eDNA transekt HY06 with watersample start	18.mar	22:05:36	194	6117.411652 N	00219.030206 E	281,3	0	7,1	5,9
CTD eDNA transekt HY06 with watersample stop	18.mar	22:13:17	194	6117.420981 N	00219.025799 E	281,56	0	7,1	7

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD nutrient transekt HY06 with watersample start	18.mar	22:18:04	195	6117.421407 N	00219.025900 E	281,59	0,1	7,1	6,2
CTD nutrient transekt HY06 with watersample stop	18.mar	22:29:08	195	6117.421189 N	00219.026631 E	281,63	0,1	7,1	5,5
CTD eDNA transekt HY06 with watersample start	18.mar	22:53:57	196	6117.686116 N	00218.029564 E	278,76	0,9	7,1	6,2
CTD eDNA transekt HY06 with watersample stop	18.mar	23:02:01	196	6117.690517 N	00218.013505 E	278,85	0	7,1	6,7
CTD nutrient transekt HY06 with watersample start	18.mar	23:06:36	197	6117.690453 N	00218.014096 E	279,02	0	7,1	7
CTD nutrient transekt HY06 with watersample stop	18.mar	23:18:03	197	6117.690364 N	00218.014236 E	278,81	0	7,1	6,8
CTD eDNA transekt HY06 with watersample start	18.mar	23:30:07	198	6117.787120 N	00217.662765 E	280,71	0	7,2	7

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD eDNA transekt HY06 with watersample stop	18.mar	23:38:03	198	6117.787010 N	00217.665903 E	280,51	0,1	7,2	7,7
CTD nutrient transekt HY06 with watersample start	18.mar	23:45:19	199	6117.786357 N	00217.665589 E	280,46	0	7,2	7,5
CTD nutrient transekt HY06 with watersample stop	18.mar	23:57:00	199	6117.786752 N	00217.665160 E	280,49	0	7,2	6,5
CTD eDNA transekt HY04 with watersample start	19.mar	00:55:10	200	6121.358036 N	00227.243917 E	326,51	0	6,8	8,9
CTD eDNA transekt HY04 with watersample stop	19.mar	01:03:30	200	6121.358509 N	00227.242566 E	326,42	0	6,8	7,5
CTD nutrient transekt HY04 with watersample start	19.mar	01:08:02	201	6121.357606 N	00227.240737 E	326,13	0	6,8	
CTD nutrient transekt HY04 with watersample stop	19.mar	01:20:31	201	6121.358361 N	00227.241945 E	326,24	0,1	6,8	

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD eDNA transekt HY04 with watersample start	19.mar	01:48:45	202	6120.736172 N	00222.166181 E	307,2	0	6,6	8,4
CTD eDNA transekt HY04 with watersample stop	19.mar	01:58:23	202	6120.736231 N	00222.167706 E	307,03	0	6,6	8,6
CTD nutrient transekt HY04 with watersample start	19.mar	02:09:08	203	6120.736784 N	00222.168372 E	307,46	0	6,6	8,9
CTD nutrient transekt HY04 with watersample stop	19.mar	02:21:20	203	6120.736758 N	00222.167760 E	307,44	0	6,6	8,2
CTD eDNA transekt HY04 with watersample start	19.mar	02:47:05	204	6120.284935 N	00218.608727 E	295,65	0,1	6,7	11,
CTD eDNA transekt HY04 with watersample stop	19.mar	02:56:48	204	6120.286651 N	00218.608489 E	295,89	0	6,7	13
CTD nutrient transekt HY04 with watersample start	19.mar	03:05:12	205	6120.286450 N	00218.609403 E	295,89	0	6,8	11,

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD nutrient transekt HY04 with watersample stop	19.mar	03:17:04	205	6120.285928 N	00218.607672 E	295,93	0	6,8	10,
CTD eDNA transekt HY04 with watersample start	19.mar	03:35:05	206	6120.141183 N	00217.558965 E	293,84	0	6,9	13,
CTD eDNA transekt HY04 with watersample stop	19.mar	03:47:22	206	6120.142023 N	00217.562051 E	293,74	0	7	
CTD nutrient transekt HY04 with watersample start	19.mar	04:04:39	207	6120.141869 N	00217.562359 E	293,9	0	7	12,
CTD nutrient transekt HY04 with watersample stop	19.mar	04:28:06	207	6120.141522 N	00217.562769 E	294,1	0	7,1	12,
CTD eDNA transekt HY04 with watersample start	19.mar	04:43:52	208	6120.096329 N	00217.152542 E	291,99	0,1	7,1	12,
CTD eDNA transekt HY04 with watersample stop	19.mar	04:57:31	208	6120.096017 N	00217.152632 E	292,16	0	7,1	13,

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD nutrient transekt HY04 with watersample start	19.mar	05:02:46	209	6120.096487 N	00217.153955 E	292,32	0,1	7,1	12,
CTD nutrient transekt HY04 with watersample stop	19.mar	05:15:57	209	6120.095331 N	00217.152178 E	292,29	0	7,1	13,
CTD eDNA transekt HY01 with watersample start	19.mar	06:19:36	210	6125.423404 N	00206.407180 E	300,17	0,3	7,3	12,
CTD eDNA transekt HY01 with watersample stop	19.mar	06:33:35	210	6125.411734 N	00206.446979 E	299,86	0	7,4	13,
CTD nutrient transekt HY01 with watersample start	19.mar	06:56:00	211	6125.412247 N	00206.446967 E	300,32	0,1	7,4	7,3
CTD nutrient transekt HY01 with watersample stop	19.mar	07:09:24	211	6125.412152 N	00206.446835 E	300,08	0,3	7,4	7,5
CTD eDNA transekt HY01 with watersample start	19.mar	07:36:53	212	6123.792009 N	00210.876908 E	299,12	0,1	7,4	5,9

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD eDNA transekt HY01 with watersample stop	19.mar	07:54:07	212	6123.789064 N	00210.873266 E	298,99	0,1	7,4	6,8
CTD nutrient transekt HY01 with watersample start	19.mar	07:57:11	213	6123.789359 N	00210.874215 E	298,89	0,1	7,4	
CTD nutrient transekt HY01 with watersample stop	19.mar	08:10:05	213	6123.789637 N	00210.873772 E	298,75	0	7,4	6,9
CTD eDNA transekt HY01 with watersample start	19.mar	08:32:18	214	6122.709570 N	00213.386165 E	298,19	1,1	7,2	8,3
CTD eDNA transekt HY01 with watersample stop	19.mar	08:48:41	214	6122.725546 N	00213.388127 E	297,83	0,1	7,2	7,5
CTD nutrient transekt HY01 with watersample start	19.mar	08:54:42	215	6122.726902 N	00213.387481 E	297,64	0	7,3	
CTD nutrient transekt HY01 with watersample stop	19.mar	09:07:11	215	6122.726895 N	00213.387748 E	297,71	0	7,3	8,2

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD eDNA transekt HY01 with watersample start	19.mar	09:25:00	216	6122.357774 N	00214.177957 E	298,25	0	7,2	7,8
CTD eDNA transekt HY01 with watersample stop	19.mar	09:38:33	216	6122.358371 N	00214.177279 E	298,27	0	7,2	9,2
CTD nutrient transekt HY01 with watersample start	19.mar	09:53:56	217	6122.357041 N	00214.174663 E	297,98	0	7,2	8,2
CTD nutrient transekt HY01 with watersample stop	19.mar	09:54:09	217	6122.357650 N	00214.174778 E	298,51	0,1	7,2	7,9
Course change back on acoustic transect flower	19.mar	10:32:33	23	6118.071546 N	00218.240264 E	282,8	4,2	7,3	10
Course change	19.mar	11:14:36	24	6120.821556 N	00227.485968 E	323,16	9,4	6,8	9,1
Course change	19.mar	11:20:00	25	6121.298947 N	00226.718078 E	324,81	8,8	6,8	8,7
Pelagic trawl start - flower	19.mar	11:56:59	56	6120.909273 N	00223.997634 E	313,55	2,8	6,9	7
Pelagic trawl stop - flower	19.mar	12:38:01	56	6121.273166 N	00227.566465 E	326,6	2,6	6,7	7,2

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
Course change - back on acoustic transect flower	19.mar	13:32:47	26	6120.150881 N	00217.270135 E	290,84	9,8	7,2	6,3
ROV SA06 control station start	19.mar	15:11:11	3	6120.952299 N	00213.626023 E	288,93	0	7,2	6,5
ROV SA06 controstation stop	19.mar	16:12:12	3	6121.142792 N	00213.229794 E	289,88	0	7,2	
ROV SA06 contro station start	19.mar	17:27:32	4	6120.949281 N	00213.632020 E	304,25	0,1	7,2	2,2
ROV SA06 contro station stop	19.mar	18:20:10	4	6120.693089 N	00213.500640 E	285,09	0	7,2	3,6
ROV SA09 chain station start	19.mar	19:20:10	5	6120.366731 N	00213.654248 E	285,89	0	7,2	3,3
ROV SA09 chain station stop	19.mar	20:15:09	5	6120.186666 N	00214.030329 E	286,15	0	7,2	3,7
ROV SA09 control station start	19.mar	20:15:55	6	6120.186748 N	00214.029926 E	286,49	0	7,2	3,8
ROV SA09 control station stop	19.mar	21:09:39	6	6120.054061 N	00214.304682 E	287	0	7,2	4,4
ROV SA09 control station start	19.mar	21:49:44	7	6119.926796 N	00213.901150 E	284,36	0	7,3	3,1

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
ROV SA09 control station stop	19.mar	22:29:08	7	6120.218063 N	00214.064492 E	286,39	0,3	7,3	3,6
ROV SA09 chain station start	19.mar	22:30:20	8	6120.218399 N	00214.064678 E	286,43	0	7,3	2,5
ROV SA09 chain station stop	19.mar	23:15:51	8	6120.353034 N	00214.138310 E	287,04	0	7,2	8,1
CTD inside wind-farm eDNA with watersample start	20.mar	00:32:39	218	6121.139227 N	00214.915813 E	293,13	0	7,2	6
CTD inside wind-farm eDNA with watersample stop	20.mar	00:44:03	218	6121.139764 N	00214.916022 E	293,4	0	7,1	6,4
CTD inside wind-farm nutriens with watersample start	20.mar	00:50:00	219	6121.139700 N	00214.914754 E	293,4	0	7,2	6,1
CTD inside wind-farm nutriens with watersample stop	20.mar	01:01:44	219	6121.139459 N	00214.914620 E	293,1	0	7,2	7,5
CTD inside wind-farm eDNA with watersample start	20.mar	01:39:30	220	6119.795289 N	00215.622629 E	287,52	0	7,2	6,9

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD inside wind-farm eDNA with watersample stop	20.mar	01:53:16	220	6119.795601 N	00215.622555 E	287,67	0	7,2	6,6
CTD inside wind-farm with nutriens watersample start	20.mar	02:00:17	221	6119.796015 N	00215.622700 E	287,42	0	7,2	7,6
CTD inside wind-farm with nutriens watersample stop	20.mar	02:11:23	221	6119.795653 N	00215.623365 E	287,39	0	7,2	7,9
CTD inside wind-farm eDNA with watersample start	20.mar	02:42:48	222	6118.767885 N	00216.161353 E	284,09	0	7	9,2
CTD inside wind-farm eDNA with watersample stop	20.mar	02:55:32	222	6118.768503 N	00216.161603 E	283,91	0	7	
CTD inside wind-farm nutriens with watersample start	20.mar	03:04:48	223	6118.768459 N	00216.161966 E	283,88	0	7	6,2
CTD inside wind-farm nutriens with watersample stop	20.mar	03:16:13	223	6118.768441 N	00216.161529 E	283,9	0	7	5,4

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
Course change - back on acoustic flower transec line 17	20.mar	07:17:43	27	6120.335537 N	00217.133687 E	294,3	7,4	7	7,2
Kayak drone stop	20.mar	13:47:00							
Kayak drone start	20.mar	16:15:00							
ROV SA12 chain station start	20.mar	17:42:35	9	6119.408749 N	00214.509032 E	281,55	0	7	0,9
ROV SA12 chain station stop	20.mar	19:22:33	9	6119.280569 N	00214.768584 E	282,86	0	7	2,4
ROV SA12 control station start	20.mar	20:00:18	10	6119.398981 N	00214.529712 E	282,19	0	7	2,4
ROV SA12 control station stop	20.mar	21:01:12	10	6119.592447 N	00214.140650 E	282,91	0	7	2,2
ROV SA12 chain station start	20.mar	22:06:30	11	6119.167329 N	00214.317875 E	283,01	0	7,1	2,7
ROV SA12 chain station stop	20.mar	22:42:39	11	6119.403683 N	00214.440751 E	283,22	0,4	7	2,8
ROV SA12 control station start	20.mar	22:42:53	12	6119.405374 N	00214.441555 E	283,3	0,4	7	3,3

Station type	**Date**	**Time (UCT)**	**St.No**	**Latitude**	**Longitude**	**Depth (m)**	**Speed**	**Water temp**	**Wi (m/**
ROV SA12 control station stop	20.mar	23:25:35	12	6119.569651 N	00214.543397 E	284,45	0	7,1	3,3
Pelagic trawl start - transect in OWF	21.mar	01:43:45	57	6118.377739 N	00216.390398 E	281,39	3,8	7	4,6
Pelagic trawl stop - transect in OWF	21.mar	02:56:59	57	6121.541274 N	00214.761275 E	294,19	1,6	7	6,5
CTD transect HY01 eDNA with watersample start	21.mar	03:31:39	224	6122.172684 N	00214.626396 E	297,34	0	7	5
CTD transect HY01 eDNA with watersample stop	21.mar	03:43:44	224	6122.171317 N	00214.631046 E	297,63	0	7	7,6
CTD transect HY01 neutrients with watersample start	21.mar	03:49:29	225	6122.171340 N	00214.630443 E	297,36	0	7	9
CTD transect HY01 neutrients with watersample stop	21.mar	04:01:25	225	6122.171580 N	00214.630965 E	297,43	0	7	8,6

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
Pelagic trawl start - fishery transect	21.mar	12:19:00	58	6112.050006 N	00152.152152 E	146,56	2,8	8	17
Pelagic trawl stop - fishery transect	21.mar	12:32:19	58	6111.645936 N	00153.075380 E	145,93	2,2	7,9	15,
Pelagic trawl start - fishery transect	21.mar	14:07:18	59	6116.142937 N	00201.561494 E	142,56	2,9	7,9	16
Pelagic trawl stop - fishery transect	21.mar	14:20:49	59	6115.666110 N	00202.484414 E	142,41	3	8	16,
Pelagic trawl start - fishery transect	21.mar	15:53:08	60	6119.878490 N	00208.850278 E	267,1	2,7	7,9	15
Pelagic trawl stop - fishery transect	21.mar	16:23:09	60	6120.887656 N	00207.253944 E	269,49	2,9	7,7	12,
CTD transect nord start	22.mar	10:02:01	226	6124.034461 N	00148.172248 E	153,83	0,1	8,2	14,
CTD transect nord stop	22.mar	10:10:43	226	6124.035089 N	00148.168158 E	154	0,1	8,2	13,
CTD transect nord start	22.mar	10:37:38	227	6126.140307 N	00152.388379 E	226,62	0,1	8,5	13,
CTD transect nord stop	22.mar	10:50:14	227	6126.139723 N	00152.387738 E	226,79	0	8,5	15

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD transect nord start	22.mar	11:21:32	228	6128.336418 N	00156.598642 E	297,86	0	8	
CTD transect nord stop	22.mar	11:33:49	228	6128.335849 N	00156.597827 E	297,81	0	7,9	15,
CTD transect nord start	22.mar	12:05:57	229	6130.506738 N	00201.096971 E	316,48	0,1	7,4	16,
CTD transect nord stop	22.mar	12:18:39	229	6130.508979 N	00201.097788 E	316,02	0	7,5	17,
CTD transect nord start	22.mar	12:50:17	230	6132.691791 N	00205.401769 E	337,04	0	7	14,
CTD transect nord stop	22.mar	13:03:16	230	6132.690268 N	00205.402511 E	336,81	0,1	7,1	14,
CTD transect nord start	22.mar	13:35:44	231	6134.894316 N	00209.800729 E	362,38	0	7,2	15
CTD transect nord stop	22.mar	13:50:49	231	6134.892981 N	00209.800060 E	362,15	0	7,2	16,
CTD transect nord start	22.mar	14:52:01	232	6137.104703 N	00214.053209 E	385,43	0,3	7	11,
CTD transect nord stop	22.mar	15:06:48	232	6137.137044 N	00214.241121 E	386,06	0,5	7	11,
CTD transect nord start	22.mar	15:31:56	233	6138.942693 N	00217.838739 E	378,27	0,2	7,2	13,

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD transect nord stop	22.mar	15:47:23	233	6138.953147 N	00217.964958 E	379,19	0,6	7,2	13,
CTD transect central nord start	22.mar	17:02:19	234	6132.977090 N	00229.861959 E	373,5	1,9	7,9	12,
CTD transect central nord stop	22.mar	17:18:25	234	6133.000125 N	00229.983432 E	372,05	0,3	7,8	12,
CTD transect central nord start	22.mar	17:45:17	235	6131.056886 N	00225.977180 E	380,93	0,7	7,9	13,
CTD transect central nord stop	22.mar	18:01:48	235	6131.058188 N	00226.331790 E	380,3	0,7	7,9	12,
CTD transect central nord start	22.mar	18:30:05	236	6128.891178 N	00221.649371 E	366,1	0,4	7,8	10
CTD transect central nord stop	22.mar	18:44:51	236	6128.922139 N	00221.799126 E	366,95	0,2	7,8	14,
CTD transect central nord start	22.mar	19:15:21	237	6126.723397 N	00217.353152 E	331,07	0	8	11,
CTD transect central nord stop	22.mar	19:29:53	237	6126.747362 N	00217.585875 E	331,42	0,7	8	7,2

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD transect central nord start	22.mar	20:02:44	238	6124.619798 N	00213.003333 E	307,29	0,2	8,1	9,7
CTD transect central nord stop	22.mar	20:15:29	238	6124.631656 N	00213.255122 E	309,51	0,5	8,1	8,6
CTD transect central nord start	22.mar	20:51:47	239	6122.369430 N	00208.779556 E	287,47	0,8	8,1	9,3
CTD transect central nord stop	22.mar	21:04:31	239	6122.351307 N	00209.125266 E	287,89	0,8	8,1	10,
CTD transect central south start	22.mar	21:39:50	240	6120.168986 N	00204.463087 E	245,69	0,5	8,1	13,
CTD transect central south stop	22.mar	21:50:54	240	6120.071052 N	00204.738426 E	245,02	0,5	8,1	14,
CTD transect central south start	22.mar	22:24:53	241	6118.034884 N	00200.104124 E	146,83	0,4	8	16,
CTD transect central south stop	22.mar	22:32:41	241	6117.975804 N	00200.224495 E	146,96	0,6	8	15,

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD transect central south start	23.mar	05:35:46	242	6112.331771 N	00209.696875 E	138,19	0,2	8,2	8
CTD transect central south stop	23.mar	05:43:53	242	6112.324771 N	00209.773135 E	138,82	0,3	8,2	7,3
CTD transect central south start	23.mar	06:10:02	243	6114.432066 N	00213.985507 E	222,62	0,9	8,1	8,7
CTD transect central south stop	23.mar	06:26:16	243	6114.492001 N	00214.463040 E	228,53	6,5	8,1	4,9
CTD transect central south start	23.mar	06:56:39	244	6116.556932 N	00218.760534 E	272,16	0,7	8	7,9
CTD transect central south stop	23.mar	07:07:46	244	6116.568044 N	00219.027792 E	273,06	0,6	8	7,9
CTD transect central south start	23.mar	07:35:36	245	6118.579648 N	00223.045078 E	297,11	0,6	8,1	6,9
CTD transect central south stop	23.mar	07:49:18	245	6118.584925 N	00223.173075 E	298,2	0,4	8,1	6,5

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD transect central south start	23.mar	08:18:26	246	6120.708552 N	00227.418049 E	323,22	0,3	7,9	6,3
CTD transect central south stop	23.mar	08:32:59	246	6120.719081 N	00227.580897 E	324,87	0,2	7,9	6,5
CTD transect central south start	23.mar	09:01:31	247	6122.948848 N	00231.880887 E	368,16	0,1	7,4	4,7
CTD transect central south stop	23.mar	09:16:58	247	6122.963215 N	00232.058664 E	367,94	0,4	7,3	7,8
CTD transect central south start	23.mar	09:44:34	248	6125.043370 N	00236.276511 E	378,29	0,3	7,1	6,1
CTD transect central south stop	23.mar	10:03:19	248	6125.051950 N	00236.482743 E	378,98	0,1	7,1	4,5
CTD transect central south start	23.mar	10:32:30	249	6127.077953 N	00240.859521 E	376,4	0,6	7,1	7,1
CTD transect central south stop	23.mar	10:48:11	249	6127.108893 N	00241.076039 E	376,66	0,6	7	5,1
CTD south start	23.mar	12:03:35	250	6118.223802 N	00249.262894 E	378,75	0,1	6,9	7,7

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
CTD south stop	23.mar	12:18:12	250	6118.221372 N	00249.250330 E	378,9	0,2	6,9	6,9
CTD south start	23.mar	12:48:01	251	6116.161326 N	00244.760437 E	375,03	0,4	7	8,5
CTD south stop	23.mar	13:02:37	251	6116.175662 N	00244.555308 E	372,78	0,2	7	8
CTD south start	23.mar	13:35:08	252	6114.027851 N	00240.307205 E	322,13	0,5	7,2	8,1
CTD south stop	23.mar	13:48:05	252	6114.087357 N	00240.056279 E	321,75	0,7	7,2	9,2
ROV station start ADCP4	23.mar	18:55:41	13	6120.747482 N	00213.569013 E	288,41	0,1	8,2	7,4
ROV station stop ADCP4	23.mar	19:17:44	13	6120.747616 N	00213.570130 E	288,51	0	8,2	7
ROV station start Hydrophon	23.mar	20:08:39	14	6120.572324 N	00213.602116 E	287,3	0	8,2	11,
ROV station stop Hydrophon	23.mar	21:40:21	14	6120.571310 N	00213.603265 E	287,71	0	8,2	9,1
ROV station start ADCP1	23.mar	22:06:08	15	6120.803067 N	00215.549517 E	294,48	0	8	8,3
ROV station stop ADCP1	23.mar	22:53:37	15	6120.802970 N	00215.548634 E	294,18	0	8,1	5,3

Station type	Date	Time (UCT)	St.No	Latitude	Longitude	Depth (m)	Speed	Water temp	Wi (m/
The 3 ADCP’s outside the windfarm area was released by acoustic releasers	23. mar	Between 20:08 and 21:40							

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