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(UGENT & ILVO/2014/MONWIN)

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Jozefien Derweduwen

Elisabeth Debusschere

Sofie Vandendriessche

Kris Hostens

ILVO Document Control

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Project manager	Jozefien Derweduwen
Report compiled by	Jozefien Derweduwen
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UGent & ILVO/2014/MonWin: Activity report 2014 – partim ILVO

Jozefien Derweduwen, Kris Hostens, Sofie Vandendriessche, Elisabeth Debusschere

Institute for Agricultural and Fisheries Research (ILVO), Bio-Environmental Research Group, Ankerstraat 1, 8400 Oostende

This report describes the activities carried out by ILVO during 2014, as part of the following contract: "Overeenkomst Monitoring Macro/Epibenthos en Vis UGent&ILVO/2014/MonWin - Monitoring van de effecten van de windmolenparken op zee op de endo-, epi- en visfauna van zachte substraten: Contract & Technische bijlage".
In contrast to what is stated in Article 7 of the contract, it has been agreed upon with UGent and ODNature to limit the reporting for the working year 2014 to two separate (ILVO and UGent) activity reports.
This study has been carried out by order of the scientific department 'Beheerseenheid Mathematisch Model van de Noordzee', part of the "Operationele Directie Natuurlijk Milieu van het Koninklijk Belgisch Instituut voor Natuurwetenschappen".

Introduction

The monitoring programme carried out by ILVO consists of two parts. The first part is the basic monitoring and focuses on the immediate impact of wind farms on the ecosystem. The second part tries to disentangle the ecological processes behind the observed impacts on the ecosystem by generating and investigating several hypotheses on cause-effects relationships (= targeted monitoring).

1. BASIC MONITORING

The basic monitoring encompasses a comprehensive description of the major changes in the wind farm zone and allows keeping track of major and unforeseen impacts. Within this basic monitoring, ILVO investigates the global impact of the construction and exploitation of wind farms and the edge effects at the border of the wind farms on the soft substrate epibenthos and fish.

Effect of wind farms on soft substrate epibenthos and fish

Jozefien Derweduwen, Sofie Vandendriessche, Kris Hostens

Objective

With the construction of wind farms, new hard substrates are introduced in the marine environment. Although, the sediment between the turbine rows and around the wind farms remains soft, the inhabiting fauna can be influenced by the presence of the turbines and the absence of fisheries. These effects were investigated for epibenthos, demersal fish and benthopelagic fish in the C-Power (Thorntonbank) and Belwind (Bligh Bank) wind farms.

Material and Methods

1. Sampling

During the RV Belgica Cruises 2014/06 (March 10th 2014 – March 21th 2014) and 2014/24 (September 23th 2014 – October 10th 2014) beam trawl samples were taken within the wind farms, i.e. between the turbine rows (8 in spring, 4 in autumn), just outside the concessions (fringe stations, 6 in spring, 6 in autumn) and at reference stations away from the concessions (11 in spring, 7 in autumn). A number of stations could not be sampled due to bad weather conditions and logistic problems (Figure 1, Table 1 and Figure 2). Up till now no samples could be taken on the Lodewijckbank (Northwind) due to the fact that no straight line of 1 Nm can be fished. Coordinates of the sampled locations are added in annex 1 (spring 2014) and annex 2 (autumn 2014). On these locations, demersal fish fauna and epibenthos were sampled with an 8-meter shrimp trawl (22 mm mesh in the cod end) equipped with a bolder-chain in the ground rope. Epibenthos and demersal fish are organisms living on or in the vicinity of the sea bottom and which can efficiently be sampled with this shrimp trawl. The net was towed over 1 nautical Mile, approximately covering 15 minutes at an average speed of 3.5 to 4 knots with the currents. Data on time, start and stop coordinates, trajectory and sampling depth were noted to enable a correct conversion towards sampled surface units. The fish tracks are more or less positioned following depth contours that run parallel to the coastline, thereby minimizing the depth variation within a single track, except for track 2 and track 3 in the C-power concession due to the positioning of the electricity cables.

2. Data collected

- Epibenthos: species, density, biomass (wet weight) (+ sex, length, parasites for some species)
- Fish: species, length, density

    - For two seasons (spring and autumn 2014)
    - For two wind farms (Thorntonbank and Bligh Bank)
    - For two subhabitats (sandbank and gullies)
    - In a BACI (CI) design

All samples gathered in spring and autumn 2014 have been processed (on board and in the lab). All data are entered in the ILVO database (developed and maintained in close cooperation with VLIZ). These data will be extracted to the BMDC templates and forwarded to the BMDC database as part of the contract.

Figure 1: Some impressions of the beam trawl catches in and around the C-power and Belwind windfarms

Table 1: Stations per sandbank system, with indication of sampling activities in spring and autumn 2014.

sandbank system	station	imp/ref/fri	top/gully	spring 2014	autumn 2014
Gootebank	WG2	ref	top	X	X
	330	ref	gully	X	X
Thorntonbank	WT1(bis)	ref	gully	X	X
	WT2(bis)	ref	top	X	X
	WT3	ref	gully	X	X
	WT7	fringe	gully	X	X
	WT9	fringe	gully	X	X
	WT10	fringe	gully	X	X
	WT11	fringe	gully	X	X
	track 2	impact	top	X	
	track 3	impact	top	X	
	track 5	impact	top	X	X
	track 6	impact	top	X	X
Lodewijckbank	BZN01	impact	top		
Bligh Bank	WBB01	ref	gully	X	X
	WBB02	ref	top	X	
	WBB03	ref	gully	X	X
	WBB04	fringe	gully	X	X
	WBB05	impact	gully	X	X
	WBB06a	impact	top	X	
	WBB06b	impact	top	X	
	WBB07	impact	gully	X	X
	WBB08	fringe	gully	X	X
Oosthinder	WOH01	ref	gully	X	
	WOH02	ref	top	X	
	WOH03	ref	gully	X	

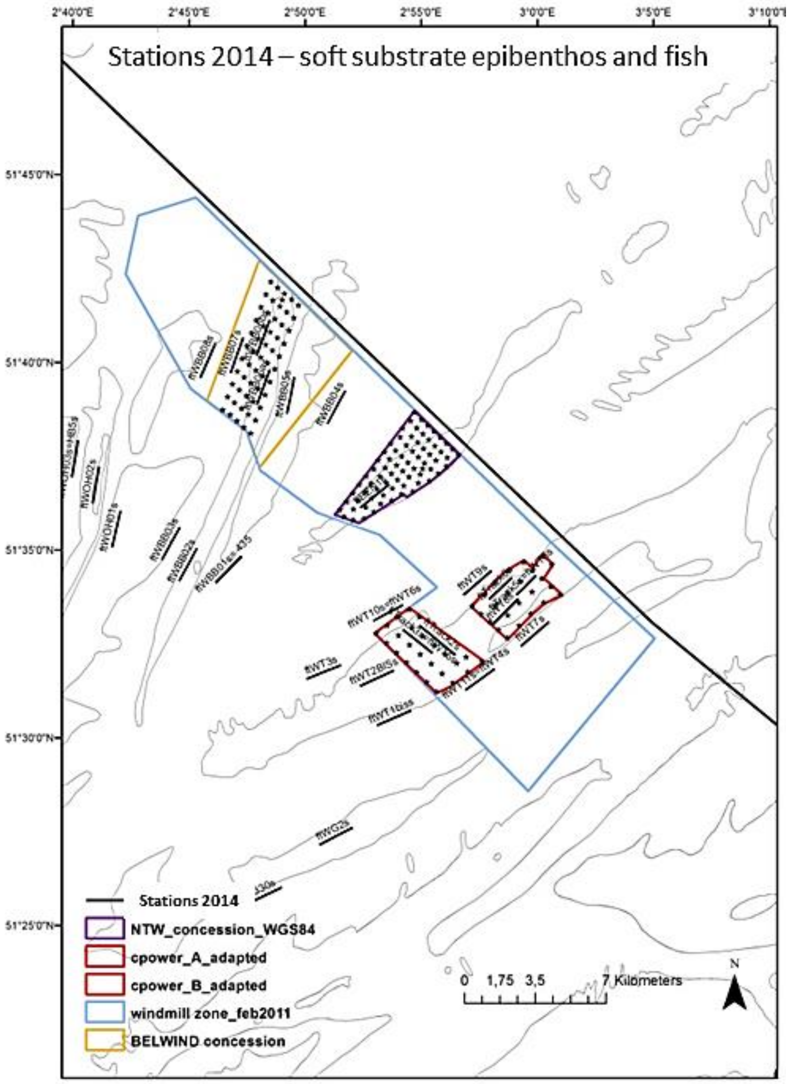

Figure 2: Map showing the 2014 sampling stations at the wind farm concession areas of C-power, Belwind (and Northwind).

Preliminary results

Table 2 gives an exploratory overview of the average densities of the ten most abundant species in and around the wind farm areas for 2013 and 2014. In spring 2013, *Pagurus bernhardus*, *Ophiura albida* and *Asterias rubens* were the most dominant species at the Bligh Bank. In spring 2014, *Echiichthys vipera* and *Merlangius merlangus* were much more abundant. Both autumn 2013 and 2014 were characterised by *E. vipera*, *Trachurus trachurus* and *P. bernhardus*, but the densities were strikingly lower in autumn 2014.
At the Thorntonbank, the spring 2013 samples were dominated by the brown shrimp *Crangon crangon*, while spring 2014 was characterised by much lower (up to 7 times) densities of brown shrimp and dominated by *M. merlangus,* which was on its turn rather rare in spring 2013. The sea star *A. rubens* was the second most abundant species for both seasons. Sprat *S. sprattus* was the third most important species in spring 2013 but hardly occurred in spring 2014.

Table 2: Average densities (ind/1000 m^2) for the ten most abundant species per sand bank system, season and year.

Bligh Bank							
spring 2013		autumn 2013		spring 2014		autumn 2014	
Pagurus bernhardus	6,50	*Echiichthys vipera*	20,10	*Echiichthys vipera*	15,63	*Trachurus trachurus*	9,36
Ophiura albida	5,31	*Trachurus trachurus*	15,09	*Merlangius merlangus*	6,79	*Echiichthys vipera*	6,46
Asterias rubens	3,13	*Pagurus bernhardus*	4,54	*Pagurus bernhardus*	3,04	*Pagurus bernhardus*	2,84
Ammodytes tobianus	2,97	*Mullus surmuletus*	4,18	*Sprattus sprattus*	2,27	*Ophiura albida*	1,85
Crangon crangon	2,86	*Ophiura albida*	3,36	*Crangon crangon*	2,15	*Asterias rubens*	1,71
Echiichthys vipera	1,38	*Asterias rubens*	2,16	*Ophiura albida*	1,93	*Mullus surmuletus*	1,61
Callionymus reticulatus	1,01	*Liocarcinus holsatus*	1,23	*Ammodytes tobianus*	1,50	*Pleuronectes platessa*	1,07
Merlangius merlangus	0,87	*Gobius niger*	0,82	*Asterias rubens*	1,44	*Macropodia rostrata*	0,84
Limanda limanda	0,68	*Callionymus reticulatus*	0,81	*Limanda limanda*	1,37	*Pomatoschistus*	0,73
Pomatoschistus	0,62	*Pomatoschistus*	0,76	*Buglossidium luteum*	0,83	*Buglossidium luteum*	0,72
Thorntonbank							
spring 2013		autumn 2013		spring 2014		autumn 2014	
Crangon crangon	53,27	*Liocarcinus holsatus*	12,96	*Merlangius merlangus*	20,68	*Echiichthys vipera*	5,61
Asterias rubens	15,22	*Asterias rubens*	12,38	*Asterias rubens*	11,61	*Asterias rubens*	5,57
Sprattus sprattus	9,33	*Echiichthys vipera*	7,42	*Crangon crangon*	7,27	*Pagurus bernhardus*	4,98
Limanda limanda	5,55	*Limanda limanda*	4,49	*Limanda limanda*	4,04	*Mullus surmuletus*	4,07
Pomatoschistus	4,16	*Pleuronectes platessa*	4,09	*Echiichthys vipera*	3,97	*Trisopterus minutus*	3,94
Pagurus bernhardus	3,42	*Pagurus bernhardus*	3,13	*Ophiura albida*	3,62	*Ophiura albida*	2,96
Liocarcinus holsatus	3,24	*Trachurus trachurus*	3,09	*Liocarcinus holsatus*	3,57	*Buglossidium luteum*	2,57
Crangon allmanni	3,20	*Buglossidium luteum*	2,91	*Callionymus reticulatus*	2,68	*Callionymus lyra*	1,53
Anthozoa	2,62	*Callionymus lyra*	2,90	*Pagurus bernhardus*	2,40	*Ophiura ophiura*	1,45
Callionymus lyra	1,98	*Merlangius merlangus*	2,80	*Pomatoschistus*	1,92	*Callionymus reticulatus*	1,29

Preliminary results indicate wind farm effects on epibenthos biomass at the Bligh Bank top (Figure 3 left) with increased values at the wind farm tops stations (purple line), both in autumn and spring. From 2011 onwards, these biomass values decreased and evolved towards (spring) or even below (autumn) the reference top values (light blue line).

Also at the Thorntonbank (Figure 3 right), the epibenthos biomass was higher at the wind farm top stations in autumn 2009 and 2012 (purple line) and declined in 2013 and 2014 to reach similar values as the reference top stations (light blue line).

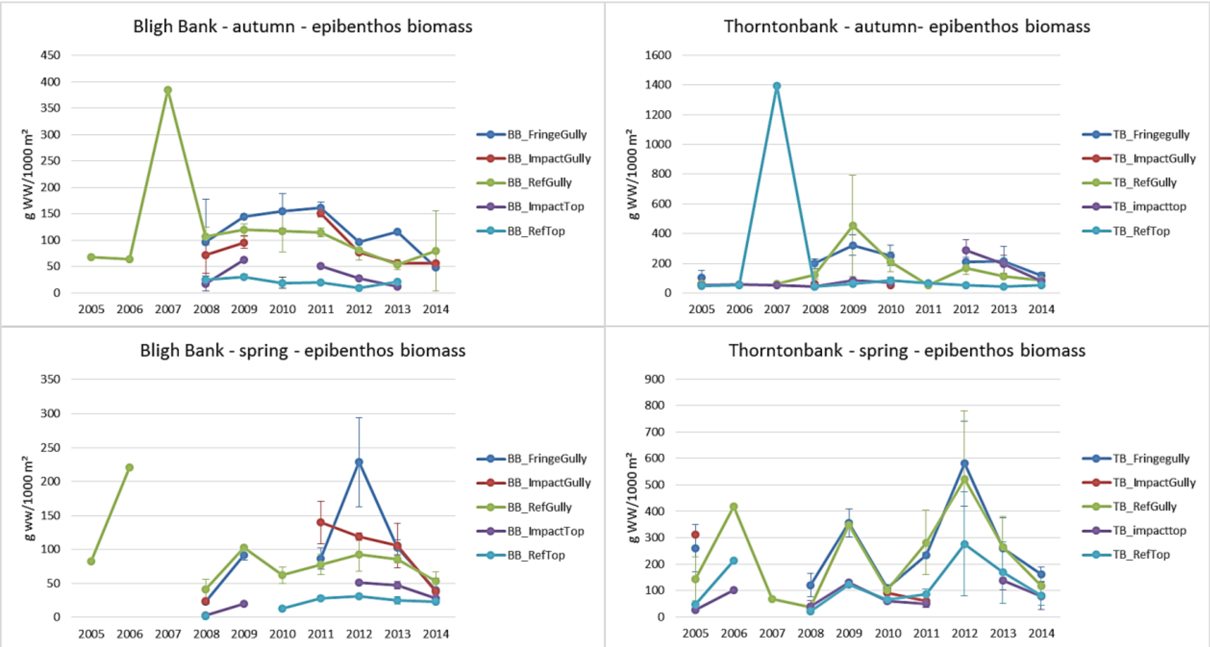

Figure 3: Epibenthos biomass (average gWW/1000 m² ± SE) for Bligh Bank (left), Thorntonbank (right), in autumn (up) and spring (below) between 2005 and 2014.

Significant fringe effects were seen for sole *Solea solea* at the Bligh Bank in spring 2012. Higher densities were observed in the fringe stations (dark blue line) in comparison with the reference stations (green line) (Figure 4). From 2013 onwards, this difference practically disappeared, so this fringe effect seems to be a temporary phenomenon.

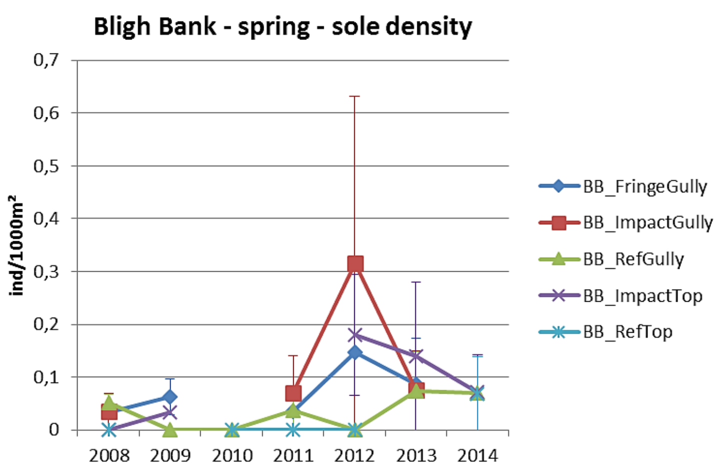

Figure 4: Average sole density (ind/1000 m² ± SE) for Bligh Bank in spring between 2008 and 2014.

Additional detailed analyses and comparison with previous years (BACI) are in progress. These results will be fully reported in 2016 (report of working year 2015), including an integration with the macrobenthos data (Ugent).

Outreach

Presentation, report and A1-paper:

- *Derweduwen, J., Vandendriessche, S., Debusschere, E. & Hostens, K. (2014). Monitoring environmental impacts of offshore wind farms in the Belgian Part of the North Sea. oral presentation ICES Working Group on Marine Benthal and Renewable Energy Developments (WGMBRED), 25-28 maart 2014, Tallinn (EE).*

- *ICES. (2014). Second Interim Report of the Working Group on Marine Benthal and Renewable Energy Developments (WGMBRED), 25-28 March 2014, Tallinn, Estonia. ICES CM 2014/SSGEF:07. 26 pp.*

- *Vandendriessche, S., Derweduwen, J., & Hostens, K. (2014). Equivocal effects of offshore wind farms in Belgium on soft substrate epibenthos and fish assemblages. Hydrobiologia, 1-17.*

2. TARGETED MONITORING

Within the second part of the monitoring program, i.e. the targeted monitoring, ILVO is investigating several topics:

- the feeding behaviour of commercially important demersal fish species
- the effect of wind farm underwater sound on fish
- wind farms as spawing sites and nurseries for commercially and ecologically important species
- changes in commercial and recreational fisheries in and in the vicinity of the wind farms
- the needs in order to optimally sample pelagic fish in the wind farms

2.1 Feeding behaviour of demersal fish at wind farms

Jozefien Derweduwen, Sofie Vandendriessche, Arne Adam, Kris Hostens

Objective

This analysis aims to reveal possible changes in feeding patterns of three fish species in and around the Thorntonbank and Bligh Bank wind farms. Stomach analyses were conducted to investigate (1) whether the presence of the turbines had an effect on the fish diet, and (2) whether there were fringe effects with regard to the diet composition at the border of the concession areas.

Material and Methods

Samples for stomach analyses were collected from 2011 to 2013 at the Thorntonbank and Bligh Bank from a selected number of trawls as described above. No additional samples for stomach analyses have been collected in 2014,. Per station, up to 15 individuals per species for three fish species (*Limanda limanda, Echiichthys vipera, Merlangius merlangus*) were collected, on board injected with formaldehyde (35%) and stored in formaldehyde (8%) until analysis. Stomachs were removed in the lab and all prey items encountered in the stomachs were identified and counted.

Results and outreach

Stomach content analyses of three fish species (*L. limanda, E. vipera, M. merlangus*) are still ongoing. Following indices will be calculated: Fullness Index (FI); Frequency of occurence (FO%) and Numerical percentage (N%). The data will be fully analysed in 2015 and reported in 2016.

2.2 Effect of underwater sound generated by wind farms on fish

Elisabeth Debusschere, Dick Botteldooren, Sofie Vandendriessche, Kris Hostens, Magda Vincx, Steven Degraer

Objective

Pile-driving for wind farm constructions has triggered a range of ecological questions regarding the impact of anthropogenically generated low frequency impulsive underwater sound on marine wildlife. This study tackles the impact of pile-driving sound on fish mortality, stress, behaviour and fitness. This study uses cultured juveniles (< 2g), of European sea bass *Dicentrarchus labrax* as a model species (Figure 5). In 2013, no acute or chronic mortality after exposure to pile driving at 45 m from the piling activity was observed. In 2014, our goal was to study the acoustic stress in juvenile sea bass through *in situ* and laboratory experiments.

Figure 5: Sea bass juveniles

Material and methods

1. *in situ* experiment

An experiment was conducted during the piling activity at the construction of the Northwind NV offshore wind farm in June and August 2013. This experiment was carried out in close cooperation with the concession holders of North Wind. From the piling platform, sea bass (*Dicentrarchus labrax*) juveniles were lowered into the sea and exposed to a complete piling event (Figure 6), at a distance of 45m from the pile-driving source. Respiration rates were monitored, whole-body cortisol, lactate and RNA samples were taken and surviving juveniles were reared in the lab to examine effects on development and growth. As a control, the same procedures and measurements were done for juveniles lowered into the sea during a piling pause. A third treatment consisted of non-handled fish that stayed in the aquaria at ILVO, which were directly stored in liquid nitrogen for whole-body cortisol, lactate and RNA analyses.

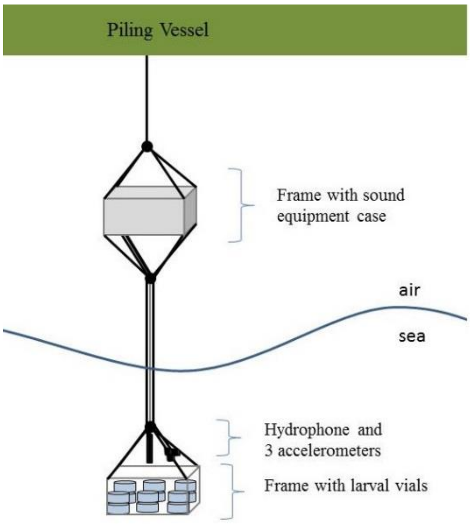

Figure 6: Experimental set-up on board of the piling platform

2. the SIG Sparker experiment

The SIG Sparker, utilised in seismic research, was used in a laboratory experiment to investigate the acute stress response of juvenile sea bass under the mid and high frequency impulsive sound. This experiment was carried out in close cooperation with UGent-RCMG and VLIZ. Cortisol, lactate, glucose and RNA samples were taken and oxygen consumption rate during the experiment was monitored. The experiment existed of three treatments: (1) a non-handled treatment; (2) a control treatment with handling stress and (3) an sound exposure treatment.

3. the Larvaebrator experiment

The larvaebrator is a device built specifically to enable controlled exposure of fish to sound in a laboratory setting. This experiment was carried out in close cooperation with IMARES (NL). In this case, a recording of pile driving at 100 m from the sound source was played back to the fish, with most energy in the lower frequency range (< 1kHz). The experiment was built out of three treatments: (1) a non-handled treatments; (2) a control treatment in the larvaebrator and (3) an sound exposure treatment in the larvaebrator. Measurements of oxygen consumption rate were taken and samples for whole-body cortisol, lactate and RNA were stored in -80°C upon analysis.

4. Pilot study behavioural impact of pile driving

An experiment was carried out to determine the impact of one hour of impulsive sound on the behaviour and condition of juvenile fish. A recording of pile driving sound at 45 m from the sound source was played back in the aquaria at ILVO at a lower sound pressure level (SELss= 165 dB re 1μPa), mimicing the impact further away from the sound source. Swimming behaviour was monitored 5 days before the sound exposure, during the sound exposure hour, just after exposure and up to five days after the sound exposure. Feeding behaviour, length and weight were monitored.

Preliminary results

1. in situ experiment

It was found that pile driving was perceived as an acoustic stressor. Elevated whole body cortisol levels were found during the pile driving exposure *in situ*. Oxygen consumption rate decreased with ~50 % during exposure and may indicate lower energy levels. After the *in situ* experiment fish were kept under optimal laboratory conditions during one month and no effect on condition and fitness were found. Lactate and RNA samples are stored until analysis. A manuscript based on these data is in preparation.

2. The SIG sparker

stress response based on this experiment is still under analysis.

3. The Larvaebrator

stress response based on this experiment is still under analysis.

4. Behavioural study

One hour of impulsive sound exposure had no impact on fitness, condition or feeding behaviour after the sound exposure. Juvenile seabass showed a startle response at the onset of the sound exposure and changed behaviour into keeping still, alternated with swimming. This experiment raised a lot of questions, leading to the execution of a second behavioural experiment to study in depth the feeding behaviour under sound exposure and habituation to the sound.

Outreach

This work is part of the Phd of Elisabeth Debusschere who acknowledges an IWT predoctoral grant.
Details on the results of the experiments will be summarized in more detail in the following report for working year 2015.

A1-Paper and presentations:

- *Debusschere, E, De Coensel, B, Bajek, A, Botteldooren, D, Hostens, K, Vanaverbeke, J, Vandendriessche, S, Van Ginderdeuren, K, Vincx, M & Degraer, S (2014,) 'In Situ Mortality Experiments with Juvenile Sea Bass (Dicentrarchus labrax) in Relation to Impulsive Sound Levels Caused by Pile Driving of Windmill Foundations' PloS one, vol 9, nr. 10., 10.1371/journal.pone.0109280*
- *Debusschere, E., De Coensel, B., Adriaens, D., Bajek, A., Botteldooren, D., Hostens, K., Vanaverbeke, J., Vandendriessche, S., Van Ginderdeuren, K., Vincx, M., Degraer, S., 2014. Impact of pile-driving of offshore monopile foundations on young sea bass. Oral presentation VLIZ Young Scientists' Day, 7 March 2014, Bruges (BE),*
- *Debusschere, E., Vercauteren, M., Botteldooren, D., Hostens, K., Vandendriessche, S., Vincx, M., Degraer, S. (2014). Startled but not traumatized: the effects of pile-driving on fish behavior. Oral presentation. First Mares Conference: Marine Ecosystems Health and Conservation, 17-21 November 2014, Olhão (Portugal).*

2.3 Ichthyoplankton: wind farms as spawning sites and nurseries?

Sofie Vandendriessche, Ana Margarida Ribeiro da Costa and Kris Hostens

Objective

Populations of fish species depositing their eggs on the seafloor are strongly influenced (positively or negatively) by changes in the seafloor structure as a result of wind farm constructions. In the Belgian part of the North Sea, these fish species include herring, bream, sculpin, hooknose, wrasse, sandeel, gobies, dogfish and rays. Generally, the creation of hard substrates is expected to have positive effects, except for species that require sandy or muddy substrates for spawning. The importance of offshore wind farms as spawning sites and nursery areas are estimated by analyzing fish larvae densities in the concession areas and in adjoining reference stations.

Material and methods

This work was carried out at the C-power concession on the Thornton bank. At three reference locations (WFL1-3) and three wind farms locations (WFL4-6) (Figure 7 left), a Bongo net (Figure 7 right) was deployed, fitted with 500 μm mesh nets, a fly weight and a flow meter. The net was towed for 10 min in an undulating fashion. At each station, a CTD SBE-19plus was used to obtain vertical profiles of temperature and salinity. Turbidity was measured with a Secchi disk and chlorophyll a data were obtained from fixed fluorimeters on board of the Belgica.
Samples were taken at each station during the spring and autumn campaigns from 2010 to 2013. Bongo net samples were sorted and partly analysed in the lab (only for ichtyoplankton):

- Fish larvae: identification to species level – counts
- Fish eggs: counts
- Squid larvae: identification to species level – counts

In total, 66 samples -over different years and seasons- have been analysed.

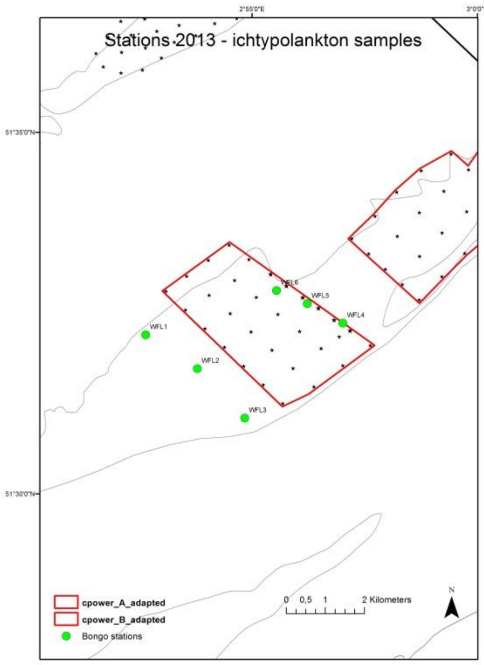

Figure 7. Left: Map showing the western part of the C-Power concession area, with indication of the ichthyoplankton sampling locations. Right: Bongonet

Preliminary results

This work was done in the framework of a MSc thesis. First results do not indicate effects of the wind farm on fish larvae, fish eggs or squid larvae. The data do provide a good baseline on ichthyoplankton and squid larvae at offshore locations that can be used in future monitoring.
Detailed results will be more fully reported in 2016.

Outreach

This work has been partly published in the MSc thesis of Ana Margarida Ribeiro da Costa.

Da Costa, A.M.R. (2014) Do offshore wind farms influence the occurrence of ichthyoplankton and squid larvae? MSc Thesis Marine Biodiversity and Conservation (Erasmus Mundus), Ghent University, 72p.

2.4 Changes in commercial and recreational fisheries in and in the vicinity of the wind farms

Sofie Vandendriessche and Kris Hostens

Changes in commercial fisheries intensity in and in the vicinity of the wind farms are investigated by means of VMS data in the BPNS. All VMS data are stored in the ILVO-database for further analyses. Detailed overview has already been given in a previous report.

The research on changes in recreational fisheries activity in and in the vicinity of the wind farms is part of the MSc thesis of Kilian Persoon (UGent - EMBC) which started in 2015, entitled "A wind of change in recreational fisheries?'. Extended results will be reported at a later stage.

2.5 Sampling pelagic fish in the wind farms

Kris Hostens and Sofie Vandendriessche

Objective

The availability of pelagic fish for seabirds is regarded as an important gap in our current knowledge of the Belgian marine ecosystem. In 2014, ILVO further investigated the presence of pelagic fish in the Belgian part of the North Sea. For this targeted monitoring study we want to explore the possibility of obtaining quantitative data on pelagic fish in the BPNS in general and in the wind farm area in particular. What are the needs for an optimal sampling program?

Materials and first results

Three types of fishing gear can be compared: an 8-m shrimp beam trawl, a semi-pelagic otter trawl and a small pelagic trawl. These have been deployed over several years from RV Belgica, RV Zeeleeuw and RV Simon Stevin. Mainly the latter system, i.e. the pelagic trawl was tested in 2014 on several campaigns, but many logistic problems were encountered. Moreover, the samples near the water surface were always less successful, questioning the efficiency of this gear towed behind our research vessels. This information will be extensively described in another report and summarized in the report 2016.

In short conclusion it might be questioned if sampling with a pelagic trawl will be feasible between the piles. Most probably the best results will be obtained with an otter trawl deployed halfway the water column. A depth meter is indispensable in both cases. Another option that has been put forward by experts is the use of 'span' fishing with two vessels, e.g. two zodiacs, trawling a 'pelagic net'.
Secondly, the real pelagic experts from the ICES working group have already stated several times that a fish finder sonar system is equally indispensable. We tried several times to see 'shoaling fish" on the normal radar screen, but never got a clue on what was really seen (or not seen).
Finally, the potential of telemetry by using acoustic transmitters, should be further explored. This work shows good results for cod, but might also be useful for other semi-pelagic or real pelagic fish species. So still lots of work to do to unravel the potential importance of wind farms for pelagic fish.

Acknowledgements

Shiptime of RV Belgica was provided by BELSPO via the Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environment (OD Nature). We thank the commander and his crew for their technical support during sampling, and the ILVO colleagues, students, and interns for all the sorting, identifying, and measuring. We also thank the wind energy sector to allow us to sample between the turbines. This study is carried out in the framework of the Belgian offshore wind farm monitoring program, financed by the Belgian offshore wind energy sector via RBINS-OD Nature. The work on the effect of wind farm underwater sound on fish is part of the Phd of Elisabeth Debusschere who acknowledges an IWT predoctoral grant. We would also like to thank Northwind NV and its contractor GeoSea NV for their collaboration and support during the sound field experiments.

Contact

Jozefien.Derweduwen@ilvo.vlaanderen.be
Kris.Hostens@ilvo.vlaanderen.be
Elisabeth.debusschere@ilvo.vlaanderen.be

ANNEX 1: Coordinates and some environmental data for the different beamtrawl locations sampled during RV Belgica Cruise 2014/06 (10 March 2014 – 21 March 2014)

Station	date	time	sept lat.n/s	sept lon.e/w	sept speed	ship heading	ea depth_33	depth sal860	sbe45 salin.	sbe21 salin.	sbe38 temp	sbe21 temp.	airtemp. dry	in-windbf pb	in-windsp sb	in-winddr pb	atm press. 2	sol-rad	ph	eh turbid I	obs low	obs high
ftWBB08sb	13/03/2014	6:19	N 51 40.3930	E 2 46.0765	3.6	204.0	-37.18			34.7552	8.779	8.7770	8.7	2	1.8	329.0	1029.4	12				
ftWBB08se	13/03/2014	6:33	N 51 39.5360	E 2 45.4040	4.2	201.2	-36.65			34.7565	8.797	8.7923	8.9	2	1.6	322.7	1029.5	28				
ftWBB07sb	13/03/2014	7:20	N 51 40.6570	E 2 47.3223	4.5	191.9	-29.75			34.7379	8.766	8.7615	8.9	2	1.4	341.9	1029.6	113				
ftWBB07se	13/03/2014	7:35	N 51 39.7350	E 2 46.8524	3.9	193.7	-33.33			34.7286	8.767	8.7622	9.0	2	1.8	345.2	1029.7	158				
ftWBB06asb	13/03/2014	8:19	N 51 38.9110	E 2 47.9716	4.0	19.2	-24.83			34.7134	8.760	8.7552	9.0	4	6.6	12.2	1029.6	285				
ftWBB06ase	13/03/2014	8:32	N 51 39.7490	E 2 48.4869	4.2	18.0	-22.89			34.7432	8.786	8.7813	9.1	4	6.2	16.0	1029.7	322				
ftWBB06bsb	13/03/2014	9:20	N 51 40.1970	E 2 47.9806	4.2	6.8	-24.74			34.7414	8.788	8.7798	9.5	3	5.6	16.8	1029.7	474				
ftWBB06bse	13/03/2014	9:34	N 51 41.0900	E 2 48.4799	4.5	10.6	-24.44			34.7551	8.787	8.7961	9.4	3	5.2	18.6	1029.8	459				
ftWBB05sb	13/03/2014	9:53	N 51 39.5940	E 2 49.5671	4.0	201.9	-38.67			34.7541	8.849	8.8458	9.9	1	1.0	314.9	1030.0	460				

Station	date	time	sept lat.n/s	sept lon.e/w	sept speed	ship heading	ea depth_33	depth sal860	sbe45 salin.	sbe21 salin.	sbe38 temp	sbe21 temp.	airtemp. dry	in-windbf pb	in-windsp sb	in-winddr pb	atm press. 2	sol-rad	ph	eh turbid l	obs low	obs high
ftWBB05se	13/03/2014	10:07	N 51 38.6480	E 2 49.2713	3.2	200.0	-39.31			34.7297	8.814	8.8002	9.9	1	0.8	298.0	1030.0	488				
ft435sb	13/03/2014	12:35	N 51 34.2100	E 2 46.2414	4.3	49.5	-34.36			34.4791	8.734	8.7310	9.4	3	4.3	12.5						1029.7
ft435se	13/03/2014	12:45	N 51 34.6430	E 2 47.0001	3.6	50.0	-33.11			34.5071	8.746	8.7169	9.2	3	4.8	28.0						1029.6
ftWBB04sb	13/03/2014	13:27	N 51 38.4130	E 2 50.9523	4.9	29.4	-36.75			34.5992	8.718	8.7101	9.6	4	5.8	17.4						1029.3
ftWBB04se	13/03/2014	13:42	N 51 39.2370	E 2 51.6995	3.5	27.9	-37.61			34.6035	8.720	8.7165	9.5	3	5.0	17.9						1029.2
ftWBB02sb	13/03/2014	14:37	N 51 34.2200	E 2 44.6702	5.1	19.8	-22.40			34.2127	9.002	8.9966	9.9	4	5.8	37.8						1029.2
ftWBB02se	13/03/2014	14:51	N 51 35.0890	E 2 45.3284	3.7	29.6	-21.16			34.4327	8.846	8.8428	9.7	3	5.0	21.1						1029.3
ftWBB03sb	13/03/2014	15:11	N 51 34.7550	E 2 43.9495	4.2	23.2	-35.61			34.3793	8.931	8.9380	9.8	4	6.4	18.2						1029.2
ftWBB03se	13/03/2014	15:26	N 51 35.6300	E 2 44.5204	3.6	28.7	-33.44			34.4619	8.973	8.9704	9.6	4	7.0	13.7						1029.3
ftWT7sb	18/03/2014	6:15	N 51 32.4620	E 2 59.2263	3.8	54.6	-35.54	-35.7			8.328		8.6	4	7.7	257.2						1016.0
ftWT7se	18/03/2014	6:30	N 51 33.0900	E 3 0.4874	3.9	55.7	-32.81	-32.8			8.352		8.6	4	6.8	253.5						1016.0

Station	date	time	sept lat.n/s	sept lon.e/w	sept speed	ship heading	ea depth_33	depth sal860	sbe45 salin.	sbe21 salin.	sbe38 temp	sbe21 temp.	airtemp. dry	in-windbf pb	in-windsp sb	in-winddr pb	atm press. 2	sol-rad	ph	eh turbid l	obs low	obs high
ftWT11sb	18/03/2014	6:51	N 51 31.9040	E 2 58.2372	3.8	234.0	-36.11	-4.3			8.329		8.7	5	7.8	259.0						1016.0
ftWT11se	18/03/2014	7:05	N 51 31.3270	E 2 56.9899	4.0	231.8	-32.85	-32.5			8.335		8.7	4	7.0	269.4						1016.2
ftWT1bissb	18/03/2014	7:22	N 51 30.7460	E 2 54.5867	4.0	245.6	-25.76	-25.3			8.347		8.6	4	7.1	271.4						1016.1
ftWT1bisse	18/03/2014	7:36	N 51 30.3580	E 2 53.2291	4.2	248.7	-28.14	-28.4			8.354		8.5	4	8.1	261.1						1016.1
ftTrack5sb	18/03/2014	8:24	N 51 33.7270	E 2 58.9653	4.0	38.4	-17.48	-18.7			8.384		8.6	3	2.8	268.0						1016.0
ftTrack5se	18/03/2014	8:45	N 51 34.8120	E 3 0.5461	3.8	35.9	-21.81	-21.5			8.419		8.7	4	6.5	256.7						1015.9
ftWT9sb	18/03/2014	9:05	N 51 34.4990	E 2 58.1023	4.3	237.5	-28.97	-28.7			8.475		8.8	4	6.6	253.8						1016.0
ftWT9se	18/03/2014	9:21	N 51 33.8270	E 2 56.8043	4.2	237.6	-27.66	-4.3			8.535		8.8	4	9.6	256.6						1015.8
ftWT10sb	18/03/2014	9:38	N 51 33.5520	E 2 54.2379	3.9	257.3	-26.70	-26.8			8.528		8.8	5	9.0	259.7						1015.9
ftWT10se	18/03/2014	9:52	N 51 33.1350	E 2 52.8927	4.1	255.5	-27.84	-28.0			8.529		8.6	4	8.5	238.8						1015.9
ftWT3sb	18/03/2014	10:07	N 51 31.8490	E 2 51.4752	5.1	275.6	-28.29	-27.9			8.549		8.6	5	9.9	246.7						1016.1

Station	date	time	sept lat.n/s	sept lon.e/w	sept speed	ship heading	ea depth_33	depth sal860	sbe45 salin.	sbe21 salin.	sbe38 temp	sbe21 temp.	airtemp. dry	in-windbf pb	in-windsp sb	in-winddr pb	atm press. 2	sol-rad	ph	eh turbid l	obs low	obs high
ftWT3se	18/03/2014	10:21	N 51 31.5970	E 2 50.0278	4.0	269.3	-26.80	-27.2			8.560		8.7	5	10.2	255.8	1015.8					
ftWT2bissb	18/03/2014	10:51	N 51 31.7200	E 2 53.6290	4.9	259.5	-21.98	-21.8			8.541		8.8	5	8.6	247.2	1015.9					
ftWT2bisse	18/03/2014	11:03	N 51 31.4100	E 2 52.3147	4.1	260.7	-22.84	-22.5			8.554		9.5	5	8.5	249.5	1015.7					
ftWG2sb	20/03/2014	8:29	N 51 27.6490	E 2 52.1419	4.2	234.0	-19.45	-19.4			8.498		9.8	6	11.6	193.4	1014.2					
ftWG2se	20/03/2014	8:43	N 51 27.2000	E 2 50.7970	3.8	232.4	-17.79	-18.3			8.515		10.0	5	10.1	190.7	1014.1					
ft330sb	20/03/2014	9:04	N 51 26.0700	E 2 49.0125	2.8	228.2	-22.44	-22.3			8.546		10.4	4	8.0	185.7	1014.0					
ft330se	20/03/2014	9:17	N 51 25.6150	E 2 47.7333	4.4	237.7	-23.77	-4.3			8.565		10.4	5	11.4	197.7	1013.7					
ftTrack6sb	20/03/2014	12:22	N 51 34.3540	E 2 58.9371	3.8	224.5	-26.66	-26.8			8.721		13.2	4	7.1	237.2	1009.6					
ftTrack6se	20/03/2014	12:35	N 51 33.7510	E 2 58.0101	3.6	232.1	-20.53	-21.7			8.755		13.8	4	7.2	212.3	1009.2					
ftTrack3sb	20/03/2014	12:59	N 51 32.3880	E 2 56.4170	4.1	301.3	-23.77	-23.4			8.737		11.5	4	6.6	259.9	1008.8					
ftTrack3se	20/03/2014	13:12	N 51 32.8570	E 2 55.3388	4.0	303.7	-26.22	-26.3			8.784		11.1	4	8.9	258.1	1008.9					

Station	date	time	sept lat.n/s	sept lon.e/w	sept speed	ship heading	ea depth_33	depth sal860	sbe45 salin.	sbe21 salin.	sbe38 temp	sbe21 temp.	airtemp. dry	in-windbf pb	in-windsp sb	in-winddr pb	atm press. 2	sol-rad	ph	eh turbid l	obs low	obs high
ftTrack2sb	20/03/2014	13:40	N 51 32.3360	E 2 55.3684	4.5	303.0	-23.81	-23.7			8.828		10.7	3	5.0	240.5						1008.6
ftTrack2se	20/03/2014	13:51	N 51 32.8540	E 2 54.4543	4.6	292.9	-27.34	-27.3			8.811		10.7	3	4.9	237.1						1008.5
ftWOH1sb	20/03/2014	16:28	N 51 34.9320	E 2 41.8102	5.3	344.4	-41.99	-43.2			9.162		10.7	5	7.3	245.1						1007.1
ftWOH1se	20/03/2014	16:43	N 51 35.9730	E 2 41.9836	4.4	344.4	-40.82	-4.3			9.174		10.8	5	10.4	247.4						1006.7
ftWOH2sb	20/03/2014	17:03	N 51 36.2440	E 2 40.8463	5.8	0.4	-24.43	-24.1			9.161		10.5	6	12.8	239.8						1006.6
ftWOH2se	20/03/2014	17:17	N 51 37.1940	E 2 41.1674	3.9	342.2	-22.08	-22.5			9.191		10.3	6	11.8	244.3						1006.7
ftWOH3sb	20/03/2014	17:35	N 51 36.9330	E 2 40.0292	4.9	331.8	-30.98	-29.9			9.218		10.2	5	8.6	235.2						1006.7
ftWOH3se	20/03/2014	17:49	N 51 37.8850	E 2 40.2565	4.1	2.5	-31.88	-31.2			9.225		10.2	5	11.2	230.2						1006.8

ANNEX 2: Coordinates and some environmental data for the different beamtrawl locations sampled during RV Belgica cruise 2014/24 (September 23th 2014 – October 10th 2014)

Station	date	time	sept lat.n/s	sept lon.e/w	ship heading	fur speed	ea depth_33	depth sal860	in-windbf	in-winddr pb	in-windsp sb	atm press. 2	sol-rad	airtemp. dry	sbe38 temp	sbe21 temp.	sbe45 salin.	sbe21 salin.	ph	eh turbid l	sbe21 s.vel.	kobold flow
ft330sb	9/10/2014	8:11	N 51 26.0960	E 2 49.0634	236.8	4.3	-22.78	-23.3	6	199.8	15.1	1001.3	99	15.2	16.921	16.915	33.545	31.816	8.5	1.0	1508.92	7.54
ft330se	9/10/2014	8:27	N 51 25.5980	E 2 47.7171	236.9	3.9	-24.99	-24.5	6	209.4	14.5	1001.5	133	15.3	16.926	16.927	33.588	31.865	8.5	1.0	1509.01	7.53
ftWT10sb	25/09/2014	13:06	N 51 33.2220	E 2 53.2155	49.8		-27.12	-30.8	5	240.6	8.5	1020.8	424	17.1	17.969	17.972	33.716	31.953	8.5	2.5		
ftWT10se	25/09/2014	13:19	N 51 33.6180	E 2 54.3921	66.3		-26.57	-30.7	4	252.3	10.6	1020.7	606	20.5	17.972	17.972	33.661	31.902	8.5	1.5		
ftTrack5sb	25/09/2014	11:59	N 51 33.7860	E 2 59.0526	30.8		-18.32	-22.1	3	264.7	5.3	1020.8	273	16.0	17.922	17.920	33.575	31.835	8.5	2.5		
ftTrack5se	25/09/2014	12:10	N 51 34.3400	E 3 0.0045	28.7			-21.2	4	251.4	6.9	1020.8	525	16.2	17.910	17.906	33.653	31.899	8.5	2.5		
ftTrack6sb	25/09/2014	11:21	N 51 34.3860	E 2 59.0043	216.5		-20.63	-25.8	4	255.2	8.1	1020.3	721	17.0	17.917	17.916	33.668	31.897	8.5	2.0		
ftTrack6se	25/09/2014	11:36	N 51 33.7640	E 2 58.0442	234.5		-20.48	-24.8	4	255.6	7.5	1020.4	398	16.3	17.933	17.931	33.600	31.840	8.5	1.5		
ftWBB01sb	9/10/2014	9:41	N 51 34.1210	E 2 46.1918	38.7	3.9	-32.67	-31.8	7	200.8	13.1	1002.1	422	17.1	17.237	17.234	34.161	32.395	8.5	1.0	1510.54	7.55
ftWBB01se	9/10/2014	9:55	N 51 34.7750	E 2 47.1953	41.1	3.8	-32.65	-32.8	7	195.4	14.2	1002.1	439	16.5	17.234	17.231	34.163	32.399	8.5	1.5	1510.54	7.48
ftWBB03sb	9/10/2014	11:13	N 51 34.9770	E 2 44.0673	22.3	3.7	-37.20	-36.7	6	212.2	17.0	1001.8	504	19.0	17.226	17.224	34.279	32.499	8.5	1.0	1510.63	7.37
ftWBB03se	9/10/2014	11:29	N 51 35.8380	E 2 44.8377	19.4	3.9	-35.96	-36.2	7	211.6	16.7	1001.8	541	19.1	17.231	17.228	34.319	32.559	8.5	1.5	1510.71	7.39
ftWBB04sb	9/10/2014	12:08	N 51 38.3610	E 2 51.0268	18.8	4.9	-36.23	-36.7	8	188.9	16.6	1002.0	544	18.0	17.248	17.244	34.315	32.558	8.5	1.5	1510.76	7.43
ftWBB04se	9/10/2014	12:21	N 51 39.2100	E 2 51.9134	21.2	4.2	-38.24	-37.3	6	214.3	14.9	1002.1	502	18.7	17.250	17.248	34.331	32.577	8.5	1.5	1510.79	7.42
ftWBB05sb	9/10/2014	13:07	N 51 39.5570	E 2 49.5873	205.3	3.2	-39.33	-38.8	8	203.3	16.3	1001.8	542	17.8	17.243	17.239	34.442	32.615	8.5	1.5	1510.81	7.09

Station	date	time	sept lat.n/s	sept lon.e/w	ship heading	fur speed	ea depth_33	depth sal860	in-windbf	in-winddr pb	in-windsp sb	atm press. 2	sol-rad	airtemp. dry	sbe38 temp	sbe21 temp.	sbe45 salin.	sbe21 salin.	ph	eh turbid l	sbe21 s.vel.	kobold flow
ftWBB05se	9/10/2014	13:24	N 51 38.6480	E 2 49.3037	202.7	2.9	-40.62	-39.4	7	228.4	18.5	1001.9	141	17.4	17.250	17.248	34.426	26.819	8.5	1.5	1504.23	6.71
ftWBB07sb	9/10/2014	15:18	N 51 40.6300	E 2 47.0809	206.8	2.6		-32.2	7	233.6	17.1	1002.2	93	17.2	17.249	17.246	34.538	32.719	8.5	1.5	1510.95	7.04
ftWBB07se	9/10/2014	15:37	N 51 39.8530	E 2 46.6841	204.9	2.4		-34.9	8	229.2	16.4	1002.5	111	17.2	17.258	17.256	34.485	32.677	8.5	2.0	1510.93	6.96
ftWBB08sb	9/10/2014	14:23	N 51 39.5940	E 2 45.4034	39.2	4.5	-38.52	-38.0	7	230.8	15.7	1002.6	259	19.2	17.251	17.246	34.571	32.806	8.5	1.5	1511.05	7.52
ftWBB08se	9/10/2014	14:38	N 51 40.4150	E 2 46.2056	14.3	3.8	-36.67	-36.7	7	221.8	17.6	1002.4	318	18.1	17.250	17.248	34.555	32.778	8.5	2.0	1511.02	7.55
ftWG2sb	9/10/2014	7:37	N 51 27.5940	E 2 52.0171	243.2	4.6	-19.07	-19.5	6	206.4	13.4	1001.1	105	15.2	16.975	16.969	33.452	31.740	8.5	2.5	1508.99	7.51
ftWG2se	9/10/2014	7:52	N 51 27.2090	E 2 50.7329	241.1	3.8		-17.4	7	200.9	17.6	1001.3	122	15.1	16.952	16.948	33.560	31.838	8.5	1.5	1509.04	7.53
ftWT11sb	25/09/2014	9:23	N 51 31.7710	E 2 58.1098	245.3		-31.21	-35.2	4	291.0	5.3	1020.5	312	15.4	17.966	17.966	33.068	31.329	8.5	1.5		
ftWT11se	25/09/2014	9:36	N 51 31.2990	E 2 56.9802	251.5		-28.93	-33.2	4	259.2	7.1	1020.5	233	15.8	17.951	17.954	33.168	31.558	8.5	1.5		
ftWT1bissb	25/09/2014	8:31	N 51 30.7370	E 2 54.7197	281.3		-23.46	-27.7	5	286.8	9.1	1020.0	272	15.8	17.956	17.954	33.388	31.676	8.5	2.0		
ftWT1bisse	25/09/2014	8:47	N 51 30.3460	E 2 53.1893	266.0		-24.23	-28.9	5	262.2	8.8	1020.2	277	16.8	17.928	17.923	33.471	31.730	8.5	2.0		
ftWT2bissb	25/09/2014	14:47	N 51 31.4520	E 2 52.6207	80.9		-19.41	-23.0	5	228.7	10.2	1020.3	400	17.9	17.931	17.928	33.815	32.053	8.5	2.0		
ftWT2bisse	25/09/2014	14:59	N 51 31.7840	E 2 53.7509	89.4		-18.35	-22.4	5	237.1	9.5	1020.3	196	18.1	17.928	17.926	33.798	32.038	8.5	2.0		
ftWT3sb	25/09/2014	14:14	N 51 31.6190	E 2 50.2053	69.7		-25.54	-29.3	4	241.0	7.8	1020.7	435	17.0	17.967	17.965	33.926	32.146	8.5	1.5		
ftWT3se	25/09/2014	14:28	N 51 31.9190	E 2 51.5017	88.0		-23.61	-27.8	4	245.9	7.3	1020.6	410	18.9	17.961	17.958	33.836	32.066	8.5	1.5		
ftWT7sb	25/09/2014	10:12	N 51 33.0950	E 3 0.5018	254.0		-28.67	-32.7	4	232.1	8.6	1020.2	658	15.7	17.871	17.868	33.488	31.789	8.5	1.5		
ftWT7se	25/09/2014	10:26	N 51 32.4700	E 2 59.3195	239.2		-31.66	-35.9	4	261.3	5.4	1020.6	531	17.2	17.905	17.904	33.457	31.711	8.5	2.0		

Station	date	time	sept lat.n/s	sept lon.e/w	ship heading	fur speed	ea depth_33	depth sal860	in-windbf	in-winddr pb	in-windsp sb	atm press. 2	sol-rad	airtemp. dry	sbe38 temp	sbe21 temp.	sbe45 salin.	sbe21 salin.	ph	eh turbid l	sbe21 s.vel.	kobold flow
ftWT9sb	25/09/2014	10:53	N 51 33.8600	E 2 56.8810	43.0			-29.4	5	270.8	9.5	1020.5	571	16.4	17.937	17.934	33.527	31.775	8.5	2.0		
ftWT9se	25/09/2014	11:08	N 51 34.4520	E 2 57.9490	39.6		-25.44	-29.3	4	266.9	8.8	1020.3	307	16.2	17.920	17.917	33.611	31.861	8.5	1.5		

Contact

Jozefien Derweduwen, Wetenschappelijk onderzoeker
Instituut voor Landbouw- en Visserijonderzoek
Dier
Ankerstraat 1
8400 Oostende
T +32 59 56 98 82
jozefien.derweduwen@ilvo.vlaanderen.be

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ILVO

Instituut voor Landbouw- en Visserijonderzoek
Burg. Van Gansberghelaan 92
9820 Merelbeke - België

T +32 9 272 25 00
ilvo@ilvo.vlaanderen.be
www.ilvo.vlaanderen.be