Cruise Report Dana0706

Conducted from 04-9-07 to 14-0-07

Summer Production across the Central North Sea

Scientific Party

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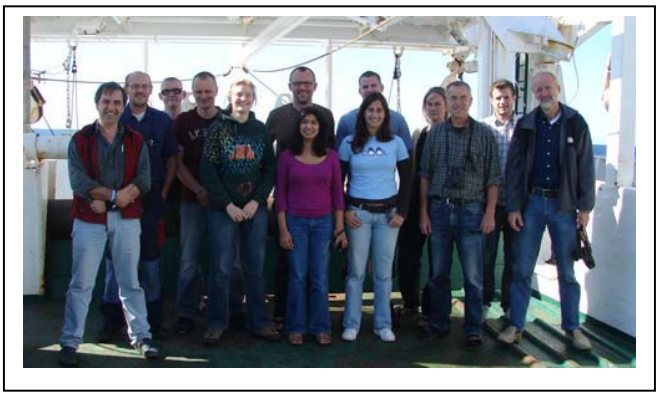

Cruise Objective

Aims and specific activities of the cruise are to

1. Collect copepods from various locations in the North sea to determine their genetic diversity. CTD, water samples and plankton nets from the hydrodeck.
2. Investigate the structure of the sub-surface chlorophyll maximum, its community structure, and nutrient status at different locations in the north sea. Sampling will be conducted with the multi sampler deployed from the aft deck. This will also involve incubations and dilution experiments.
3. The subsurface structure will also be mapped with the CTD, water sampler and flowcytometer deployed from the hydro-deck.
4. If it is deemed feasible, Triaxus will be also used to map sub-surface structure. This however, is a decision that will have to be made at the time, depending on available time, sea state, and the condition of the instrument.
5. The multi net will be deployed from the aft-deck along the three transects to collect spatially resolved plankton and larval fish distributions. This may be augmented with zooplankon pump samples from the hydrodeck.
6. The sea corer will be deployed when suitable to collect in situ subsurface samples of living plankton and intact marine snow aggregates. This will take place on the aft deck. The filming will be conducted in a container positioned on the trawl deck.

The productivity of the North Sea during the summer is fuelled by subsurface primary production in central regions, and frontal production around its periphery. Over the years DIFRES has built up a time series of observations with a view to understanding the dynamics, both physical and biological, ecological consequences and the inter-annual variability of this system. There were three specific objectives to the cruise:

- To observe the subsurface chlorophyll maximum adjacent to the Dogger Bank, its plankton community structure and 2^o production.
- To observe the frontal production in the western and eastern margins of the North Sea – specifically off the Scottish and Jutland coasts.
- To collect biological samples to map the genetic diversity of both copepods and protest within the North Sea.

Narrative of the Cruise

The cruise left Hirtshals at 15:00 on Tuesday 4th September and sailed for two stations, one in the relatively deep waters along the Norwegian trench, and the second west of the Little Fisher Bank where copepod samples were collected.

The first transect was started at 10:00 Wednesday 5th September. The transect comprised of 12 stations proceeding from the deep central North Sea basin up along the flanks and to the top of the Dogger Bank (see Table 1, and Figure 1). Stations were set a distance of 5 nautical miles apart.

Sampling at stations included CTD, water samples for salt, nutrients, oxygen and chlorophyll analysis, the Sea Corer for video observations, WP2 nets to collect live copepods for production experiments, and Multinets for zooplankton and larval fish vertical and cross transect distributions. Multinets were mostly deployed during daylight hours, at the Dogger Bank transect also some night hauls were carried out.

Each station on the Dogger Bank transect was visited twice over a two day period.

Station Number	Latitude	Longitude
1	56° 012.0'N	03° 005.0'E
2	56° 007.5'N	03° 008.8'E
3	56° 003.0'N	03° 012.7'E
4	55° 058.5'N	03° 016.5'E
5	55° 054.0'N	03° 020.3'E
6	55° 049.5'N	03° 024.1'E
7	55° 045.0'N	03° 028.0'E
8	55° 040.5'N	03° 031.8'E
9	55° 035.9'N	03° 035.6'E
10	55° 031.4'N	03° 039.4'E
11	55° 026.9'N	03° 043.3'E
12	55° 022.4'N	03° 047.1'E

Table 1. Station positions along Dogger Bank transects

Dana then sailed 105 nautical miles to the Buchan transect, of the coast of Aberdeen. As at the Dogger Bank, sampling at stations included CTD, water samples for salt, nutrients, oxygen and chlorophyll analysis, the Sea Corer for video observations, WP2 nets to

collect live copepods for production experiments, and Multinets. On this transect Multinets and WP2 zooplankton nets were only deployed during day light hours.

Station Number	Latitude	Longitude
1	57° 000.0'N	00° 009.0'E
2	57° 000.0'N	00° 001.0'E
3	57° 000.0'N	00° 006.9'W
4	57° 000.0'N	00° 014.9'W
5	57° 000.0'N	00° 022.9'W
6	57° 000.0'N	00° 030.8'W
7	57° 000.0'N	00° 038.8'W
8	57° 000.0'N	00° 046.8'W
9	57° 000.0'N	00° 054.7'W
10	57° 000.0'N	01° 002.7'W

Table 2. Station positions along Buchan transect

Sampling along the Buchan transect started at 06:00 on Saturday the 8th at the eastern most station. 4 full stations were sampled the first day before night fall, and sampling continued over the night with CTD stations along the transect. Full sampling resumed from the western most station the following morning with 6 full stations finished off with 4 CTD stations after dark. We departed the Buchan transect at 02:30 in the small hour of Monday 10th under increasingly stormy conditions.

Sailing ENE for 170 nautical miles brought us to a station at 58° 0'N 4° 0'E where zooplankton samples were collected for genetic analysis. A similar station was then visited at 57° 40'N 7° 20'E some 120 nautical miles distance. The seas were rough during this period.

At 08:00 on Tuesday the 11th September, we started work on the Hanstholm transects. These were 3 parallel transects running from the deep waters of the Skagerrak up towards the Danish coast.

Station Number	eastern		central		western	
	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
1	57o 19.0'N	08o 38.0'E	57o 12.0'N	08o 26.0'E	57o 05.0'N	08o 11.0'E
2	57o 21.3'N	08o 34.0'E	57o 14.3'N	08o 22.0'E	57o 07.3'N	08o 7.0'E
3	57o 23.6'N	08o 30.0'E	57o 16.6'N	08o 18.0'E	57o 09.6'N	08o 3.0'E
4	57o 25.9'N	08o 26.0'E	57o 18.9'N	08o 14.0'E	57o 11.9'N	07o 59.0'E
5	57o 28.1'N	08o 22.0'E	57o 21.1'N	08o 10.0'E	57o 14.1'N	07o 55.0'E
6	57o 30.4'N	08o 18.0'E	57o 23.4'N	08o 6.0'E	57o 16.4'N	07o 51.0'E
7	57o 32.7'N	08o 14.0'E	57o 25.7'N	08o 2.0'E	57o 18.7'N	07o 47.0'E
8	57o 35.0'N	08o 10.0'E	57o 28.0'N	07o 58.0'E	57o 21.0'N	07o 43.0'E

Table 3. Station positions along Hanstholm transect

Weather conditions forced us to abandon multinet and sea corer sampling on Tuesday afternoon, and this could only be resumed on Thursday morning. In the meantime, CTD and WP2 nets were deployed along the 3 transects.

On Wednesday evening we sailed to a deep station in the Skagerrak to take zooplankton samples for genetic analysis.

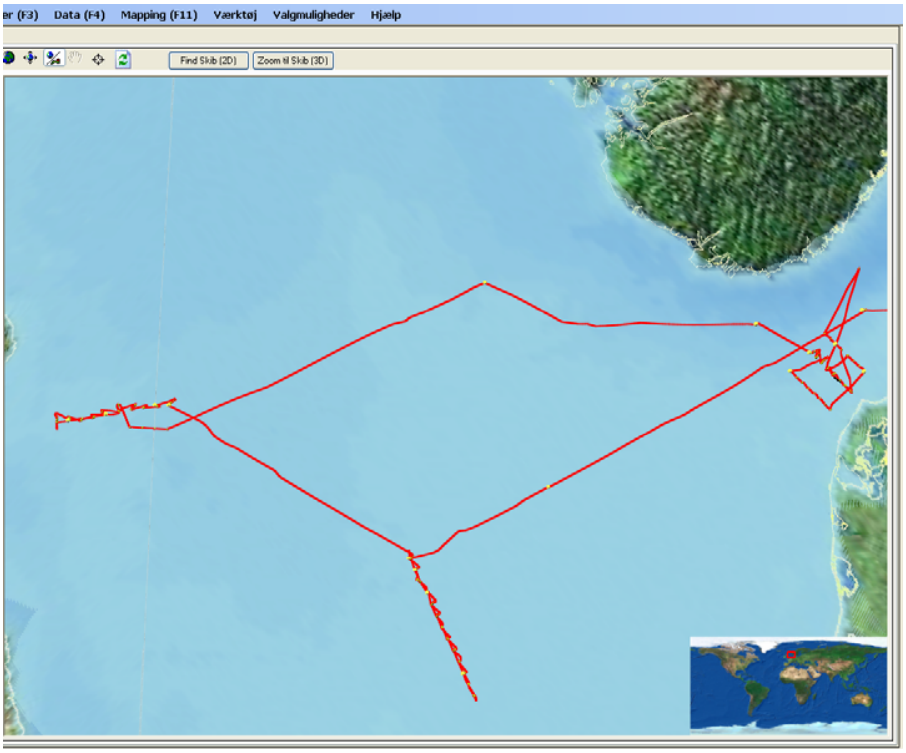

Figure 1: Locations of station visited during the cruise and depth contours.

After an intensive multinet sampling along the central Hanstholm transect, we sailed for Hirtshals, arriving at the wharf at 16:15.

Specific activities and findings

Hydrography

The northern approaches to the Dogger bank were strongly stratified with well mixed warm water (>15^{o}C) over lying a well mixed cold (<9^{o}C) bottom layer. The thermocline was located at about 40 m and varied in thickness from 10 to 20 m. This was deeper than found on previous years, although this cruise was later in the year. The pronounced chlorophyll maximum found on previous years was much weaker, and was only evident as isolated subsurface patches. Again the lateness in the season is the likely explanation.

The Buchan transect was characterized by a typical shelf sea tidal mixing front – with stratified waters in deep waters, becoming more mixed in towards shallow waters. Stratification was mainly temperature driven with a small contribution from salinity. The tidal mixing front was found along a depth contour of about 70 m.

The Hanstsholm transect exhibited a complex interaction between central North Sea waters, deep Norwegian trench waters, the Jutland coastal current and the low salinity Baltic outflow. Strong north westerly winds had spread the Baltic outflow waters out across the Sagerrak so that surface salinities off Hanstholm were relatively low. This,

together with a steep vertical temperature gradient (14 to 9 oC) produced a strongly stratified water column. A relatively weak front along the 30 m depth contour.

Zooplankton for cultures and DNA analysis

Although the global distribution of copepod species is relatively well known, the degree to which populations are inter-related remains uncertain. For instance, does the population of *Calanus helgolandicus* in the North Sea share genetic material with the populations in the Bay of Biscay and the Mediterranean, and if so, to what degree. Throughout the cruise, a number of net hauls were made to collect live copepods of various species. These species included *Calanus helgolandicus*, *Temora longicornis*, *Pseudocalanus* spp. and *Centropages typicus*. Additional samples were collected and preserved for subsequent DNA analysis.

In addition to copepods, samples were also collected to investigate the genetic diversity of a variety of protists.

Egg production of copepods

The egg productions of copepods can be used a proxy for the productivity of the copepods community, since the growth of adult females is realised as egg production. On all stations visited the egg production rate of the calanoid copepod *Centropages typicus* was monitored. In general the was a peak in the egg production rate in association with the front indicating higher production of the copepods in association with the front

Fig 2. Professor Thomas Kiørboe and his sea corer after deployment

The Sea Corer: a window into the life of plankton

In situ observations of planktonic marine life has up until recently remained difficult. With the help of our newly developed sea corer, we have come some way in being able to look directly into this microscopic world to observe delicate structure and intimate behaviour of various plantonic species. The sea corer is a square sided, transparent “aquarium” of some 50L volume, that can be lowered to a prescribed depth and closed, so capturing an undisturbed volume of seawater. When brought back on board, video recordings of organisms within this volume can be made, The sea corer was deployed 26 times during the cruise at all 3 operation sites, and video recordings made of copepods, wing snails, starfish larvae, appendicularia and ctenophores amongst others. A video film of some of these observations can be seen on Dana network.

Dilution grazing experiments

The effective growth rate of phytoplankton can be strongly controlled by microzooplankton grazing. By progressively diluting natural assemblages of plankton < 100 µ, the encounter rate between predator and prey can be manipulated. Measuring the effective growth rate in a series of the dilutions gives information of both the community grazing rate, and the actual phytoplankton growth rate – two parameters that are crucial in puzzling together the dynamics of the food web, and interpreting our field observations. 4 dilution experiments were conducted, one at each of the intensive stations and two of which were conducted concurrently with zooplankton grazing experiments.

Dinoflagellates with eyes

A family of dinoflagellates have what appears to be a complex eye. A few species of the Warnowiaceae are found in temperate waters, and the object of this cruise was to find cells for further studies into the function of this ocelloid. Water from the Buchan transect turned of to have a few cells pr. 10L and from filtering obscene amounts of water I found ~10 individuals of *Nematodinium armatum/vigilans.* I hope these cells will form the basis of a laboratory culture to use for studies of the physical/chemical properties of the eyes as well behaviour.

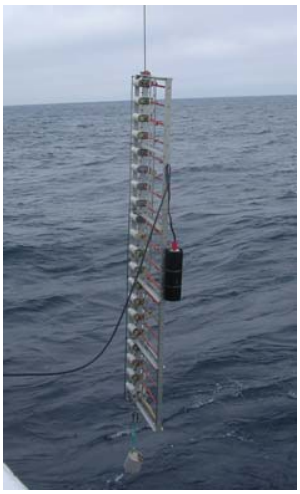

Fig 3. The "Door" multi sampler, a vertical array of 150 ml sampling syringes spaced at 15 cm intervals

The Fluoroprobe: spectral fingerprints of plankton

A regular feature of most CTD deployments as well as the "Door" multi sampler, was the use of our fluoroprobe, a multi wavelength fluorometer. This allows different classes of phytoplankton to be distinguished as a function of their spectral fingerprint. For example, dinoflagellates can be distinguished from diatoms. This yielded quite interesting results in that on several occasions it was observed that the subsurface chlorophyll peak was in fact stratified, with diatoms and protists occupying distinct strata.

Stratified sampling of zooplankton and fish larvae.

At every transect station two haul were carried out with a 0.25 m2 Multinet. The first haul were done vertically, lowering the gear to a 5-10 m above bottom, and opening 53 micron meshed nets at every 10 m to the surface. During the second haul the multinet were hauled at a speed of 2 knots, lowered with one net open to 5-10 m above bottom, and opening 500 micron meshed nets at every 10 m to the surface.
The samples are preserved for later processing, preliminary examination show marked differences in zooplankton communities between transects. Pronounced vertical differences were also evident. The fish larvae were not abundant in the samples, and the expected high abundances of herring larvae at the Buchan transect were not observed.

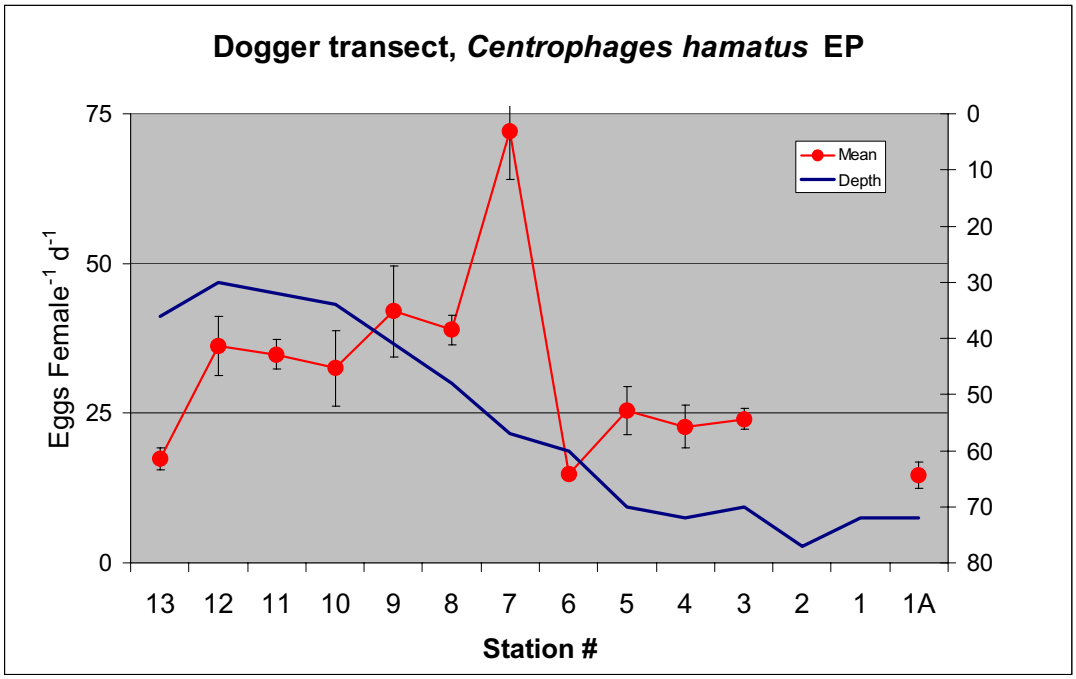

Fig 4. Egg production of *Centropahes typicus* across the Dogger Bank. The peak in production is co-located with the subsurface front.

As always, we would like to thank the captain and crew of RV Dana for their hospitality, interest and help during the cruise. We would also like to thank ship services and technical support for their preparation.

Appendices: Temperature, salinity, fluorescence, oxygen and density across the transects visited.

200706 HØK Dogger Bank Transect 1

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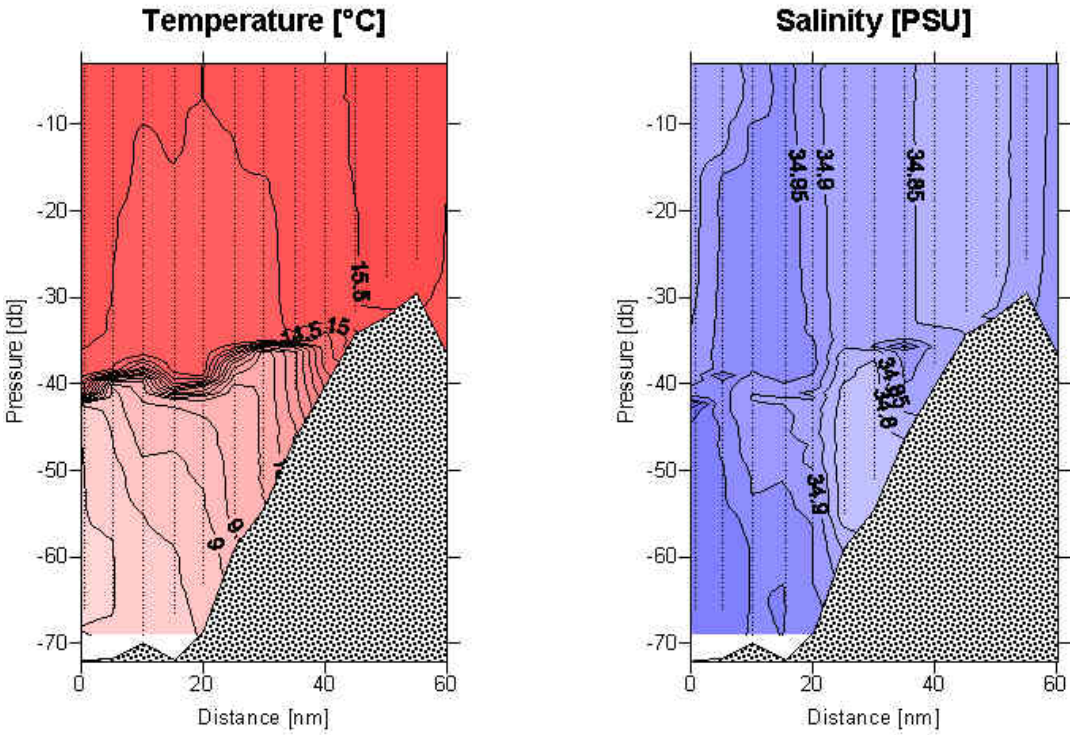
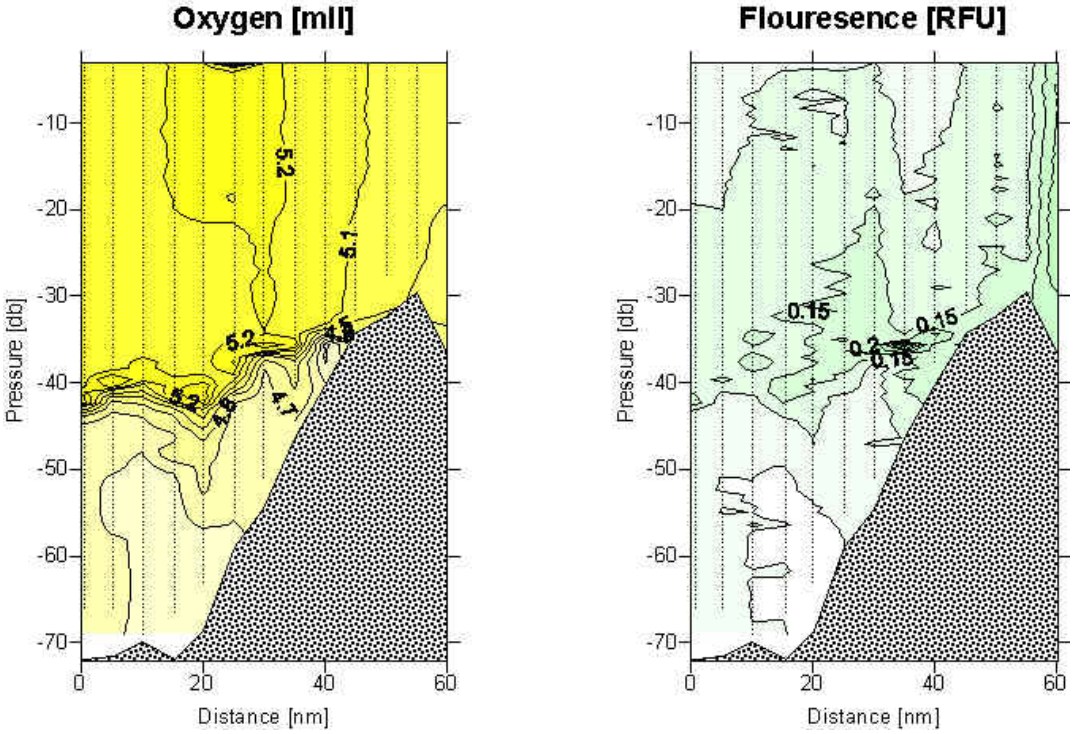
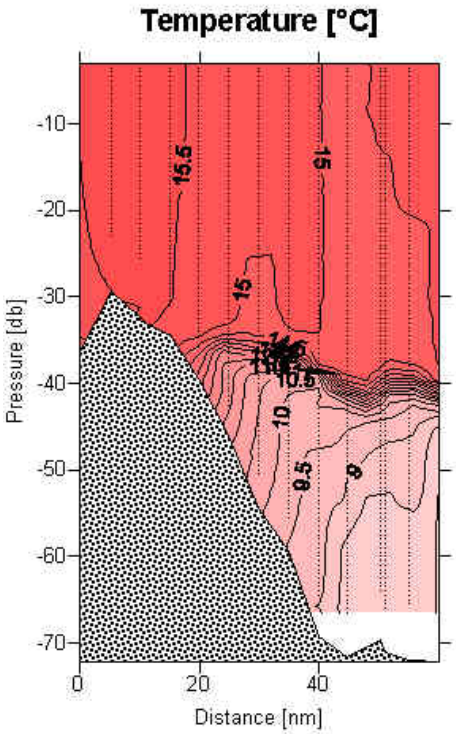
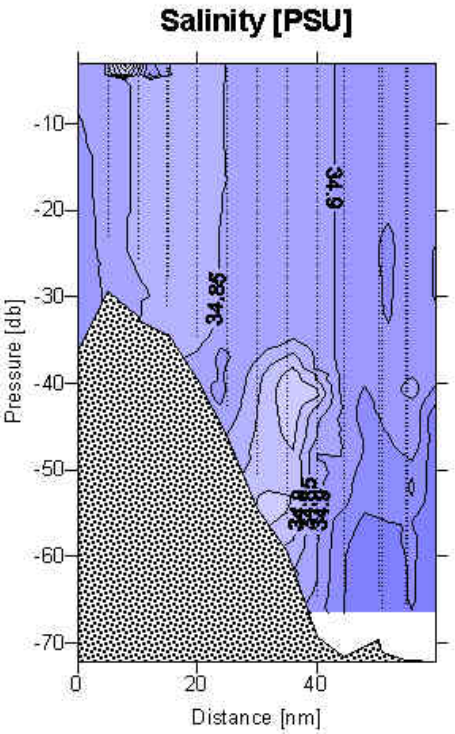


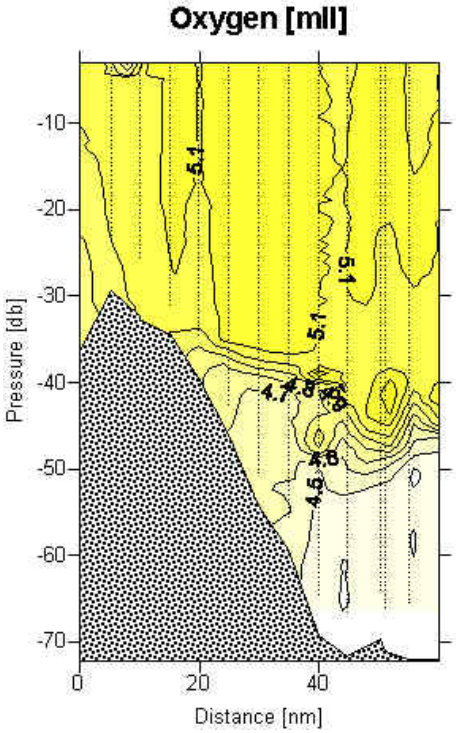


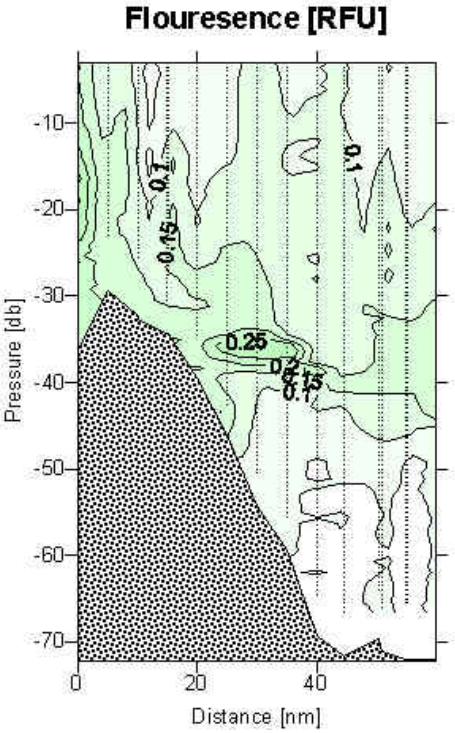
200706 HØK Dogger Bank Transect 2

28, 35, 42, 47, 50, 54, 57, 61, 66, 70, 75, 81, 88, 93, 98, 102, 107,









200706 HØK Buchan Transect 1

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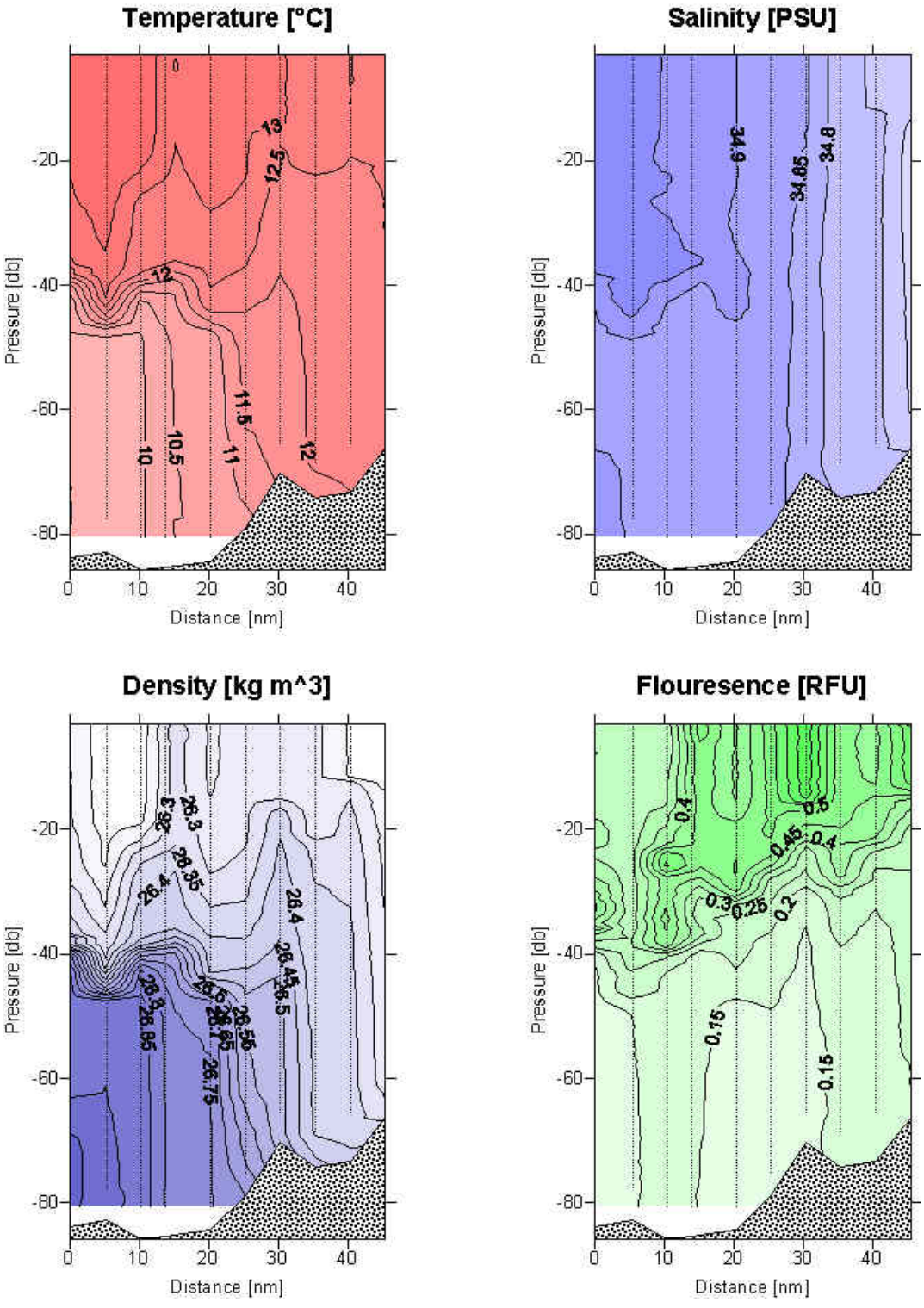

200706 HØK Buchan Transect 2

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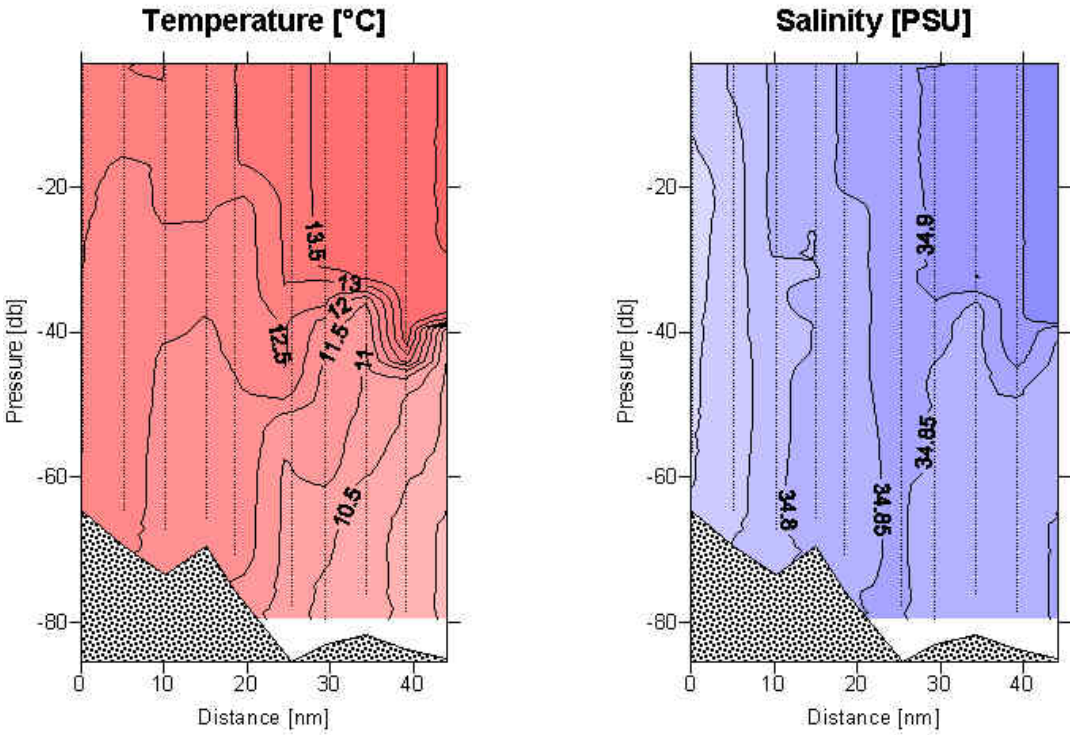

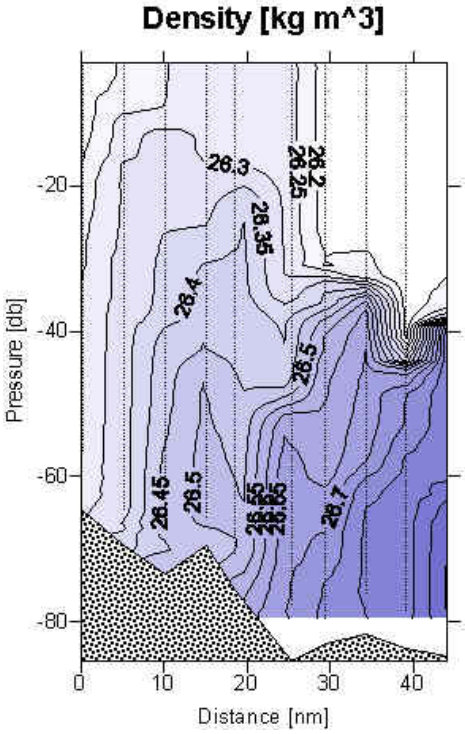

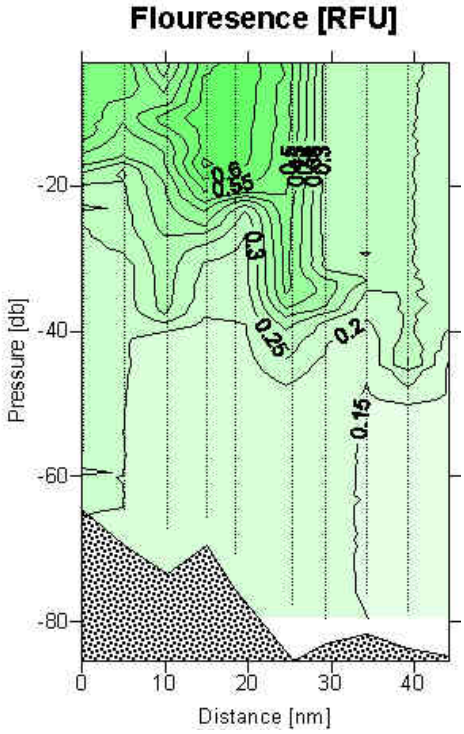

200706 HØK Hanstholm Transect East

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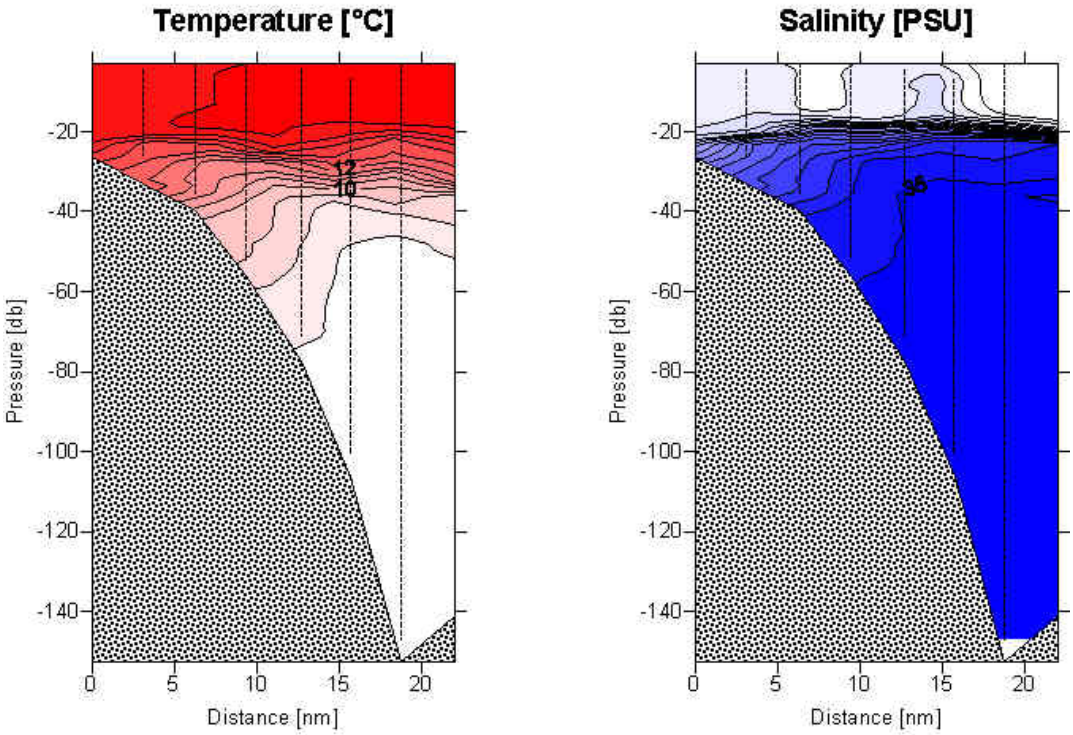

200706 HØK Hanstholm Transect Central

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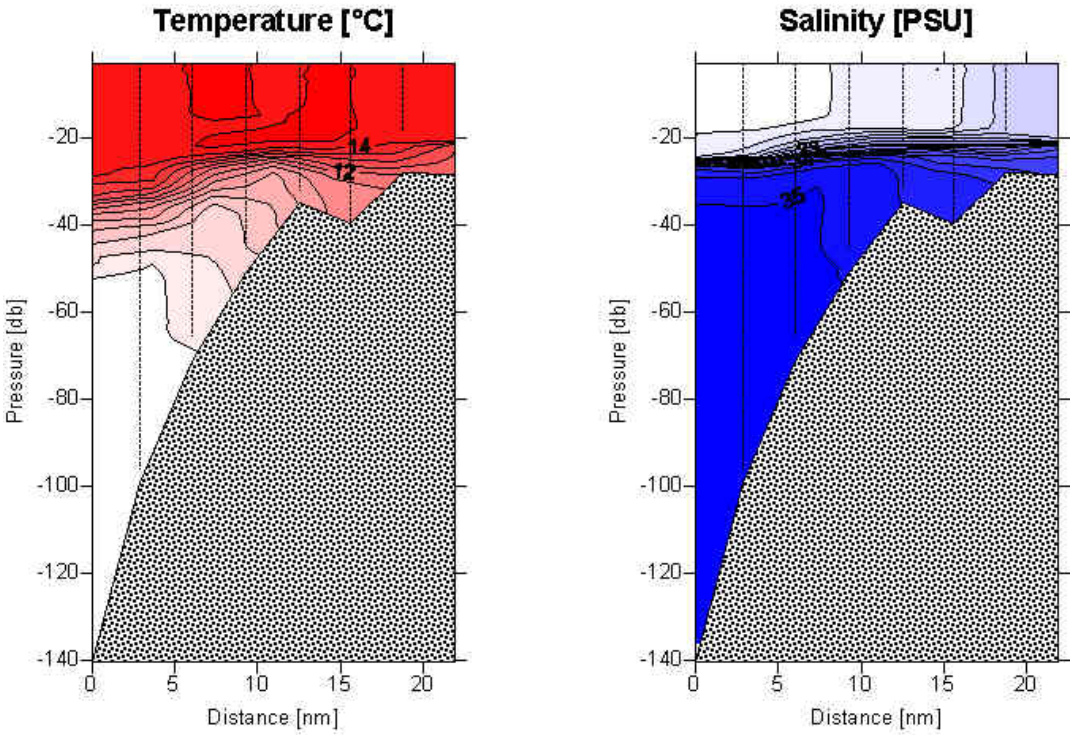

200706 HØK Hanstholm Transect West

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