Cruise Report Dana0505

Conducted from 26-7-05 to 4-8-05

Summer Production over the Dogger Bank and the Central North Sea

Scientific Party

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Cruise Objective

The productivity of the central North Sea during the summer is fuelled by subsurface primary production. This is at a time of year when there is very little other production to sustain juvenile fish at a critical stage of their development. Over the years DFU 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, sample its phytoplankton composition, and measure its geographic extent, fluorescence characteristics, 1^{o} production and its related subsurface oxygen surplus.
- To investigate the importance of the chlorophyll maximum and its quality as food for the micro- and mesozooplankton community in terms of secondary production.
- To develop a method for detecting selection and utilization of the protist community by secondary producers in the microzooplankton class.

In addition, some topics to be addressed include (i) pigments as tracers in trophic transfer to secondary producers, (ii) production, consumption and degradation of appendicularian houses, (iii) the vertical distribution of tissue pigments in calanoid copepods as a

protection against harmful radiation (iv) bacterial production in association with copepod sloppy feeding.

Narrative of the Cruise

The cruise left Hirtshals at 15:00 on Tuesday 26th July 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 13:30 Wednesday 27th July. The transect comprised of nominally 15 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).

Primary sampling at stations included CTD, water samples for salt, nutrients, oxygen and chlorophyll analysis. 4 stations were identified as intensive stations. These were stations 1,3, 5 and 8. Additional measurements were taken at these stations including primary production (C14 incubations and Phyto-pam), preserved phytoplankton samples, and phytoplankton pigment samples. In addition, intensive stations were chosen as sites for many of the ship board experiments that were conducted, including copepod secondary production (egg production, hatching success and naupliar development), grazing experiments, and vertical distributions of zooplankton.

Transects were primarily sampled during daylight hours, while nights were devoted to sailing back to the first station with occasional stops to collect night time zooplankton profiles.

In all, the transect was covered 7 times. Apart from the first transect, all of these covered stations 1 to 13-15 giving a complete coverage of the Dogger Bank.

Station Number	Distance (nm)	Latitude	Longitude
1	0	56° 39.0'	03° 27.0'
2	10	56° 30.0'	03° 35.5'
3	20	56° 21.0'	03° 44.0'
4	30	56° 12.0'	03° 52.5'
5	40	56° 03.0'	04° 01.0'
6	45	55° 58.5'	04° 05.3'
7	50	55° 54.0'	04° 09.5'
8	55	55° 49.5'	04° 13.8'
9	60	55° 45.0'	04° 18.0'
10	65	55° 40.5'	04° 22.3'
11	70	55° 36.0'	04° 26.5'
12	75	55° 31.5'	04° 30.8'
13	80	55° 27.0'	04° 35.0'
14	85	55° 22.5'	04° 39.3'
15	90	55° 18.0'	04° 43.5'

Table 1. Station positions along Dogger Bank transects

A total of 130 CTD casts were made from which 279 nutrient samples (nitrate, nitrite & phosphate). To calibrate the CTD data, 72 salt samples, 136 chlorophyll and 118 oxygen samples were also taken. All of the chlorophyll and oxygen samples were analysed during the cruise, and preliminary calibrations showed reasonably linear regression fits. At intensive stations, chlorophyll samples were fractionated larger and smaller than 22 µ.

date	*latitude*	*longitude*
26-7-05	57° 40'	7° 20'
27-7-05	57° 00'	4° 42'
3-8-05	56° 40'	5° 40'
3-8-05	57° 10'	6° 45'
3-8-05	57° 25'	7° 55'

Table 2: Zooplankton stations for collecting live copepods. CTD profiles were also taken at these locations.

The last station on the last transect was station 15 on the 7th transect, taken at 22:40 on Tuesday 2nd August. Dana then sailed towards her home port, stopping at three stations (see Table 2) on the way to collect copepods for live culture, DNA analysis, and to collect Appendicularia and *Microsetella* for behavioural observations. Dana docked in Hirtshals at 07:30 on Thursday 4th of August.

Specific deployments of special instruments include

- Zooplankton pump: on 7 stations (4 day time and 3 night time) zooplankton pumps were taken at 5 m intervals to estimate the vertical distribution of zooplankton > 30 µ. The pump was run for 3 minutes giving a sampled volume of about 500L. The zooplankton pump was also deployed twice to gather samples for zooplankton pigment analysis. In these cases, the pump was run for 6 minutes.
- Appendicularian net. This special net was deployed many times to collect intact appendicularian houses with undisturbed animals. These were used for on board experiments.
- Bongo nets: bongo nets were trawled at the very surface to collect samples of the pigmented calanoid copepod *Anomalocera*. Bongo nets were towed at the surface while the ship steamed forward at about 2 knots. Tows were 4 minutes long, and the actual time spent in the water (between waves) was noted on a stop watch.
- WP2 nets: these were used to collect vertically integrated zooplankton samples. 2 mesh sizes were used, the finer (90 µ) targeting the small harpacticoid copepods *Microsetella norwegica*.

A total of 56 vertical net tows of one type or the other were conducted during the cruise. In addition 82 zooplankton pump deployments, and 9 surface bongo tows were also made.

There was a heavy demand on Dana's laboratory facilities during the cruise. The wet lab was used for filtration for chlorophyll, phytoplankton pigments, and lugols fixation. The C14 lab was used for primary production and Phyto-pam measurements. Phyto-pam is a 4 wavelength fluorometer that can be used to measure chlorophyll and the rate at which phytoplankton absorb light energy. The dry lab had 6 microscopes set up and were used to set up and analysed copepod egg production experiments, hatching experiments, and grazing experiments, and to identify zooplankton and pick individuals to set up cultures. Both aquarium rooms were used to incubate experiments on 2 plankton wheels and

several aerated buckets and the fish lab was used to set up grazing experiments, bacteria production experiments and fix samples.

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 (<7^{o}C) bottom layer. The thermocline was located at about 30 m and varied in thickness from 10 to 20 m. At the base of the thermocline there was a pronounced chlorophyll maximum with concentrations typically 10 times higher than in the surface. In association with the chlorophyll maximum, there was also an oxygen maximum. Approaching the crest of the Dogger Bank, there was a bottom front at water column depth of about 40 to 50 m marking the transition from stratified to well mixed waters. Over that bank at shallower depth, the water column became isothermal with low chlorophyll concentrations.

Appendicularia – Microsetella coupling
On this cruise we were able to examine the suspected association of the harpacticoid copepods (in this case *Microsetella norwegica*) with discarded appendicularian houses. The tunicate, appendicularia (primarily *Oikopleura* sp) extract food particles by filtering seawater through a mucus house. The filtering system on these houses becomes clogged from time to time, and the animal periodically has to abandon its house to build a new one – this can happen as frequently as 4 times a day. The clogged, discarded houses form a rich resource for detrital feeders such as harpacticoid copepods. The rate at which these copepods colonize and graze on discarded houses in the water column is potentially an important factor in pelagic bentic coupling. In addition to vertical distributions, grazing experiments were conducted to study the feeding rate of harpacticoids on discarded houses.

Bacteria and Copepods
Copepods are not the most graceful of eaters – varying degrees of the internal content of their prey is spilled out into the surrounding water – a process known as sloppy feeding. This spilled material – dissolved organic carbon (DOC) – is a rich resource for bacteria. Furthermore bacteria may find it convenient to hitch a ride on the copepods themselves, as they are the effective source of this DOC. On this cruise we were able to measure the DOC and CDOM (coloured dissolved organic material) produced by copepods in natural sea water, composition both in free living bacteria and those attached to copepods, and bacterial production both in the water column and on copepods.

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.

Anomalocera: a very blue calanoid copepod.
The pigment astaxanthine is common in many marine animals ranging from lobsters to jellyfish. Oftentimes it is a vivid blue. The calanoid copepod *Anomalocera* is highly pigmented and lives almost exclusively in the upper meter of the water column. These were found in relatively high abundance during the cruise (10's m^{-2}). The reason for their high pigmentation is unknown – it maybe a camouflage and/or it could be to protect the animal from harmful solar radiation. Their eggs, also pigmented, appear to sink very rapidly in the order of 5 m per hour. During the cruise, samples were collected for pigment analysis, and to conduct grazing experiments.

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.

Copepod secondary production experiments
Not all phytoplankton is the same; some are highly nutritious while others are of lower food quality. The effect of this on the copepods that feed on them is reflected in both the rate at which they lay eggs, and the eventual hatching success of these eggs and development of nauplii. Female copepods of the species *Calanus helgolandicus* were incubated in sea water samples collected form the surface and chlorophyll maximum at the 4 intensive stations for 4 days, and the number of egg produced, the percentage of these eggs that hatched, and the development time of nauplii were measured. At the same time, samples of phytoplankton were collected for pigment and fatty acid (lipid) analysis to be done later on land.

Copepod grazing experiments
In connection with food quality, copepods are also selective feeders – they don't just eat everything in the same proportion as it is found in the water. Some prey is too big or too little, some are more easily caught, some are more conspicuous, some escape better and some don't taste so good. Specific algal groups have unique pigment combinations that can be used as biomarkers. Thus, in order to get an idea of what is being eaten, biomarkers in the form of the relative pigment composition (pigment "fingerprint") of the potential diet is compared to the actual pigment finger print in the gut of copepods. Specifically, copepods of the species *Calanus helgolandicus* and *Temora longicornis* were incubated in natural assemblages of micro plankton < 100 µ from the chlorophyll maximum at station 1 and 5. Samples of copepods and their diet were taken at the end of the incubations for pigment analysis. In conjunction, field samples of phytoplankton were

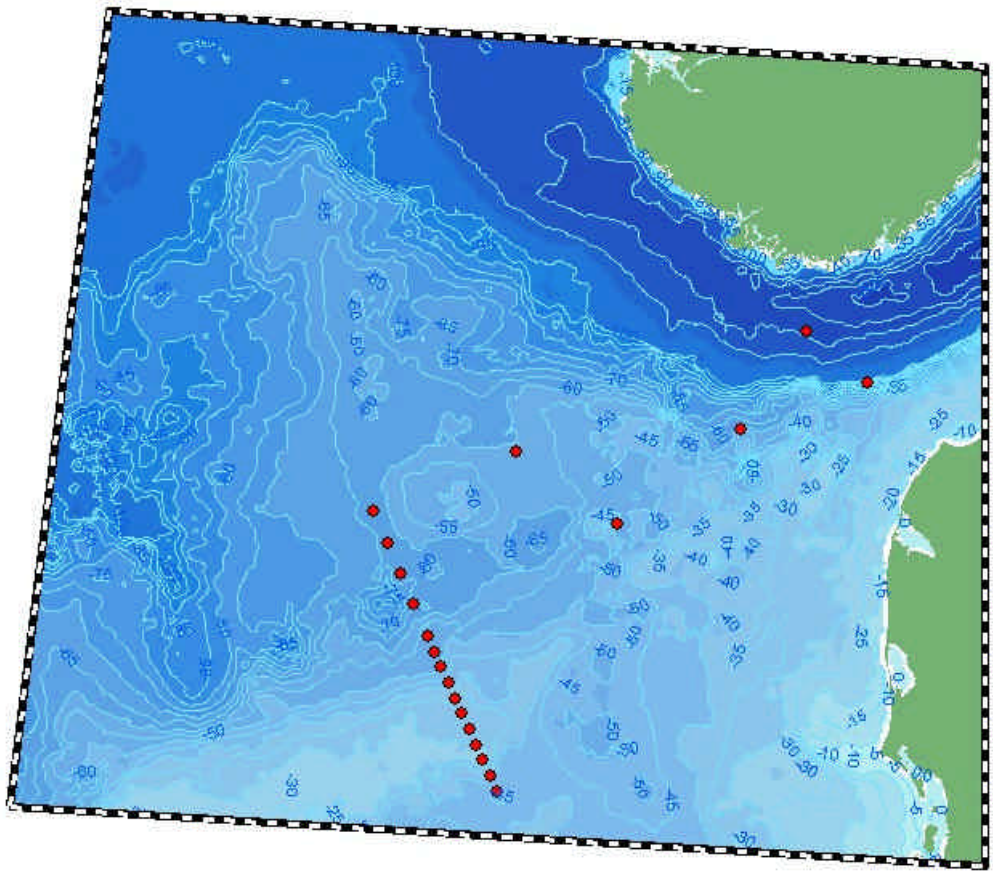


Figure 1: Locations of station visited during the cruise and depth contours.

preserved for later analysis as were frozen samples of zooplankton for gut pigment analysis.

Some comments

There was a potentially serious problem with the CTD when on Saturday night (July 30th) it was discovered that there was hydraulic oil mixed with rusty water dripping on the CTD. This was of particular concern for the water samplers. It appeared that the problem was associated with heavy rain that drained along the extendable arm. A bucket was slung under the arm to catch the dripping fluid, and the CTD unit and water bottles were thoroughly washed in hot water, and rinsed in seawater. This is a problem that should be looked into as it could have serious consequences if not caught in time.

A nagging question throughout the cruise was what does “WP2” stand for.

In the C14 lab, a sample was accidentally dropped and broke on the floor. The room was immediately hosed down with warm water, a process which continued for at least 15 minutes. After this, a Geiger counter showed a reading close to background, and it was concluded that it was safe to continue.

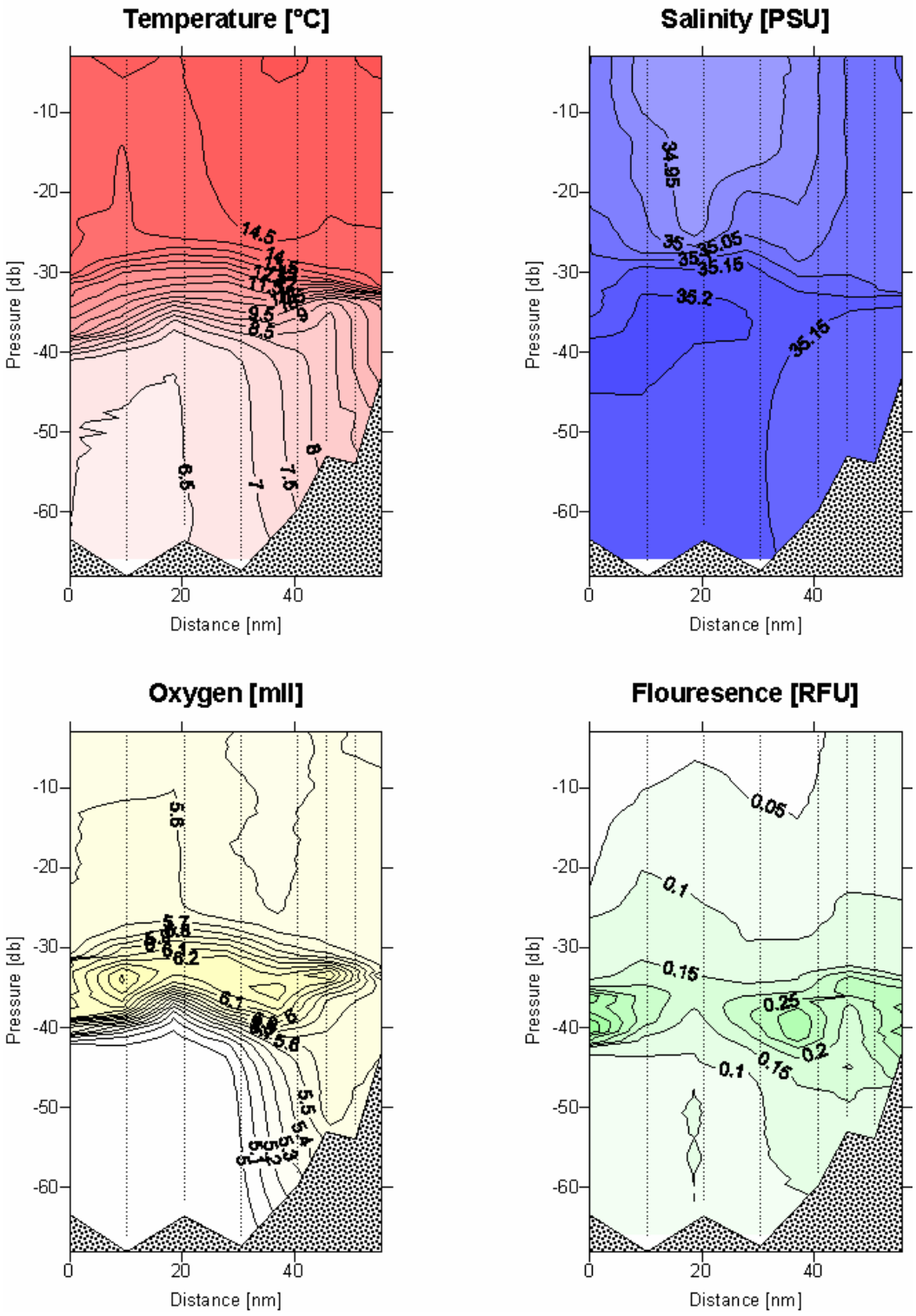
We were very pleased with the double configuration of the CTD as on 2 occasions at least, it saved us from retaking profiles. On the first occasion, a jelly fish got sucked into the intake of the 1st string resulting in erratic readings. On the second occasion, the pump on the second occasion the pump on the 2nd string broke. Both problems were easily identified and quickly remedied.

Finally we would like to thank the crew of the RV Dana for their cooperation, their enthusiasm and interest, and not least, their most excellent hospitality throughout the cruise.

Appendix
Temperature, salinity, oxygen and fluorescence profiles along the primary transect.

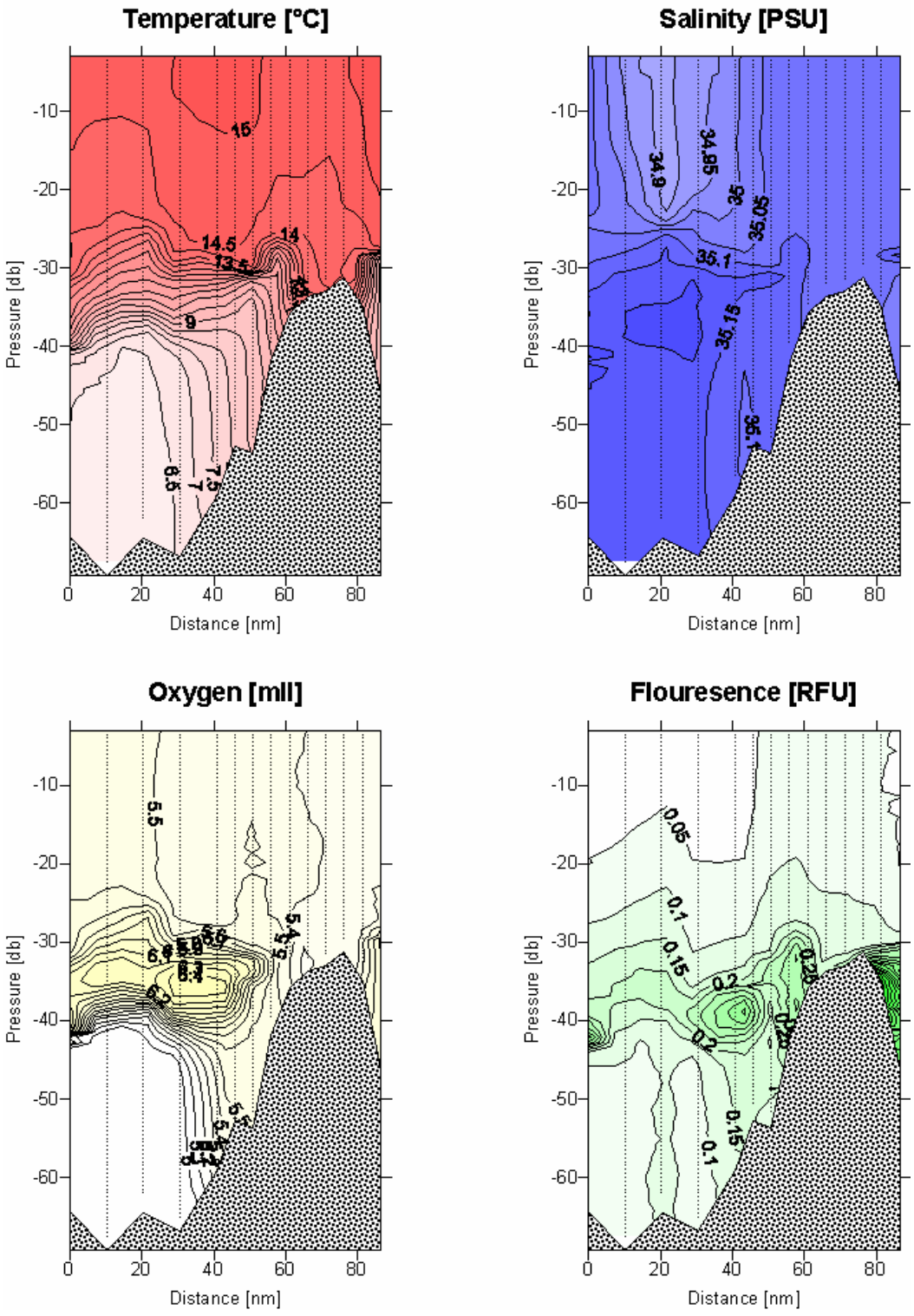
200505 Conwoy Transect 1

8, 10, 11, 14, 15, 17, 18, 19,



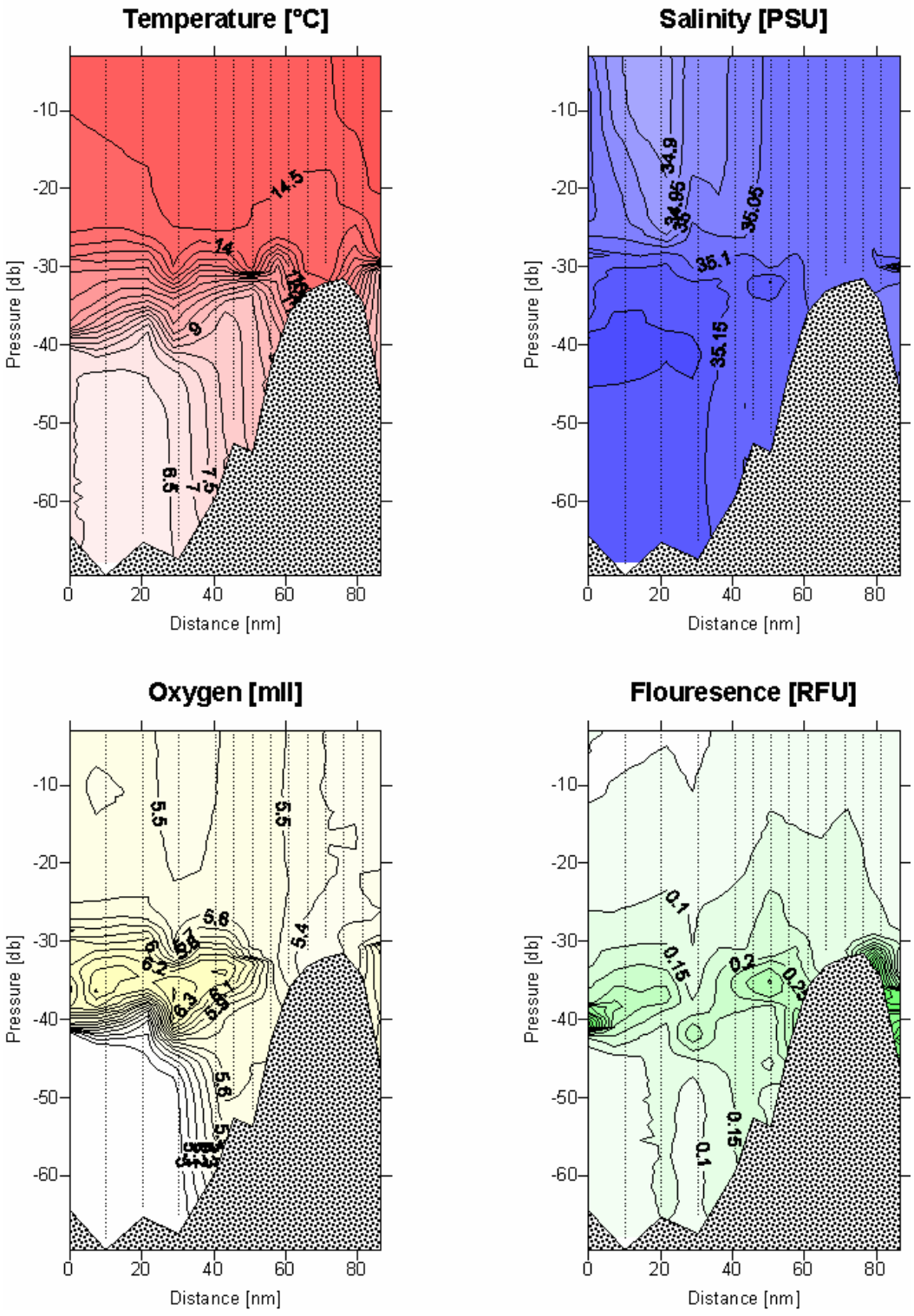
200505 Conwoy Transect 2

32, 47, 48, 49, 50, 61, 62, 63, 64, 65, 66, 67, 68, 69,



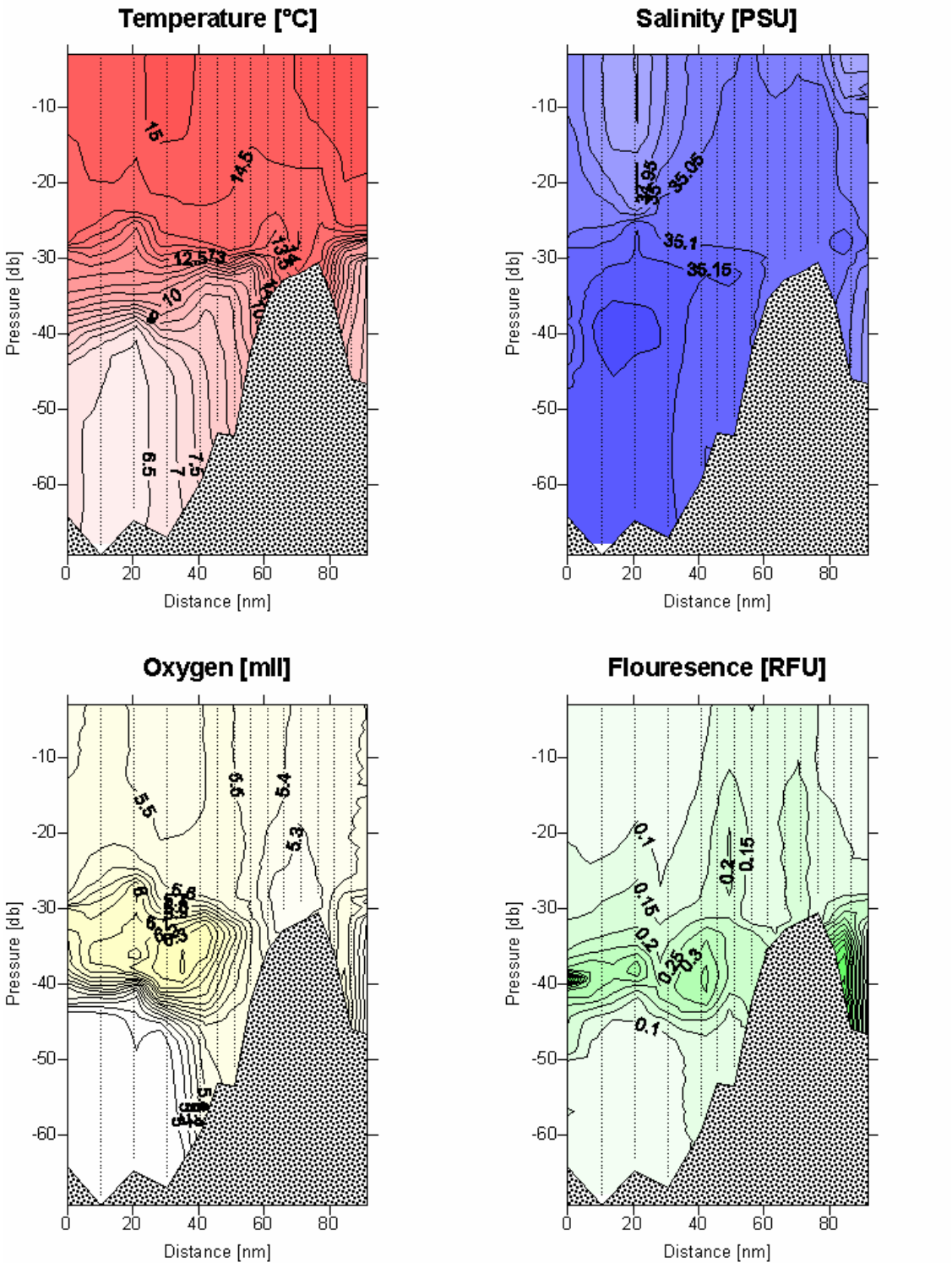
200505 Conwoy Transect 3

70, 79, 80, 83, 84, 86, 87, 88, 96, 97, 98, 99, 100, 101,



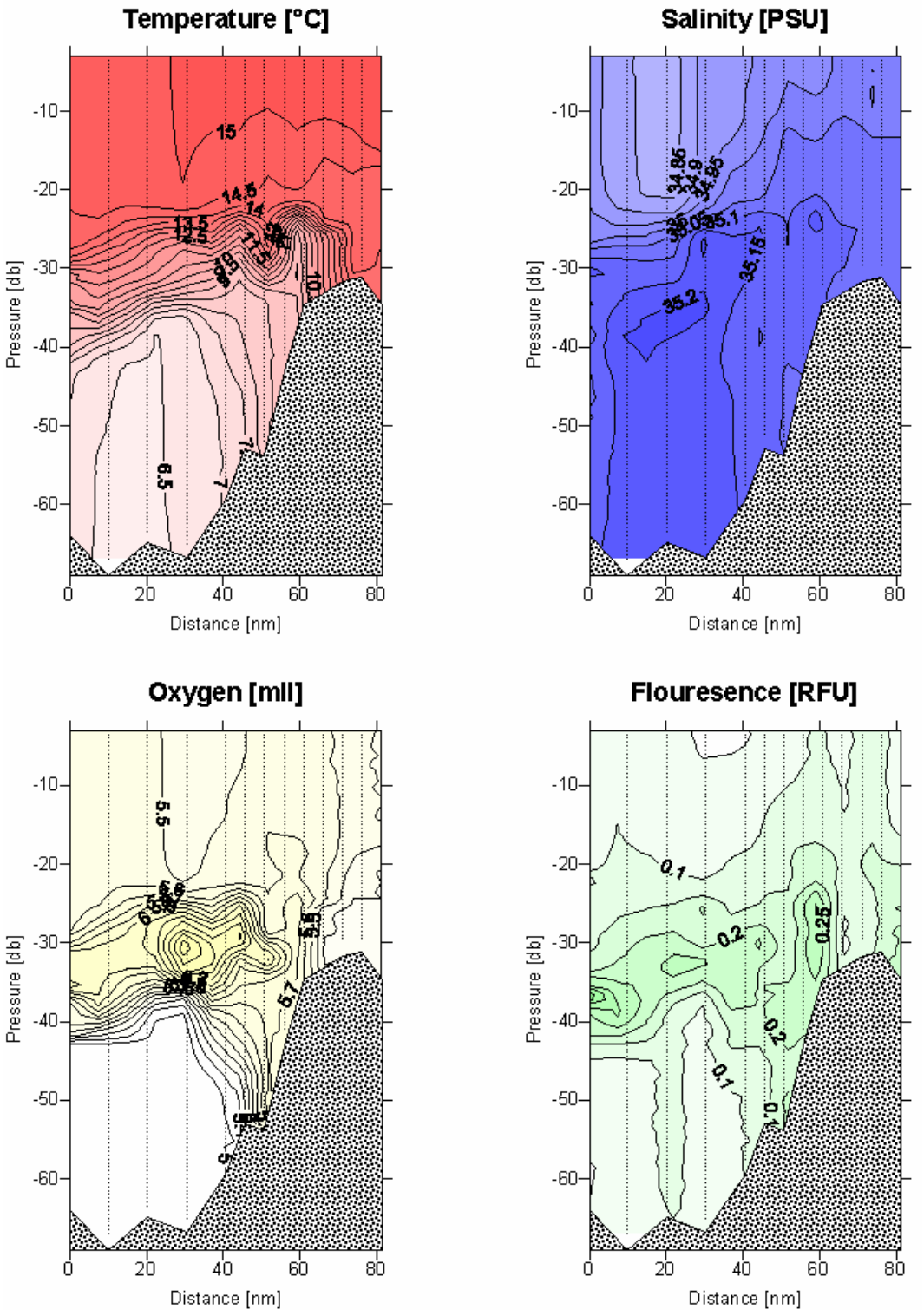
200505 Conwoy Transect 4

109, 112, 113, 132, 133, 136, 137, 138, 142, 143, 144, 145, 146, 147, 148,



200505 Conwoy Transect 5

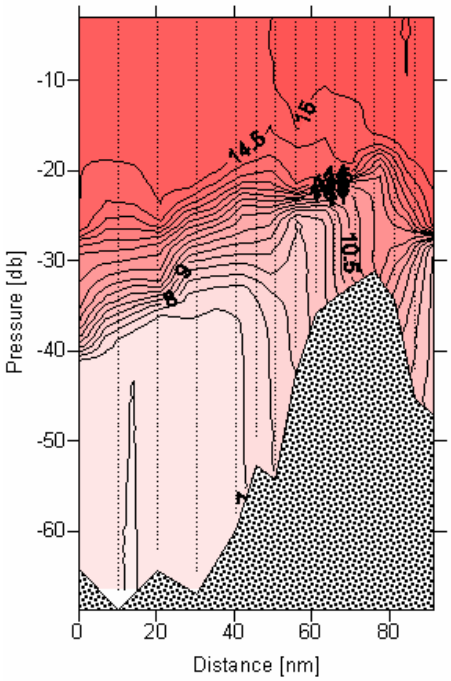
160, 163, 164, 168, 169, 170, 171, 172, 174, 175, 176, 177, 178,



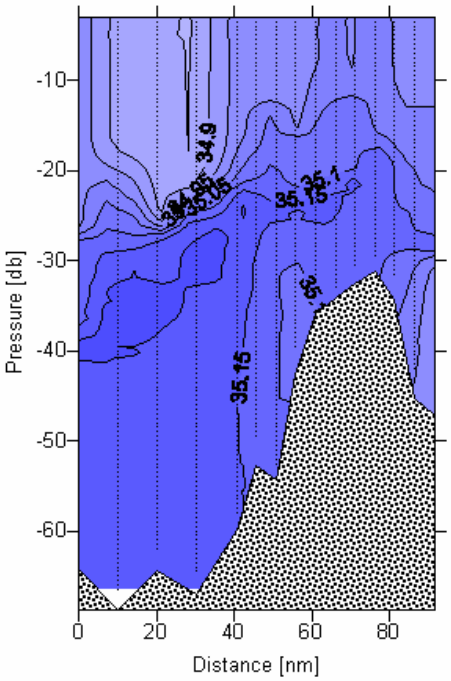
200505 Conwoy Transect 6

191, 199, 200, 201, 202, 208, 209, 210, 212, 213, 214, 215, 216, 217, 218,

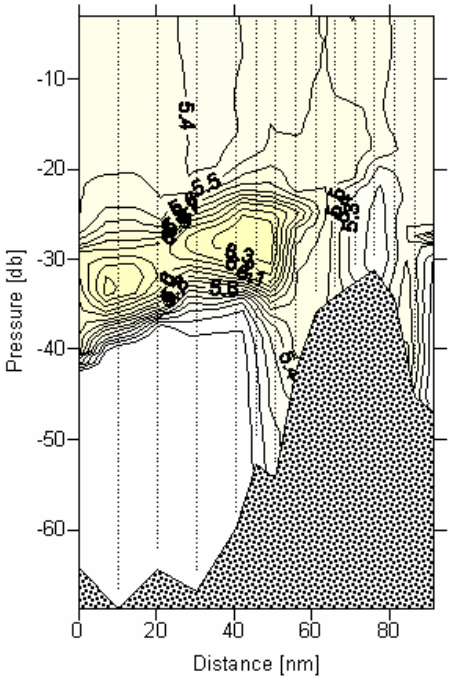
Temperature [°C]



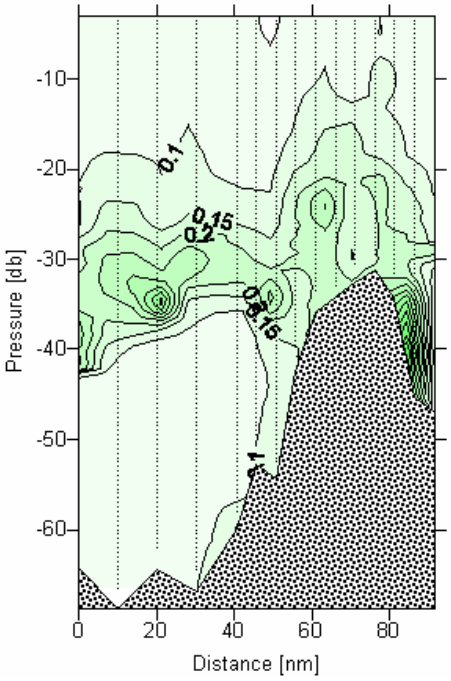
Salinity [PSU]



Oxygen [ml]



Flouresence [RFU]



200505 Conwoy Transect 7

219, 224, 225, 228, 230, 247, 248, 251, 252, 254, 255, 256, 257, 258, 259,