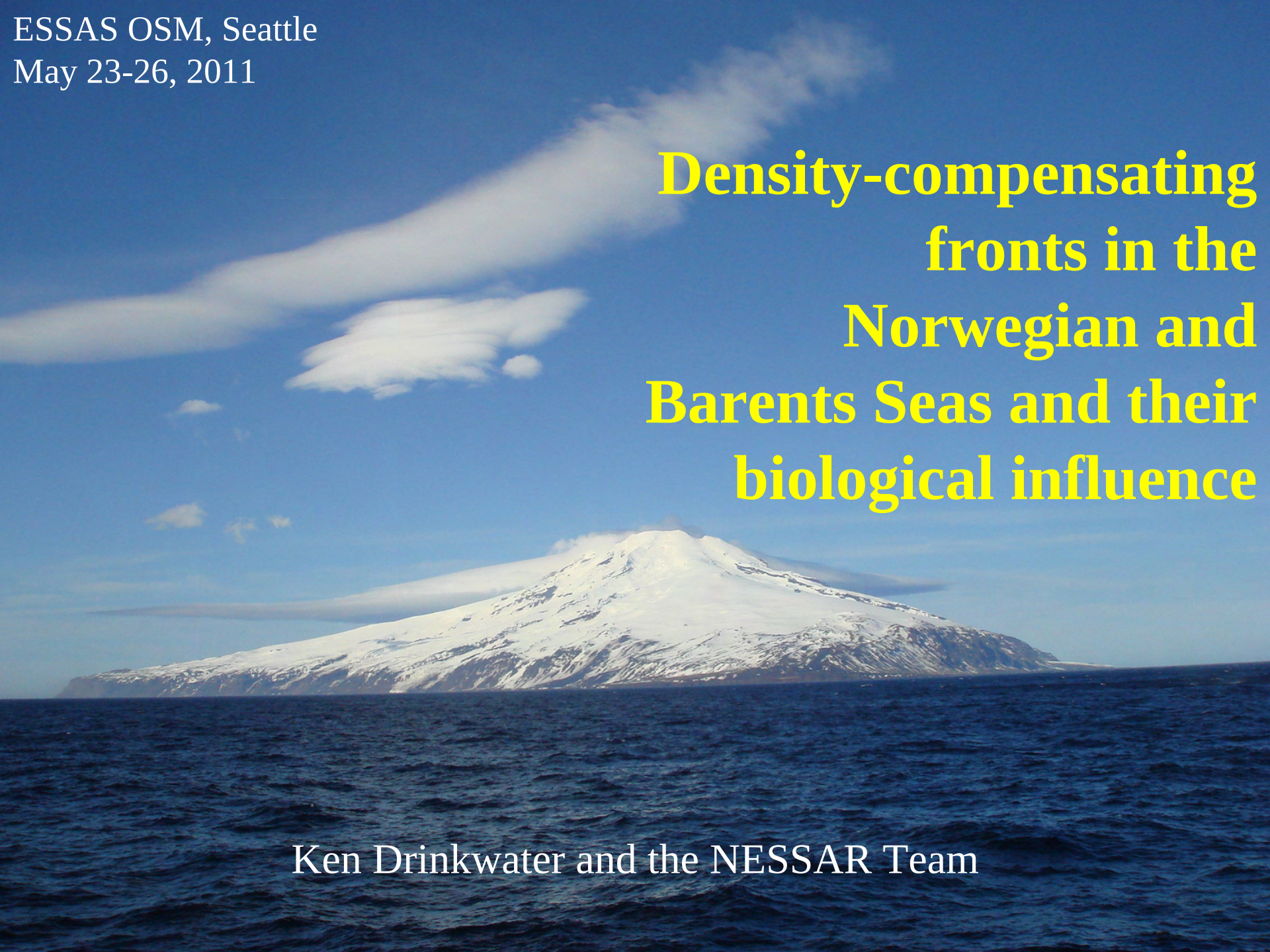
ESSAS OSM, Seattle
May 23-26, 2011

Density-compensating fronts in the Norwegian and Barents Seas and their biological influence

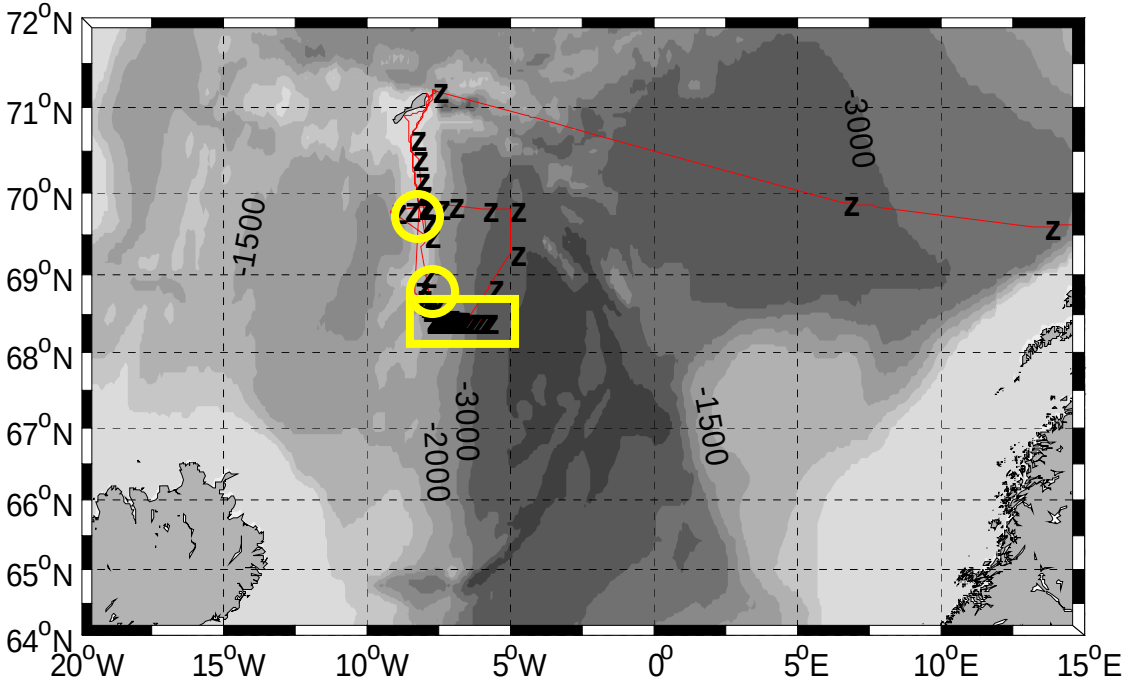


Ken Drinkwater and the NESSAR Team

Norwegian Ecosystem Studies of Subarctic and Arctic Regions (NESSAR)

- **NESSAR Objective** - ***To understand the frontal dynamics in the Barents and Norwegian Seas & their effect on biological production & distribution***
  - ***Motivation: fish distributions (herring and capelin)***
- **What is an ocean front?** - ***Boundary between two different water masses, in our case between warm, salty water and cold, fresher water***
- **What did we do?** – ***Physical and benthic field studies in Barents Sea in 2007, 2008 and 2009; Biophysical cruises in 2007 and 2008 to Norwegian Sea and the Barents Sea***

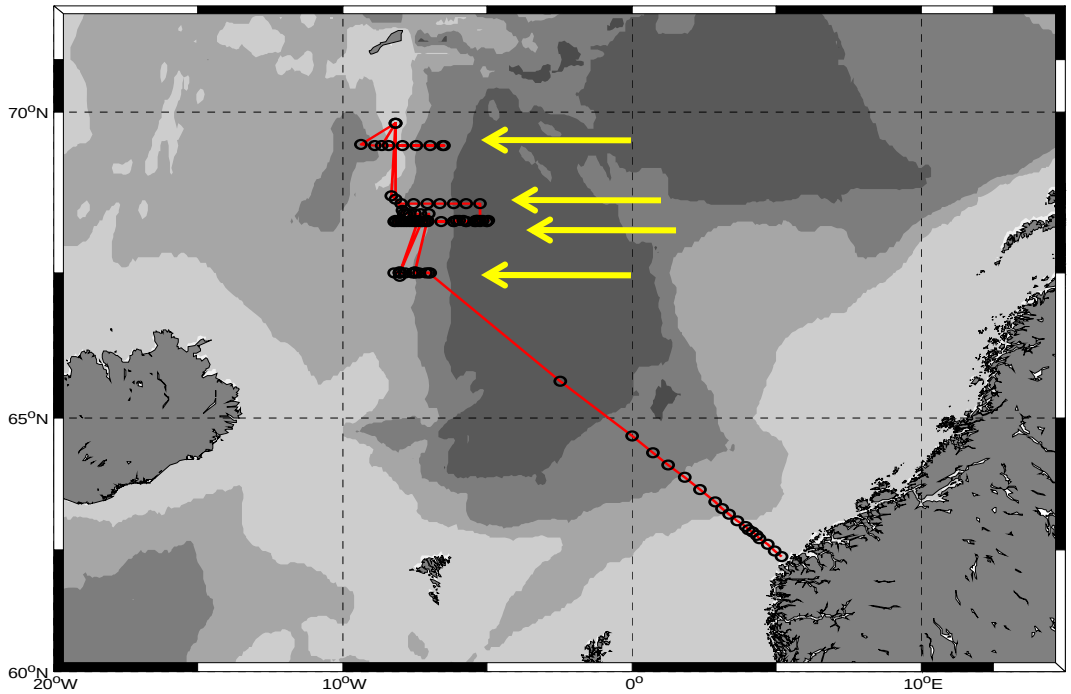
Norwegian Sea



June 2007

Moored CM on Ridge

Concentrated on X-Front Transect



May-June 2008

Recovered and redeployed CM on Ridge

Examined along-Front variability

First detailed studies in the area.

CTD Section

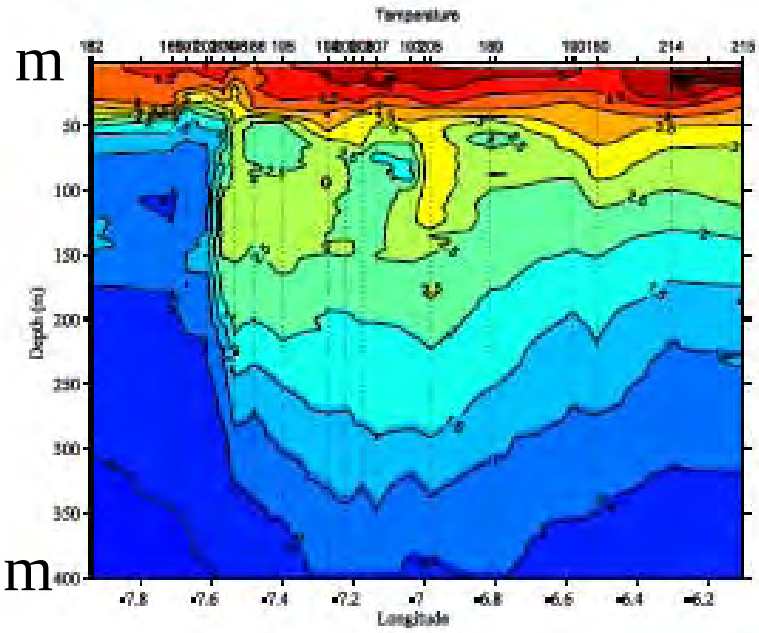
Temperature

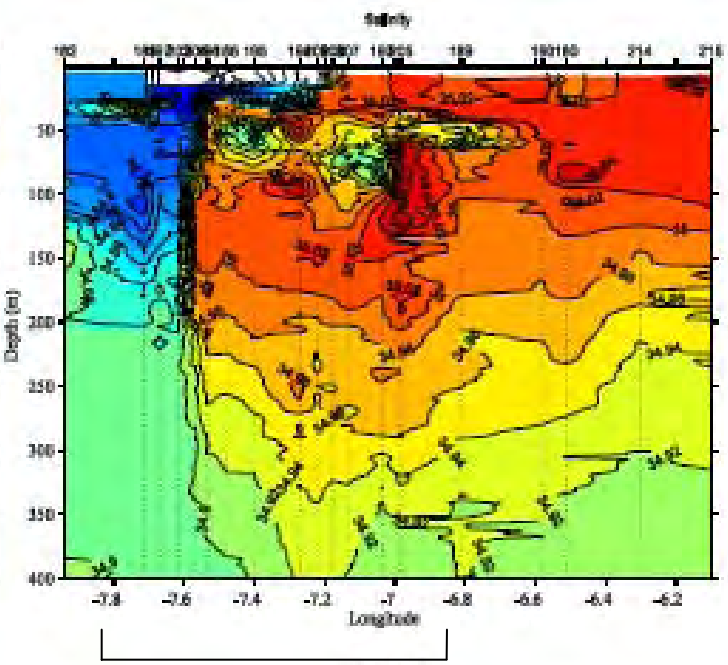
Salinity

0 m

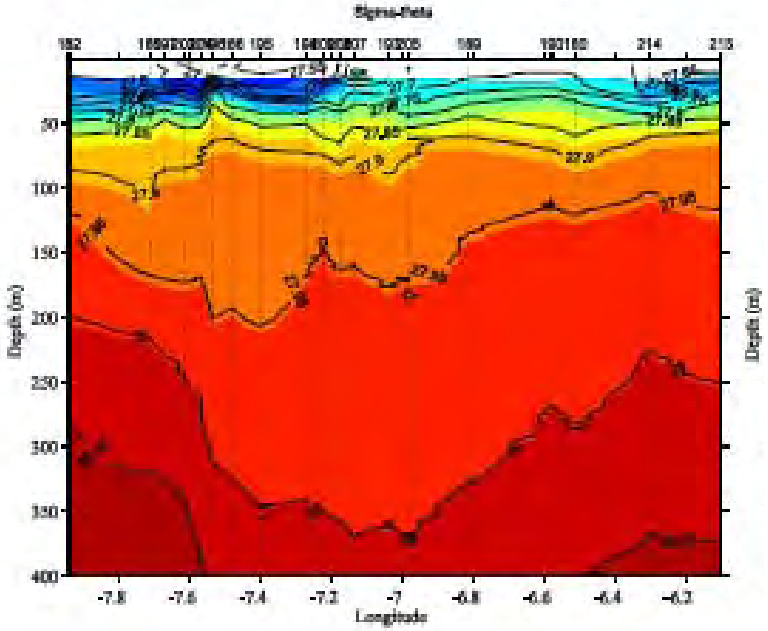
400 m

From June 2007 CTD data





40 km



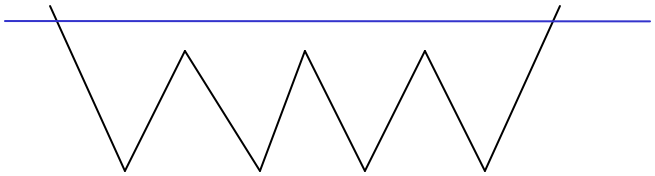
Density compensating (passive) front.

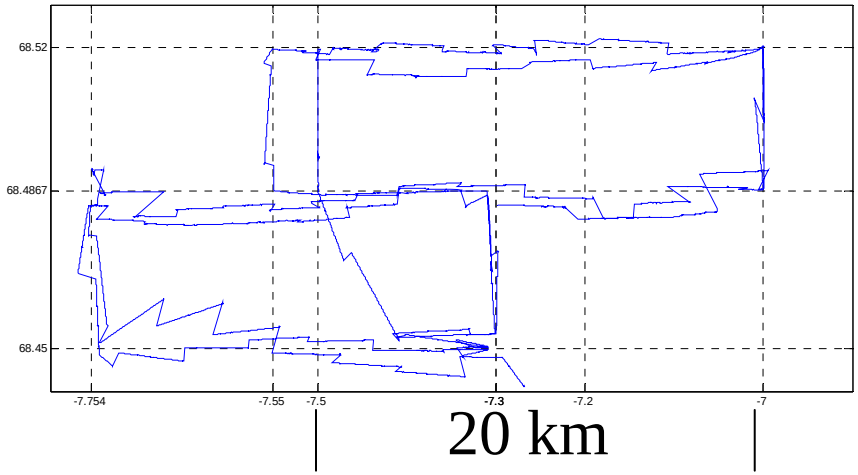
Glider Deployment

-first deployment of an autonomous glider by Norway

Web Slocan Glider

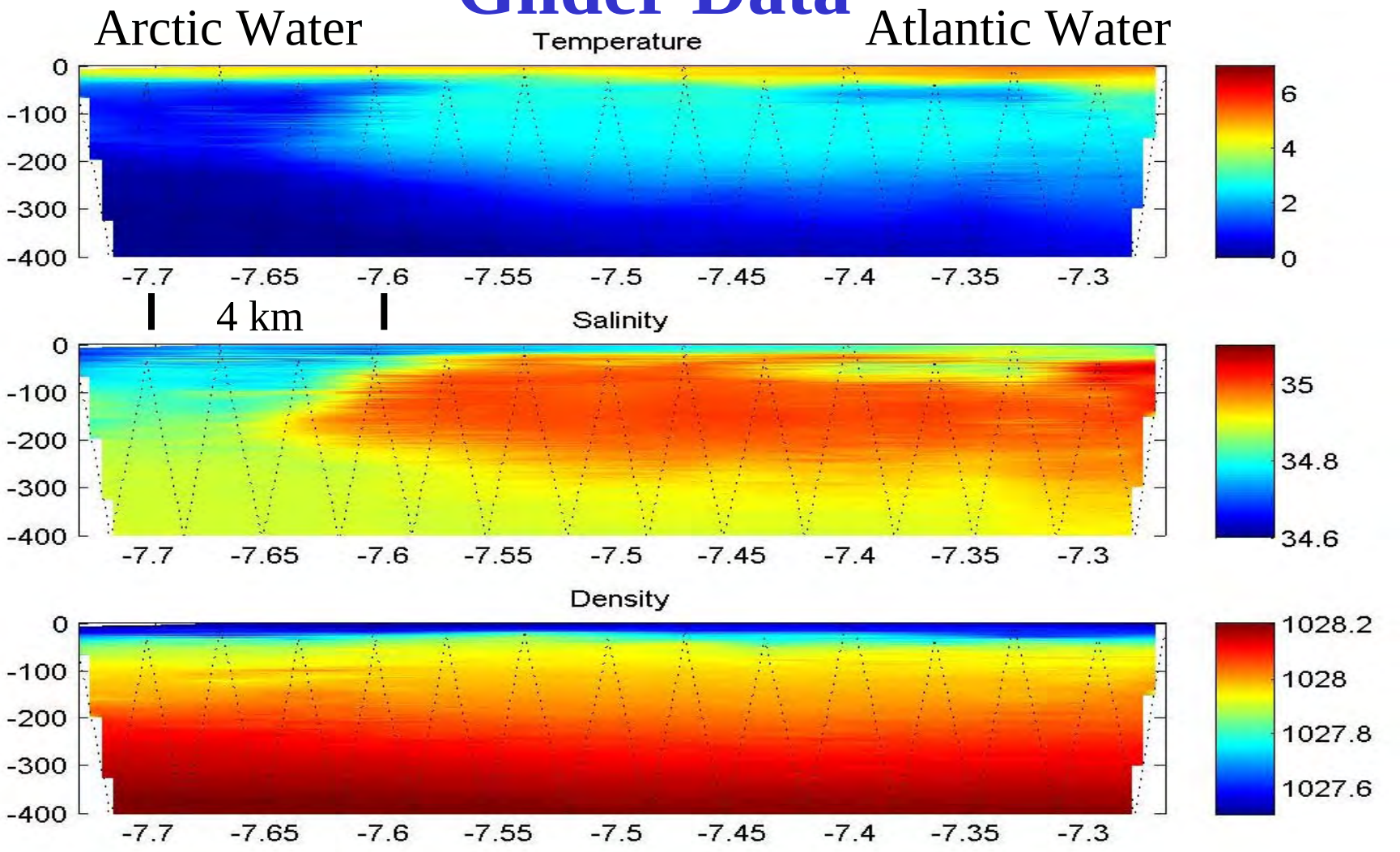
- Two-way Communication via satellite
- Travels between specified points
- Makes sawtooth vertical profile by variable buoyancy



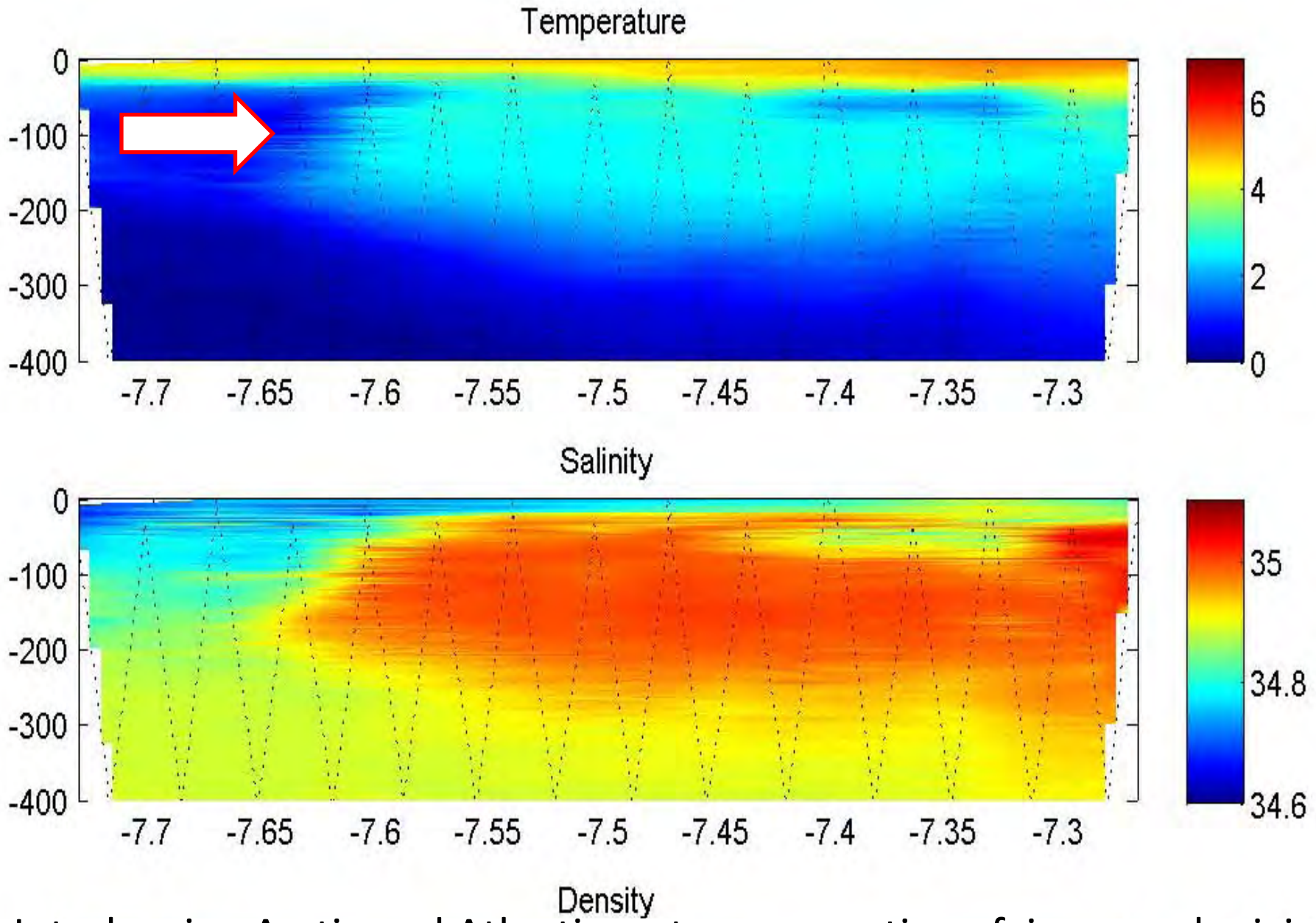


- Box-shaped transects
- Dove to 400 m
-Horizontal speed: 0.43 ms^{-1}
- Deployed for 10 days

Glider Data



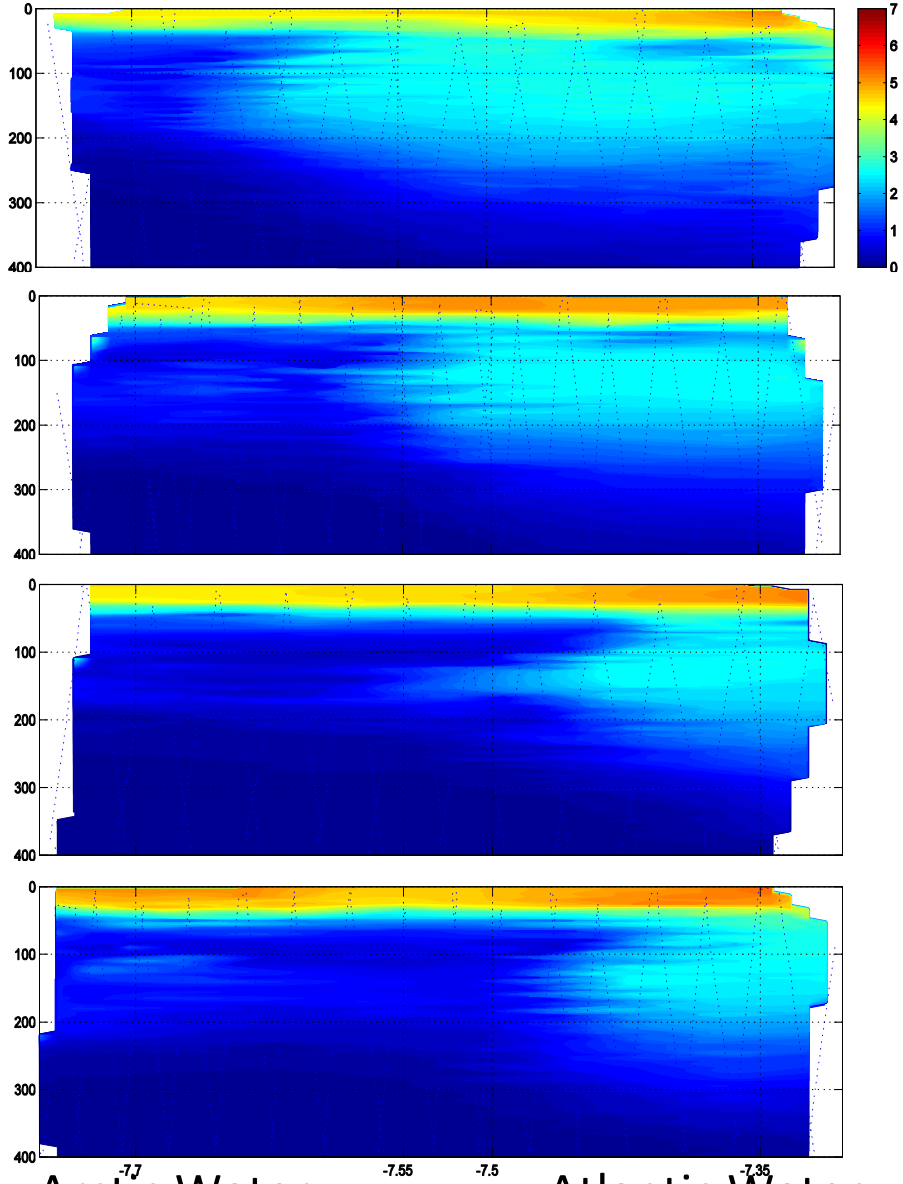
- Sharp fronts in temperature and salinity clearly visible from 30-250 m
- Little density contrast, density compensating

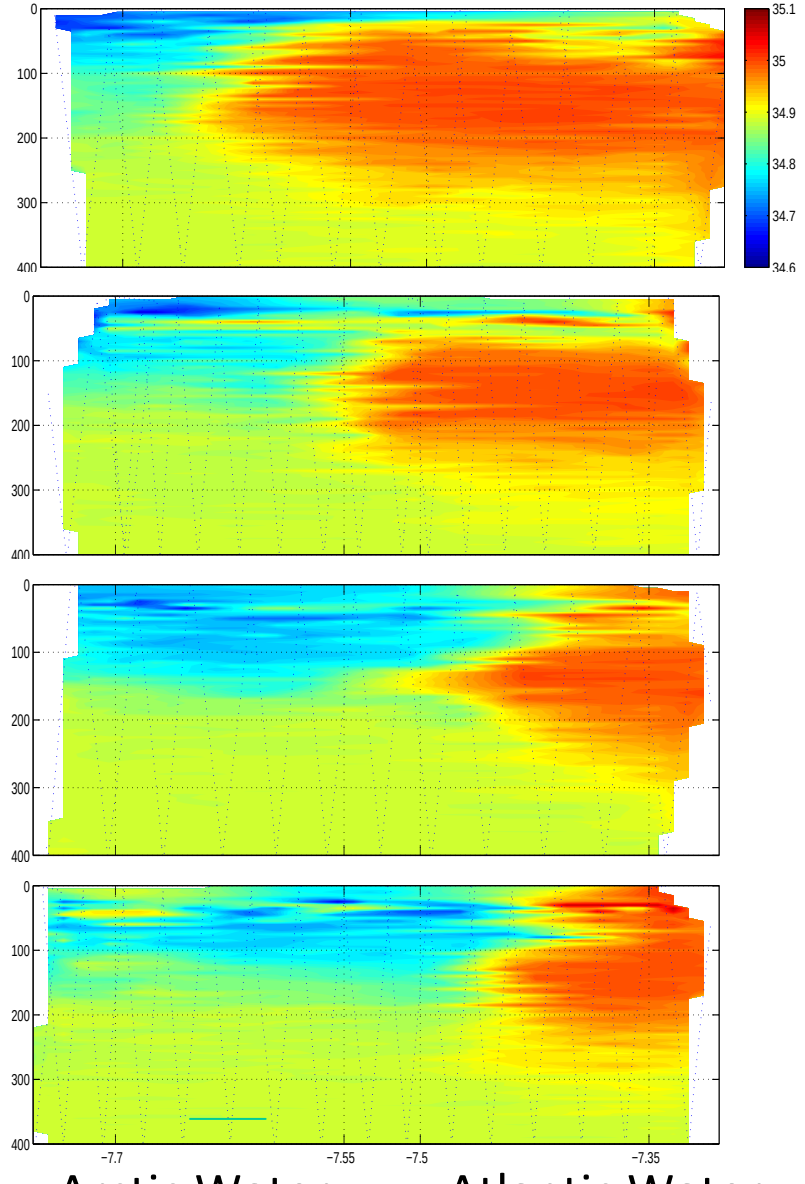


- Interleaving Arctic and Atlantic waters suggestive of isopycnal mixing
- Layers 10-50 m thick and 1-4 km long

Temperature

Salinity





Arctic Water

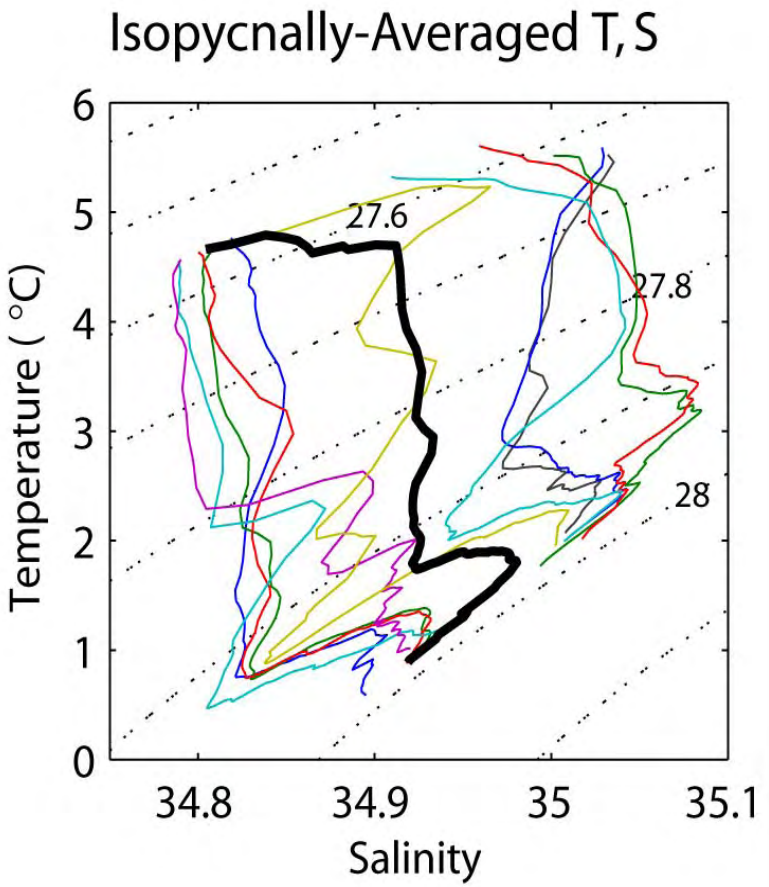
Atlantic Water

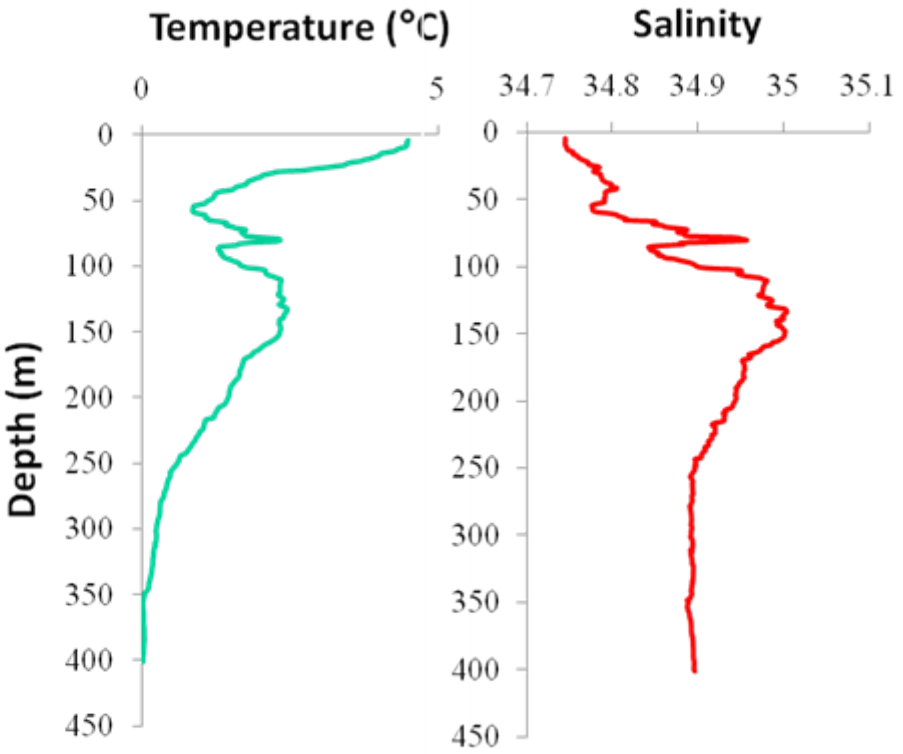
Arctic Water

Atlantic Water

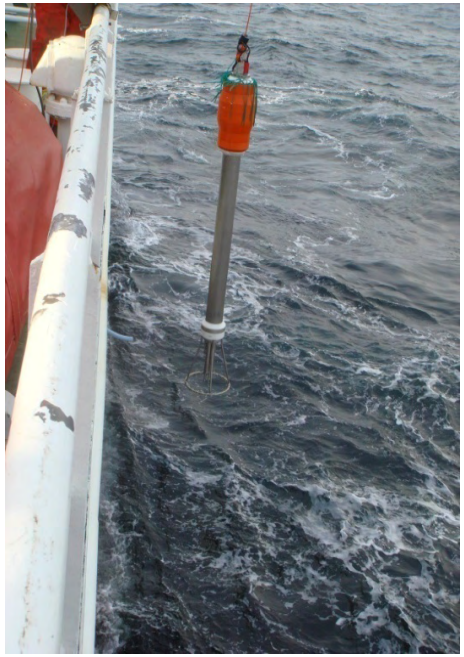
- Front moved approximately 8 km eastward over 6 days

Large variations in the T,S properties with depth corresponding to interleving

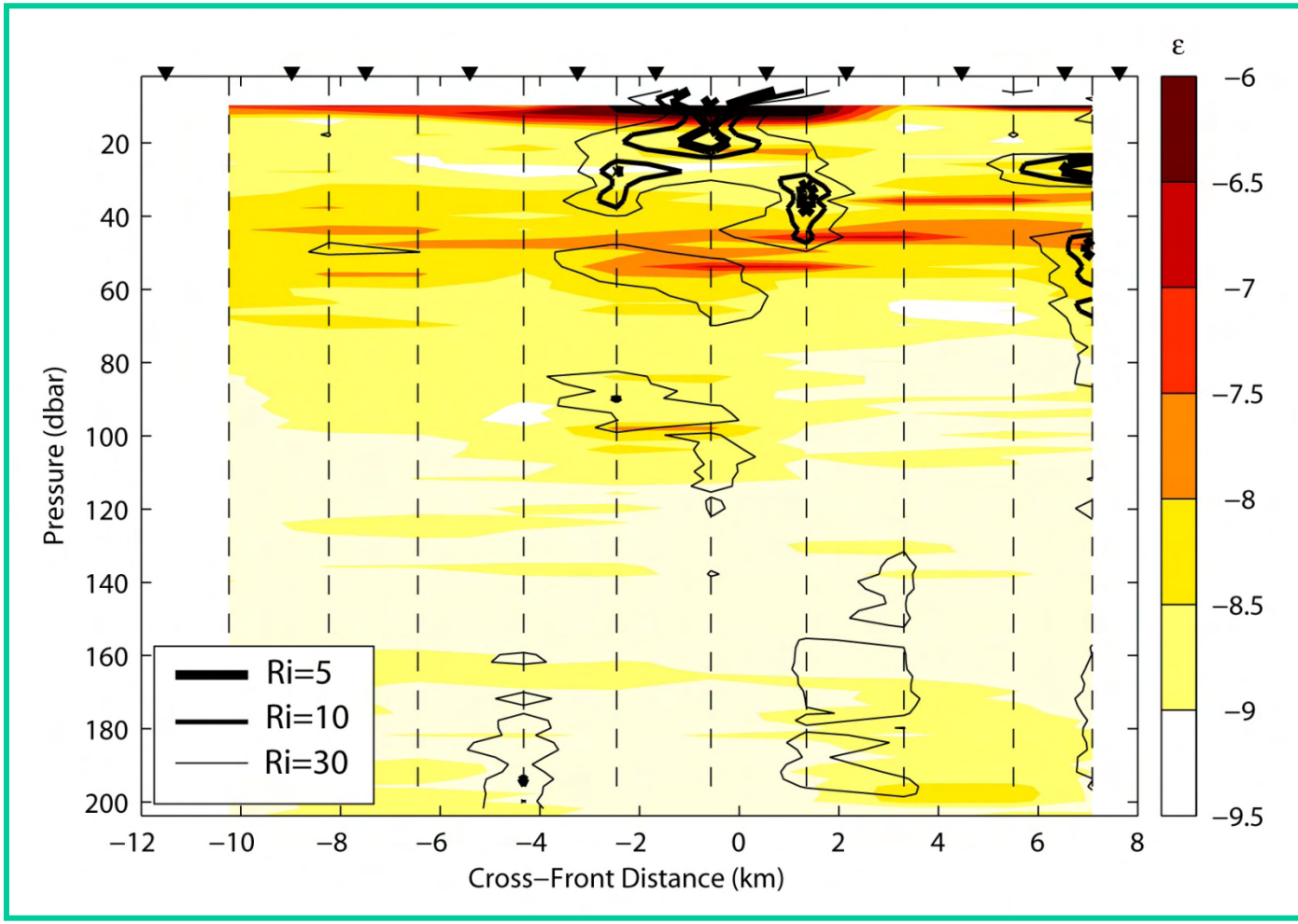




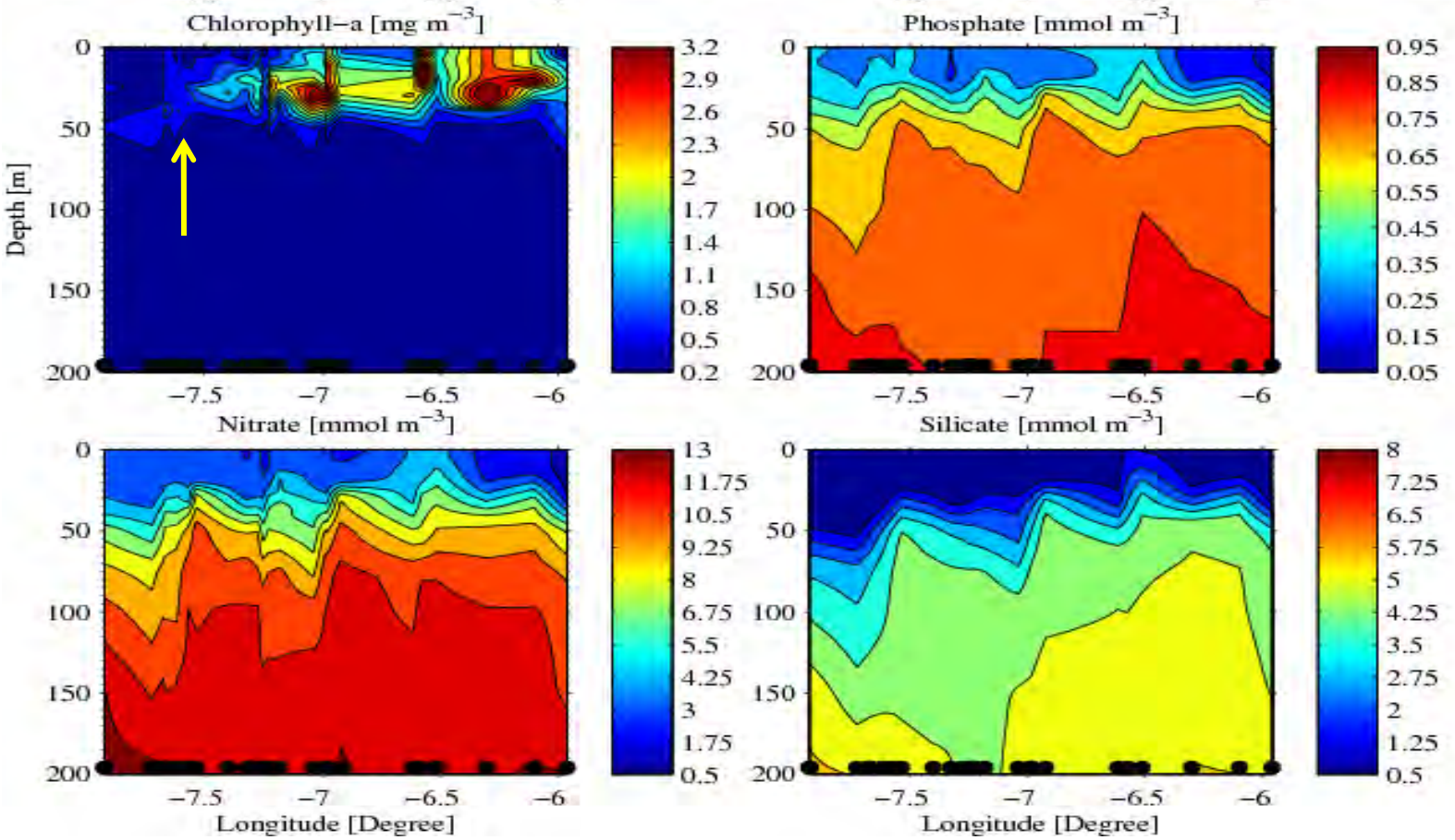
Turbulence Measurements



Ilker Fer

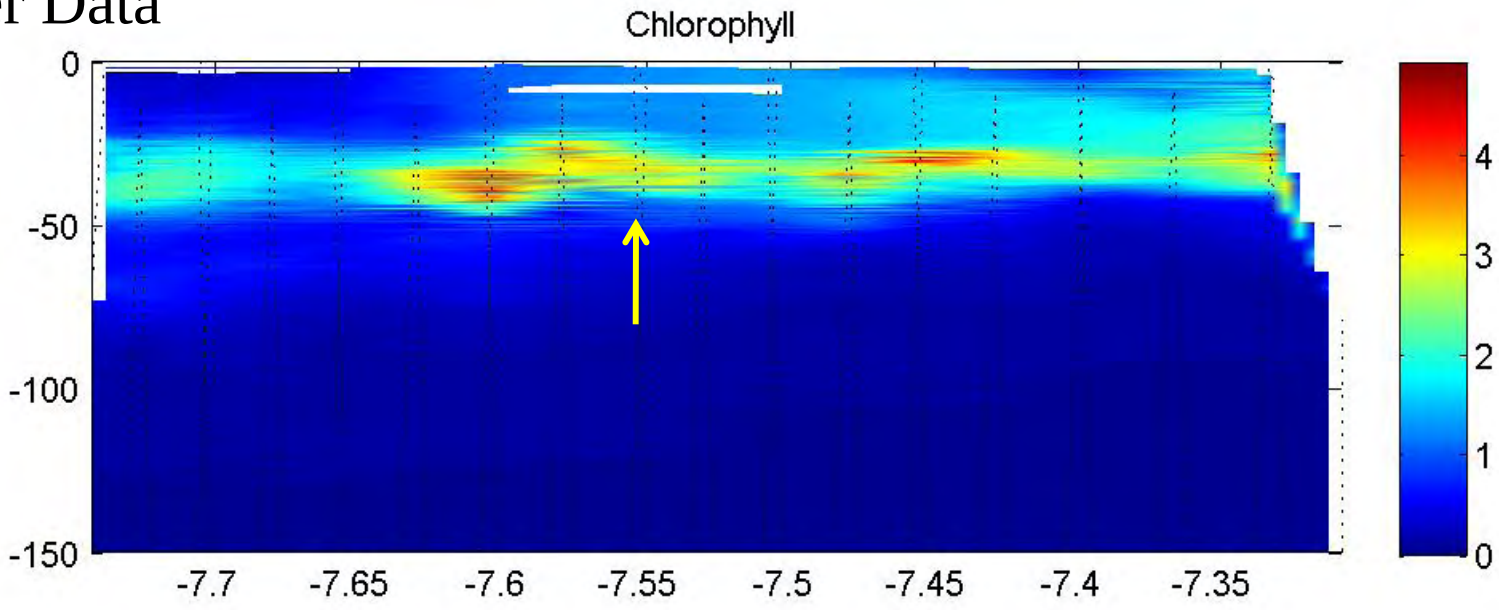


Increased turbulence levels (mixing) at the front generated by current shear and double diffusive processes but levels still relatively low.

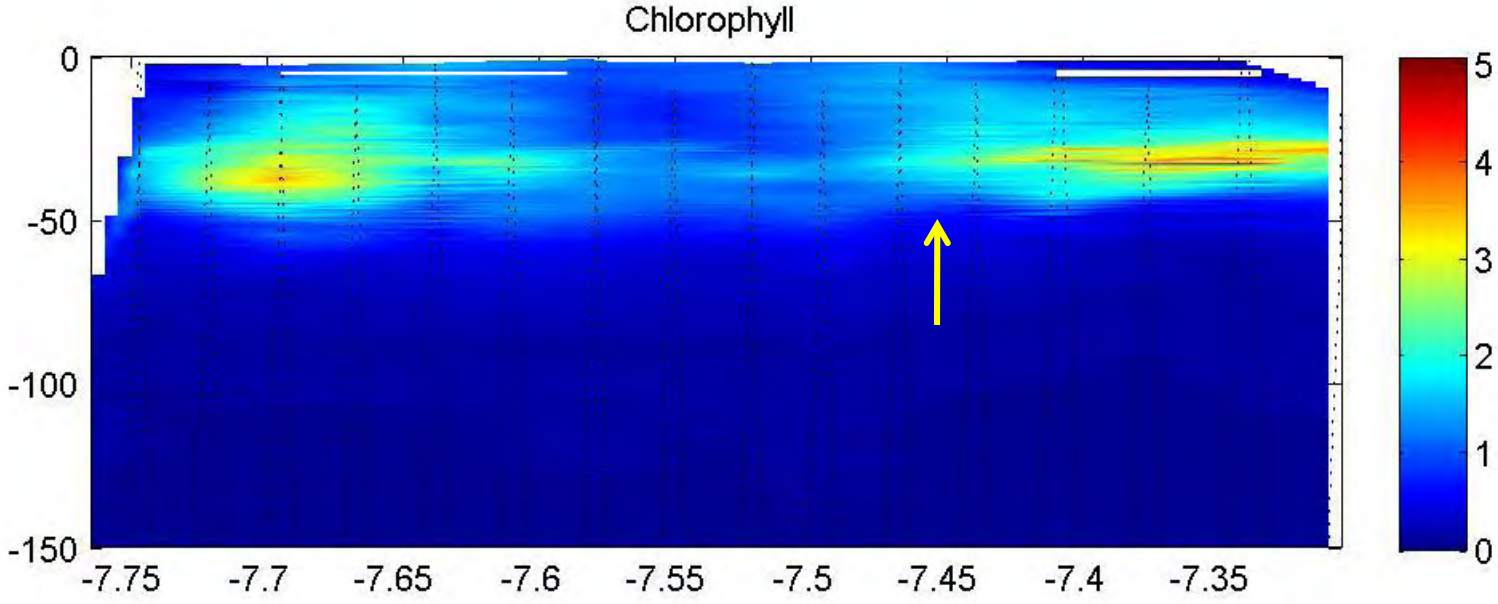


High fluorescence in near surface Atlantic Waters with some suggestion of subduction in Arctic Waters. There was no indication of increased biomass at the front or of higher nutrient concentrations in the surface waters near the front.

Glider Data



June 11-12

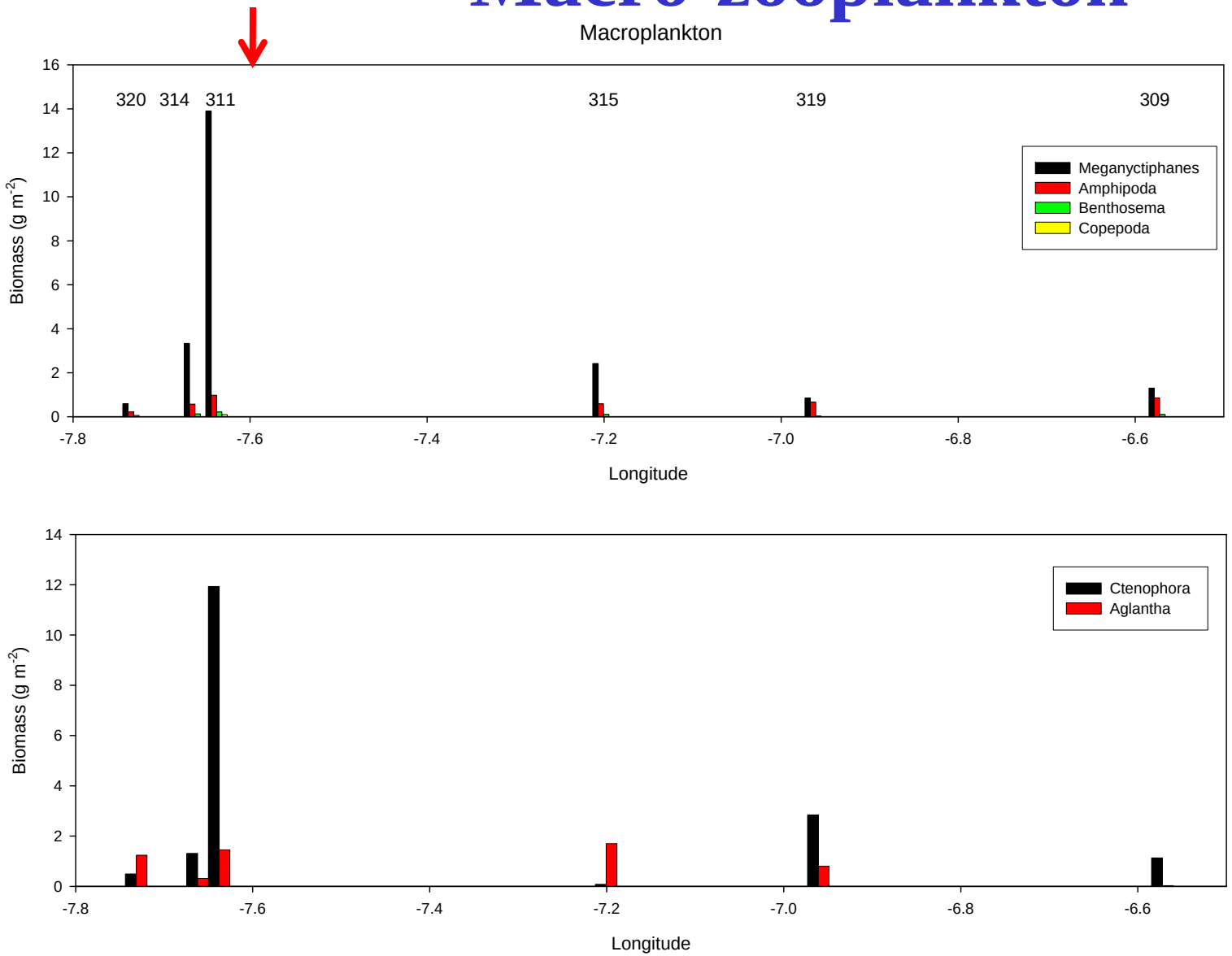


June 13-14

Deep Front

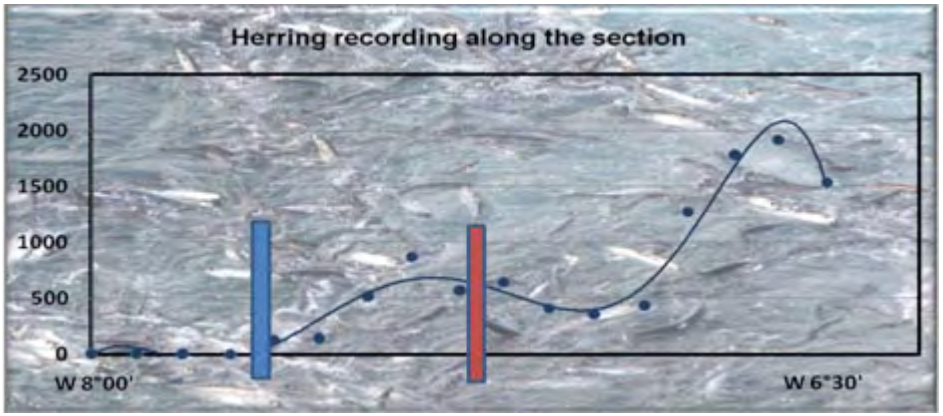
Macro-zooplankton

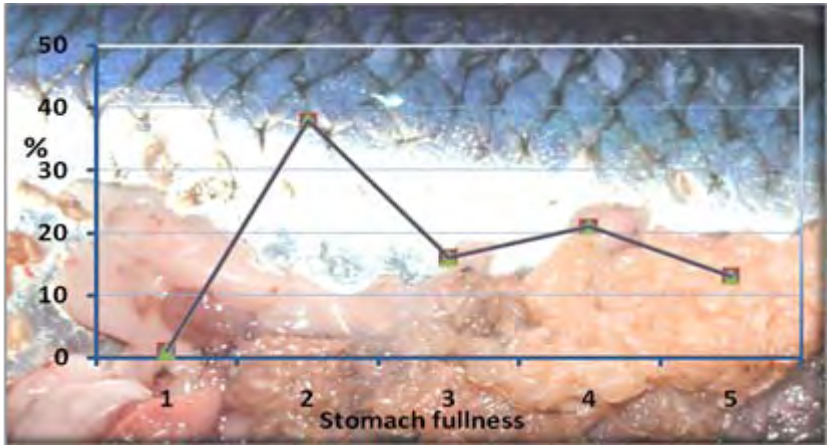
Biomass (g m^{-2})

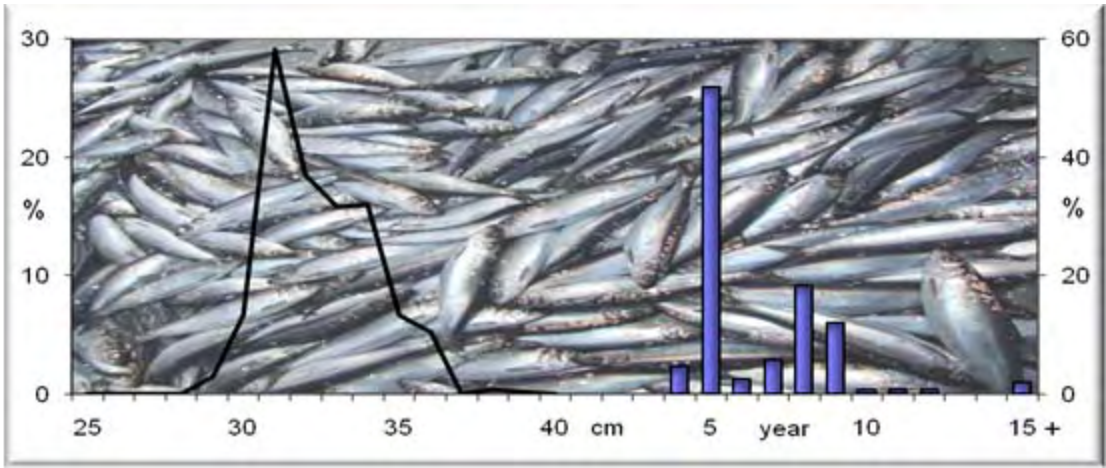


Webjørn Melle & Cecilie Broms

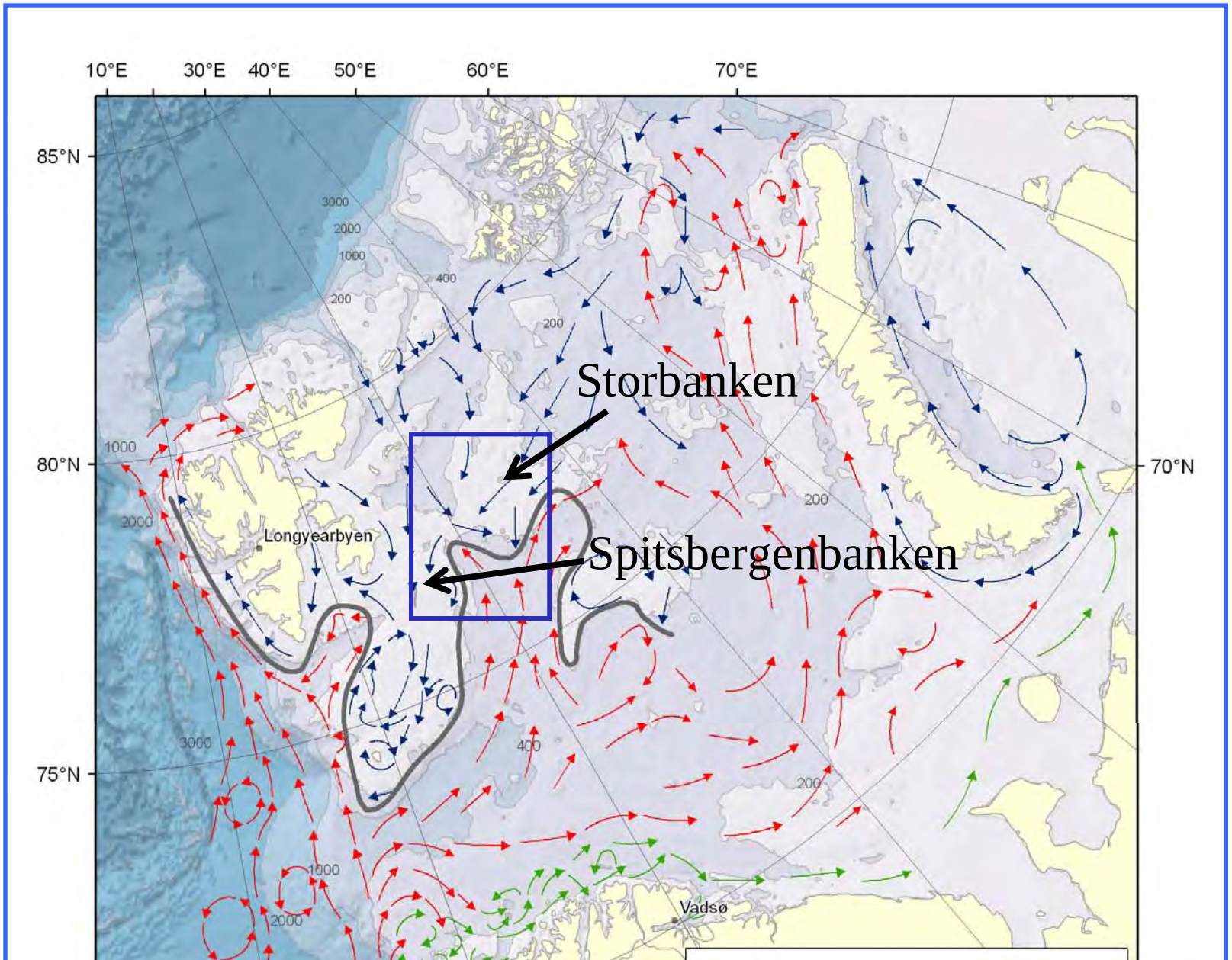
Atlantic Herring Distribution and Diet



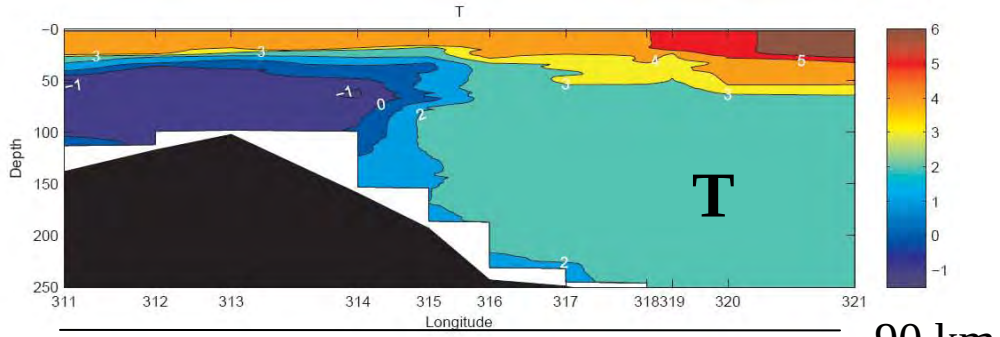




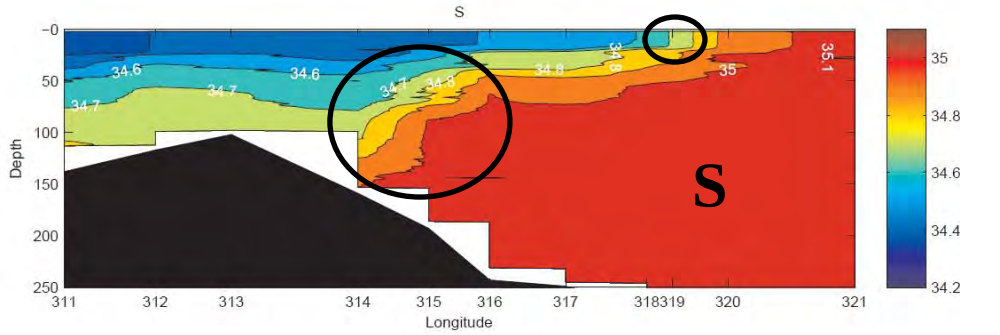
Barents Sea

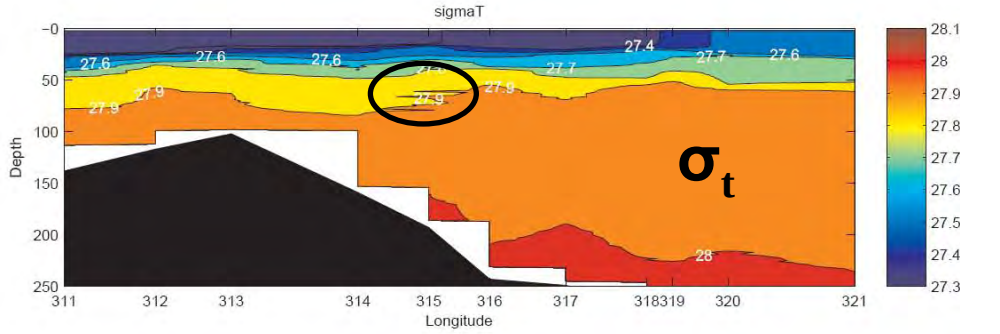

10°E
30°E
40°E
50°E
60°E
70°E
85°N
80°N
75°N
70°N
3000
2000
1000
400
200
Storbanken
Spitsbergenbanken
Longyearbyen
Vadsø

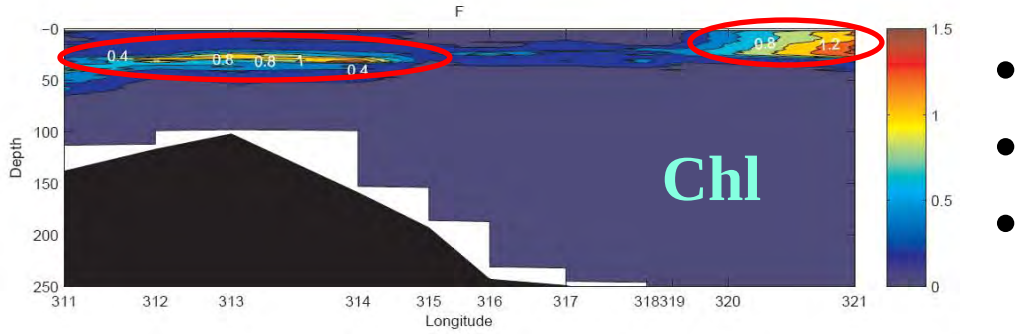
Storbanken



90 km







Weak Surface T contrast
Subsurface cold Polar Water over Storbanken

Strong Surface S Front

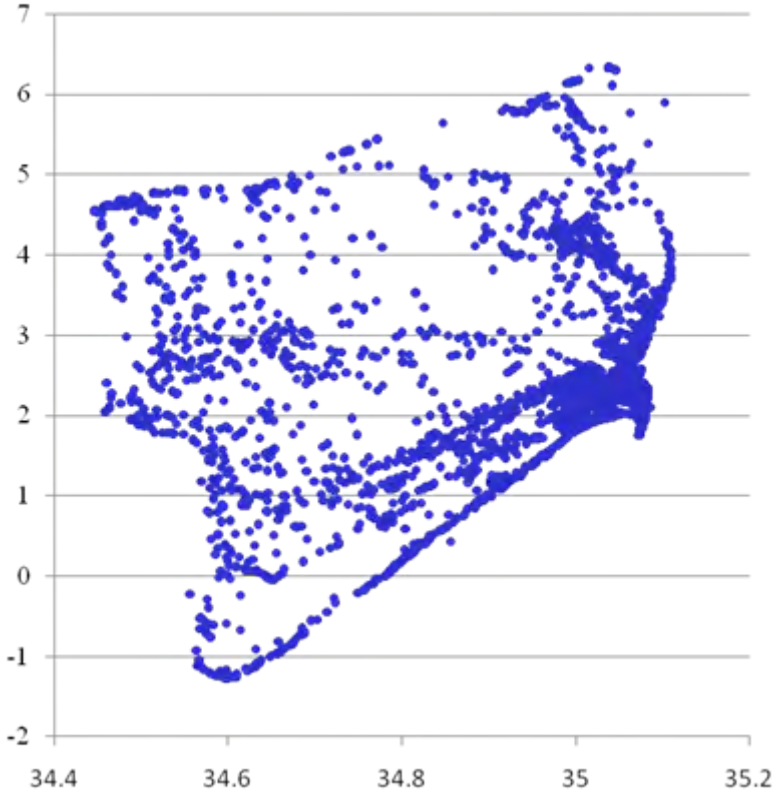
Polar Front (50-150 m)

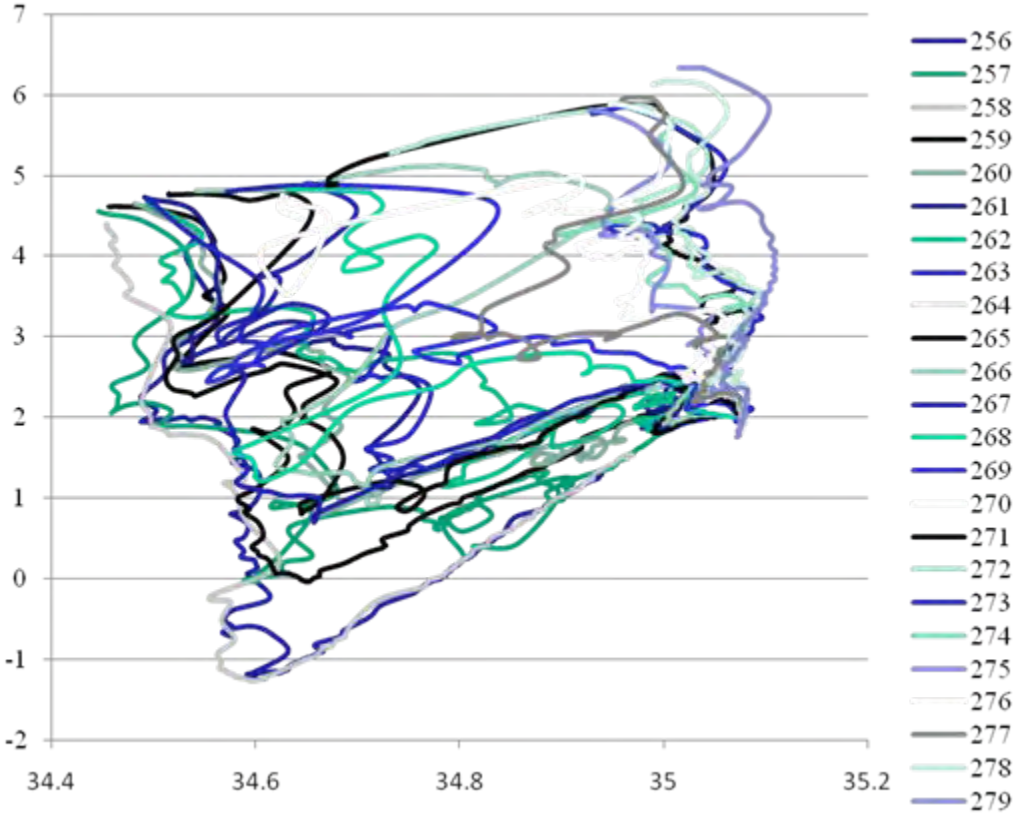
- Strong T, S, contrast

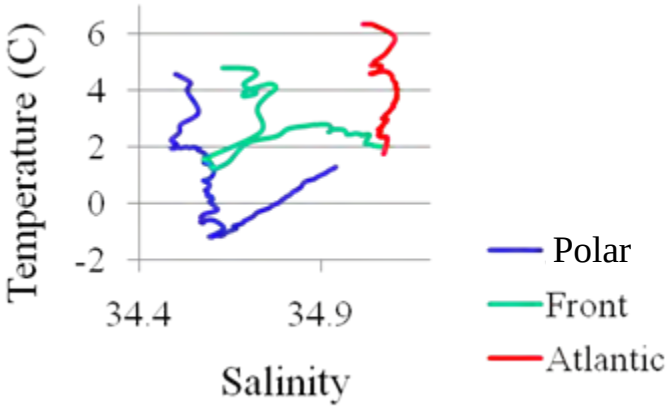
•Weak density contrast
-Interleaving of water masses

•Surface chl-a max. in Atlantic W.
•Subsurface max. in Polar W.
• Lower chl-a in Front

T,S Properties Storbanken Transect





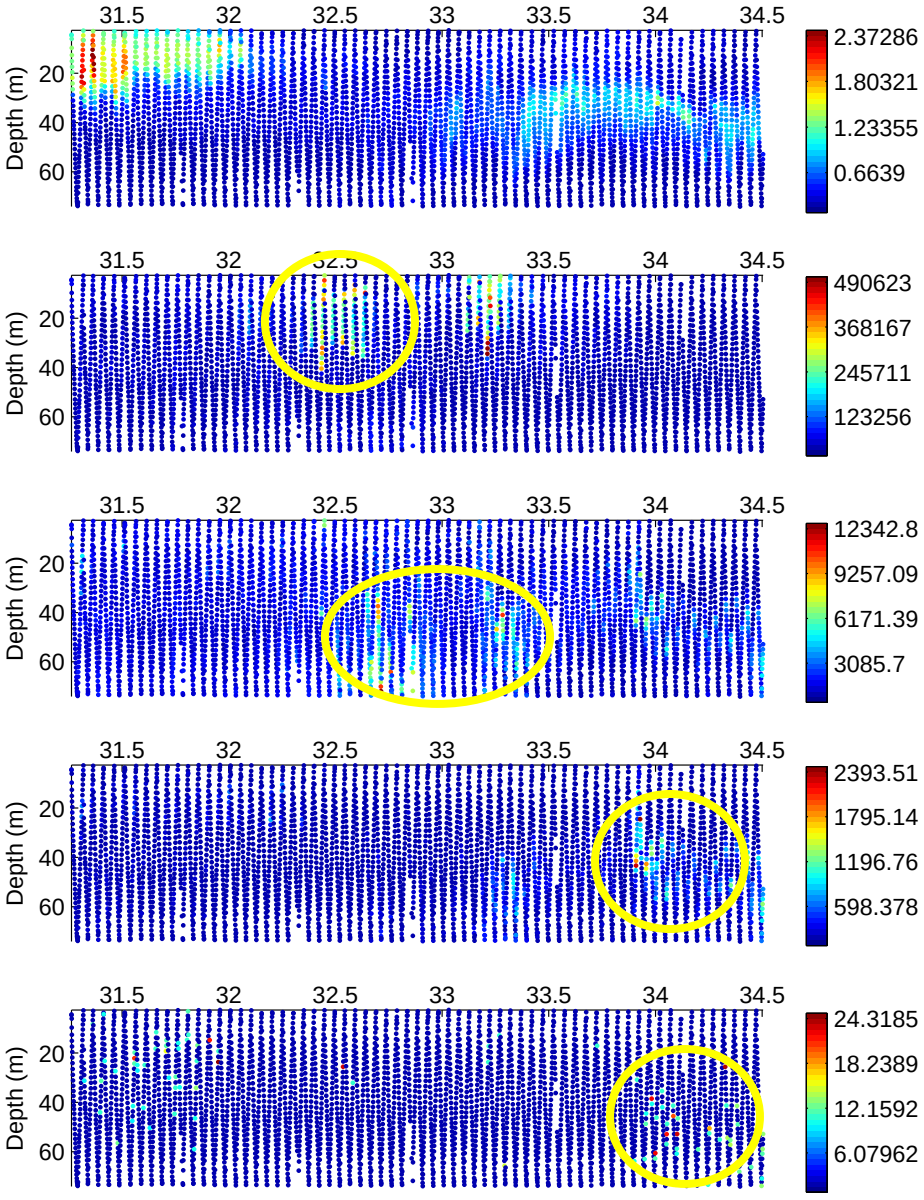


Similar T,S structure in the vicinity of the front as in Norwegian Sea, indicating interleving between the water masses.

Scanfish OPC Data

Sunnje Basedow

Atlantic Front Polar



Flourescence

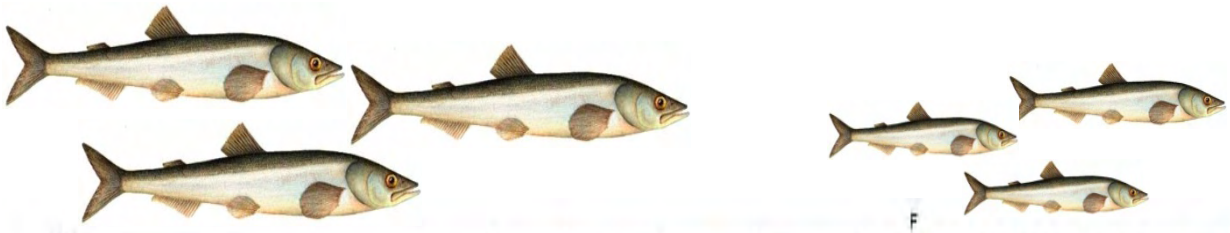
Extra Small (250-600 µm; *Oithona*, *Pseudocalanus*)

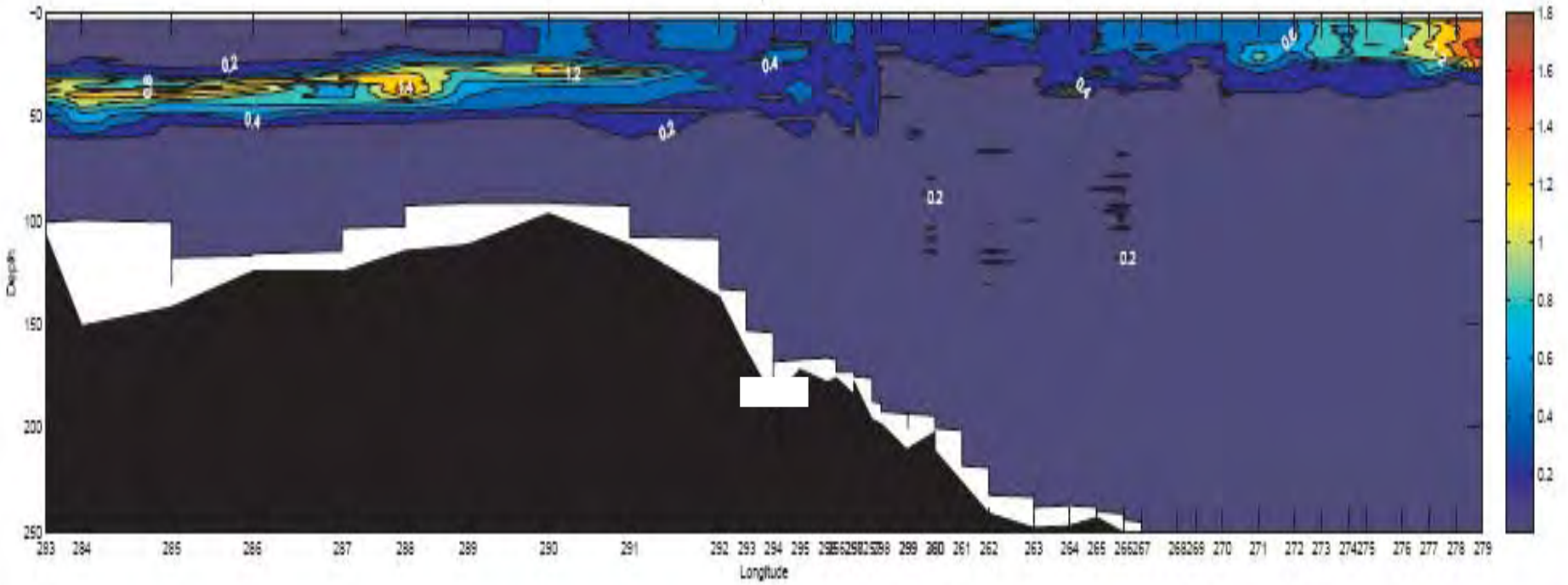
Small (600-1000 µm)

Medium (1000-1500 µm; early stage *Calanus glacialis*)

Large (1500-2000 µm; late stage *Calanus glacialis*)

Capelin Distribution Relative to the Front

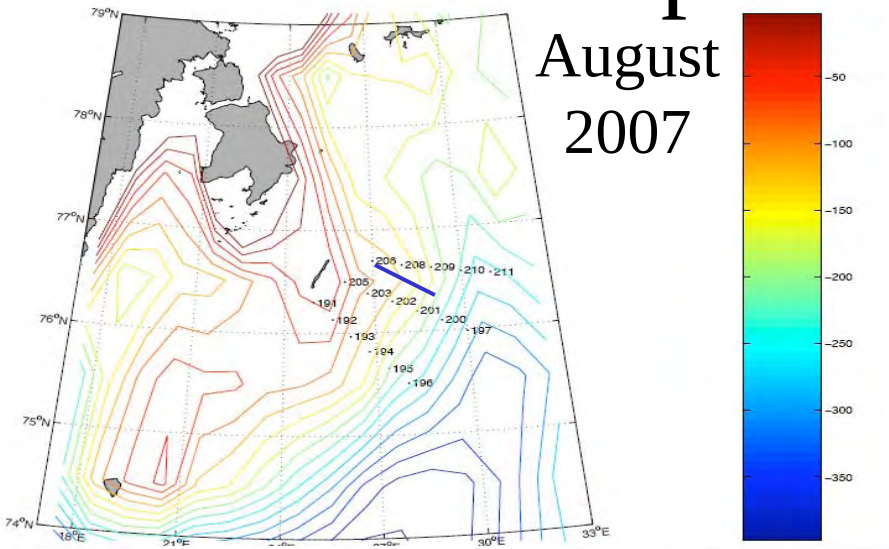


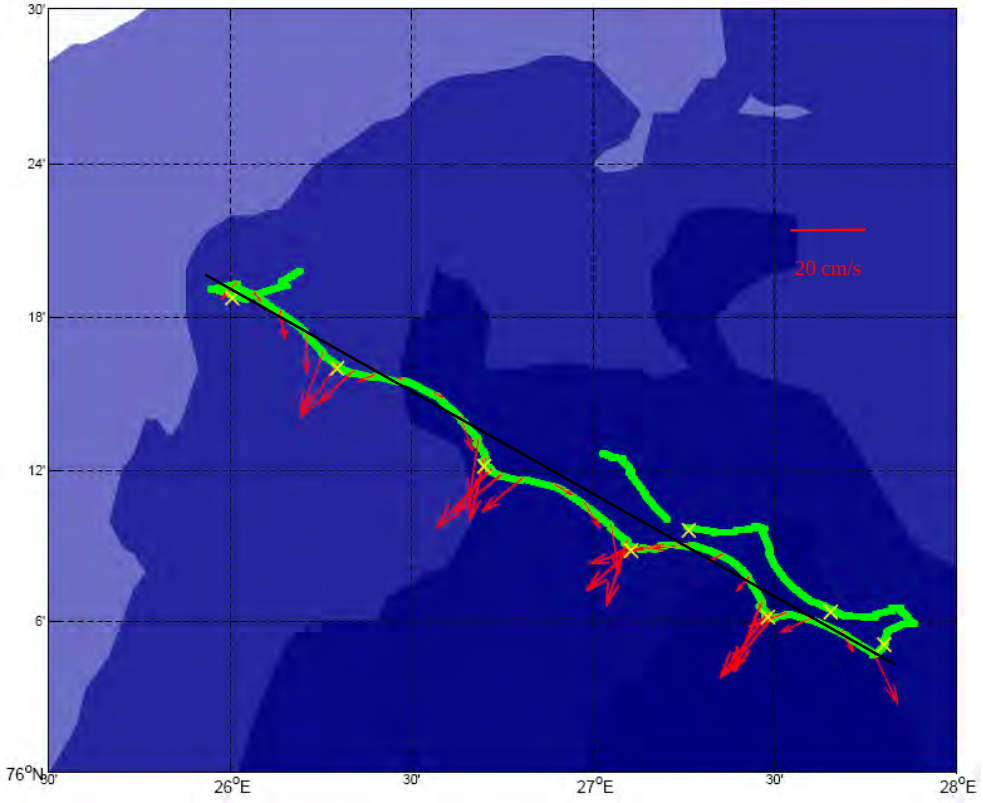


Small capelin fround in the frontal area and big capelin on the bank.

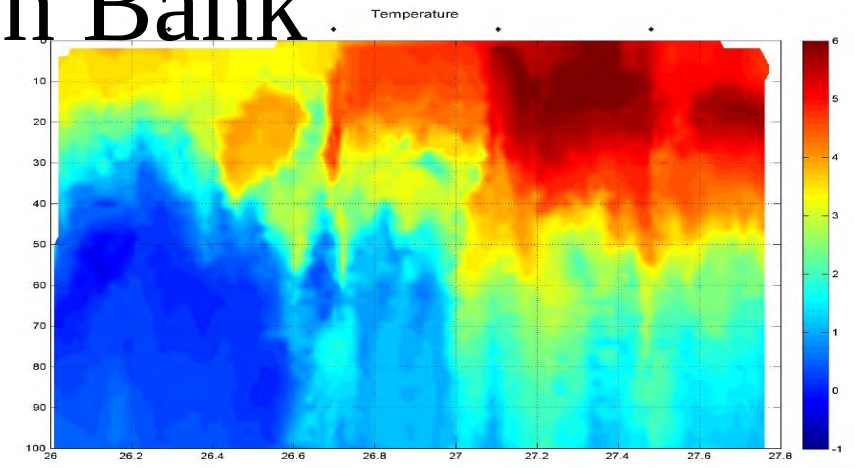
Spitsbergen Bank

August
2007

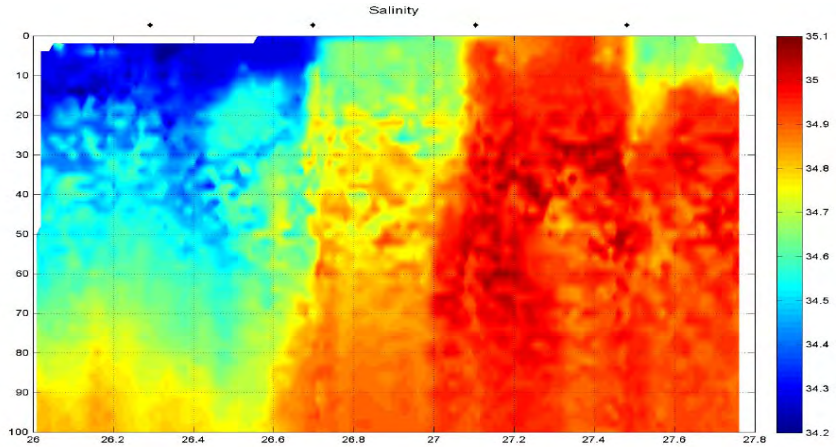




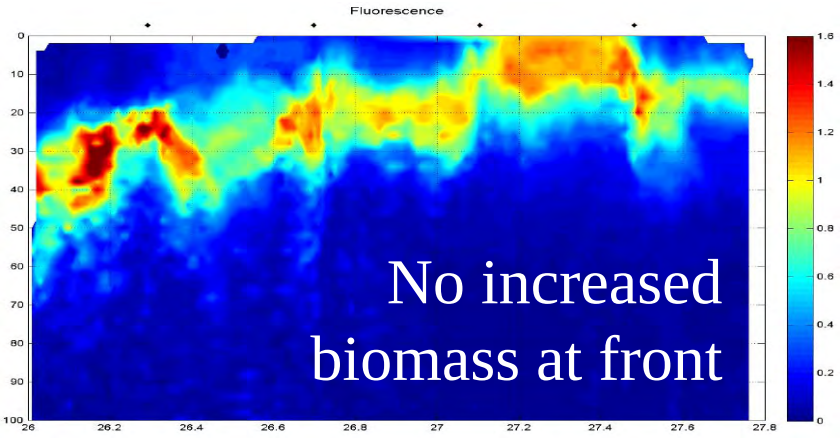
T

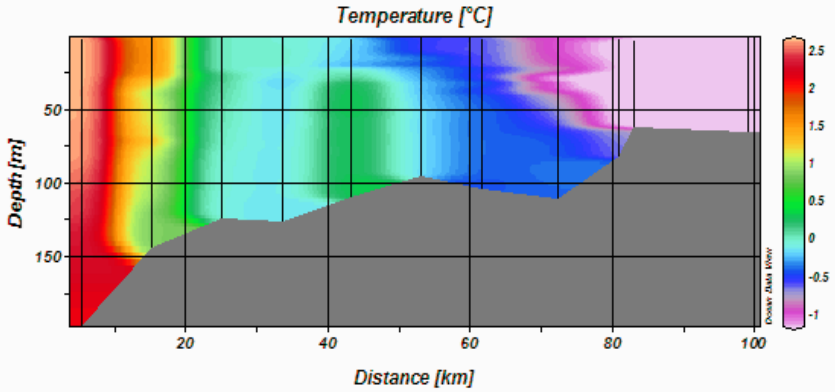


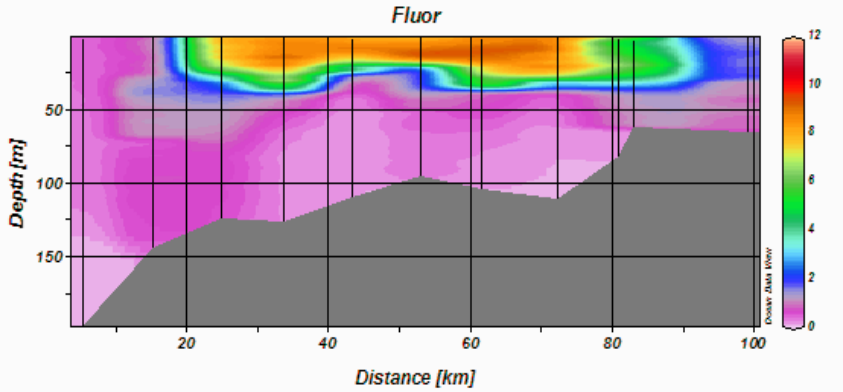
S

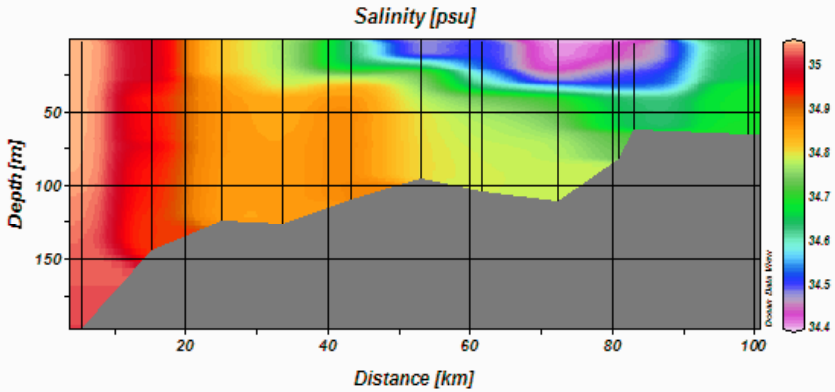


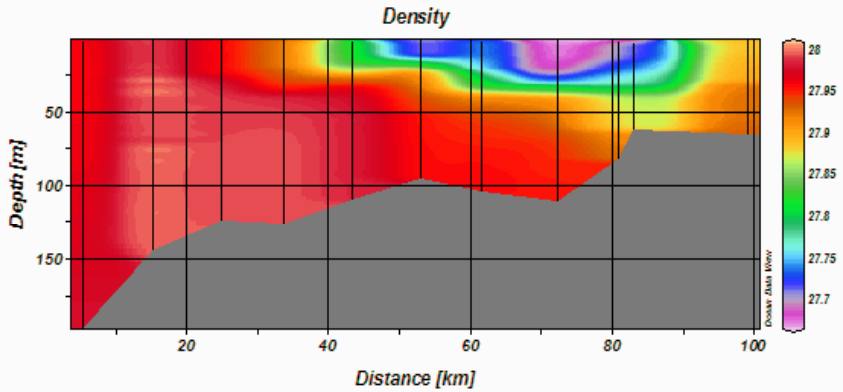
F



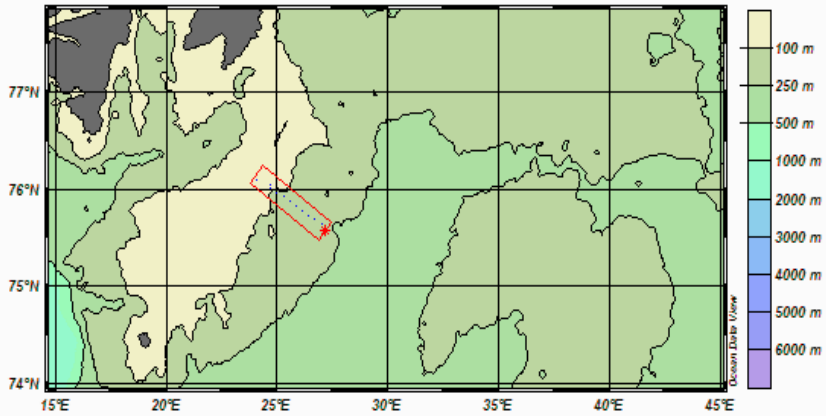




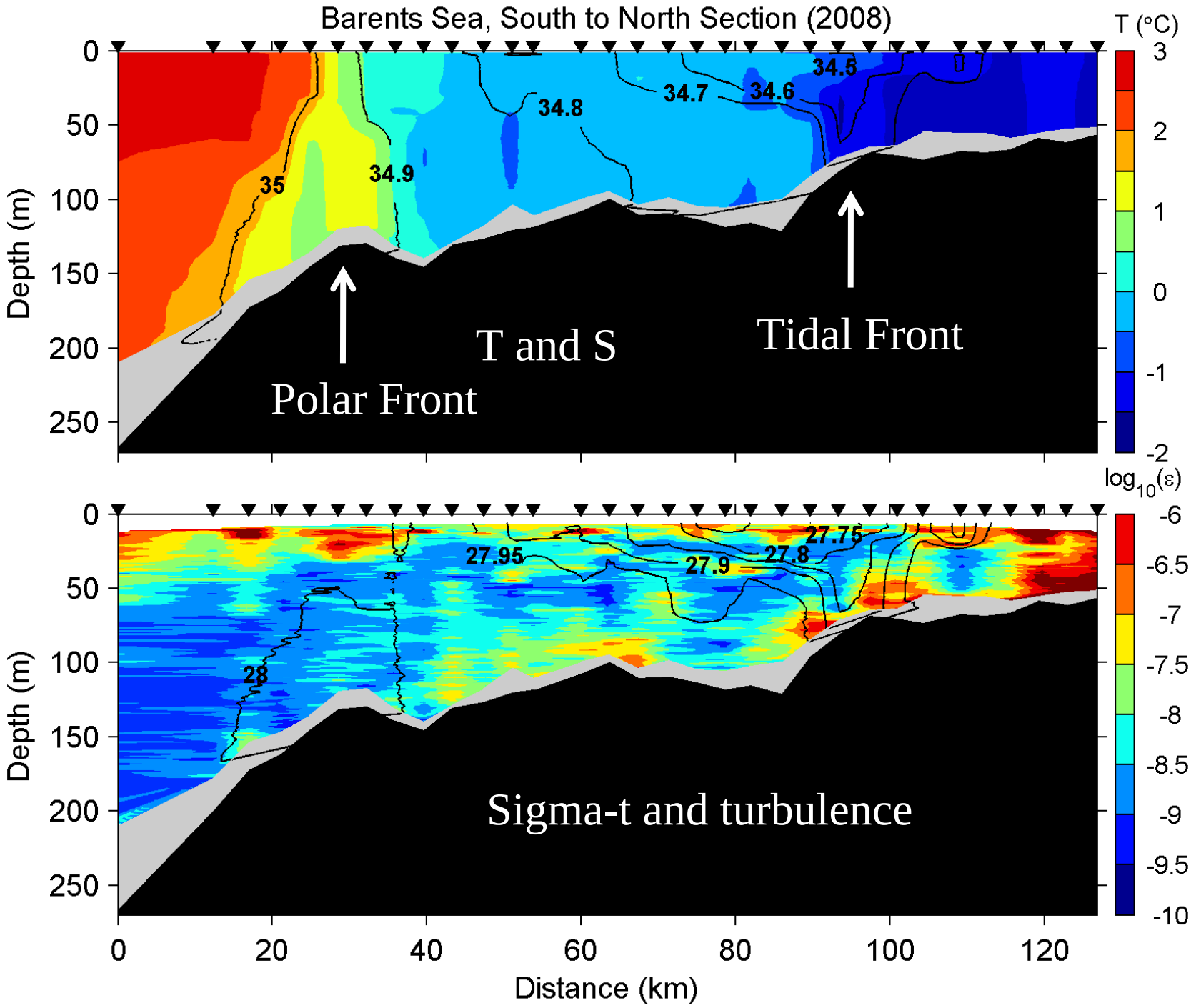




Spitzbergen Bank May 8-9 2008



Melt water formed low density waters allowing intiation of primary production. There was no indication of high production at the Polar Front.


Barents Sea, South to North Section (2008)
T (°C)
Depth (m)
35
34.9
34.8
34.7
34.6
34.5
T and S
Polar Front
Tidal Front
log10(ε)
28
27.95
27.9
27.8
27.75
Sigma-t and turbulence
Distance (km)
Ilker Fer

Conclusions

1. Arctic and Polar Fronts have strong horizontal gradients in temperature and salinity but weak density gradients (fronts are density compensating, i.e. passive).
2. They are characterized by strong interleving with layers 10-50 m thick and 2-4 km long.
3. Mixing is enhanced at the front but is relatively weak.
4. There is no enhanced phytoplankton biomass at the front over the long term (i.e. after spring bloom) but may be short-term increases.
5. Fronts structure the biology as different communities on either side (create “biological front”) but are “leaky”.
6. How and why the fish use the fronts remains unclear – speculate that they may provide access to the right size or best food for the fish.