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Physical and Biological Tow-Yo Data from Trinity Bay, July 2000

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Abstract

Trinity Bay is a large, northward facing embayment on the Avalon peninsula that regularly exhibits strong upwelling activity. Strong, summer winds from the southwest lead to an upwelling response that is most intense on the western side of the Bay. We report on an oceanographic study conducted in July 2000 in which a towed body was cycled through the Bay. The survey was conducted with a Chelsea *Nu-Shuttle* towed body that collected CTD, fluorescence, and biomass data. We present the towed body data together with some of our quality control analysis of the data from the Chelsea *Nu-Shuttle* instrument.

Acknowledgements

We thank the captain and crew of the Templeman for their assistance and Dr. P. Pepin for his help in this oceanographic study.

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Introduction

The *Nu-Shuttle*, manufactured by Chelsea, provides an ideal means to gather CTD data in a fast and effective manner. By continuously oscillating up and down to and from specific depths while being towed, the *Tow-yo* (as the *Nu-Shuttle* is called from here on) gathers physical data profiles along any transect. Data collected on 20-21 July provide temperature, salinity, density and fluorescence profiles within Trinity Bay. We towed the instrument at 8-10 knots. Although we tried to get the towed body to cycle between 10 and 80 m, we found that we could not obtain a cycle range greater than 40-50m. We were able to tow at slower speeds after attaching a four-bladed propellor. In the May deployment of the instrument (Schillinger et al. 2000) we used about 125m of ribbon fairing attached to the bottom of the cable. The primary purpose of the fairing is to reduce drag and strumming, particularly since we are towing this system at speeds above 5 knots. As the body descends, it appears likely that the ribbon fairing, rather than reducing drag, actually generated lift and/or increased drag. By removing some of the fairing from the first 100 m of the cable, we were able to increase the dynamic range of the oscillations compared to our May deployment. The lower portion of the fairing, just above the towed body, is probably reducing drag but it appears that the ribbon fairing in the upper portion of the cable is creating drag. This drag from the upper portion of the cable, where the orientation of the cable is closer to the horizontal, is probably a result of the ribbon fairing lying perpendicular to the flow rather than lying parallel to the flow. With the fairing removed we were able to cover depths from 15 to 80 m. Some experimentation with adjusting the tow speed did not substantially improve the range situation. In principle, the *Tow-yo* can be towed at speeds between 6 and 12 knots.

An Optical Plankton Counter (OPC) was deployed on the *Tow-yo* providing a measure of biomass in the bay. There we some problems with the data obtained from the *Tow-yo,* similar in nature to those documented by Schillinger et al. (2000), but not identical. In this deployment, the data collected by the OPC did not show the lack of sampling capability on down tows. While the temperature data showed a difference between measurements taken on the up-cast when compared to the down-cast, these

lagged differences were smaller during this deployment then last (compare 1 m shift to 3 m shift). A problem common to both deployments, although much more prevalent in this deployment, were salinity spikes. These spikes (of low salinity) appeared in every transect during this deployment, whereas they only appeared in transects I and J of the May deployment. To eliminate these spikes, the data taken while the Tow-Yo was descending have been not been used. A section detailing the data processing required to overcome these problems is included in this report. The path of the ship is shown in Figure 1. The measurements from both the CTD and OPC were interpolated in x and z for all transect lines, although only three of these are included in this report (see Figures 3-5). Using this vertically interpolated data the mean temperature, salinity and fluorescence were calculated for each lat/long grid position. These values were then interpolated in the horizontal (plan view) and are presented in Figures 6-8. In addition, the depth of maximum fluorescence, the depth integrated biomass, depth of the 0 ° and 3 ° C isotherm are also presented by plan view in Figures 9-11. Plan views of the temperature for depths of 25, 35, 50 and 60 m are included in Figures 12-14.

Data Processing

The CTD and OPC data were averaged into bins 100m in the horizontal, and 0.5 m in the vertical. Using these bin-averaged data, the profiles of adjacent up and down tows were compared. An example demonstrating the salinity spiking occurring during the down tow is shown in Figure 2. It is not clear why the spiking is so large during the down tow. It may be that the differential response is a result of the tow speed and cable configuration of the *Nu-Shuttle* deployment. The temperature data was shifted for the up tows, to eliminate the lag between measurements of neighbouring up and down tows. The method used to determine the shift is described in Schillinger et. al (2000). A maximum shift distance of 10 m was chosen by trial and error. In addition, only the temperature data measured between 20 and 40 m were adjusted in this manner. These depths were determined by visual inspection of the data.

After bin averaging and depth correction were performed, the data were then interpolated in two dimensions (x and z) using an inverse linear distance squared

weighting algorithm. This algorithm was limited to bins within 4 km in the horizontal and 5 m in the vertical. Paired bins in the horizontal were assigned equal value. For the salinity data, this weighting was doubled to account for the reduction in resolution resulting from discarding the down tow data. From this data, the biomass was depth-integrated at each latitude and longitude grid location, and the depth of the maximum fluorescence was determined. When several depth bins measured the maximum fluorescence, the mean depth of these bins was recorded. Similarly, the depths of both the 0 ° and 3 ° C isotherms were determined by averaging the depth of bins which had temperatures plus or minus 0.5 degree of the desired isotherm. In addition, at each latitude and longitude grid location, the mean temperature, salinity and fluorescence were computed. All of these characteristics of the water column as well as the measured temperature at depths of 25, 35, 50 and 60 m were interpolated again using an inverse distance squared routine, for which paired bins were assigned equal value. This algorithm was limited to bins within 4 km in both horizontal directions.

Data Interpretation

The plan view contour plots of mean temperature shows a cross bay gradient, with generally colder water on the west and northwest side of the bay (see Figure 6). The southeast coast is generally warmer, in particular along the coast directly opposite Random Island. In addition, the mean temperature of the water column is higher at the mouth of the bay than the head. The mean salinity contour plot of Figure 7 shows more of an along bay gradient, with low salinity in the water column at the mouth of the bay.

The plan view in Figure 10 shows that the depth of the 3 ° C isotherm is deepest near Random Island on the western side of the Bay, but shows more of an along bay structure rather than a cross bay structure expected during upwelling events. The presence of relatively cold water along the northwest coast is supported by the plan view plots of temperature at 25, 35, 50 and 60 m (Figures 12-14). Colder water along the northern coast is prevalent at 35 m, and become isolated to two locations at 50 m and one location at 60 m.

The depth of maximum fluorescence is shallower at various locations along the northern coast, particularly along the at Random Island (40 m) and to the north of Random Island (40 m), and is deepest along the southern coast. The depth integrated biomass does not show a distribution to match this phenomenon; in fact, the maximum depth integrated biomass value occurs at the head of the Bay near the northern coast, and at the mouth of the Bay (Figure 16).

References

Schillinger, D. J., deYoung, B. and J. Foley. Tow-Yo and Temperature Data from Trinity Bay, May 2000. Physics and Physical Oeanography Data Report 2000-2, Memorial University of Newfoundland, St. John's NF, (2000).

Figures

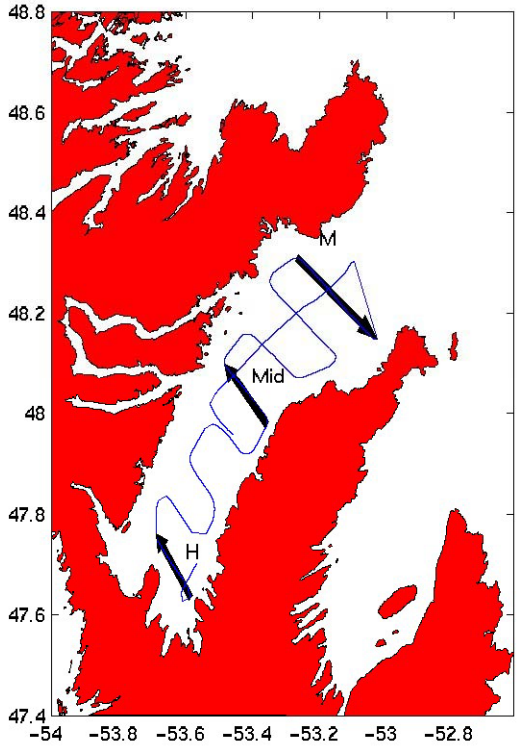


Figure 1: Map of Trinity Bay, with the ship's path indicated by the solid blue line. The transect lines and direction of travel for the three vertical 2 dimensional interpolation figures (Figures 3, 4 and 5) are indicated by the solid black arrows (H – Head of the Bay, Mid – Middle of the Bay, M – Mouth of the Bay).

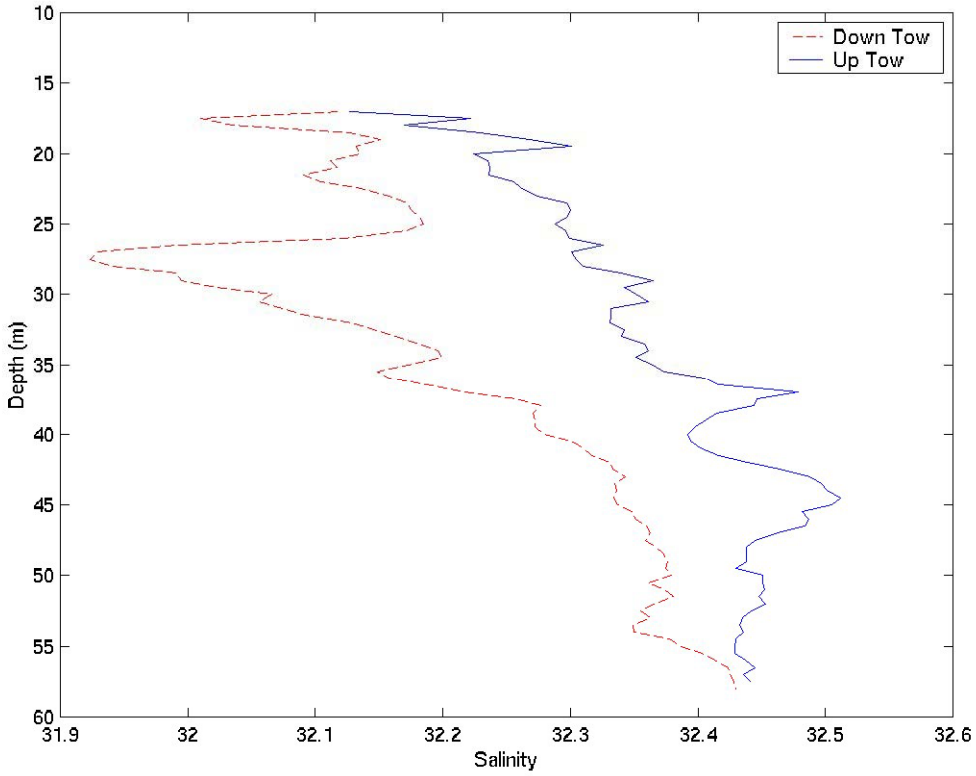
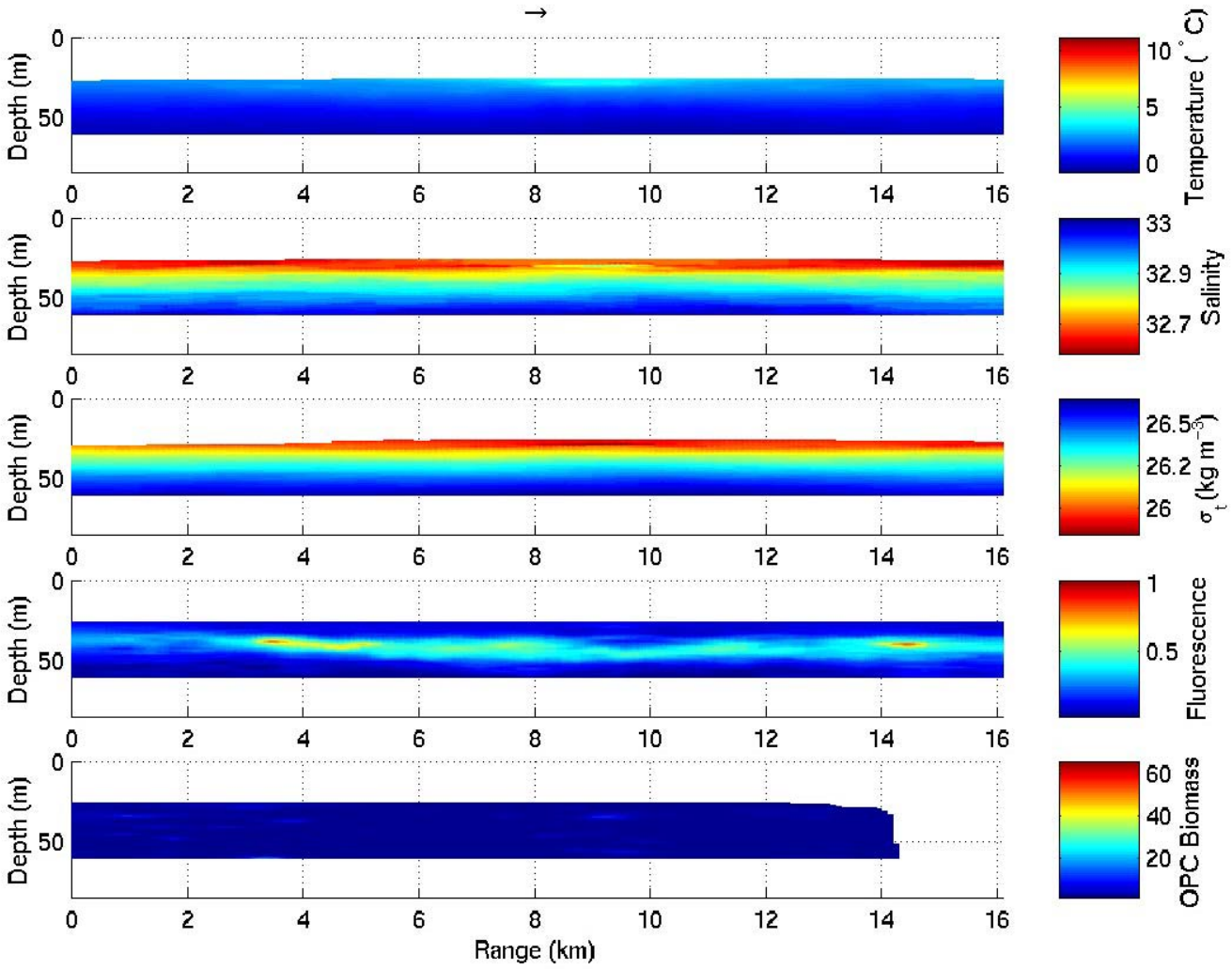


Figure 2: Two vertical salinity profiles from the first transect line. The data collected on the down tow of the OPC (dashed line) shows a large negative salinity spike at 27 m. The data from the up tow (solid line) does not show such large spiking.



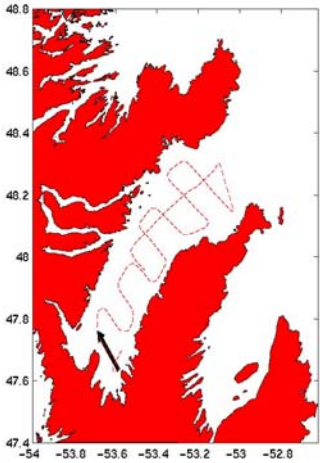


Figure 3: Vertical interpolation for the transect line at the head of the Bay for Temperature (° C), Salinity, Density , Fluorescence and OPC Biomass. The solid arrow in the inset figure shows the location and direction of travel.

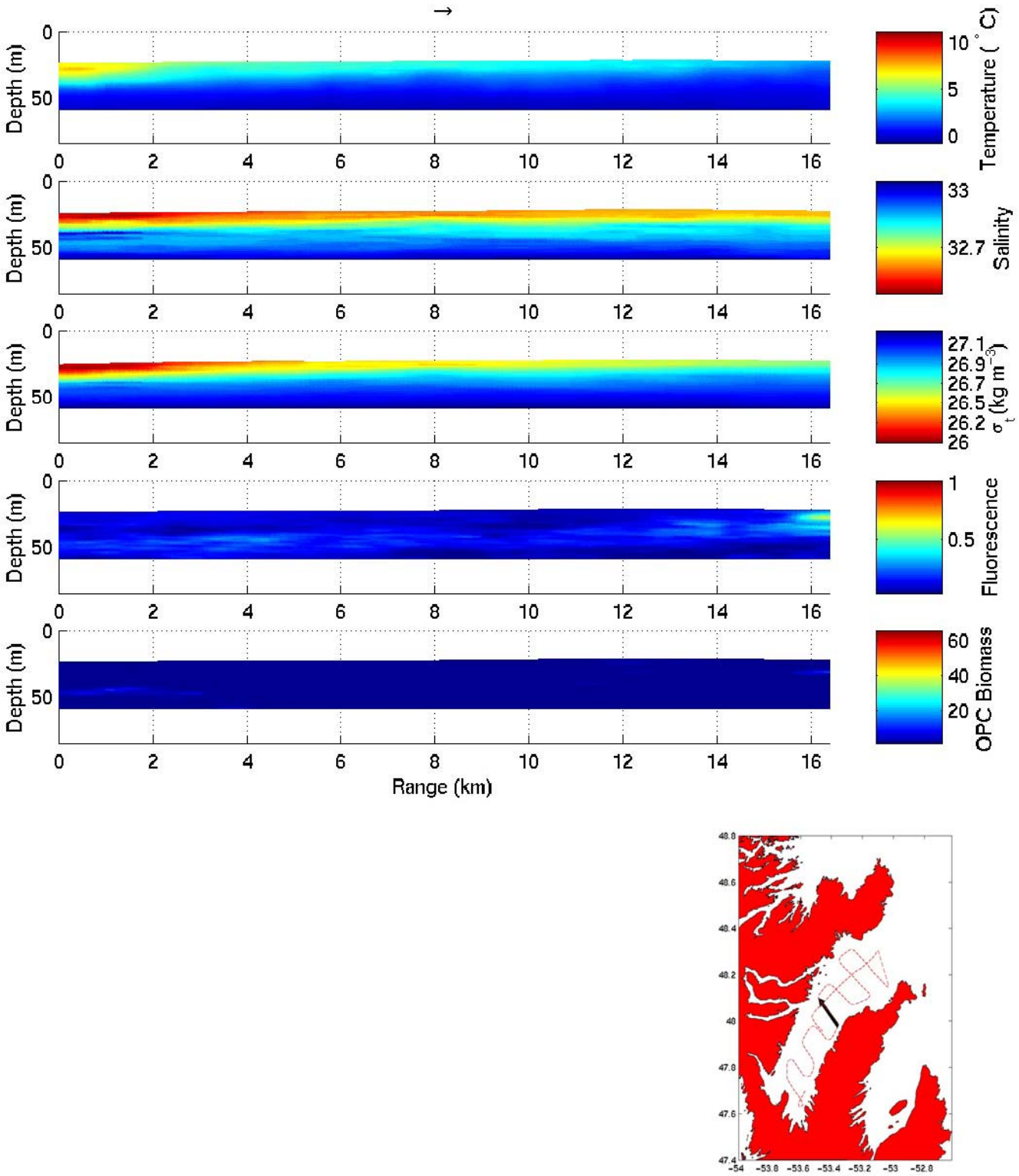


Figure 4: Vertical interpolation for the transect line at the head of the Bay for Temperature (° C), Salinity, Density, Fluorescence and OPC Biomass. The solid arrow in the inset figure shows the location and direction of travel.

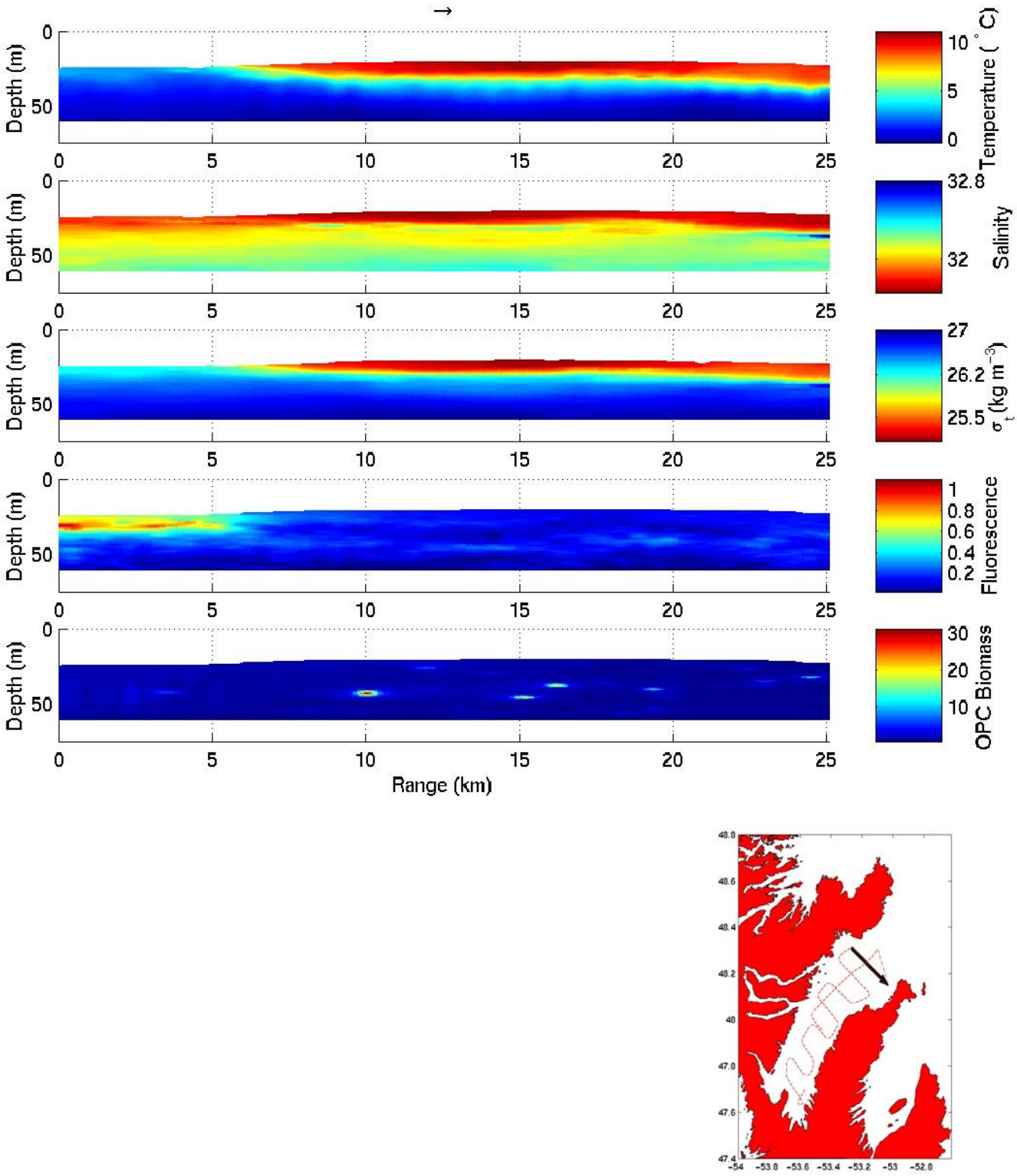


Figure 5: Vertical interpolation for the transect line at the head of the Bay for Temperature (° C), Salinity, Density , Fluorescence and OPC Biomass. The solid arrow in the inset figure shows the location and direction of travel.

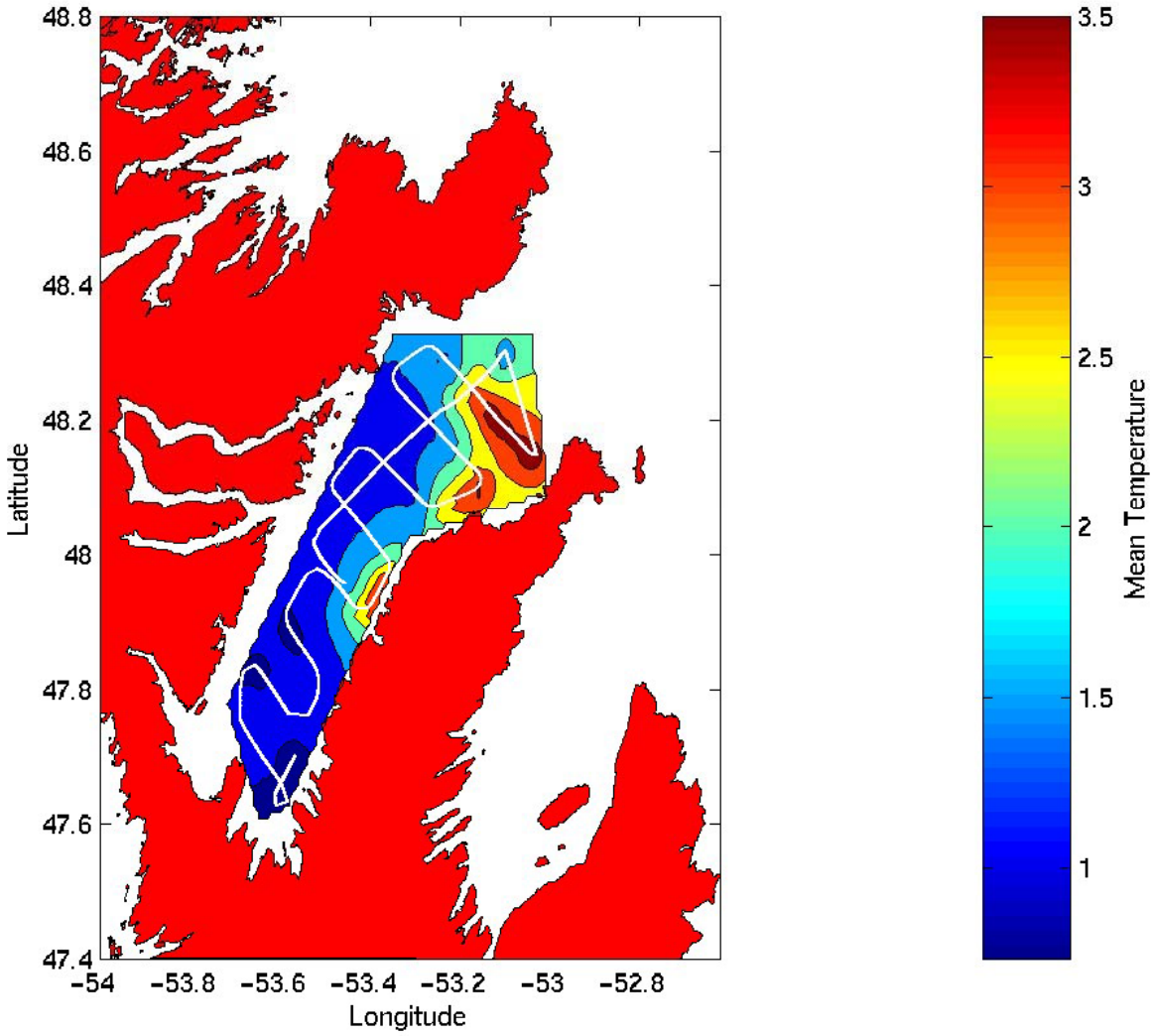


Figure 6: Mean temperature (° C).

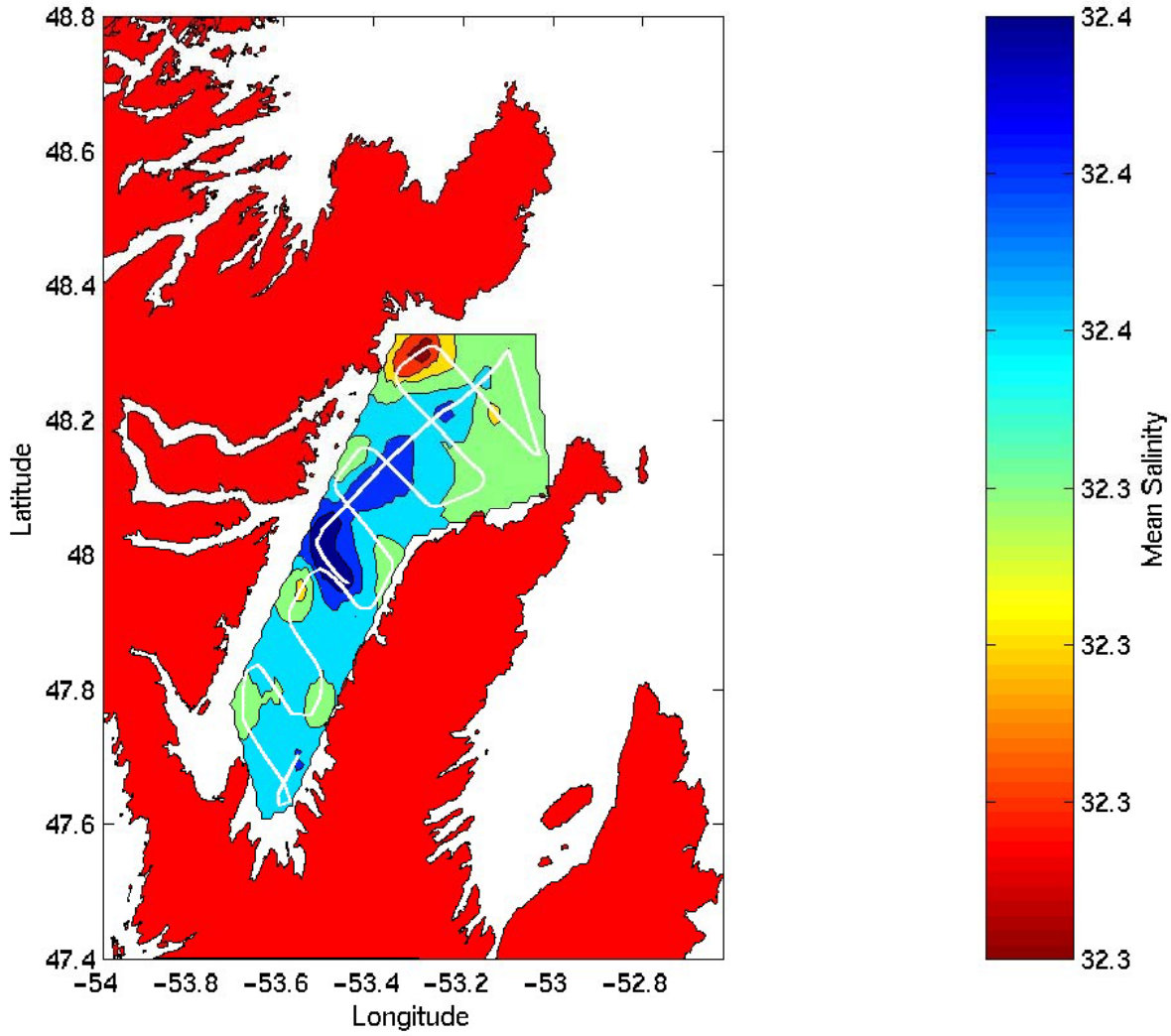


Figure 7: Mean Salinity.

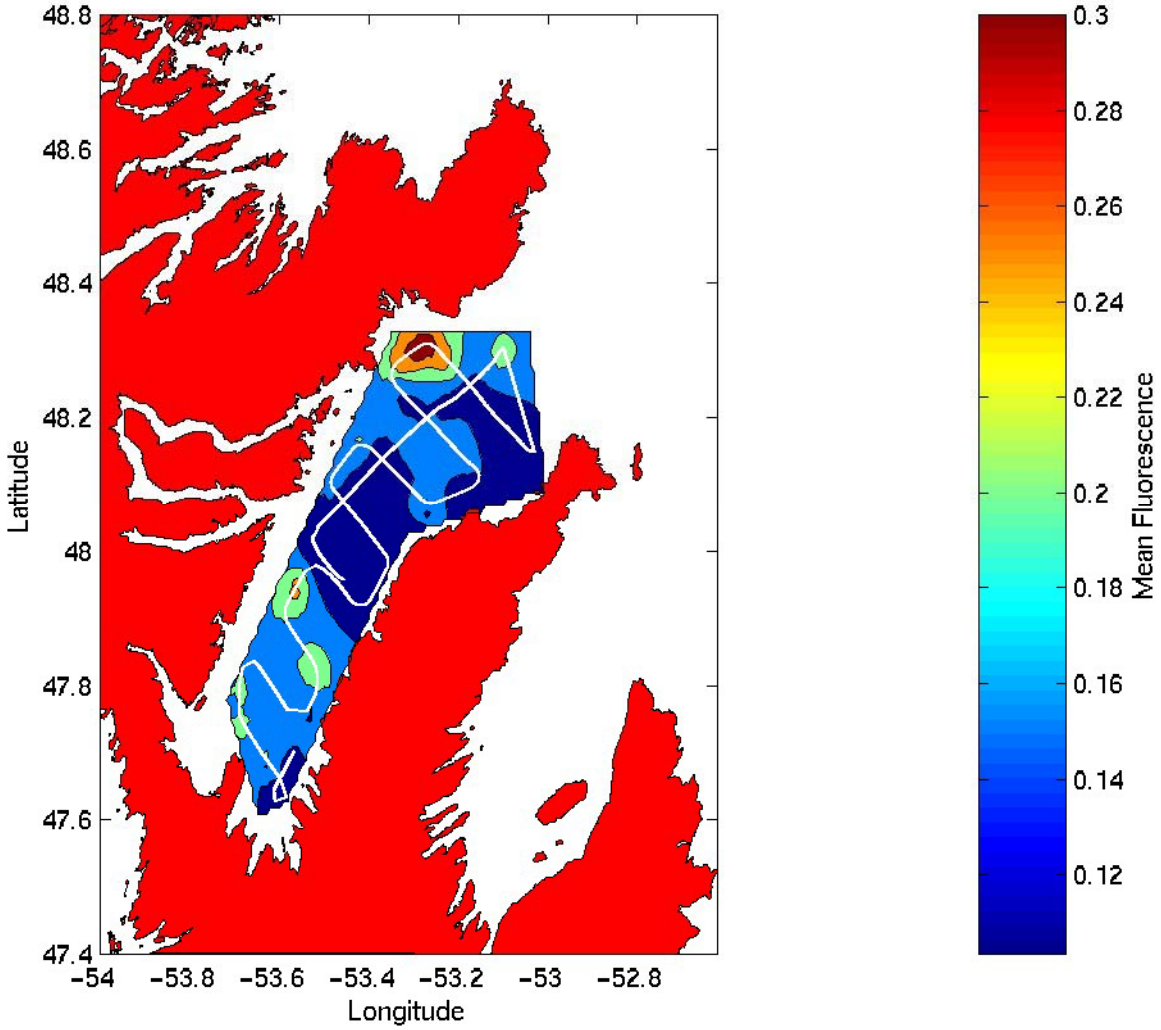


Figure 8: Mean fluorescence.

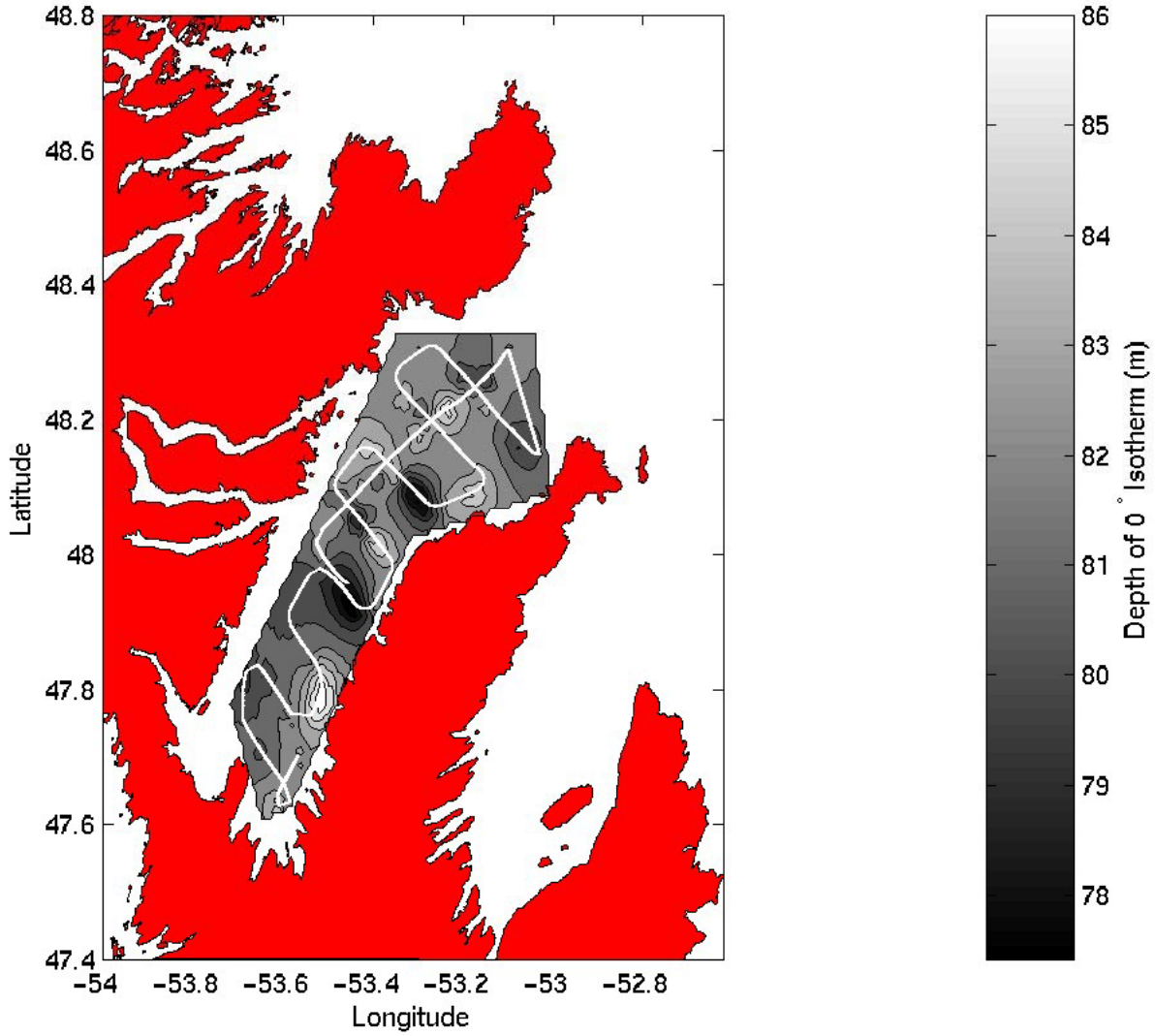


Figure 9: Depth of the 0° C isotherm (m).

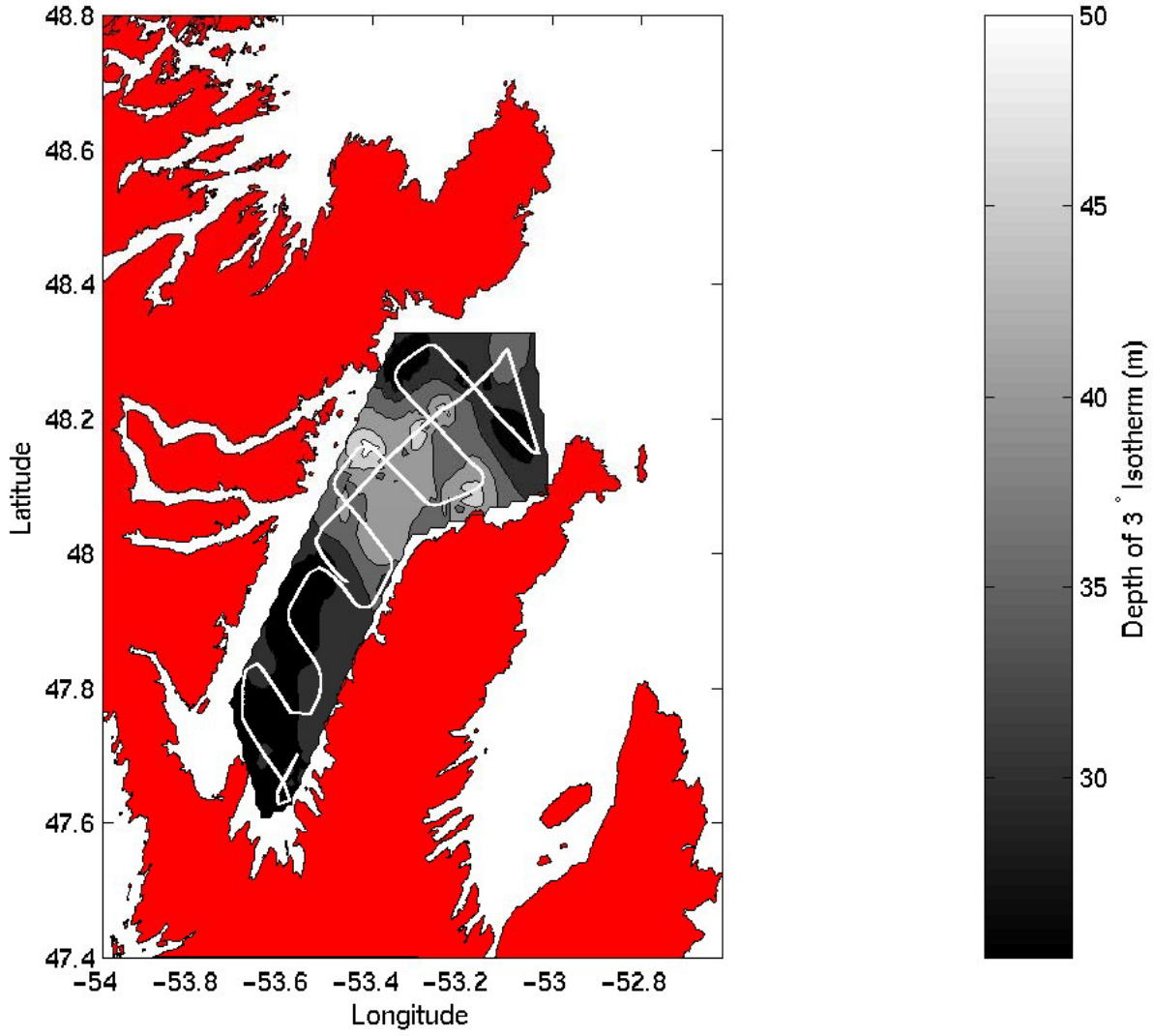


Figure 10: Depth of the 3° C isotherm (m).

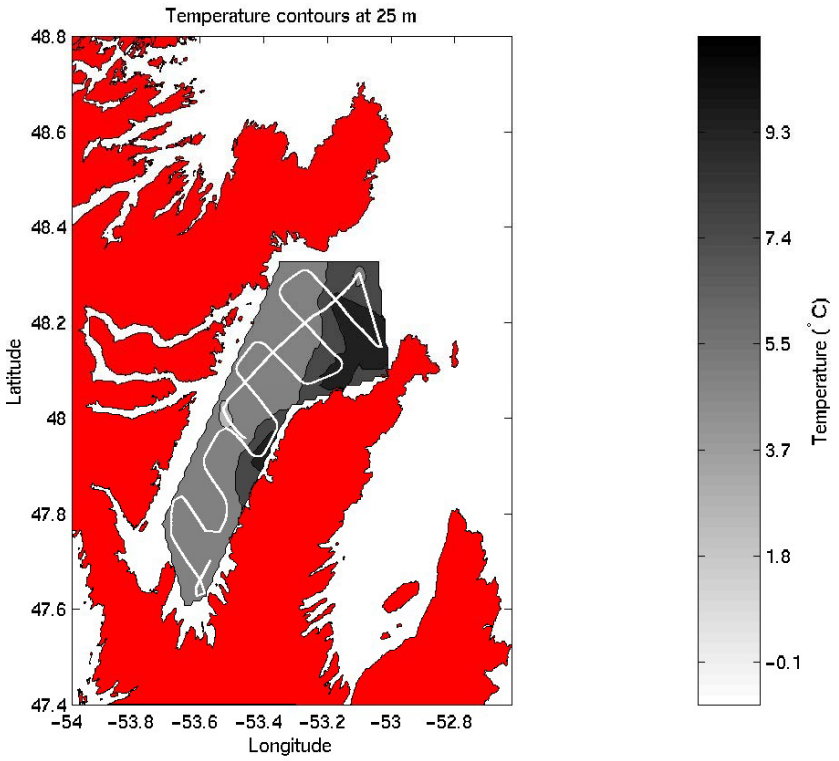


Figure 11: The interpolated temperature (° C) at 25 m depth.

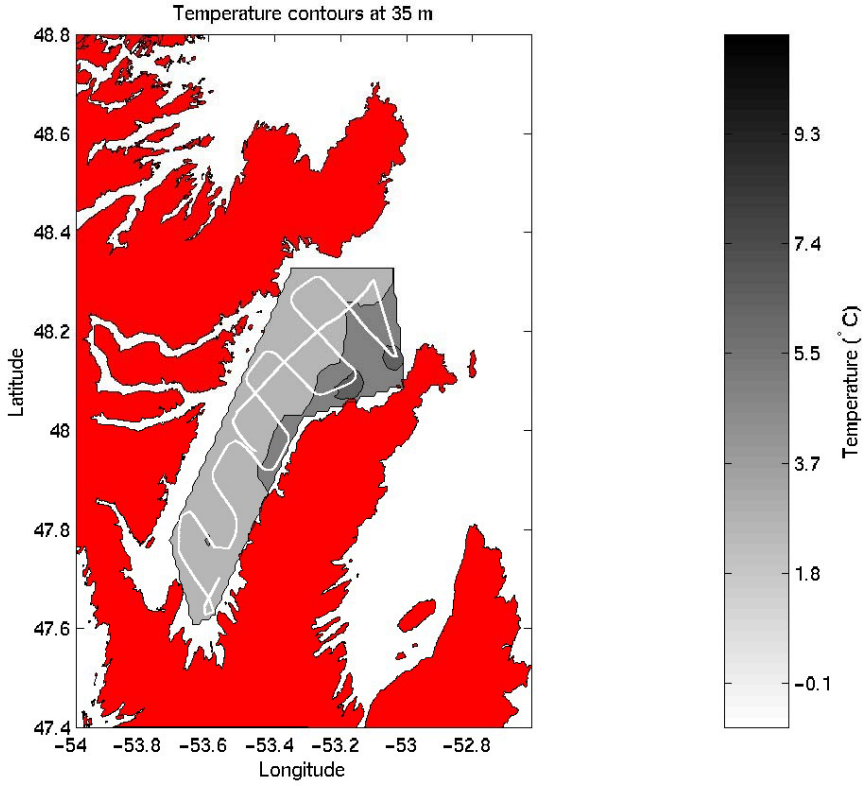


Figure 12: The interpolated temperature (° C) at 35 m depth.

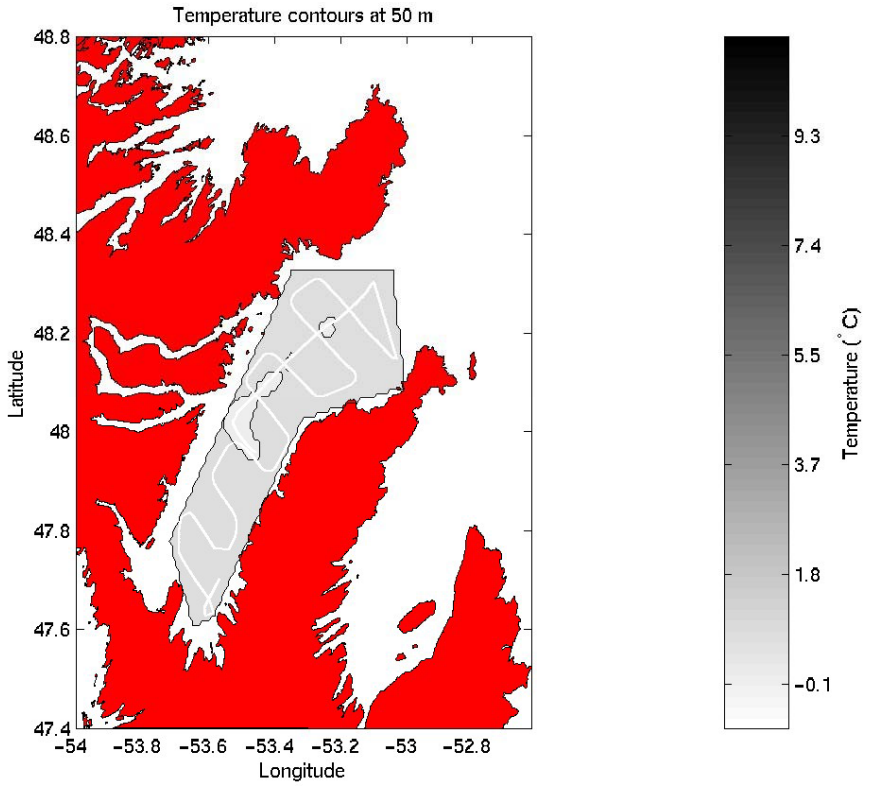


Figure 13: The interpolated temperature (° C) at 50 m depth.

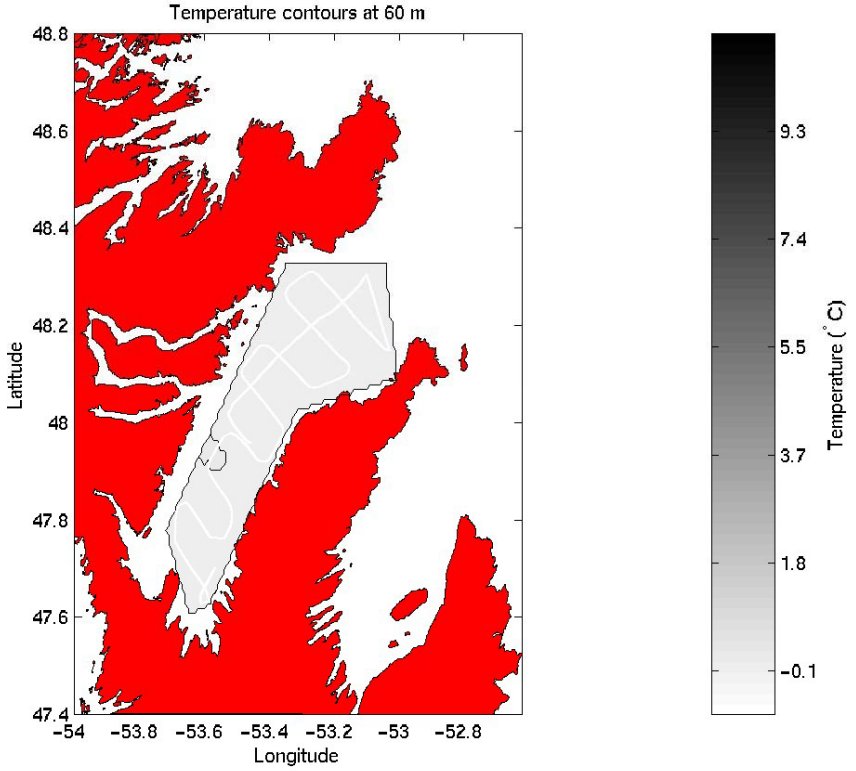


Figure 14: The interpolated temperature (° C) at 60 m depth.

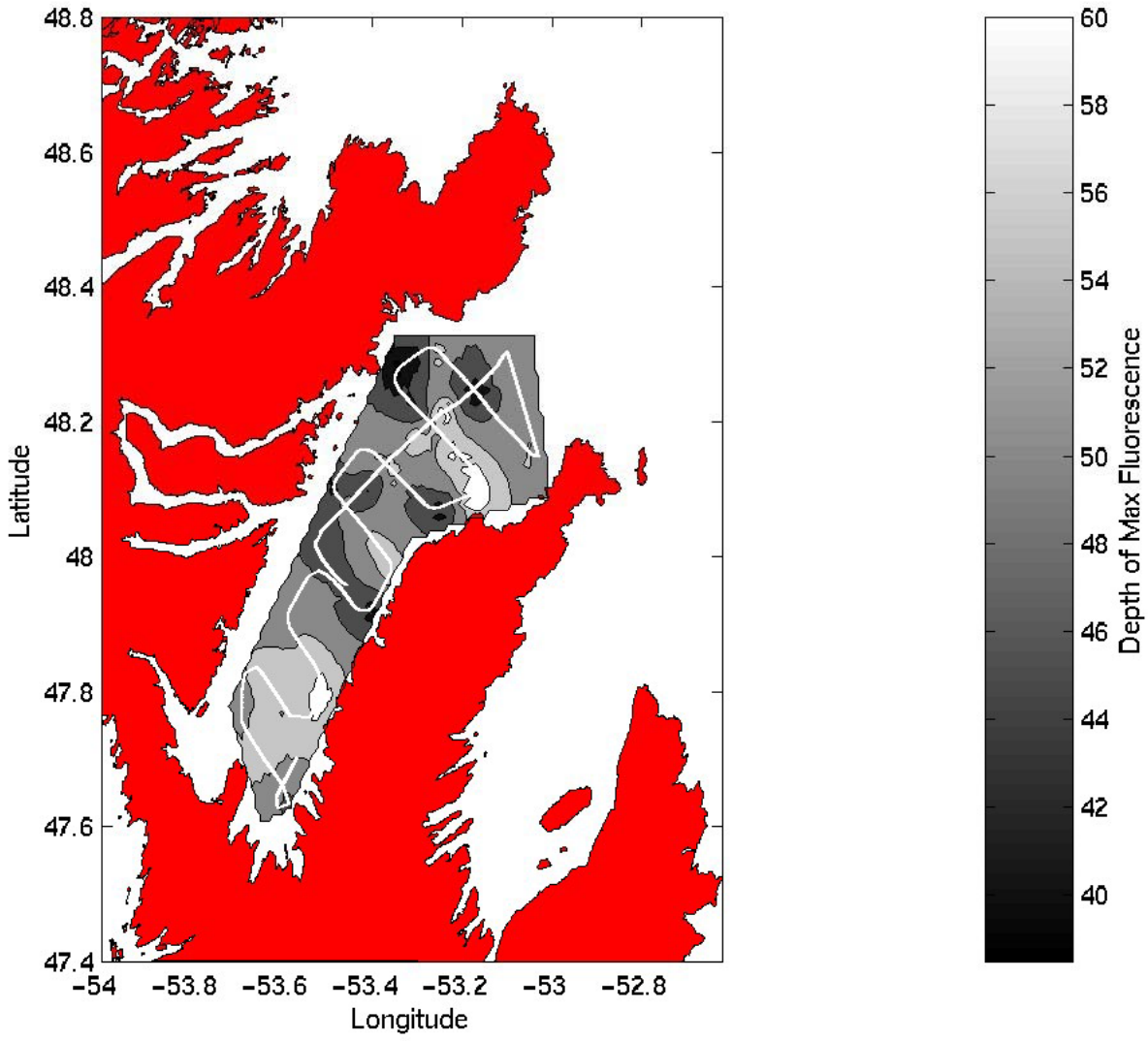


Figure 15: The interpolated depth (m) of maximum fluorescence.

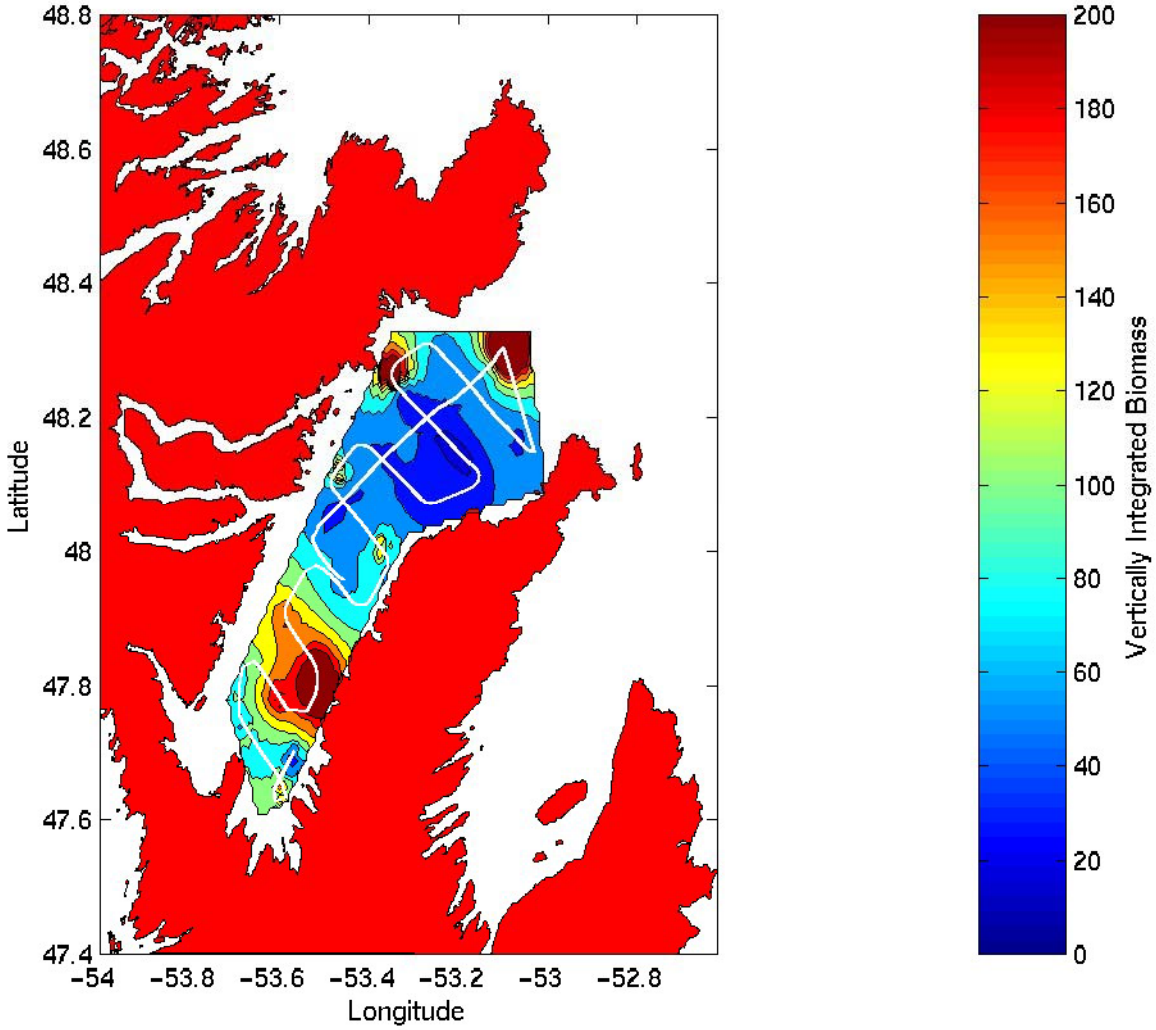


Figure 16: The interpolated vertically integrated biomass values.