Work Term Report I

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May 1 - August 20, 2012
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1.0 Summary

This work term was completed under the supervision of Dr. Christopher Taggart and Dr. Kenneth Frank in the Fisheries Oceanography Laboratory in the Department of Oceanography at Dalhousie University. As part of the Northumberland Strait Ecosystem Research Initiative, a study was conducted to provide insight on the role of zooplankton in the Northumberland Strait to help develop ecosystem models and to trace energy transfer in the area using the biomass size-spectrum, a statistical approach that classifies plankton on the basic of size. It is hypothesised that the Strait is a single, well mixed, water body with a uniform habitat and community structure. The slope and intercept of the biomass size-spectrum of the zooplankton will be relatively invariant. It is predicted that the null hypothesis would be rejected. A decrease in both the slope and intercept of the biomass size-spectrum will occur from late spring to autumn. Fieldwork was completed between June and September 2009. Data collected by a Sea-Bird SBE-25 profiling CTD (Conductivity, Temperature, Depth) and BIONESS (Bedford Institute of Oceanography Net and Environmental Sampling System) equipped with an OPC (Optical Plankton Counter) and a CTD (Conductivity, Temperature, Depth) sensor at 26 sampling stations in June and July along and across the Strait were analysed. MATLAB® tools developed and used in the analysis process are discussed. Data collected by the CTD were used to identify and trace the movement of water masses using changes in temperature, salinity and density structure. Sectional and vertical temperature, salinity and density trends are also examined. Recommendations for future directions include

focusing on the completion of required analyses to compare data collected during the first cruise in late spring and the second cruise in early autumn.

All personal objectives set at the beginning of the work term such as participating in faculty events were fulfilled. How these were fulfilled throughout the work term is examined. An assessment of personal development and performance focuses on the discovery of the optimal atmosphere needed to succeed. Additionally, observations of the workplace regarding relationships within and outside the office with supervisors and co-workers, office politics, the important of self-confidence and assertiveness and other aspects of the work environment are presented. A comparison of work styles between the workplace and academic setting is also made.

The work term was of an appropriate difficulty level based on skills and previous experience. Future co-op students should consider a similar work term if they possess adequate programming skills. Both academic and personal aspects of this work term exceeded expectations. Research experience and skills acquired will contribute to future career success. A greater sense of confidence about being able to succeed in this type of workplace environment has been gained. I sincerely hope to have the opportunity to work with Dr. Christopher Taggart and members of the Fisheries Oceanography Lab in the future.

2.0 General Information About the Hiring Organization

2.1 Dalhousie University

Dalhousie University is a leading, research-intensive Canadian university. The university receives over $132 million in research grants and awards per year for researchers in 12 faculties (Dalhousie University, 2012). The Globe and Mail named Dalhousie one of Canada's Top Employers for 2012 (McNutt, 2011). Dalhousie currently serves over 18,000 full- and part-time students, and 5,500 employees.

Dalhousie University is an international leader in ocean research and innovation, with more than 100 faculty members involved in research ranging from oceanography and marine biology to law and engineering (Nicholson, 2011).

2.2 Department of Oceanography

The Department of Oceanography at Dalhousie University is a world-class interdisciplinary centre in oceanographic research. The department's main focus is the education and training of the future leaders in oceanography. Faculty members conduct research in physical, biological, chemical and geological oceanography. The Department of Oceanography is also home to many national and international organisations such as the Ocean Tracking Network (OTN), and the Centre for Marine Environmental Prediction (CMEP).

2.3 Dr. Christopher T. Taggart and the Fisheries Oceanography Laboratory

Dr. Christopher T. Taggart has been a professor in the Department of Oceanography at Dalhousie University since 1995. As the principal investigator in the Fisheries Oceanography Laboratory, Dr. Taggart has been involved in many multi-institutional research initiatives focused on physical to genetic influences on various aspects of the life history of marine organisms such as recruitment, population structure and conservation. His recent work has been focused on the development of particle tracing technology for use in aquatic systems. Dr. Taggart was the primary co-supervisor for the work term.

Dr. Taggart conducts oceanographic research with undergraduate and graduate students, research assistants and post-doctorate fellows. Current members of the Fisheries Oceanography Laboratory include Dr. Diego Ibarra, a post-doctoral fellow, Franziska Broell, a PhD candidate, Janelle Hrycik, a PhD candidate, Tara Tapics, a PhD candidate, Kendra Chisholm, a co-op research assistant and Kimberly Davies, a PhD candidate. Study organisms of laboratory members range from zooplankton to fishes, turtles and whales in systems as small as the Bay of Fundy and as large as the Coral Sea.

2.4 Dr. Kenneth Frank

Dr. Kenneth Frank has been a research scientist at the Department of Fisheries and Oceans, Bedford Institute of Oceanography in Dartmouth, Nova Scotia since 1983. His areas of research are in fisheries ecology, resource conservation, biogeographic theory, fisheries oceanography and marine ecosystem assessment. Dr. Frank was a co-supervisor for the work term.

3.0 Northumberland Strait Ecosystem Research Initiative

The Northumberland Strait Ecosystem Research Initiative (NSERI) is a government-funded program that aims to provide a quantitative baseline of the structure of the Northumberland Strait. The project coordinators are Michel Comeau and Mark Hanson from the Department of Fisheries and Oceans, The Gulf Fisheries Centre in Moncton, New Brunswick.

3.1 Study Area

The NSERI focuses on the Northumberland Strait, a north-west to south-east flow-through system dominated by Gulf of St Lawrence inflow water and freshwater from several adjoining rivers and nutrient-rich estuaries located along the coasts of Prince Edward Island, Nova Scotia, and New Brunswick. This area has recently experienced changes in the abundance and distribution of key species. It is unknown if these changes are due to the cumulative effects of several stressors or the impact of larger-scale processes.

3.2 Goals of the NSERI

The minimum goal of the NSERI is to create a quantitative reference-point database against which to test for postulated or to measure observed changes in the future. Short-term goals include creating models of mass (pools) and movement (flux) of material within the Strait and between adjacent waters, and creating various measures of community diversity. Creating mass-balance and food web ecosystem models including Strait/estuaries connections is a long-term objective of the NSERI.

3.3 Explanation of the Biomass Size-Spectrum and Related Concepts

The biomass size-spectrum is a prey-predator theory of aquatic production (Kerr & Dickie, 2001, p. 2). It is a statistical approach that classifies plankton on the basic of size (Sheldon, Prakash, & Sutcliffe, Jr., 1972; Sheldon, Sutcliffe, Jr., & Paranjape, 1977). Advantages of using sized-based classification include enabling the use of automated counting instruments for measuring plankton in situ and of advanced mathematics for expressing population processes (Heath, 1995; Herman, Beanlands, & Phillips, 2004; Silver & Platt, 1978; Zhou and Huntley, 1997). Community structure is greatly simplified, and individual growth and abundance changes can be estimated from allometrically scaled rates (Huntley & Boyd, 1984; Hirst & Lampitt, 1998).

Recently, numerous studies have been performed to understand the biomass size-spectrum's characteristics particularly in aquatic plankton communities in both inland lakes and oceans. Observations of biomass size-spectra indicate that the slope of a biomass spectrum is around -1 on the logarithmic coordinates (Zhou, 2006). Significant efforts have been made to interpret the meaning of the slope and shape of a biomass size-spectrum in terms of growth rates, respiration, mortality and trophic dynamics (Heath, 1995; Silver & Platt, 1978; Zhou & Huntley, 1997). Additionally, inverse mathematical methods have been developed to explain the biomass size-spectrum since the realization that the time-dependent variation of a biomass size-spectrum represents the dynamics and imbalance between population processes within a plankton community (Heath, 1995; Zhou, 2006).

3.4 Zooplankton biomass size-spectra in the Northumberland Strait

Although it has been an important economic area for generations, the Northumberland Strait is characterized as data deficient; particularly regarding the role that the zooplankton component ranging from 200 µm to 20 mm has on the functioning of the regional ecosystem. Using the biomass size-spectrum as a tool to identify areas of high diversity, the analysis of collected data aims to provide insight on the role of zooplankton in the area to help develop ecosystem models and to trace energy transfer in the Strait. This study was started in 2008 by former M. Sc student Julie Sperl at Dalhousie University in the Fisheries Oceanography Laboratory under the supervision of Dr. Christopher T. Taggart, but was never completed. Fieldwork was completed by Julie Sperl between June and September 2009.

3.4.1 Null Hypotheses

Assuming the complete mixing of source waters and their associated nutrients and small particles, it is hypothesised that the Strait waters will be well mixed and uniform, with the same ecological structure throughout. Consequently, the slope and intercept of the biomass size-spectrum of the zooplankton will be relatively invariant because the amount of nutrients, and thus the productivity of the zooplankton remain constant throughout the Strait in both space and time. It is predicted that the null hypothesis will be rejected, and that a decrease in the slope and intercept of the biomass size-spectrum will occur from late spring to autumn. In late spring, an increase in primary production near the mouths of estuaries due to nutrient enrichment should result in an increase in the biomass of small zooplankton, resulting in an increase in the slope of the biomass size-spectrum; an index of secondary production. This is an example of bottom-up control.

3.4.2 Sampling

A Sea-Bird SBE-25 profiling CTD (Conductivity, Temperature, Depth) was deployed from, on average, 1.5 m below the surface at 26 sampling stations along and across the Strait between June 25 and July 5, 2009 aboard CCGS Opillio. Most sampling stations were located before and near Confederation Bridge. Appendix I provides further information about each sampling station. In addition, BIONESS (Bedford Institute of Oceanography Net and Environmental Sampling System) equipped with an OPC (Optical Plankton Counter) and a CTD (Conductivity, Temperature, Depth) sensor was deployed and used to measure zooplankton biomass and light attenuation in situ, and associated hydrographic properties at the same 26 sampling stations. TUBSS (Towered Underwater Biological Sampling System), which was also equipped with an OPC and a CTD sensor, was towed along eighteen transects.

Data collected by the SBE-25 profiling CTD were used to identify and trace the movement of water masses using changes in temperature, salinity and density structure. Water mass variation will be presented in terms of temperature, salinity and density in a plane and section view. Data collected by BIONESS will not be presented graphically. Data collected by TUBSS were not analysed. The analysis process for both data sets will be discussed. Similar data were also collected at different sampling stations throughout the Strait during a second cruise aboard CCGS Opillio between August 31 and September 16, 2009. This data were not analysed and will not be discussed.

3.5 Other NSERI Student Research in the Fisheries Oceanography Laboratory

PhD candidate Janelle Hrycik is currently tracking nutrient fluxes in the Northumberland Strait using micro beads, a new particle-tracing technology.

4.0 Detailed Description of Duties and Techniques Used

4.1 Organisation and Maintenance of Data Records and Files

The organisation of electronic data records and files associated with both 2009 CCGS Opillio cruises was improved throughout the work term as they were analysed or used. A sample Read_me.txt file that is included in each folder is shown in Appendix II.

4.2 Comprehension of Concepts Related to the Biomass Size-Spectrum through Literature Searches and Compilations

Literature searches and compilations were conducted using Google Scholar® to comprehend concepts related to the biomass size-spectrum. Over 30 scientific papers were gathered and read. The key authors were Iain Suthers and Mark Baird from the University of New South Wales in Sydney, Australia, and supervisor Dr. Christopher T. Taggart. Relevant articles were published as early as 1982, however the majority of articles were published after 2005. The biomass size-spectrum was explained in detail in section 3.3 of this report.

4.3 MATLAB® Tools for Data Analysis and Presentation

The MathWorks program called MATLAB® (2012) was used during the work term to analyse data. All MATLAB® tools discussed were either created or significantly edited by Camille Pagniello except for Sections.m which was jointly created with Dr. Diego Ibarra during the work term, and BIONESS_cmb_average.m and associated functions which was created by Dr. Josée Michaud for her PhD thesis research. A sample of code for a tool is included in Appendix III.

4.3.1 Analysis and Presentation of CTD Data

Temperature (International Temperature Scale of 1990 in Celsius (°C)), salinity (PSU), sigma-t density ($kg \cdot m^{-3}$), hereafter referred to as density, and depth (decibars (db)) data were processed and plotted using the MATLAB® tool CTD25_data_processing.m. This tool uses the sub-functions plotxxx.m provided by Franziska Broell, and moving_average.m. Only temperature, salinity and density downcast data and data recorded at or below the surface layer CTD acclimation depth[1] were used. Data were smoothed using a centered, uniformly weighted, moving average with a window of extent 4 (2 s) or by using a bin average with bin width of 1 m. Bin averaged data were used for graphical presentation while moving averaged data were used in determining the summary statistics.

Bin averaged data were used to build section plots in the MATLAB® tool Sections.m. Sections were contoured using linear data interpolation at every meter horizontally and vertically in the Strait.

Bin averaged data were used to construct a temperature-salinity (TS) diagram in the MATLAB® tool CTD_TS_plots.m. This tool uses the sub-function tsdiagram.m.

4.3.2 Analysis of BIONESS Data

Time stamp errors in files containing BIONESS data collected by the CTD sensor were identified. The MATLAB® tool BIONESS_CTD_check.m was developed to notify the user if a time stamp error, that is if the time stamp does not increase by two seconds, was present in the file. The tool does not correct the error. Time stamp errors were also detected in files containing BIONESS data collected by the OPC sensor. A MATLAB®

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[1] The acclimation depth is the depth at which the CTD is placed in the water and allowed to acclimate for approximately three minutes before taking readings.

tool called BIONESS_OPC_check_and_correct.m was created not only to verify that no time stamps were missing and that time stamps continually increase by one, but to correct all detected errors and create an associated error report.

The MATLAB® tool BIONESS_OPC_CTD_merge.m was developed to extract the processed BIONESS data collected by the CTD and OPC sensor and combine the data into one file for additional analysis by the MATLAB® tool BIONESS_cmb_average.m. This tool is a translation of the TURBO BASIC program OPCBIO2012.BAS created by Dr. Christopher T. Taggart, and was edited by various Fisheries Oceanography Laboratory members.

BIONESS_cmb_average.m calculates and outputs the two-second average of various variables such as temperature, salinity, light attenuation, and depth to a new file. This tool uses sub-functions bugs.m, CTD.m, average.m and printoutave.m to enable the processing and output of the averaged data. However, due to breaks in the file combined by BIONESS_OPC_CTD_merge.m, NaN values are inserted into the output file where no data were recorded during a two-second interval. The MATLAB® tool BIONESS_txt_interpolator.m was created to interpolate values where NaN values were inserted into the output file.

5.0 Study Conclusions and Recommendations

5.1 Movement of Water Masses in the Northumberland Strait

Graphical presentation for all sectional hydrographic trends discussed can be found in Appendix IV. Graphical presentation of the vertical hydrographic structure discussed can be found in Appendix V.

5.1.1 Sectional Temperature, Salinity and Density Trends in Late Spring

Sections along the Strait show that the water temperature continuously increases until Confederation Bridge. Here, this trend is reversed, and the water temperature decreases. Sections also show that the salinity increases along the sampled area of the Strait. Additionally, sections reveal that the water density decreases from the northwest end to the southeast end until station 10. After this station, the water density increases. Sectional trends correspond to observed trends in mean water temperature and density at each station (Table A1.2). However, mean salinity trends are not in agreement with sectional trends. The mean salinity increases from station to station along the Strait, except from station 11 to 10, where the mean salinity decreases.

Between stations 10 and 17, a water mass of lower temperature, higher salinity and higher density is formed in the middle of the Strait. This water mass is also present around station 22. Accordingly, water near land in the southeast end has a higher temperature, lower salinity and lower density than water in the middle.

5.1.2 Vertical Temperature, Salinity and Density Trends in Late Spring

The vertical temperature, salinity and density structure at each station varies greatly. Stations located near the coast of PEI have little vertical structure. At these stations, the water temperature varies by 0.7 °C or less, the salinity varies by 0.2 PSU or less, and the water density varies by 0.2 $kg \cdot m^{-3}$ or less between the surface and the ocean floor. Similarly, stations not located near the mouth of a river, but also near the coast of NB have little vertical structure. There is no visible vertical structure at stations 6 to 8, including station 7a, and stations 15 to 18. Distinct thermoclines are present at stations 1, 2, 3, and 22.

5.1.3 Interpretation of Temperature, Salinity and Density Trends in Late Spring

Cold, salty, dense water from the Gulf of St Lawrence enters the northwest end of the Strait. Around station 2, warm, fresh, light water from the Richibucto River also enters the Strait. Near stations 1 and 9, warm, fresh, light water from the Shediac and Scoudouc Rivers enters the Strait. Warm, fresh, light water from the Gaspereau River, Timber River, and Baie Verte River enters the Strait around station 25.

5.1.4 Trends Observed in the TS Diagram in Late Spring

Trends observed show that the oceanic system in the Northumberland Strait is mostly temperature driven (Figure 1). Most stations show vertical temperature stratification, but have fairly constant salinity and water density. Trends also show that the water temperature notably increases at each station along the Strait. However, although the salinity and water density does change, changes are negligible compared to observed changes in water temperature along the Strait. Hence, the mixing of two distinct water masses occurs both the northwest end and southeast end of the Strait. Water in the middle of the Strait is completely mixed.

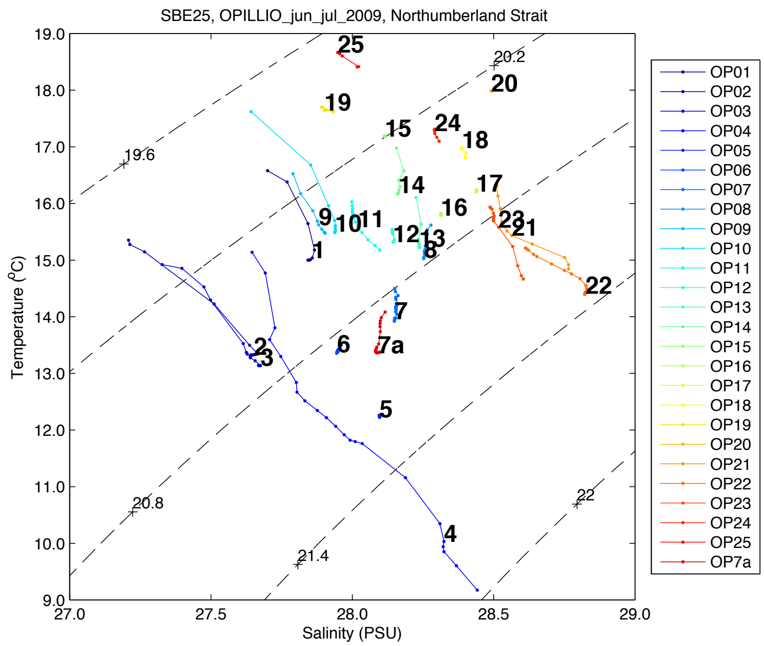


Figure 1. Temperature-salinity (TS) diagram derived from CTD profiles at each sampling station in the Northumberland Strait. Lines of constant density (σ_t) are noted.

5.2 Unmet Workplace Objectives

The following workplace objectives were not met during the work term:

1. Estimating the variation in zooplankton biomass size-spectra in both time and space in the Northumberland Strait.
2. Comparing patterns in the slope and intercept of biomass size-spectra with variation in water mass structure to explain spatial and seasonal variation in the contemporary physical and biological structure and ecological functioning of the Northumberland Strait ecosystem from a bottom up and potentially top down perspective.

3. Quantifying the role that zooplankton play in the functioning of the Northumberland Strait ecosystem.

Developing MATLAB® tools for the analysis and presentation of CTD data proved to be a difficult and lengthy process. Thus, due to time constraints, no MATLAB® tools were developed for the presentation of BIONESS data. This data set was to be used to estimate variation in the zooplankton biomass size-spectra in both time and space. Because this objective was not met, other objectives that were dependent on the completion of this estimate such as the comparison of patterns in the biomass distribution and size-spectra with the variation in water mass structure could not be met. Without this comparison, species-independent measures of ecosystem structure and functioning for various water masses of the Strait could not be established.

5.3 Recommendations of Future Directions for Study and Analysis

Future directions for study and analysis should focus on a comparison between data collected during the first cruise in late spring, and the second cruise in early autumn. However, unmet objectives outlined in section 5.2 should first be completed for the first data set. The same analysis process, i.e. CTD, BIONESS and TUBSS data analysis, should also be repeated for the second data set in order to be able to accurately compare the data from both cruises. This will enable the researcher to explore spatial and seasonal variation in the contemporary physical and biological structure, and ecological functioning of the Northumberland Strait ecosystem.

5.4 Relevant Academic Courses

The most useful previously taken academic class for the work term was Physics Tools: Experiment (PHYC 2150). This class provided some of the problem-solving skills needed when conducting independent research such as data handling, analysis and reporting skills. However, previous summer research in the Department of Physics at Dalhousie University was the most useful experience during the work term. Programming experience in Python greatly reduced the learning curve associated with learning a new programming language such as MATLAB®, and enabled the creation of tools that can be used for any universal data set.

Recommended future classes include Introduction to Biological Oceanography (OCEA 3003), Biological Oceanography (OCEA 4140), Time Series Analysis in Oceanography and Meteorology (OCEA 4210), Marine Modelling (OCEA 4380), and Introduction to Numerical Programming (PHYC 3050). These classes focus on the interactions between living organisms and the ocean environment or have a heavy emphasis on programming.

6.0 Personal Objectives

6.1 Review of Personal Objectives

All personal objectives were fulfilled during the work term. Each was realistic and appropriate. The discussion below focuses on how each objective was fulfilled.

6.1.1 Learning to Make a Clear Distinction between the Personal and Professional Environment

The workplace presents a unique challenge to students. While attending classes, it is the norm for students to complete work outside of the classroom environment. Conversely, in the workplace, employees are not necessarily expected to complete work outside of normal office hours. This was a challenging aspect of the work term as it meant that after leaving the office, time was not consumed with work that had to be completed. For the first month of the work term, I was unable to break the norm and regularly completed work outside of the office. However, during the final three months, I joined the local soccer team, worked as a soccer official and spent more time with friends. Such activities *impeded* me from completing work outside of the office. To find the balance between work and fun, it is important for me to participate in activities outside of the workplace.

6.1.2 Developing Better Problem-Solving Skills, and Scientific Writing and Communication Skills

Problem-solving skills, and scientific writing and communication skills are essential skills when working in the academic-based scientific community. Problem-solving skills were especially improved and used while creating MATLAB® tools to analyse and present various data set. For example, each MATLAB® tool developed is completely automated and able to process any data set recorded by the specified instrument, eliminating the need to create a new tool for each new data set. Scientific writing and communication skills were improved when recording data and creating a data report. Balancing conciseness and details was emphasised.

6.1.3 Exploring Different Topics in Marine Biology and Oceanography

During the academic year, students are limited to choosing five classes. Consequently, in most cases, students only have the opportunity to explore five topics of interest. Through seminars and symposiums, I had the chance to explore topics that I cannot during the academic year such as fish accelerometry and tagging, and physical oceanographic models. All topics explored were oceanography related. Topics in marine biology were, unfortunately, not explored.

6.1.4 Discovering the Academic-Based Scientific Community

Observations of the academic-based scientific community will be discussed in section 7.0.

6.1.5 Building Relationships with Supervisors, Superiors and Co-Workers

Networking has become a necessity to ensure future success and development of one's career. Working in harmony with others and contributing to group effectiveness are essential when building relationships with supervisors, superiors and co-workers. During the work term, I secured a position as a research assistant at Memorial University of Newfoundland in the laboratory of Dr. Ted Miller for the next work term based on the recommendation of my current supervisor, Dr. Christopher Taggart. Without his recommendation, I do not believe that I would have secured this position.

6.1.6 Understanding the Role of a Graduate Student

Masters and doctoral programs are essentially apprenticeships: most of a student's time is spent working on research in their advisor's lab. The emphasis is on learning how to gather information and construct knowledge independently. Thus, graduate students are scientists in training. Additionally, the importance of choosing the right supervisor is greatly emphasised, as supervisors can become mentors and help shape a student's career. Graduate students often are required to serve as teaching assistants and sometimes, course instructors.

6.1.7 Participating in Faculty Events

During the work term, I had the opportunity to attend Methods in Ten Minutes (MTM) sessions, departmental seminars and the Ocean Tracking Network (OTN) Canada Annual Symposium. MTM sessions covered topics such as methods for using the statistical computing program R, avoiding grading bias and bibliography software. Departmental seminars covered topics ranging from the distribution of whales to estimating global ocean denitrification rates, and featured speakers from around the world. The OTN Canada Annual Symposium brought together scientists across Canada participating in OTN projects. Here, I met Dr. Ian Fleming of the Department of Ocean Sciences at Memorial University of Newfoundland, who offered me a tour of his laboratory when I arrive in Newfoundland in January. I also had the opportunity to attend the thesis defense of Kimberly Davies.

6.2 Assessment of Personal Development and Performance

During the work term, I gained a sense of self-awareness about the atmosphere that I need to succeed. I have established the best ways for me to thrive in the workplace particularly in terms of balance and time management. First, it is important that I participate in social activities outside of the workplace to make a clear distinct between the personal and workplace environment. Second, time management and minimising distractions are key to remain focused on the assigned duties. This will be discussed in section 7.5. In future work terms, I hope to use these discoveries to succeed in the workplace.

7.0 Observations of the Workplace

The academic-based scientific community is a unique workplace for undergraduate students. Undergraduates become research assistants, teaching assistants often become co-workers, and professors become supervisors and mentors. However, after four short months, undergraduates, once again, become onlookers of the academic-based scientific community. Observations of working in such a dynamic environment will be discussed.

7.1 Relationships Within and Outside of the Workplace

I felt as though I "fit in" perfectly while on the work term. Similarly to the graduate students in the Fisheries Oceanography Laboratory, I was given my own personal office. In addition, I was invited to the same seminars, symposiums and thesis defenses as graduate students, and felt as though I was able to contribute to conversations. I never felt forgotten and was always included in discussions.

7.1.1 Relationship with Supervisors

Dr. Christopher Taggart was extremely helpful and present throughout the work term. He created an excellent work environment, introducing myself to his graduate students, and encouraging me to seek advice and help from them. Dr. Taggart was always available to answer any questions, and to help with any difficulties I encountered. During the work term, he became a great mentor, not only aiding me in course selection, but also helping me develop future career goals. Although we do not have a relationship outside of the office, Dr. Taggart and I did discuss topics unrelated to the work environment such as his adoration of motorcycles and my involvement with local soccer. Unfortunately, I never had the opportunity to meet Dr. Kenneth Frank, but had frequent email contact with him.

7.1.2 Relationship with Co-Workers

Co-workers were extremely helpful and incredibly supportive throughout the work term. Many became a repeatedly used resource when problems were encountered. All generously gave advice about graduate studies and future career goals. Together we celebrated successes through social gatherings and supported one another in times of need. Topics ranging from fashion to science were readily discussed during breaks.

7.2 Comparison of Work Styles Between the Workplace and the Academic Setting

Observations about various aspects common in both the workplace and academic setting are discussed. Comments are based on personal experiences during the work term and academic year. They should not be interpreted as generalisations.

7.2.1 Participation in the Decision Making Process

In the workplace, employees can be actively involved in the decision making process with superiors. However, on many occasions, employees can be asked to independently make important decisions without direction.

In the academic environment, students are not commonly involved in the process. Students are informed about decisions and in most cases, are expected to abide by them.

7.2.2 Implications of Working as a Member of a Team

In the workplace environment, goals are team oriented. Success is achieved as a team. If one individual does not complete their assigned tasks, the entire team will suffer the consequences.

However, in the academic setting, although students may work as a team, students are achieving more individualistic goals such as marks. There is individual glory. In many cases, other students will not be penalised if one member of the team does not complete their assigned tasks.

7.2.3 Working on Large-Scale Studies Compared to Small-Scale Studies

In the workplace, small-scale studies are components of large-scale studies. Because of the number of individuals involved in a study, reporting and recording work is key as many studies are not started and completed by the same individuals.

In the academic environment, most projects are small-scale. Although the study may be part of a class, the completion of one small-scale study generally does not affect the completion of others.

7.2.4 Resolution of Difficulties and Differences of Opinion

In the workplace, everyone is given the opportunity to express his or her opinion. However, individuals working on the problem are given the responsibility to decide which solution is most appropriate. Innovative solutions are always encouraged.

In the academic setting, it is common to compromise or to select one "correct" opinion to save time. Not all methods can be tested. Differences are not always encouraged.

7.2.5 Communication between Colleagues

In the workplace environment, email is extremely important for communication between colleagues. It is often used to set meeting times and inform others about upcoming events. Creating a rapport and being friendly are particularly important. Colleagues often briefly discuss their personal lives outside of the office.

In the academic setting, communication between students is more informal. Students exchange cell phone number and communicate through social media such as Facebook. Students regularly discuss their personal lives, as many students are both classmates and friends.

7.2.6 Supervision

In the workplace, the amount of supervision needed and provided varies depending on the stage of the study. For example, in early stages, more supervision is required to ensure that the employee understands their duties and the study itself. After these initial stages, employees are expected to independently work on assignments. However, some supervisors regularly require updates.

In the academic environment, students only experience supervision during the laboratory. Because classes are very large, students do not usually experience one-on-one supervision with the professor or the laboratory instructor. There is no one verifying that student completes assigned work on a regular basis.

7.2.7 Responsibility and Initiative

In the workplace environment, initiative and taking responsibility are greatly valued. It is the responsibility of the individual to find resources, to ask for additional help if needed and to complete tasks in a timely manner.

Similarly, in the academic setting, it is the student's responsibility to complete assignments on time and to attend classes. Initiative is emphasised in the academic setting as it often leads to greater success.

7.2.8 Importance of Problem-Solving Skills

In the workplace, problem-solving skills are essential for success. Such skills allow for innovative solutions and lead studies to new directions. Problem-solving skills are especially needed when creating and debugging programs.

In the academic environment, learning new problem solving skills is emphasised. Problem-solving skills are needed when applying knowledge such as during laboratories, tests or exams. However, in most cases, problem-solving skills are not needed on a daily basis.

7.3 Workplace Politics and Lines of Authority

In the academic-based scientific community, faculty members receive different amounts of funding for their research. Office politics surrounded around this central issue. It was often suggested, but never explicitly said, that faculty members with higher positions within the department received greater funds than others, especially regarding student awards. An on-going debate was about if biologists were *real* scientists compared to oceanographers. Finally, challenging of the norms on any of these topics was usually not favourably met by superiors.

7.4 Feedback and Criticism

During the work term, constructive feedback was regularly sought out to help improve workplace performance. I attempted to always respond promptly and positively to suggestions and criticism. I was frequently asked if the amount of support, directions provided and other aspects of the work environment were suitable. I was always direct and positive with my responses.

7.5 Time Management

Creating a to-do list was key for time management. However, prioritising assignments and estimating the amount of time it took to complete each item were equally important. Minimising distractions and avoid procrastination were also crucial. Using the resources available helped saved copious amounts of time.

7.6 Impact of Self-Confidence and Assertiveness

Self-confidence and assertiveness were not only valued, but encouraged throughout the work term. It was not merely enough to have a good idea. One needed to develop it, fight for it, win supporters for it and do everything within one's power to see that it get translated into reality.

7.7 Stress Management

Recognising the warning signs of excessive stress at work such as fatigue and trouble concentrating is the first step in my stress management. Taking responsibility for improving my physical and emotional well being by prioritising, organising and not over-committing were keys to reducing stress during the later stages of the work term. Creating a balanced schedule that includes breaks and social activities was also important in reducing stress. Resisting perfectionism was difficult, but improved the overall quality of my work, and thus, also reduced stress.

8.0 Work Term Conclusions and Recommendations

8.1 Expectations of the Work Term

The work term far exceeded all of my expectations. Based on my previous experience in the academic-based research community, I expected that I would be given the resources necessary to perform the duties assigned to me, and have little direction from and interaction with the professor himself. However, Dr. Christopher Taggart was extremely helpful and present throughout the work term. The amount of support and advice that I received from both him and the graduate students in the Fisheries Oceanography Laboratory on various topics was overwhelming. I accomplished much more than both Dr. Taggart and I expected.

8.2 Difficulty Level of the Work Term

Based on my skills and previous experience, the work term was of an appropriate level. During the work term, I was challenged to create innovative solutions to problems on a daily basis. However, without previous programming skills, this work term would have been too difficult for a student having only completed their second year in marine biology. Programming skills were essential to success during this work term.

8.3 Enjoyment of the Work Term

I extremely enjoyed this work term. Since the material was both interesting and challenging, I remained engaged throughout the work term. I sincerely hope to have the opportunity to work with Dr. Christopher Taggart and members of the Fisheries Oceanography Lab in the future. I would be overjoyed to continue working on this study in future work terms and complete my honours thesis based on the work accomplished during this work term.

8.4 Recommendations for other Co-op Students

Science co-op students interested in a similar work term should have previous experience in programming, particularly in MATLAB® or in R. Programming skills were vital to the completion of many of the duties outlined and expected during the work term. For students with this type of previous experience, I would absolutely recommend the position. It was an incredible first work term. However, this position could be an incredible work term at any point during a student's co-op degree.

8.5 Working in a Similar Environment on a Permanent Basis

Working on a permanent basis in the academic-based research community would be highly desirable. It is an environment that I find suits my personality. The setting values initiative, organisation and creativity in individuals. Additionally, there is considerable flexibility in terms of both subject investigated and hours worked. However, the biomass size-spectrum and zooplankton community are not particular subjects that I wish to further investigate in the future. Topics focused on echolocation in marine mammals and the effects of anthropogenic noise on marine mammals would be desired research areas.

8.6 Conclusions on the Academic Aspects of the Work Term

During the work term, I gained additional experience in research, and skills that will greatly help secure future work terms. This research experience may lead to my honours thesis and helped increased my ability to successfully enter graduate school. I also had the opportunity to explore various topics that I do not have the opportunity to learn in the classroom. Additionally, I have found an amazing mentor in Dr. Christopher Taggart, an invaluable outcome. The academic aspects of the work term far exceeded my expectations.

8.7 Conclusions on the Personal Aspects of the Work Term

I am very pleased that I had the opportunity to fulfil my personal objectives throughout the work term. Accomplishing each personal objective has given me a greater sense of confidence that I will be able to succeed in this type of workplace environment, as it is the type of setting that I wish to work in on a permanent basis in the future. In addition, I am now self-aware of the atmosphere that I need to succeed. I have determined the optimal techniques for me to succeed particularly in terms of balance and time management. In future work terms, I will use these traits to prosper in the workplace.

Appendix I: Overview of Sampling Stations

Table A1.1. Stations and data range included in each section.

Section no.	Station no.	Date range
1	2, 3, 4, 5	26-Jun-2009
2	1, 11, 12, 13	25-Jun-2009, 28-Jun-2009
3	6, 7, 7a, 8, 13	26-Jun-2009, 27-Jun-2009, 28-Jun-2009
4	9, 10, 14	28-Jun-2009
5	15, 16, 17, 18, 19	1-Jul-2009
6	20, 21, 22, 23, 24, 25	2-Jul-2009
7	5, 6, 10, 11, 16, 22	26-Jun-2009, 28-Jun-2009, 1-Jul-2009, 2-Jul-2009

Table A1.2. Summary of CTD profile stations (Stn) occupied in the Northumberland Strait in June-July 2009 listing station coordinates (latitude, longitude), start time, sounding depth (m), minimum, maximum, mean and standard error of the mean for temperature (°C), salinity (PSU) and density (kg·m^{-3}).

Stn no.	Date	Latitude (°N)	Longitude (°W)	Start time (hh:mm)	Sounding (m)	Temperature (°C)			Salinity (PSU)			Density (σ_t, kg·m^{-3})		
						Min	Max	Mean ± SE	Min	Max	Mean ± SE	Min	Max	Mean ± SE
1	25-Jun-09	46.2792	64.4596	16:29	10.2	14.999	16.581	15.258 ± 0.036	27.697	27.8720	27.838 ± 0.003	20.012	20.470	20.404 ± 0.010
2	26-Jun-09	46.7240	64.7291	10:15	12.8	13.325	15.419	13.744 ± 0.044	27.205	27.669	27.566 ± 0.010	19.892	20.654	20.498 ± 0.016
3	26-Jun-09	46.7034	64.6533	11:15	17.8	13.133	14.941	13.600 ± 0.031	27.310	27.679	27.597 ± 0.005	20.064	20.700	20.551 ± 0.010
4	26-Jun-09	46.7	64.5719	11:23	25.3	9.046	15.146	11.905 ± 0.072	27.638	28.466	28.001 ± 0.011	20.279	21.996	21.165 ± 0.021
5	26-Jun-09	46.7088	64.4904	15:15	13.4	12.224	12.273	12.241 ± 0.001	28.092	28.100	28.096 ± 0.000	21.183	21.194	21.191 ± 0.000
6	26-Jun-09	46.5788	64.5160	17:27	27.7	13.351	13.501	13.405 ± 0.002	27.943	27.965	27.950 ± 0.000	20.850	20.868	20.861 ± 0.000
7	26-Jun-09	46.5682	64.4349	18:40	28.2	13.918	14.517	14.116 ± 0.007	28.138	28.178	28.153 ± 0.000	20.794	20.918	20.880 ± 0.001
7a	27-Jun-09	46.5611	64.4257	9:12	25.2	13.362	14.145	13.491 ± 0.007	28.080	28.119	28.090 ± 0.000	20.832	20.983	20.954 ± 0.001
8	27-Jun-09	46.5360	64.3213	10:43	21.4	15.019	15.639	15.152 ± 0.006	28.250	28.285	28.256 ± 0.000	20.666	20.773	20.748 ± 0.001
9	28-Jun-09	46.2831	64.4147	07:59	12.7	15.474	17.003	15.767 ± 0.018	27.708	27.905	27.869 ± 0.002	19.926	20.411	20.320 ± 0.005
10	28-Jun-09	46.3485	64.2996	09:02	15.6	15.485	17.637	15.655 ± 0.016	27.636	27.945	27.929 ± 0.002	19.726	20.434	20.390 ± 0.005
11	28-Jun-09	46.3814	64.3626	10:06	17.0	15.171	16.047	15.725 ± 0.010	27.993	28.099	28.015 ± 0.001	20.358	20.623	20.441 ± 0.003
12	28-Jun-09	46.4415	64.2708	11:29	19.3	15.318	15.548	15.406 ± 0.004	28.138	28.155	28.144 ± 0.000	20.575	20.630	20.609 ± 0.001
13	28-Jun-09	46.5120	64.1796	13:17	14.0	15.216	16.171	15.304 ± 0.007	28.218	28.255	28.237 ± 0.000	20.501	20.720	20.701 ± 0.002

Table A1.2. (continued)

14	28-Jun-09	46.4285	64.1729	14:41	14.2	16.166	17.005	16.378 ± 0.014	28.125	28.219	28.164 ± 0.001	20.264	20.462	20.414 ± 0.003
15	1-Jul-09	46.1971	64.0440	09:10	11.5	17.180	17.192	17.186 ± 0.000	28.112	28.117	28.115 ± 0.000	20.192	20.199	20.196 ± 0.000
16	1-Jul-09	46.2372	63.9871	10:28	19.0	15.790	15.834	15.801 ± 0.001	28.311	28.317	28.314 ± 0.000	20.646	20.658	20.655 ± 0.000
17	1-Jul-09	46.2920	63.9303	11:45	22.5	16.198	16.246	16.222 ± 0.001	28.436	28.441	28.438 ± 0.000	20.654	20.664	20.659 ± 0.000
18	1-Jul-09	46.3350	63.8759	13:26	9.0	16.798	16.992	16.917 ± 0.008	28.384	28.410	28.393 ± 0.001	20.446	20.502	20.470 ± 0.002
19	1-Jul-09	46.3708	63.8342	14:13	7.1	17.610	17.725	17.665 ± 0.004	27.879	27.940	27.906 ± 0.002	19.891	19.964	19.926 ± 0.003
20	2-Jul-09	46.1769	63.4885	09:22	8.4	17.982	17.986	17.983 ± 0.000	28.289	28.491	28.491 ± 0.000	20.297	20.299	20.298 ± 0.000
21	2-Jul-09	46.1175	63.5434	10:16	14.8	14.784	16.338	15.588 ± 0.036	28.499	28.769	28.601 ± 0.007	20.688	21.219	20.920 ± 0.013
22	2-Jul-09	46.1175	63.5819	11:09	21.7	14.395	15.232	14.731 ± 0.017	28.608 0	28.883	28.752 ± 0.005	21.002	21.340	21.216 ± 0.007
23	2-Jul-09	46.0870	63.6311	12:57	18.4	14.653	15.939	15.512 ± 0.029	28.487	28.609	28.525 ± 0.003	20.758	21.122	20.878 ± 0.008
24	2-Jul-09	46.0233	63.7915	14:28	10.6	17.092	17.313	17.252 ± 0.006	28.289	28.308	28.294 ± 0.000	20.301	20.365	20.317 ± 0.002
25	2-Jul-09	46.0109	63.9337	15:35	7.8	18.384	18.669	18.533 ± 0.012	27.948	28.033	27.985 ± 0.004	19.721	19.853	19.782 ± 0.006

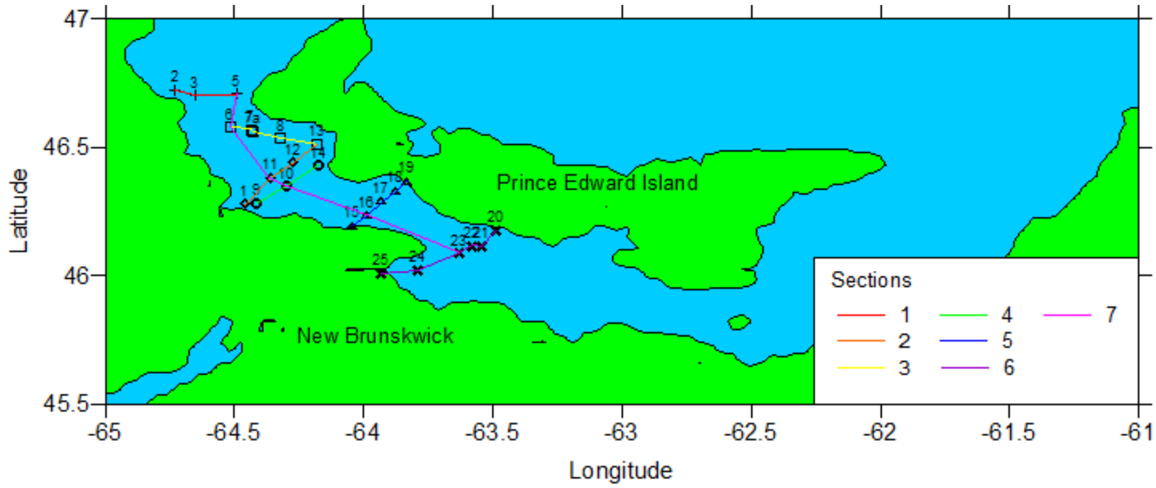


Figure A1.1. Locations of all stations and sections in the Northumberland Strait.

Appendix II: Sample of Read-Me.txt File

About /C_files/C_processed_data/Summer_2009/OPC_BIONESS/T00_files/

/C_files/C_processed_data/Summer_2009/OPC_BIONESS/T00_files/ contains OP09B**P.T00 files, which are processed files (hence P) of the data files OP09B**.T00 from /camille/BC_files/BC_data/Summer_2009/OPC/T00_files/ in taggart3.ocean.dal.ca. These files have been processed using the MATLAB program BIONESS_OPC_check_and_correct.m from /camille/C_files/C_MATLAB_programs/OPC_BIONESS_MATLAB_Code/ in taggart3.ocean.dal.ca.

Associated report files detailing the number, location and type of errors in each original OP09B**.T00 file can be found in /camille/C_files/C_processed_data/Summer_2009/OPC_BIONESS/OPC_RPT_files/ in taggart3.ocean.dal.ca.

The file OP09B02M.T00 was manually altered before running it BIONESS_OPC_check_and_correct.m because the first flag 3 time stamp in the file was missing. Thus, if the OP09B02.T00 file found in /camille/C_files/C_processed_data/Summer_2009/OPC_BIONESS/OPC_RPT_files/ in taggart3.ocean.dal.ca was run in BIONESS_OPC_check_and_correct.m, all of the time stamps would be changed. It is important to note that OP09B02M.T00 was run in BIONESS_OPC_check_and_correct.m to produce OP09B02P.T00.

Note: These are the corrected .T00 files and should be used when running BIONESS_OPC_CTD_merge.m to combine the BIONESS CTD and OPC files.

Contents

OP09B01P.T00, OP09B02M.T00, OP09B02P.T00, OP09B03P.T00, OP09B04P.T00, OP09B05P.T00, OP09B06P.T00, OP09C07aP.T00, OP09B08P.T00, OP09B09P.T00, OP09B10P.T00, OP09B11P.T00, OP09B12P.T00, OP09B13P.T00, OP09B14P.T00, OP09B15P.T00, OP09B16P.T00, OP09B17P.T00, OP09B18P.T00, OP09B19P.T00, OP09B20P.T00, OP09B21P.T00, OP09B22P.T00, OP09B23P.T00, OP09B24P.T00, OP09B25P.T00

/C_files/C_processed_data/Summer_2009/OPC_BIONESS/T00_files/ requirements

Software
Matlab

A note about copyright

This Read_me file was created by Camille Pagniello on August 22, 2012.

Last update: August 22, 2012

Appendix III: Sample Code for a MATLAB® Tool

```
%% BIONESS_OPC_CTD_merge.m (located in /camille/C_files/C_MATLAB_programs/CTD_25_Code/
on
%  taggart3.ocean.dal.ca)
%
% Created: July 10, 2012
% Last update: August 20, 2012
% Author: Camille Pagniello (camillepagniello@dal.ca)
%
% BIONESS_OPC_CTD_merge.m extracts and merges OPC .T00 files with their respective
% BIONESS CTD .cnv files. This is a translation of OPCBIO2012.BAS for
% TURBO. The TURBO operating system is located in
% /Volumes/camille/C_files/C_TB_operating_sytem/TURBO/.
%
% Files used are .cnv files named OP09B**.cnv and .T00 files named
% OP09B**P.T00. .cnv files are located in the default folder
% /Volumes/camille/BC_files/BC_data/Summer_2009/BIONESS/CNV_files/.
% .T00 files are located in the default folder
% /Volumes/camille/C_files/C_processed_data/Summer_2009/OPC_BIONESS/T00_files/.
%
% Please use BIONESS_CTD_check.m and BIONESS_OPC_check_and_correct.m to
% check for time stamp errors before running the files in this program.
%
% .cmb files produced are saved in
% /Volumes/camille/C_files/C_processed_data/Summer_2009/OPC_BIONESS/CMB_files/.
% .cmb files are not necessarily identical to .cmb files produced in TURBO.
% This program produces the correct .cmb files for further processing use.
%
% All locations must be changed before running file if running from
% different computer or if files are in different location. Locations can
% be changed while running the program.
%
% Must clear all workspace values before running for
% a second time. Clear commands are included. Make sure they are not
% commented out.
%
% Prompted Inputs:      - filelocation_1, location of BIONESS CTD .cnv file
%                         (default is
%                         /Volumes/camille/BC_files/BC_data/Summer_2009/BIONESS/CNV_files/)
%                       - filelocation_2, location of OPC .T00 file
%                         (default is
%                         /Volumes/camille/C_files/C_processed_data/Summer_2009/OPC_BIONESS/T00_files/)
%                       - filelocation_3, location to save .cmb file to
%                         (default is
%
/Volumes/camille/C_files/C_processed_data/Summer_2009/OPC_BIONESS/CMB_files/)
%
%                       - file_number_1, last two digits of BIONESS CTD
%                         OP09B**.cnv file
%                       - file_number_2, last two digits of OPC OP09B**P.T00
%                         file
%
```

```
% Note: Error messages are purposely produced to indicate that the CTD and
% OPC data have been merged.
%% Opening BIONESS CTD file

fid = -1;
msg = 'Where is the BIONESS CTD .cnv file located?';
disp(msg);
filelocation_1 = input(...
    'default is /Volumes/camille/BC_files/BC_data/Summer_2009/BIONESS/CNV_files/ : ',...
    's');
if isempty(filelocation_1) == 1
    filelocation_1 = ...
        '/Volumes/camille/BC_files/BC_data/Summer_2009/BIONESS/CNV_files/';
end

msg = ...
    'What are last two digits of the BIONESS CTD .cnv file?';
disp(msg);
file_number_1 = input(...
    'last two digits of .cnv file, no default ', 's');
if isempty(file_number_1) == 1
    error(...
        'Error: Last two digits must be entered. Please restart the program.');
end

while fid < 0
    filename = strcat('OP09B', file_number_1, '.cnv');
    file_location = strcat(filelocation_1, filename);
    fid = fopen(file_location);
end

%% Reading BIONESS CTD file - determining date and start time

DA = fgets(fid);
if strcmp(DA(1),'#')
    BIO_start = DA(1:21);
    BIO_start_hh = str2double(DA(14:15));
    BIO_start_mm = str2double(DA(17:18));
    BIO_start_ss = str2double(DA(20:21));
end

%% Setting BIONESS CTD Counter based on start time

BIO_cnt = BIO_start_hh*60*60 + BIO_start_mm*60 + BIO_start_ss;

%% Opening OPC file

fid_2 = -1;
msg = 'Where is the OPC .T00 file located?';
disp(msg);
filelocation_2 = input(...
    'default is /Volumes/camille/C_files/C_processed_data/Summer_2009/OPC_BIONESS/T00_files/ : ',...
    's');
if isempty(filelocation_2) == 1
```

```
    filelocation_2 = ...
        '/Volumes/camille/C_files/C_processed_data/Summer_2009/OPC_BIONESS/T00_files/';
end

msg = ...
    'What are last two digits of the OPC .T00 file?';
disp(msg);
file_number_2 = input(...
    'last two digits of .T00 file, no default ', 's');
if isempty(file_number_2) == 1
    error(...
        'Error: Last two digits must be entered. Please restart the program.');
end

while fid_2 < 0
    filename = strcat('OP09B', file_number_2, 'P.T00');
    file_location = strcat(filelocation_2, filename);
    fid_2 = fopen(file_location);
end

%% Reading OPC file - determining date and start time

DD = fgetl(fid_2);
OPC_start = DD(1:24);
OPC_start_hh = str2double(DD(12:13));
OPC_start_mm = str2double(DD(15:16));
OPC_start_ss = str2double(DD(18:19));

%% Setting OPC Counter based on start time

OPC_cnt = OPC_start_hh*60*60 + OPC_start_mm*60 + OPC_start_ss;

%% Create .cmb output file

msg = 'Where would you like to save the .cmb output file?';
disp(msg)
filelocation_3 = input(...
    'default is /Volumes/camille/C_files/C_processed_data/Summer_2009/OPC_BIONESS/CMB_files/ : ',...
    's');
if isempty(filelocation_3) == 1
    filelocation_3 = ...
        '/Volumes/camille/C_files/C_processed_data/Summer_2009/OPC_BIONESS/CMB_files/';
end

msg = strcat('File name is OP09B', file_number_1, 'P.cmb');
disp(msg)

cd(filelocation_3)
output_file = fopen(strcat('OP09B', file_number_1, 'P.cmb'), 'w');

%% Printing BIONESS CTD and OPC date and start time to .cmb output file

BIO_line_1 = ['BIO start at:' BIO_start];
```

```
BIO_line_2 = ['counter set at:' num2str(BIO_cnt)];
fprintf(output_file, '%s     ', BIO_line_1);
fprintf(output_file, '%s \n', BIO_line_2);
OPC_line_1 = ['OPC start at:' OPC_start];
OPC_line_2 = ['counter set at: ' num2str(OPC_cnt)];
fprintf(output_file, '%s ', OPC_line_1);
fprintf(output_file, '%s \n', OPC_line_2);

%% Determining where to start counter & combining BIONESS CTD and OPC files with fprintf

diff = OPC_cnt - BIO_cnt;

if diff == 0
    msg_result = 'Both start at same time.';
    disp(msg_result)

    while OPC_cnt < BIO_cnt+2

        DD = fgetl(fid_2);

        if strcmp(DD(1), '3')
            OPC_cnt = OPC_cnt + 0.5;
        end
    end

    net_numb = 1;
    DA = fgets(fid);
    BIO_new_start_hh = str2double(DA(3:4));
    BIO_new_start_mm = str2double(DA(6:7));
    BIO_new_start_ss = str2double(DA(9:10));
    BIO_cnt = BIO_new_start_hh*60*60 + BIO_new_start_mm*60 + BIO_new_start_ss;

    while ~feof(fid)
        while ~feof(fid_2)
            if strcmp(DA(1), '*')
                clear DD
                DD = fgetl(fid_2);
                if numel(DD) == 0
                    fclose(output_file);
                    clear
                    error('OPC and BIONESS CTD files have been merged. OPC closed before BIONESS file.
This is not an error.');
                elseif OPC_cnt ~= BIO_cnt

                    if strcmp(DD(1), '1')
                        flag_1 = [' 1 , ' DD(3:end)];
                        fprintf(output_file, '%s \n', flag_1);
                        clear flag_1
                    elseif strcmp(DD(1), '2')
                        flag_2 = [' 2 , ' DD(3:end)];
                        fprintf(output_file, '%s \n', flag_2);
                        clear flag_2
                    elseif strcmp(DD(1), '3')
                        flag_3 = [' 3 , ' DD(3:end)];
```

```
            fprintf(output_file, '%s \n', flag_3);
            clear flag_3
            OPC_cnt = OPC_cnt +0.5;
        end
    elseif OPC_cnt == BIO_cnt
        if strcmp(DD(1), '1')
            flag_1 = [' 1 , ' DD(3:end)];
            fprintf(output_file, '%s \n', flag_1);
            clear flag_1
        elseif strcmp(DD(1), '2')
            flag_2 = [' 2 , ' DD(3:end)];
            fprintf(output_file, '%s \n', flag_2);
            disp('Found flag 2. YES BIONESS CTD. Printed to file.')
            clear flag_2
        elseif strcmp(DD(1), '3')

            str_BIO_cnt = num2str(BIO_cnt);
            input_BIO_cnt = str_BIO_cnt;
            str_OPC_cnt = num2str(OPC_cnt);
            input_OPC_cnt = ['  ' str_OPC_cnt];
            flag_9 = [' 9 , ' DA(3:81) input_BIO_cnt input_OPC_cnt];
            fprintf(output_file, '%s \n', flag_9);
            clear flag_9

            DA = fgets(fid);

            BIO_new_start_hh = str2double(DA(3:4));
            BIO_new_start_mm = str2double(DA(6:7));
            BIO_new_start_ss = str2double(DA(9:10));
            BIO_cnt = BIO_new_start_hh*60*60 + BIO_new_start_mm*60 + BIO_new_start_ss;

            flag_3 = [' 3 , ' DD(3:end)];
            fprintf(output_file, '%s \n', flag_3);
            disp('Found flag 3. YES BIONESS CTD. Printed to file.')
            clear flag_3
            OPC_cnt = OPC_cnt + 0.5;

        end
    end

elseif strcmp(DA(1:3), '# C')

    flag_8 = [' 8 , ' num2str(net_numb)];
    fprintf(output_file, '%s \n', flag_8);
    clear flag_8
    net_numb = net_numb + 1;

    DA = fgets(fid);

    BIO_new_start_hh = str2double(DA(3:4));
    BIO_new_start_mm = str2double(DA(6:7));
    BIO_new_start_ss = str2double(DA(9:10));
    BIO_cnt = BIO_new_start_hh*60*60 + BIO_new_start_mm*60 + BIO_new_start_ss;
```

```
        elseif strcmp(DA(1), '@')

          DA = fgets(fid);

          BIO_new_start_hh = str2double(DA(3:4));
          BIO_new_start_mm = str2double(DA(6:7));
          BIO_new_start_ss = str2double(DA(9:10));
          BIO_cnt = BIO_new_start_hh*60*60 + BIO_new_start_mm*60 + BIO_new_start_ss;

        elseif strcmp(DA(1), '$') || strcmp(DA(1), ';')
          fclose(output_file);
          clear
          error('OPC and BIONESS CTD files have been merged. This is not an error.');
        end
      end
    end
end

if diff > 0
    msg_result = 'BIONESS CTD starts first.';
    disp(msg_result)
    start = BIO_cnt+diff;
    msg_print = ['First logical start is at: ' num2str(start)];
    disp(msg_print)

    OPC_cnt = OPC_cnt + 0.5;

    while OPC_cnt >= BIO_cnt
      DA = fgets(fid);

      if BIO_cnt < OPC_cnt
        if strcmp(DA(1), '*')

          BIO_new_start_hh = str2double(DA(3:4));
          BIO_new_start_mm = str2double(DA(6:7));
          BIO_new_start_ss = str2double(DA(9:10));
          BIO_cnt = BIO_new_start_hh*60*60 + BIO_new_start_mm*60 + BIO_new_start_ss;

        end
      end
    end

    net_numb = 1;
    BIO_new_start_hh = str2double(DA(3:4));
    BIO_new_start_mm = str2double(DA(6:7));
    BIO_new_start_ss = str2double(DA(9:10));
    BIO_cnt = BIO_new_start_hh*60*60 + BIO_new_start_mm*60 + BIO_new_start_ss;

    while ~feof(fid)
      while ~feof(fid_2)
        if strcmp(DA(1), '*')
          clear DD
          DD = fgetl(fid_2);
          if numel(DD) == 0
```

```
            fclose(output_file);
            clear
            error('OPC and BIONESS CTD files have been merged. OPC closed before BIONESS file.
This is not an error.');
        elseif OPC_cnt ~= BIO_cnt
            if strcmp(DD(1), '1')
                flag_1 = [' 1 , ' DD(3:end)];
                fprintf(output_file, '%s \n', flag_1);
                clear flag_1
            elseif strcmp(DD(1), '2')
                flag_2 = [' 2 , ' DD(3:end)];
                fprintf(output_file, '%s \n', flag_2);
                clear flag_2
            elseif strcmp(DD(1), '3')
                flag_3 = [' 3 , ' DD(3:end)];
                fprintf(output_file, '%s \n', flag_3);
                clear flag_3
                OPC_cnt = OPC_cnt +0.5;
            end
        elseif OPC_cnt == BIO_cnt
            if strcmp(DD(1), '1')
                flag_1 = [' 1 , ' DD(3:end)];
                fprintf(output_file, '%s \n', flag_1);
                clear flag_1
            elseif strcmp(DD(1), '2')
                flag_2 = [' 2 , ' DD(3:end)];
                fprintf(output_file, '%s \n', flag_2);
                disp('Found flag 2. YES BIONESS CTD. Printed to file.')
                clear flag_2
            elseif strcmp(DD(1), '3')

                str_BIO_cnt = num2str(BIO_cnt);
                input_BIO_cnt = str_BIO_cnt;
                str_OPC_cnt = num2str(OPC_cnt);
                input_OPC_cnt = ['  ' str_OPC_cnt];
                flag_9 = [' 9 , ' DA(3:81) input_BIO_cnt input_OPC_cnt];
                fprintf(output_file, '%s \n', flag_9);
                clear flag_9

                DA = fgets(fid);

                BIO_new_start_hh = str2double(DA(3:4));
                BIO_new_start_mm = str2double(DA(6:7));
                BIO_new_start_ss = str2double(DA(9:10));
                BIO_cnt = BIO_new_start_hh*60*60 + BIO_new_start_mm*60 + BIO_new_start_ss;

                flag_3 = [' 3 , ' DD(3:end)];
                fprintf(output_file, '%s \n', flag_3);
                disp('Found flag 3. YES BIONESS CTD. Printed to file.')
                clear flag_3
                OPC_cnt = OPC_cnt + 0.5;
            end
        end
    elseif strcmp(DA(1:3), '# C')
        flag_8 = [' 8 , ' num2str(net_numb)];
```

```
            fprintf(output_file, '%s \n', flag_8);
            clear flag_8
            net_numb = net_numb + 1;

            DA = fgets(fid);

            BIO_new_start_hh = str2double(DA(3:4));
            BIO_new_start_mm = str2double(DA(6:7));
            BIO_new_start_ss = str2double(DA(9:10));
            BIO_cnt = BIO_new_start_hh*60*60 + BIO_new_start_mm*60 + BIO_new_start_ss;

         elseif strcmp(DA(1), '@')

            DA = fgets(fid);

            BIO_new_start_hh = str2double(DA(3:4));
            BIO_new_start_mm = str2double(DA(6:7));
            BIO_new_start_ss = str2double(DA(9:10));
            BIO_cnt = BIO_new_start_hh*60*60 + BIO_new_start_mm*60 + BIO_new_start_ss;

         elseif strcmp(DA(1), '$') || strcmp(DA(1), ';')
            fclose(output_file);
            clear
            error('OPC and BIONESS CTD files have been merged. This is not an error.');
         end
      end
   end
end

if diff < 0
   msg_result = 'OPC starts first.';
   disp(msg_result)
   start = BIO_cnt + diff;
   msg_print = ['First logical start is at: ' num2str(start)];
   disp(msg_print)

   OPC_cnt = OPC_cnt + 0.5;

   while OPC_cnt < BIO_cnt+2

      DD = fgetl(fid_2);

      if strcmp(DD(1), '3')
         OPC_cnt = OPC_cnt + 0.5;
      end
   end

   disp('Out of loop.')

   net_numb = 1;
   DA = fgets(fid);
   BIO_new_start_hh = str2double(DA(3:4));
   BIO_new_start_mm = str2double(DA(6:7));
```

```
    BIO_new_start_ss = str2double(DA(9:10));
    BIO_cnt = BIO_new_start_hh*60*60 + BIO_new_start_mm*60 + BIO_new_start_ss;

    while ~feof(fid)
        while ~feof(fid_2)
            if strcmp(DA(1), '*')
                clear DD
                DD = fgetl(fid_2);
                if numel(DD) == 0
                    fclose(output_file);
                    clear
                    error('OPC and BIONESS CTD files have been merged. OPC closed before BIONESS file. This is not an error.');
                elseif OPC_cnt ~= BIO_cnt
                    if strcmp(DD(1), '1')
                        flag_1 = [' 1 , ' DD(3:end)];
                        fprintf(output_file, '%s \n', flag_1);
                        clear flag_1
                    elseif strcmp(DD(1), '2')
                        flag_2 = [' 2 , ' DD(3:end)];
                        fprintf(output_file, '%s \n', flag_2);
                        clear flag_2
                    elseif strcmp(DD(1), '3')
                        flag_3 = [' 3 , ' DD(3:end)];
                        fprintf(output_file, '%s \n', flag_3);
                        clear flag_3
                        OPC_cnt = OPC_cnt +0.5;
                    end
                elseif OPC_cnt == BIO_cnt
                    if strcmp(DD(1), '1')
                        flag_1 = [' 1 , ' DD(3:end)];
                        fprintf(output_file, '%s \n', flag_1);
                        clear flag_1
                    elseif strcmp(DD(1), '2')
                        flag_2 = [' 2 , ' DD(3:end)];
                        fprintf(output_file, '%s \n', flag_2);
                        disp('Found flag 2. YES BIONESS CTD. Printed to file.')
                        clear flag_2
                    elseif strcmp(DD(1), '3')

                        str_BIO_cnt = num2str(BIO_cnt);
                        input_BIO_cnt = str_BIO_cnt;
                        str_OPC_cnt = num2str(OPC_cnt);
                        input_OPC_cnt = ['  ' str_OPC_cnt];
                        flag_9 = [' 9 , ' DA(3:81) input_BIO_cnt input_OPC_cnt];
                        fprintf(output_file, '%s \n', flag_9);
                        clear flag_9

                        DA = fgets(fid);

                        BIO_new_start_hh = str2double(DA(3:4));
                        BIO_new_start_mm = str2double(DA(6:7));
                        BIO_new_start_ss = str2double(DA(9:10));
                        BIO_cnt = BIO_new_start_hh*60*60 + BIO_new_start_mm*60 + BIO_new_start_ss;
```

```
                flag_3 = [' 3 , ' DD(3:end)];
                fprintf(output_file, '%s \n', flag_3);
                disp('Found flag 3. YES BIONESS CTD. Printed to file.')
                clear flag_3
                OPC_cnt = OPC_cnt + 0.5;
            end
        end
    elseif strcmp(DA(1:3), '# C')
        flag_8 = [' 8 , ' num2str(net_numb)];
        fprintf(output_file, '%s \n', flag_8);
        clear flag_8
        net_numb = net_numb + 1;

        DA = fgets(fid);

        BIO_new_start_hh = str2double(DA(3:4));
        BIO_new_start_mm = str2double(DA(6:7));
        BIO_new_start_ss = str2double(DA(9:10));
        BIO_cnt = BIO_new_start_hh*60*60 + BIO_new_start_mm*60 + BIO_new_start_ss;

    elseif strcmp(DA(1), '@')

        DA = fgets(fid);

        BIO_new_start_hh = str2double(DA(3:4));
        BIO_new_start_mm = str2double(DA(6:7));
        BIO_new_start_ss = str2double(DA(9:10));
        BIO_cnt = BIO_new_start_hh*60*60 + BIO_new_start_mm*60 + BIO_new_start_ss;

    elseif strcmp(DA(1), '$') || strcmp(DA(1), ';')
        fclose(output_file);
        clear
        error('OPC and BIONESS CTD files have been merged. This is not an error.');
    end
  end
 end
end
```

Appendix IV: Graphical Presentation of Vertical Hydrographic Structure

Figure A4.1. Temperature, salinity and density profiles presented in station order from station 1 (a) through station 25 (z).

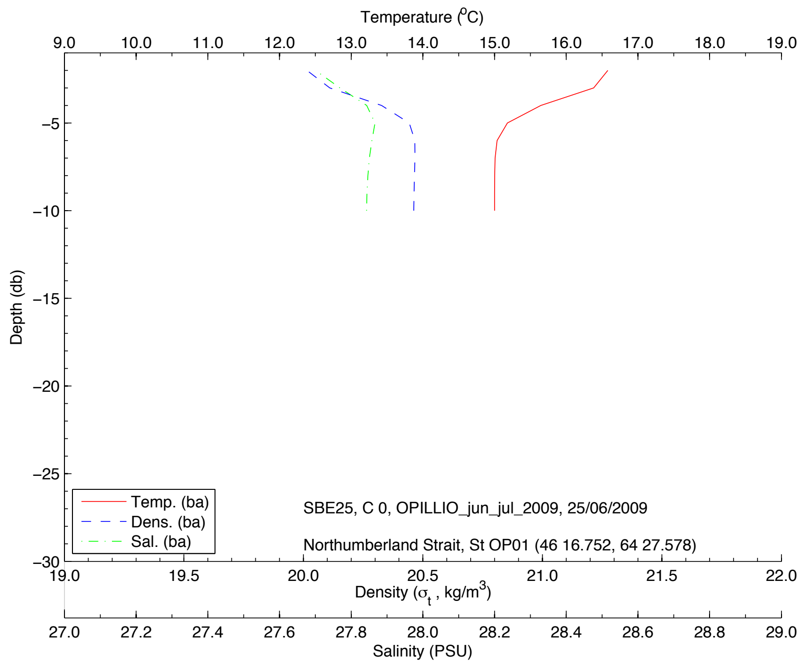


Figure A4.1a

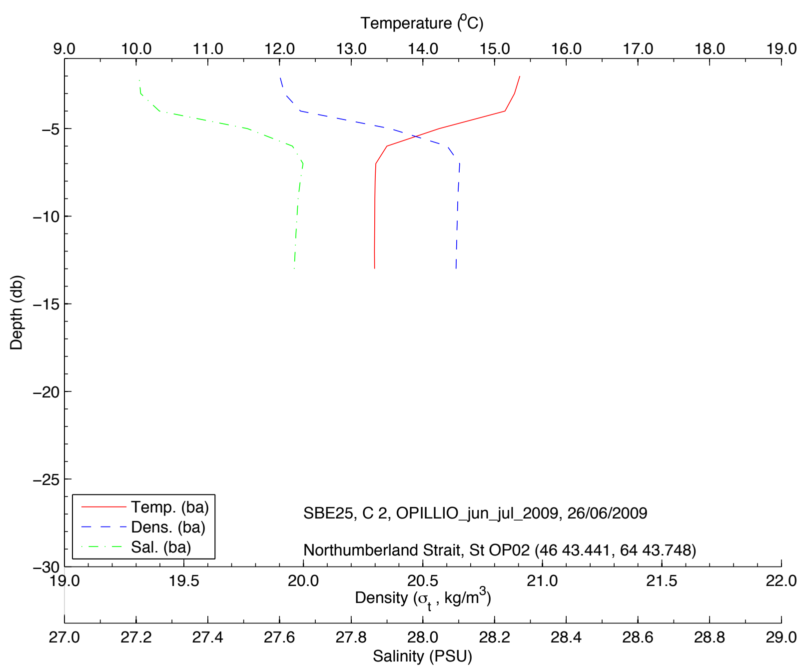


Figure A4.1b

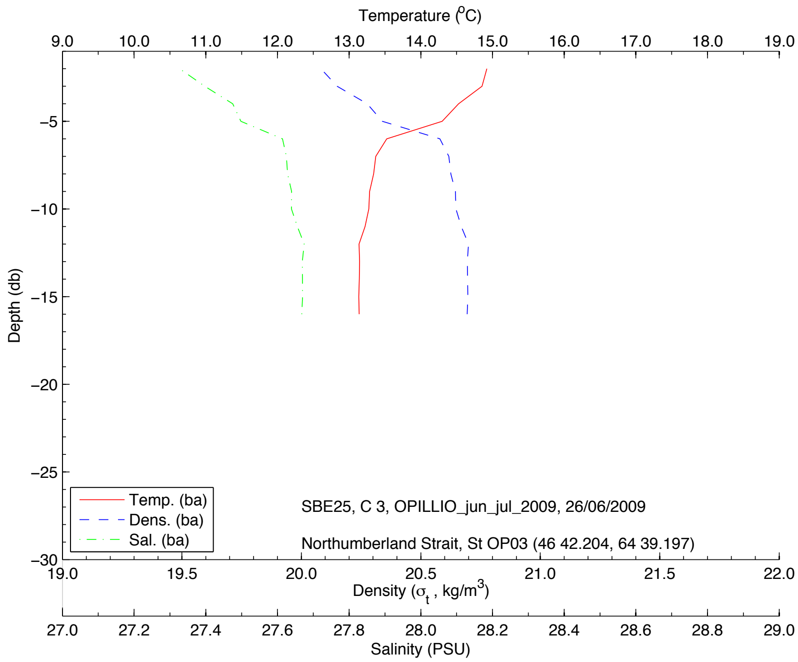


Figure A4.1c

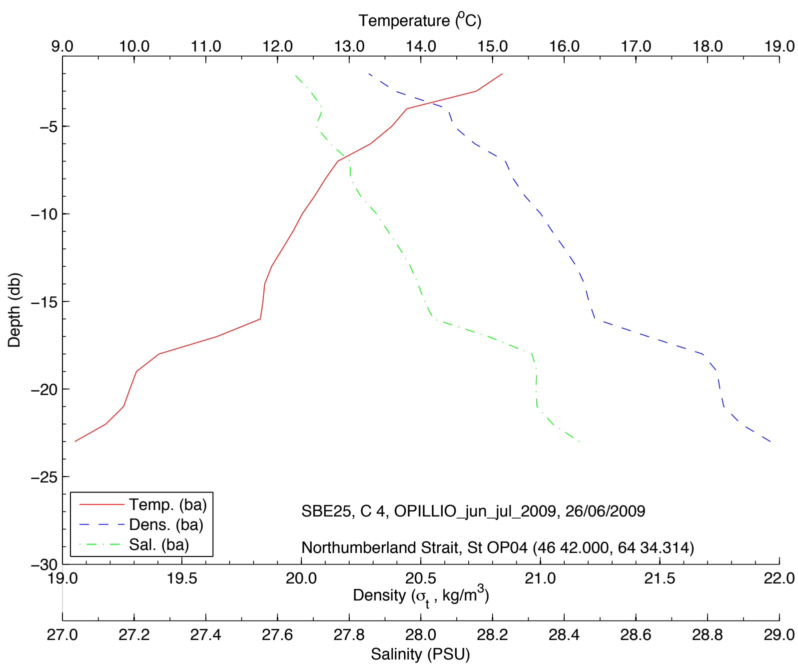


Figure A4.1d

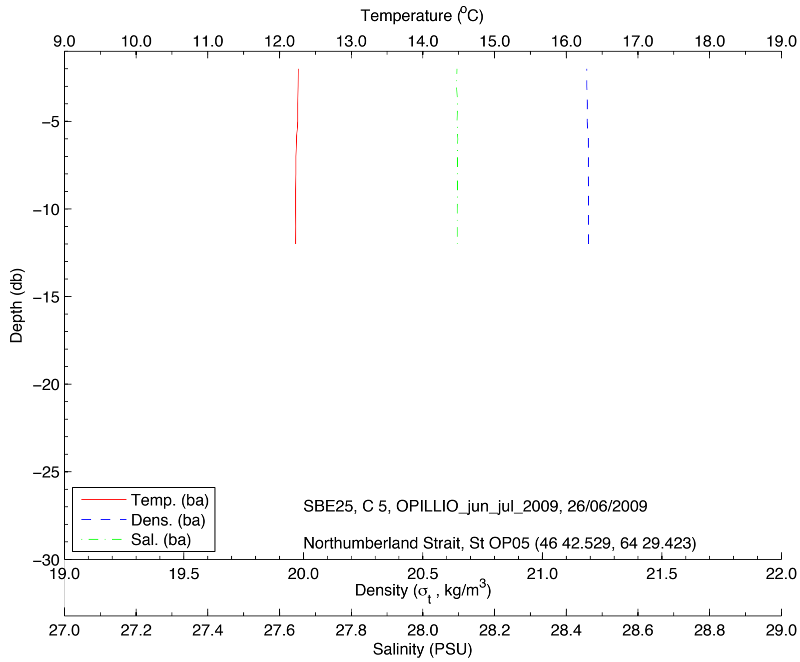


Figure A4.1e

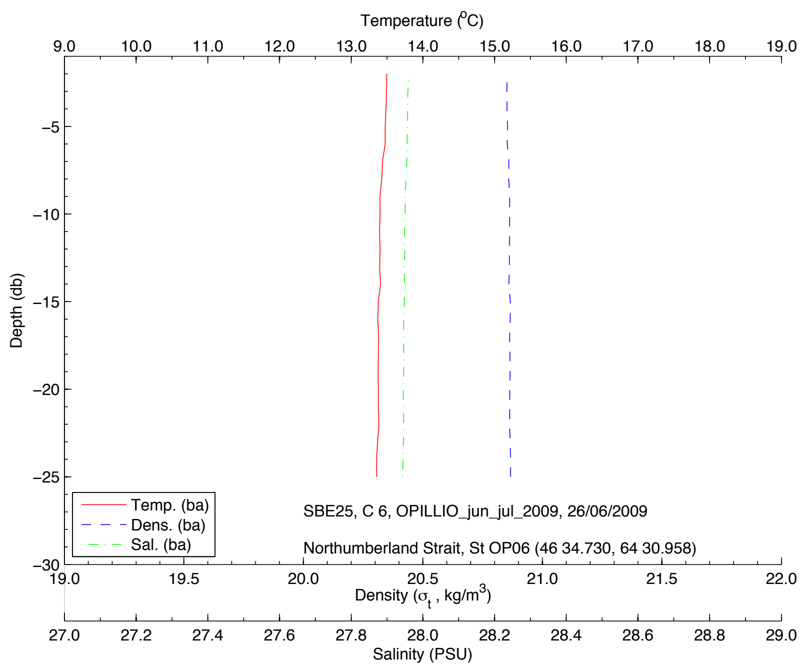


Figure A4.1f

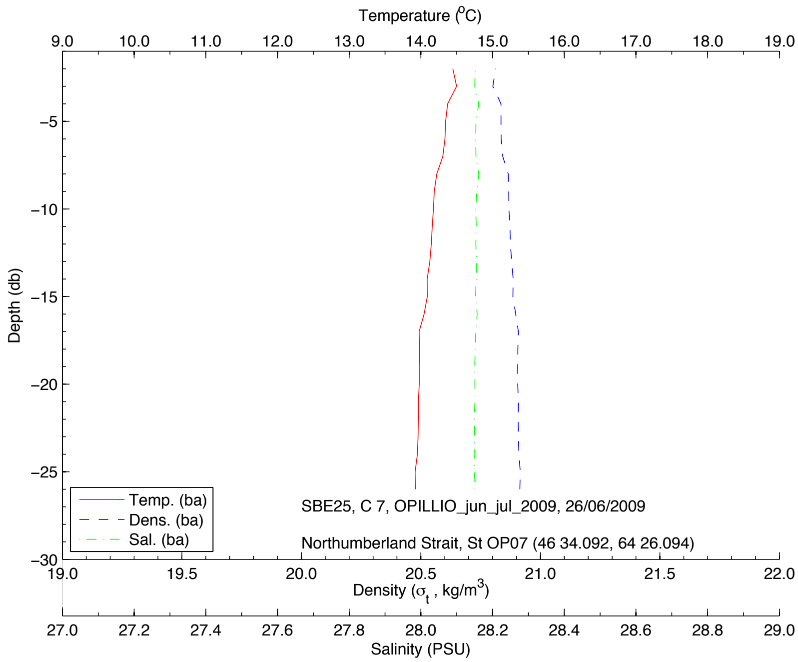


Figure A4.1g

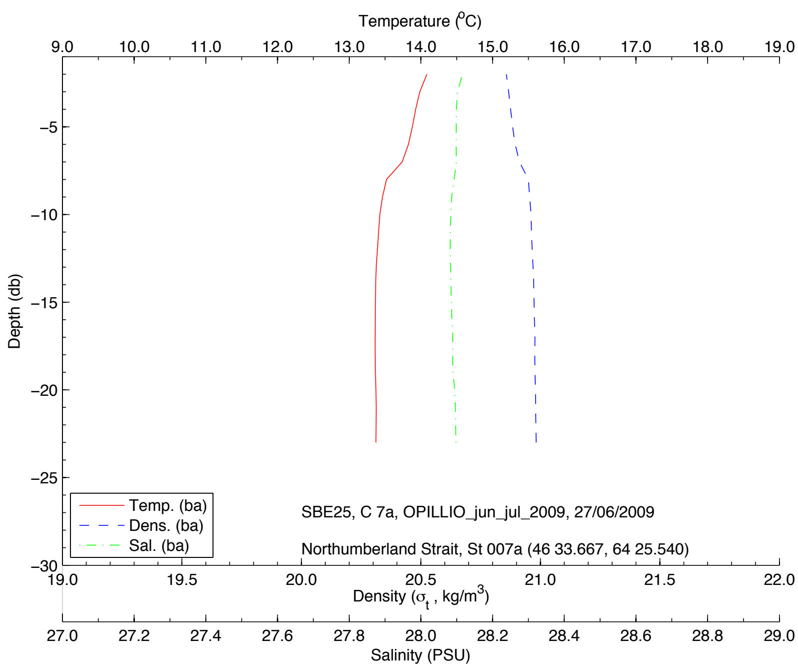


Figure A4.1h

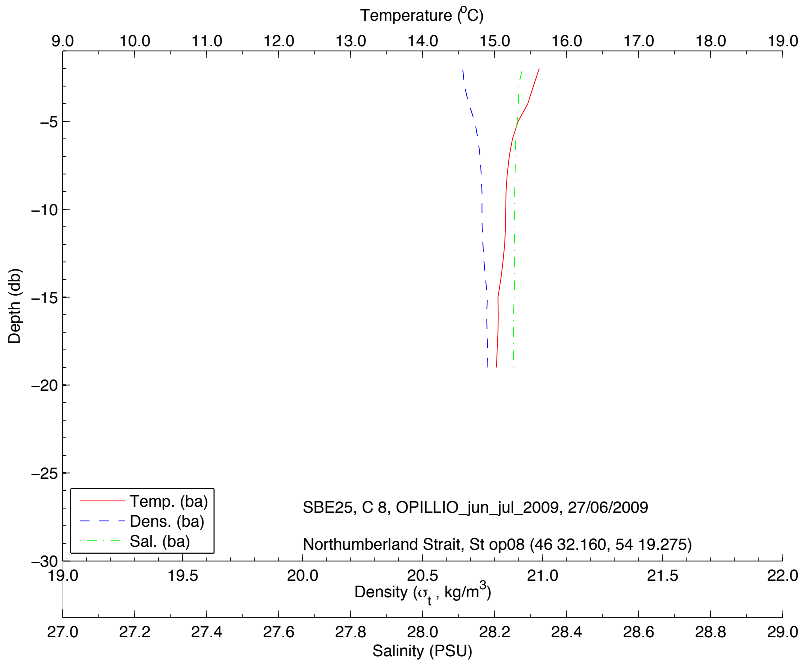


Figure A4.1i

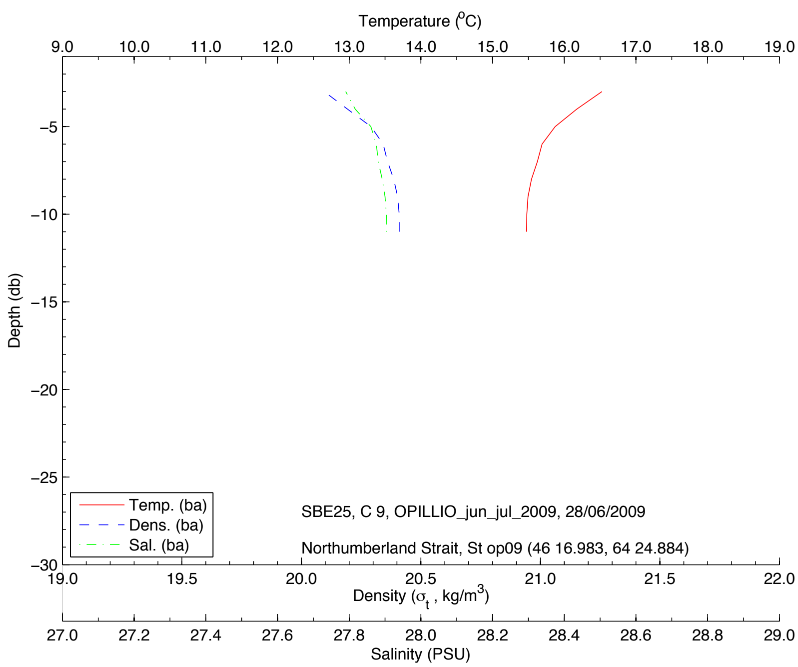


Figure A4.1j

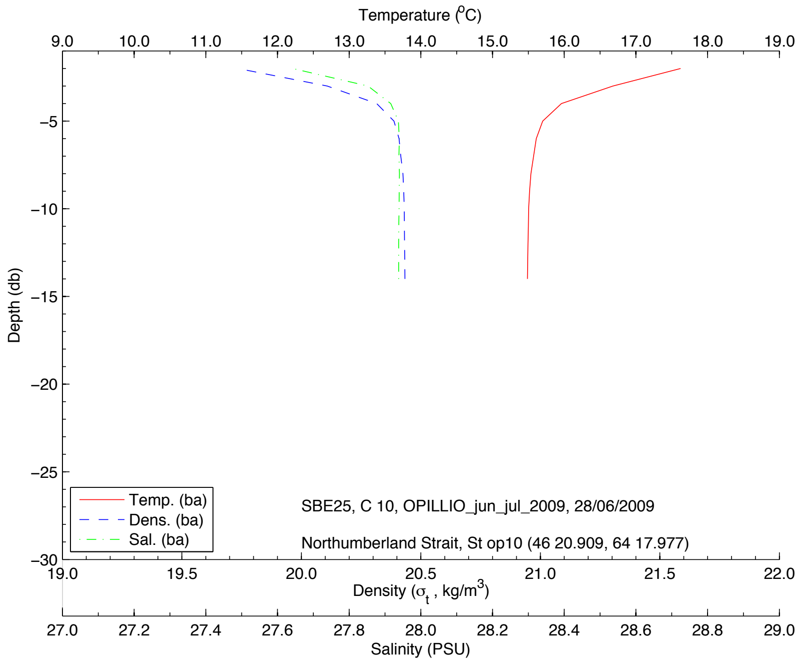


Figure A4.1k

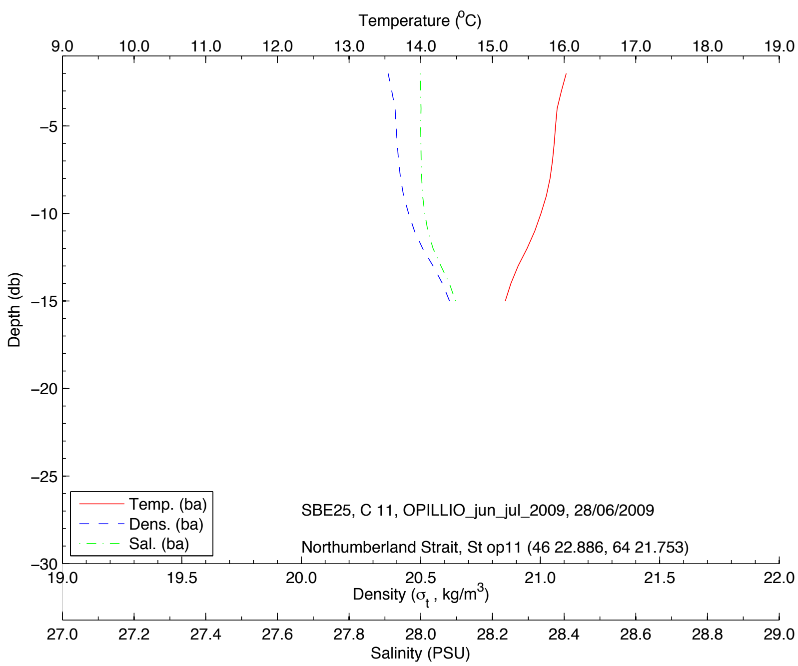


Figure A4.1l

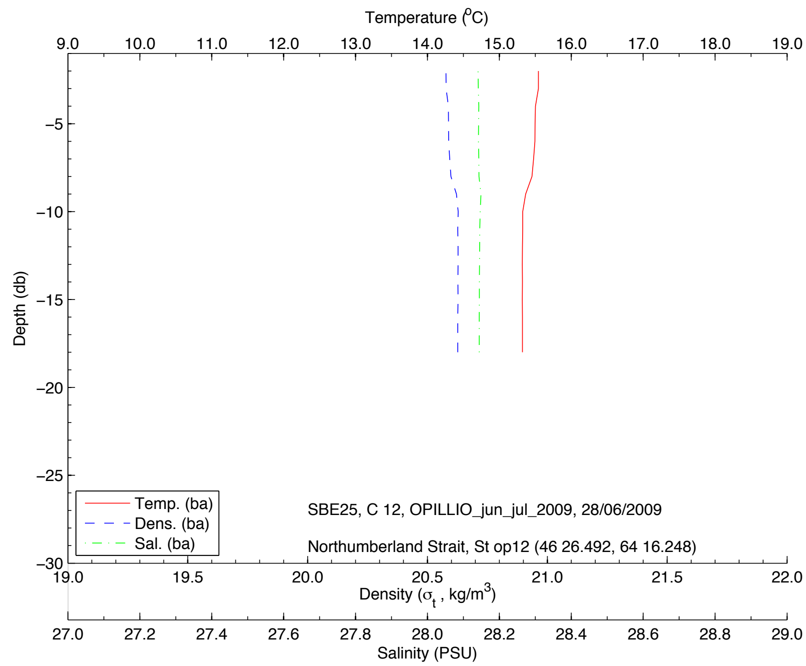


Figure A4.1m

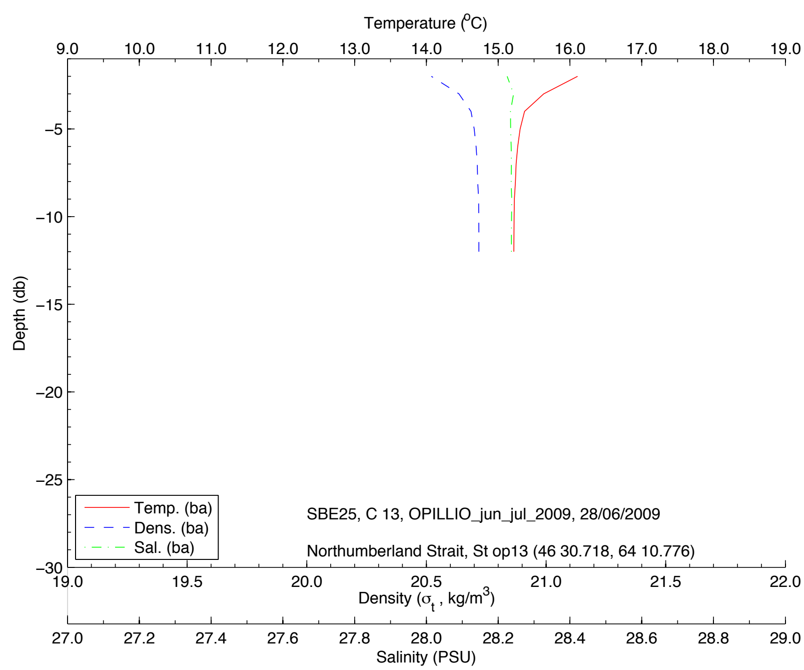


Figure A4.1n

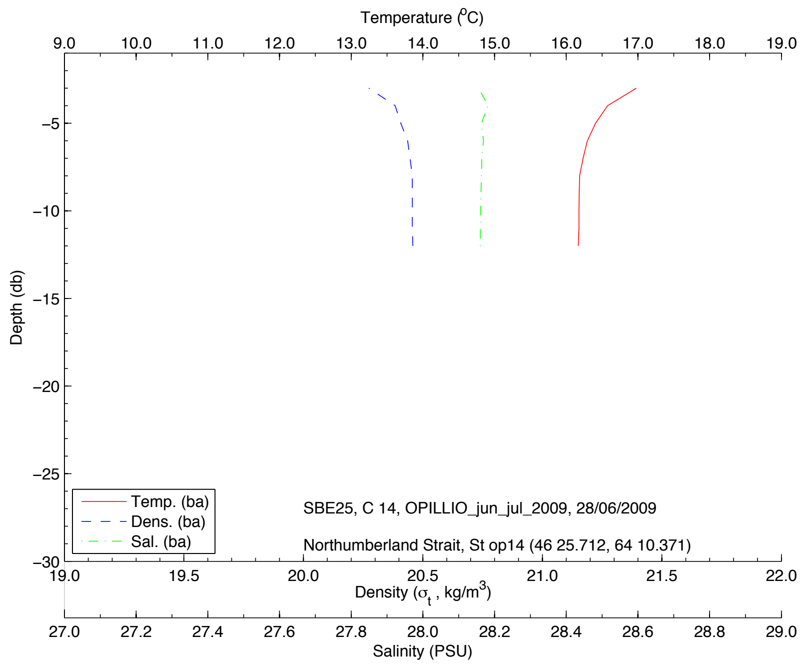


Figure A4.1o

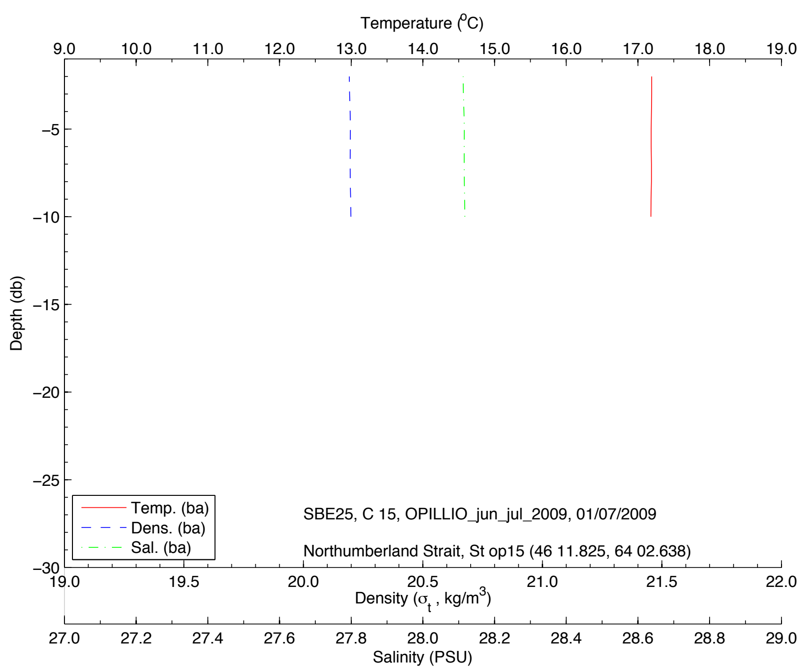


Figure A4.1p

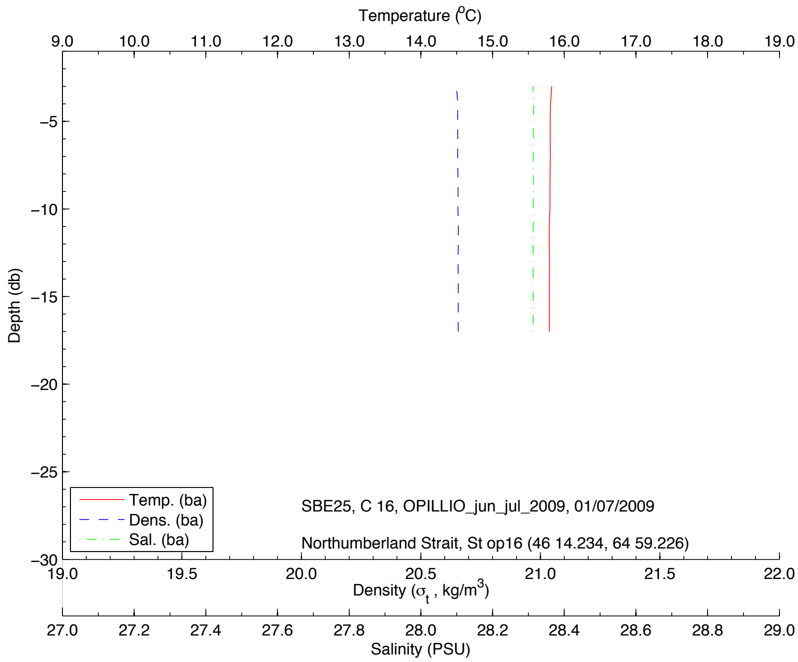


Figure A4.1q

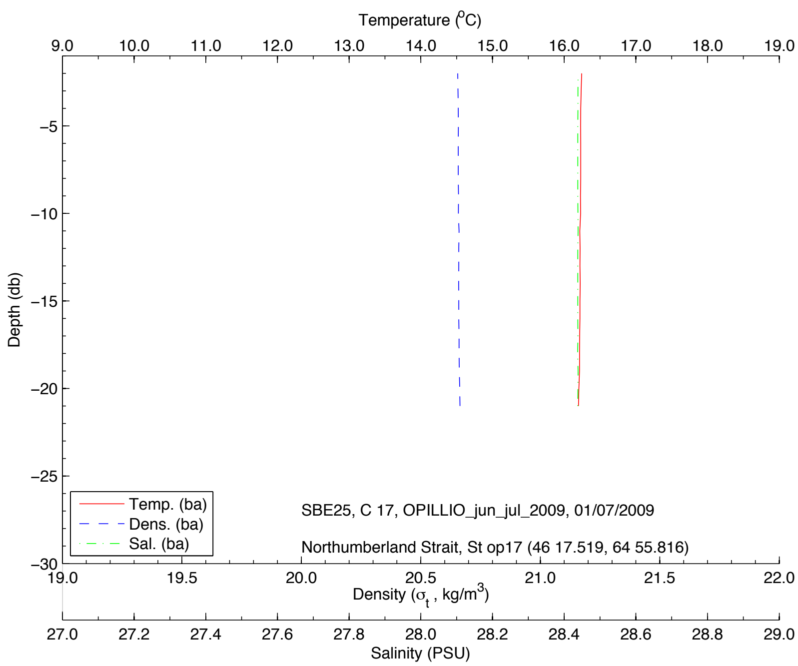


Figure A4.1r

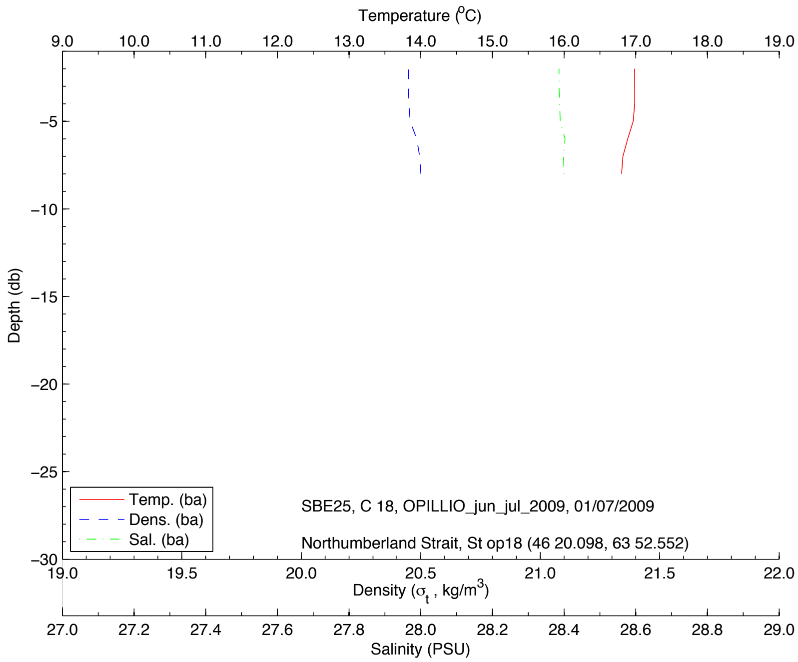


Figure A4.1s

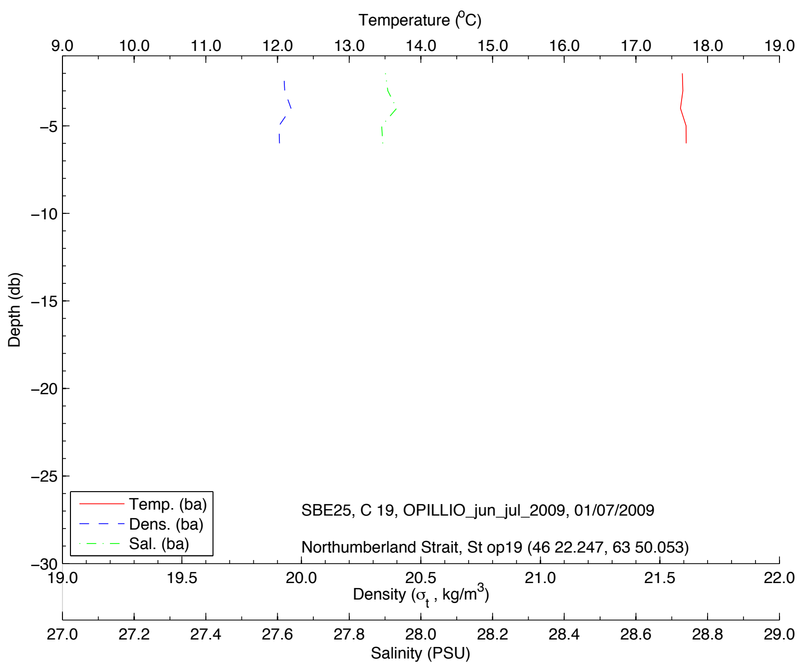


Figure A4.1t

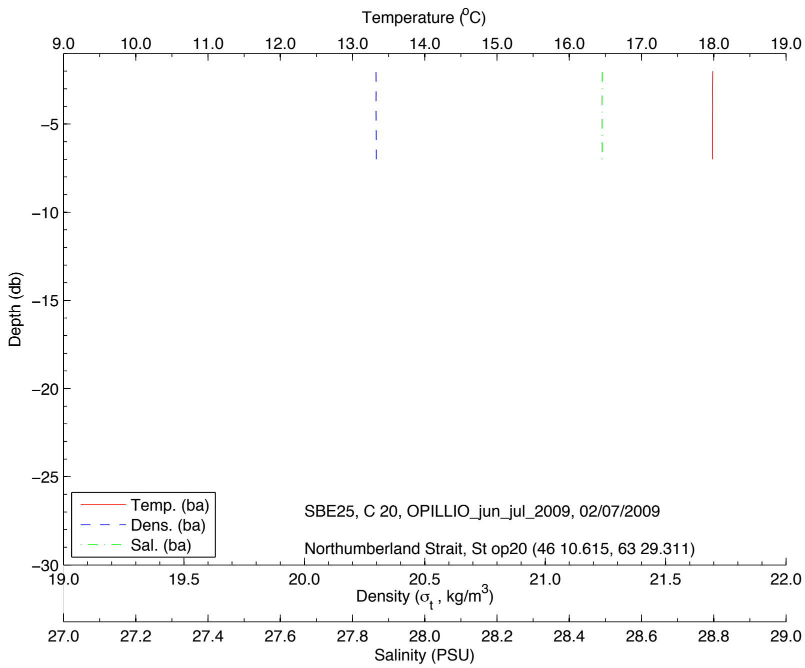


Figure A4.1u

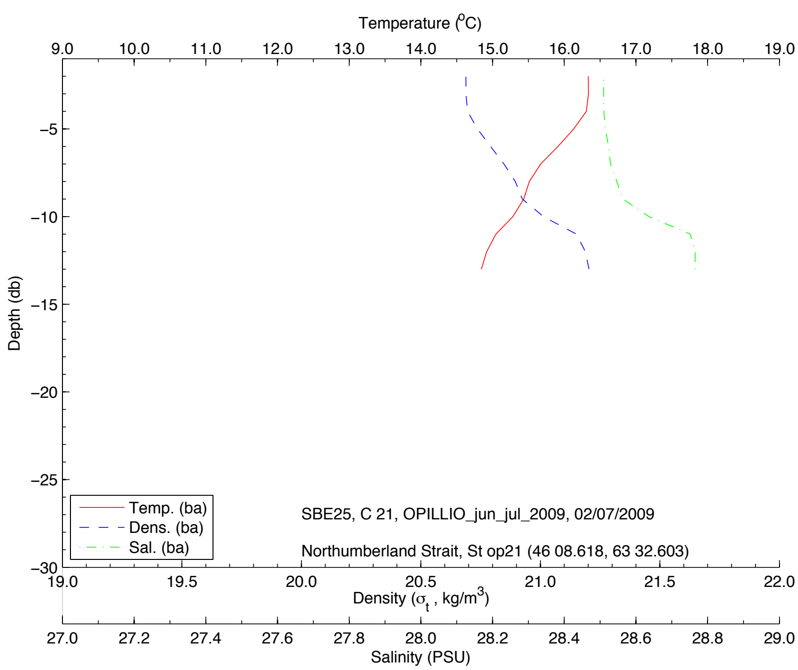


Figure A4.1v

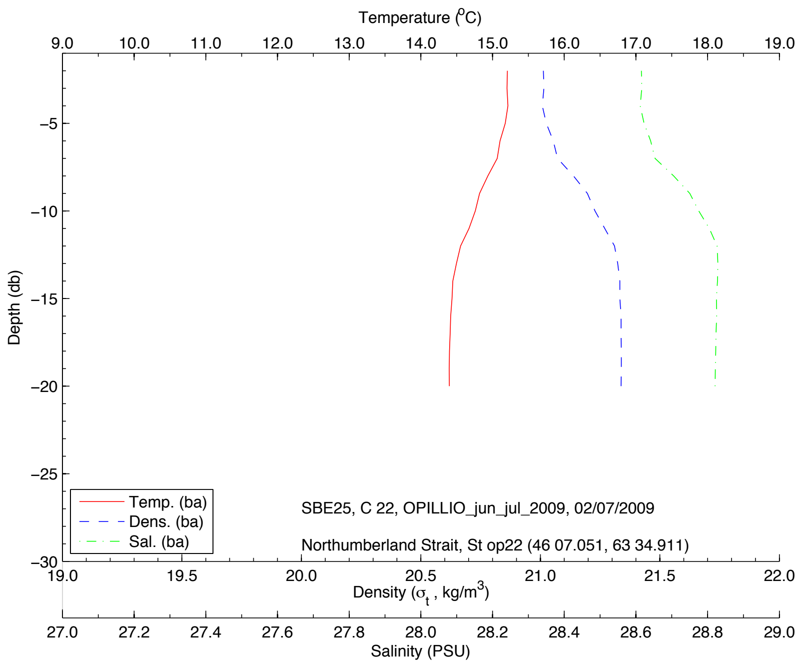


Figure A4.1w

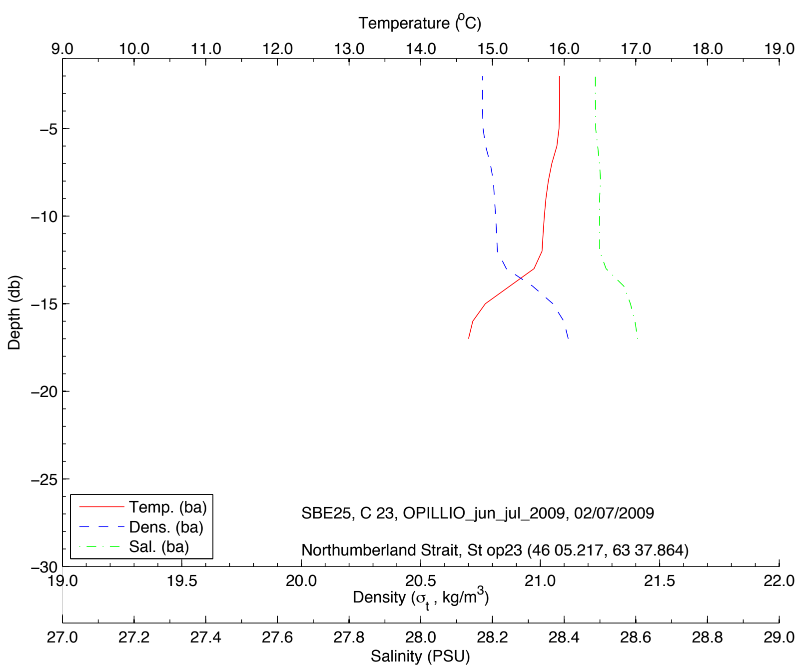


Figure A4.1x

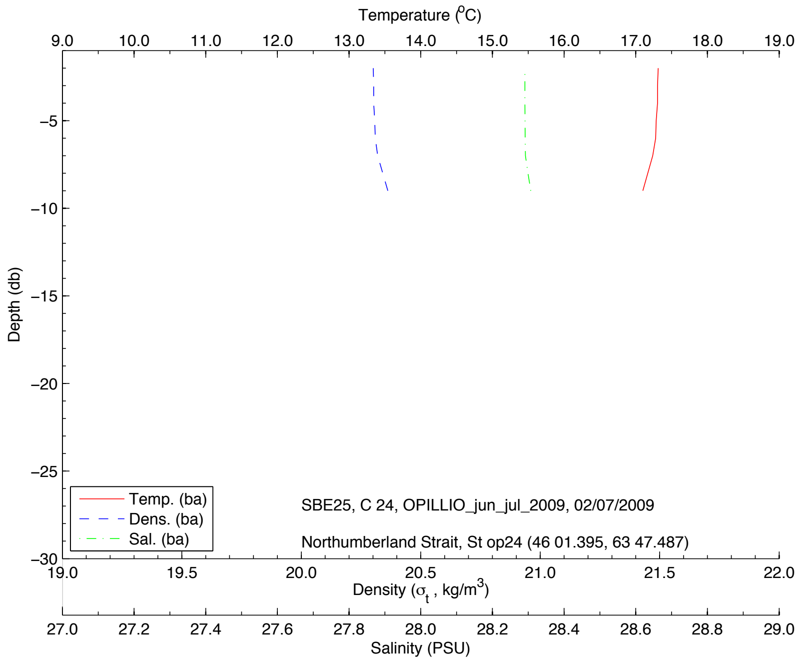


Figure A4.1y

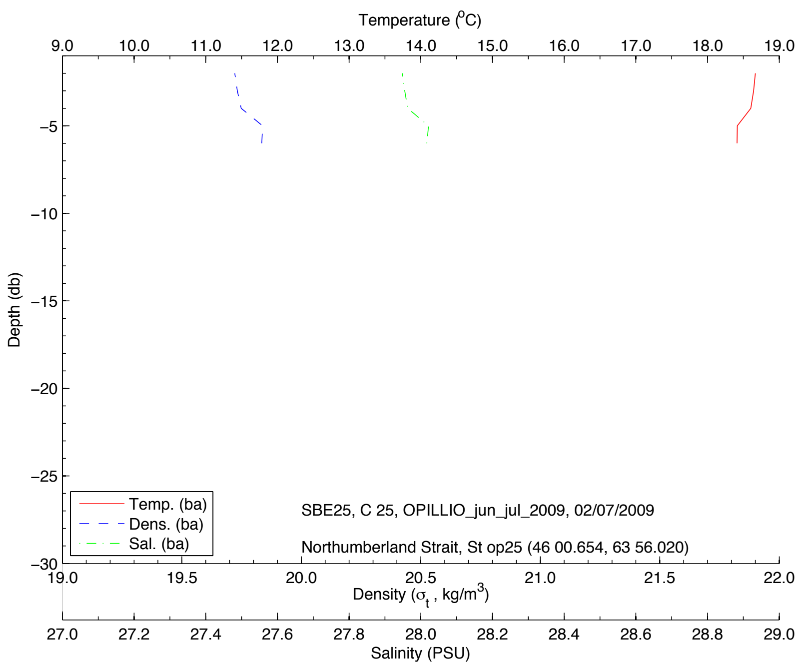


Figure A4.1z

Appendix V: Graphical Presentation of Sectional Hydrographic Trends

Distances between stations were calculated using great-circle distances. Sections across the Strait are presented with stations near the coast of New Brunswick (NB) on the left, and with stations near the coast of Prince Edward Island (PEI) on the right. Sections along the Strait are presented with stations near the northwest end of the Strait on the left, and with stations near the southeast end, that is stations near Confederation Bridge, of the Strait on the right.

Figure A5.1. Temperature sections presented in section-station order from (a) section 1 (stn. 2, 3, 5) through (g) section 7 (stn. 5, 6, 11, 10, 16, 22).

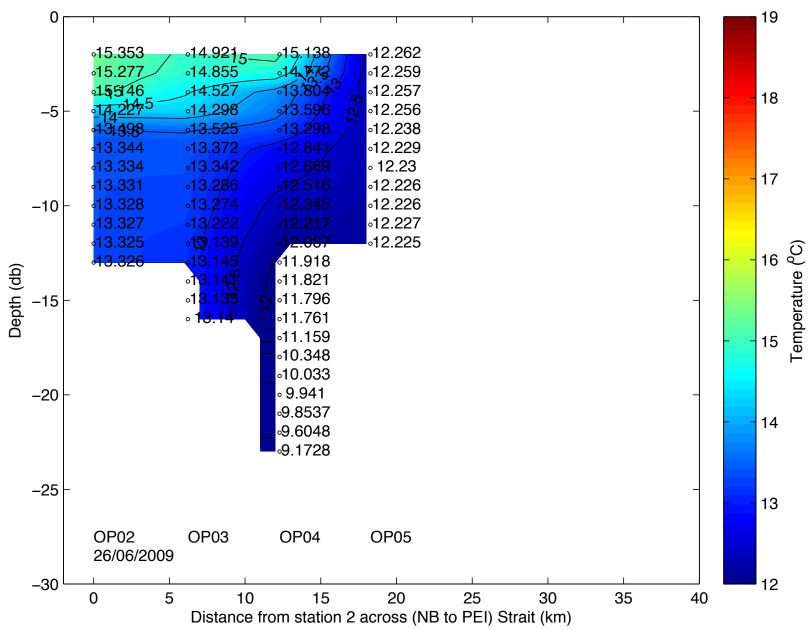


Figure A5.1a

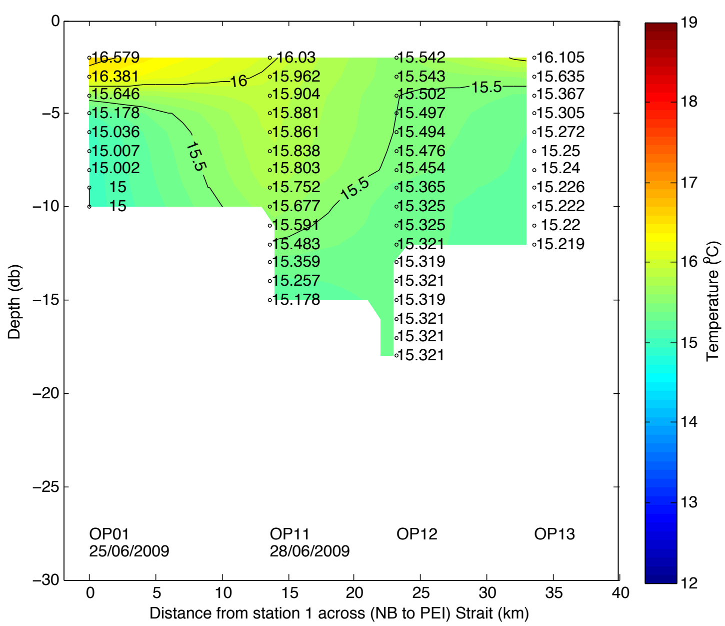


Figure A5.1b

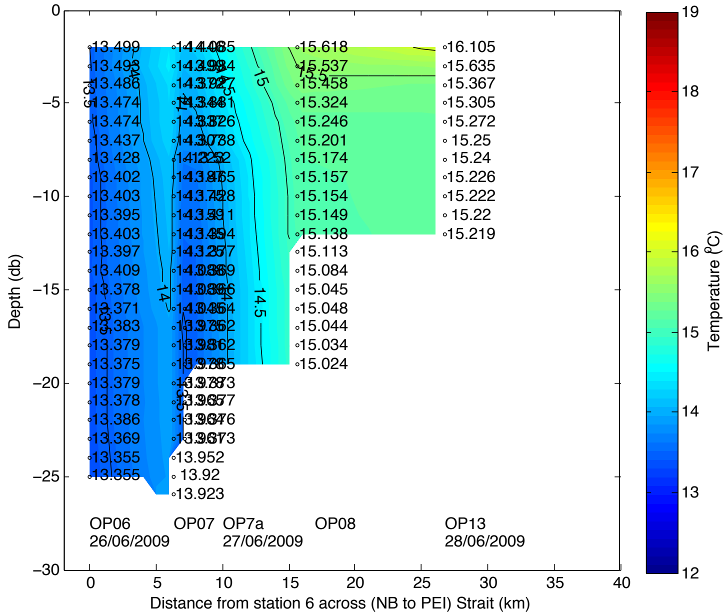


Figure A5.1c

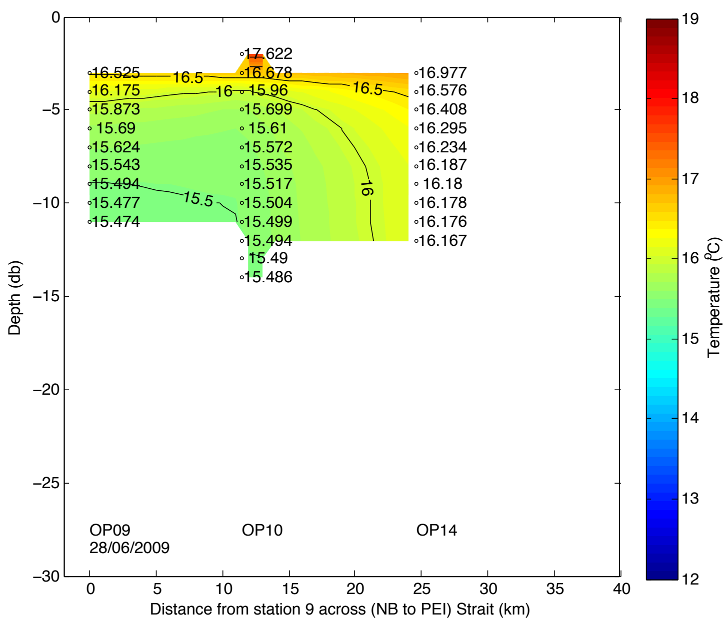


Figure A5.1d

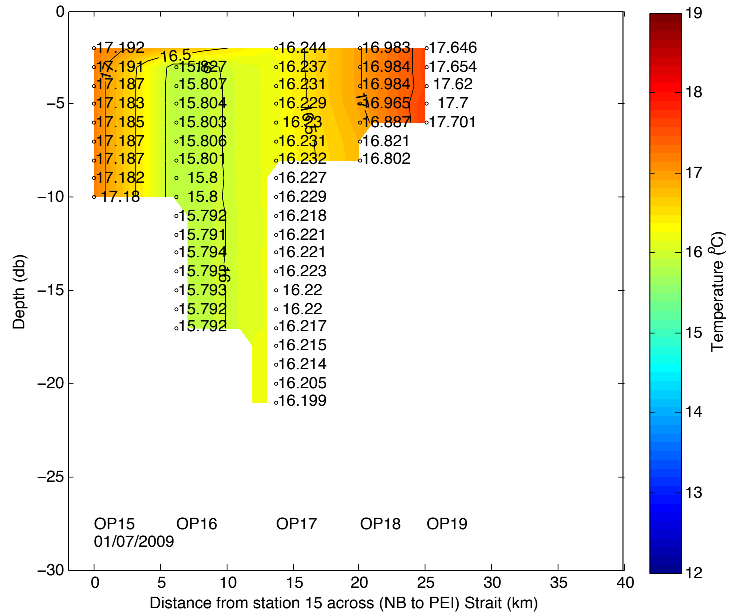


Figure A5.1e

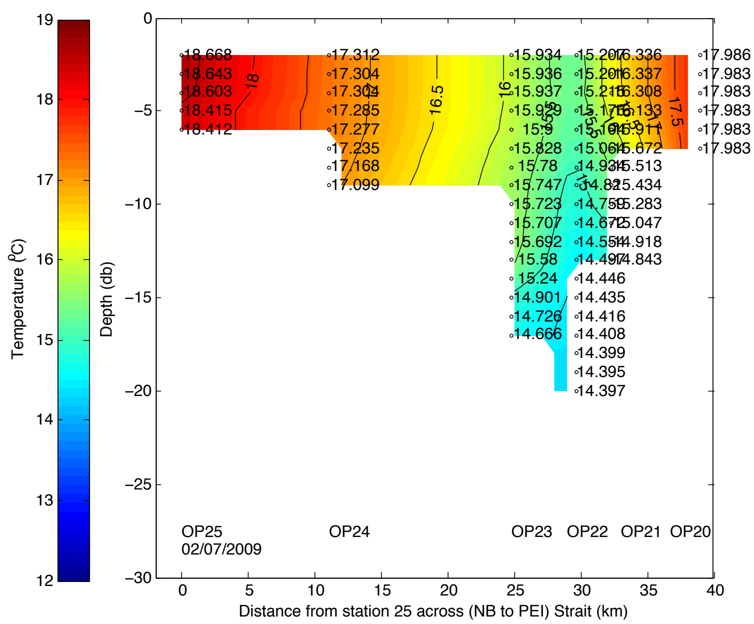


Figure A5.1f

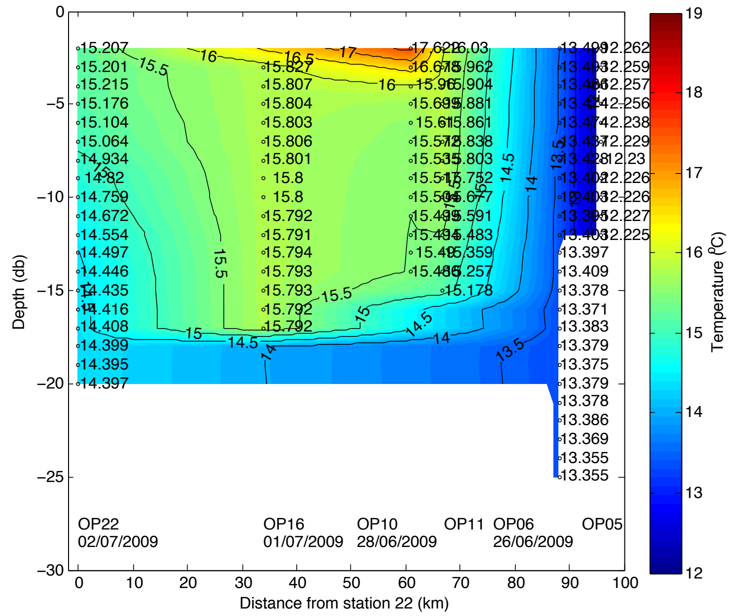

Depth (db)
Distance from station 22 (km)
Temperature (°C)
OP22
02/07/2009
OP16
01/07/2009
OP10
28/06/2009
OP11
OP06
26/06/2009
OP05

Figure A5.1g

Figure A5.2. Salinity sections presented in section-station order from (a) section 1 (stn. 2, 3, 5) through (g) section 7 (stn. 5, 6, 11, 10, 16, 22).

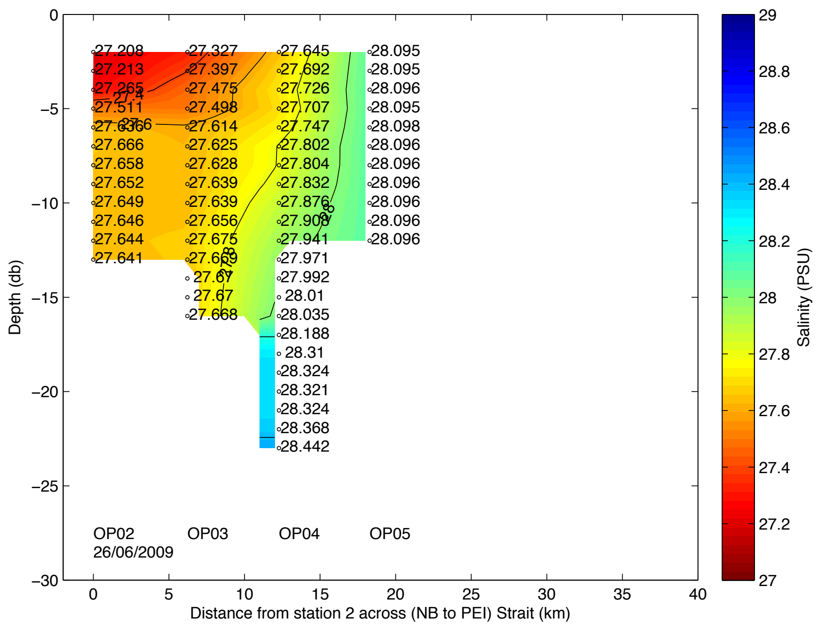


Figure A5.2a

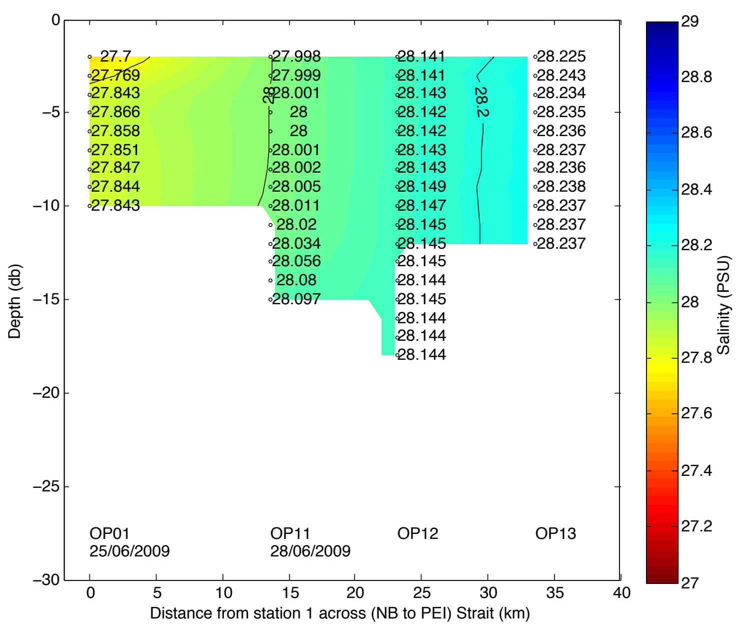


Figure A5.2b

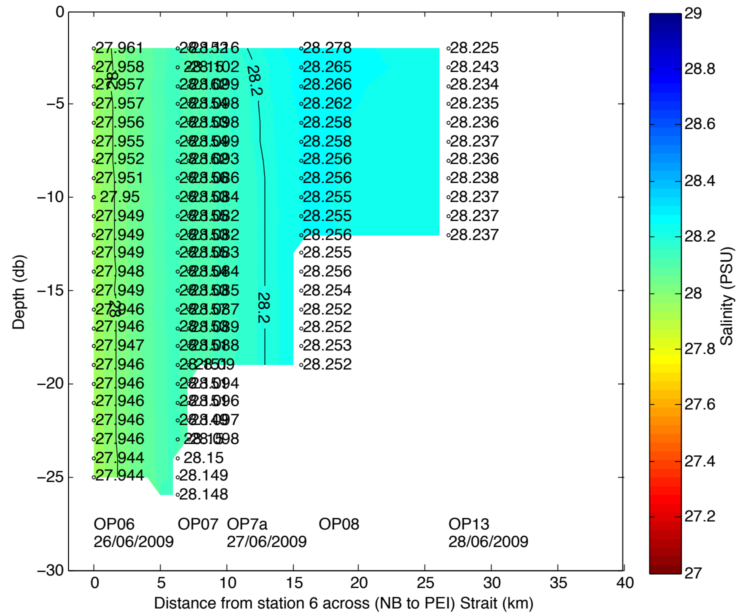


Figure A5.2c

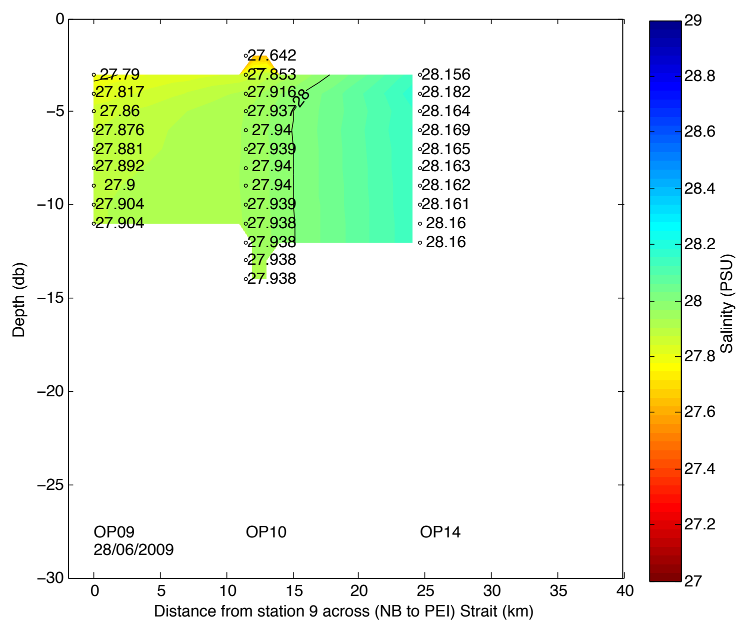


Figure A5.2d

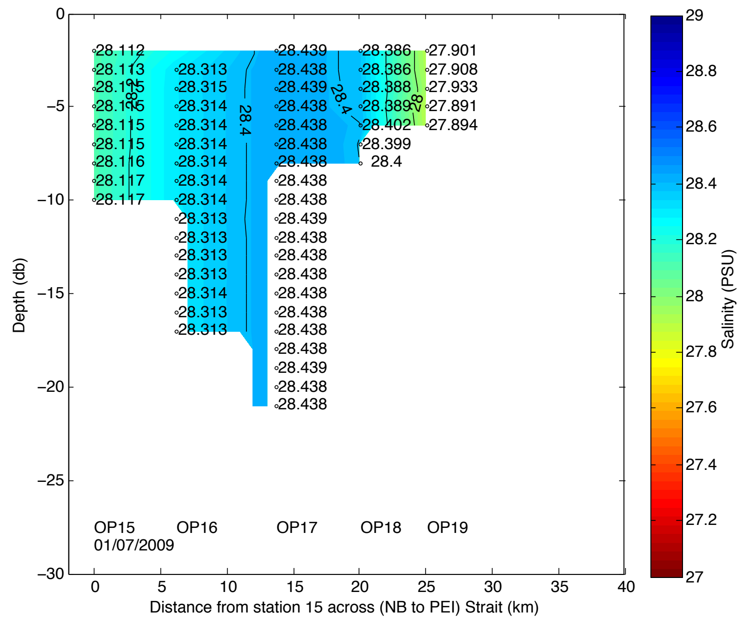


Figure A5.2e

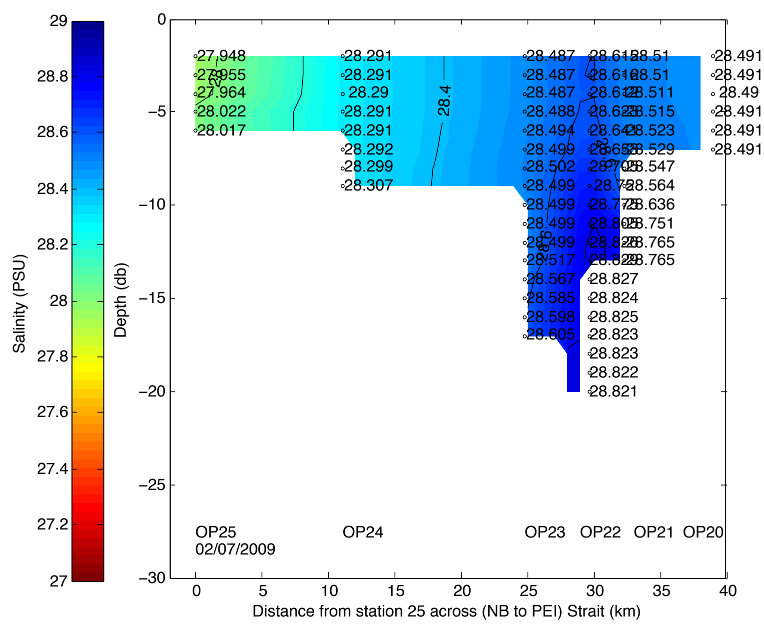


Figure A5.2f

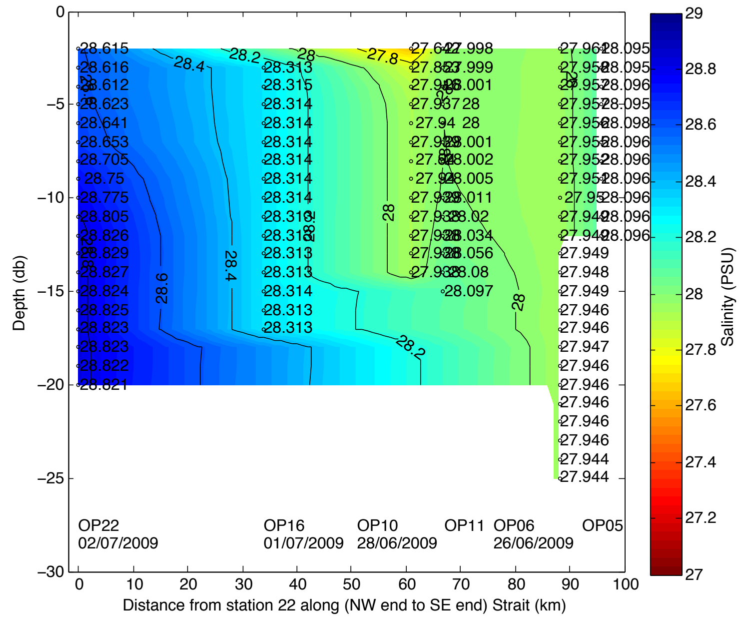

Depth (db)
Distance from station 22 along (NW end to SE end) Strait (km)
Salinity (PSU)
OP22
02/07/2009
OP16
01/07/2009
OP10
28/06/2009
OP11
OP06
26/06/2009
OP05

Figure A5.2g

Figure A5.3. Density sections presented in section-station order from (a) section 1 (stn. 2, 3, 5) through (g) section 7 (stn. 5, 6, 11, 10, 16, 22).

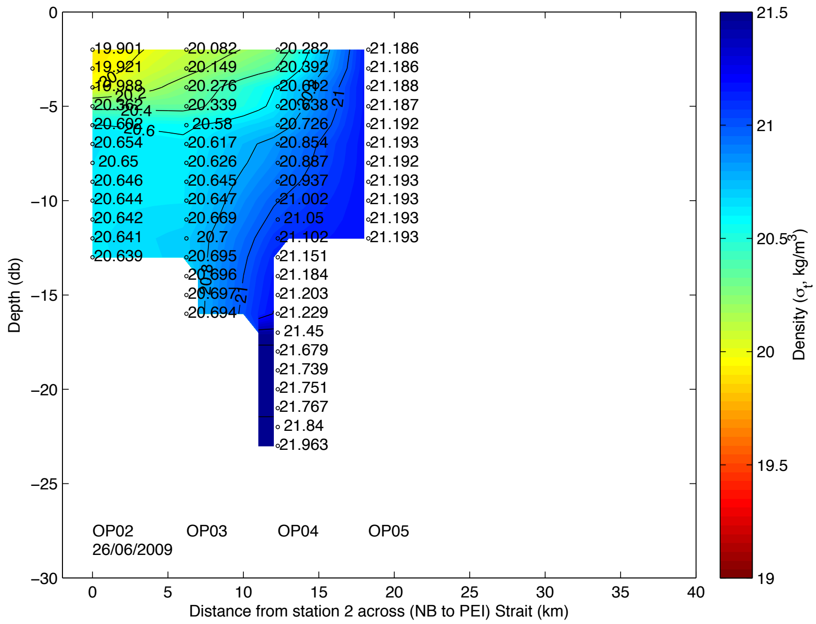


Figure A5.3a

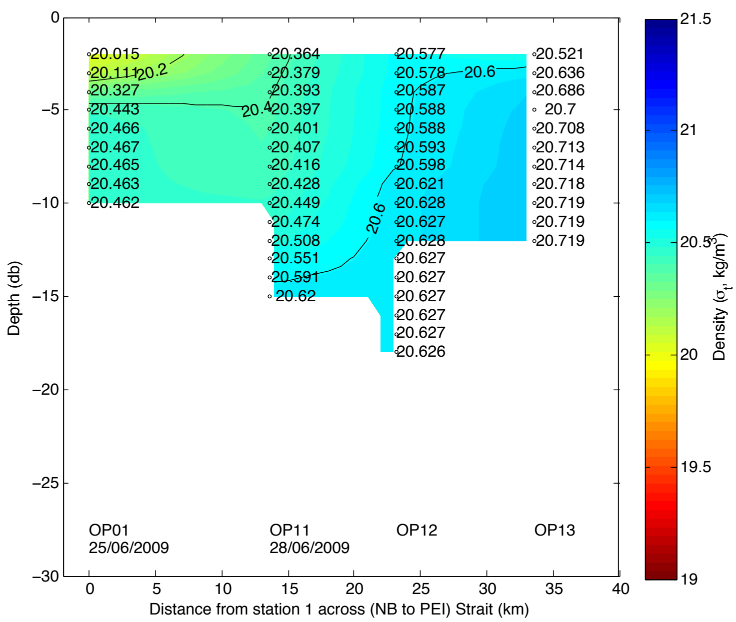


Figure A5.3b

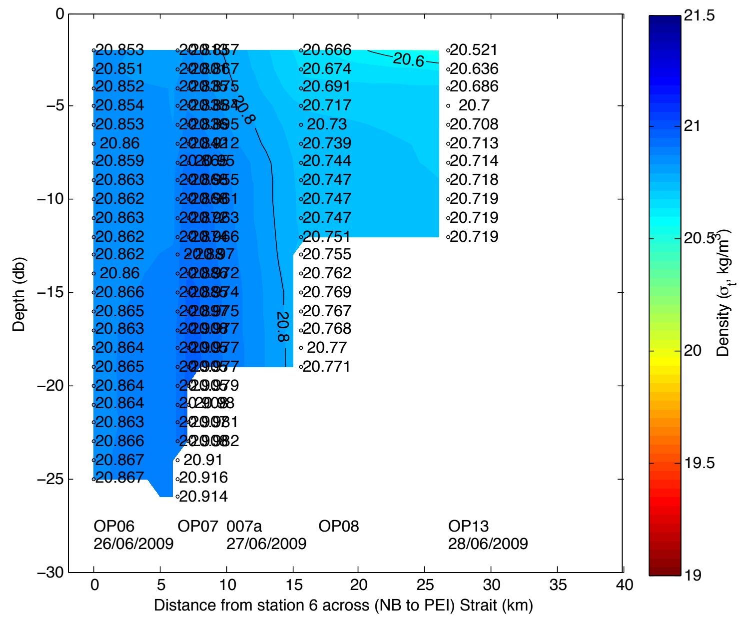


Figure A5.3c

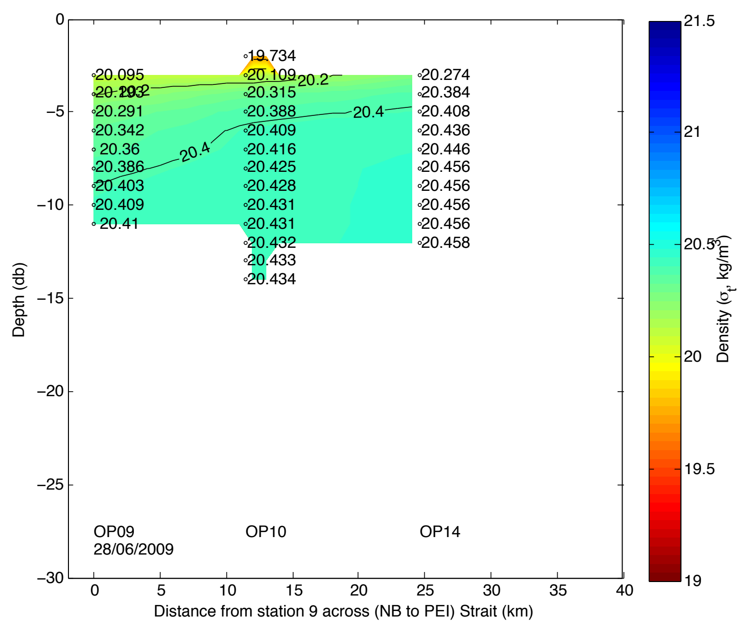


Figure A5.3d

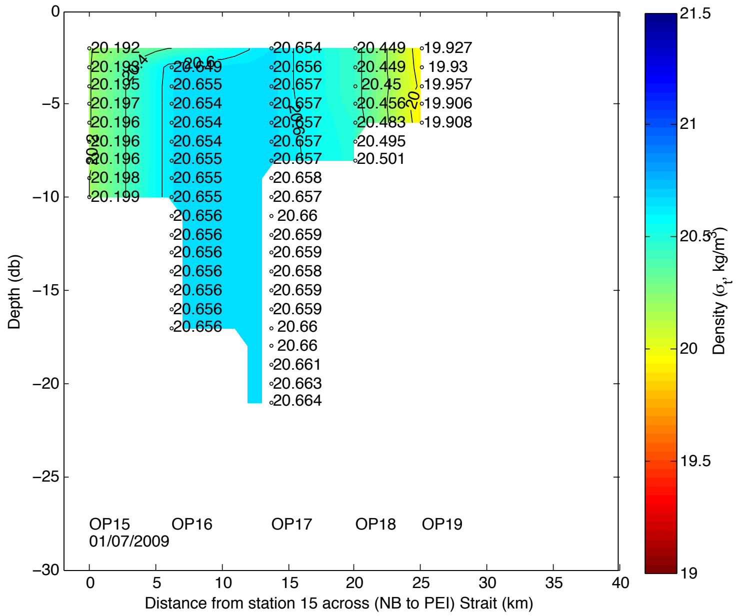


Figure A5.3e

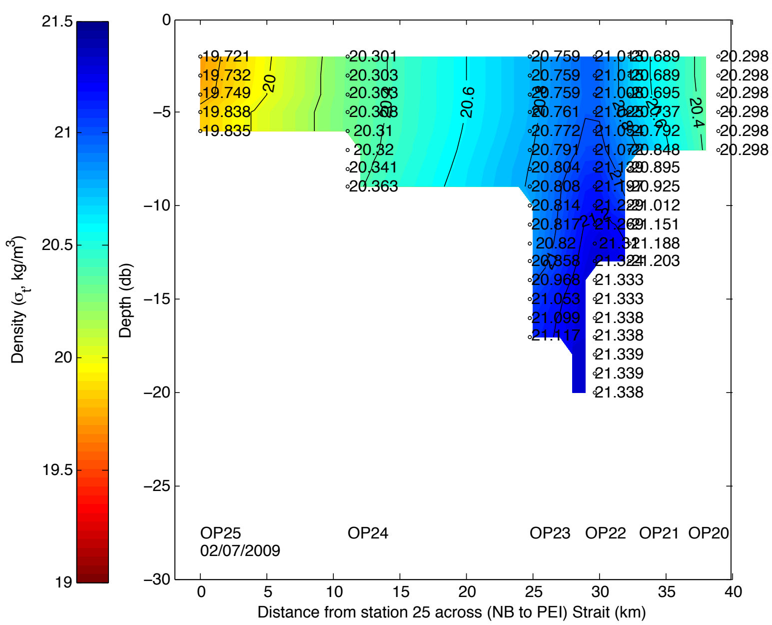
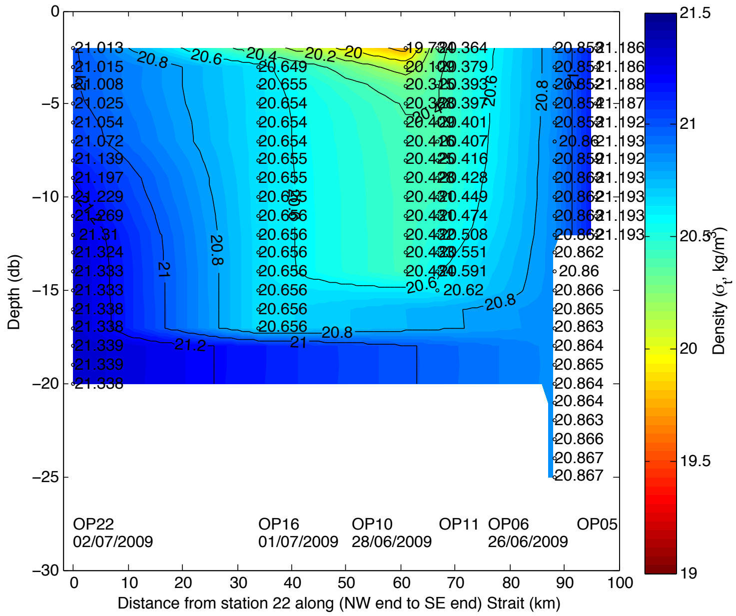


Figure A5.3f



Depth (db)
Distance from station 22 along (NW end to SE end) Strait (km)
Density (σ_t, kg/m^3)
OP22
02/07/2009
OP16
01/07/2009
OP10
28/06/2009
OP11
OP06
26/06/2009
OP05

Figure A5.3g

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Signature: ____