Physical, chemical and biological oceanographic data from the Beaufort Regional Environmental Assessment: Marine Fishes Project, August-September 2012

J. Eert[1], G. Meisterhans[2], C. Michel[2], A. Niemi[2], J. Reist[2], W.J. Williams[1]

[1]Fisheries and Oceans Canada
Institute of Ocean Sciences
9860 West Saanich Road
Sidney, BC V8L 4B2

[2]Fisheries and Oceans Canada
Freshwater Institute
501 University Crescent
Winnipeg, MB R3T 2N6

2015

Canadian Data Report of Hydrography and Ocean Sciences 197

Fisheries and Oceans / Pêches et Océans

Canada

Canadian Data Report of Hydrography and Ocean Sciences

Data reports provide a medium for the documentation and dissemination of data in a form directly useable by the scientific and engineering communities. Generally, the reports will contain raw and/or analyzed data but will not contain interpretations of the data. Such compilations will commonly have been prepared in support of work related to the programs and interests of the Oceans and Science sectors of Fisheries and Oceans Canada.

The correct citation for data reports appears above the abstract of each report. Each report is abstracted in the data base *Aquatic Sciences and Fisheries Abstracts.*

Data reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page.

Regional and headquarters establishments of the former Ocean Science and Surveys sector ceased publication of their various report series in December 1981. A complete listing of these publications and the last number issued under each title are published in the *Canadian Journal of Fisheries and Aquatic Sciences*, Volume 38: Index to Publications 1981. The current series began with Report Number 1 in January 1982.

Rapport statistique canadien sur l'hydrographie et les sciences océaniques

Les rapports statistiques servent de véhicule pour la compilation et la diffusion des données sous une forme directement utilisable par les scientifiques et les ingénieurs. En général, les rapports contiennent des données brutes ou analysées mais ne fournissent pas d'interprétations des données. Ces compilations sont préparées le plus souvent à l'appui de travaux reliés aux programmes et intérêts des secteurs des Océans et des Sciences de Pêches et Océans Canada.

Le titre exact des rapports statistiques figure au-dessus du résumé de chaque rapport. Les rapports statistiques sont résumés dans la base de données *Résumés des sciences aquatiques et halieutiques*.

Les rapports statistiques sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page de titre.

Les établissements de l'ancien secteur des Sciences et Levés océaniques dans les régions et à l'administration centrale ont cessé de publier leurs diverses séries de rapports en décembre 1981. Vous trouverez dans l'index des publications du volume 38 du *Journal canadien des sciences halieutiques et aquatiques*, la liste de ces publications ainsi que le dernier numéro paru dans chaque catégorie. La nouvelle série a commencé avec la publication du rapport numéro 1 en janvier 1982.

Canadian Data Report of
Hydrography and Ocean Sciences 197

2015

PHYSICAL, CHEMICAL AND BIOLOGICAL OCEANOGRAPHIC DATA FROM THE BEAUFORT REGIONAL ENVIRONMENTAL ASSESSMENT: MARINE FISHES PROJECT, AUGUST-SEPTEMBER 2012

J. Eert[1], G. Meisterhans[2], C. Michel[2], A. Niemi[2], J. Reist[2], W.J. Williams[1]

[1]Fisheries and Oceans Canada
Institute of Ocean Sciences
9860 West Saanich Road
Sidney, BC V8L 4B2

[2]Fisheries and Oceans Canada
Freshwater Institute
501 University Crescent
Winnipeg, MB R3T 2N6

Cat. No. Fs 97-16/197E ISBN 978-0-660-02946-7 ISSN 0711-6721 (print version)
Cat. No. Fs 97-16/197E-PDF ISBN 978-0-660-02947-4 ISSN 1488-5433 (online version)

Correct citation for this publication:

Eert, J., Meisterhans, G., Michel, C., Niemi, A., Reist, J., Williams, W.J. 2015. Physical, chemical and biological oceanographic data from the Beaufort Regional Environmental Assessment: Marine Fishes Project, August-September 2012. Can. Data Rep. Hydrogr. Ocean Sci. 197: vii + 84 p.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Eert, J., Meisterhans, G., Michel, C., Niemi, A., Reist, J., Williams, W.J. 2015. Physical, chemical and biological oceanographic data from the Beaufort Regional Environmental Assessment: Marine Fishes Project, August-September 2012. Can. Data Rep. Hydrogr. Ocean Sci. 197: vii + 84 p.

Oceanographic and biochemical sampling was conducted as part of the Beaufort Regional Environmental Assessment (BREA) Marine Fishes project in 2012. The goal of the BREA Marine Fishes project was to conduct the first systematic fish and ecosystem study on the outer shelf and slope areas of the Beaufort Sea, in support of regulatory decision-making for future hydrocarbon activities in the region. This report presents results from the CTD (Conductivity Temperature Depth)/Rosette sampling activities of the Marine Fishes project, providing a basis for understanding fish habitat and enhancing our knowledge of ecosystem structure in the Beaufort Sea. CTD/Rosette sampling was conducted at 32 stations, distributed along five transects on the Mackenzie shelf and slope, between 5 August and 3 September 2012. Vertical profile plots are presented for the CTD data including, pressure, temperature, salinity, oxygen, transmission and fluorescence, as well as discrete rosette sampling for inorganic nutrients (nitrate+nitrite, silicate and phosphate), oxygen isotope ratio ($\delta^{18}O$), total and >5 µm chlorophyll *a* and dissolved organic carbon. The data reported supports Canada-USA ecosystem and fisheries assessments and builds on coastal data from the Northern Coastal Marine Systems program.

RÉSUMÉ

Eert, J., Meisterhans, G., Michel, C., Niemi, A., Reist, J., Williams, W.J. 2015. Physical, chemical and biological oceanographic data from the Beaufort Regional Environmental Assessment: Marine Fishes Project, August-September 2012. Can. Data Rep. Hydrogr. Ocean Sci. 197: vii + 84 p.

L'échantillonnage océanographique et biochimiques a été réalisé dans le cadre de l'évaluation environnementale régionale de Beaufort (EERB). (Projet des poissons marins en 2012. Le Projet des poissons marins de l'EERB avait pour objet de mener la première étude systématique des poissons et des écosystèmes et des zones du plateau extérieur et du talus de la mer de Beaufort, à l'appui de la prise de décisions réglementaires pour les futures activités d'exploitation des hydrocarbures dans la région. Le présent rapport propose les résultats des activités d'échantillonnage de l'instrument de mesure de la conductivité, de la température et de la profondeur/Rosette CTD du projet des poissons marins, offrant un fondement pour la compréhension de l'habitat du poisson et pour l'amélioration de notre connaissance de la structure de l'écosystème dans la mer de Beaufort. On a procédé à un échantillonnage au moyen de la rosette CTD à 32 stations, répartis le long des cinq transects sur le plateau de Mackenzie et de la pente continentale, entre le 5 août et le 3 septembre 2012. Des tracés de profil vertical sont présentés pour les données de CTD, y compris la pression, la température, la salinité, l'oxygène, la transmission et la fluorescence, ainsi qu'un échantillonnage de rosette discret pour les nutriments inorganiques (nitrate+nitrite, silicate et phosphate) et le ratio isotopique d'oxygène ($\delta^{18}O$), des échantillons de chlorophylle *a* total et supérieur à 5 µm et du carbone organique dissous. Les données consignées appuient les évaluations des écosystèmes et des pêches du Canada et des États-Unis et se fondent sur les données côtières du programme d'étude des eaux marines côtières du Nord.

ACKNOWLEDGEMENTS

We gratefully acknowledge the Captain and crew of the *F/V Frosti* for their excellent support throughout the expedition. Additionally, we thank the management and staff of Frosti Fishing Ltd., who were more than cooperative while setting up the ship for science work. We also thank the Inuvialuit Game Council for supporting the Marine Fishes project and providing valuable input to the study design and logistics. We also appreciate the guidance and support of the chief scientist, Andrew Majewski (DFO) and all team members of the Marine Fishes project. Laboratory and/or report support was provided by Anke Reppchen, Matt Gale, Jean-François Hélie and Line McLaughlin. We also thank Al Mucci for overseeing the $\delta^{18}O$ measurements and Jim Hamilton and Tim Siferd for helpful reviews of this report. Project funding was provided by the Beaufort Regional Environmental Assessment (Aboriginal Affairs and Northern Development Canada), Environmental Studies Research Fund (Natural Resources Canada), International Governance Strategy (Fisheries and Oceans Canada), Program of Energy Research and Development (PERD, Natural Resources Canada) and ArcticNet. Additional funding was provided to projects PIs by PERD and Fisheries and Oceans Canada.

1.0 INTRODUCTION

The Beaufort Regional Environmental Assessment (BREA) is a multi-stakeholder initiative supporting regional environmental and socio-economic research required for future management of hydrocarbon activities in the Beaufort Sea. A regional knowledge base for offshore exploration and development is required for effective regulatory decision making by stakeholders including government, Inuvialuit and industry. This report presents work by Fisheries and Oceans Canada (DFO) that enhances the regional information base for the Beaufort Sea by delivering a project focused on fishes, habitats and ecosystem linkages in areas of potential oil and gas development. The Marine Fishes project was conducted in collaboration with co-management partners from the six communities within the Inuvialuit Settlement Region (ISR). The general scientific approach for the program was ratified with the Inuvialuit Game Council (IGC) through consultations over the winter of 2011/2012.

The Marine Fishes project addressed information gaps relating to deep-water fish communities in the Beaufort Sea thereby improving our understanding of ecosystem linkages and the role of marine fishes in the wider Beaufort Sea ecosystem. The 2012 research provided the first systematic fish and ecosystem study at depths from 150 to 1000 m on the outer continental shelf and slope areas of the Beaufort Sea. The study also included shallower stations to provide a comprehensive assessment of populations, habitats and ecosystem linkages. Specific objectives for the 2012 Marine Fishes project were to:

- conduct a field survey of offshore areas to 1000 m depths to establish fish occurrence and community diversity, habitat associations, and food web/trophic couplings within and among offshore habitats,
- establish functional relationships within/among offshore and slope, shelf and coastal, benthic and pelagic sub-ecosystems, and
- establish regional contexts for future monitoring and assessments (e.g., hydrocarbon metabolites, mercury, species diversity, habitat usage).

The Marine Fishes project involved collaborations between DFO programs as well as University, Alaskan and ISR Community partners. The research activities comprised a comprehensive ecosystem assessment including benthic and mid-water fishes, hydroacoustics, zooplankton, sea sediments and benthic epifauna and infauna. This data report presents the oceanography and marine productivity components of the Marine Fishes project that were delivered by DFO research partners. The information herein is important for understanding fish habitat and enhancing our knowledge of ecosystem structure in the regional context of the Beaufort Sea. The water sampling activities of the project enabled the characterization of water masses and oceanographic conditions, such as upwelling and stratification, which can alter habitat structure and fish distributions.

This data report provides a summary of science activities and data collected from CTD (Conductivity Temperature Depth) profiles and rosette deployments at each sampling station. Data collected by the CTD includes pressure, temperature, salinity, dissolved oxygen (DO), transmissivity, photosynthetically active radiation (PAR) and fluorescence. The rosette sampled water at discrete depths providing samples for salinity, nutrients including nitrate plus nitrite, silicate and phosphate, oxygen isotope ratio ($\delta^{18}O$), total and >5 µm chlorophyll *a* and dissolved organic carbon (DOC). Other oceanographic and marine productivity samples collected, but not included in this report are barium, bacteria and protist counts, microbial DNA, fatty acids of particulate organic material and phytoplankton taxonomy. Dissolved inorganic carbon (DIC) was also sampled at select stations and will be reported separately.

1.1 Field Program

The 2012 Marine Fishes project was conducted between 5 August and 3 September 2012 onboard the *F/V Frosti*, a commercial stern trawler based in Richmond, BC. The study area lies within the Beaufort Sea Large Ocean Management Area (LOMA, Cobb et al., 2008) which contains the marine component of the ISR. The BREA Marine Fishes project targeted four primary transects (TBS, GRY, KUG and DAL) in 2012, extending from near to offshore, reaching depths >1000 m (Fig. 1). A fifth transect (HCT, Fig. 1) was also completed as a hydroacoustic survey. The DAL, KUG and GRY transects were planned extensions of near-shore transects sampled between 2006 and 2009, during the Northern Coastal Marine Systems program with the CCGS Nahidik (Walkusz and Williams, 2013 and references therein). The DAL, KUG and GRY transects also lie offshore from the Tarium Niryutait Marine Protected Area (TNMPA).

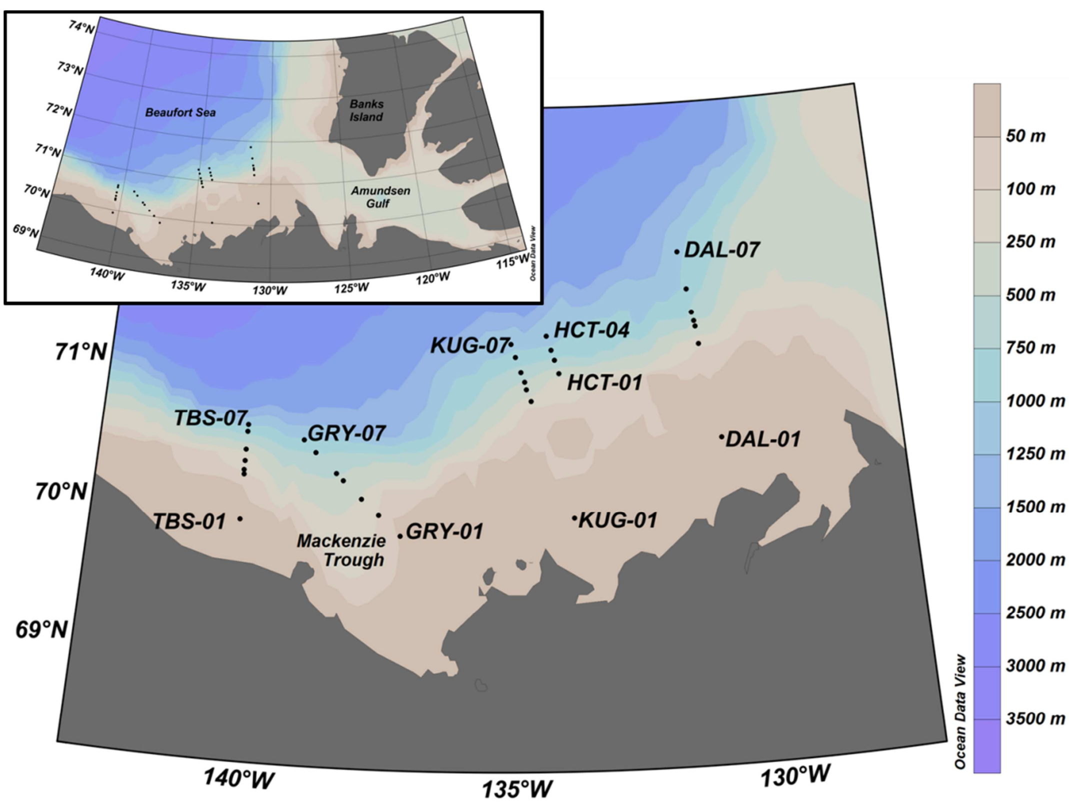


Figure 1. The five transects of the 2012 BREA Marine Fishes project with the first and last CTD/Rosette station of each transect identified.

The study area is characterized by a shallow shelf, extending approximately 100 to 150 km offshore, and a relatively steep shelf break to depths of 1000 m. Beyond the shelf break the sea floor continues to drop to depths over 3000 m in the Canada Basin. Sampling was conducted on the wide Canadian Beaufort Shelf in the eastern part of the study area (DAL, HCT, KUG and GRY), and the Alaska Beaufort Shelf (TBS) in the west. The two shelves are separated by the Mackenzie Trough, an area of intensified currents.

The study area is impacted by the Mackenzie River plume and the presence of seasonal landfast and pack ice. The concentration and type of sea ice in the sampling area during the study period are shown in Figures 2 and 3. The BREA Marine Fishes project in 2012 occurred just prior to the record low Arctic summer sea-ice extent (1.2×10^6 km^2), on September 16^{th} 2012.

The four primary transects were completed from east to west, starting with the shallowest station. The HCT transect was completed near the end of the expedition (September 1^{st}) and included hydroacoustic data, which are not reported here, and CTD measurements with no discrete water samples collected during the CTD/Rosette deployments. CTD data are available for all stations, but due to inclement weather and safety concerns, the rosette was not deployed at stations DAL-05, KUG-05 and GRY-07. Details for each CTD/Rosette cast are summarized in Appendix 1.

A

B

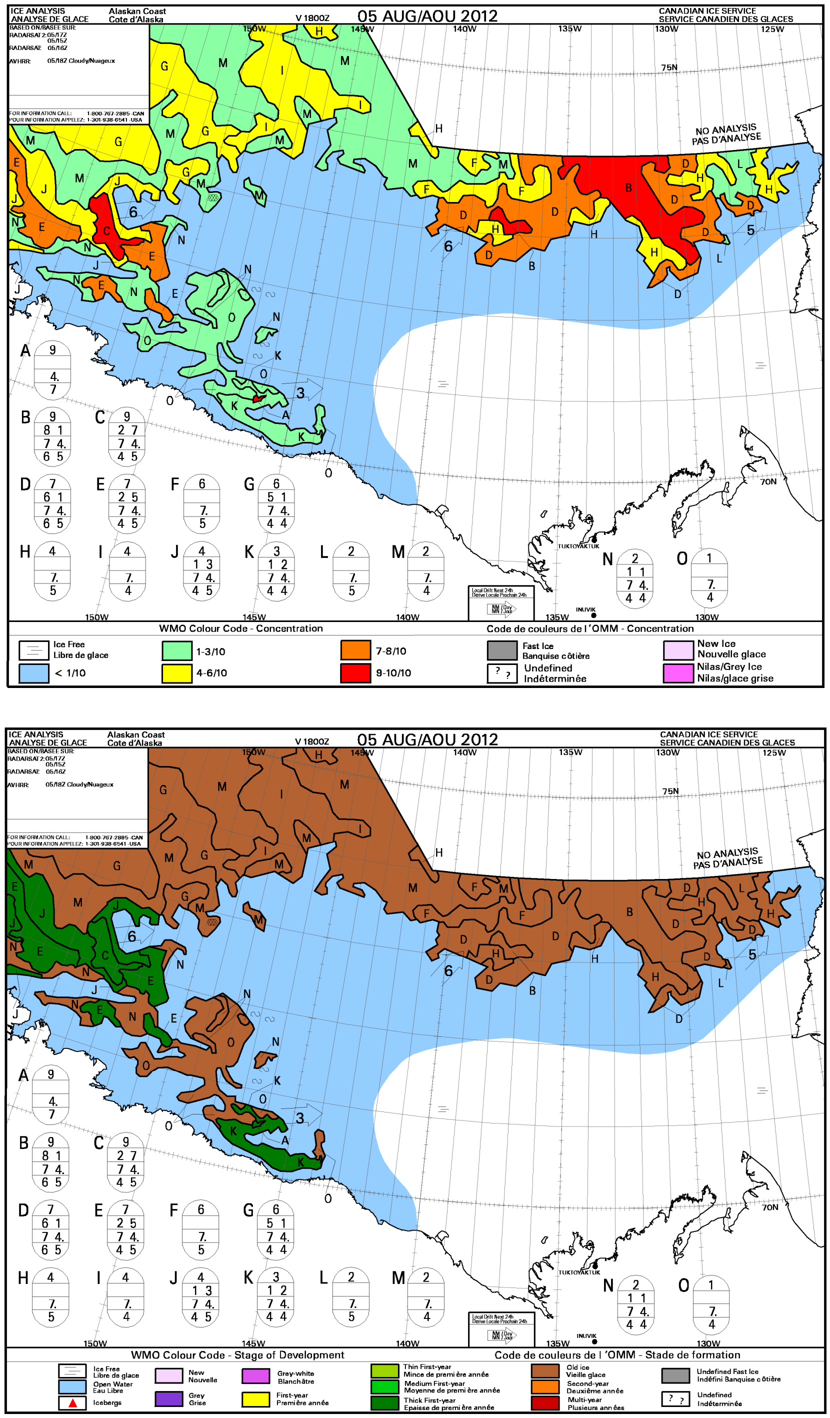
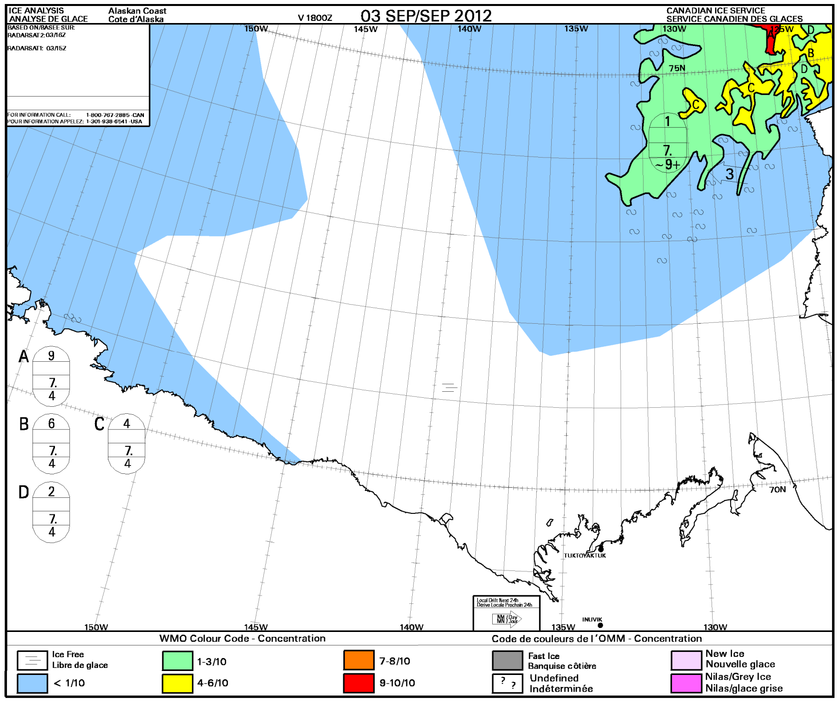


Figure 2. Study area sea-ice (A) concentration and (B) stage of development at the beginning of the expedition (5 August 2012) (Canadian Ice Service).

A



B

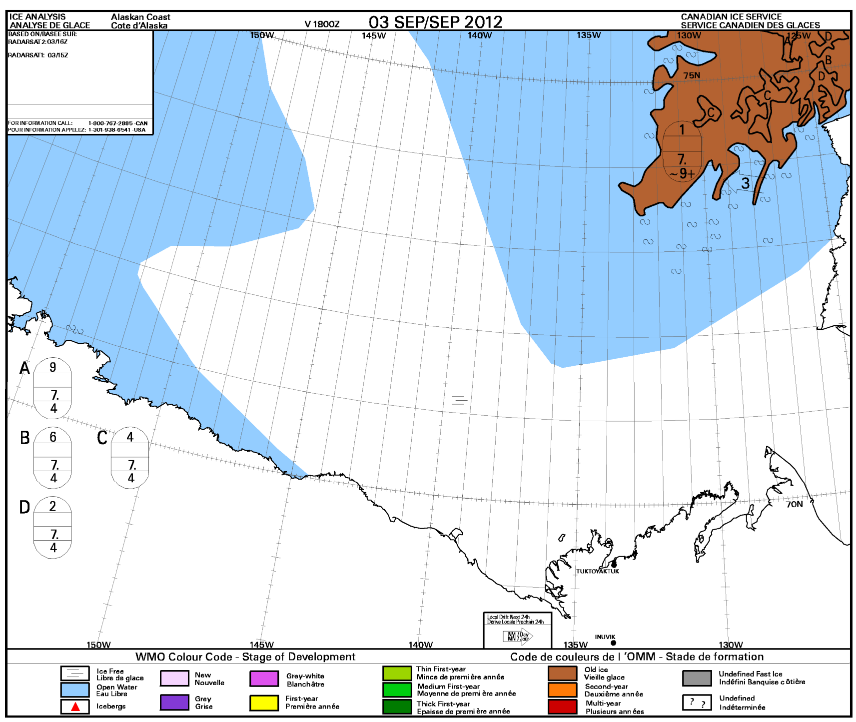


Figure 3. Study area sea-ice (A) concentration and (B) stage of development at the end of the expedition (3 September 2012) (Canadian Ice Service).

2.0 METHODS AND ANALYSES

2.1 CTD/Rosette Casts

CTD profiles and discrete water samples were taken with a 24-bottle rosette that included a Seabird SBE-25 and external sensors mounted within a stainless steel frame. The Benthos altimeter and Biospherical/LiCor underwater PAR sensors were mounted to the top of the rosette frame. The 24-10 L Ocean Test Niskin bottles were controlled by a SBE-32 carousel water sampler. Data signals from the SBE-25 were hardwired through a sea cable to the SBE-33 deck unit and Acer laptop located in the bridge for real-time telemetry and data acquisition.

The sensors used during each cast were:

- Seabird temperature 4444
- Seabird conductivity 3209
- Seabird pressure (strain gauge) 0603
- Seabird SBE-43 Dissolved Oxygen 1202
- Seapoint Fluorometer
- Wetlab CSTAR transmissometer CST-1047DR
- Seapoint turbidity meter (OBS) 11074
- Biospherical/LiCor PAR 20280
- Teledyne Benthos Altimeter 41098

Standard deployment was to start data acquisition while the rosette was on deck and to record in-air pressure. The rosette was then submerged (ca. 2 m) for two minutes before lowering to ca. 10 m off the bottom at approximately 0.8 m/s. The ship drifted while on station such that several casts had outboard wire angles of 10-15 degrees and the rosette's descent was stopped more than 10 m off the bottom. Niskin bottles were closed on the upcast without stopping. Once onboard, the conductivity cell and dissolved oxygen sensor were rinsed with reverse-osmosis water and the cell left full. Every 3 or 4 casts, the conductivity cell was also cleaned with dilute Triton-X. A total of 32 CTD/Rosette and UCTD casts were completed and 384 Niskin bottles were collected during the expedition.

Rosette/CTD cable communication was compromised on multiple occasions during the expedition due to software issues. In cases where bottle closure depth was not properly recorded by the acquisition software, the planned depth of closure was assumed. Statistical analyses of bottle closure depths where both the planned and actual depth were known show that the expected error in this assumption was, on average, less than 1 m.

To further verify bottle closure depths, comparisons were made between CTD and bottle salinity measurements. Figure 4 shows the difference between CTD and bottle salinity measurements, with the bottles for which the closure depth had to be assumed coloured pink. The difference between CTD and bottle salinity was on average $-.00023 \pm .019$ PSU for assumed closure depths deeper than 100 m. Above 100 m, the comparison cannot be made with confidence due to large salinity gradients and, therefore, large expected differences in salinity between CTD and bottle measurements.

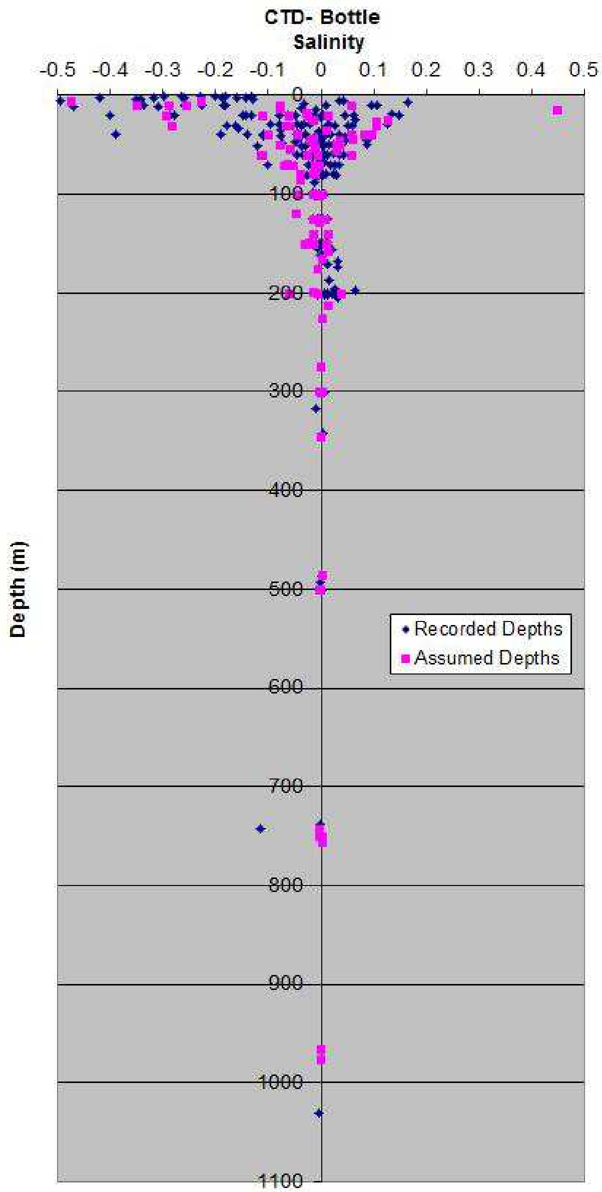


Figure 4. Salinity difference between CTD values and Niskin bottle measurements. Closure depths were assumed (pink data) when acquisition software did not properly record the bottle closure depth.

At three stations (DAL-05, KUG-05 and GRY-05) the sea state did not allow for the deployment of the rosette. CTD measurements of temperature and salinity were taken at these three stations with an Underway CTD (UCTD, serial number 0014) (Appendix 1). The UCTD/winch system made by OceanScience (Oceanside, CA) consists of a Seabird FastCat CTD (sampling rate 16Hz) installed in a torpedo-like shell, and attached to 500 lb test Spectra line by way of a 0.75 m long tailpiece. Before deployment a target depth is chosen and an appropriate amount of line is wound on the tailpiece. Once the probe is in the water the line unwinds from the tail letting the probe fall vertically from its point of entry at a rate of 3.5-4 m/s when in free fall. UCTD deployments reported here were conducted while the ship was drifting downwind.

2.2 Chemical and biological sampling

Discrete water samples were collected at target depths of: surface, 5, 10, 20, 30, 40, 50, 60, 70, 80, 100, 125, 150, 200, 300, 500, 750 m and ca. 10 m above the bottom. Depths corresponding to the maximum chlorophyll fluorescence (chl*a*max) and the 33.1 psu Pacific water layer were also sampled. Salinity, nutrients and $\delta^{18}O$ samples were taken at all depths whereas DOC and chlorophyll *a* samples were collected at selected target depths. Table 1 provides an overview of the rosette water sampling presented in this report.

CTD/Rosette deployments were generally the first activity at each station. Water samples were processed immediately on deck and in the onboard laboratory. Samples for DIC, DOC, nutrients, bacteria, salinity, barium and $\delta^{18}O$ were drawn directly from the Niskin bottle spigot. The rest of the Niskin water was transferred to acid washed carboys for the remaining analyses.

2.2.1 Salinity

A 125 ml bottle and cap were rinsed three times with the sample, the bottle filled to shoulder height and cap securely closed. The sample bottles were sealed with parafilm, stored at room temperature onboard and later at 4°C in a cold room until analyzed. Salinity samples were analyzed with a Guildline Portasal salinometer Model 8410A at the Freshwater Institute.

In the laboratory, the samples acclimatized to room temperature during 24 hours prior to analysis. The Portasal bath temperature was set to 24°C and allowed to stabilize for 24 hours. At the beginning of each day of analysis, the instrument was flushed 10 times with standard seawater, and then standardised with IAPSO Standard Seawater (OSIL, batch P153, K_{15} = 0.99979, Practical Salinity 34.992) according to Guildline protocols. Standardization was accepted if values of two conductivity measurements in succession were within ± 0.0001 of the standard K_{15}. The flow rate was kept the same during standardization and sample analyses.

The samples were inverted several times and gently mixed prior to analysis. The Portasal was flushed three times with the respective sample and duplicate readings were accepted with a maximum standard deviation of 0.0002. Salinity was calculated according to JGOFS (1996) and data are reported in practical salinity units (PSU). At the end of each day, another bottle of IAPSO Standard Seawater was measured as quality control.

2.2.2 Nutrients

Sample tubes (15 ml acid-washed Falcon tubes) and lids were rinsed three times with sample and then filled. The samples were immediately frozen at -50°C and later stored at -80°C until analyzed. All nutrient samples were analyzed for nitrate plus nitrite (NO_3 + NO_2), phosphate (PO_4) and silicate ($Si(OH)_4$) using a Seal Analytical AutoAnalyzer 3, at the Maurice-Lamontagne Institute. Stock solutions were made using potassium nitrate, 99.99% (Sigma 204110), sodium nitrite, 99.99%, (Sigma 431605), potassium dihydrogen-phosphate, 99.99% (Sigma 229806) and sodium hexafluorosilicate, puriss >99% (Sigma 71596), for nitrate plus nitrite, phosphate and silicate, respectively. Each chemical was dried for 1 hour at 105°C and then diluted to make 1 L of the respective stock solution. 1 ml of chloroform was added to phosphate, nitrite and nitrate stocks. The solutions were kept in the dark at 4°C and were stable for 6 months.

Fresh working standards were prepared daily by diluting the stock solutions. Working standards were analyzed and compared with reference solutions provided by the National Research Council (MOOS-2) and by the Ricca Chemical Company (phosphorus standard 0.025 mg P/ml, silicate standard 1 mg SiO_2/ml, nitrogen standard as nitrite 250 µg N/ml and nitrate standard 226 mg N/ml). Saltwater was used for the preparation of standards and as rinsing water. Silicate concentrations were corrected for salinity according to standard protocols (Grasshoff et al., 1999).

Table 1. Range of target depths for reported rosette water samples collected during the BREA Marine Fishes project 2012. Laboratories where samples were analyzed include: FWI: Freshwater Institute, MLI: Maurice-Lamontagne Institute, and UQAM: Université du Québec à Montréal.

Sample	Casts*	Depth range	Analyses
Salinity	All	Surface-near bottom	Shore lab - FWI
Nutrients	All	Surface-near bottom	Shore lab - MLI
$\delta^{18}O$	All	Surface-near bottom	Shore lab - UQAM
Chlorophyll *a*	All	0-100 m including chl*a*max	Onboard
DOC	All	0-70 m; chl*a*max; 33.1 salinity; bottom	Shore lab - FWI

*excludes casts for stations DAL-05, KUG-05 and GRY-07.

2.2.3 $\delta^{18}O$

Oxygen-18 samples were collected in 125 ml High-Density Polyethylene (HDPE) bottles at each station and depth. The bottles were rinsed three times prior to filling and the samples were stored at room temperature until analyzed.

Analyses were carried out at GEOTOP (UQAM) using the isotopic CO_2-H_2O equilibration method. A Micromass Isoprime™ isotope ratio mass spectrometer in dual inlet mode coupled to an Aquaprep™ system was used. Each sample analysis used 200 µl of water equilibrated to 40^0C for 7 hours. The isotopic values are expressed as the δ notation and reported in ‰ vs. VSMOW (Vienna-Standard Mean Ocean Water, Coplen, 2011). The $\delta^{18}O$ values were corrected with a calibration to three internal laboratory standards ($\delta^{18}O$= -6.71‰, -13.98‰ and -20.31‰), which were normalized against the VSMOW-SLAP (Standard Light Antarctic Precipitation) scale. The precision of the analyses was estimated at +/- 0.05‰ reproducibility and 0.24‰ repeatability.

2.2.4 DOC

Duplicate DOC samples were collected with a sterile 60 cc syringe. The syringe was rinsed three times with sample prior to filling. The sample was passed through a combusted (450°C for 24 h) 25 mm Whatman GF/F filter held in an acid washed sweenex filter holder. Each sample was acidified with 50% phosphoric acid (H_3PO_4) at a final concentration of ca. 0.05%.

The DOC sample bottles were 20 or 40 ml amber glass bottles that were thoroughly washed prior to use. The washing procedure involves soaking in 10% HCl for 12-24 h, four subsequent rinses with ultrapure water, and a final rinse with ultrapure water directly from the ultrapure unit. The bottles are then dried at 60°C in a clean oven and combusted at 550°C for 8 h. After cooling, each bottle is closed with an acid washed Teflon-lined septa and cap.

All DOC samples were kept refrigerated (4°C) and in the dark until analyzed at the Marine Productivity Laboratory, Freshwater Institute, Winnipeg. DOC was analyzed using a Shimadzu TOC-VCPH equipped with a Shimadzu ASI-V autosampler (Hedges et al., 1993; Knap et al., 1996). Due to the build-up of salt on the combustion tube during sample analyses, the combustion tube and catalyst were changed frequently (i.e. every 90-120 samples/standards) followed by multiple ultrapure water rinses and a calibration using a standard potassium hydrogen phthalate acid (KHP) solution. The calibration curve was prepared by programmed auto-dilution (20-166 mmol m^{-3}) using ultrapure water as the diluent. The range of calibration standards was selected to encompass expected DOC concentration in the samples. For the BREA 2012 DOC dataset, only 1% of samples were outside (i.e. higher) the calibration range. Standard error of the calibration standards averaged 1.5% (range: 0.6 to 4%) and the calibration curve R^2 was consistently > 0.99.

The analyses were systematically checked against Deep Sargasso Sea Reference water (DSR, 41-44 mmol m^{-3} DOC) obtained from the Hansell's Certified Reference Materials (CRM) program, University of Miami (rsmas.miami.edu/groups/biogeochem/CRM.html, Dickson et al., 2007). The DSR samples averaged 42 mmol m^{-3} DOC (range: 32-52 mmol m^{-3} DOC, n = 60). Replicability of duplicate water samples averaged 2.9% (range: 0-13%, n = 250).

2.2.5 Chlorophyll *a*

Chlorophyll *a* (chl *a*) concentrations were determined fluorometrically on fresh pigments extracted in 90% acetone according to Parsons et al. (1984), as detailed below. All chl *a* samples were analyzed onboard using a Turner Designs 10AU fluorometer calibrated using pure chl *a* extract (*Anacystis nidulans*, Sigma Chemicals). Fd and Tau values prior to the expedition were 0.174 (R^2 = 0.99) and 2.019, respectively, and 0.174 (R^2 = 0.99) and 1.953 afterwards.

Duplicate chl *a* sub-samples were filtered onto Whatman 25 mm GF/F filters (nominal pore size of 0.7 µm) for the determination of total chl *a*, and onto 5 µm Nuclepore membrane filters to determine the > 5 µm chl *a* size fraction. Pigments were extracted in 10 ml of 90% acetone for

24 h at 4°C in the dark. After 24 h, the samples were allowed to warm to room temperature prior to fluorometric readings.

3.0 DATA

Individual station plots are presented for transects DAL, KUG, GRY, TBS and HCT in Appendices 2 to 6. CTD profiles, without accompanying discrete rosette sampling, are presented for the HCT transect only. The station plot data are linked to fish habitat groups identified by the Marine Fishes project (Fig. 4, Appendix 1). The habitat groupings for marine fish were defined by water depths on the shelf and slope. The three habitat categories identified for the 2012 sampling stations were shelf (<200 m), upper slope (200-500 m), and lower slope (500-1000 m) (Fig. 4).

The CTD data shown in the station plots (Appendices 2-6) compare temperature, salinity, transmissivity, fluorescence, DO and PAR profiles. Bottle data for salinity and total chl *a* concentrations are also overlain with the CTD salinity and fluorescence profiles, respectively, for comparison purposes. Due to a leaky connector on the PAR sensor that resulted in increasingly intermittent and noisy data, PAR data are reported only to cast 48, station DAL-06 (Appendix 2). Station plots provided for the discrete rosette sampling compare profiles of the inorganic nutrients and total and 5 µm chl *a* and present $\delta^{18}O$ and DOC profiles separately.

Salinity, $\delta^{18}O$ and nutrient data from the discrete rosette sampling are also presented in section plots for DAL, KUG, GRY and TBS transects (Appendices 7-10). The upper 150 m of the water column is shown reflecting the section of most intense sampling.

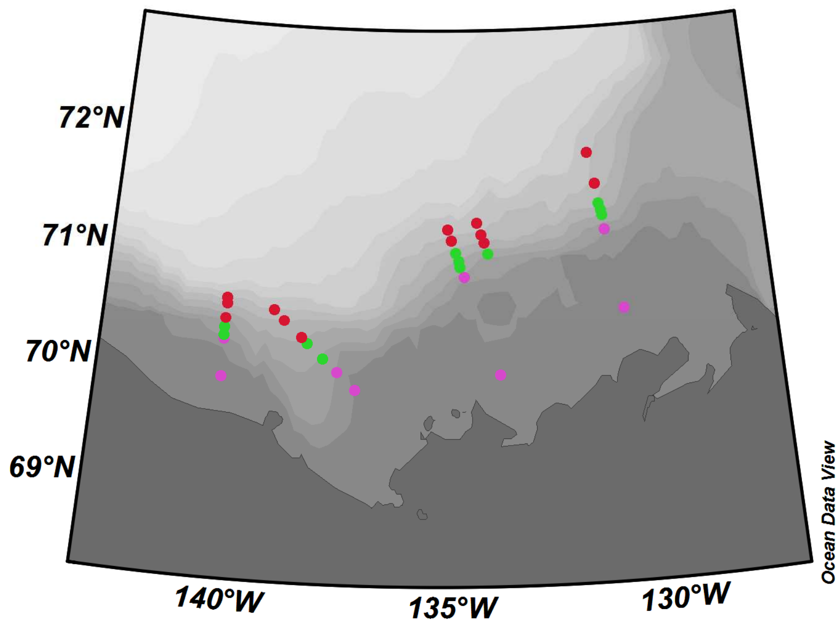


Figure 5. CTD/Rosette sampling stations corresponding to fish habitat groups on the shelf and slope of the 2012 BREA Marine Fishes study area. Fish habitat groups were identified as shelf (pink, < 200 m), upper slope (green, 200-500 m) and lower slope (red, 500-1000 m).

4.0 REFERENCES

Cobb, D., Fast, H., Papst, M.H., Rosenberg, D., Rutherford, R., Sareault, J.E. 2008. Beaufort Sea Large Ocean Management Area: Ecosystem Overview and Assessment Report. Can. Tech. Rep. Fish. Aquat. Sci. 2780: ii-ix + 188 p.

Coplen, T.B. 2011 Guidelines and recommended terms for expression of stable-isotope-ratio and gas-ratio measurement results: Rapid Communications in Mass Spectrometry. 25: 2538-2560.

Dickson, A.G., Sabine, C.L., Christian, J.R. (Eds). 2007. Guide to best practices for ocean CO_2 measurements. PICES Special Publication 3, 191 pp.

Grasshoff, K., Kremling, K., Ehrhardt, M. (Eds). 1999. Methods of seawater analysis, 3rd edn. Wiley, Weinheim.

Hedges, J.I., Bergamaschi, B.A., Benner, R. 1993. Comparative analyses of DOC and DON in natural waters. Mar. Chem. 41: 121-134.

Knap, A., Michaels, A., Close, A., Ducklow, H., Dickson, A. 1996. Protocols for the Joint Global Ocean Flux Study (JGOFS) Core Measurements. JGOFS Report Nor. 19, Reprint of the IOC Manuals and Guides No. 29, UNESCO 1994.

Parsons, T.R., Maita, Y., Lalli, C.M. 1984. A Manual of Chemical and Biological Methods for Seawater Analysis, Vol. Pergamon Press, Oxford.

Walkusz, W., Williams, W.J. 2013. Northern Coastal Marine Studies – the *Nahidik* program – environmental research of the coastal Beaufort Sea. J. Mar. Syst. 127: 2-4.

Appendix 1: CTD/Rosette (ROS) and Underway CTD (UCTD) deployment information for each sampling station of the 2012 BREA Marine Fishes project.

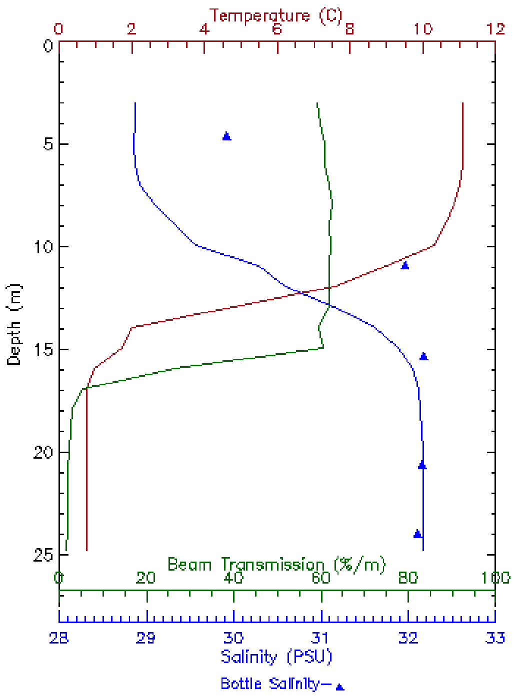
Event #	Cast Type	Station	Lat Deg (N)	Lat Min (N)	Lon Deg (W)	Lon Min (W)	Cast Start Time (d/m/y; UTC)	Water Depth (m)	Habitat group
13	ROS	DAL-01	70	31.88	130	52.69	07/08/2012 02:24	26	Shelf
14	ROS	DAL-02	71	12.46	131	10.72	07/08/2012 14:12	82	Shelf
22	ROS	DAL-03	71	19.87	131	13.06	07/08/2012 22:08	212	Upper slope
29	ROS	DAL-04	71	22.3	131	14.38	08/08/2012 16:10	326	Upper slope
34	UCTD	DAL-05	71	25.97	131	16.65	08/08/2012 9:47	498	Upper slope
48	ROS	DAL-06	71	35.99	131	21.05	10/08/2012 00:11	749	Lower slope
64	ROS	DAL-07	71	51.87	131	28.72	11/08/2012 13:13	989	Lower slope
78	ROS	KUG-01	70	0.63	133	50.42	13/08/2012 13:25	23	Shelf
93	ROS	KUG-02	70	50.89	134	40.07	14/08/2012 13:26	79	Shelf
101	ROS	KUG-03	70	55.85	134	45.65	14/08/2012 19:02	220	Upper slope
110	ROS	KUG-04	70	59.06	134	47.65	15/08/2012 13:14	353	Upper slope
121	UCTD	KUG-05	71	3.0	134	52.26	15/08/2012 22:07	499	Upper slope
143	ROS	KUG-06	71	9.42	134	58.73	16/08/2012 17:04	770	Lower slope
149	ROS	KUG-07	71	15.05	135	4.31	17/08/2012 01:25	984	Lower slope
170	ROS	GRY-01	69	52.56	137	14.55	19/08/2012 14:14	50	Shelf
182	ROS	GRY-02	70	1.05	137	40.5	19/08/2012 19:19	80	Shelf
194	ROS	GRY-03	70	7.83	138	1.52	20/08/2012 01:02	204	Upper slope
203	ROS	GRY-04	70	15.29	138	24.23	20/08/2012 19:31	351	Upper slope
211	ROS	GRY-05	70	18.12	138	32.97	22/08/2012 14:00	500	Lower slope
221	ROS	GRY-06	70	26.45	138	58.93	22/08/2012 21:36	761	Lower slope
228	UCTD	GRY-07	70	31.56	139	13.76	23/08/2012 15:31	1019	Lower slope
253	ROS	TBS-01	69	55.79	140	22.59	25/08/2012 13:21	45	Shelf
263	ROS	TBS-02	70	15.11	140	22.63	25/08/2012 19:30	75	Shelf
276	ROS	TBS-03	70	16.94	140	22.84	26/08/2012 13:16	206	Upper slope
285	ROS	TBS-04	70	20.82	140	22.85	26/08/2012 18:27	353	Upper slope
297	ROS	TBS-05	70	25.71	140	22.69	27/08/2012 13:06	497	Lower slope
306	ROS	TBS-06	70	33.22	140	22.32	27/08/2012 19:34	744	Lower slope

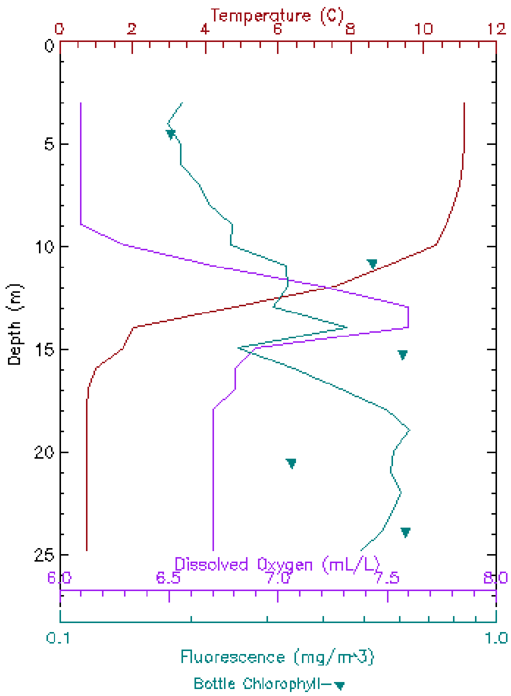
Appendix 1 cont.

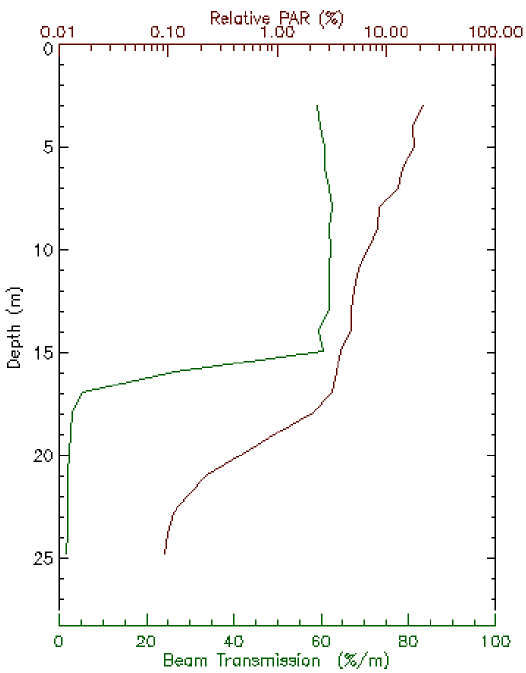
Event #	Cast Type	Station	Lat Deg (N)	Lat Min (N)	Lon Deg (W)	Lon Min (W)	Cast Start Time (d/m/y; UTC)	Water Depth (m)	Habitat group
332	ROS	TBS-07	70	36.16	140	22.41	30/08/2012 14:45	1038	Lower slope
336	ROS	HCT-01	71	2.44	134	5.15	01/09/2012 13:37	350	Upper slope
339	ROS	HCT-02	71	8.16	134	10.55	01/09/2012 17:30	558	Lower slope
342	ROS	HCT-03	71	12.38	134	14.6	01/09/2012 21:24	752	Lower slope
346	ROS	HCT-04	71	18.33	134	20.24	02/09/2012 01:42	1017	Lower slope

Appendix 2. CTD/Rosette station plots for the DAL transect stations during the BREA Marine Fishes project, August-September 2012. Plots are identified by station name and sampling date, expedition event number and fish habitat grouping. CTD plots (temperature, salinity, transmissivity, fluorescence, dissolved oxygen (DO) and photosynthetically active radiation (PAR)) are presented first, followed by the rosette plots (inorganic nutrients (NO_3 + NO_2, PO_4, $Si(OH)_4$), $\delta^{18}O$, chlorophyll a (total and 5 µm) and dissolved organic carbon (DOC)). Transect and cast details are provided in Figure 1 and Appendix 1.

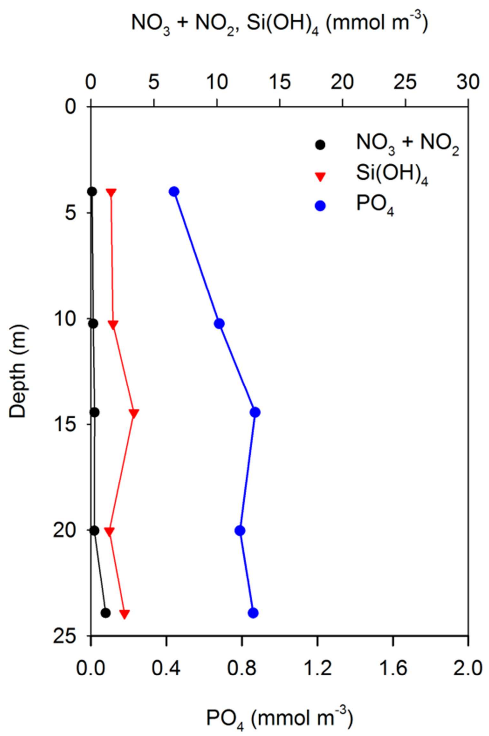
07/08/2102: Event 13, Station DAL-01 (Shelf)

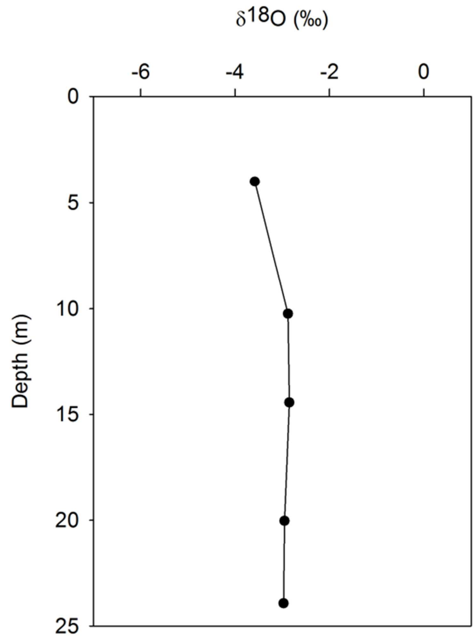


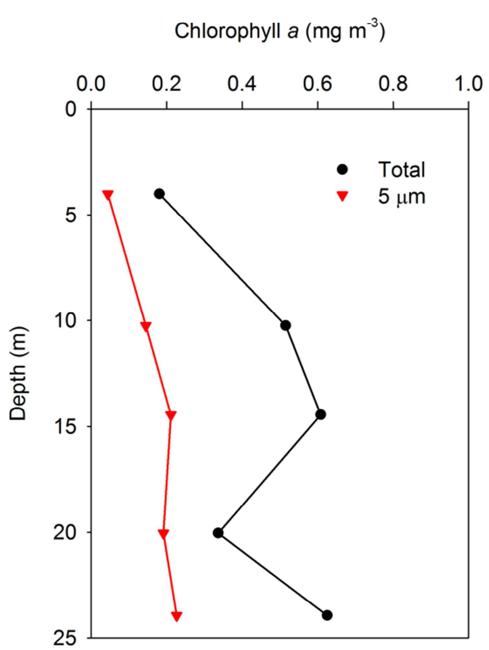


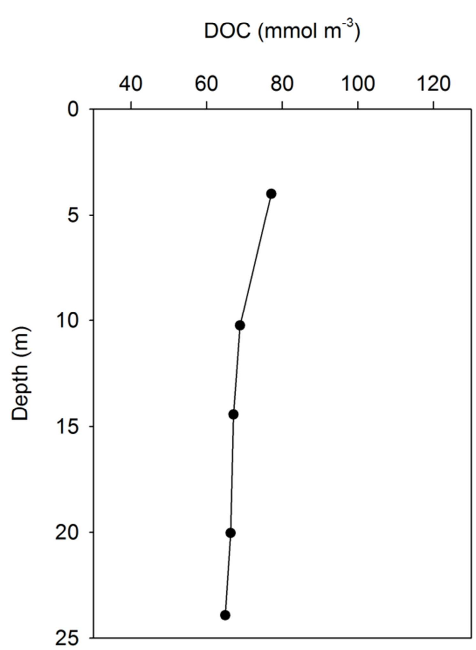


07/08/2102: Event 13, Station DAL-01 (Shelf)

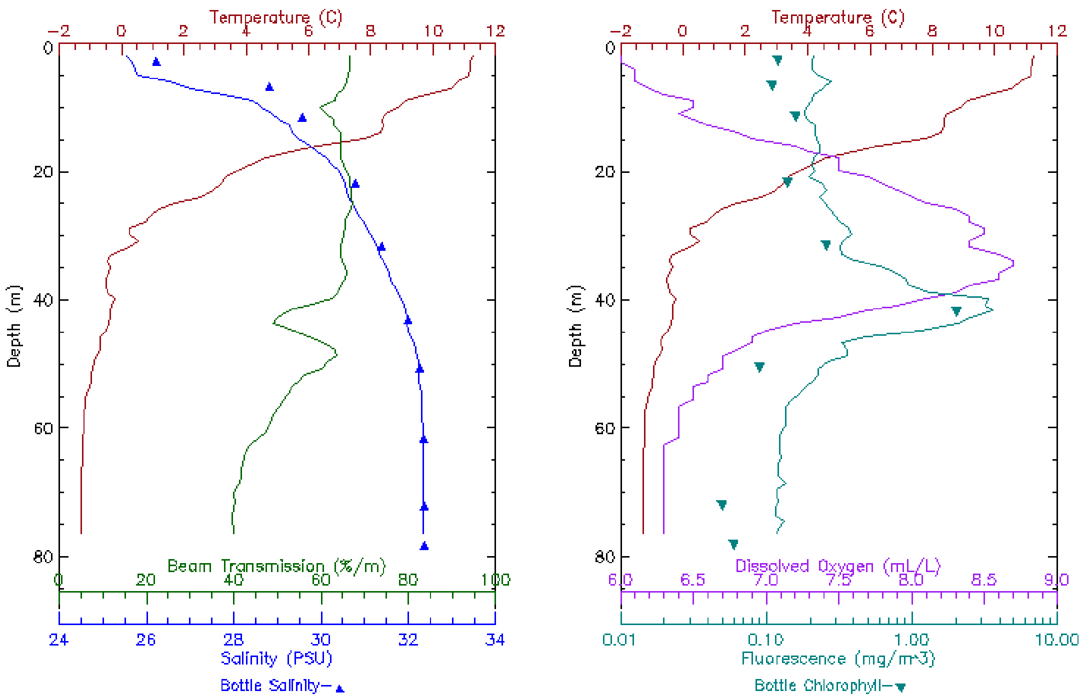




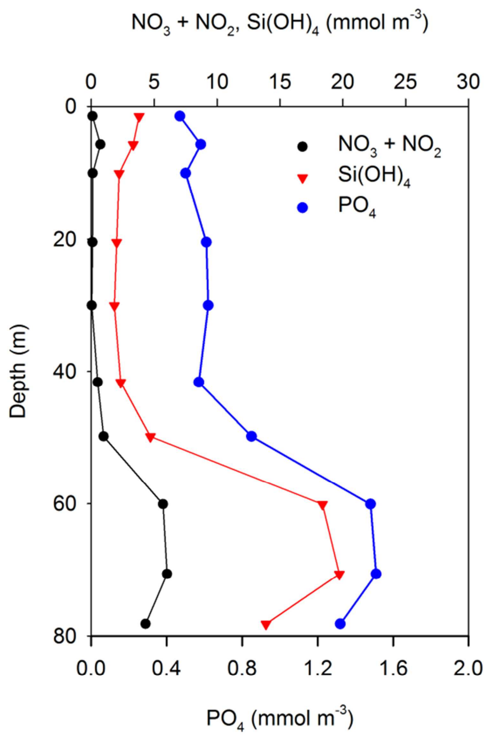


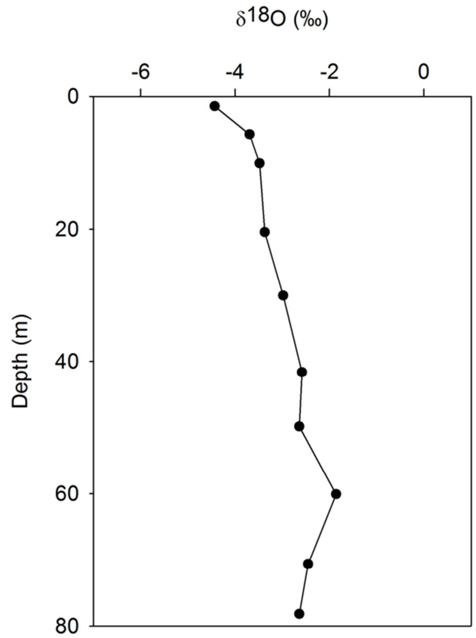


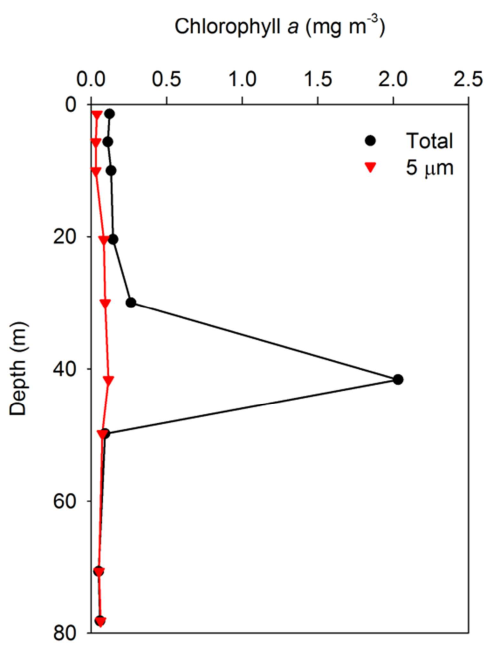
07/08/2102: Event 14, Station DAL-02 (Shelf)

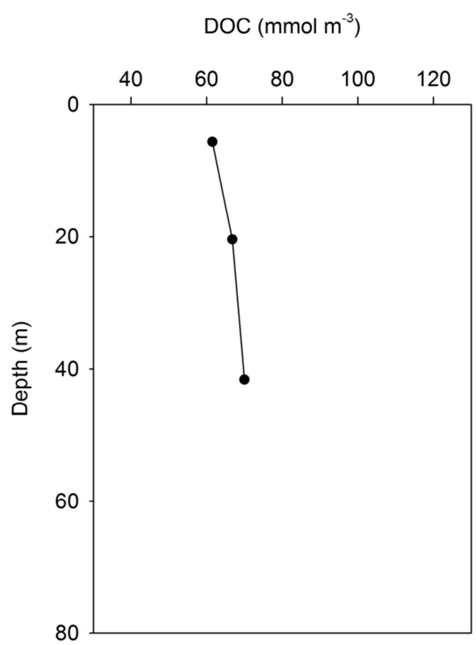


07/08/2102: Event 14, Station DAL-02 (Shelf)

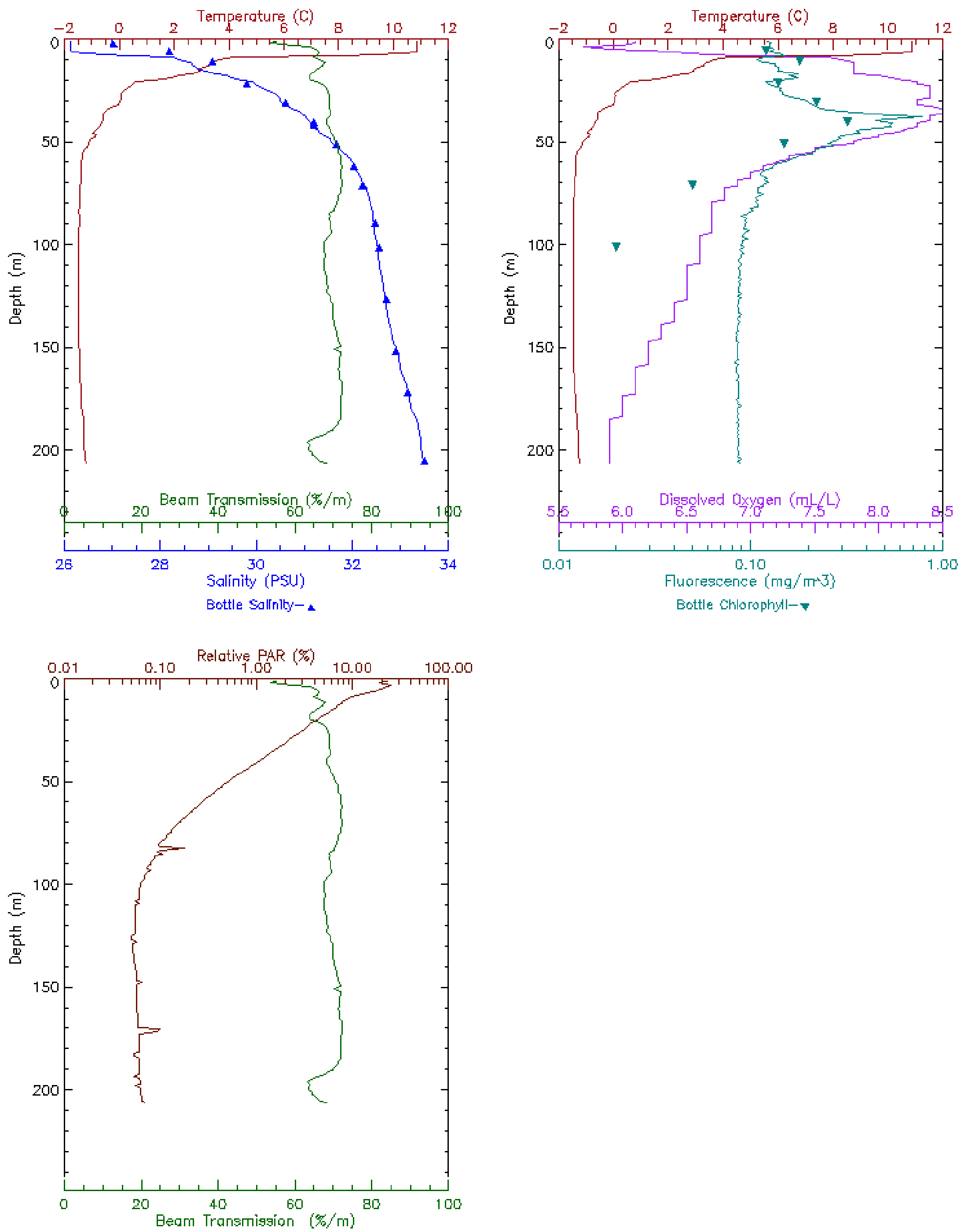




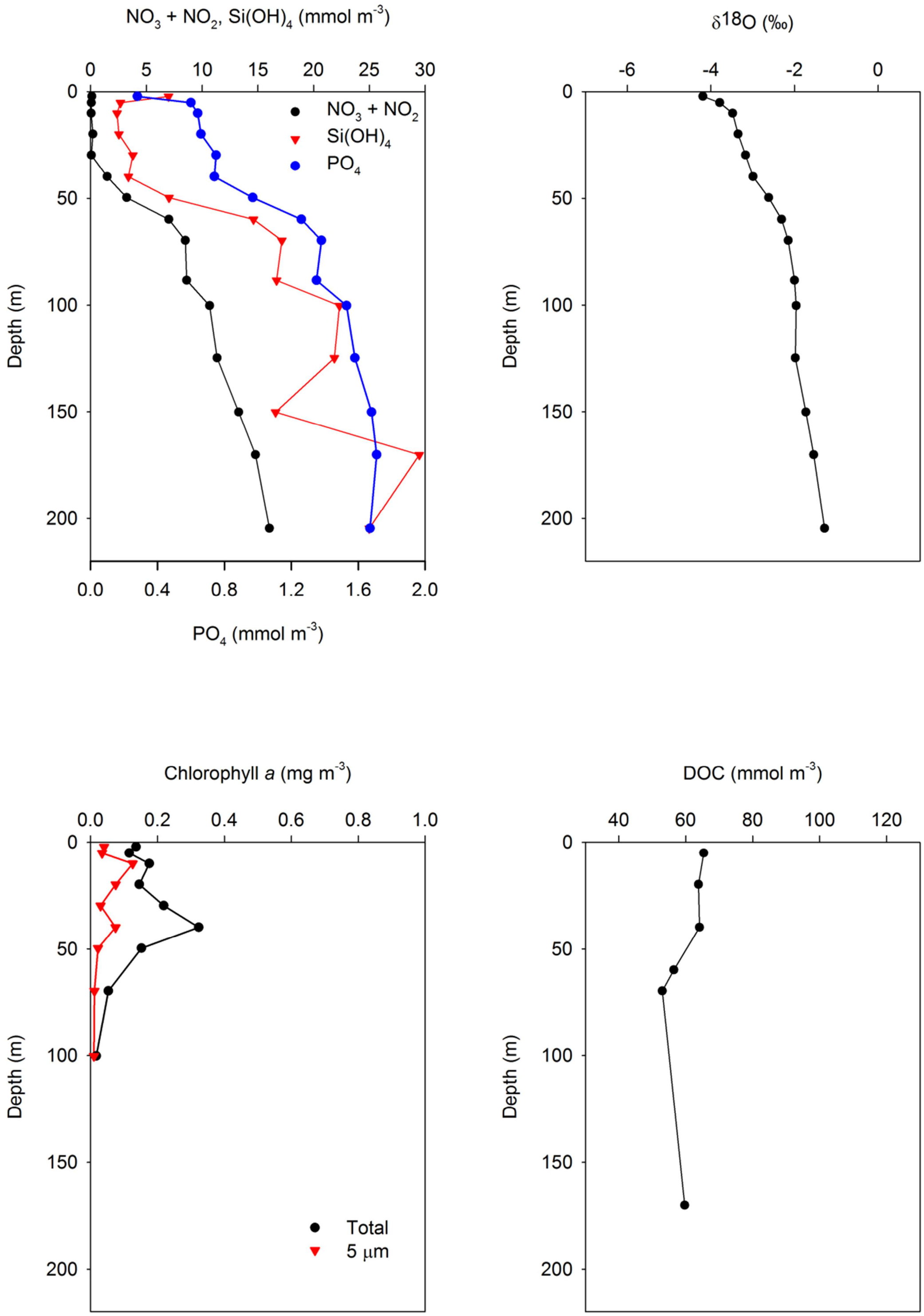




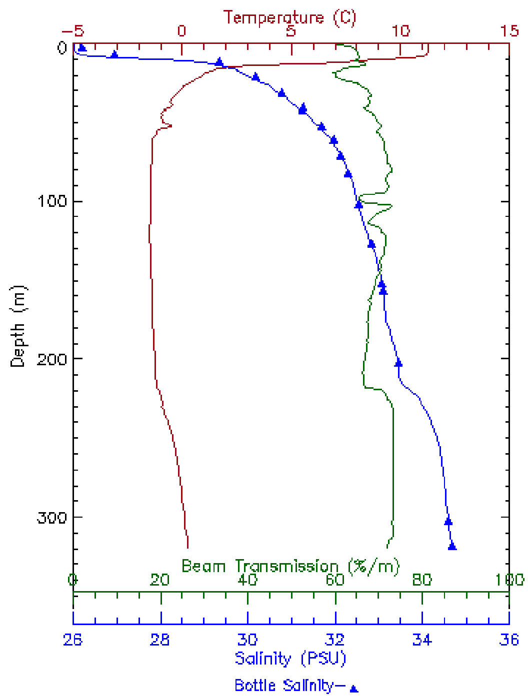
07/08/2102: Event 22, Station DAL-03 (Upper Slope)

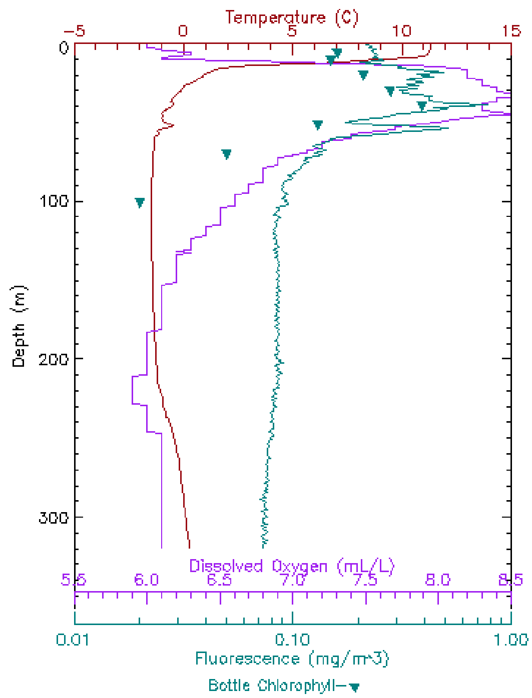


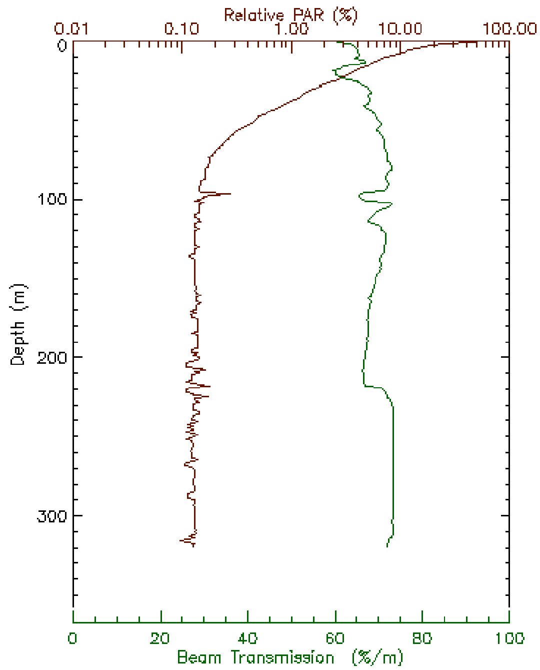
07/08/2102: Event 22, Station DAL-03 (Upper Slope)



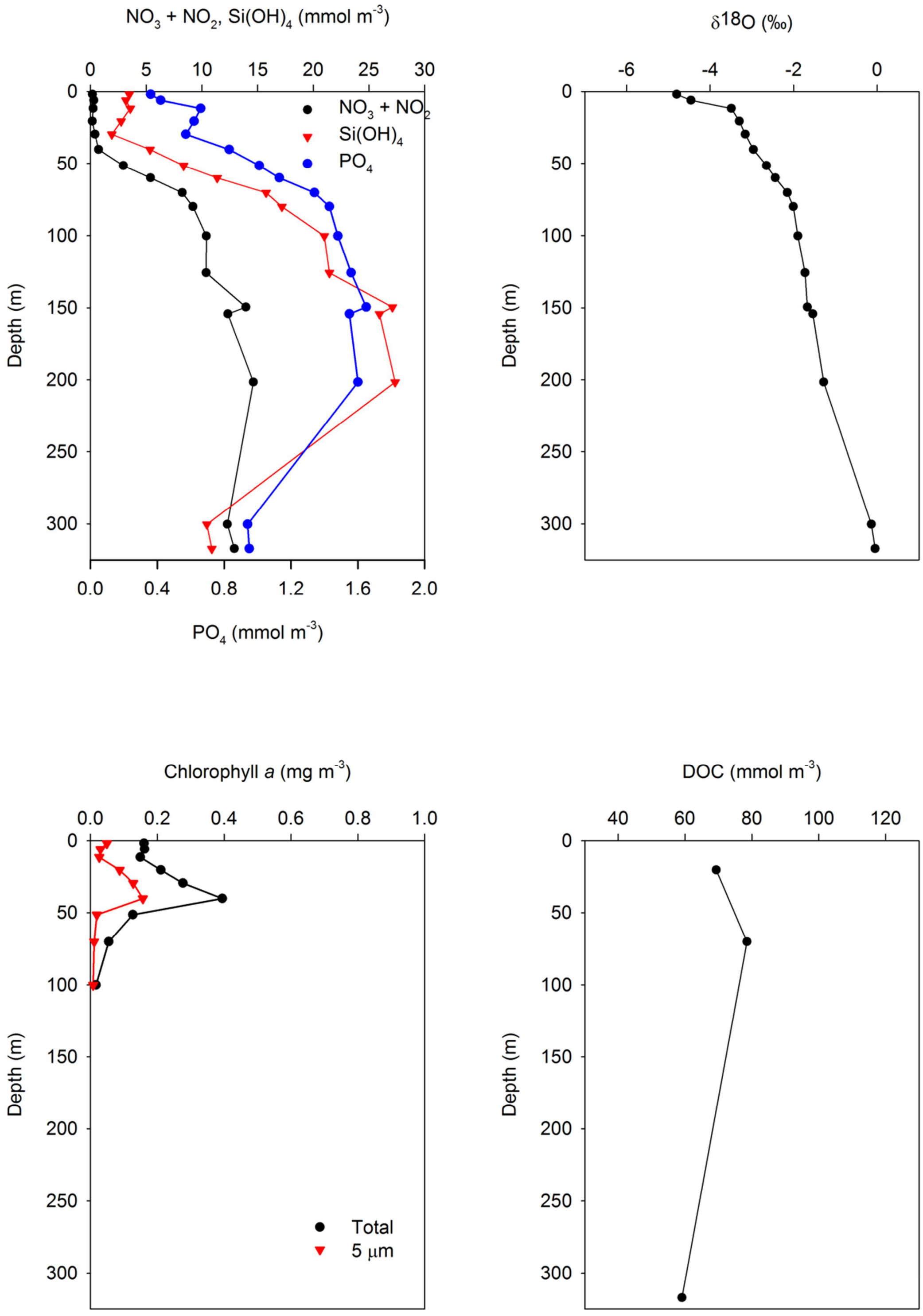
08/08/2102: Event 29, Station DAL-04 (Upper Slope)



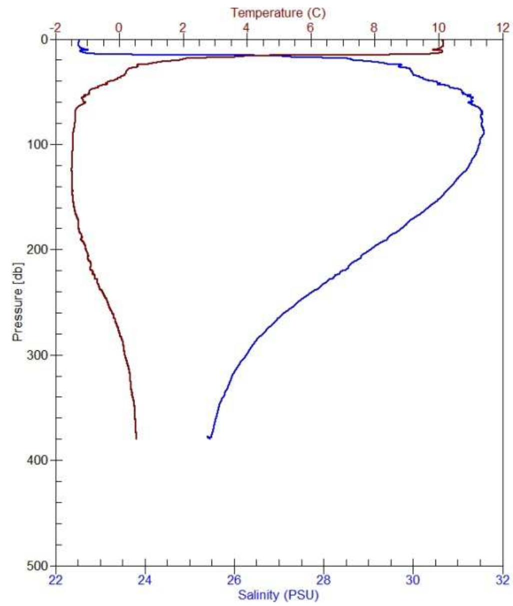




08/08/2102: Event 29, Station DAL-04 (Upper Slope)



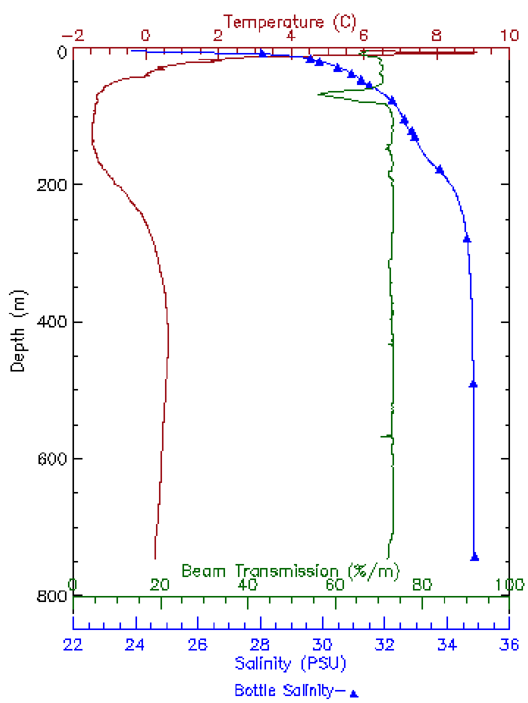
08/08/2102: Event 34, Station DAL-05 (Upper Slope)

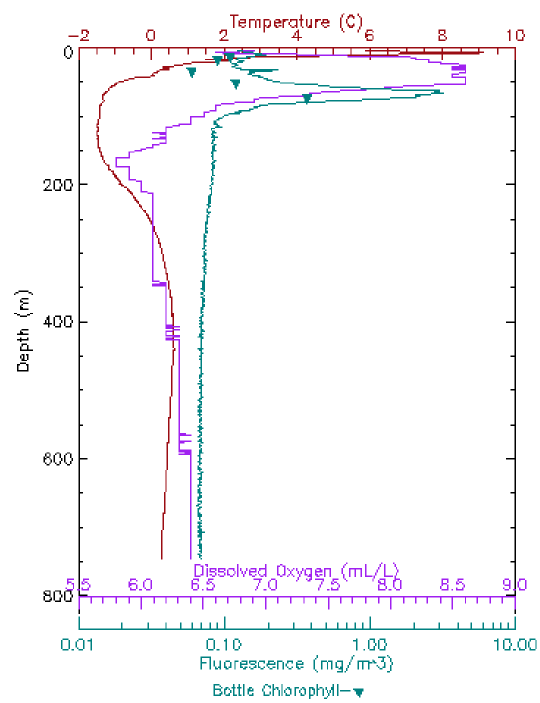


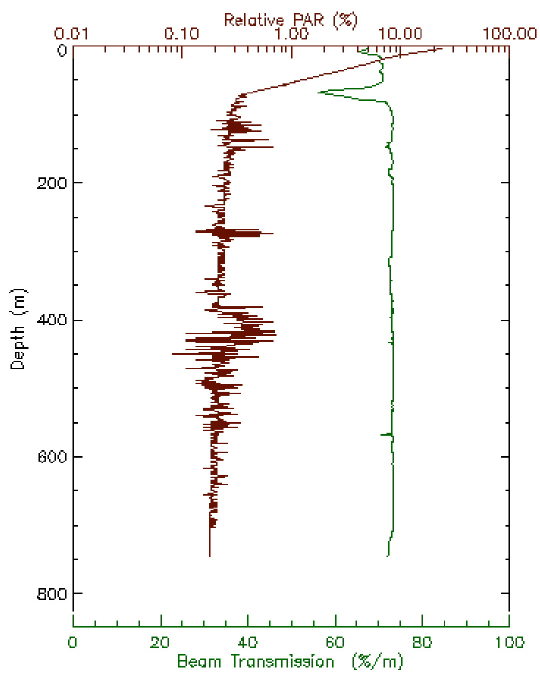
08/08/2102: Event 34, Station DAL-05 (Upper Slope)

No rosette sampling

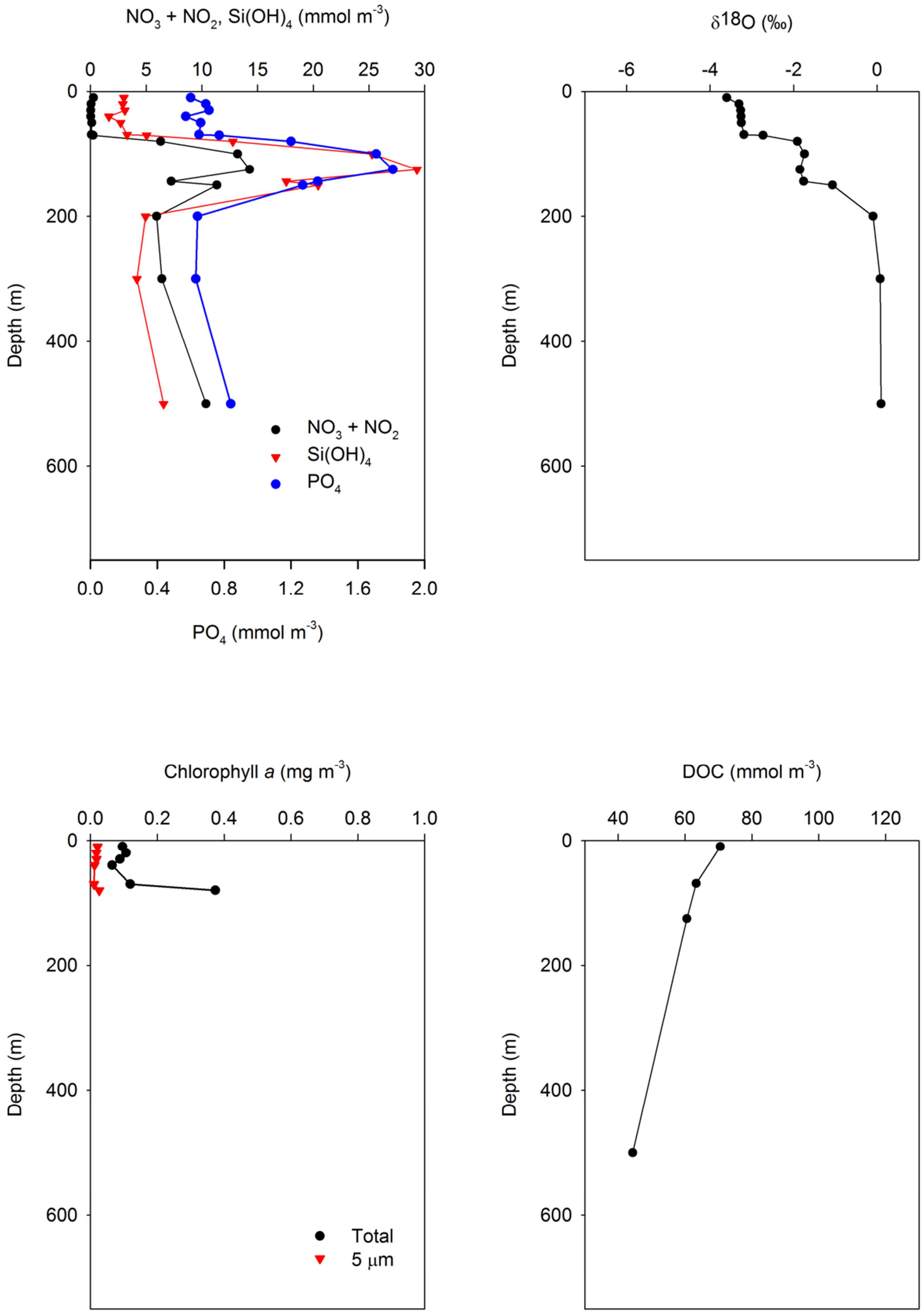
10/08/2102: Event 48, Station DAL-06 (Lower Slope)



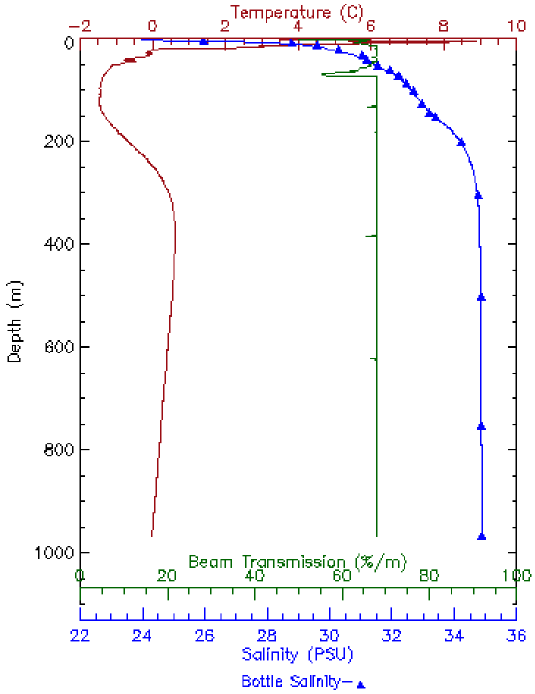


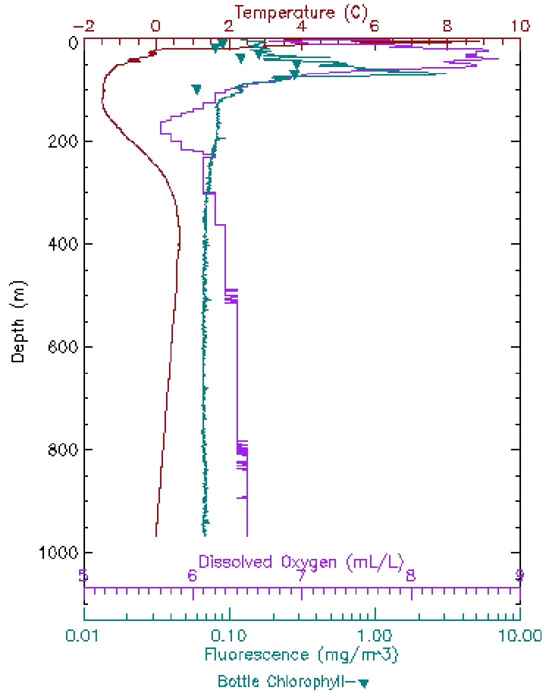


10/08/2102: Event 48, Station DAL-06 (Lower Slope)

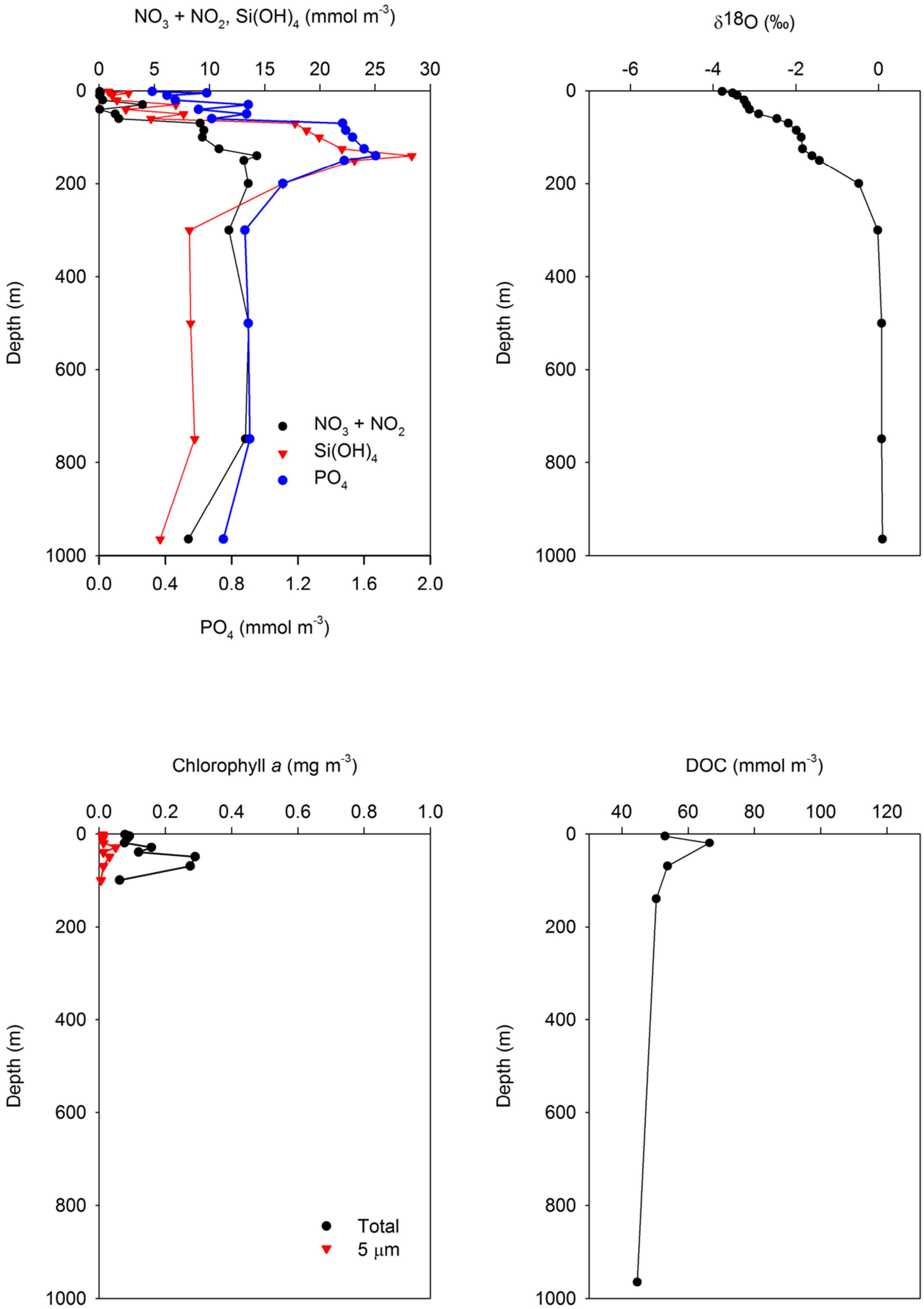


11/08/2102: Event 64, Station DAL-07 (Lower Slope)



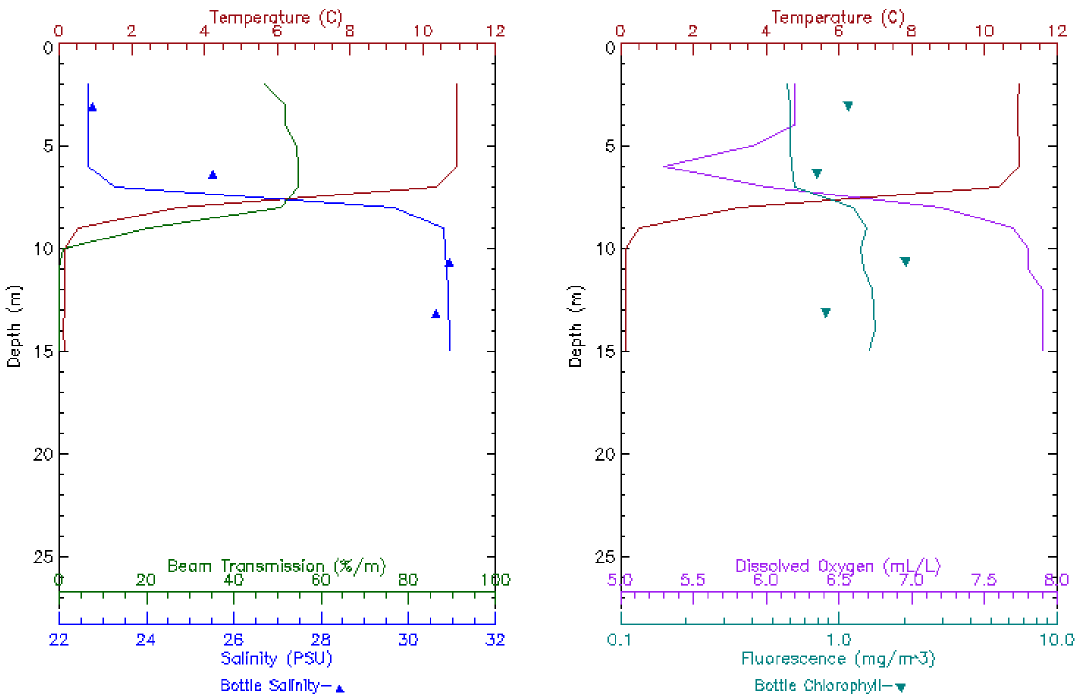


11/08/2102: Event 64, Station DAL-07 (Lower Slope)

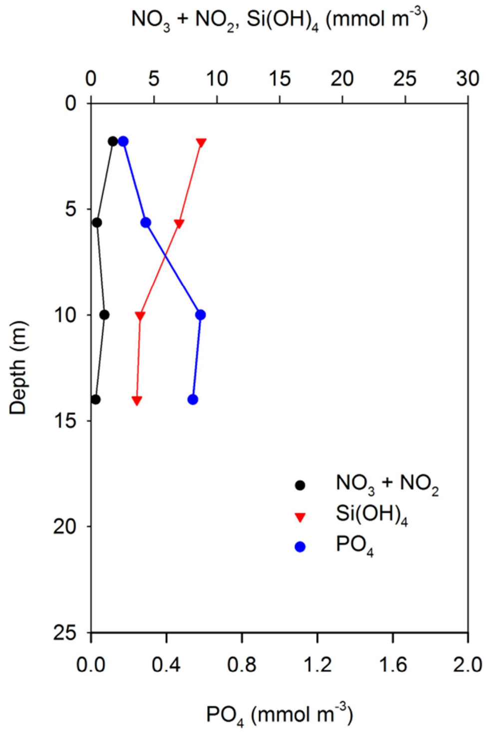


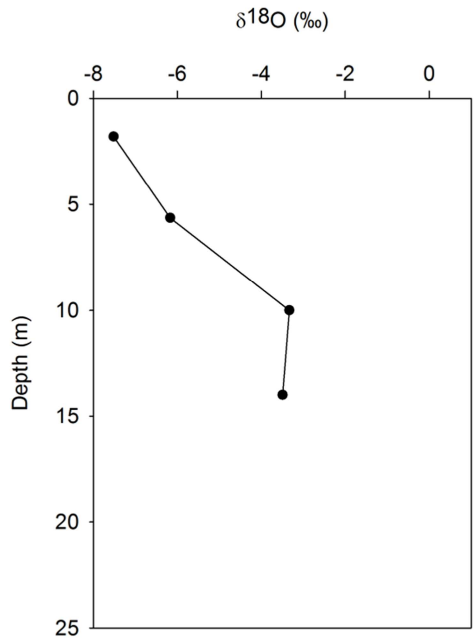
Appendix 3. CTD/Rosette station plots for the KUG transect stations during the BREA Marine Fishes project, August-September 2012. Plots are identified by station name and sampling date, expedition event number and fish habitat grouping. CTD plots (temperature, salinity, transmissivity, fluorescence and dissolved oxygen (DO)) are presented first, followed by the rosette plots (inorganic nutrients (NO_3 + NO_2, PO_4, $Si(OH)_4$), $\delta^{18}O$, chlorophyll a (total and 5 µm) and dissolved organic carbon (DOC)). Transect and cast details are provided in Figure 1 and Appendix 1.

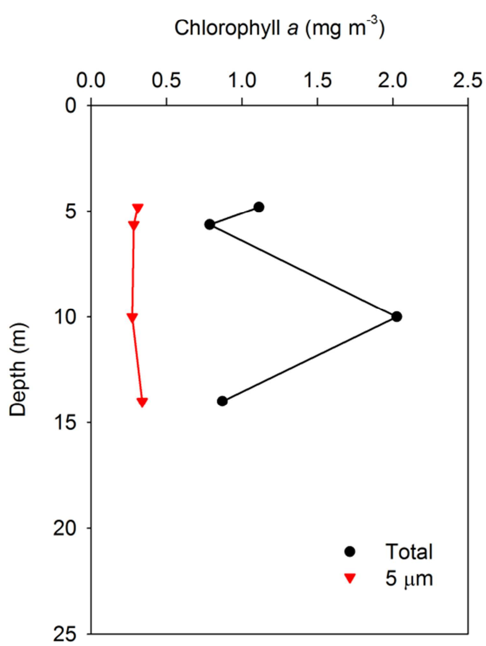
13/08/2102: Event 78, Station KUG-01 (Shelf)

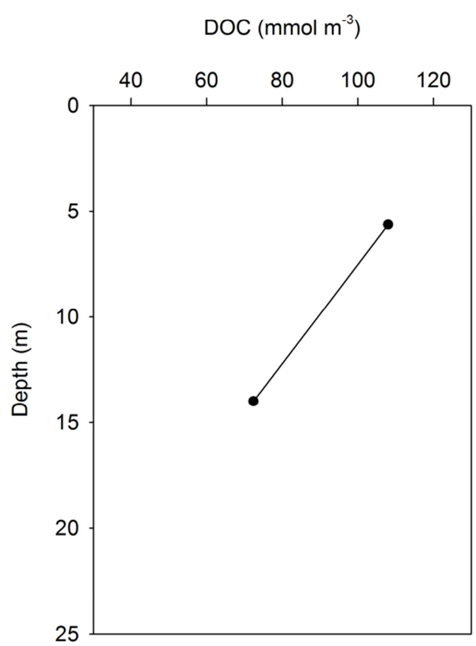


13/08/2102: Event 78, Station KUG-01 (Shelf)

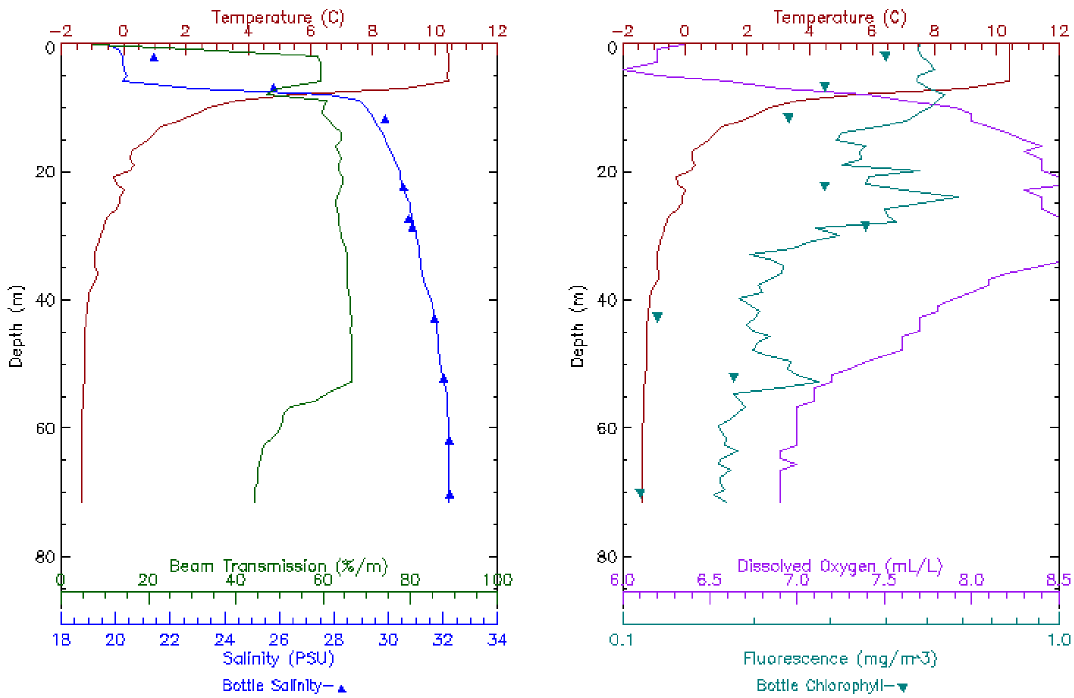




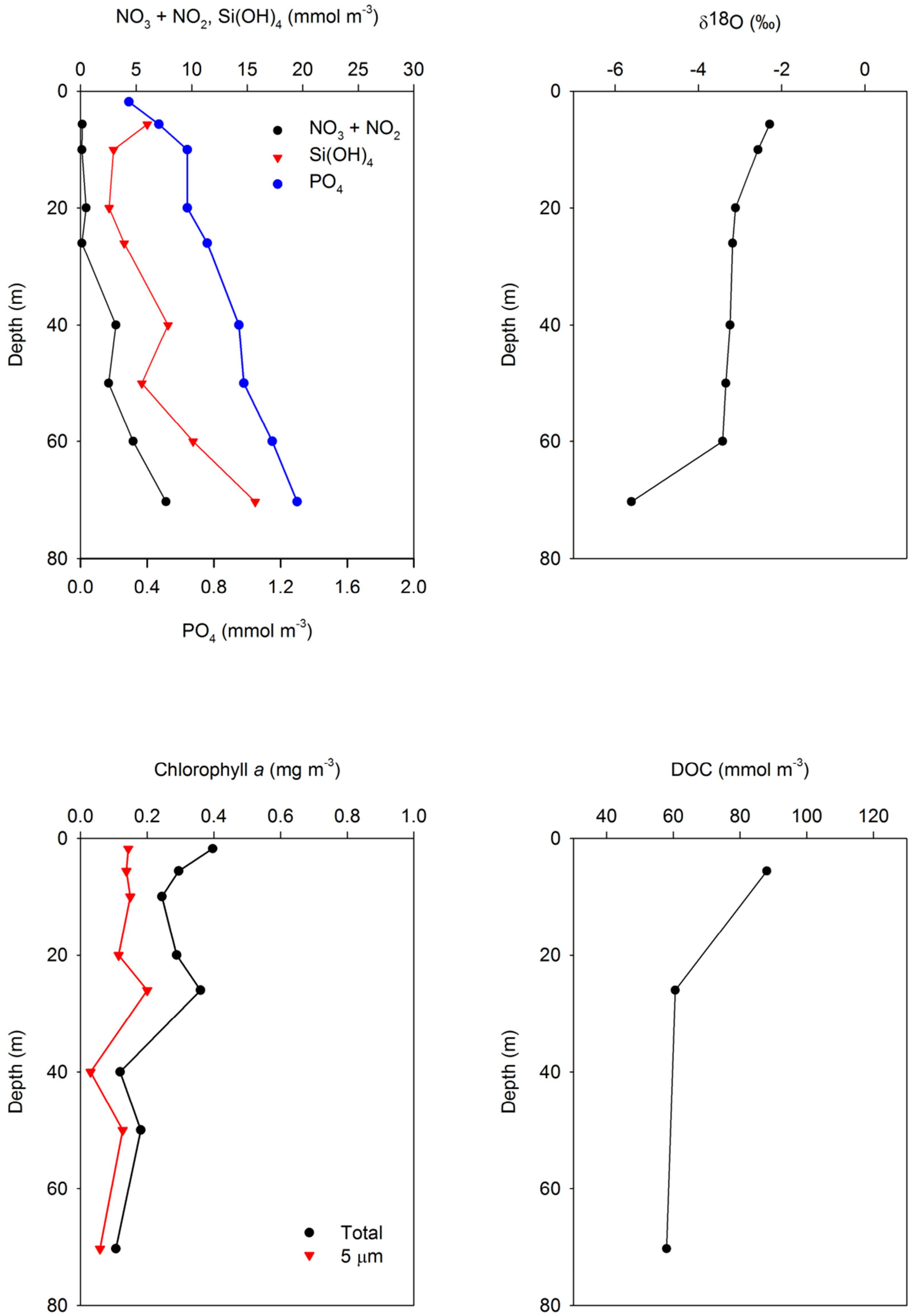




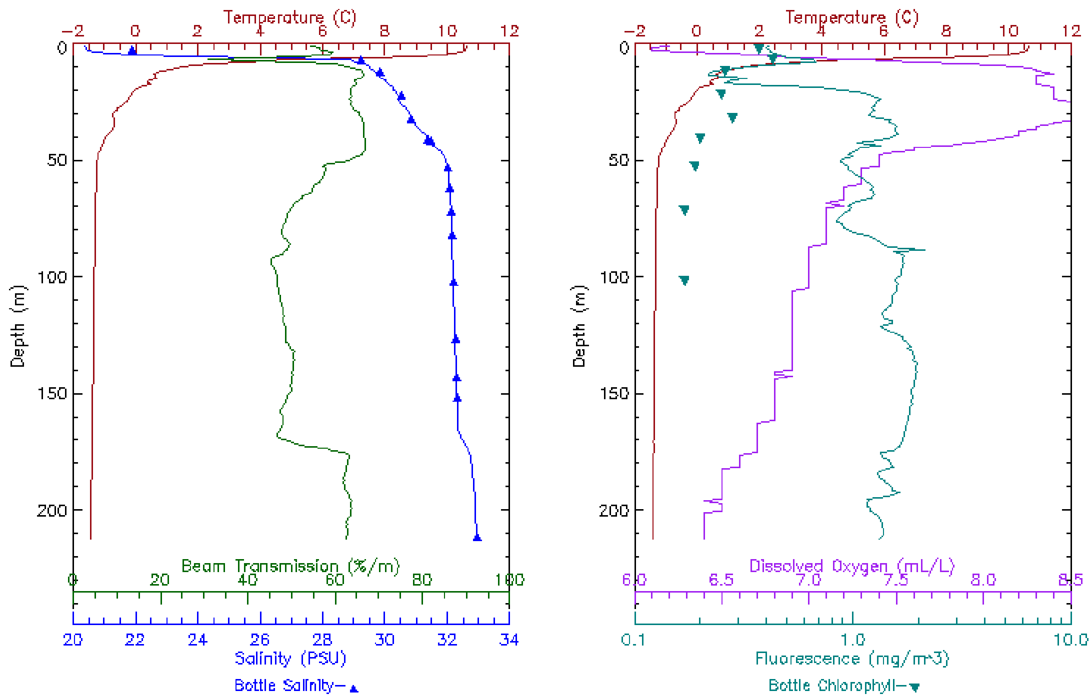
14/08/2102: Event 93, Station KUG-02 (Shelf)



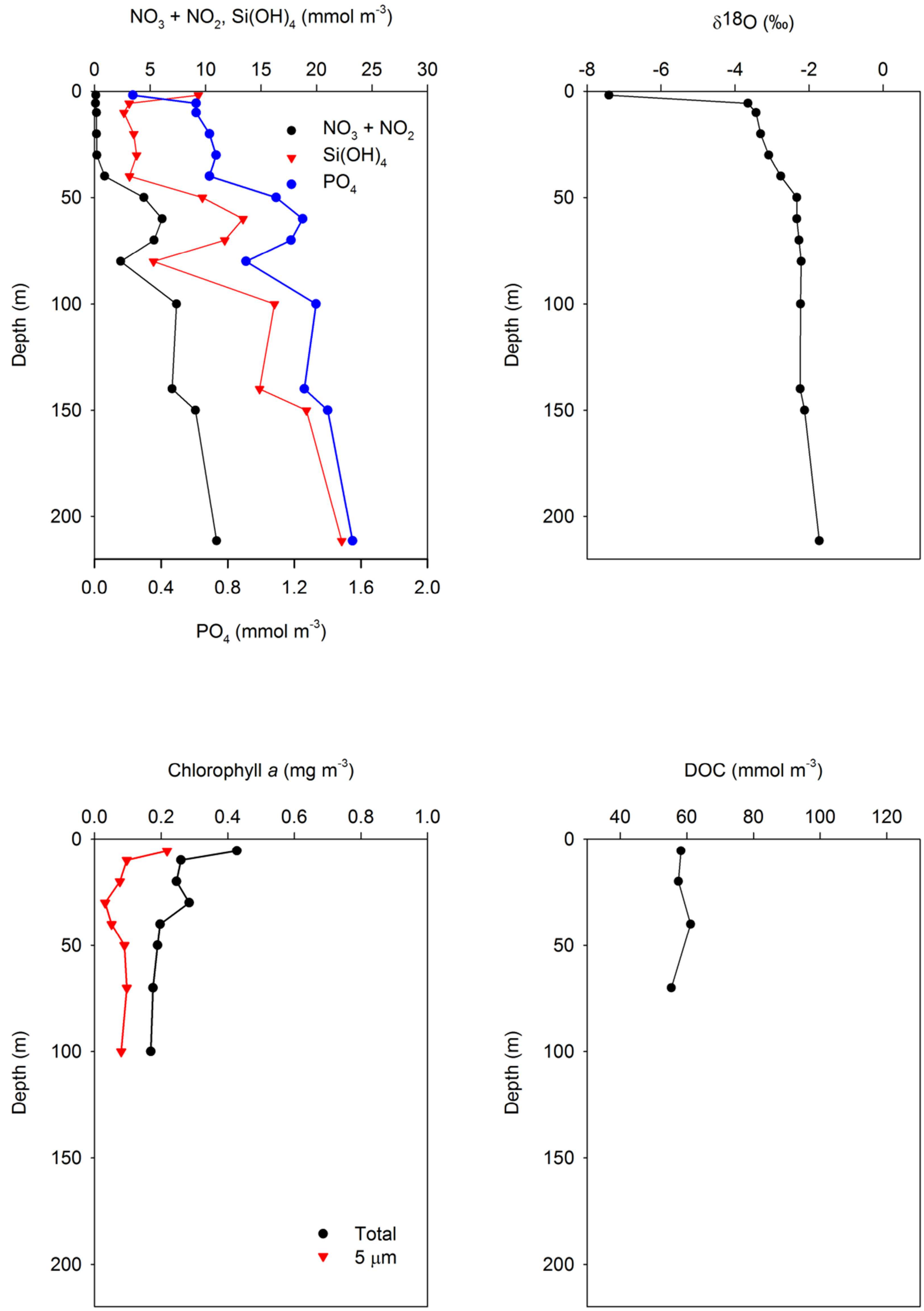
14/08/2102: Event 93, Station KUG-02 (Shelf)



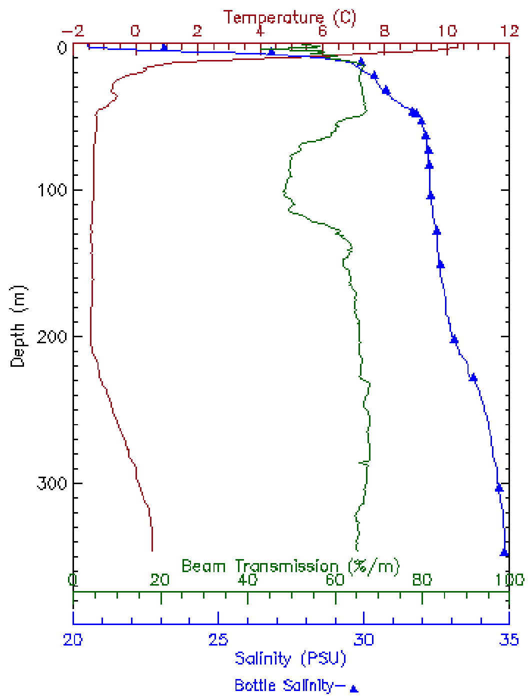
14/08/2102: Event 101, Station KUG-03 (Upper Slope)

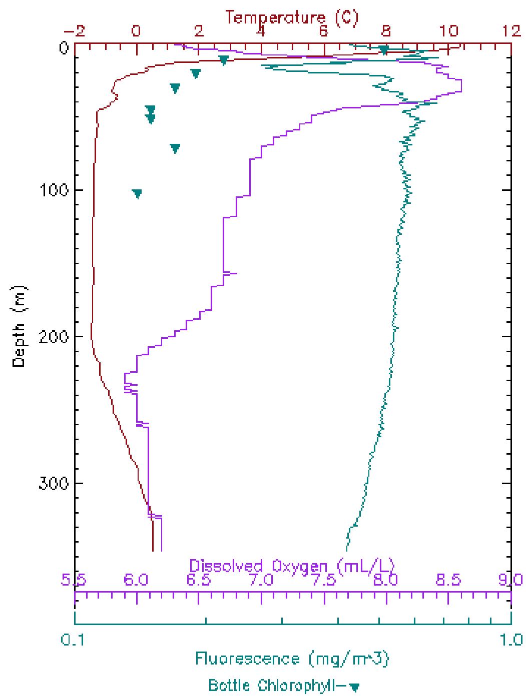


14/08/2102: Event 101, Station KUG-03 (Upper Slope)

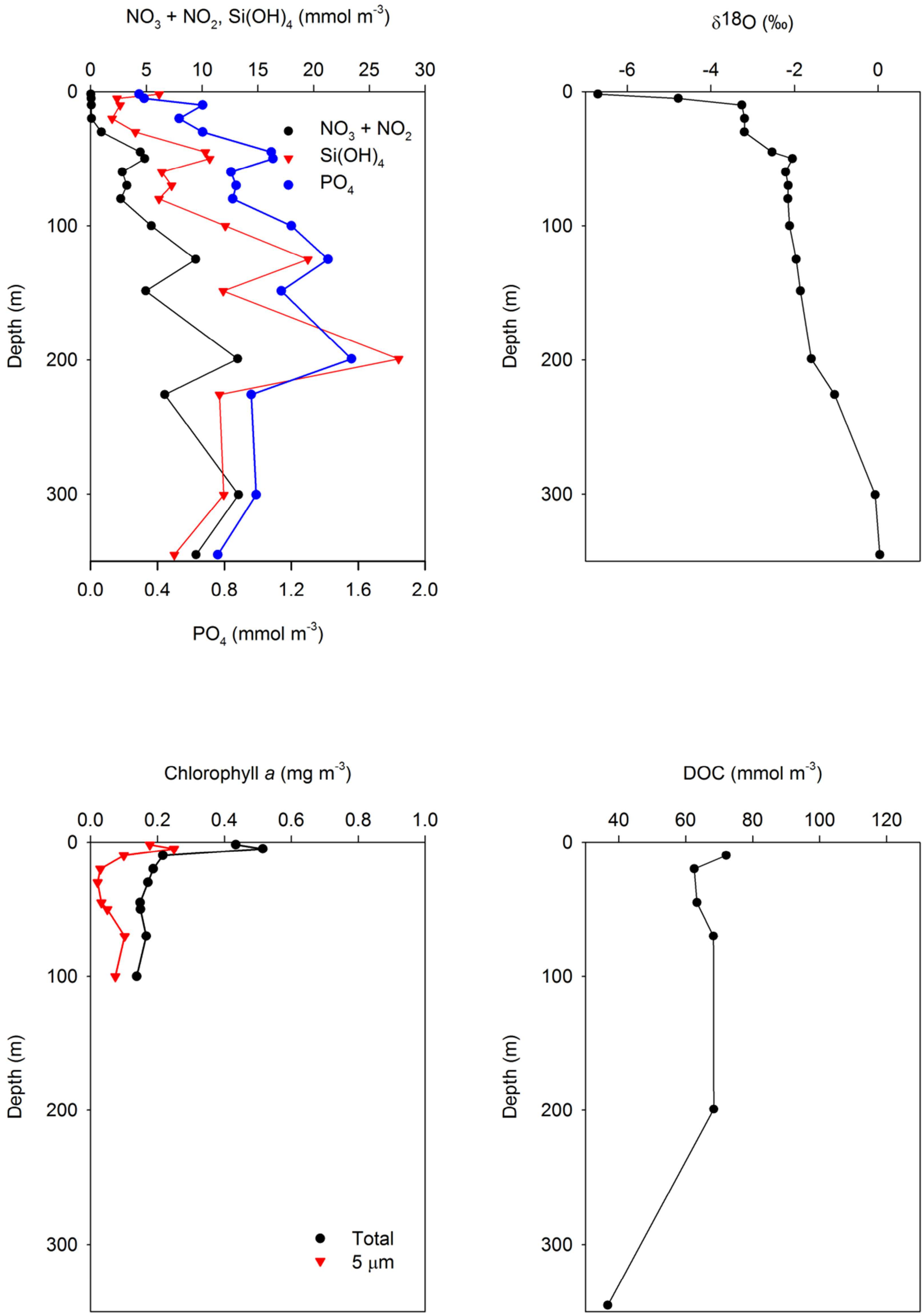


15/08/2102: Event 110, Station KUG-04 (Upper Slope)

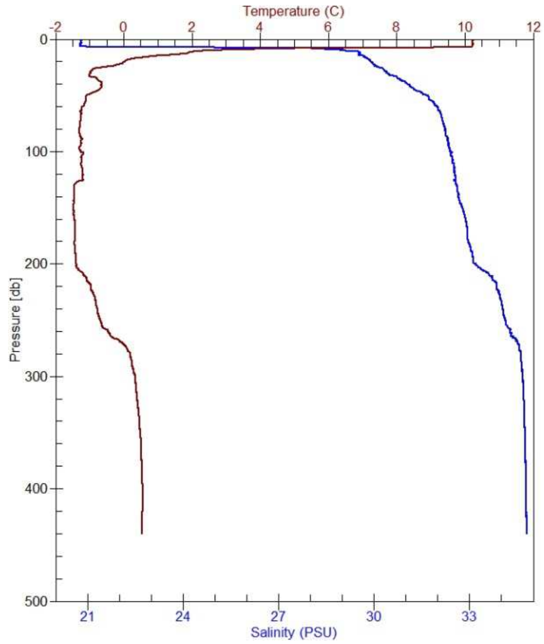




15/08/2102: Event 110, Station KUG-04 (Upper Slope)



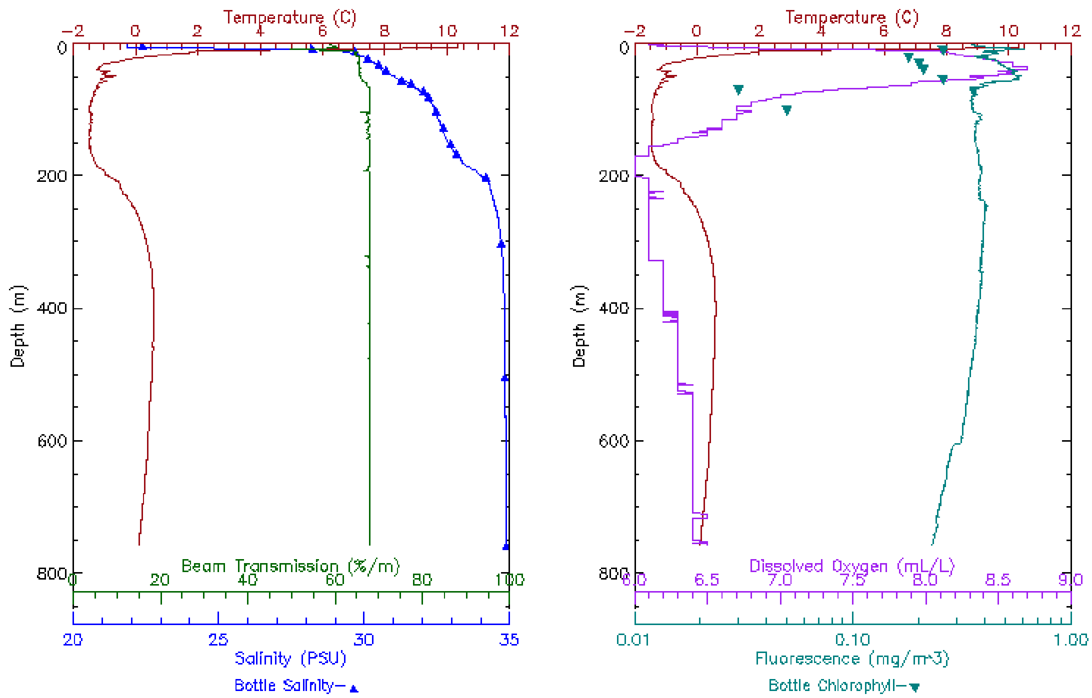
15/08/2012: Event 121, Station KUG-05 (Upper Slope)



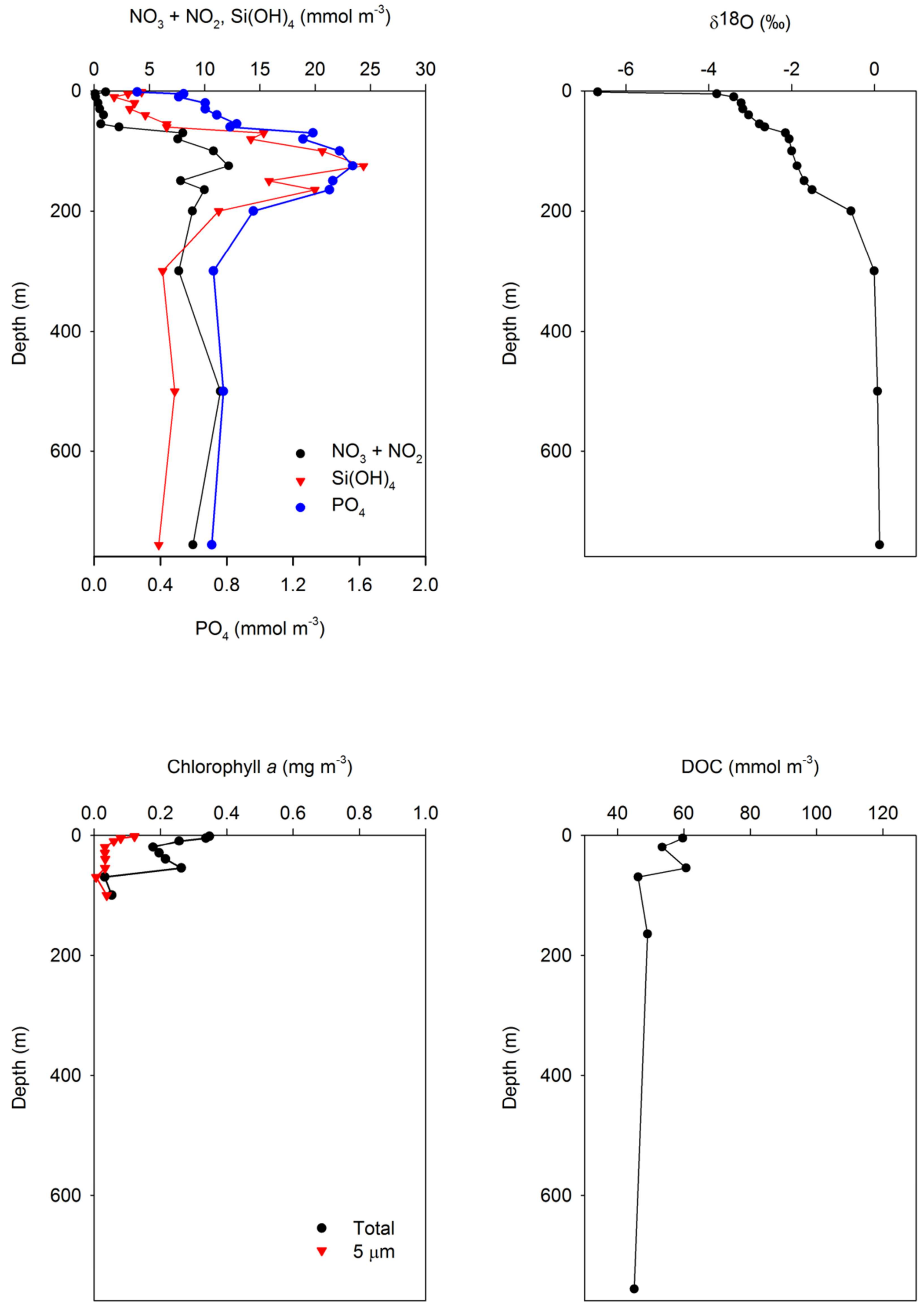
15/08/2012: Event 121, Station KUG-05 (Upper Slope)

No rosette sampling

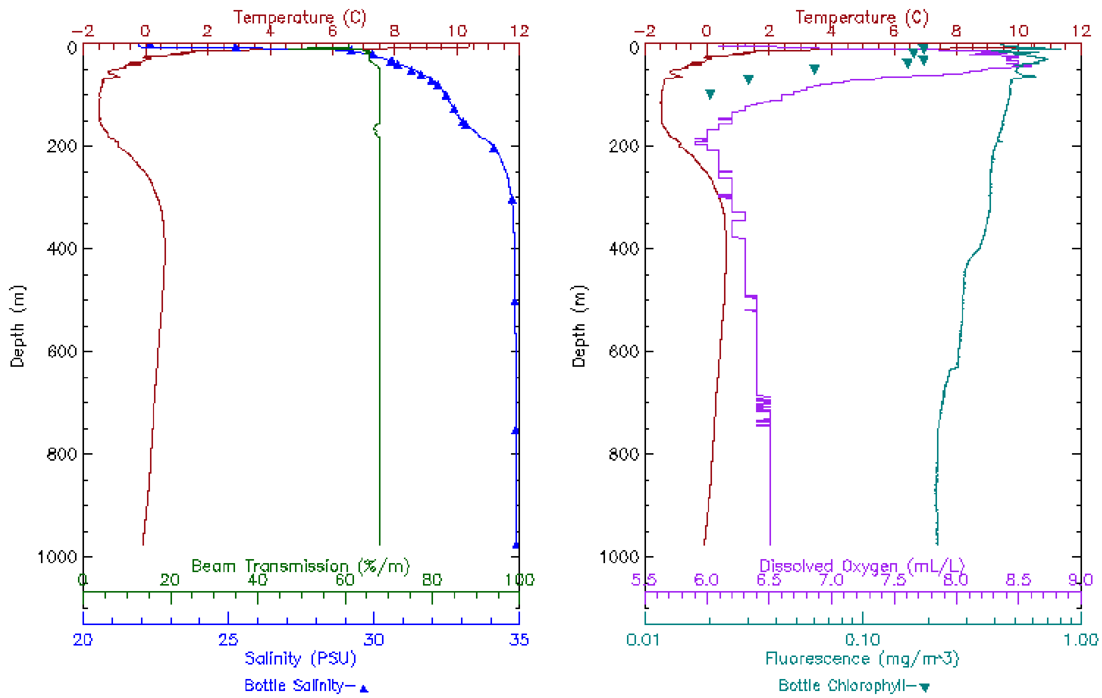
16/08/2012: Event 143, Station KUG-06 (Lower Slope)



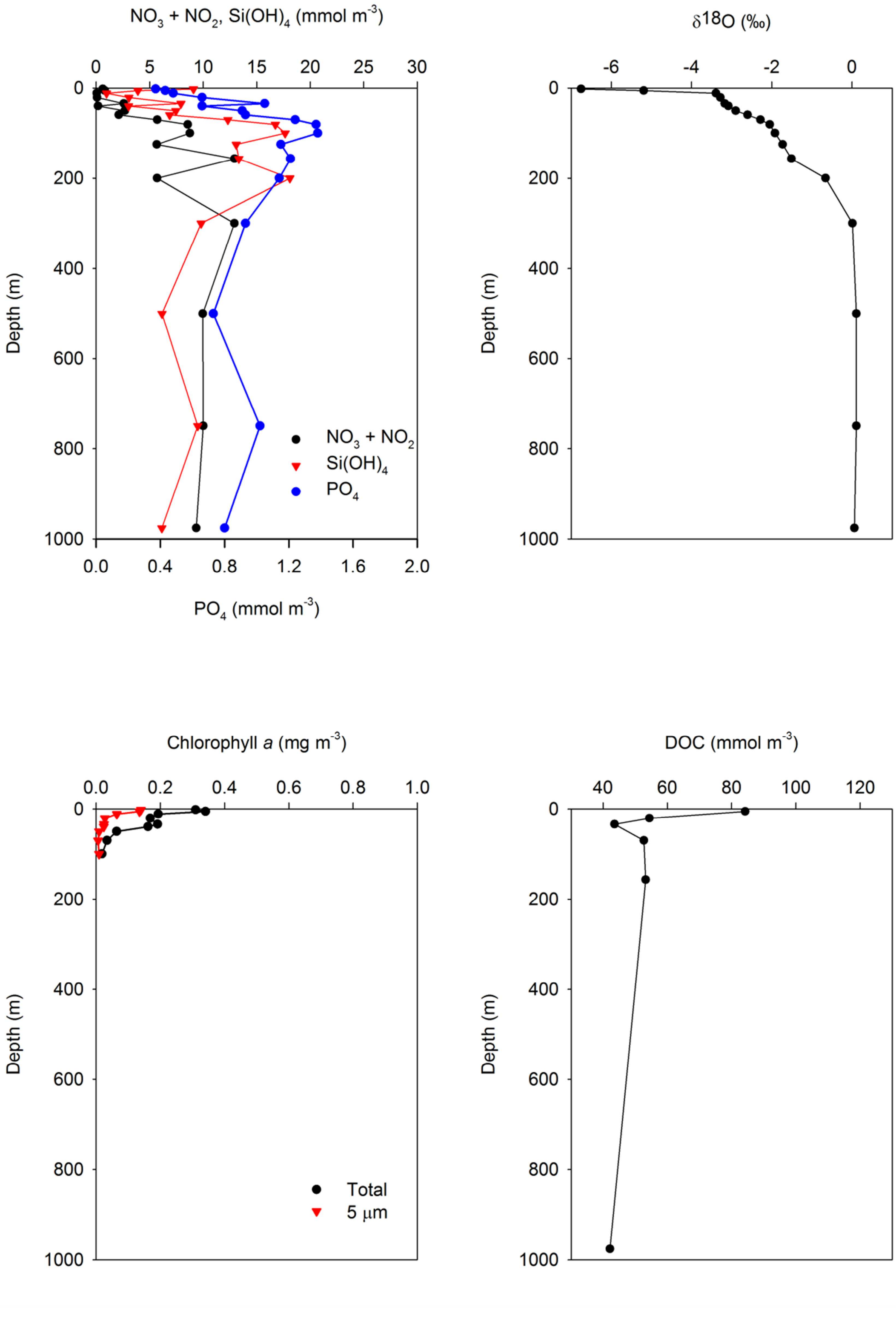
16/08/2012: Event 143, Station KUG-06 (Lower Slope)



17/08/2012: Event 149, Station KUG-07 (Lower Slope)

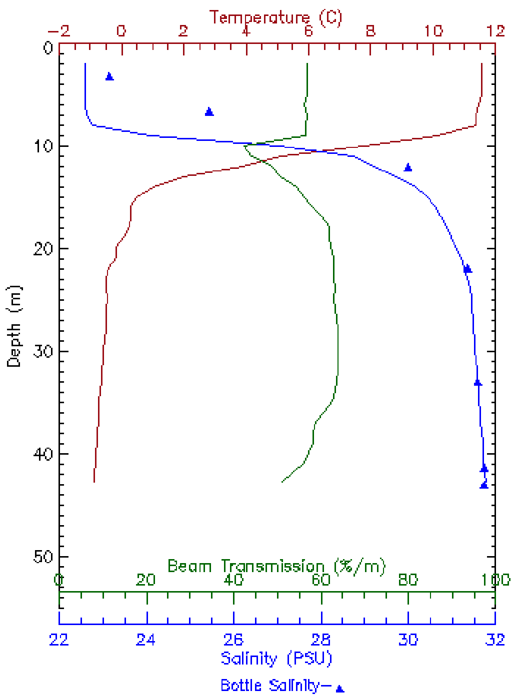


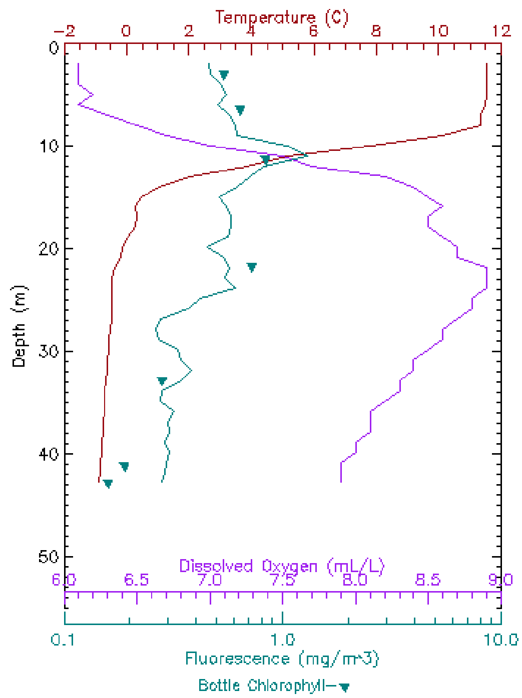
17/08/2012: Event 149, Station KUG-07 (Lower Slope)



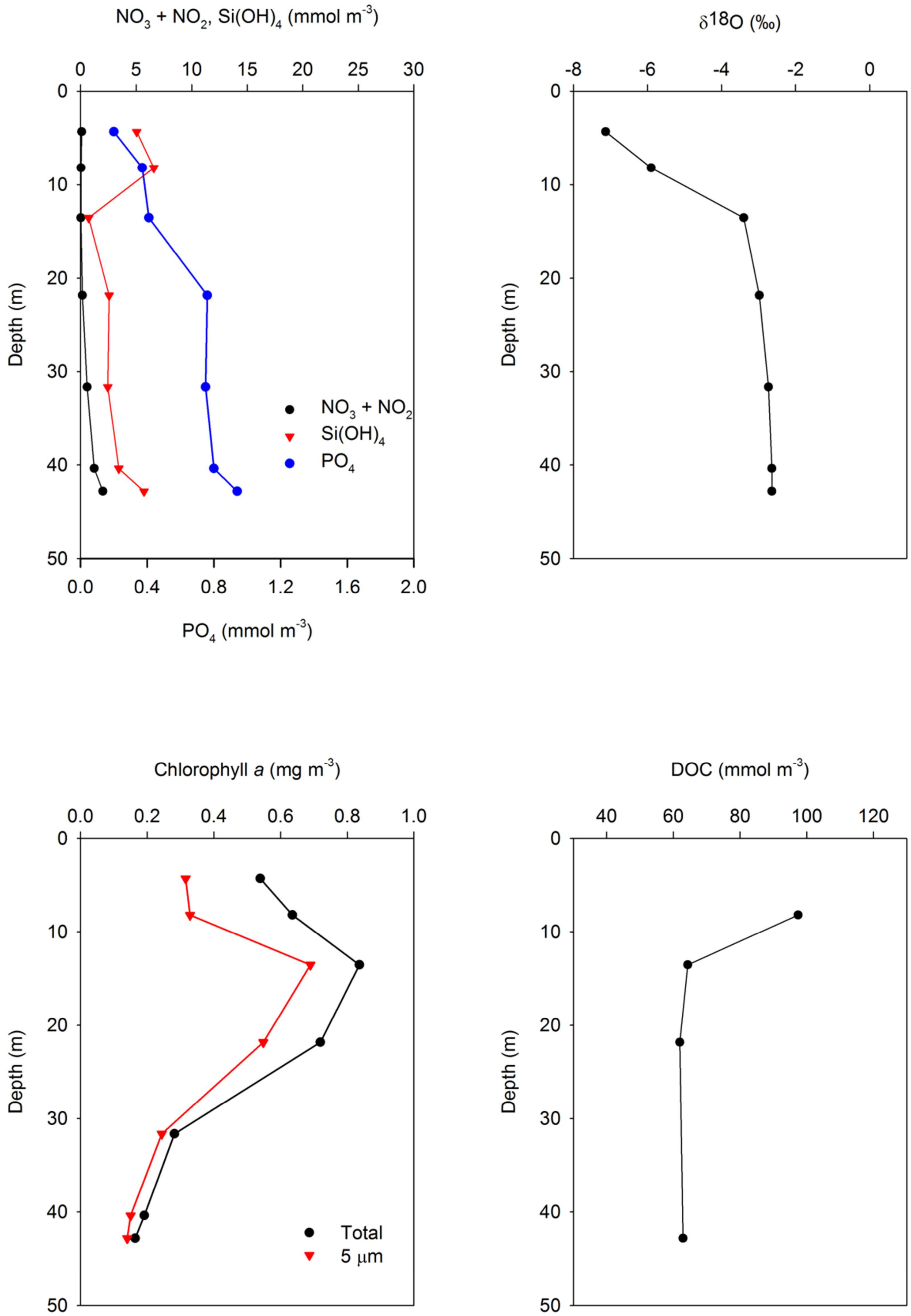
Appendix 4. CTD/Rosette station plots for the GRY transect stations during the BREA Marine Fishes project, August-September 2012. Plots are identified by station name and sampling date, expedition event number and fish habitat grouping. CTD plots (temperature, salinity, transmissivity, fluorescence and dissolved oxygen (DO)) are presented first, followed by the rosette plots (inorganic nutrients (NO_3 + NO_2, PO_4, $Si(OH)_4$), $\delta^{18}O$, chlorophyll a (total and 5 µm) and dissolved organic carbon (DOC)). Transect and cast details are provided in Figure 1 and Appendix 1.

19/08/2012: Event 170, Station GRY-01 (Shelf)

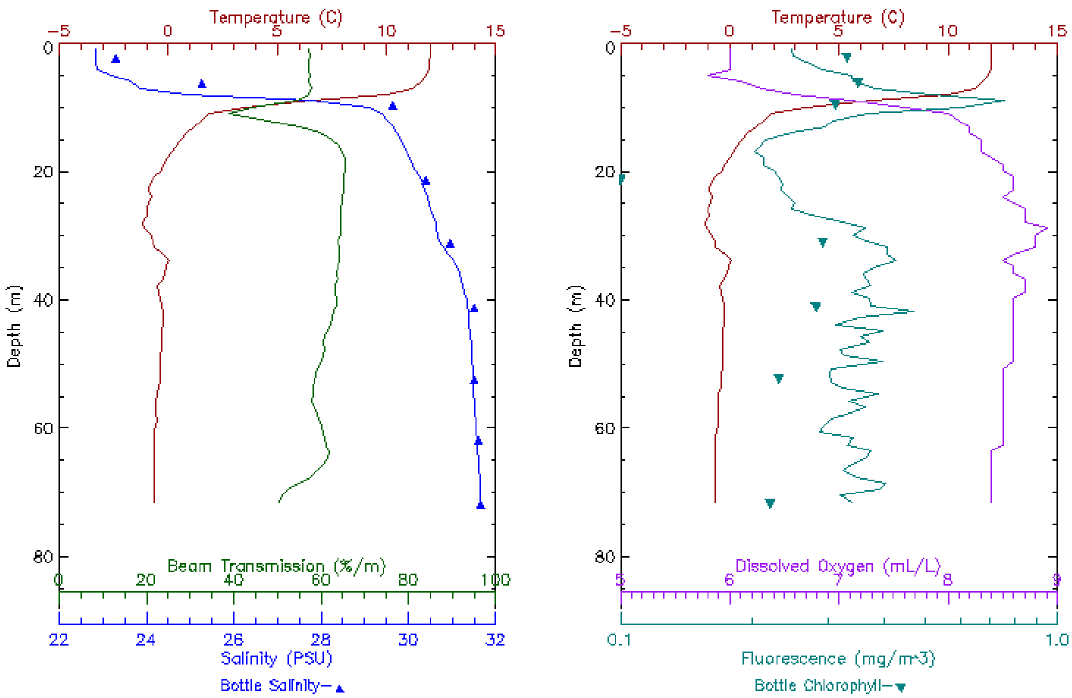




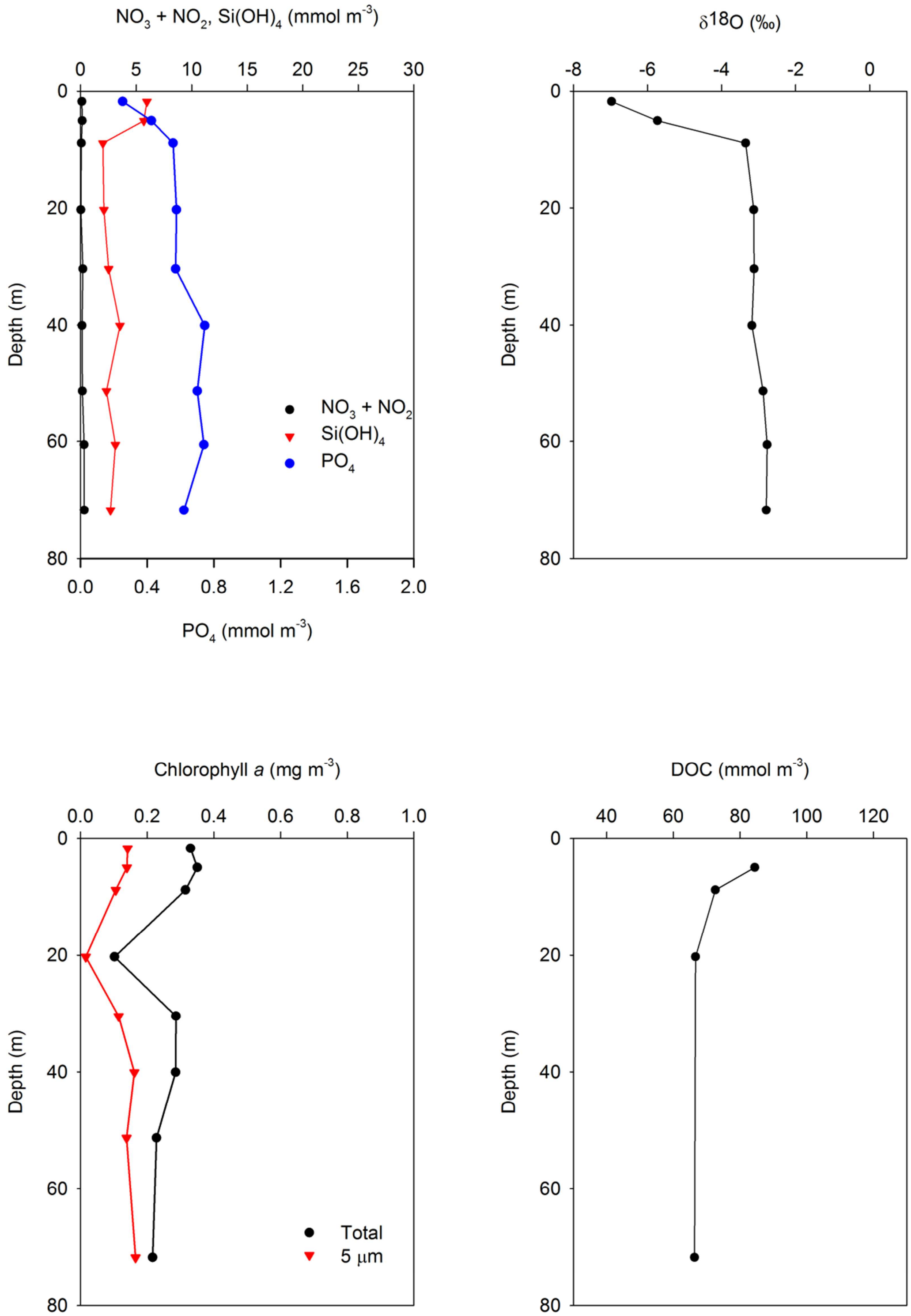
19/08/2012: Event 170, Station GRY-01 (Shelf)



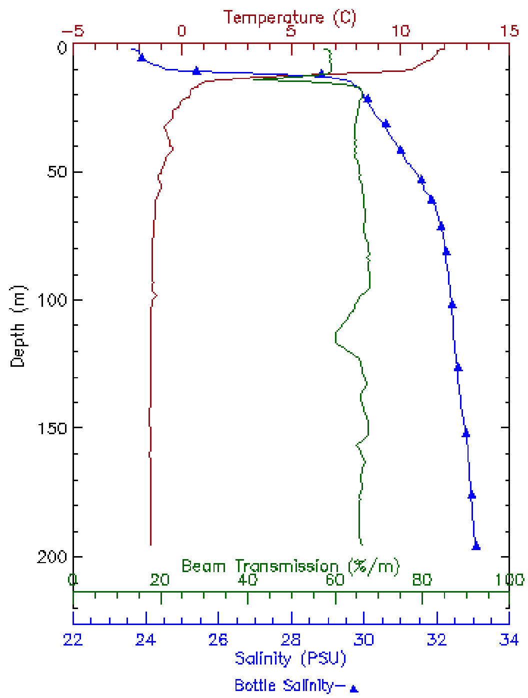
19/08/2012: Event 182, Station GRY-02 (Shelf)

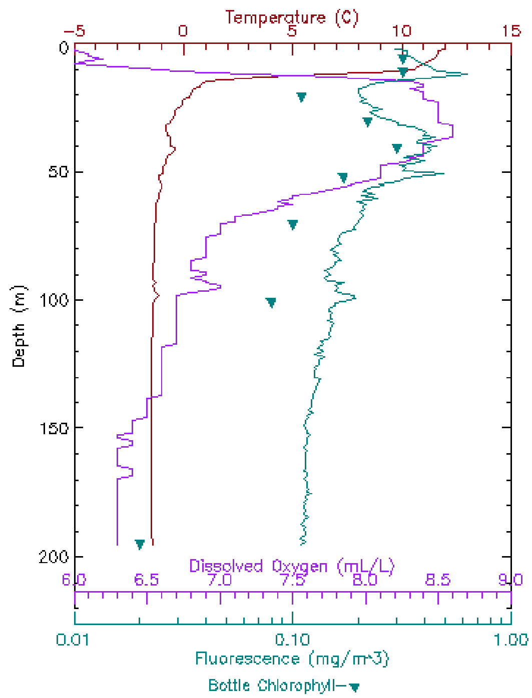


19/08/2012: Event 182, Station GRY-02 (Shelf)

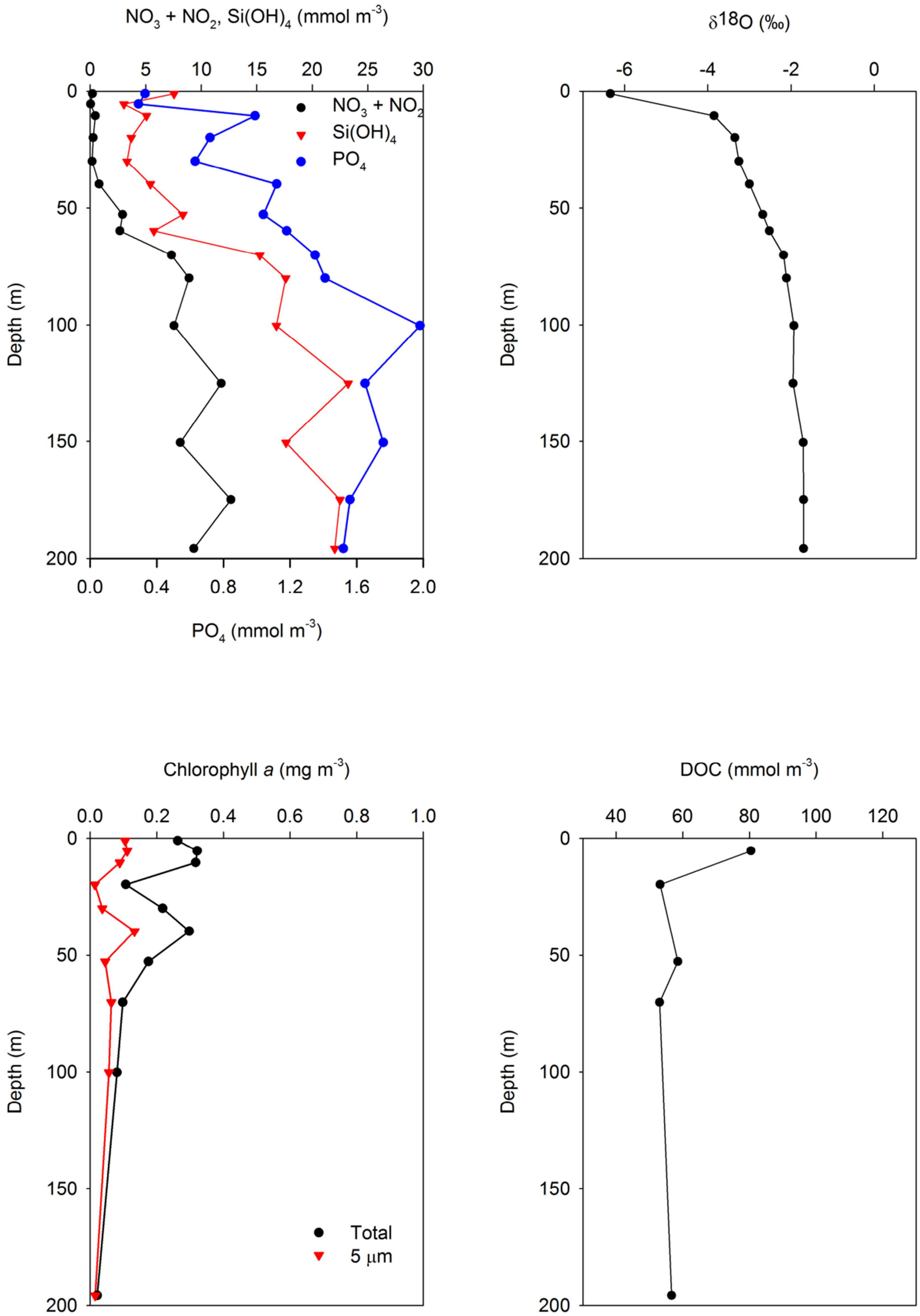


20/08/2012: Event 194, Station GRY-03 (Upper Slope)

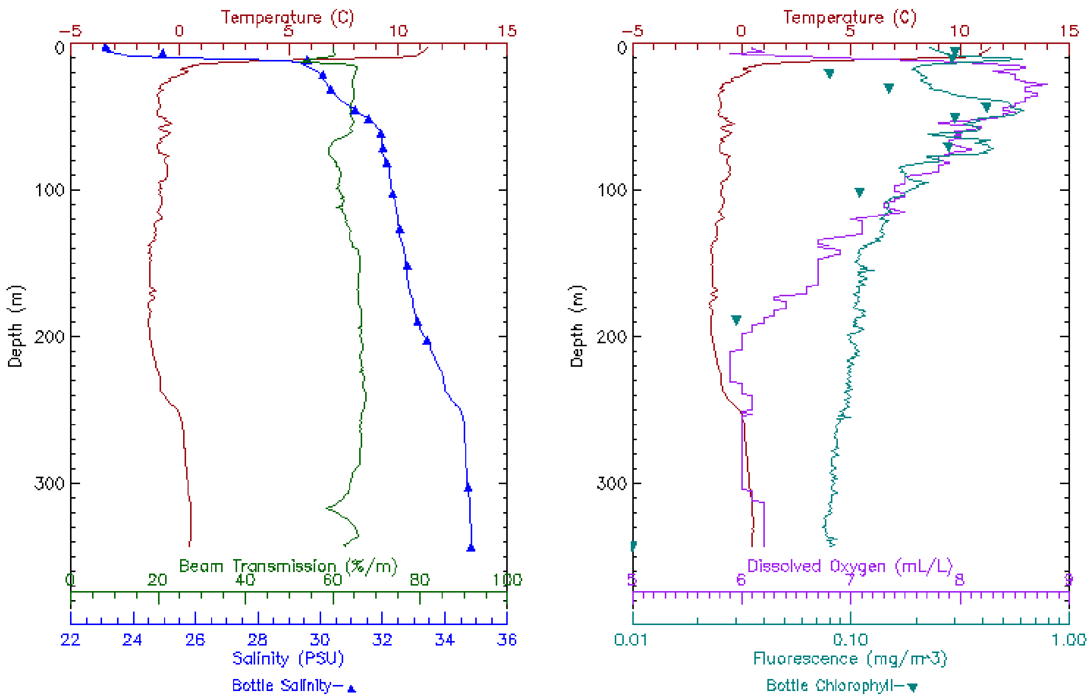




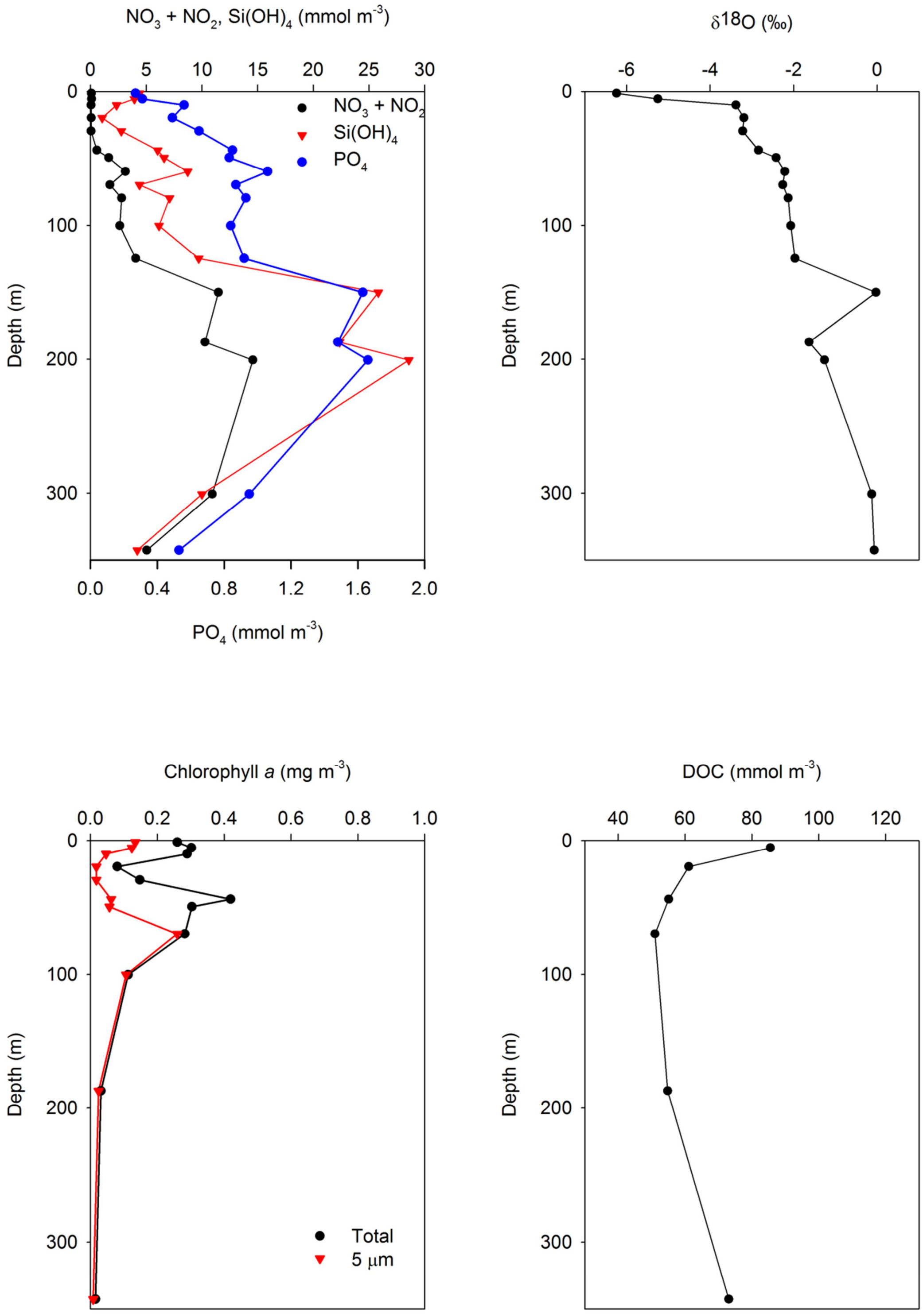
20/08/2012: Event 194, Station GRY-03 (Upper Slope)



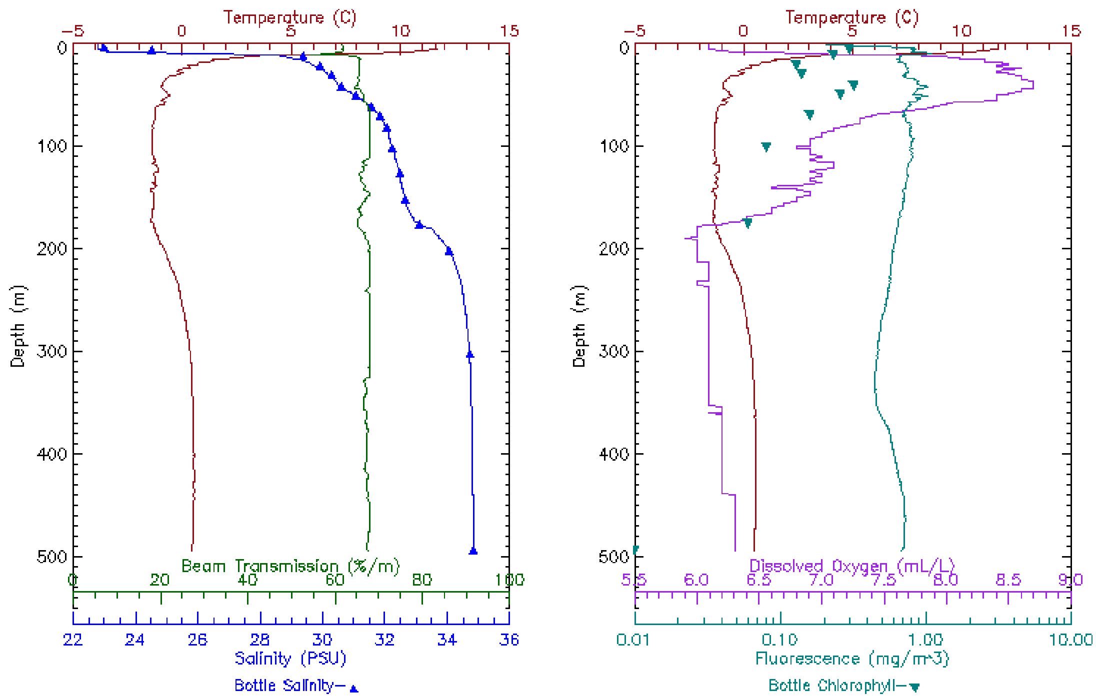
20/08/2012: Event 203, Station GRY-04 (Upper Slope)



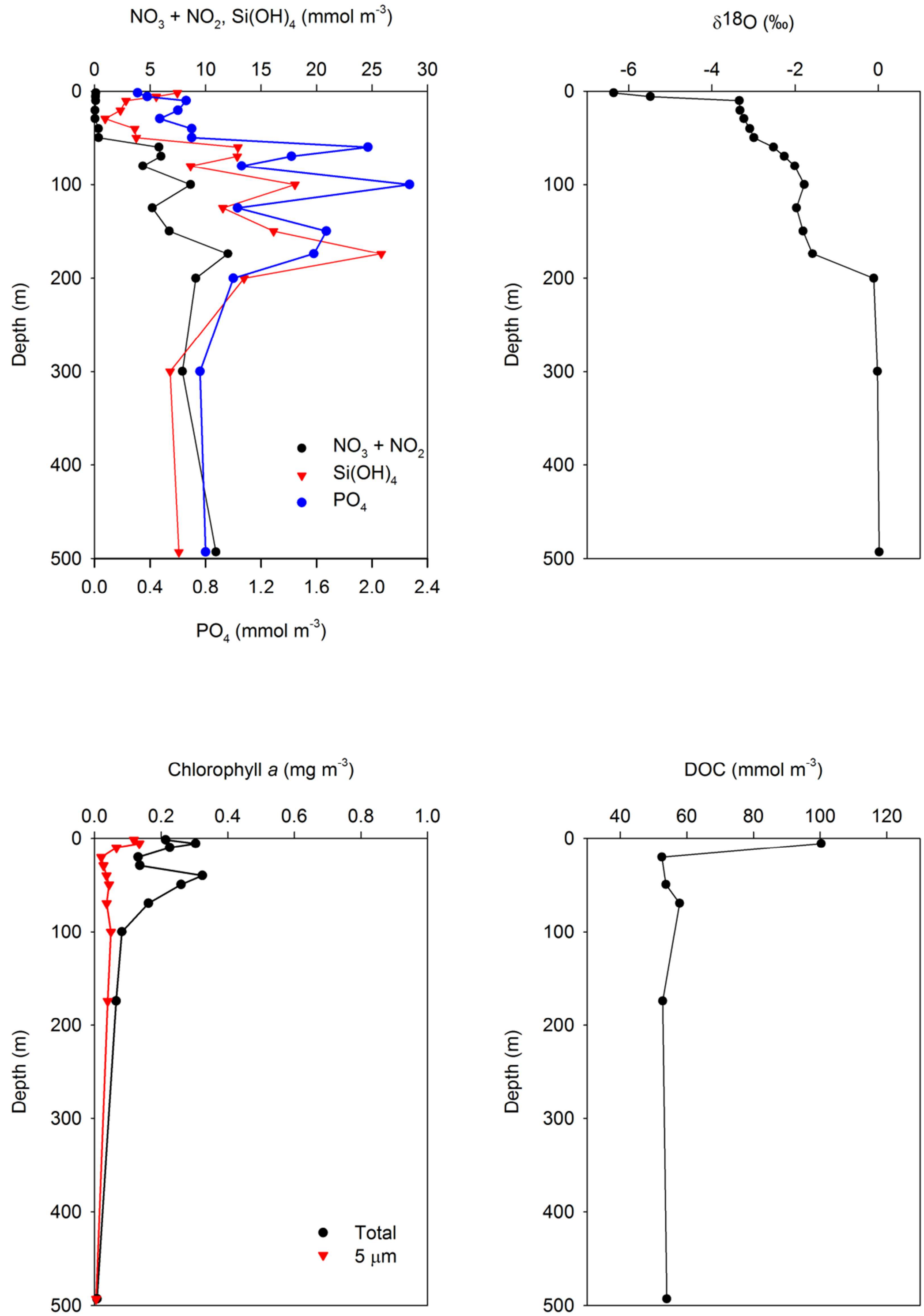
20/08/2012: Event 203, Station GRY-04 (Upper Slope)



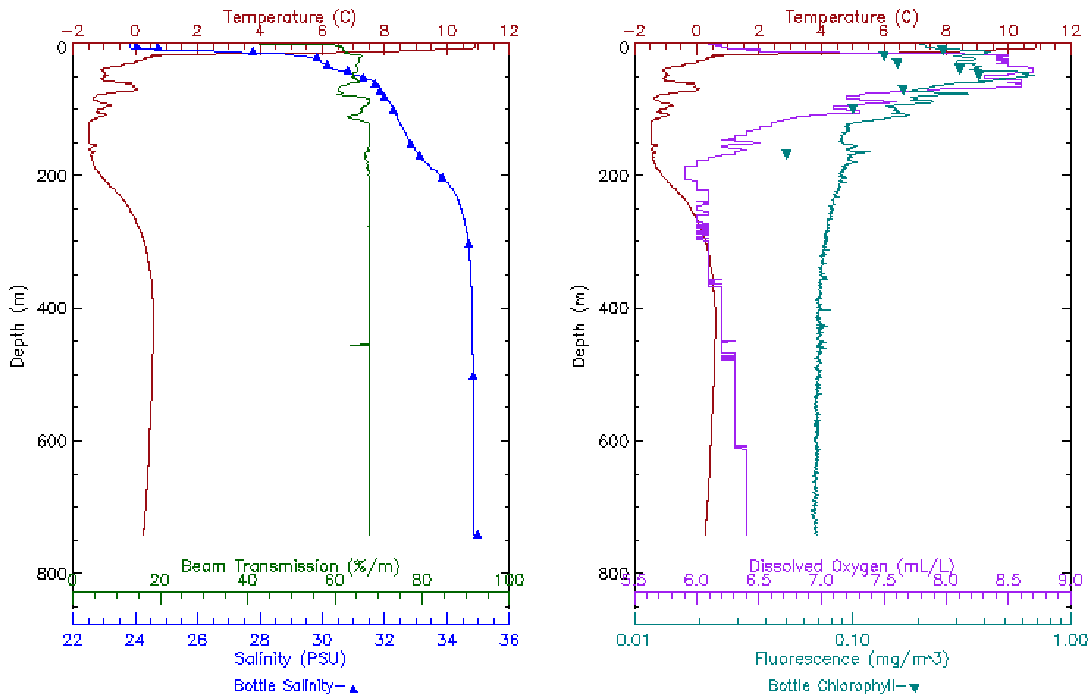
22/08/2012: Event 211, Station GRY-05 (Lower Slope)



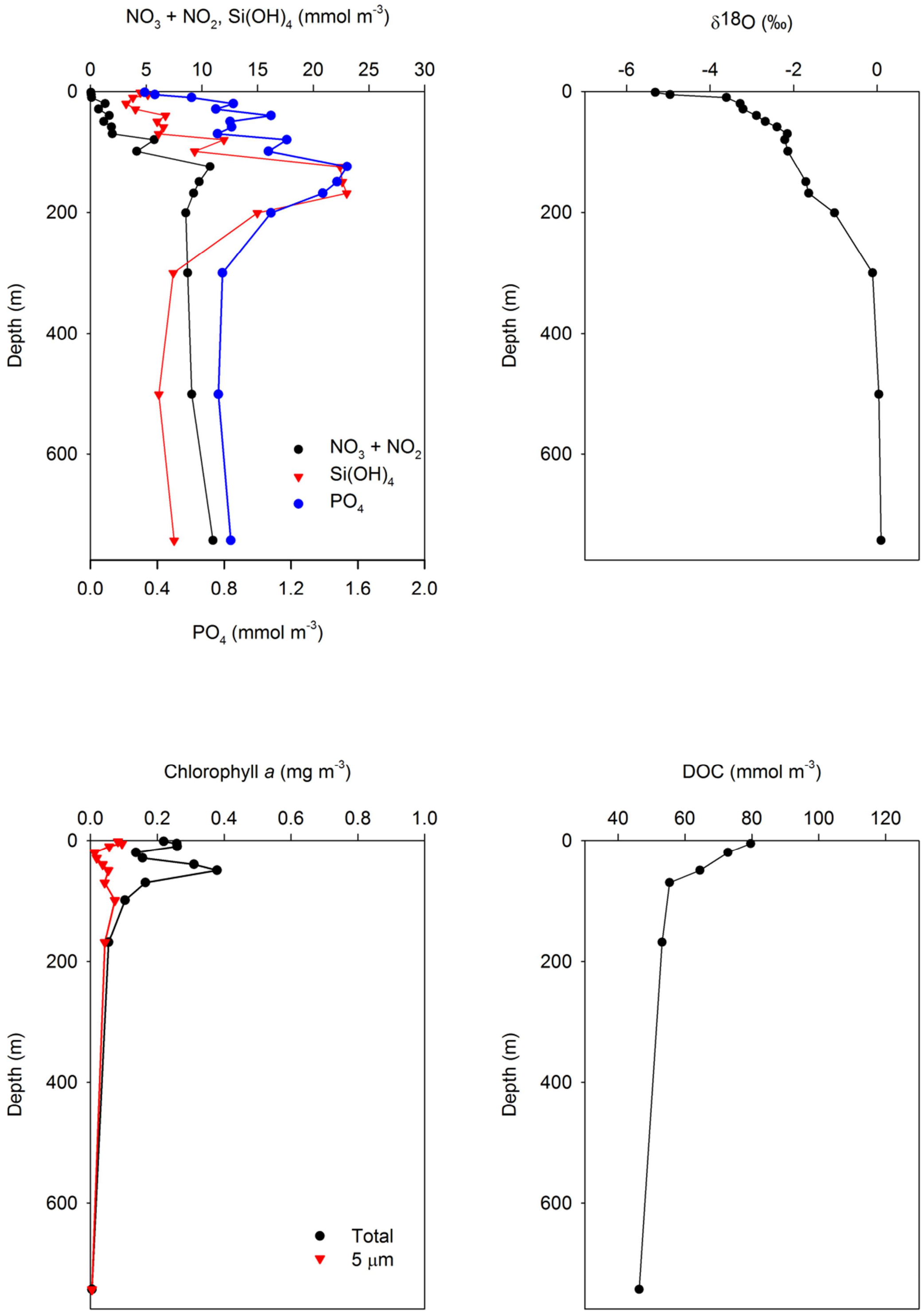
22/08/2012: Event 211, Station GRY-05 (Lower Slope)



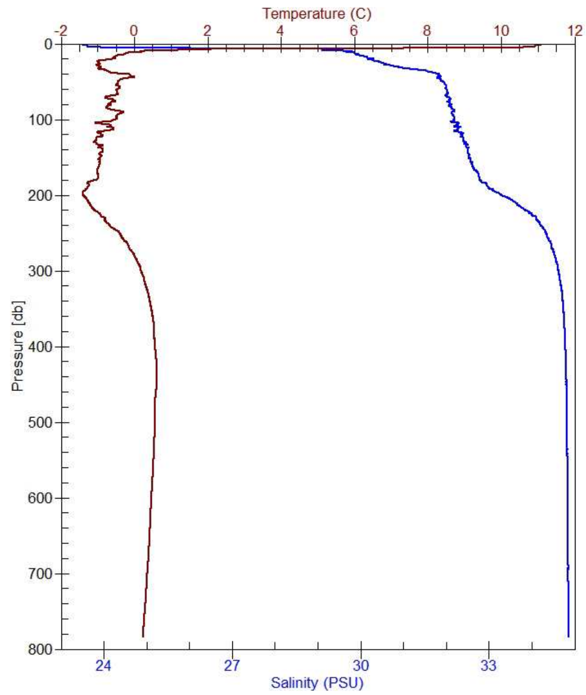
22/08/2012: Event 221, Station GRY-06 (Lower Slope)



22/08/2012: Event 221, Station GRY-06 (Lower Slope)



23/08/2012: Event 228, Station GRY-07 (Lower Slope)

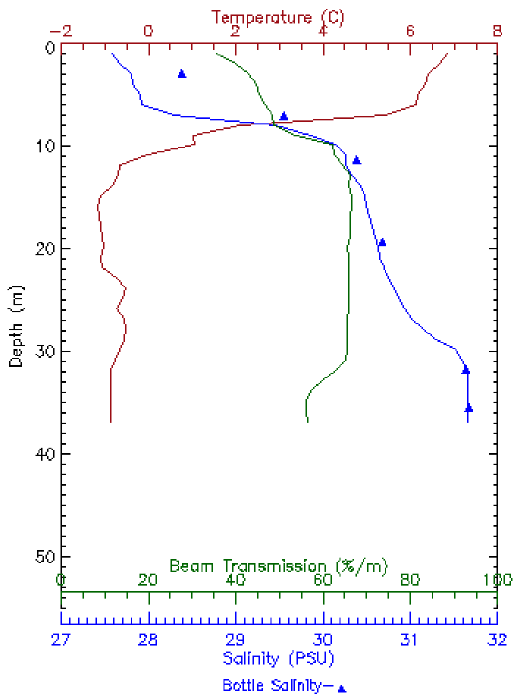


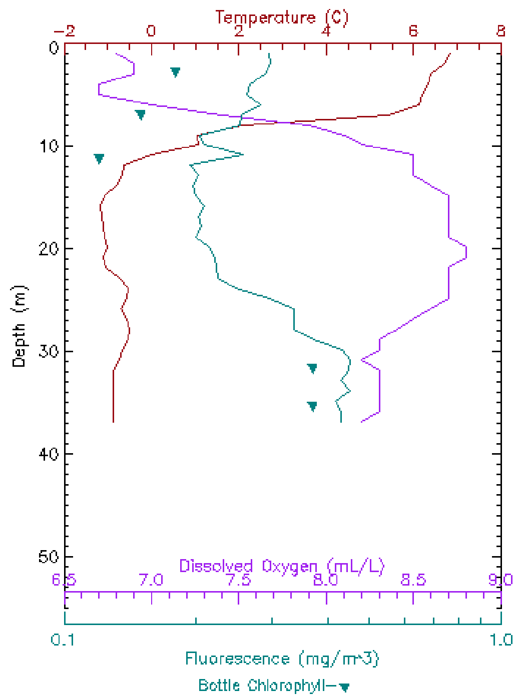
23/08/2012: Event 228, Station GRY-07 (Lower Slope)

No rosette sampling

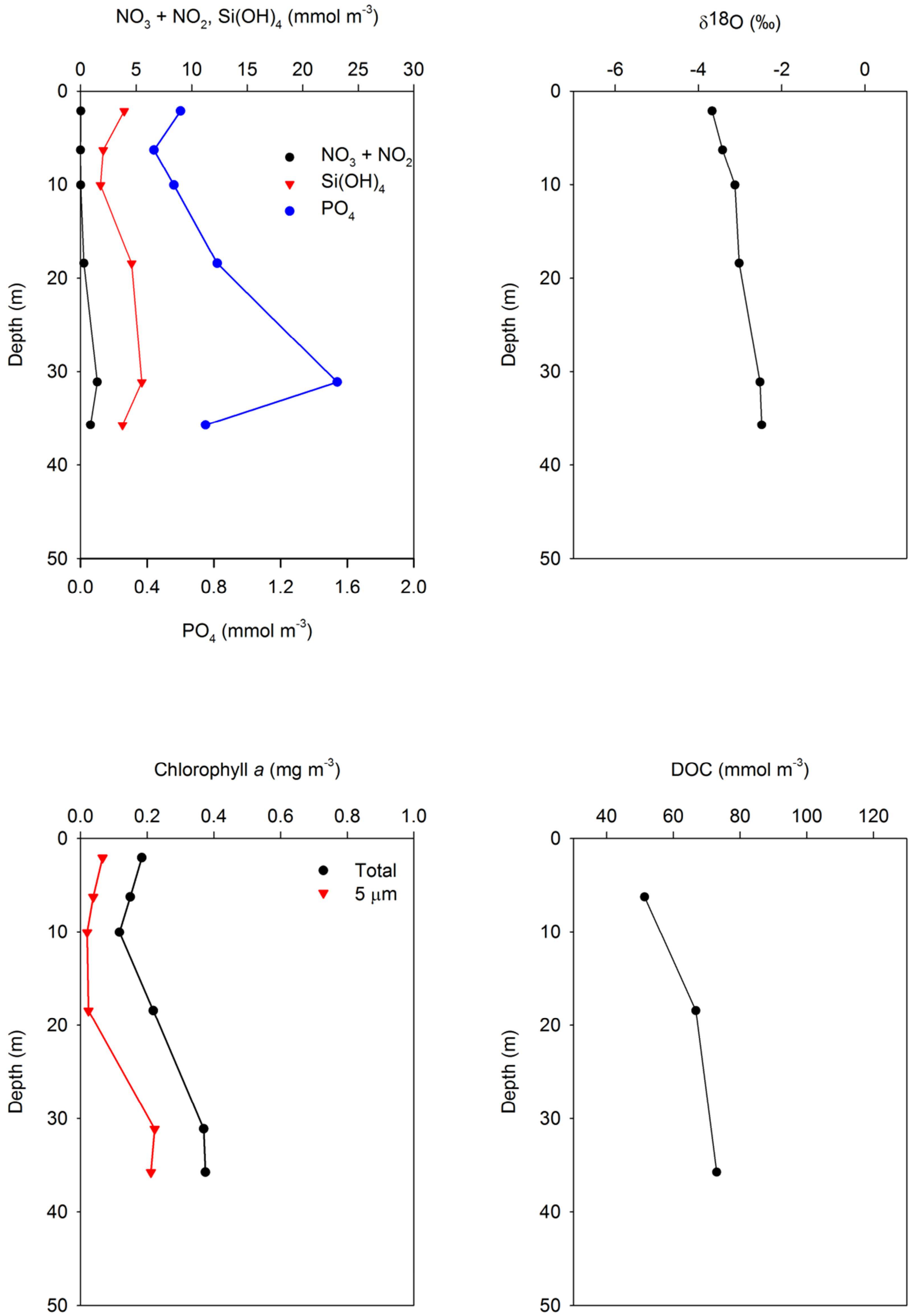
Appendix 5. CTD/Rosette station plots for the TBS transect stations during the BREA Marine Fishes project, August-September 2012. Plots are identified by station name and sampling date, expedition event number and fish habitat grouping. CTD plots (temperature, salinity, transmissivity, fluorescence and dissolved oxygen (DO)) are presented first, followed by the rosette plots (inorganic nutrients (NO_3 + NO_2, PO_4, $Si(OH)_4$), $\delta^{18}O$, chlorophyll a (total and 5 µm) and dissolved organic carbon (DOC)). Transect and cast details are provided in Figure 1 and Appendix 1.

25/08/2012: Event 253, Station TBS-01 (Shelf)

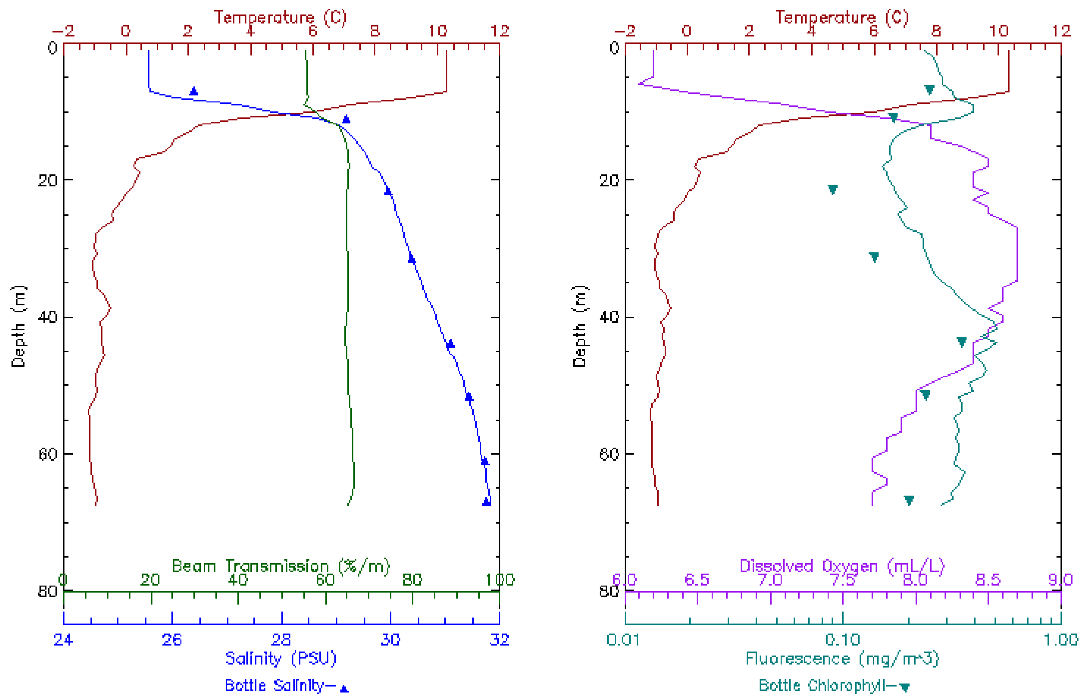




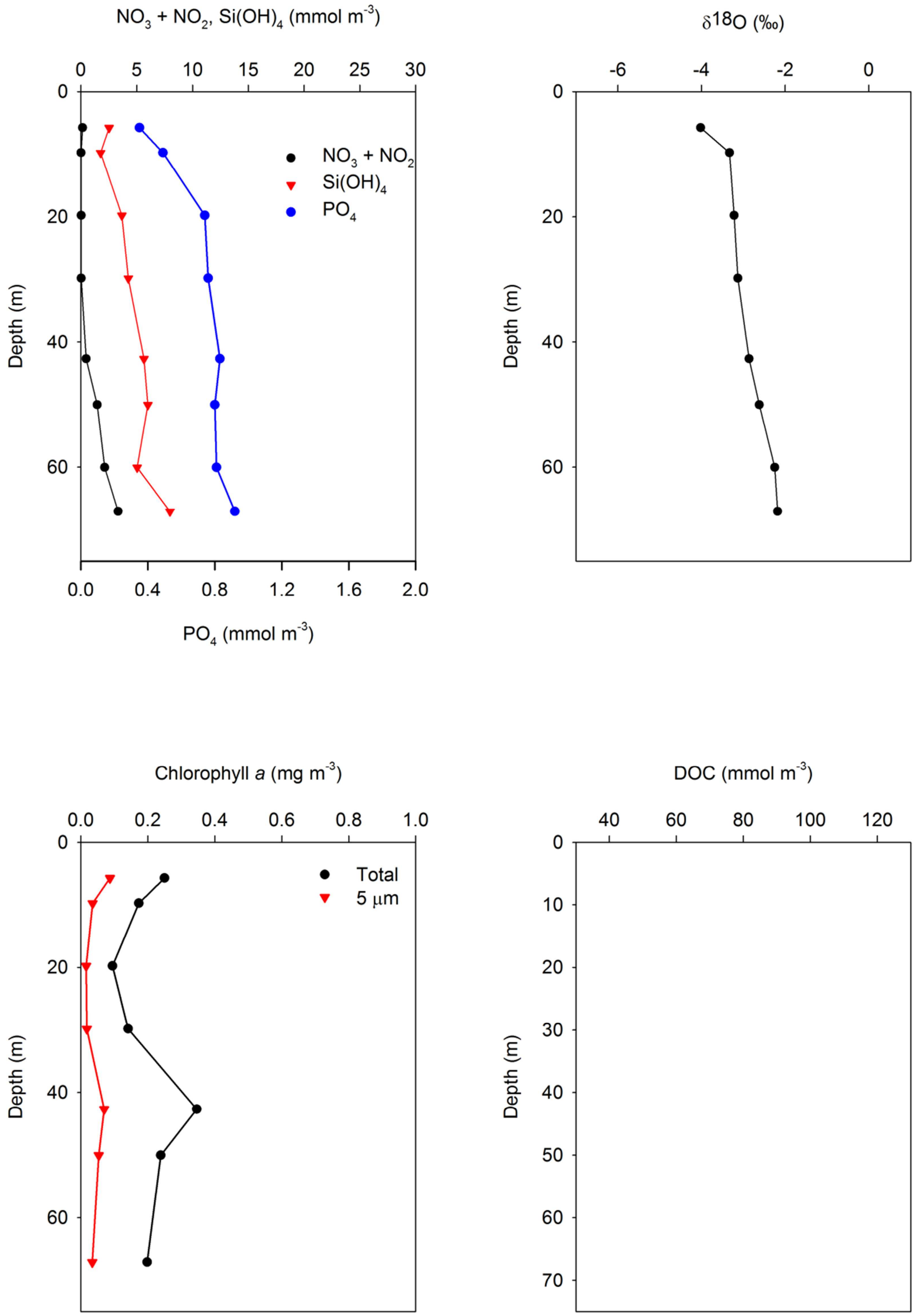
25/08/2012: Event 253, Station TBS-01 (Shelf)



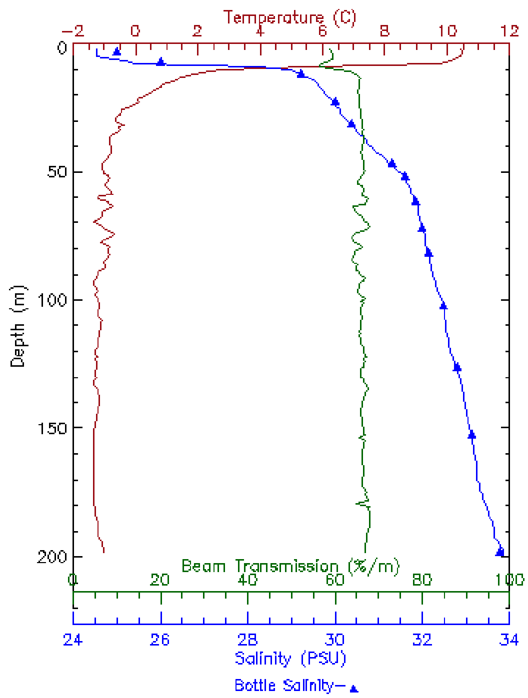
25/08/2012: Event 263, Station TBS-02 (Shelf)

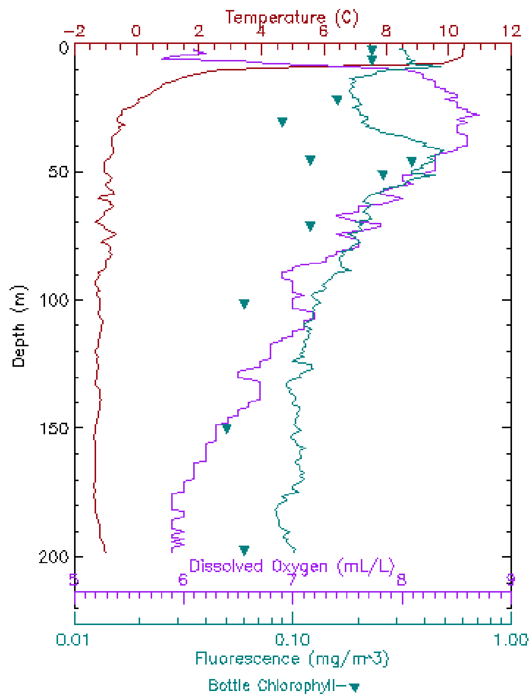


25/08/2012: Event 263, Station TBS-02 (Shelf)

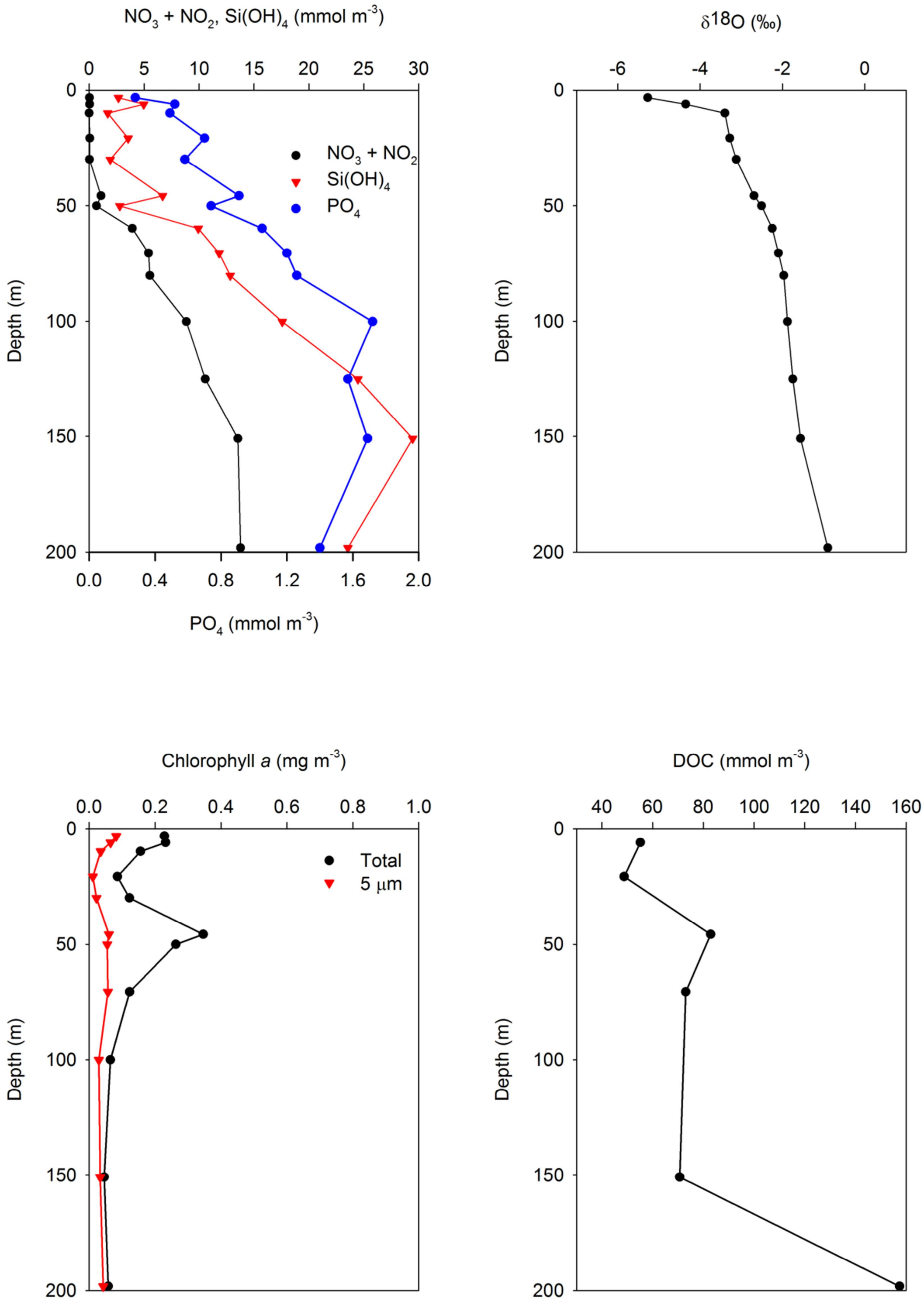


26/08/2012: Event 276, Station TBS-03 (Upper Slope)

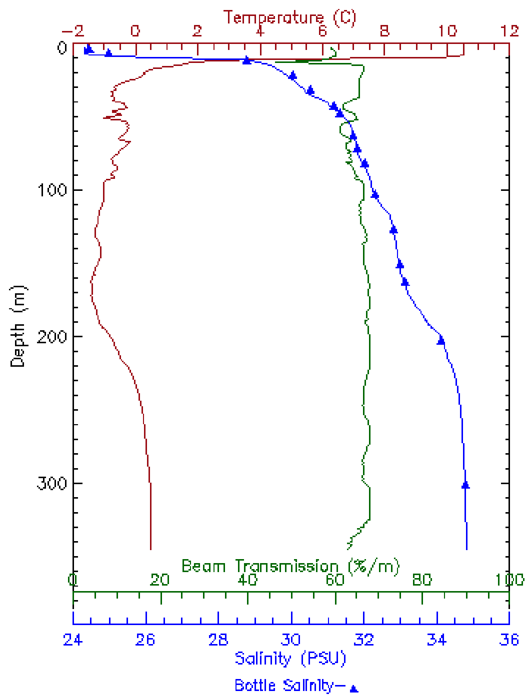


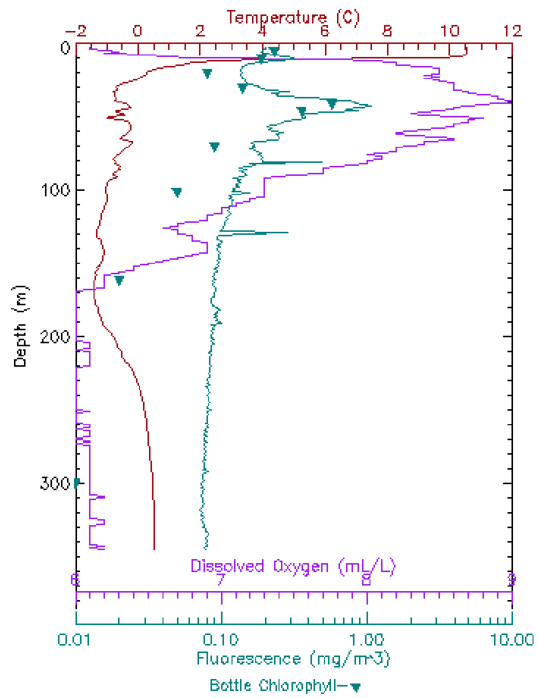


26/08/2012: Event 276, Station TBS-03 (Upper Slope)

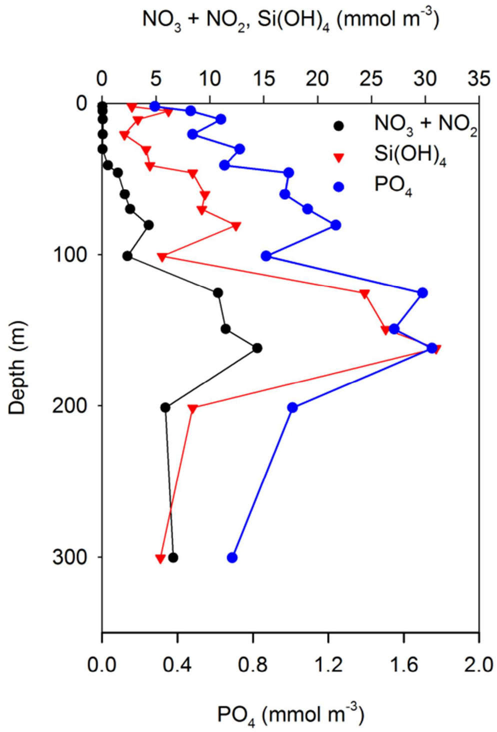


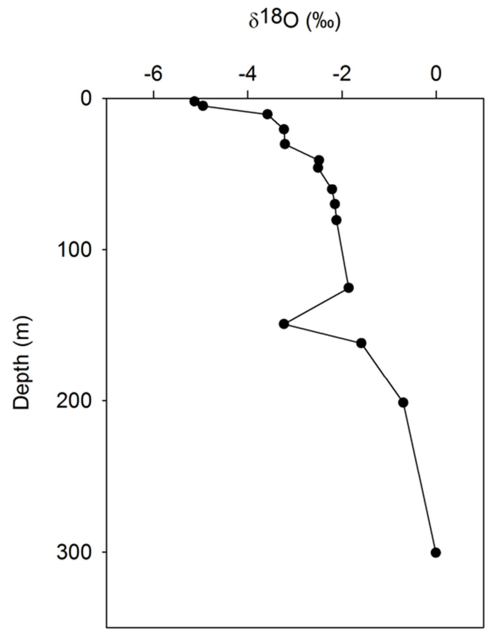
26/08/2012: Event 285, Station TBS-04 (Upper Slope)

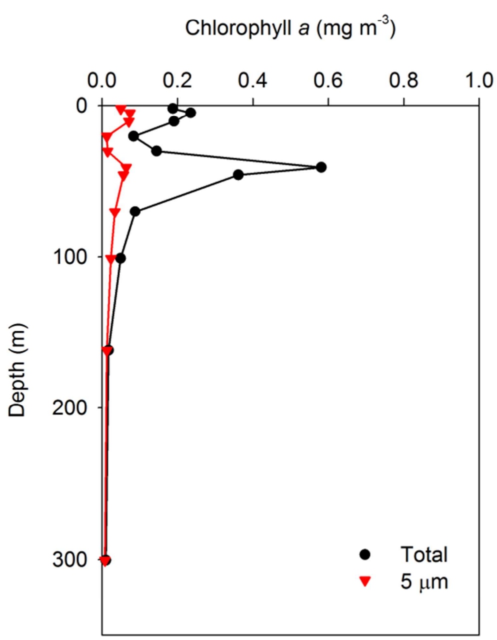


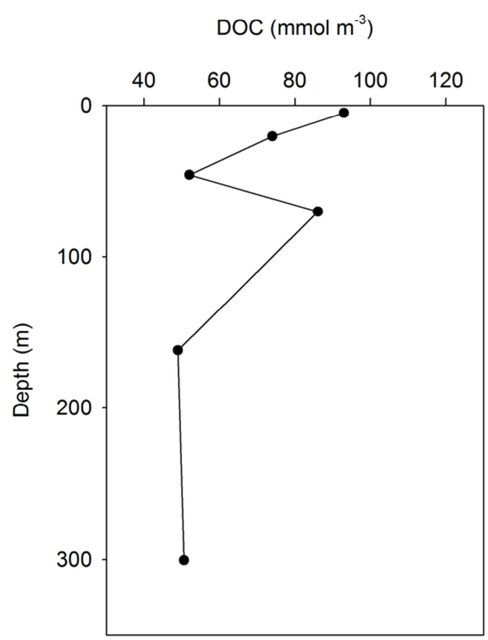


26/08/2012: Event 285, Station TBS-04 (Upper Slope)

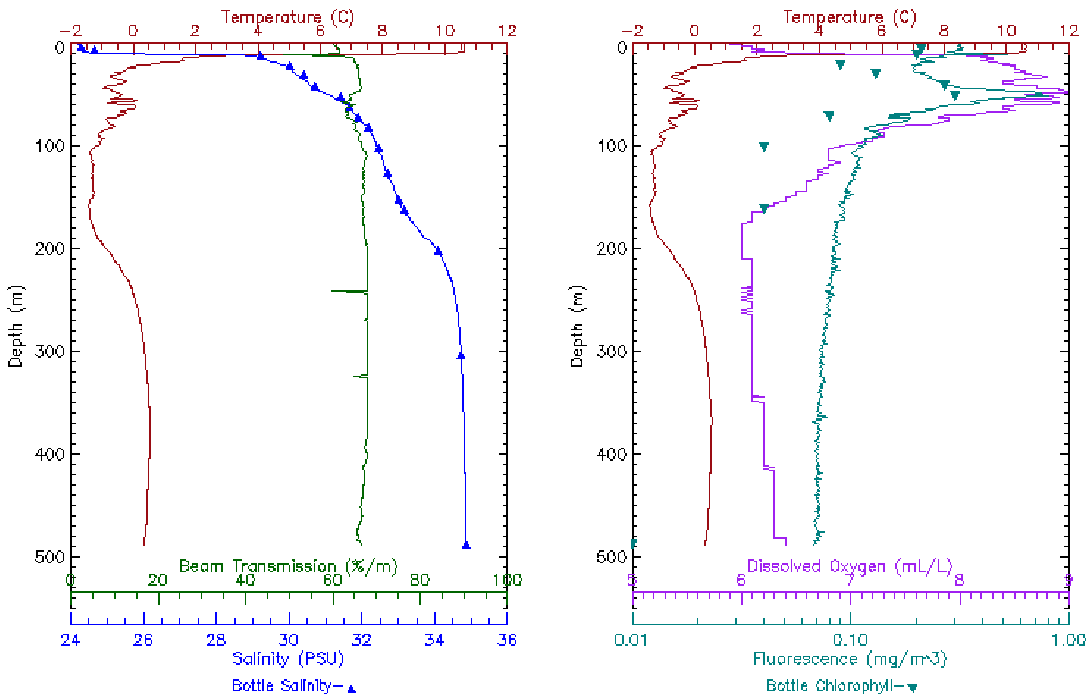




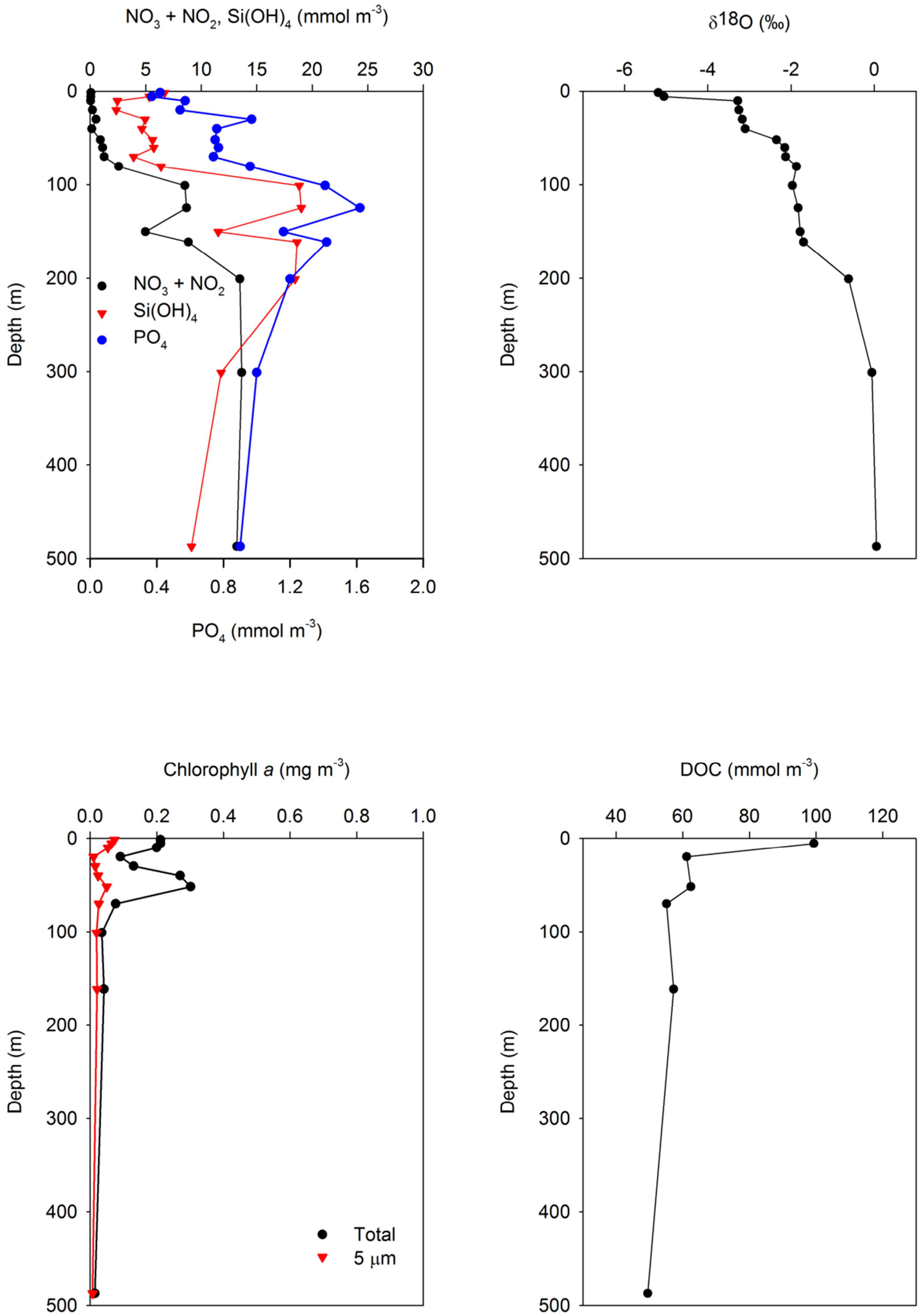




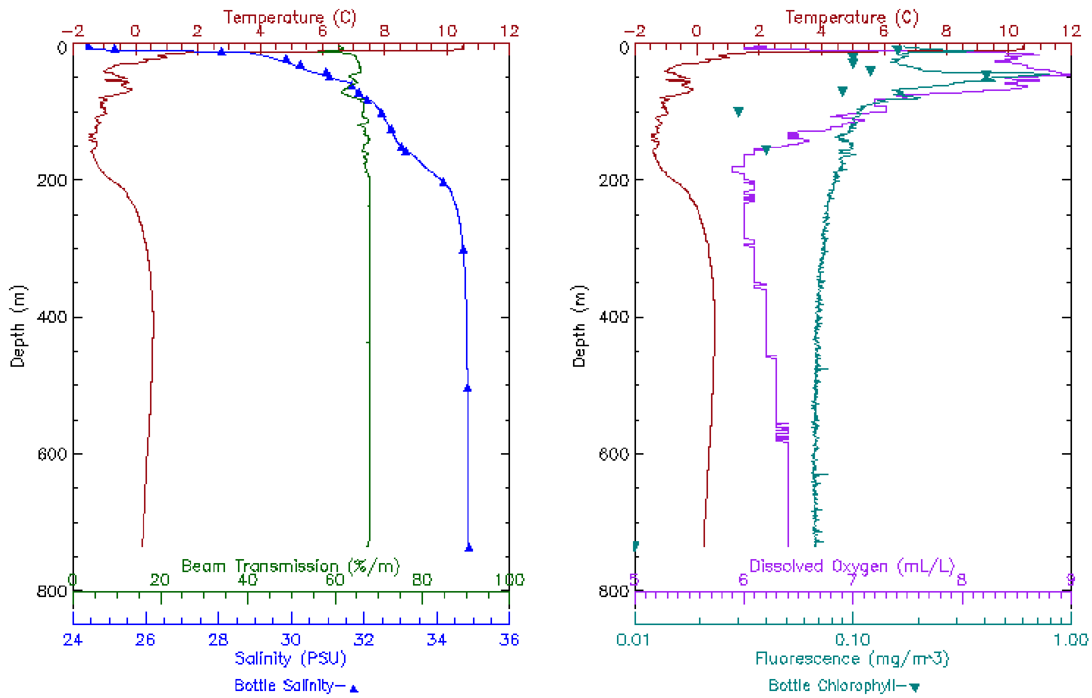
27/08/2012: Event 297, Station TBS-05 (Lower Slope)



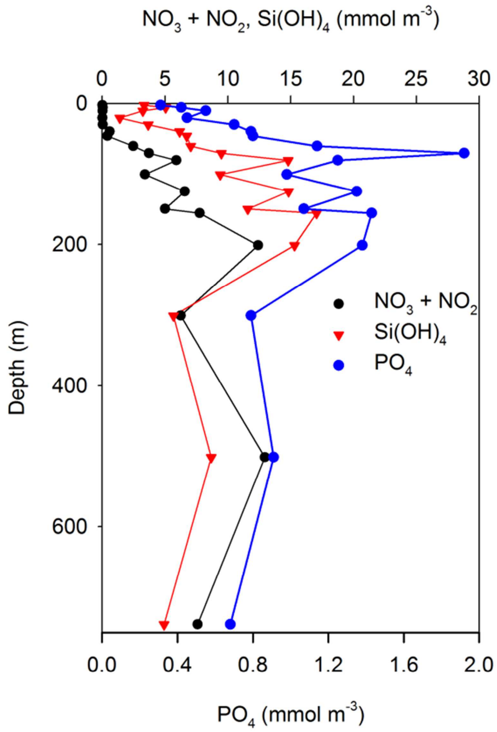
27/08/2012: Event 297, Station TBS-05 (Lower Slope)

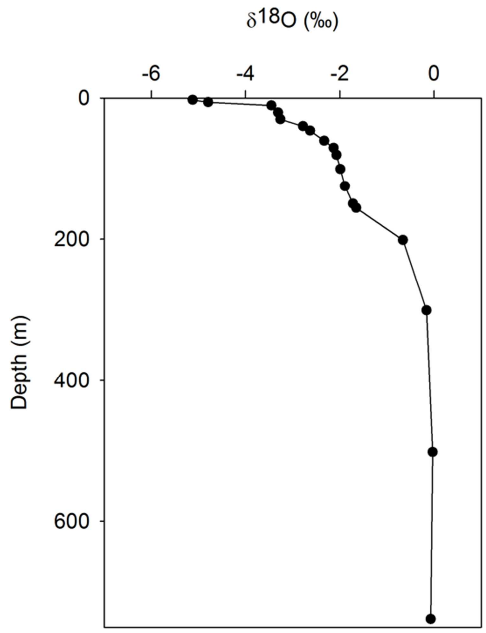


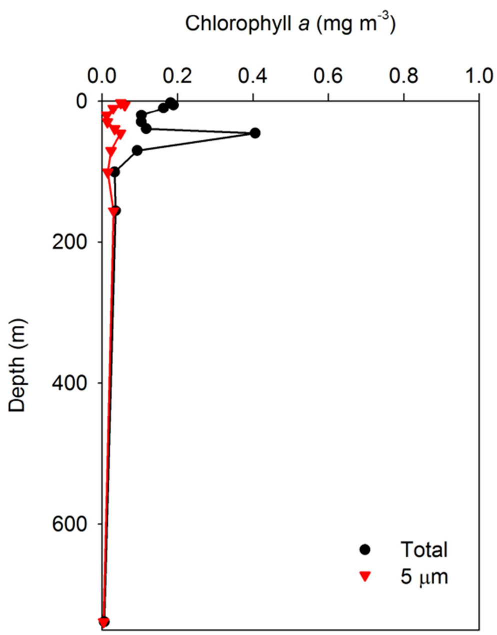
27/08/2012: Event 306, Station TBS-06 (Lower Slope)

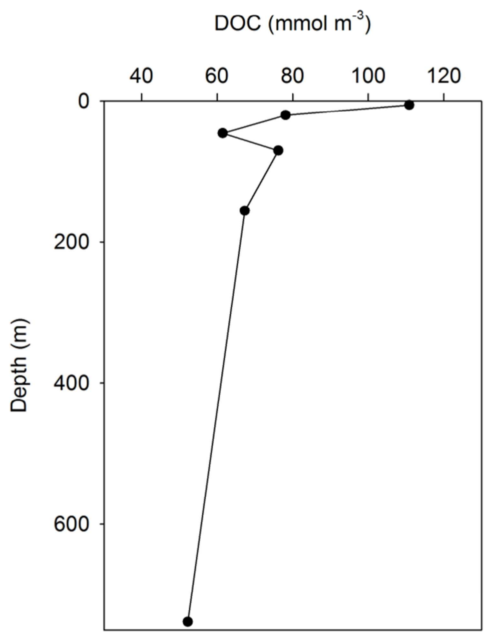


27/08/2012: Event 306, Station TBS-06 (Lower Slope)

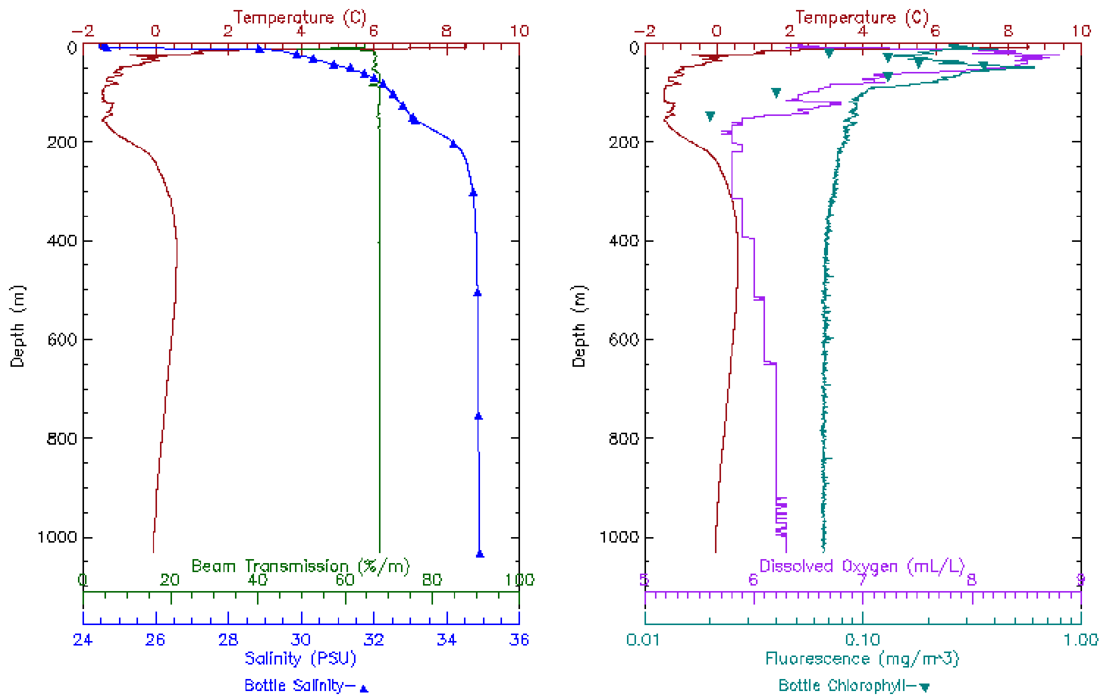




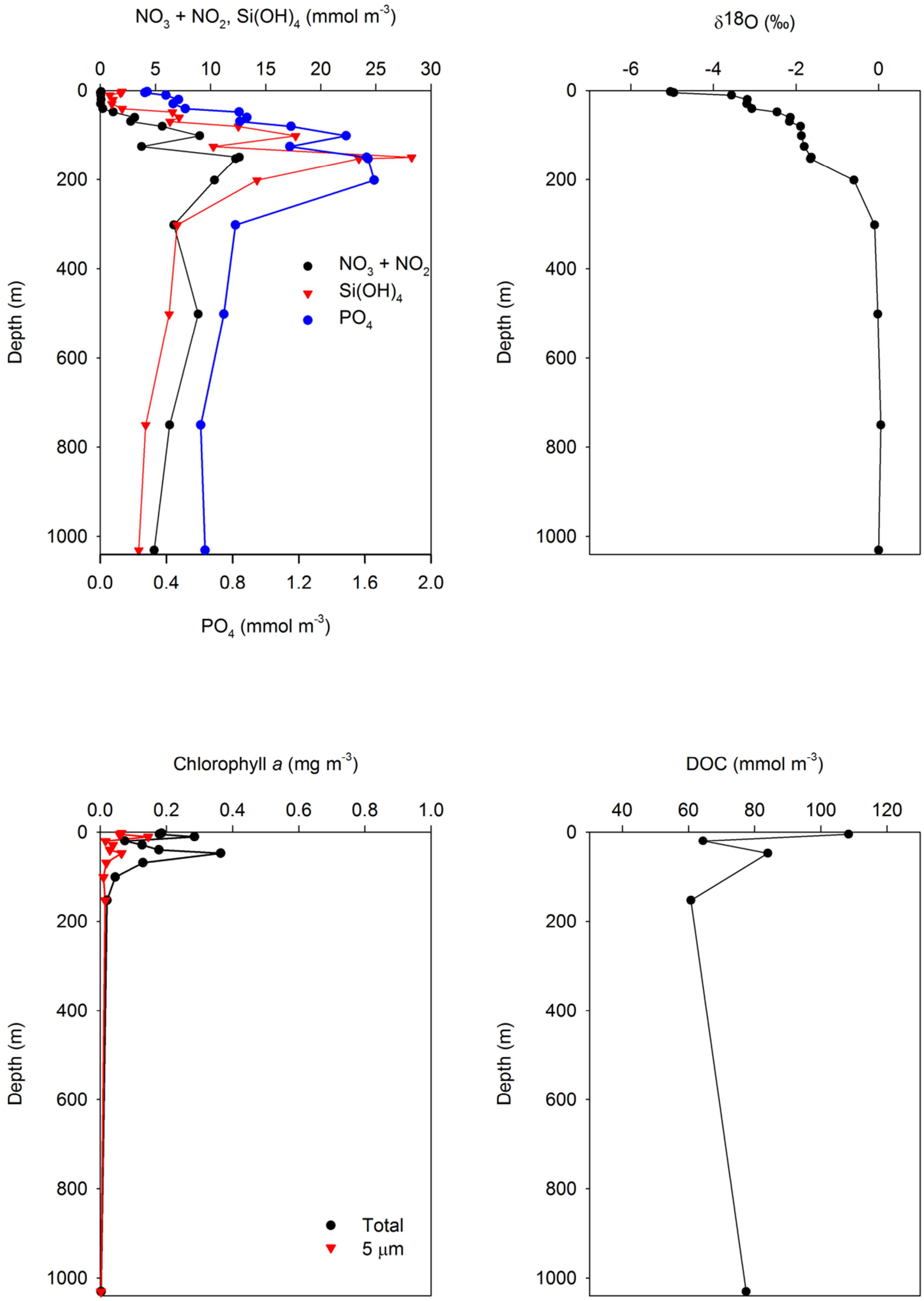




30/08/2012: Event 332, Station TBS-07 (Lower Slope)

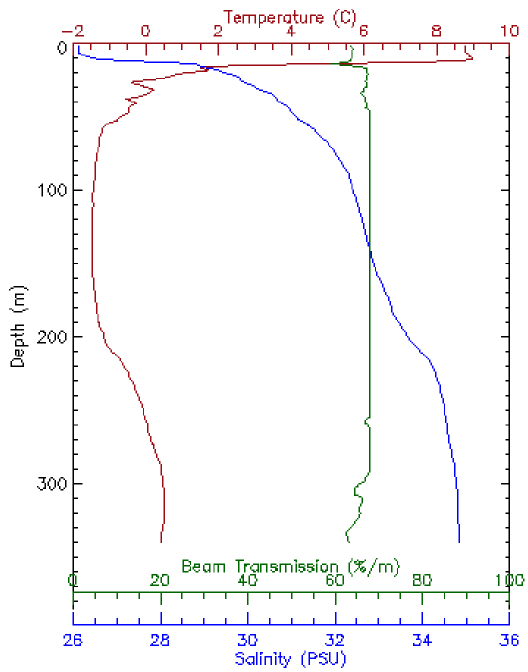


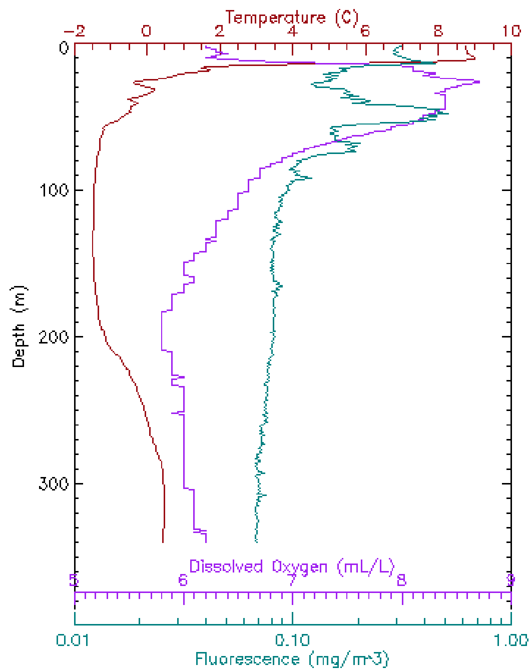
30/08/2012: Event 332, Station TBS-07 (Lower Slope)



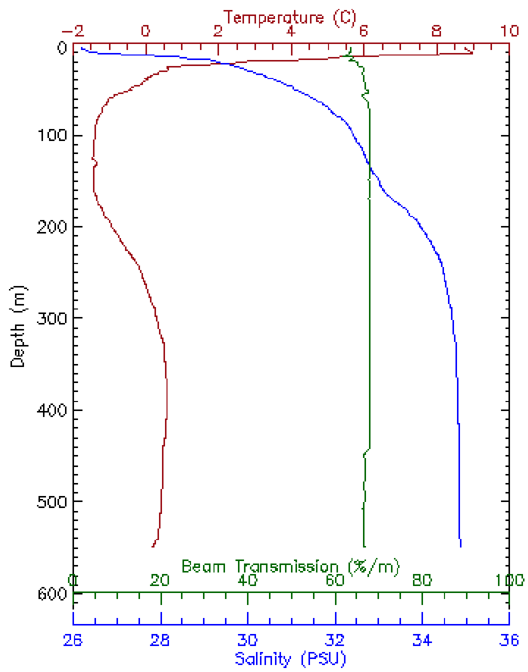
Appendix 6. CTD station plots for the HCT transect stations during the BREA Marine Fishes project, September 2012. Plots are identified by station name and sampling date, expedition event number and fish habitat grouping. CTD plots present temperature, salinity, transmissivity, fluorescence and dissolved oxygen (DO) data. Transect and cast details are provided in Figure 1 and Appendix 1.

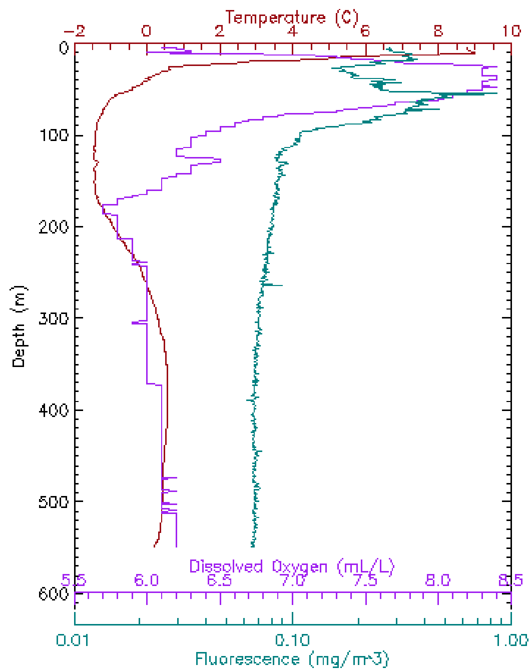
01/09/2012: Event 336, Station HCT-01 (Upper Slope)



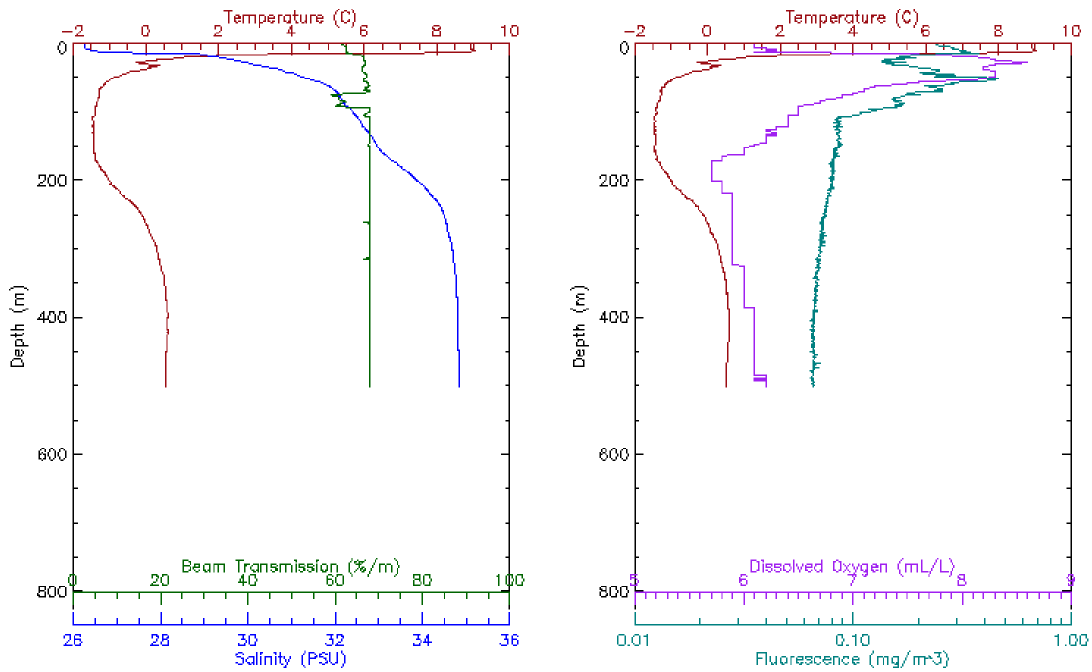


01/09/2012: Event 339, Station HCT-02 (Lower Slope)

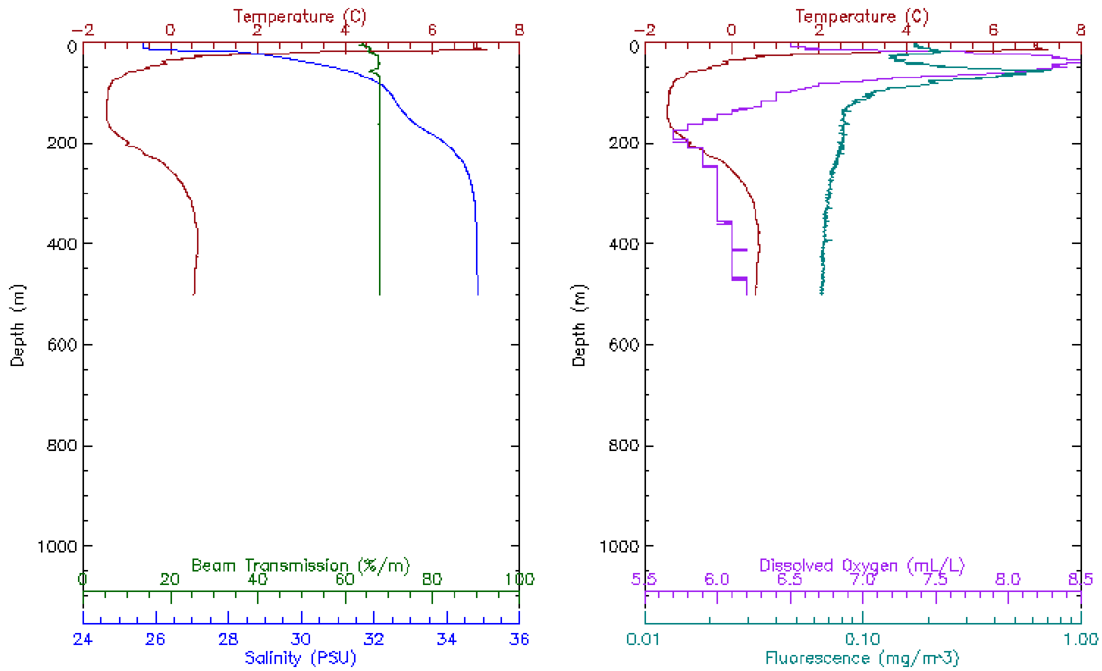




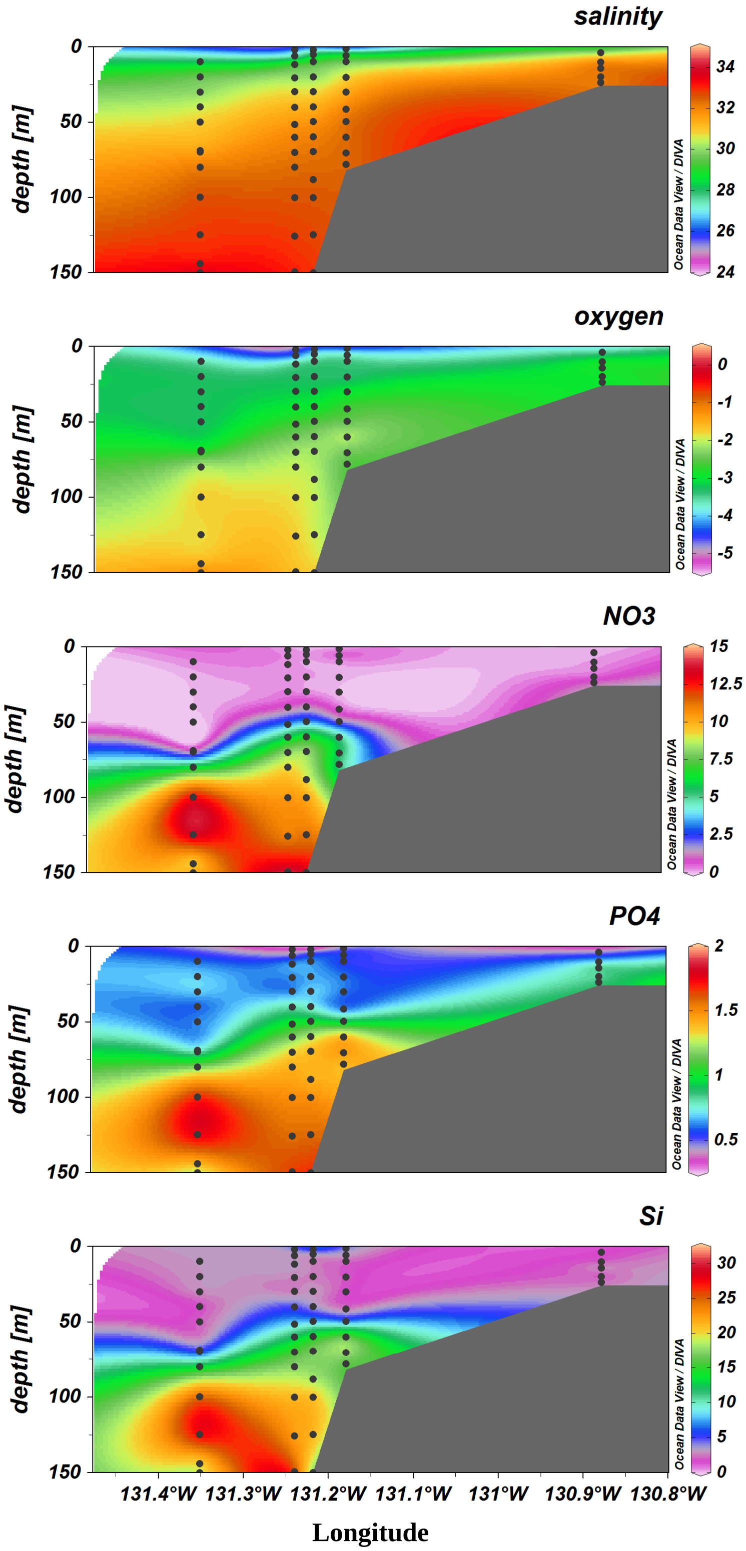
01/09/2012: Event 342, Station HCT-03 (Lower Slope)



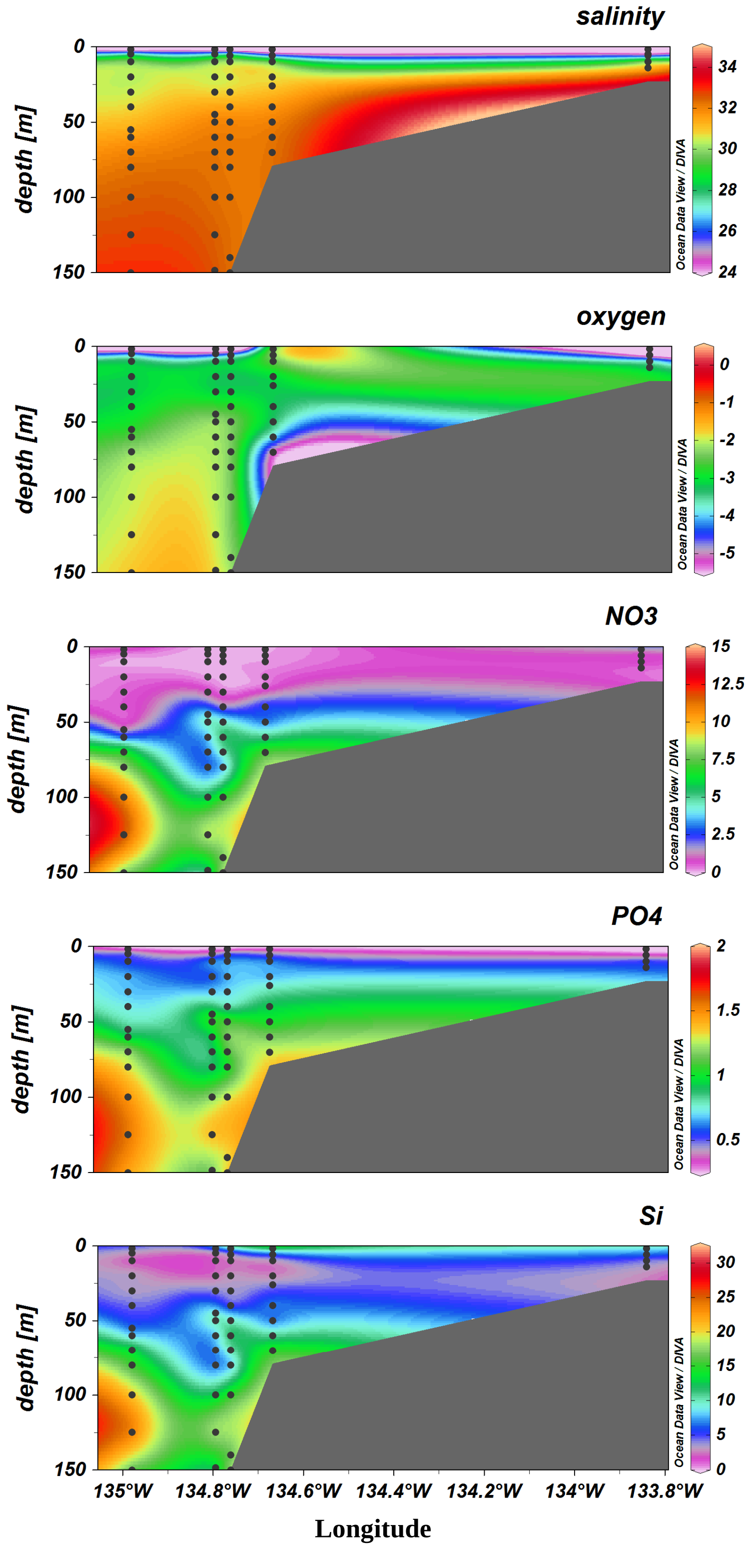
02/09/2012: Event 346, Station HCT-04 (Lower Slope)



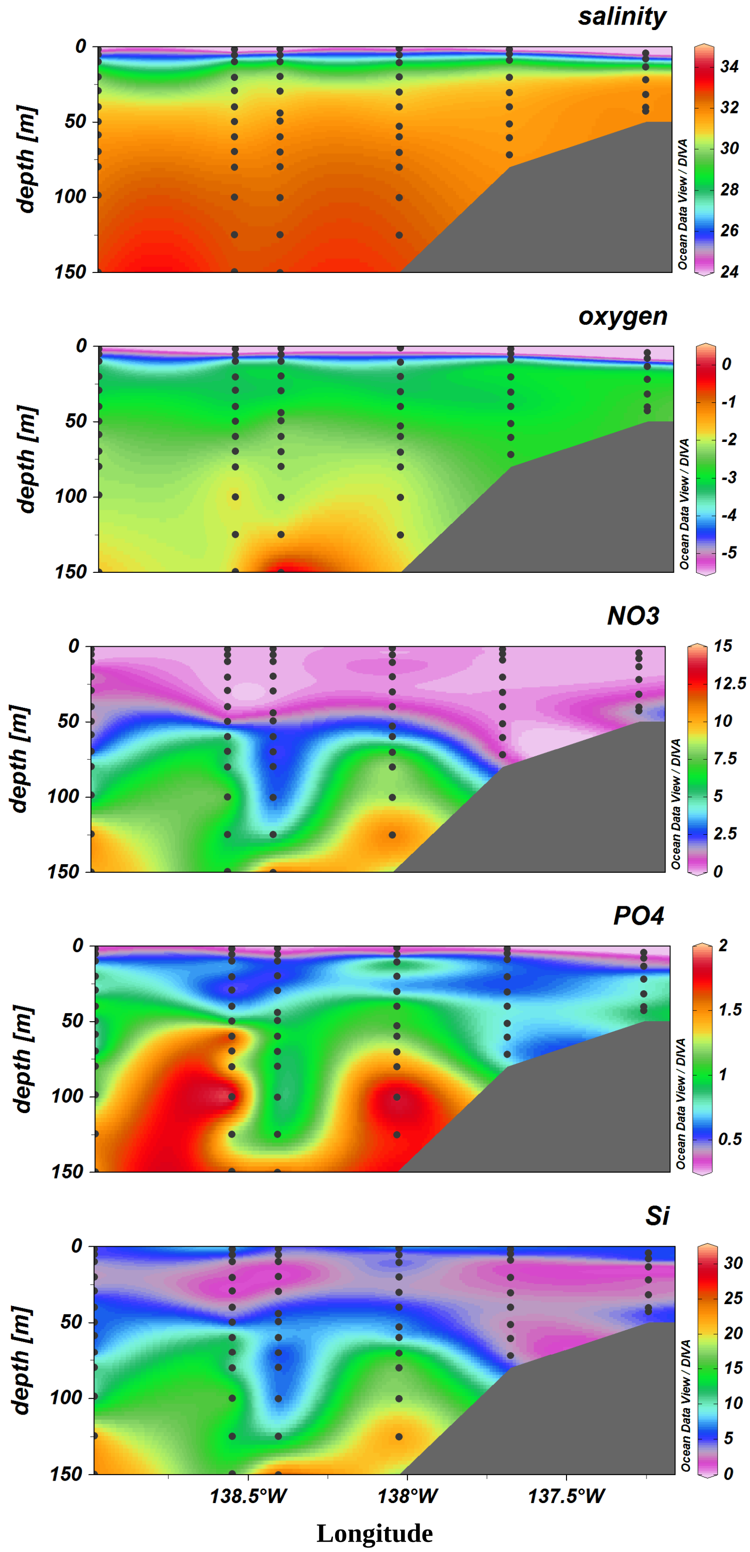
Appendix 7. Salinity (bottle values, PSU), $\delta^{18}O$ (‰) and nutrient (mmol m^{-3}) section plots for the upper 150 m of the DAL transect, August 2012.



Appendix 8. Salinity (bottle values, PSU), $\delta^{18}O$ (‰) and nutrient (mmol m^{-3}) section plots for the upper 150 m of the KUG transect, August 2012.



Appendix 9. Salinity (bottle values, PSU), δ^{18}O (‰) and nutrient (mmol m^{-3}) section plots for the upper 150 m of the GRY transect, August 2012.



Appendix 10. Salinity (bottle values, PSU), $\delta^{18}O$ (‰) and nutrient (mmol m^{-3}) section plots for the upper 150 m of the TBS transect, August 2012. Note change in x-axis orientation.