OCEANOGRAPHIC DATA IN SUPPORT OF BENTHIC BIODIVERSITY SURVEYS IN BAFFIN BAY AND DAVIS STRAIT, 2012

A. Niemi[1], C. Michel[1], G. Deslongchamps[2], J.-É. Tremblay[2], E. Kenchington[3]

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

[2]Université Laval
Département de biologie
2325 Rue de l'Université
Québec, QC G1V 0A6

[3]Fisheries and Oceans Canada
Bedford Institute of Oceanography
1 Challenger Drive
Dartmouth, NS B2Y 4A2

2017

Canadian Data Report of Hydrography and Oceans Sciences 201

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Canadian Data Report of Hydrography and Ocean Sciences

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[3]Fisheries and Oceans Canada
Bedford Institute of Oceanography
1 Challenger Drive
Dartmouth, NS B2Y 4A2

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Cat. No. Fs 97-16/201E ISBN 978-0-660-07673-7 ISSN 0711-6721
Cat. No. Fs 97-16/201E-PDF ISBN978-0-660-07674-4 ISSN 1488-5433

Correct citation for this publication:

Niemi, A., Michel, C., Deslongchamps, G., Tremblay, J.-É., Kenchington, E. 2017. Oceanographic data in support of benthic biodiversity surveys in Baffin Bay and Davis Strait, 2012. Can. Data Rep. Hydro. Ocean Sci. 201: vii + 55 p.

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Niemi, A., Michel, C., Deslongchamps, G., Tremblay, J.-É., Kenchington, E. 2017. Oceanographic data in support of benthic biodiversity surveys in Baffin Bay and Davis Strait, 2012. Can. Data Rep. Hydro. Ocean Sci. 201: vii + 55 p.

Oceanographic and biochemical sampling was conducted in Baffin Bay and Davis Strait providing ecosystem data for surveys of Arctic marine benthic biodiversity. The benthic survey work was led by Fisheries and Oceans Canada in support of the Arctic Marine Biodiversity Monitoring Plan. CTD (Conductivity, Temperature, Depth) and auxiliary sensors were deployed between 16 September and 12 October 2012 at 24 stations ranging in depth from 200 to 1100 m. Eight of the stations were located across Davis Strait and the remaining stations were in Baffin Bay. For each station, vertical profile plots of CTD data are presented including temperature, salinity, transmissivity, fluorescence, dissolved oxygen, photosynthetically active radiation and pH. The CTD was deployed with a rosette for the collection of discrete water samples to measure inorganic nutrients throughout the water column. At select stations, chlorophyll *a* was also measured in the upper 100 m of the water column. Vertical profile plots are presented for the discrete water sampling of inorganic nutrients (NO_3, NO_2, PO_4, $Si(OH)_4$), and total and size fractioned chlorophyll *a* concentrations. The physical characteristics of the water column and productivity indicators (i.e. nutrients and chlorophyll *a*) presented are relevant for the management of ecosystems (e.g. VMEs and EBSAs) as well as shrimp and Greenland Halibut fisheries in the study area.

RÉSUMÉ

Niemi, A., Michel, C., Deslongchamps, G., Tremblay, J.-É., Kenchington, E. 2017. Oceanographic data in support of benthic biodiversity surveys in Baffin Bay and Davis Strait, 2012. Can. Data Rep. Hydro. Ocean Sci. 201: vii + 55 p.

Un échantillonnage océanographique et biochimique a été réalisé dans la baie de Baffin et le détroit de Davis pour fournir des données écosystémiques aux fins des relevés de la biodiversité marine benthique de l'Arctique. Les relevés benthiques ont été dirigés par Pêches et Océans Canada à l'appui du plan de surveillance de la biodiversité marine dans l'Arctique. Des capteurs de données CTP (conductivité, température, profondeur) et auxiliaires ont été déployés entre le 16 septembre et le 12 octobre 2012 à 24 stations, à des profondeurs allant de 200 à 1 100 m. Huit stations sont situées le long du détroit de Davis et les autres se trouvent dans la baie de Baffin. Pour chaque coup de sonde, des tracés de profil vertical des données CTP sont présentés, notamment la température, la salinité, la transmissivité, la fluorescence, l'oxygène dissous, le rayonnement photosynthétiquement actif et le pH. Les capteurs de données CTP ont été déployés avec une rosette pour recueillir des échantillons d'eau distincts afin de mesurer les nutriments inorganiques dans toute la colonne d'eau. À certaines stations, la chlorophylle *a* a également été mesurée dans la portion supérieure de 100 m de la colonne d'eau. Des tracés de profil vertical sont présentés pour les échantillons d'eau distincts de nutriments inorganiques (NO_3, NO_2, PO_4, $Si(OH)_4$), et les concentrations totales de chlorophylle *a* fractionnées selon la taille. Les caractéristiques physiques de la colonne d'eau et les indicateurs de productivité (p. ex., les éléments nutritifs et la chlorophylle *a*) présentés sont pertinents pour la gestion des écosystèmes (p. ex., écosystèmes marins vulnérables et zones d'importance écologique et biologique), de même que pour la pêche de la crevette et du flétan du Groenland dans la zone d'étude.

ACKNOWLEDGEMENTS

We sincerely thank the captain and crew of the *CCGS Larson* for their support throughout the cruise. We acknowledge Sylvain Blondeau for CTD/Rosette operations and Pascal Guillot for data processing and quality control. We also thank Jonathan Gagnon and Amandine Lapoussière for their hard work to collect and process samples during the cruise. We gratefully acknowledge financial support received from Fisheries and Oceans Canada (International Governance Strategy), Québec-Océan and ArcticNet.

1.0 INTRODUCTION

Davis Strait-Baffin Bay was identified as an Arctic Marine Area (AMA) designated for biodiversity monitoring by the Marine Expert Monitoring Group of the Circumpolar Biodiversity Monitoring Program (CBMP), as directed by CAFF, the biodiversity working group of the Arctic Council. Biodiversity monitoring of the Davis Strait-Baffin Bay AMA was included in the Arctic Marine Biodiversity Monitoring Plan (CBMP-Marine Plan), the first of the CBMP's four pan-Arctic biodiversity monitoring plans. The main objective of the CBMP-Marine Plan was to enhance our ability to detect and understand the causes of long-term change in the composition, structure and function of Arctic marine ecosystems, as well as to develop authoritative assessments of key elements of Arctic marine biodiversity (e.g., indicators, ecologically pivotal and/or other important taxa; Gill et al. 2011). The Arctic Marine Biodiversity Monitoring Plan was intended to integrate with existing monitoring capacity to facilitate improved and cost-effective monitoring that allowed for earlier detection of trends and more effective policy and management response.

As part of Canada's contribution to the Arctic Marine Biodiversity Monitoring Plan, Fisheries and Oceans Canada coordinated a collaborative ecosystem assessment of sub-arctic and arctic ecosystems in Davis Strait and Baffin Bay including targeted monitoring of Arctic marine benthic biodiversity. The 2012 assessment took place primarily in the Northwest Atlantic Fisheries Organization (NAFO) subareas 0A and 0B with single stations in subareas 1D and 1E. Survey work was also conducted in the Narwhal Over-wintering and Hard Corals zone that is closed to Greenland Halibut fishing (DFO 2007, Figure 1). The 2012 assessment of benthic biodiversity and oceanographic variables supports the identification and characterization of benthic Vulnerable Marine Ecosystems (VMEs) and Ecologically and Biologically Significant Areas (EBSAs) in the Eastern Arctic bioregion as well as improves knowledge of ecosystem impacts on valuable fisheries for Greenland Halibut and shrimp in the study area.

The Davis Strait-Baffin Bay study area is a semi-enclosed basin and is part of a key Arctic outflow (Michel et al. 2015). Baffin Bay connects the Arctic and Atlantic Oceans, providing an important pathway for the exchange of salt, heat, ice and other oceanographic properties (Hamilton and Wu 2013). The Arctic Ocean flows into Baffin Bay via three passages: Jones Sound, Lancaster Sound, and Nares Strait, of the Canadian Arctic Archipelago. Arctic waters entering Baffin Bay from the north flow through Davis Strait to enter the Northwest Atlantic. The Davis Strait-Baffin Bay AMA is also influenced by the Greenland Current that carries Arctic waters northward along the western coast of Greenland and by freshwater inputs from sea-ice and ice shelves.

The physical and chemical properties of Baffin Bay and Davis Strait are susceptible to localized and indirect impacts of climate change and other environmental stressors. Oceanographic changes including warming water temperature, ocean acidification, and changing nutrient regimes have been observed within the Davis Strait-Baffin Bay AMA

with the potential for significant impacts on ecosystem biodiversity, productivity and species distribution (Hamilton and Wu 2013, Yamamoto-Kawai et al. 2013, Bergeron and Tremblay 2014). Oceanographic measurements are critical for identifying the drivers of biological processes within this productive marine region.

In this report, data from CTD (conductivity-temperature-depth) and water sampling (i.e. rosette) science activities is provided for 24 sampling stations during the 2012 biodiversity expedition. CTD profiles provide temperature, salinity, dissolved oxygen, transmission, fluorescence, irradiance and pH sensor data. Discrete bottle sampling from the rosette provides data for nutrients including nitrate, nitrite, silicate and phosphate as well as total and >5 µm chlorophyll *a*. The oceanographic data was collected to support onboard benthic sampling included box coring, Van Veen sampling, gravity cores and benthic camera observations. Results from the benthic sampling will be reported elsewhere.

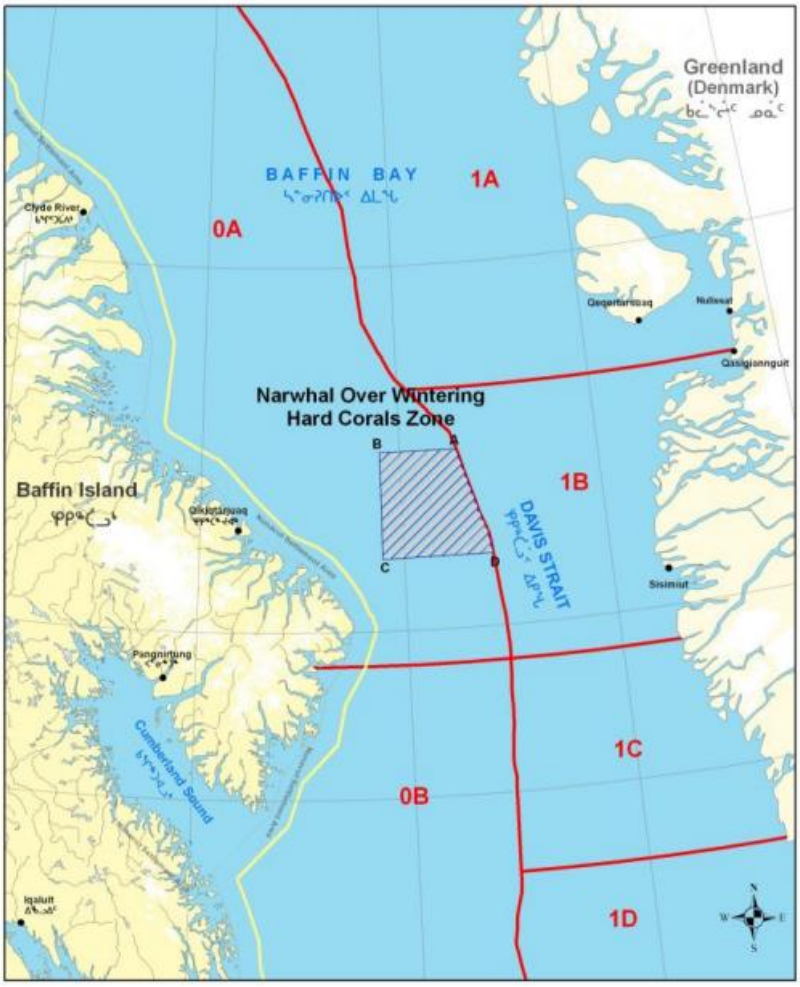

Figure 1. Map of NAFO subareas and the Narwhal Over-wintering and Hard Corals zone in the study area (DFO unpublished).

2.0 METHODS AND ANALYSES

2.1 Field Program

CTD/Rosette casts were conducted between 16 September and 12 October 2012 onboard the *CCGS Larson*. Sampling occurred from north to south in Baffin Bay and from east to west across Davis Strait (Figure 2). Sampling station depth ranged between 199 and 978 m (n = 16) in Baffin Bay and between 304 and 1093 m (n = 8) in Davis Strait. Metadata for the CTD/Rosette casts is summarized in Table 1. Rosette sampling for inorganic nutrients was conducted at all stations except CON39, 115 and 149. Chlorophyll *a* data is available for 17 of the 24 stations and is measured at 10 m intervals from surface to a depth of 100 m. At stations CON117, 133 and 147, total chlorophyll *a* concentrations were also measured at depths >100 m.

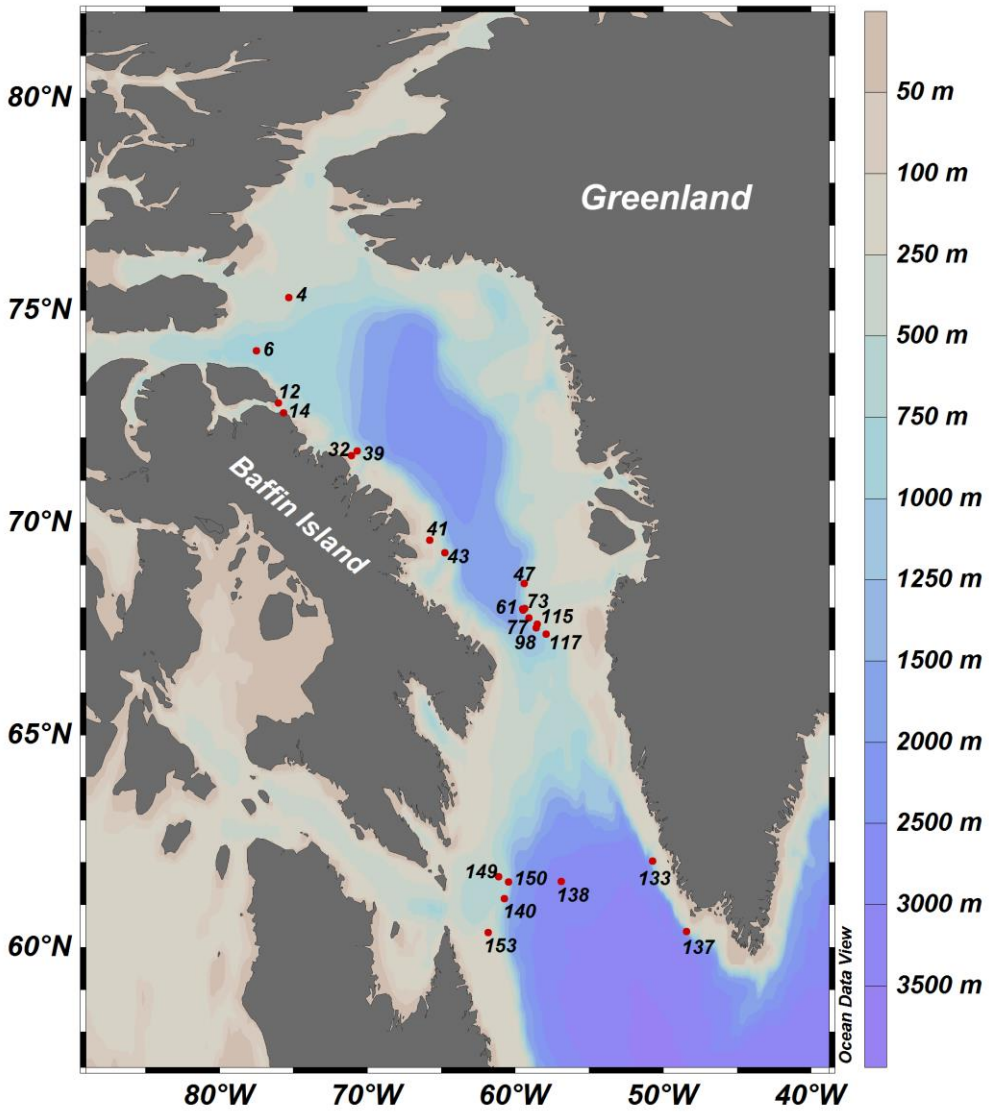

Figure 2. CTD/Rosette sampling stations (CON numbers shown) in the Davis Strait-Baffin Bay Arctic Marine Area (AMA) during the 2012 benthic biodiversity assessment.

Table 1. CTD/Rosette sampling station information for the 2012 benthic biodiversity assessment. General sampling locations are Northern Baffin Basin (NBB), mouth of Pond Inlet (MPI), Scott Trough Slope (STS), mouth of Home Trough (MHT), Narwhal Closure Area (NCA) and Davis Strait (DS).

CON	Station	Location	DD/MM	Sampling Time (UTC)	Decimal Degrees Lat (N)	Long (W)	Water Depth (m)
4	BB9_A	NBB	16/09	13:44	75.3073	75.312	417
6	CTD 4	NBB	16/09	22:31	74.0552	77.531	859
12	BB8_A	MPI	17/09	14:58	72.8305	76.041	250
14	BB8_B	MPI	17/09	19:49	72.5955	75.693	203
32	CTD 10	STS	22/09	13:33	71.5847	71.09	213
39	STS_B_ 600 m	STS	23/09	0:25	71.6975	70.706	582
41	PII-B3	MHT	23/09	17:53	69.5988	65.805	199
43	H_T_CTD	MHT	23/09	22:44	69.297	64.79	590
47	BB2_A_ 600 m	NCA	24/09	16:34	68.5803	59.421	612
54	BB1_B_ 400 m	NCA	26/09	12:20	67.9427	59.474	418
61	BB1_B_ 1000 m	NCA	27/09	13:25	67.9748	59.529	951
73	BB1_B_ 600 m	NCA	28/09	10:25	67.991	59.38	561
77	BB1_A_ 600 m	NCA	28/09	17:39	67.7678	59.087	689
98	BB1_C_ 1000 m	NCA	30/09	12:11	67.5275	58.603	978
115	BB1_C_ 400 m	NCA	01/10	12:32	67.6125	58.538	375
117	BB1_D	NCA	01/10	17:37	67.3817	57.922	635
133	SWGS1_ B	DS	03/10	18:35	62.0352	50.74	599
137	SWGS3	DS	04/10	16:45	60.3837	48.459	599
138	DS_CTD	DS	05/10	20:13	61.5608	56.898	1093
140	DS1_S	DS	09/10	12:37	61.1507	60.767	1035
147	DS1_G	DS	10/10	12:35	61.6727	61.134	553
149	DS1_G_B	DS	10/10	15:17	61.673	61.138	549
150	DS1_T	DS	10/10	17:45	61.5397	60.489	1046
153	DS1-N	DS	12/10	10:55	60.3508	61.864	304

2.2 CTD/Rosette Casts

CTD casts and concurrent water samples were collected by a 24-bottle rosette with a Seabird SBE 911 CTD and external sensors mounted within a stainless steel frame. The 24-12 L Niskin bottles were controlled by a carousel water sampler and deck unit.

The sensors used during each cast were:

- Temperature SBE 3plus
- Conductivity SBE 4C
- Pressure Paroscientific 410K-105
- Dissolved Oxygen SBE-43
- Seapoint Fluorometer
- Wetlab CSTAR transmissometer
- Biospherical/LiCor PAR
- pH SBE18
- Benthos Altimeter PSA-916

The CTD/Rosette system was soaked in surface waters (ca. 3 minutes) before profiling began. Rosette bottles were triggered on the up-cast for water collection. The rosette was stopped for approximately one minute at selected depths before the sample was taken by closing the bottle. Water samples from the surface layer were generally collected at ca. 5 m and the deepest sample was taken at ca. 10 m above the bottom. In the upper water column (i.e. ≤ 100 m), water samples were generally collected at 10 m intervals. At depths >100 m, samples were taken every 20, 50 or 100 m, depending on the water depth.

The Seabird CTD data and auxiliary sensors were processed using the Seabird software Seasoft according to ArcticNet data processing protocols (e.g. Guillot 2013). All sensors were calibrated at the Seabird factory prior to the cruise. The pH data presented are direct measurements from the SBE18 sensor which is factory calibrated using NBS pH standard solutions. Density (sigmaTheta; σ_θ) and Brunt-Väisälä buoyancy frequency (N^2) data was calculated using the oce package for R.

2.3 Sample analyses

Samples for the analysis of inorganic nutrients (NO_3, NO_2, PO_4, $Si(OH)_4$) were pre-filtered through a combusted GF/F filter and stored in acid washed and sample rinsed 15 ml polyethylene tubes. The nutrient samples were stored frozen at -20˚C until analysis at Laval University. Nutrient concentrations were determined using standard colorimetric methods adapted from Hansen and Koroleff (2007) with a Bran and Luebbe Autoanalyzer III. The analytical detection limit was 0.02 µmol l^{-1} for NO_2, 0.03 µmol l^{-1} for NO_3, 0.05 µmol l^{-1} for PO_4 and 0.1 µmol l^{-1} for $Si(OH)_4$.

Chlorophyll *a* (chl *a*) concentrations were determined fluorometrically on fresh pigments (i.e. analyses conducted the same day as sampling) using a method directly adapted from Parsons et al. (1984). All chl *a* samples were analyzed onboard using a Turner

Designs 10AU fluorometer that was calibrated (Parsons et al. 1984) at the Freshwater Institute, Winnipeg, prior to and following the cruise.

Onboard, duplicate chl *a* sub-samples were filtered onto Whatman 25 mm GF/F filters for the determination of total chl *a*, and onto 5 µm Nuclepore membrane filters to determine the fraction of the chl *a* sample ≥ 5 µm in size. Filtrations were carried out using a low vacuum pressure (5-10 psi). Each sample filter was placed in a 20 ml scintillation vial, and pigments were immediately extracted in 10 ml of 90% acetone. Extraction continued during 24 h at 4°C in the dark. After 24 h, the samples were allowed to warm to room temperature and fluorometric readings were taken. Chlorophyll *a* concentrations were calculated according to Parsons et al. (1984).

3.0 DATA

Profiles of CTD sensor data and discrete measurements of inorganic nutrients and chl *a* are presented in Appendix 1. Appendix 2 presents section plots of salinity, temperature, fluorescence, pH and dissolved oxygen for the transect of stations (CON54-CON117) within the Narwhal over-wintering Hard Corals zone (Table 1, Figures 1, 2). The CTD profiles show an upper mixed layer of Arctic waters with a temperature minimum of ca. -1.5°C at depths between 50 and 100 m (Figure 3). Below 200 to 300 m lies an intermediate water layer sourced from Atlantic (West Greenland current) waters.

The depth of the subsurface chlorophyll maximum (SCM) ranged from 10 m (CON150) to 55 m (CON 6) with an average total chlorophyll *a* concentration of 2.1 µg l^{-1}.Total chl *a* concentrations were highest (14 µg l^{-1}) in northern Baffin Bay (CON4) with 79% of the phytoplankton comprised of large (i.e. >5 µm) cells. At the SCM, cells >5 µm comprised, on average, 37% of total chlorophyll *a* concentrations. At 100 m, there were proportionally more >5 µm cells (average 52%) than at the SCM indicating that not all large cells were grazed within surface waters. Nutrient concentrations were generally drawn down in surfaces waters and were highest in intermediate waters at depths >400 m.

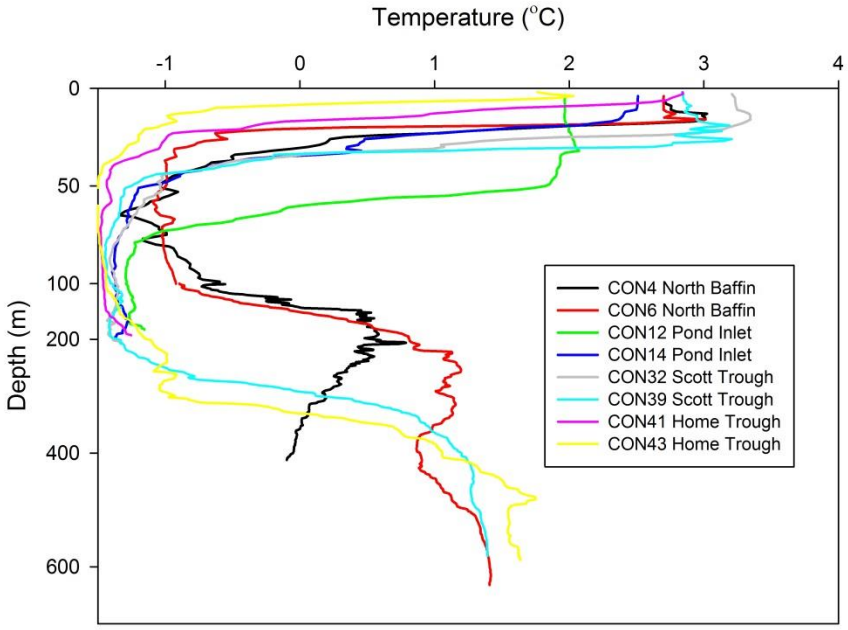

Figure 3. Temperature profiles of Baffin Bay stations (Table 1) showing the temperature minimum of the upper Arctic water layer and temperature variability between adjacent stations (Figure 2). Note break in y-axis.

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APPENDIX 1. Profile plots of conductivity-temperature-depth (CTD) and rosette data collected in the Arctic Marine Area (AMA) during the 2012 benthic biodiversity assessment. Plots are identified by sampling date and station name (CON). CTD plots (temperature, salinity, density (σ_θ), Brunt-Väisälä frequency (N^2), transmissivity, fluorescence, photosynthetically active radiation (PAR), dissolved oxygen, and pH) are presented first followed by profiles for discrete samples of inorganic nutrients (NO_3, NO_2, PO_4, and $Si(OH)_4$) and chlorophyll *a* (chl *a* total (tot) and 5 µm). Station details are provided in Figure 2 and Table 1.

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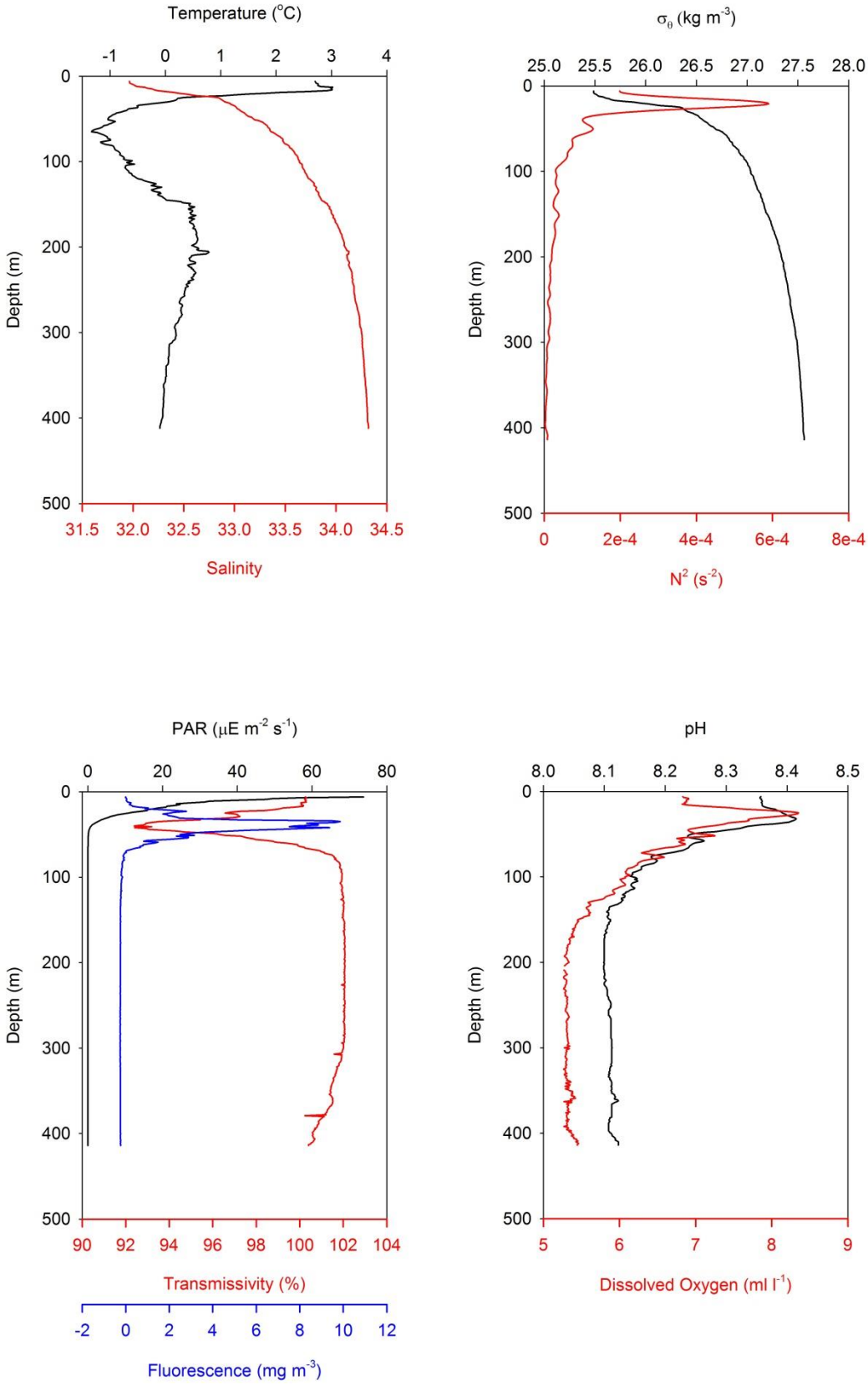

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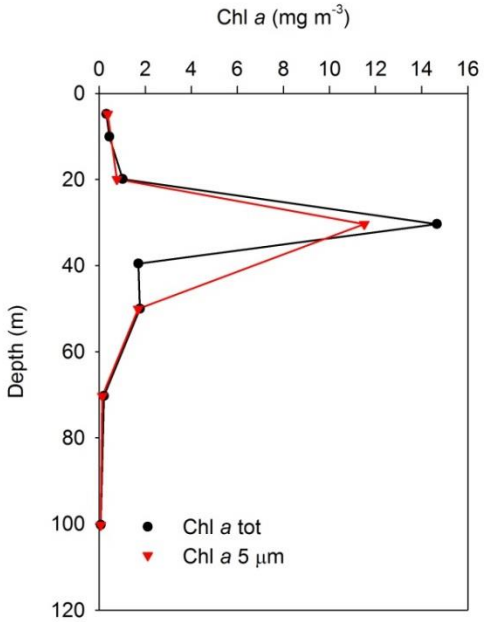

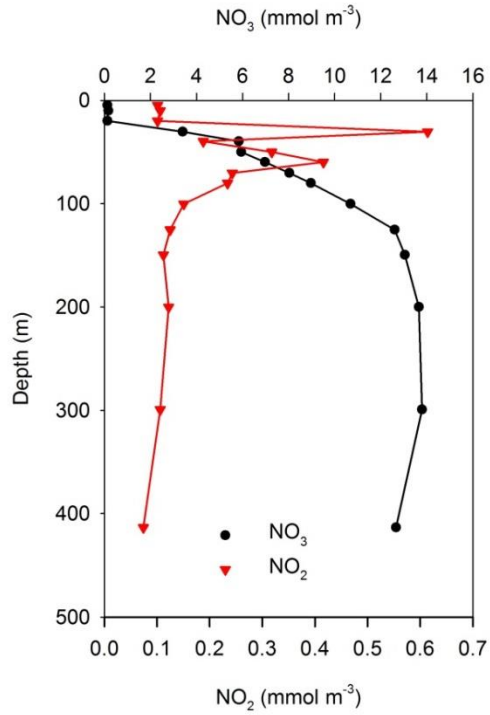

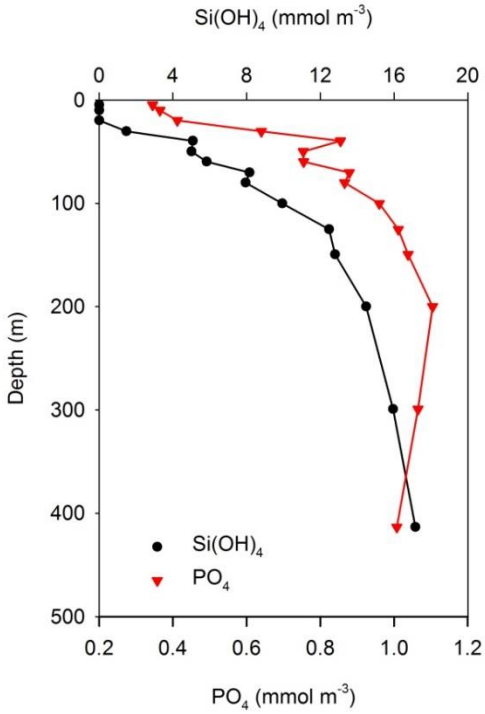

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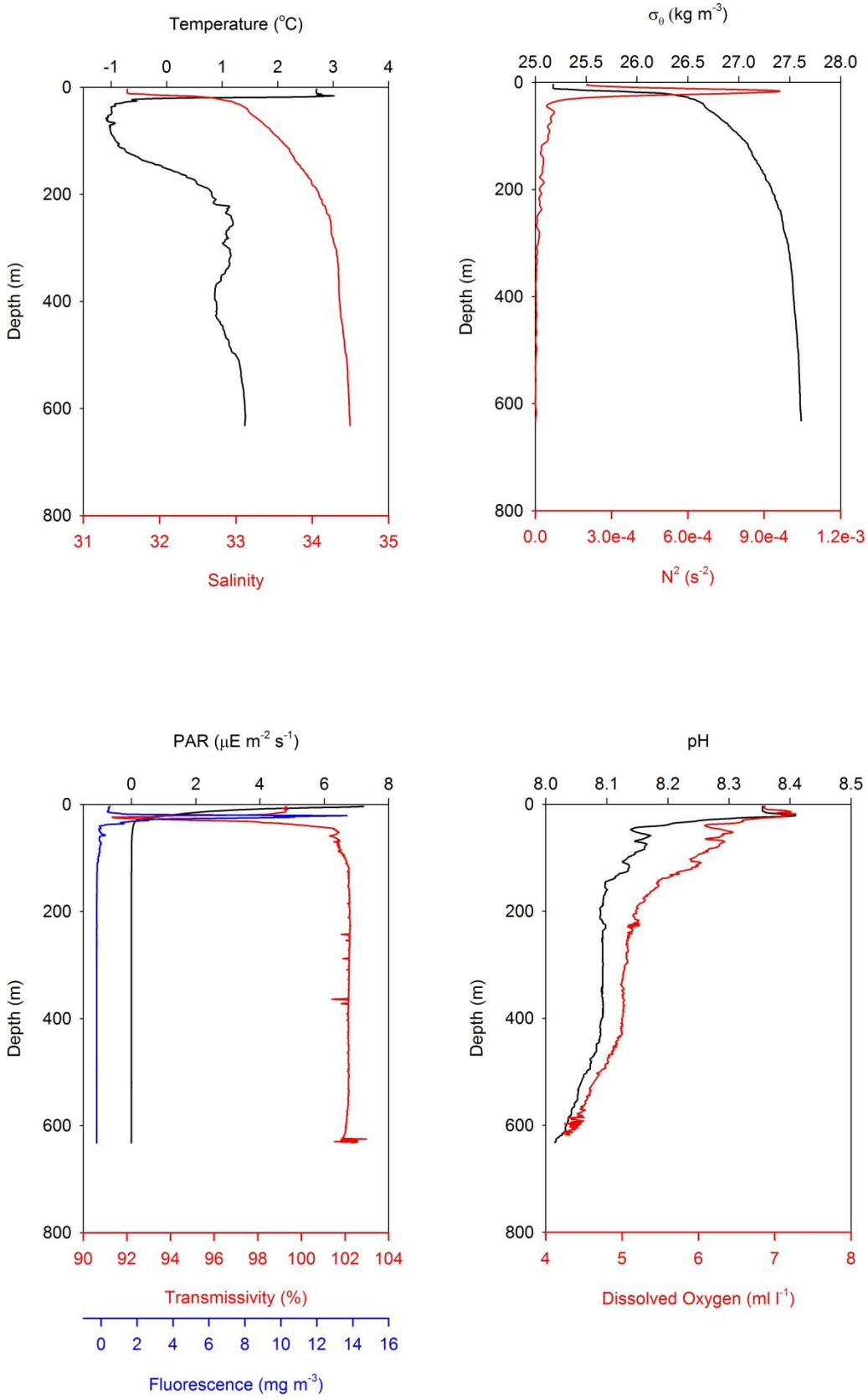

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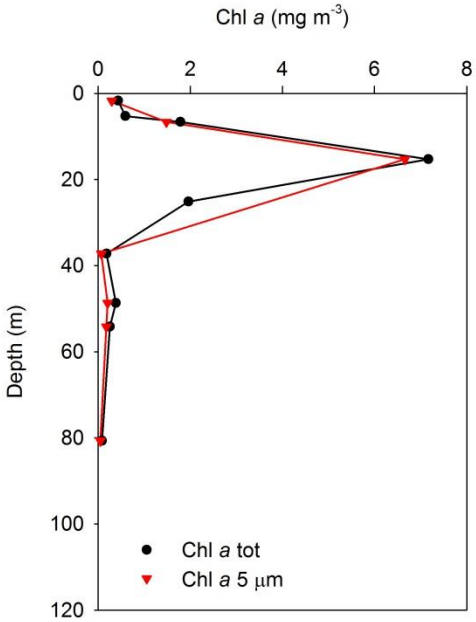

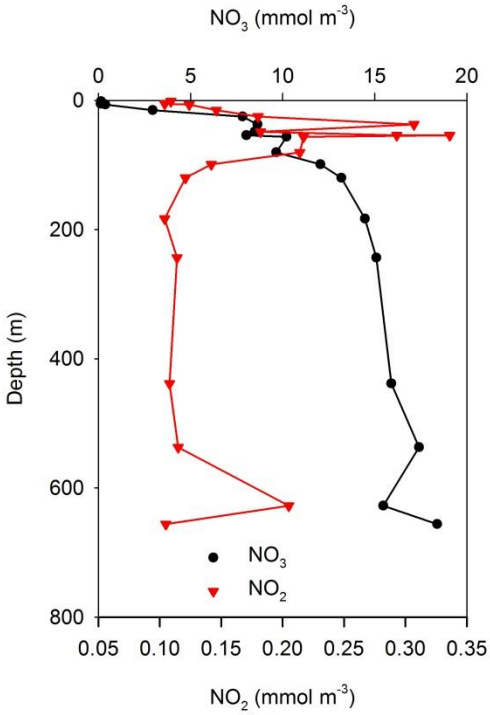

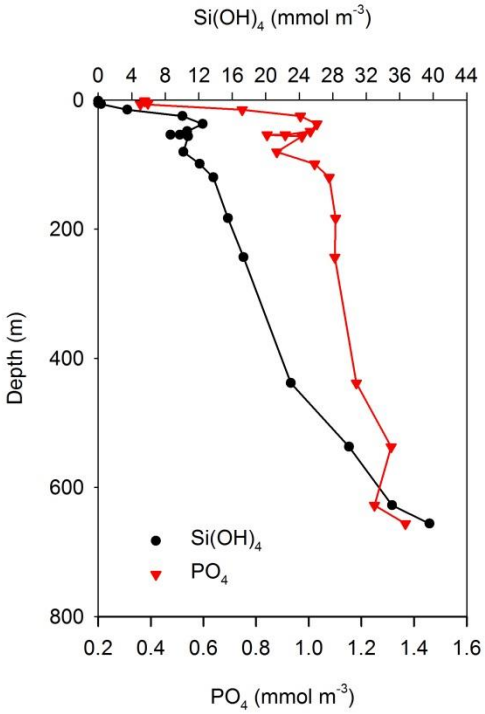

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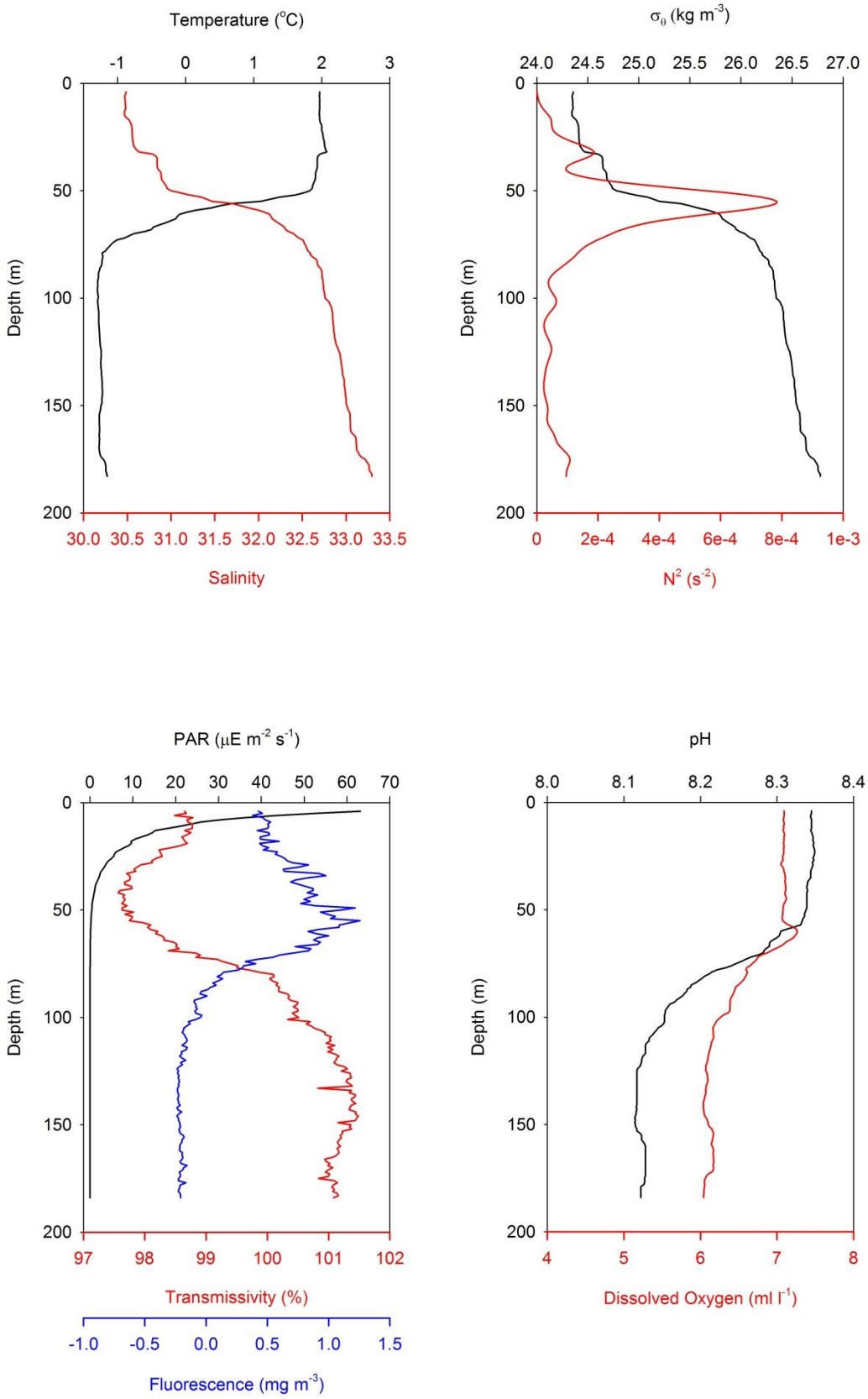

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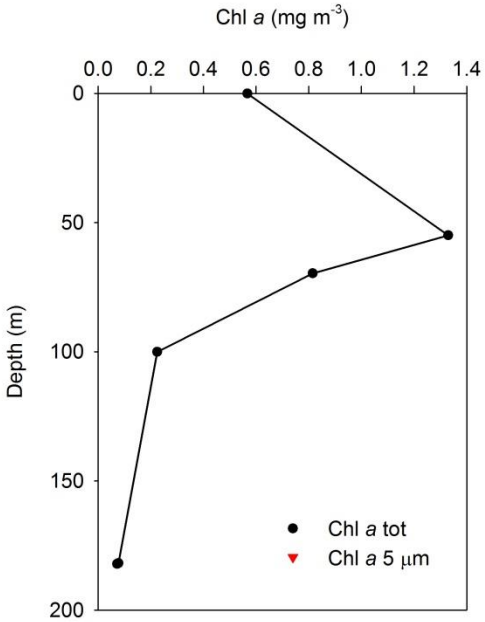
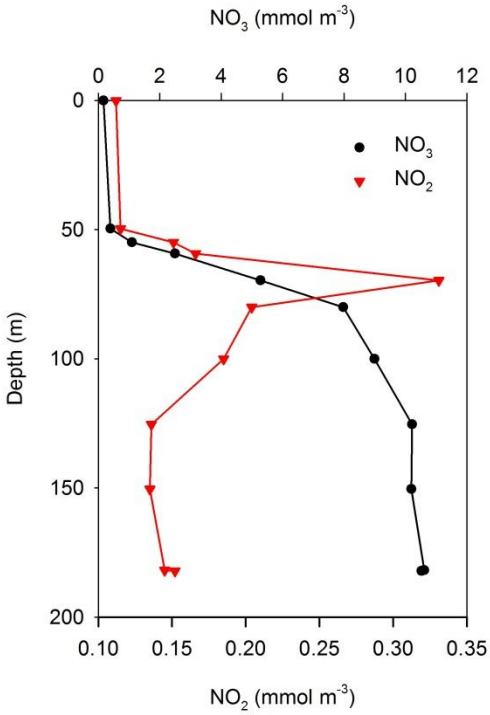
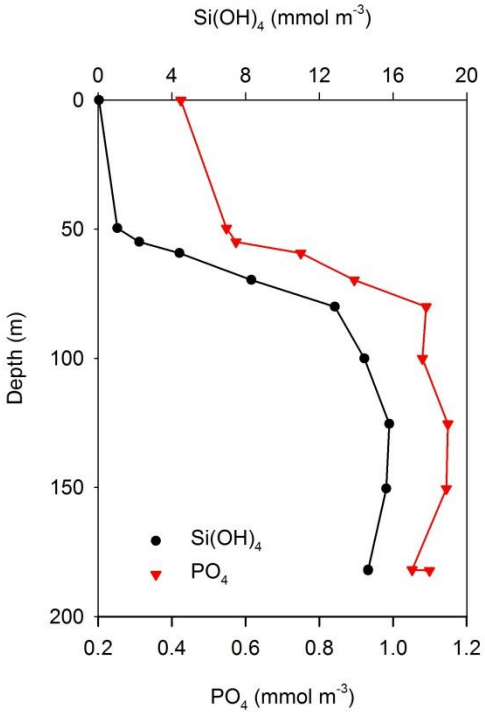
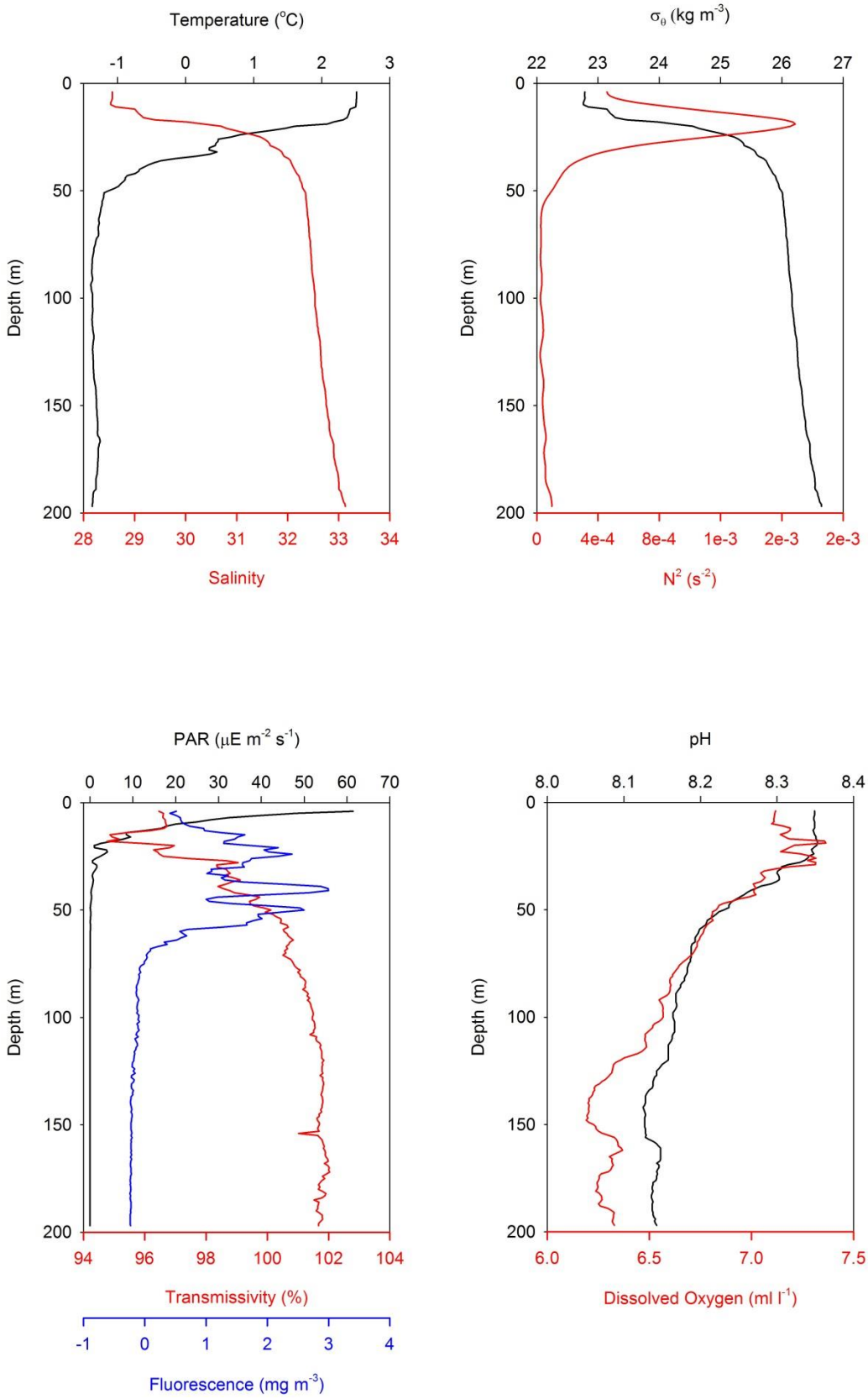


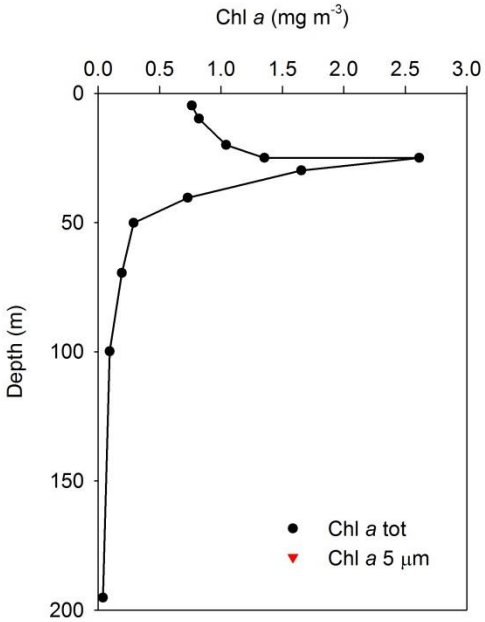


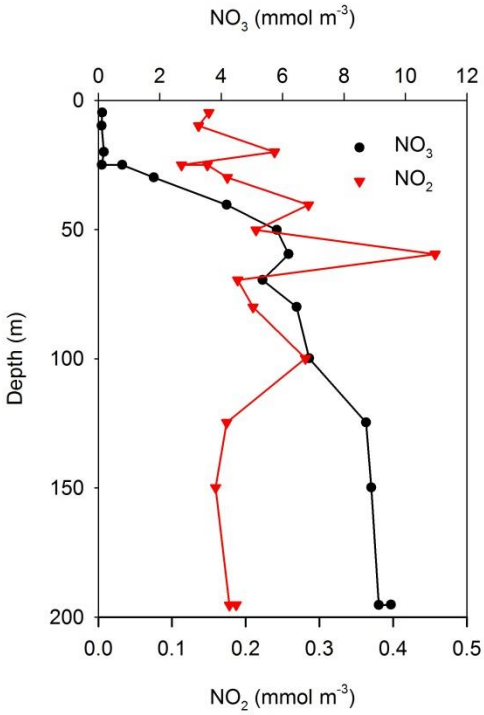


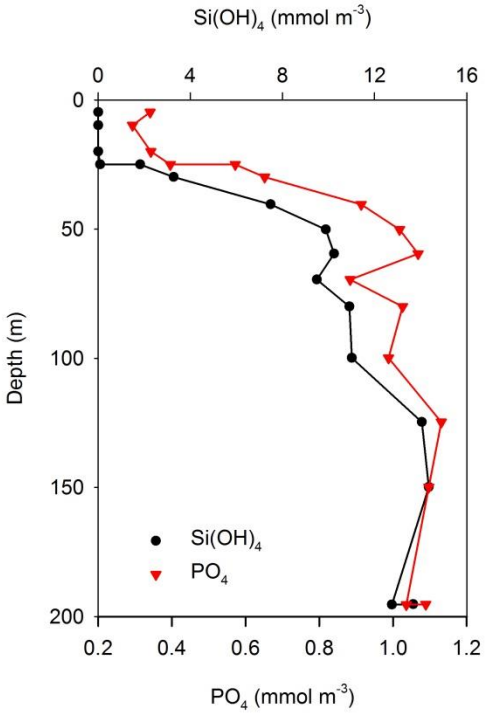
17/09/2012: CON14



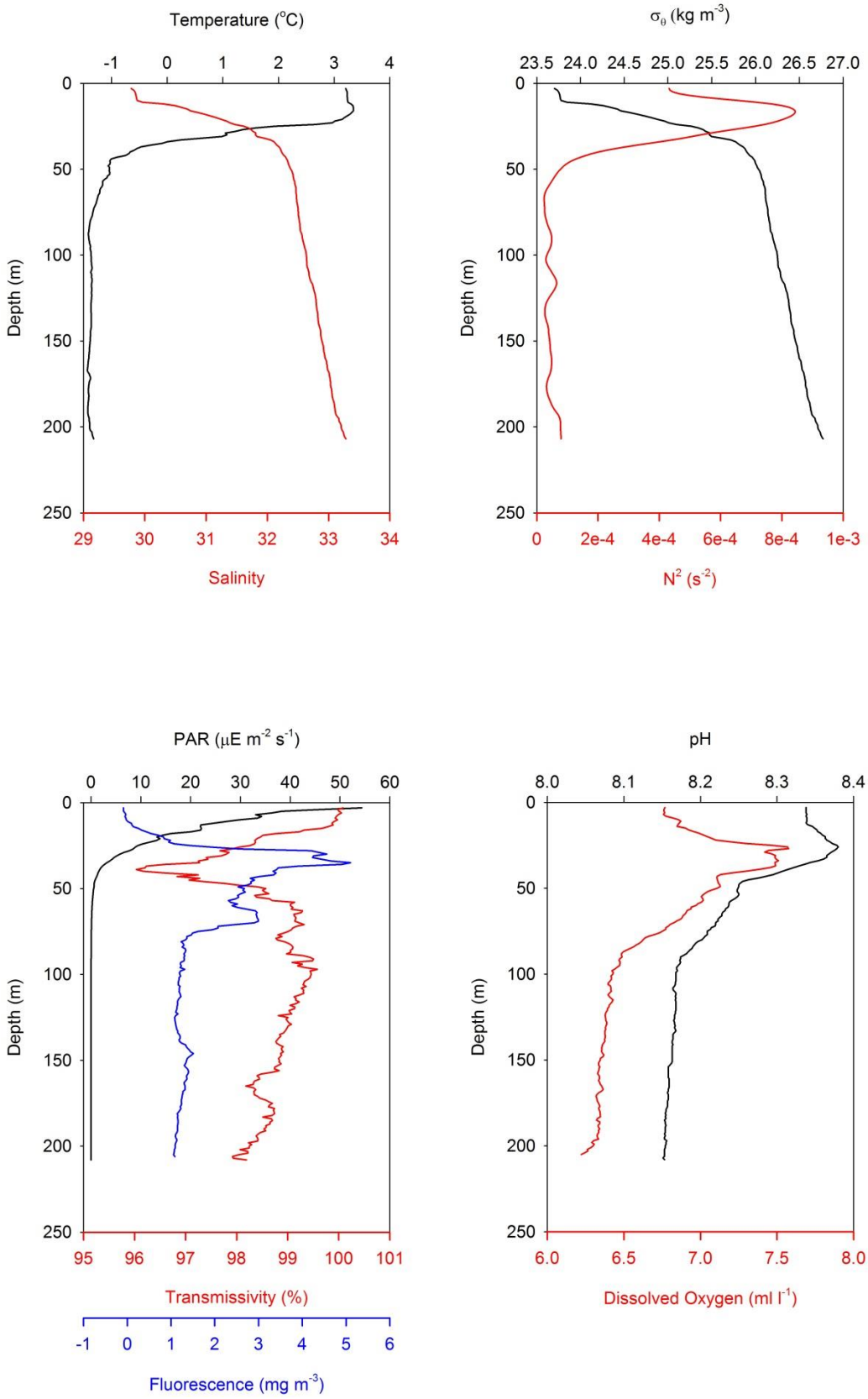
17/09/2012: CON14



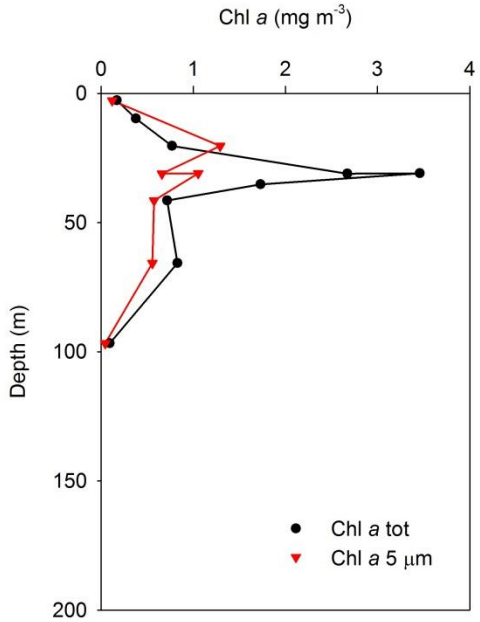


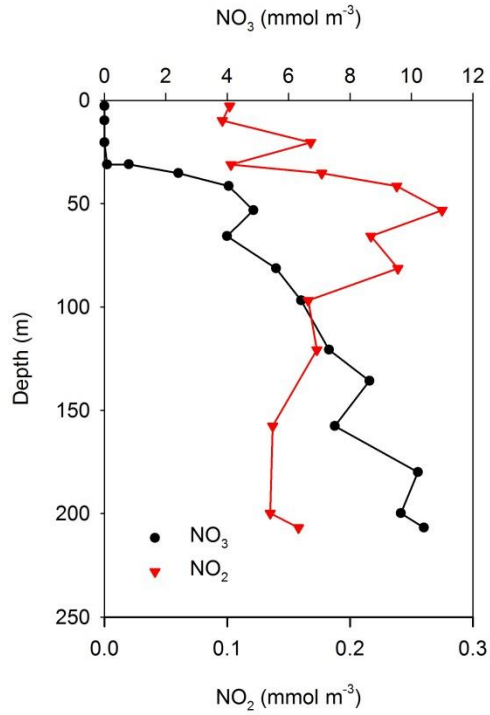


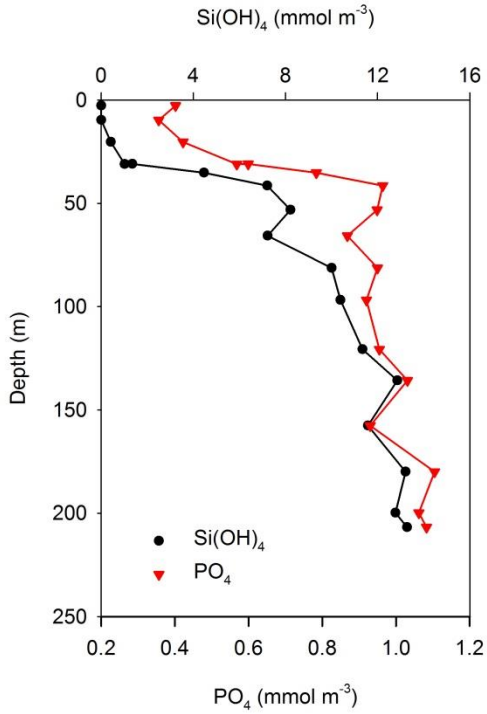
22/09/2012: CON32



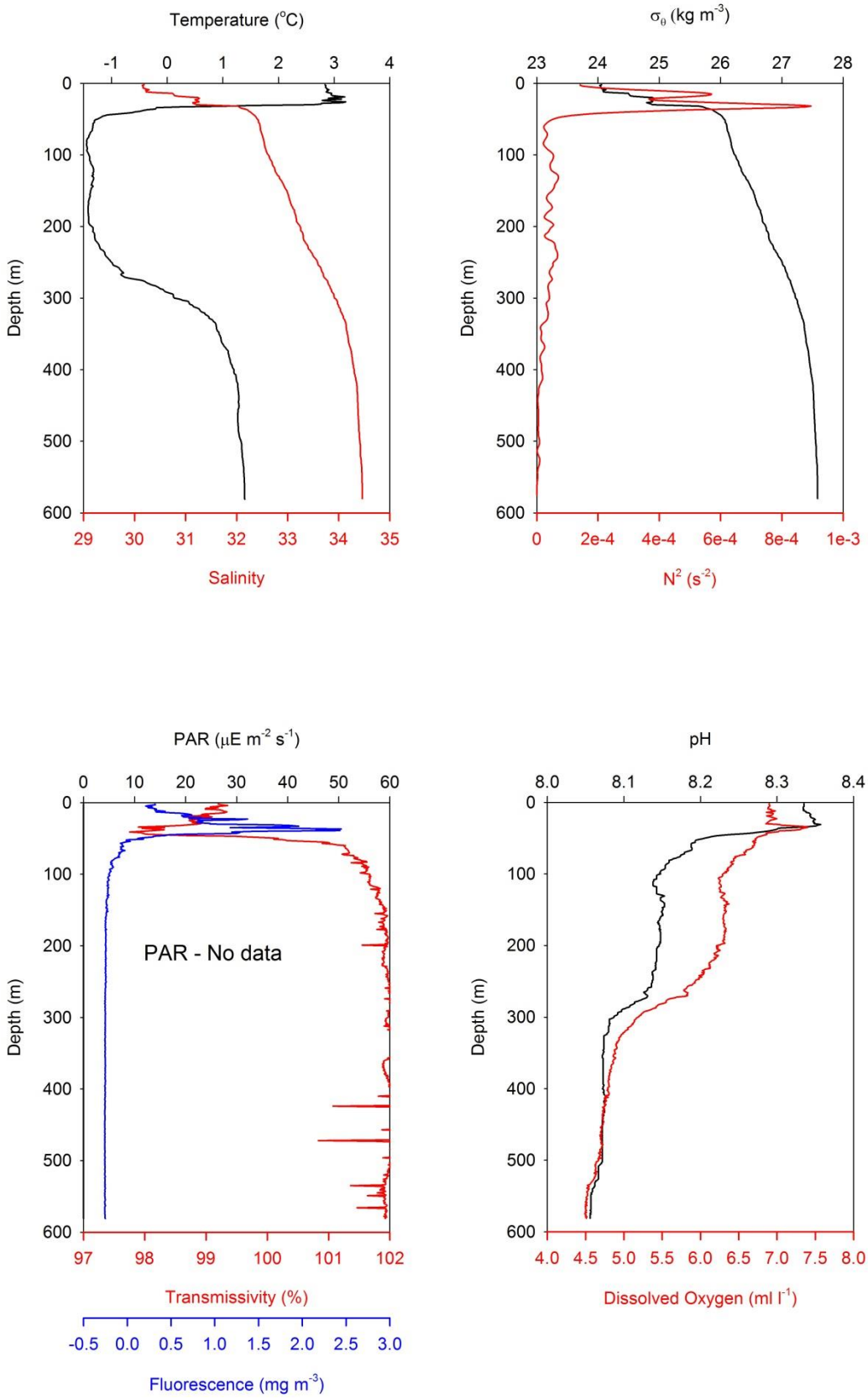
22/09/2012: CON32



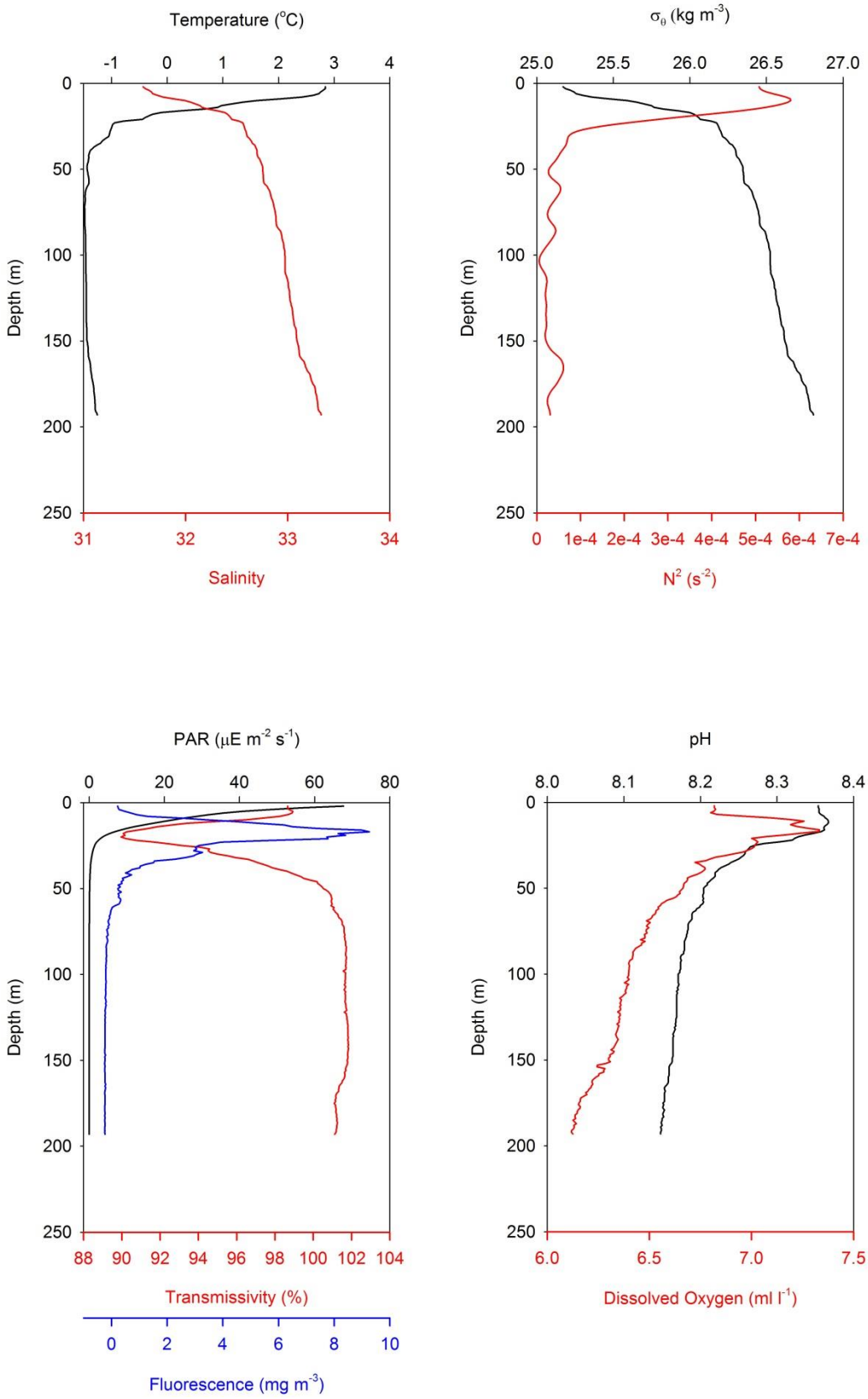




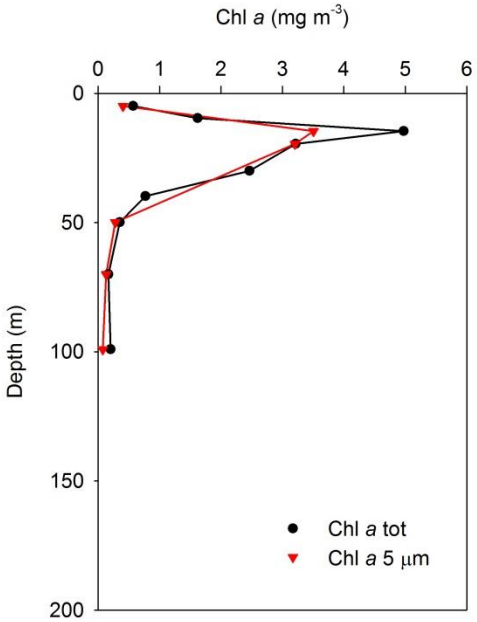
23/09/2012: CON39

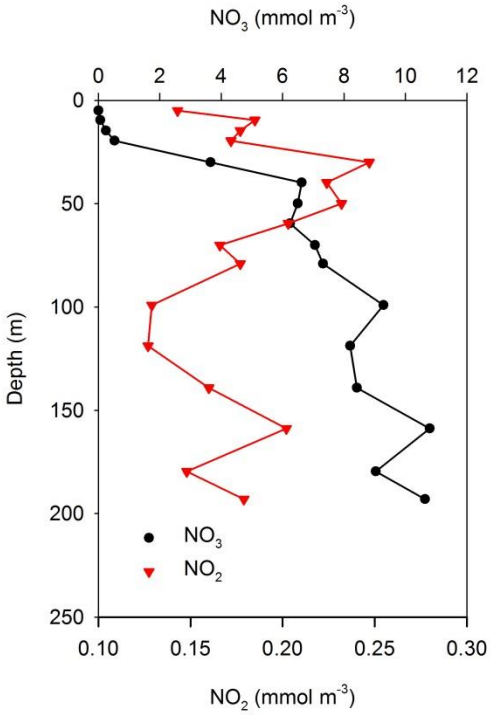


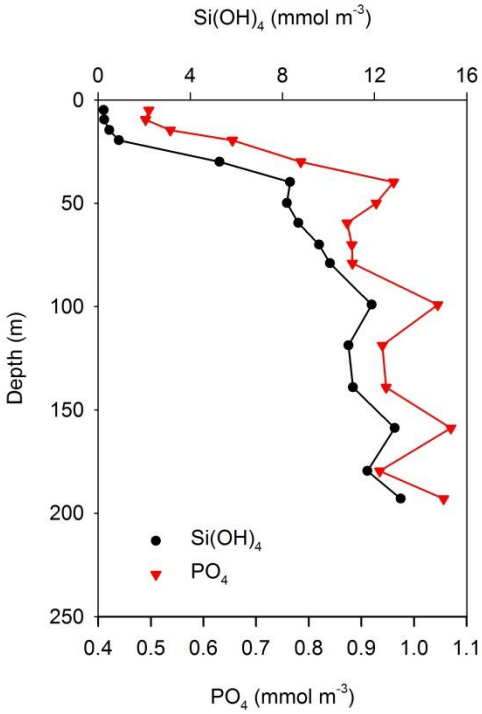
23/09/2012: CON41



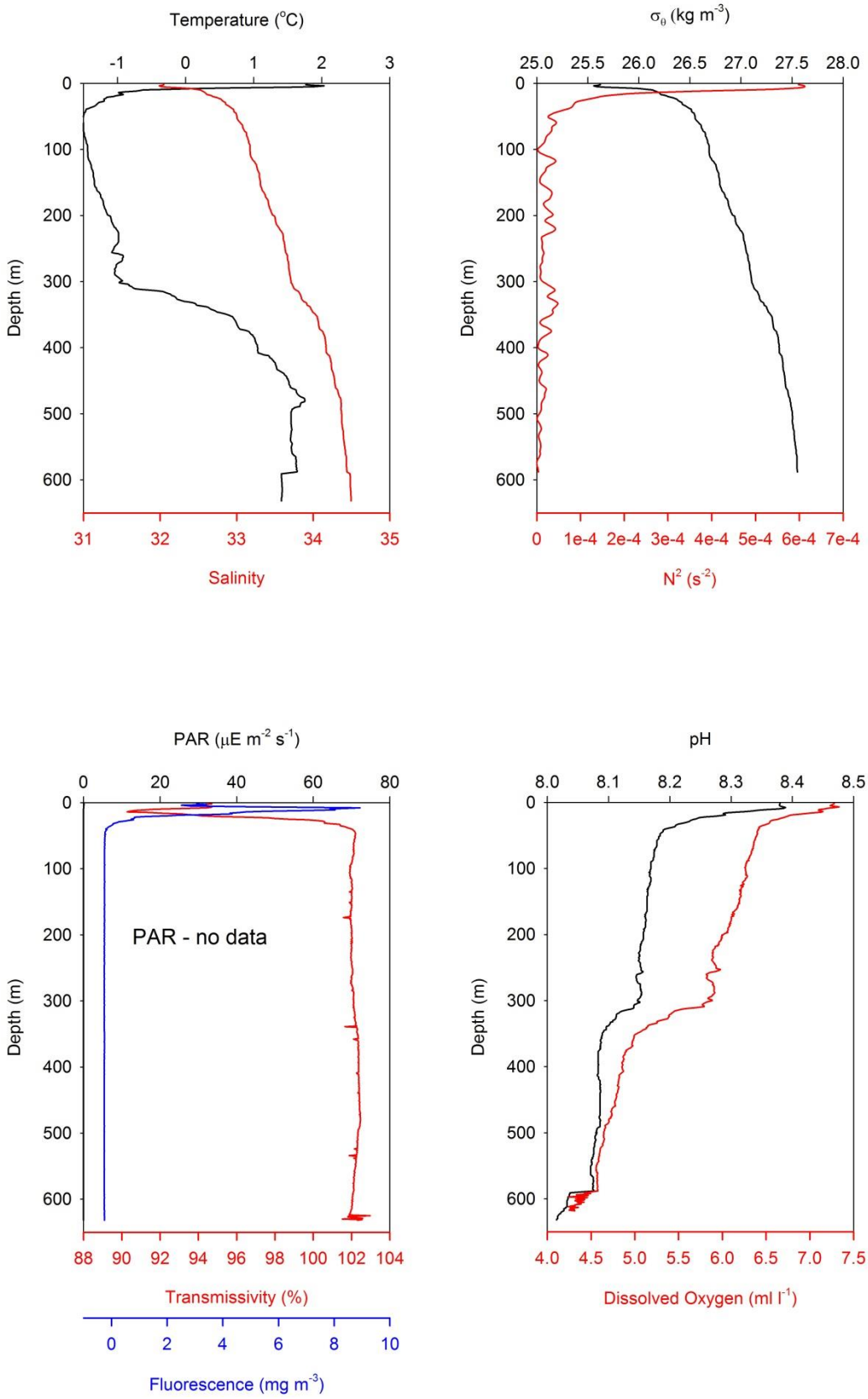
23/09/2012: CON41



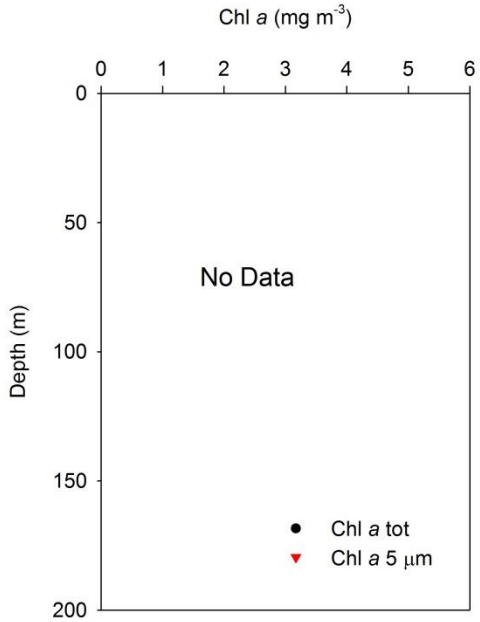


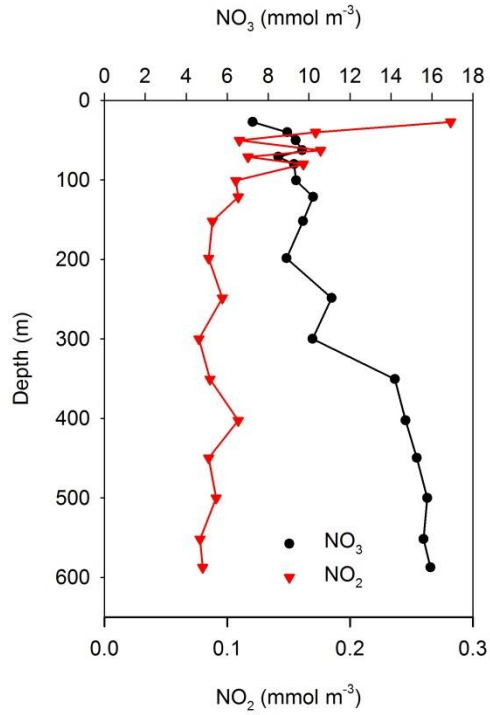


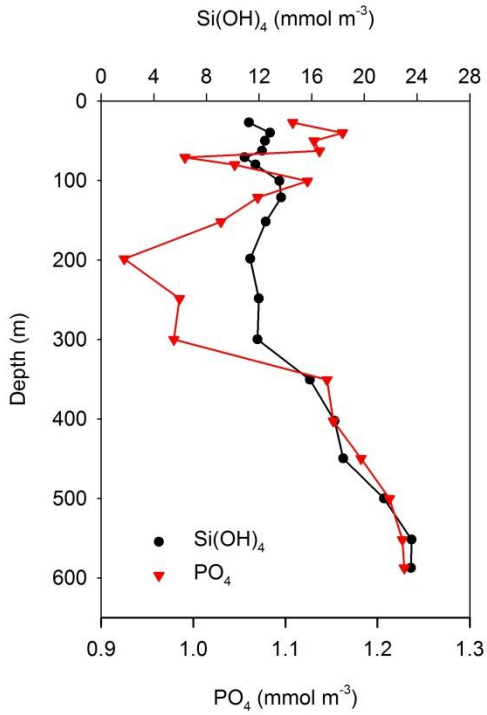
23/09/2012: CON43



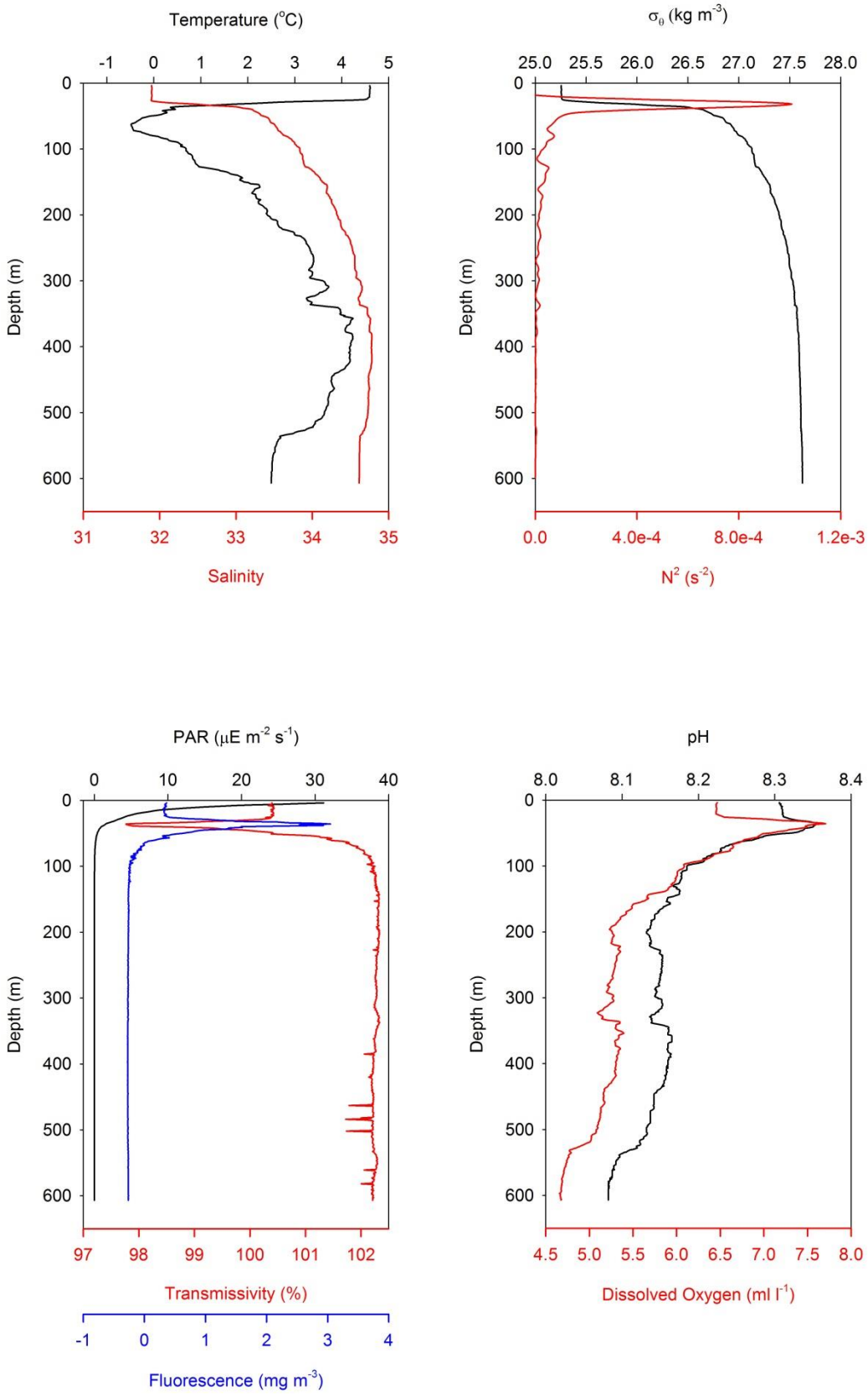
23/09/2012: CON43



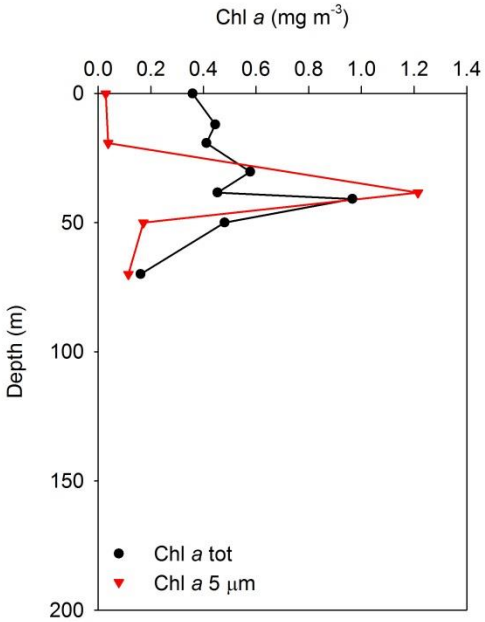


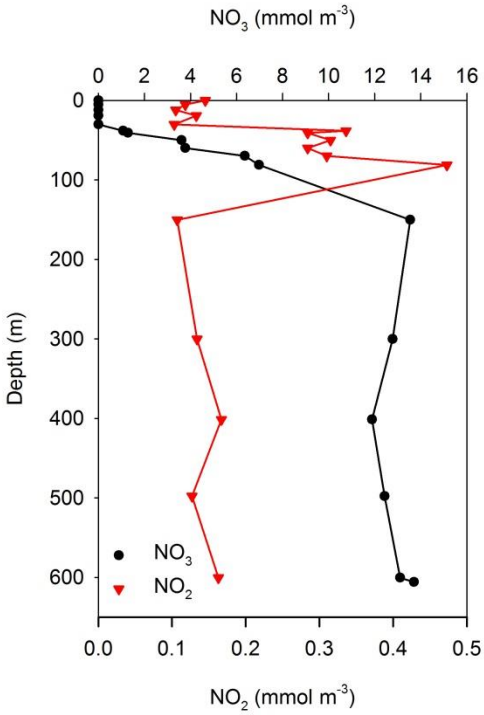


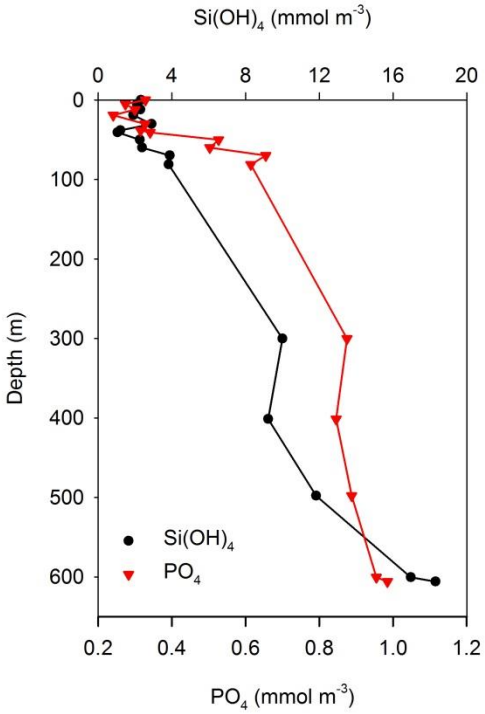
24/09/2012: CON47



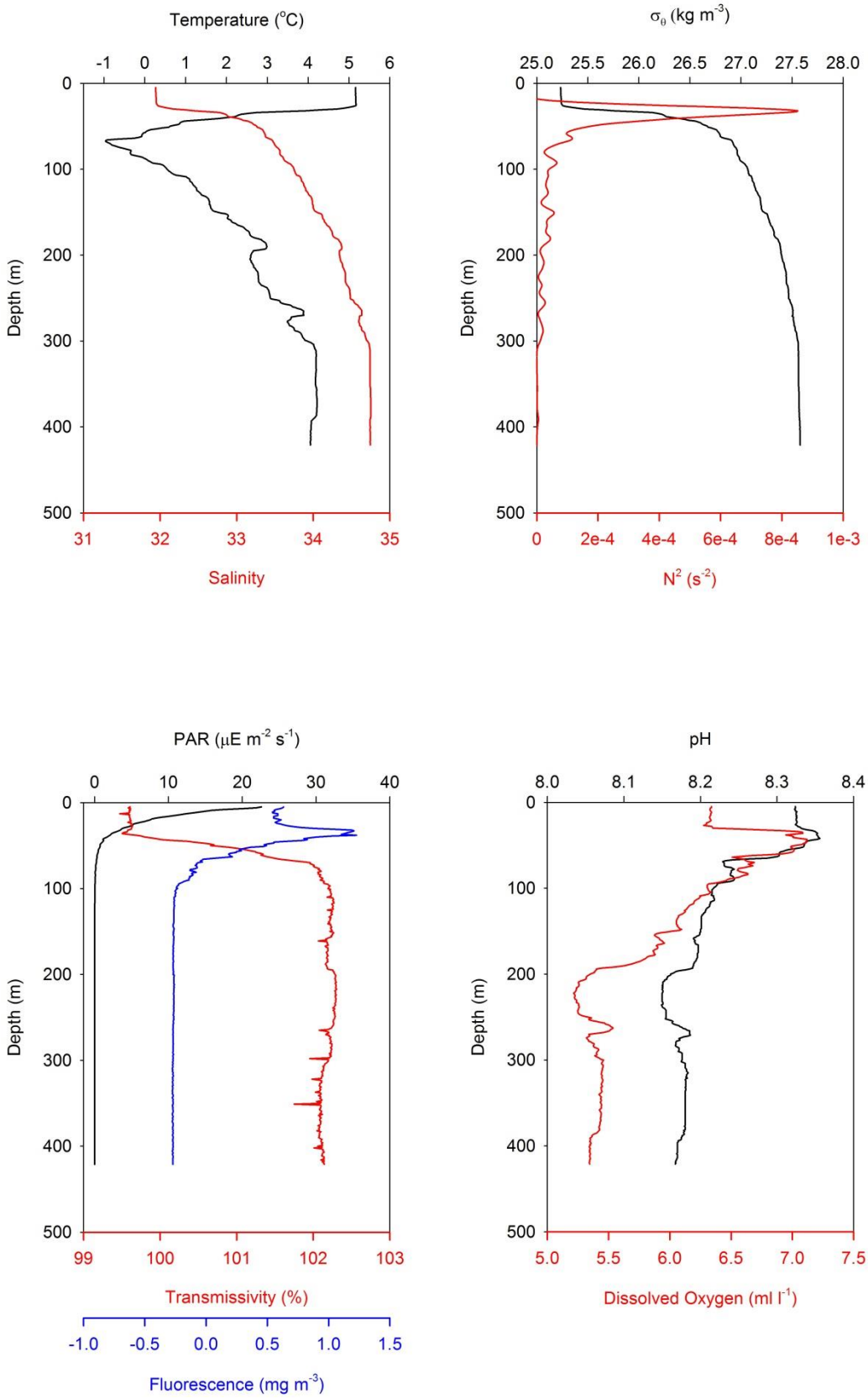
24/09/2012: CON47



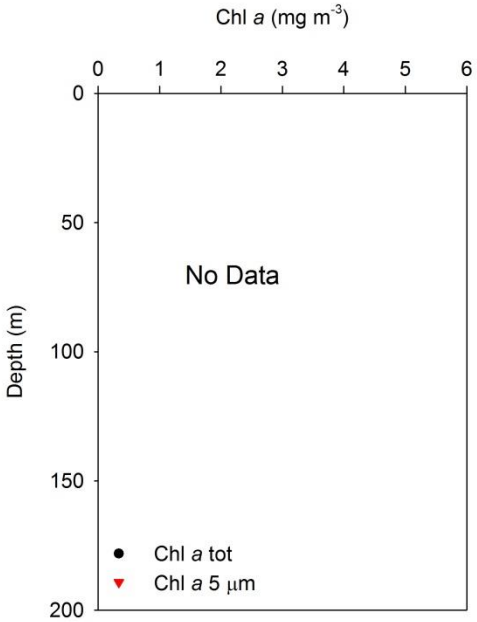


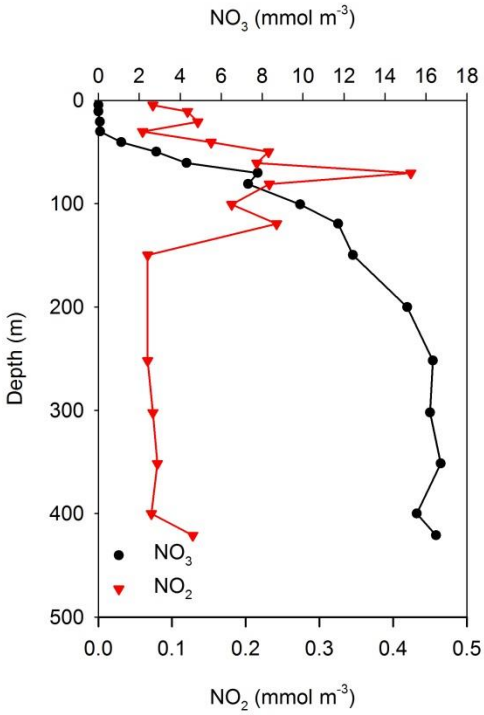


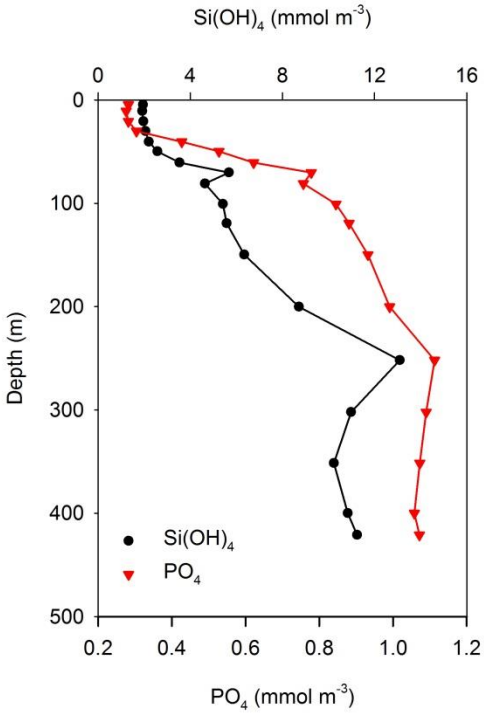
26/09/2012: CON54



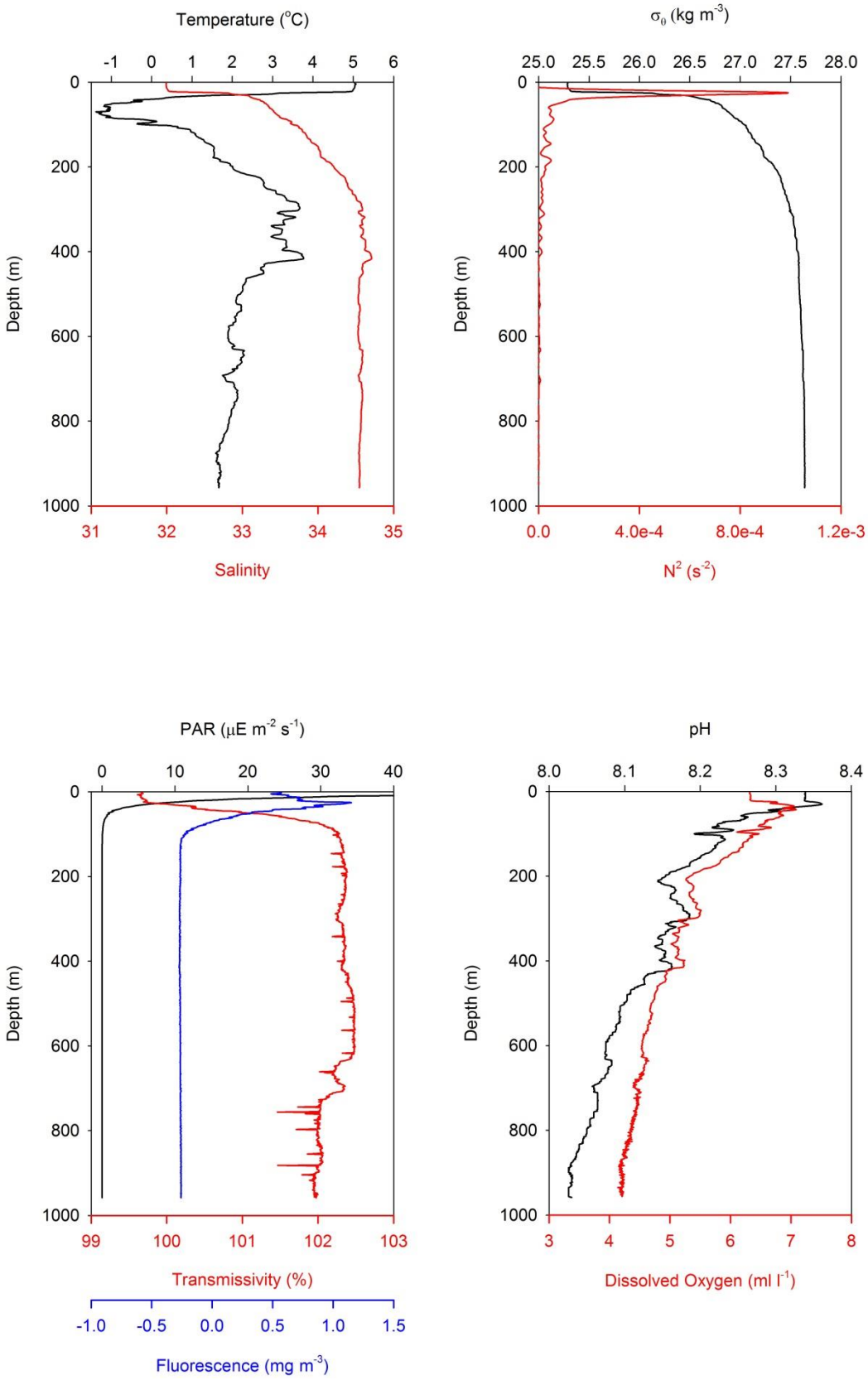
26/09/2012: CON54



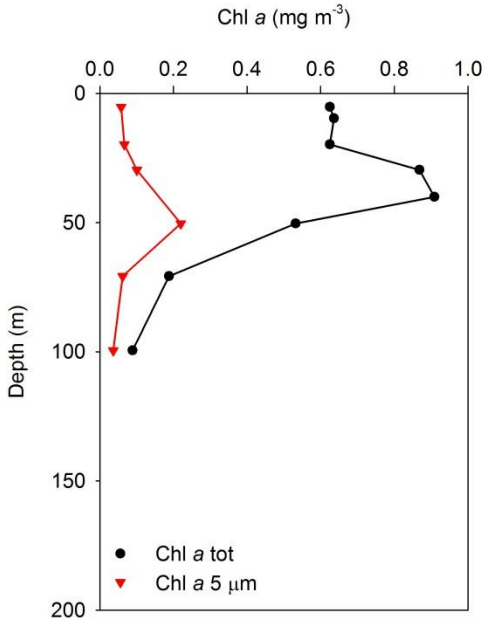


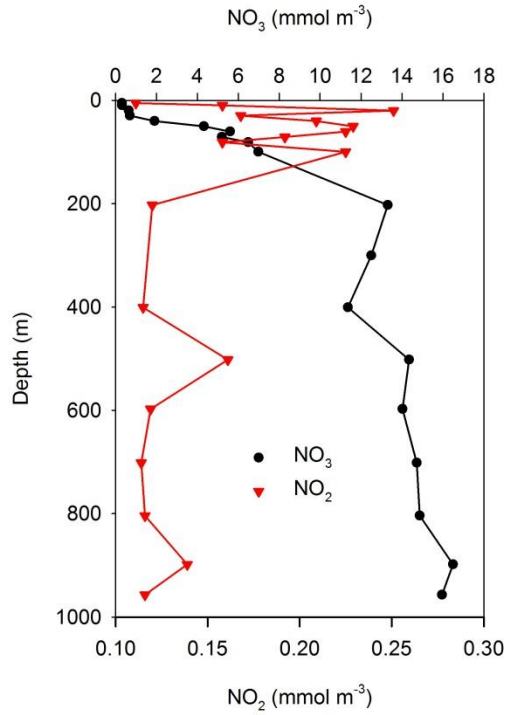


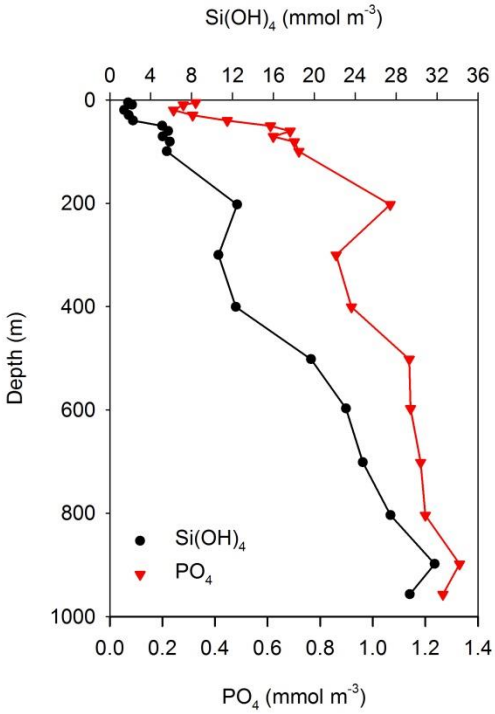
27/09/2012: CON61



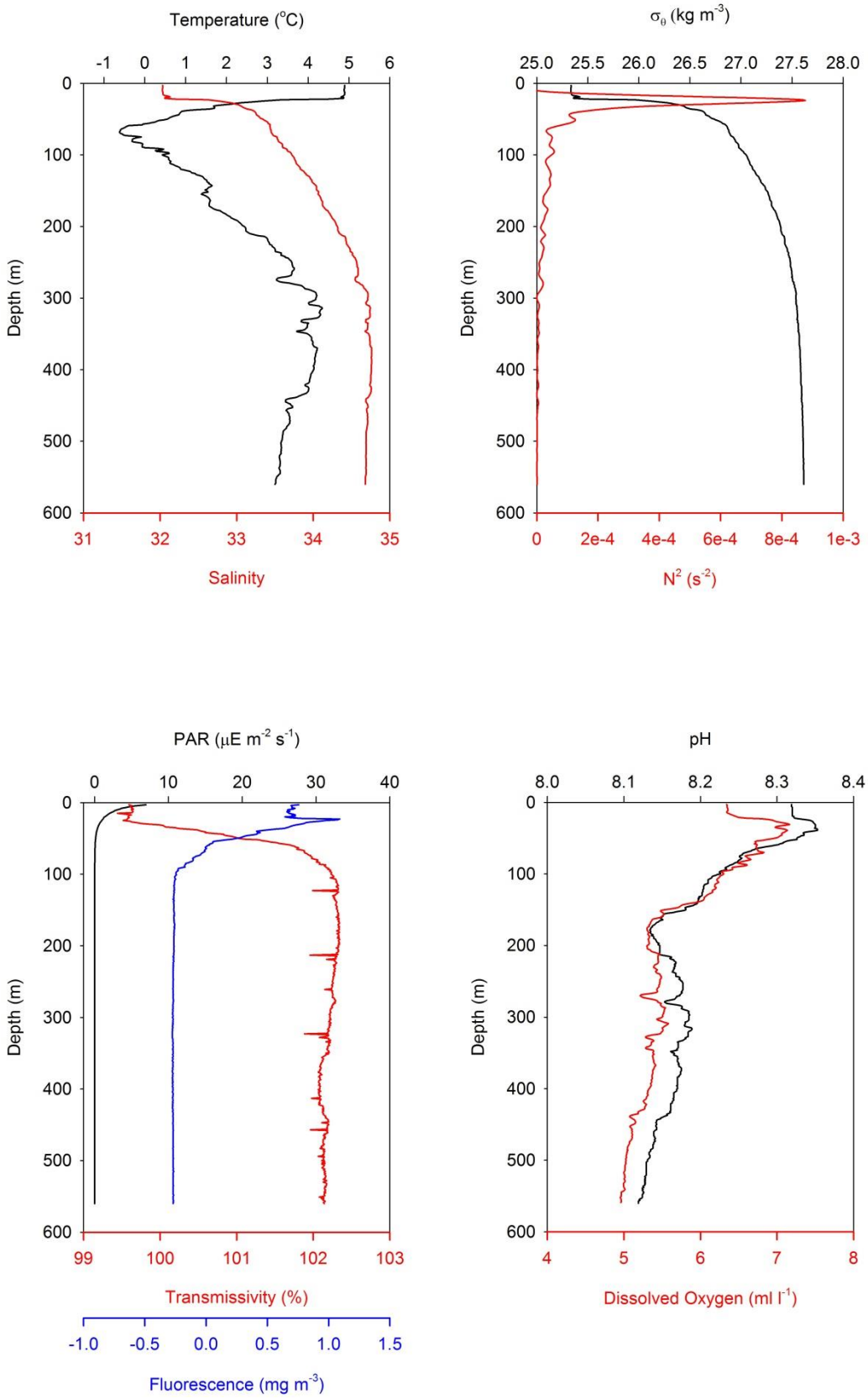
27/09/2012: CON61



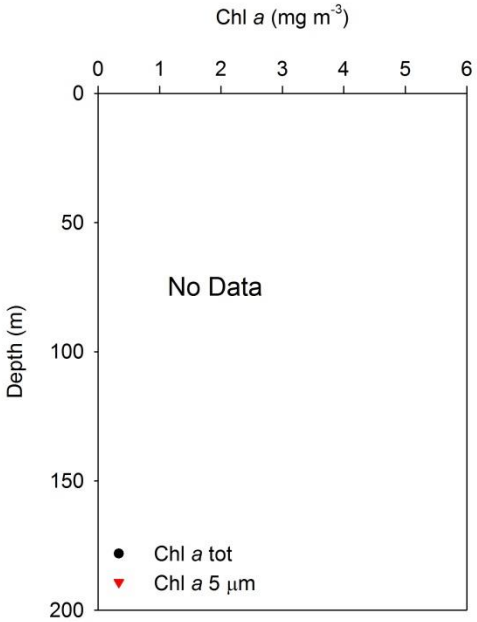


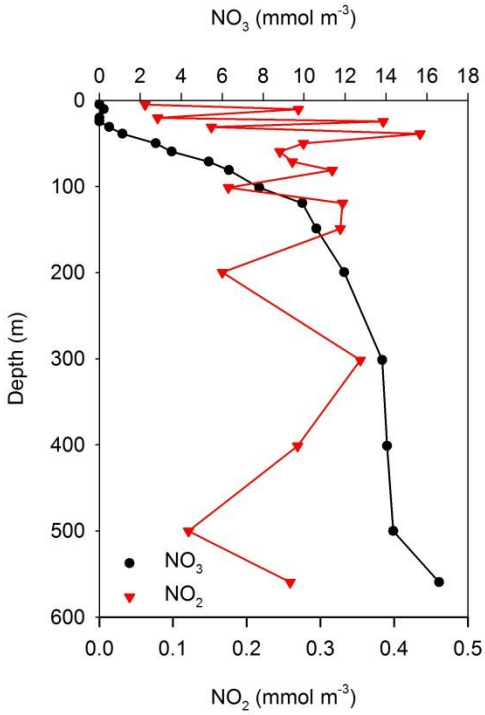


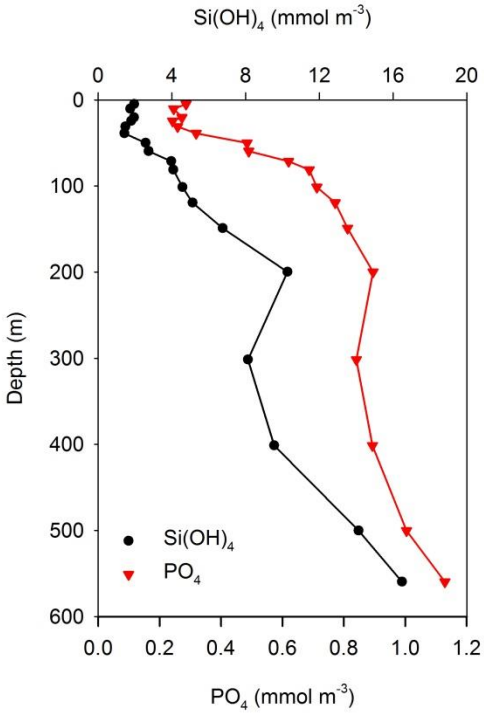
28/09/2012: CON73



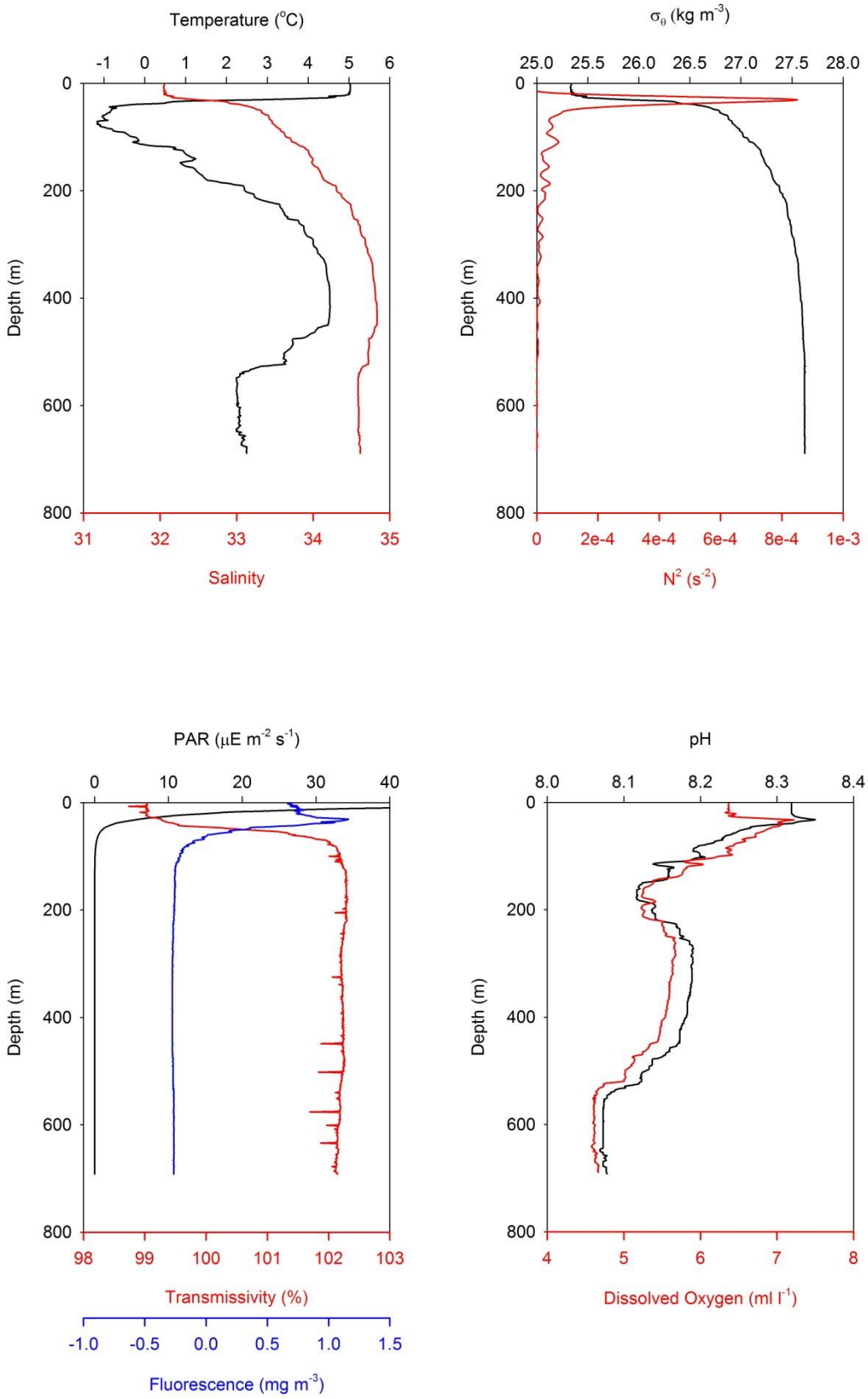
28/09/2012: CON73



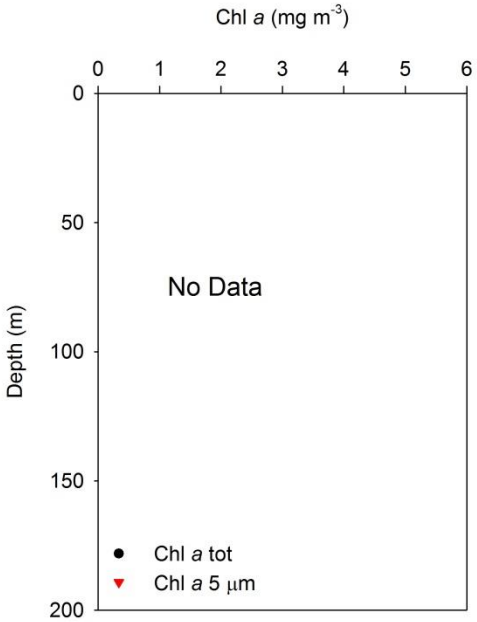


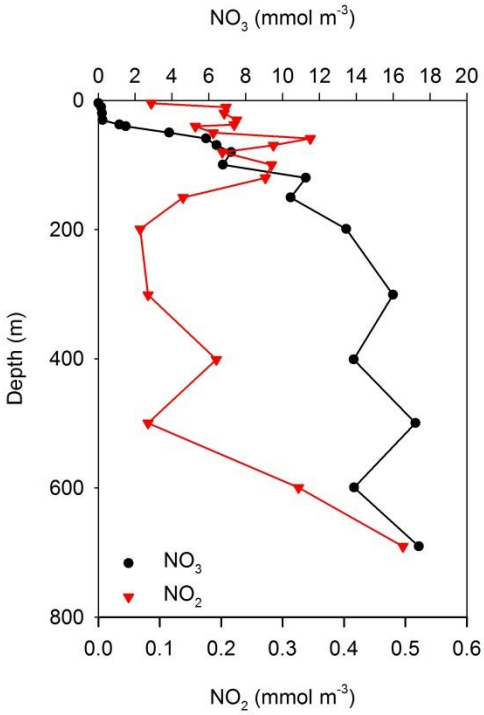


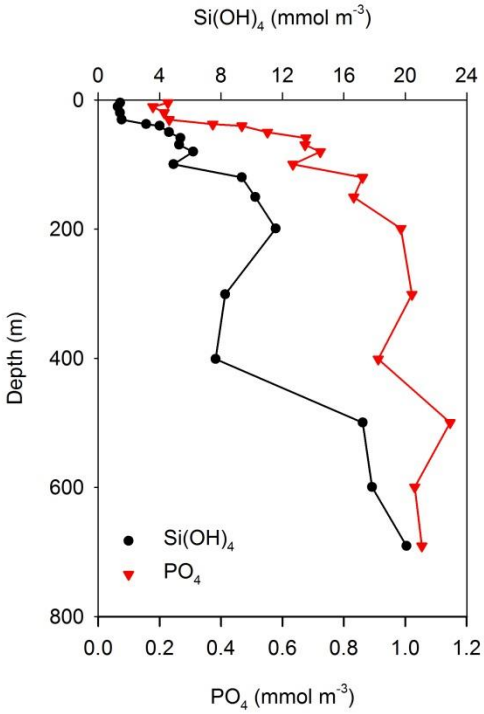
28/09/2012: CON77



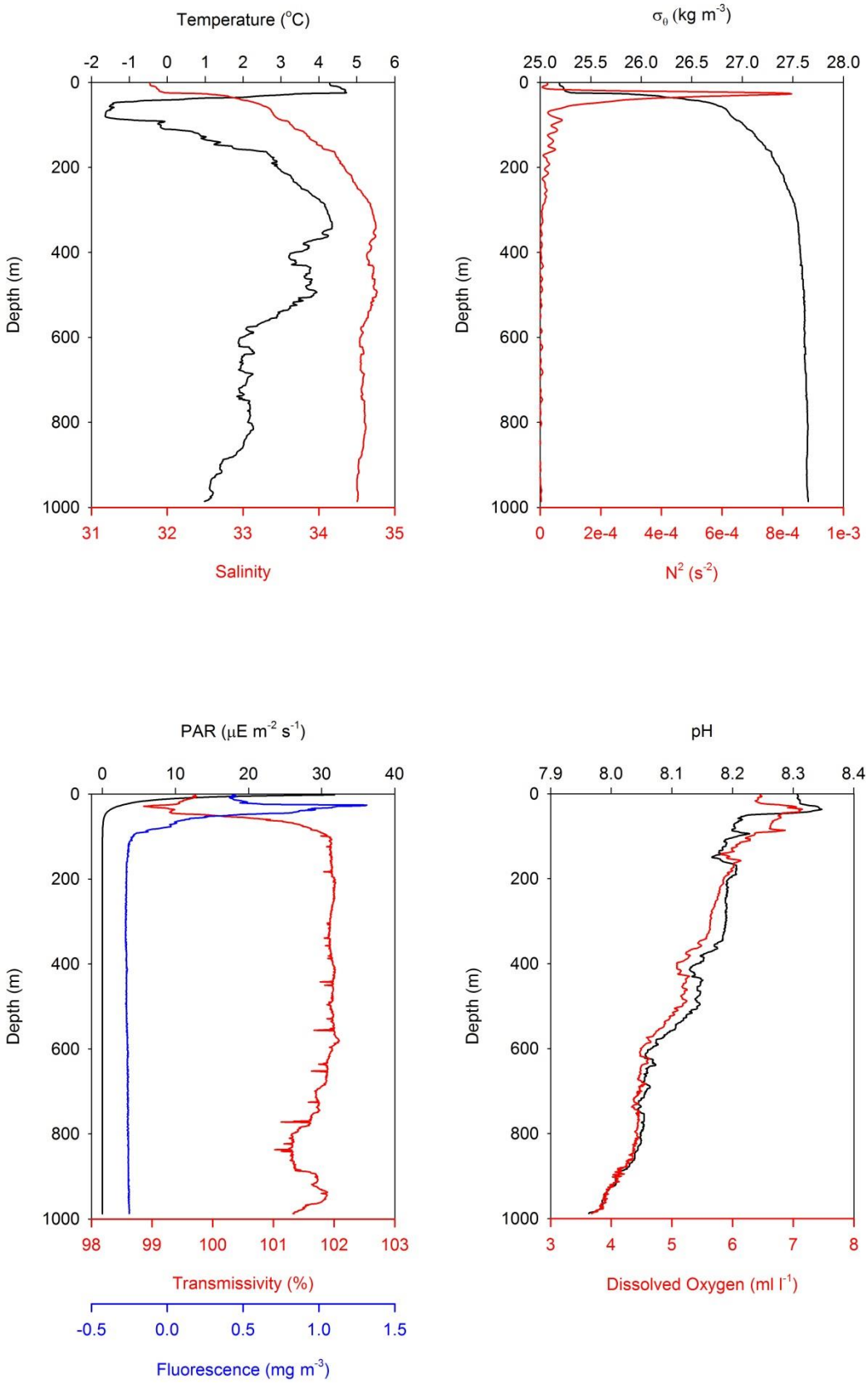
28/09/2012: CON77



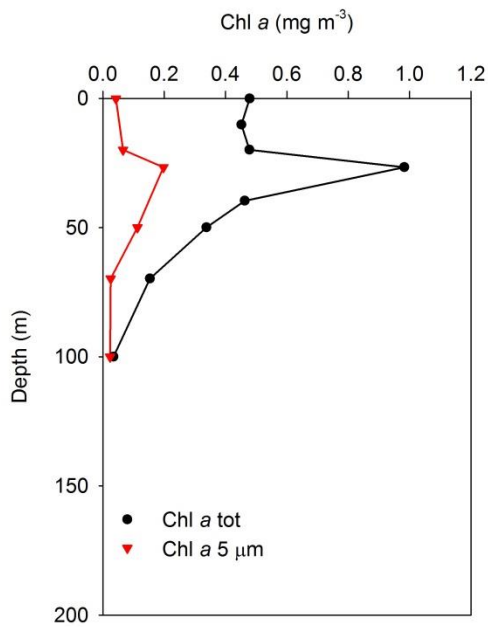


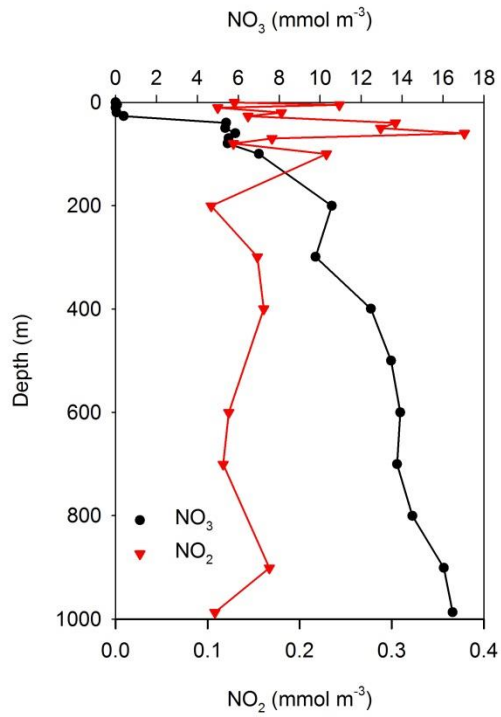


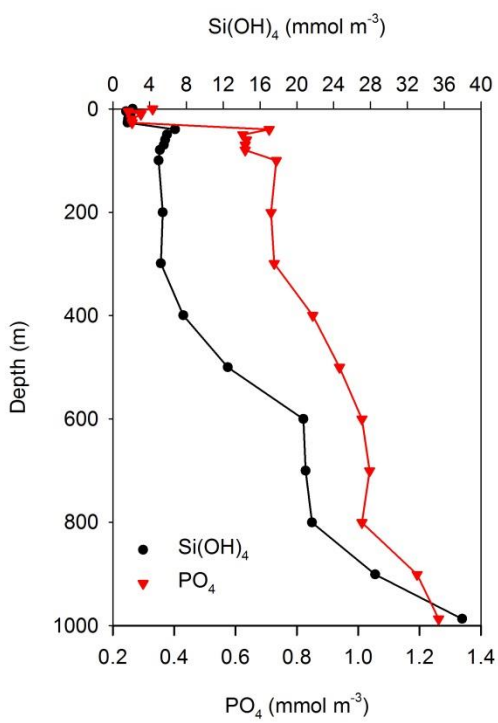
30/09/2012: CON98



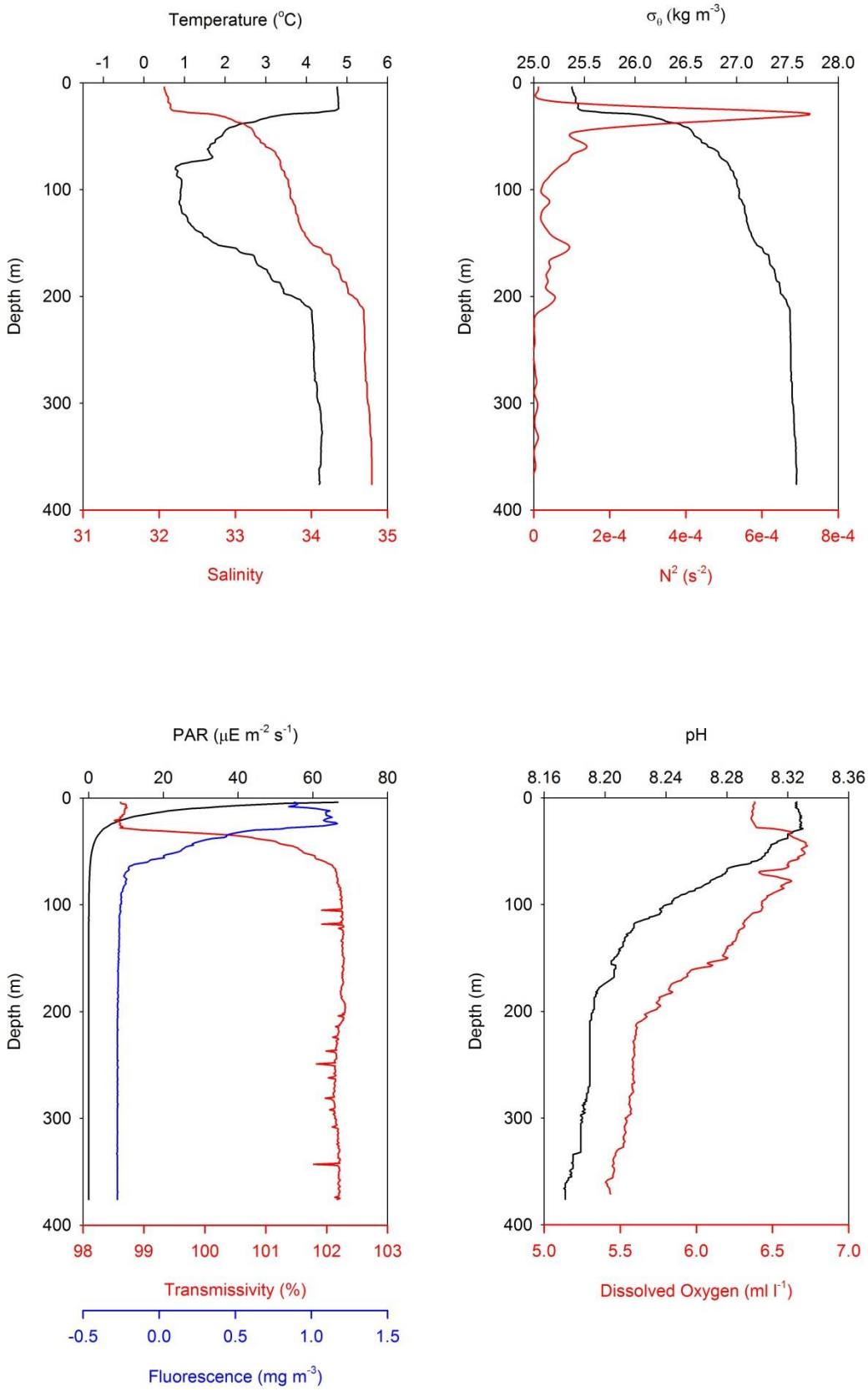
30/09/2012: CON98



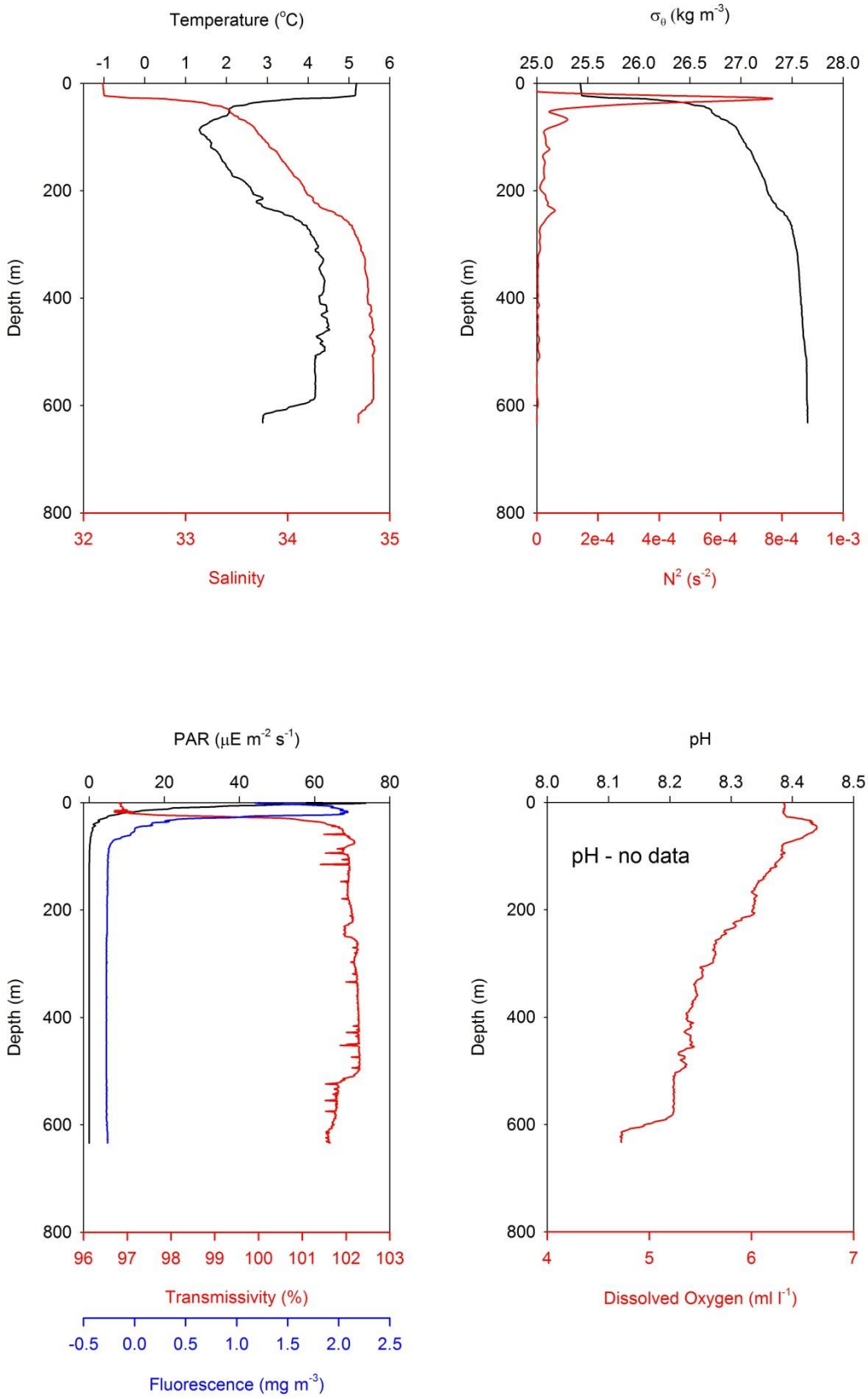




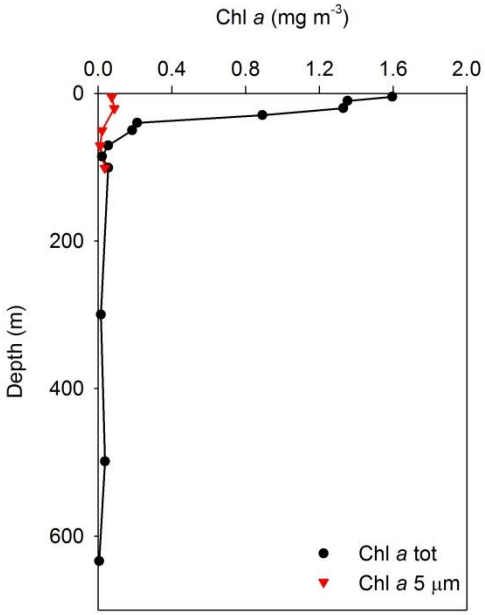
01/10/2012: CON115

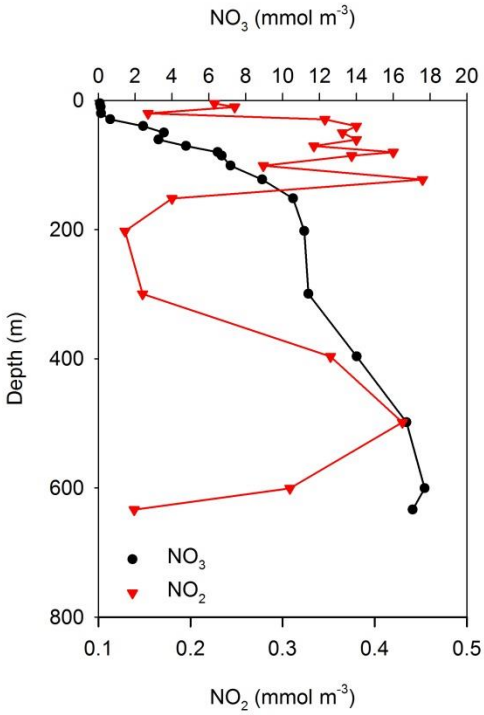


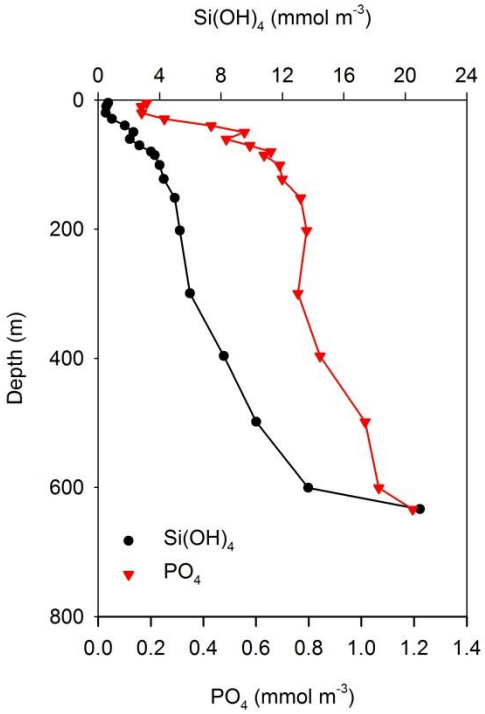
01/10/2012: CON117



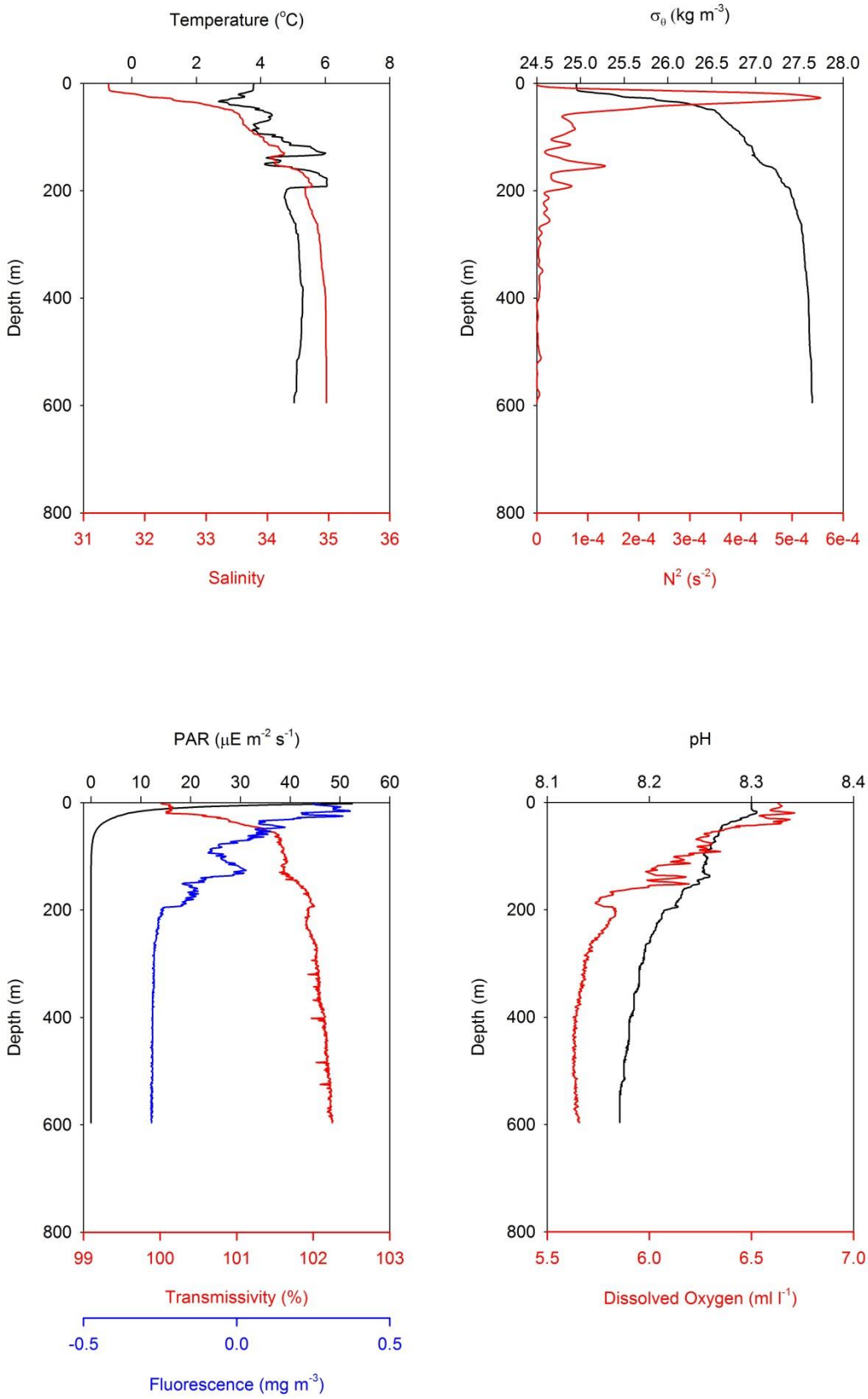
01/10/2012: CON117



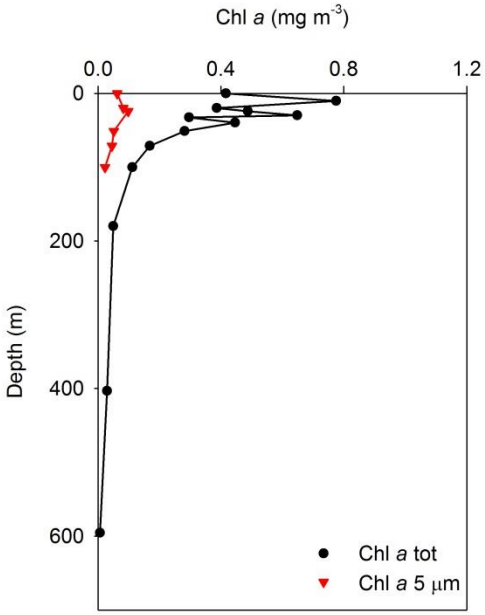


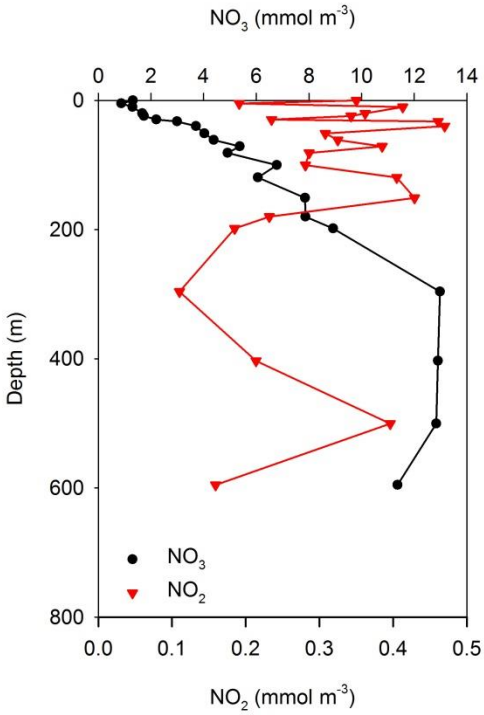


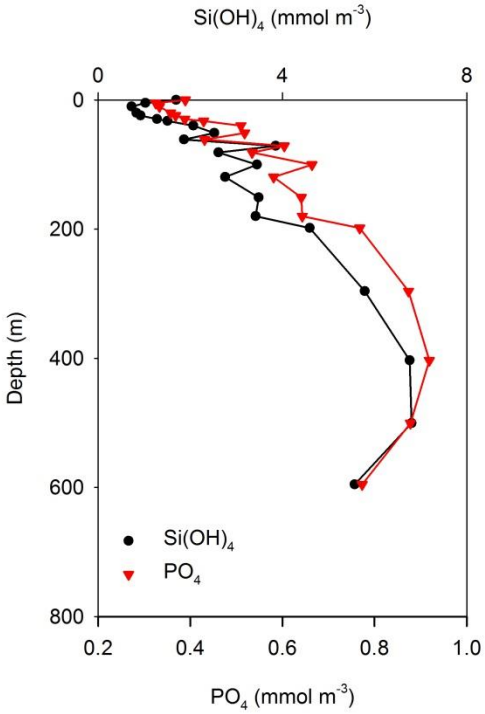
03/10/2012: CON133



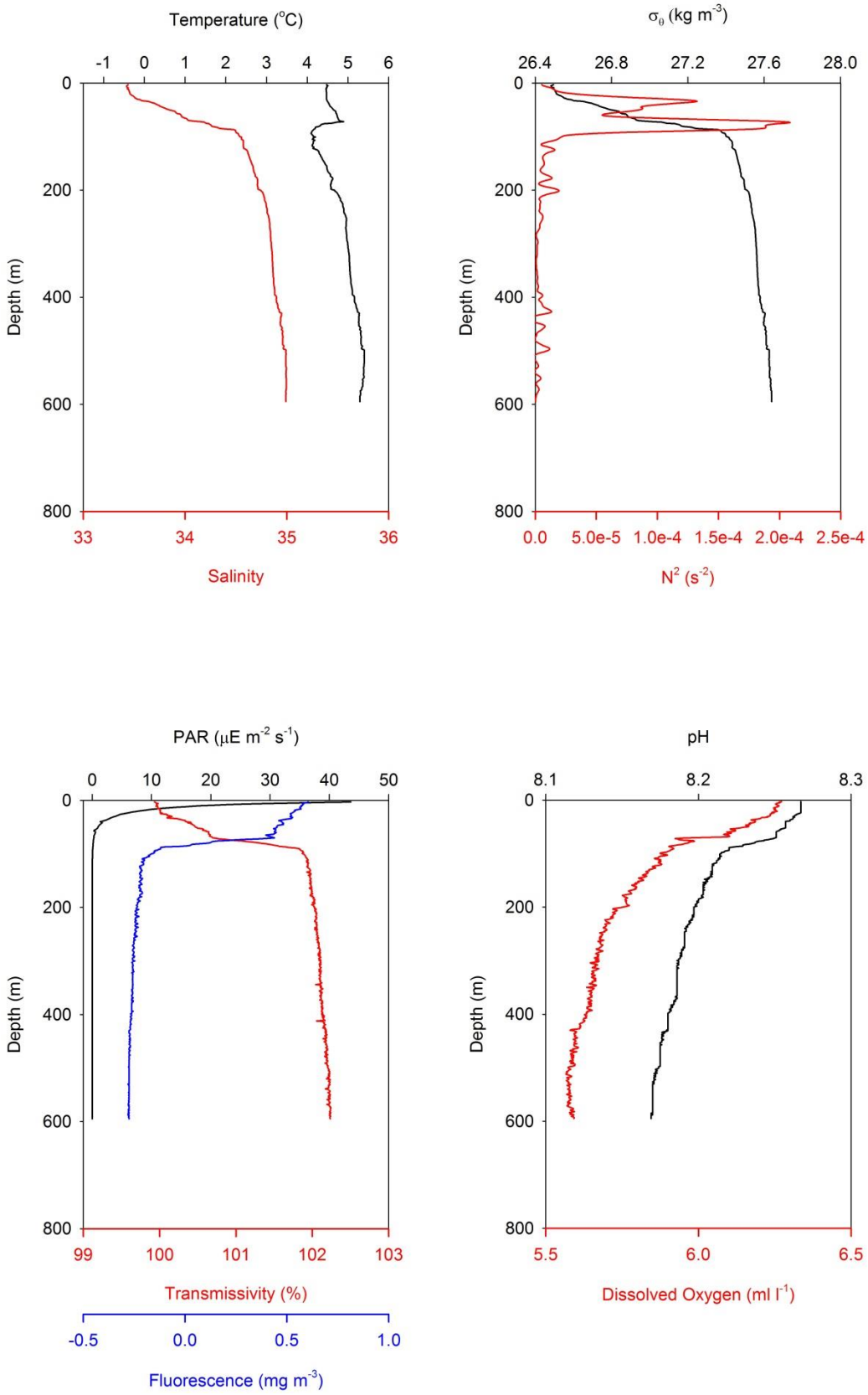
03/10/2012: CON133



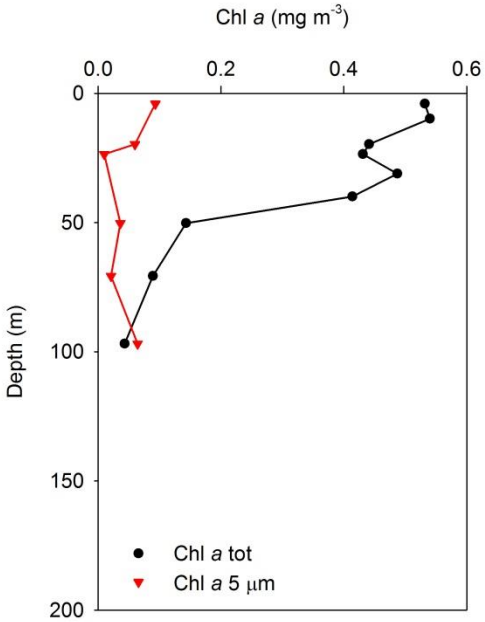


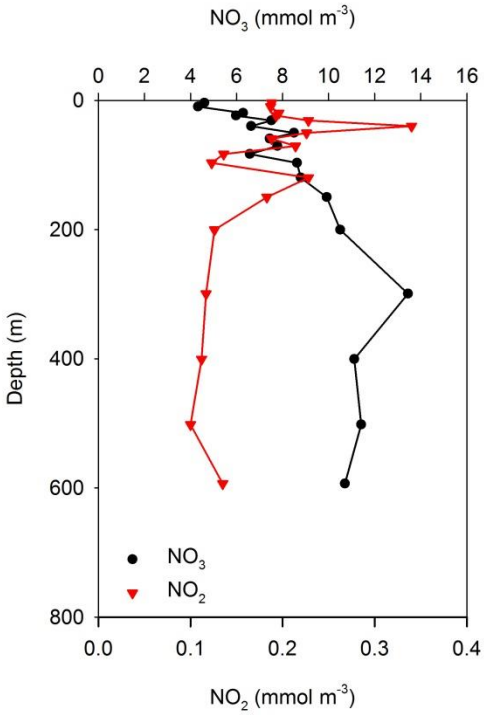


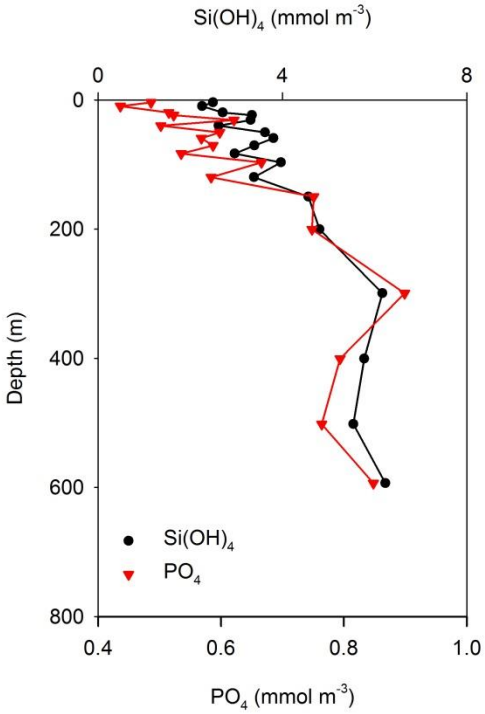
04/10/2012: CON137



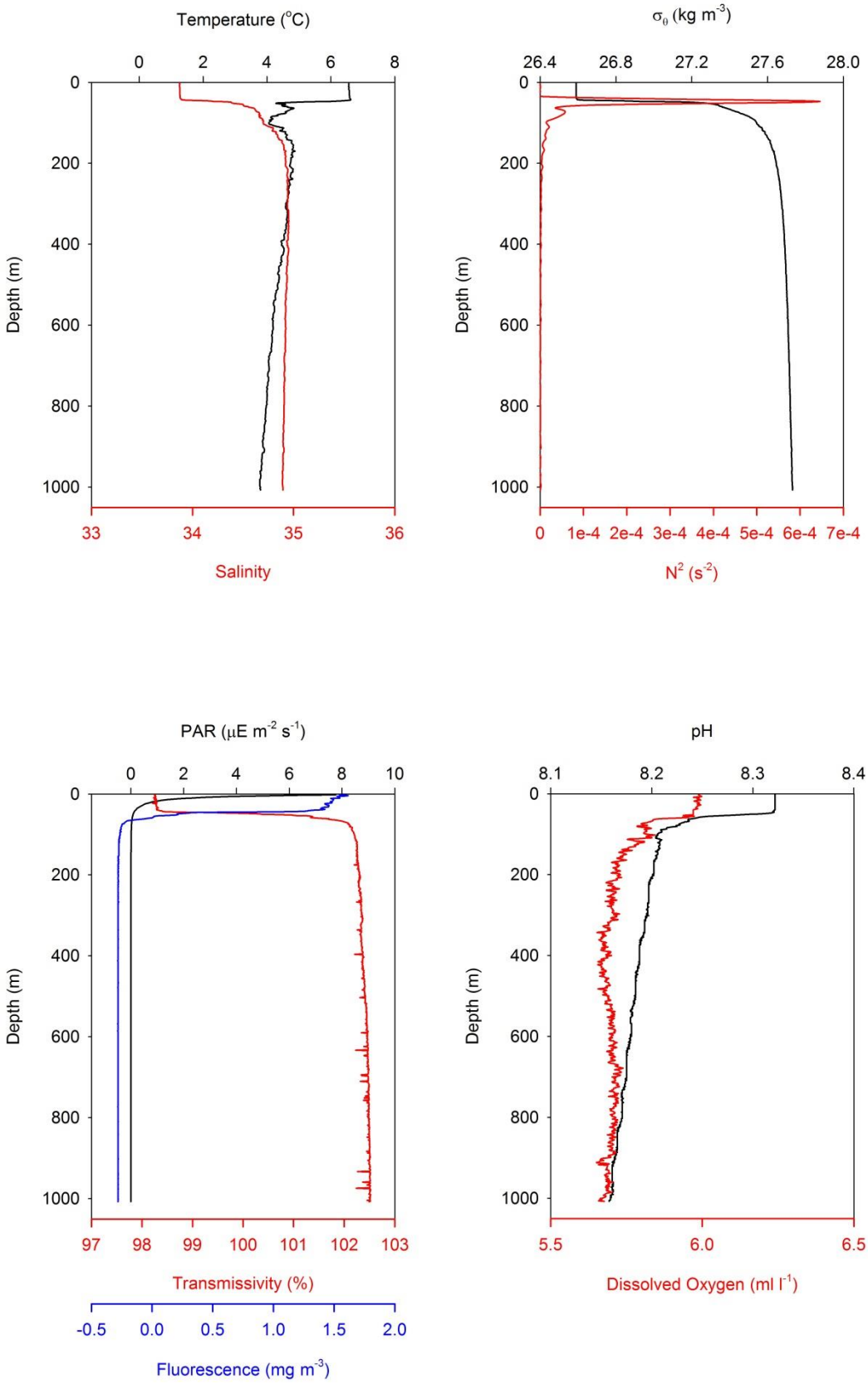
04/10/2012: CON137



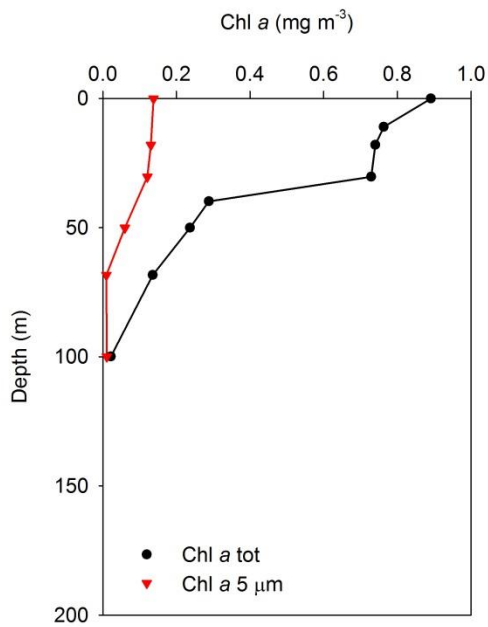


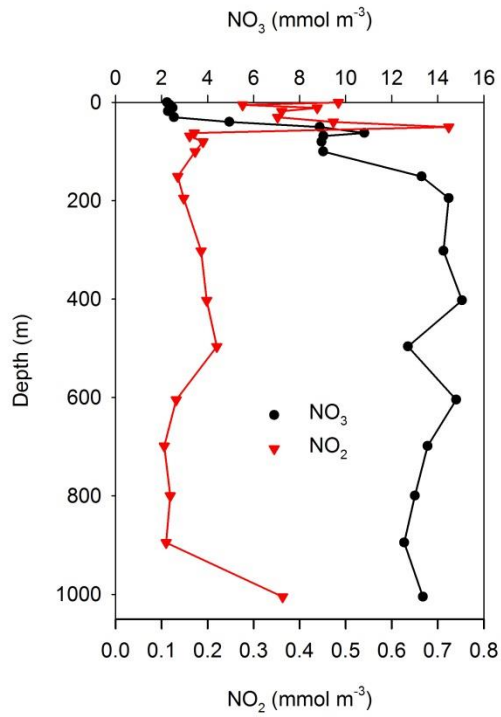


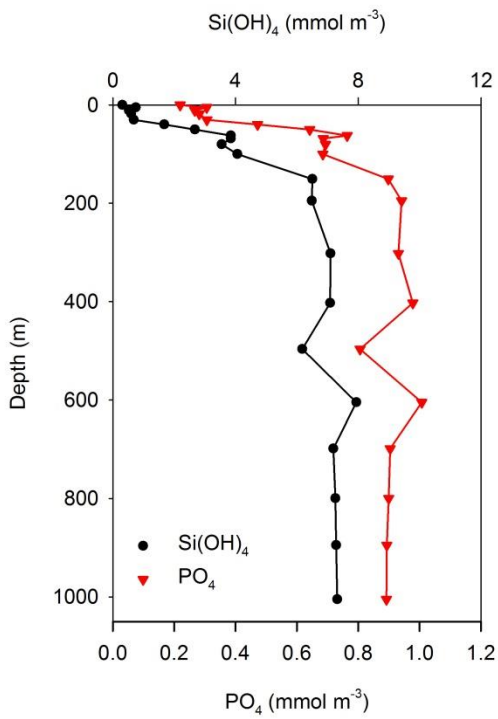
05/10/2012: CON138



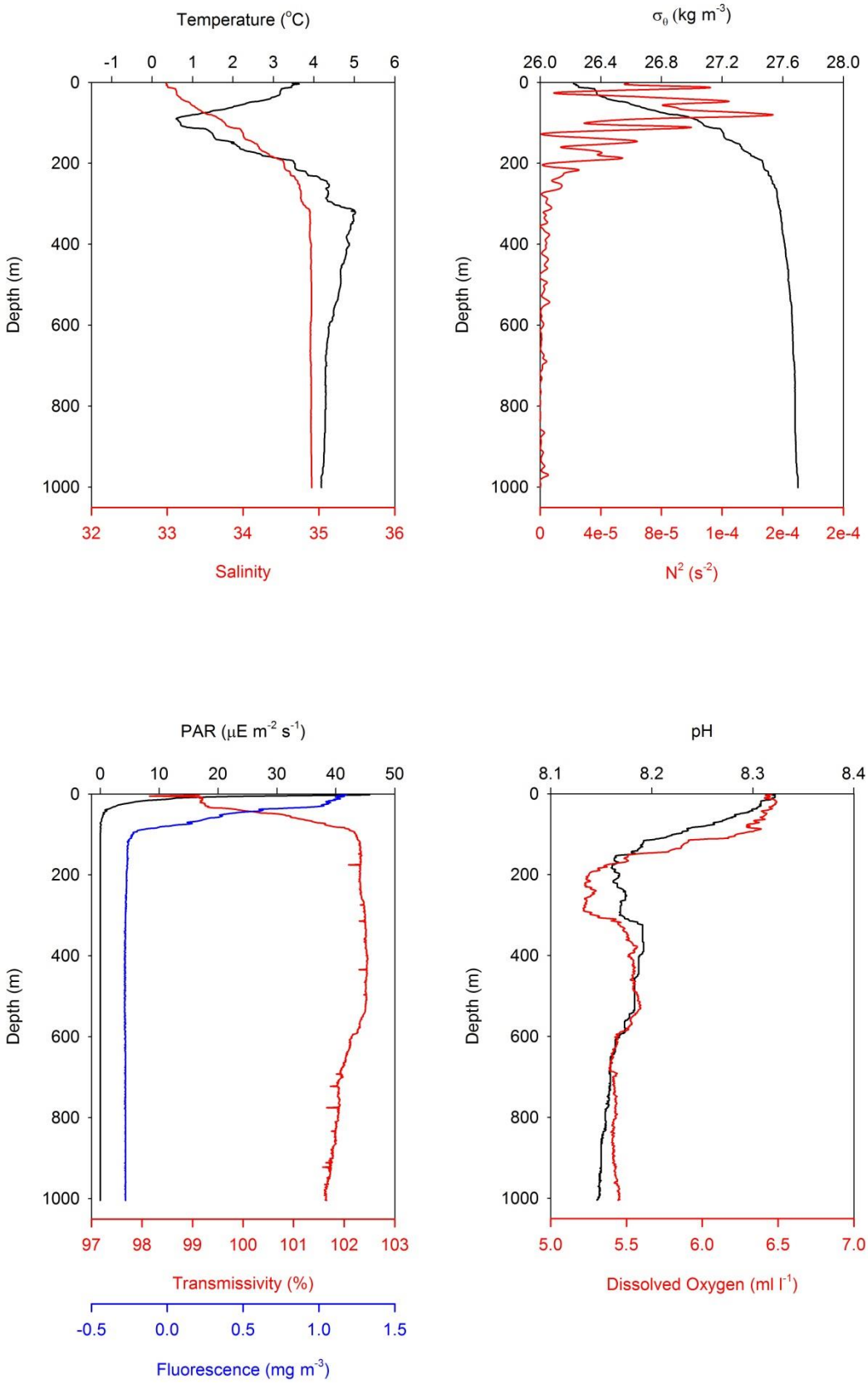
05/10/2012: CON138







09/10/2012: CON140



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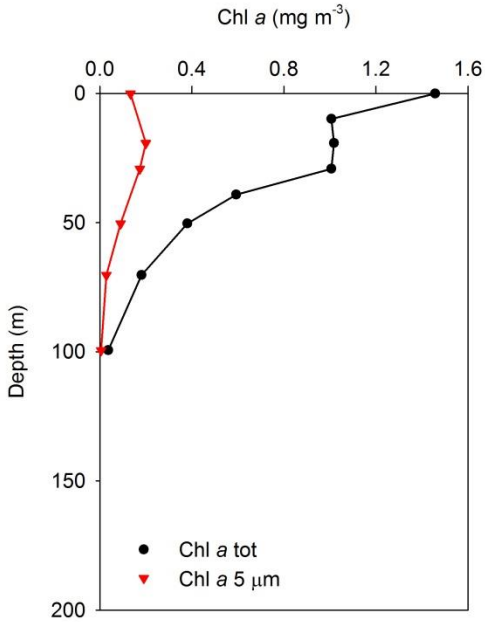

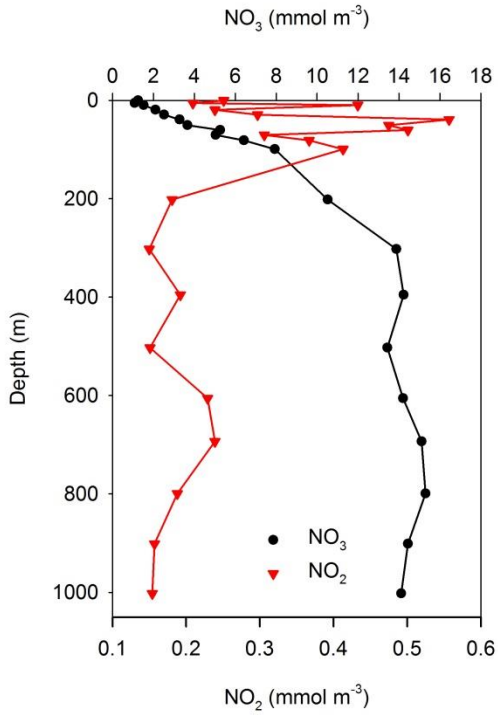

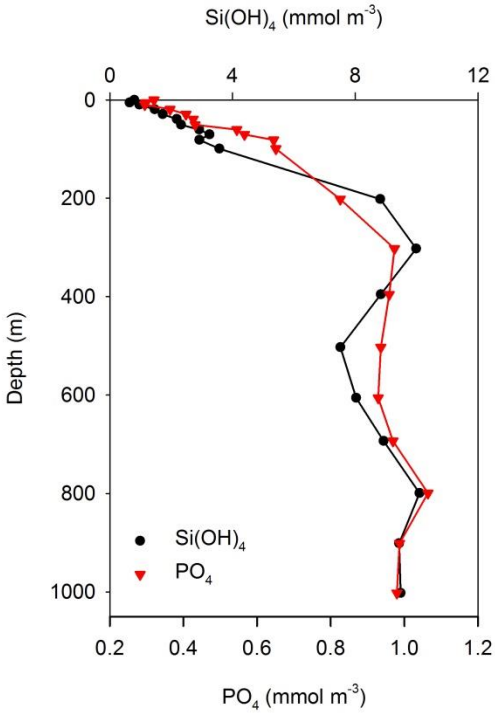

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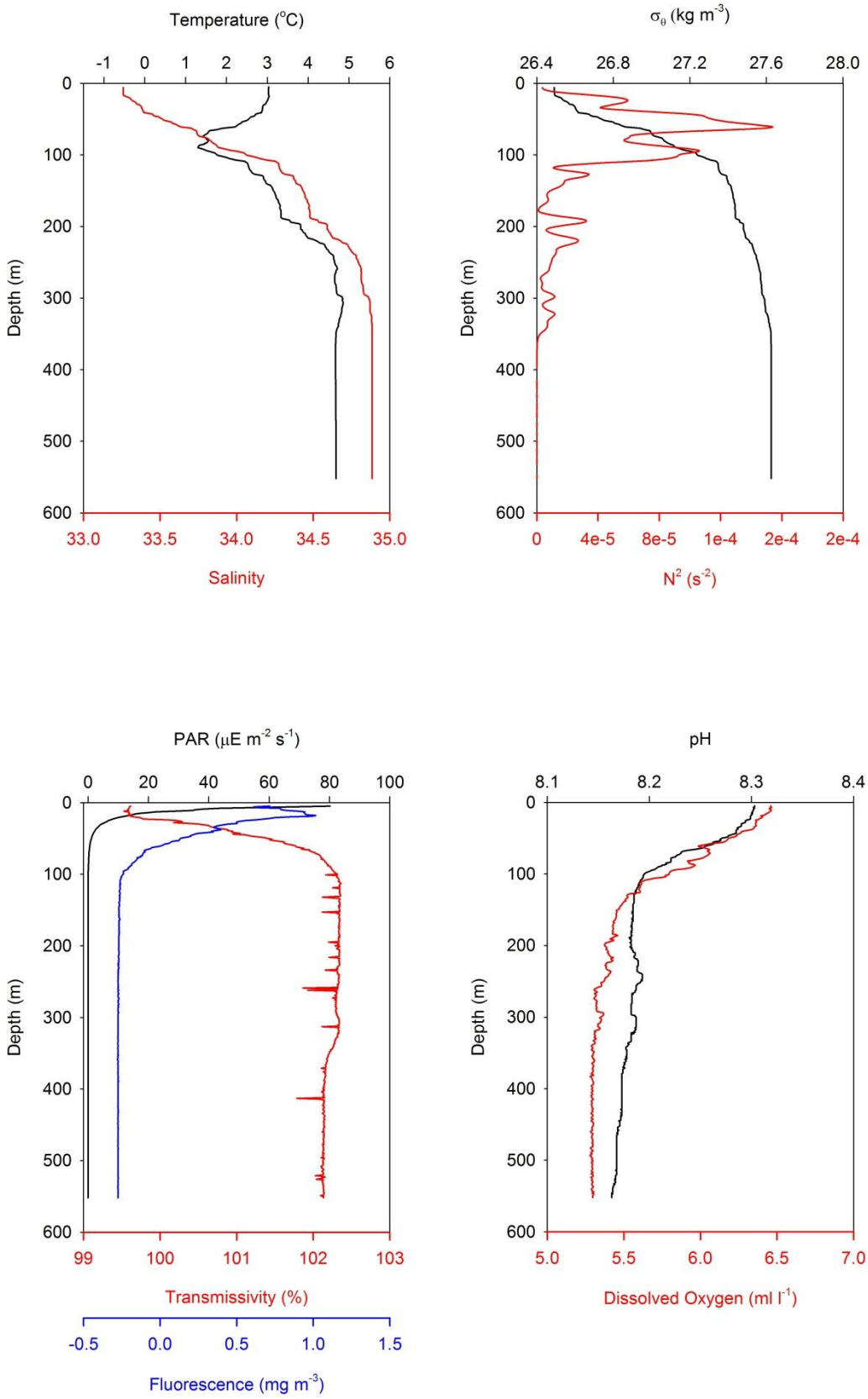

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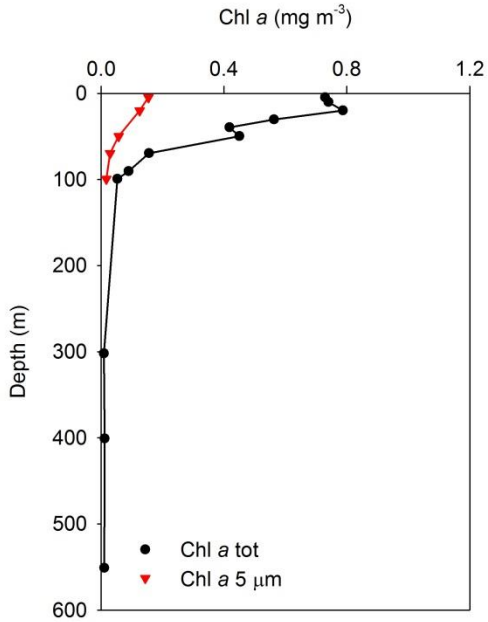

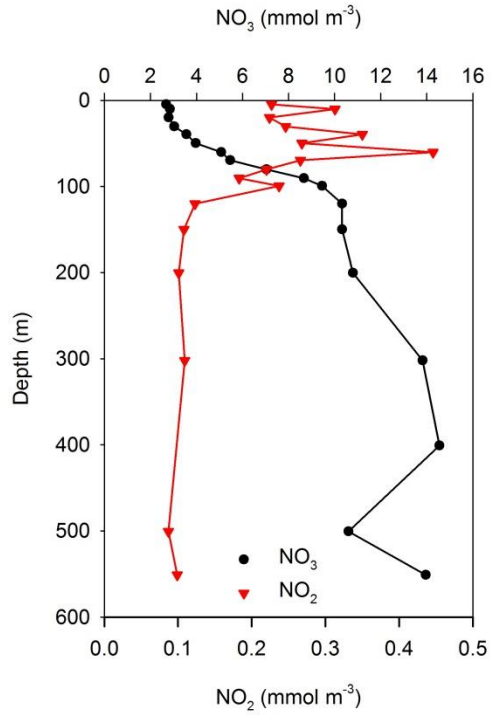

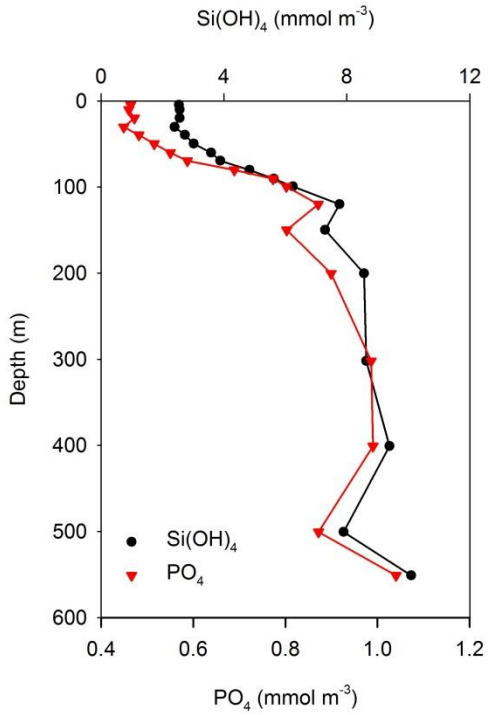

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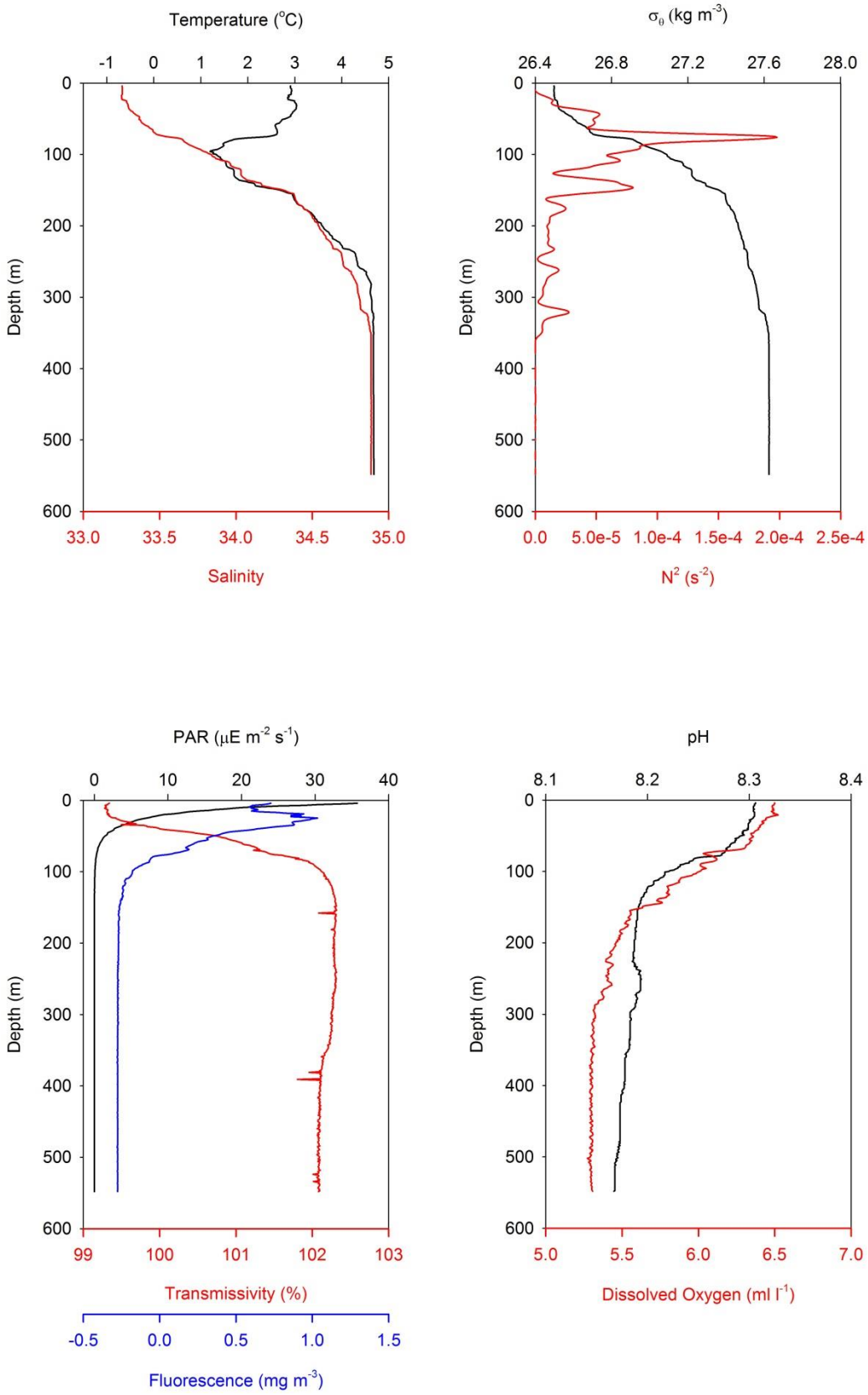

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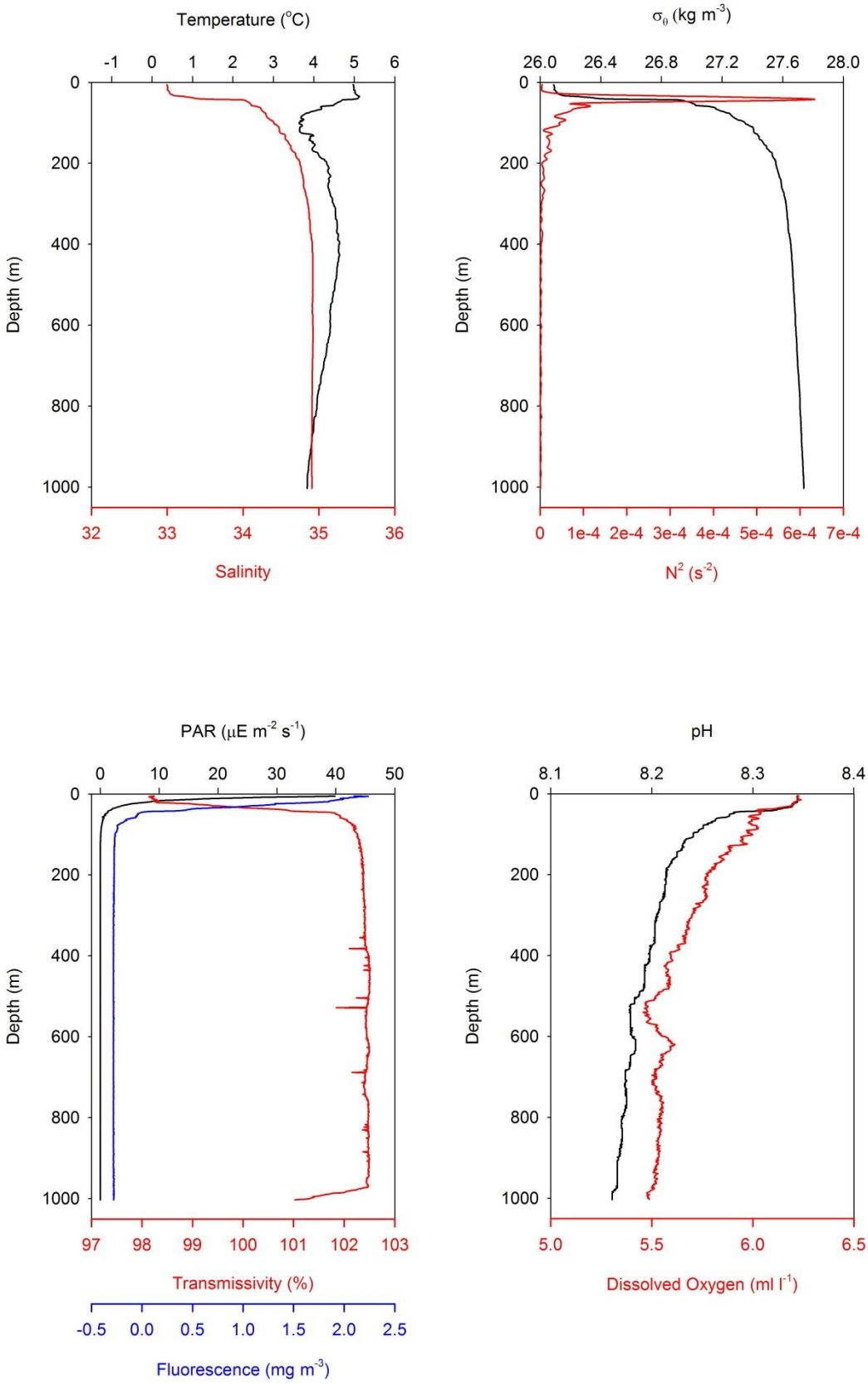

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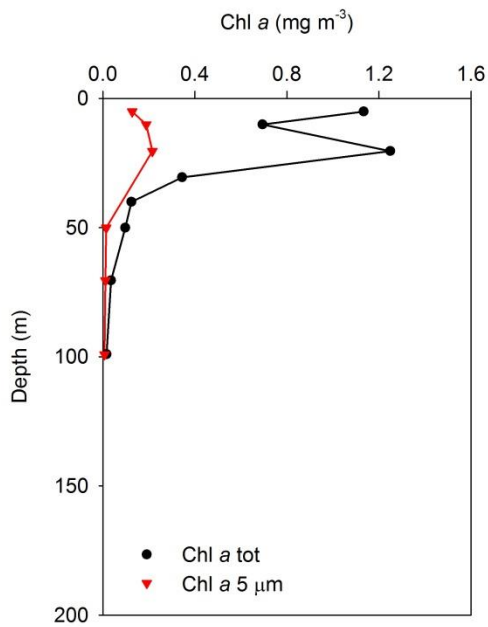

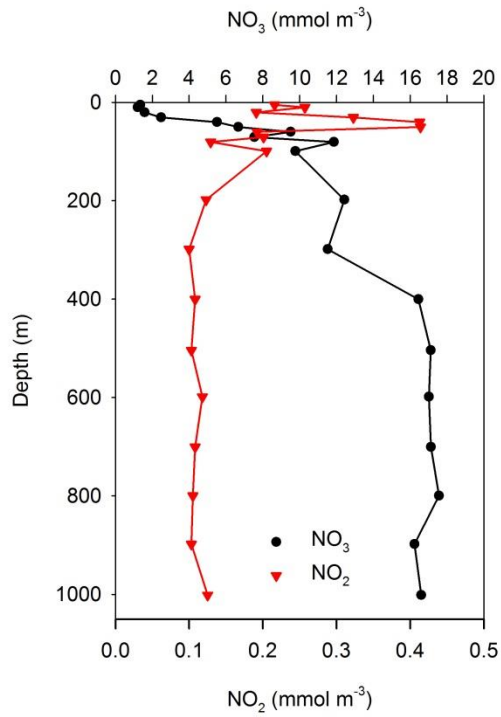

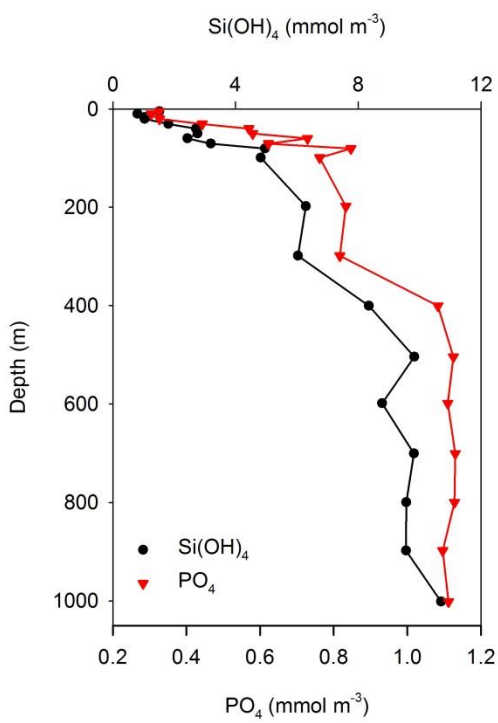

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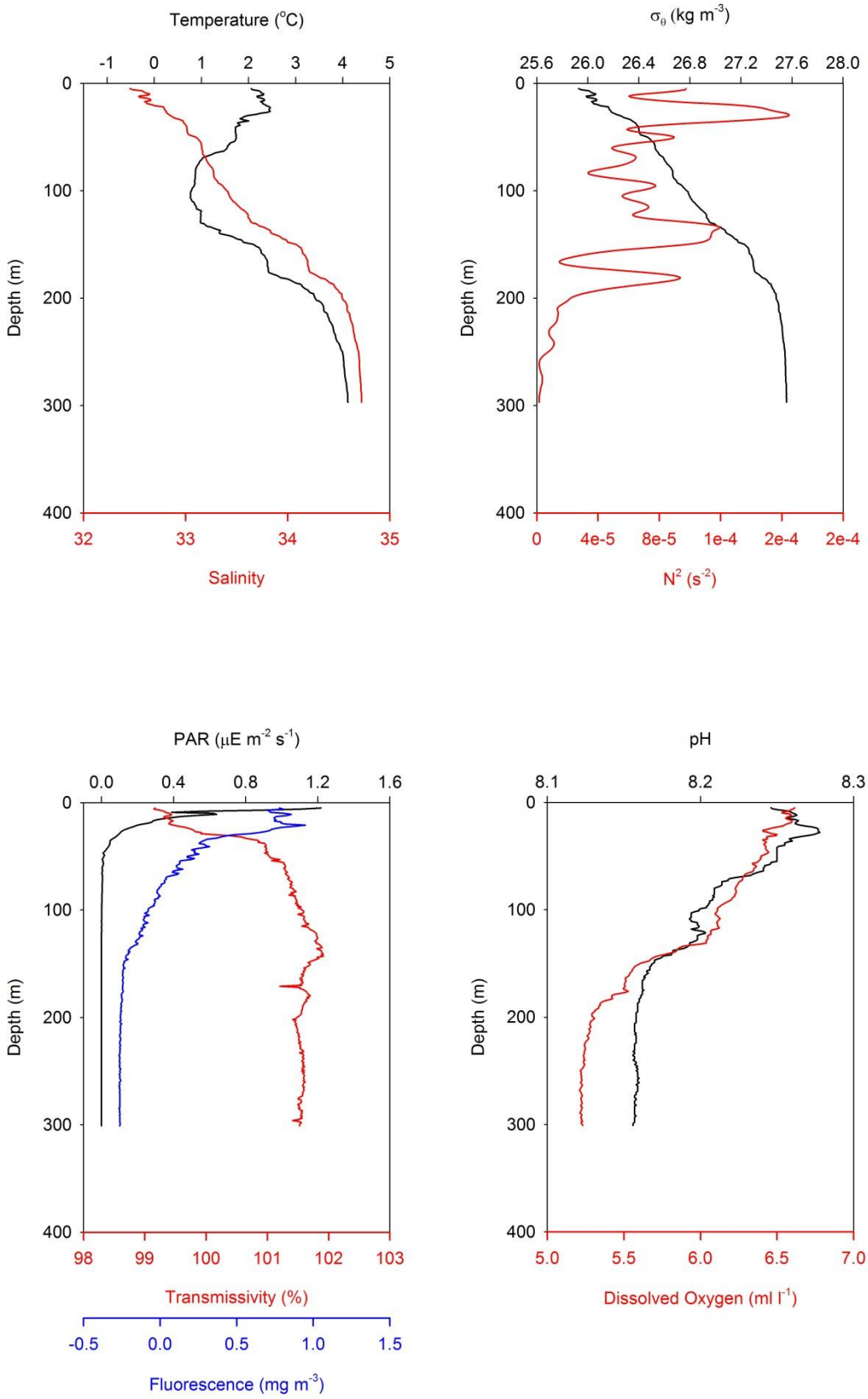

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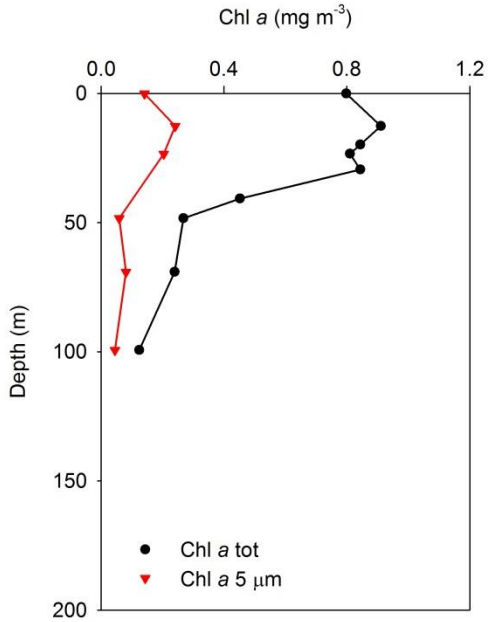

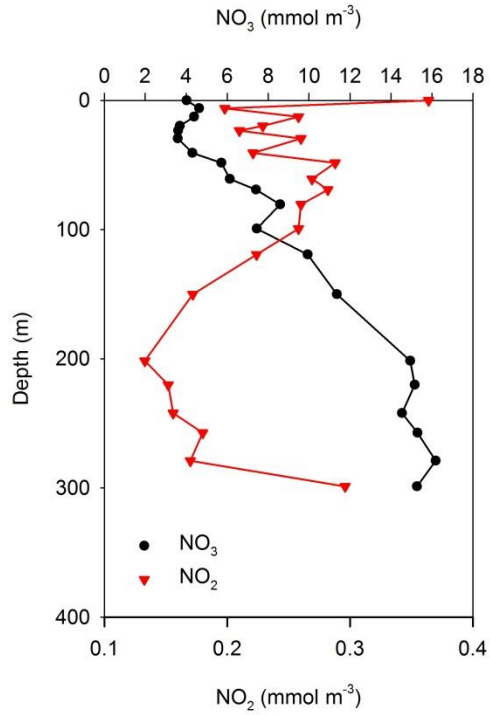

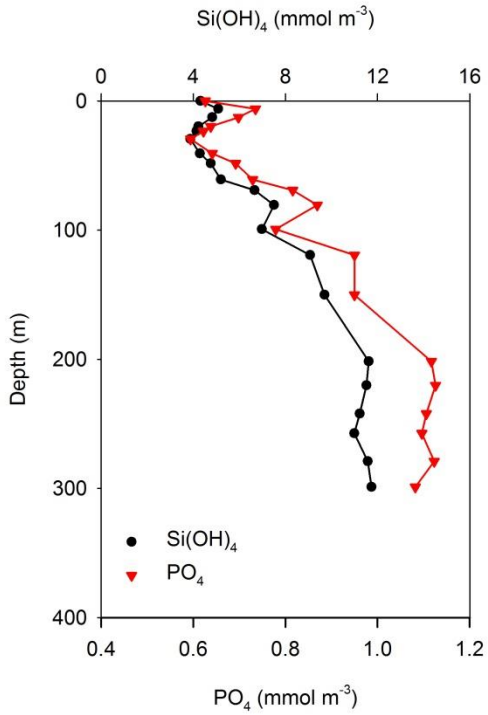

APPENDIX 2. Salinity, temperature (°C), fluorescence (mg m^{-3}), pH and dissolved oxygen (ml l^{-1}) section plots for seven stations (CON 54-CON117) in the Narwhal over-wintering Hard Corals zone, Baffin Bay 2012. ND: no data.