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Data Report: Summary and Assessment of Environmental Data from MDBC Expedition R/V *Point Sur*, May 31–June 11, 2022

Habitat Assessment and Evaluation Project and Coral Propagation Technique Development Project

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For more information on MDBC Restoration, please visit:

https://coastalscience.noaa.gov/project/scientific-support-for-mesophotic-and-deep-benthic-community-restoration-in-the-gulf-of-mexico/

and

https://www.fisheries.noaa.gov/southeast/habitat-conservation/mesophotic-and-deep-benthic-communities-restoration

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Deepwater Horizon Mesophotic and Deep Benthic Communities Restoration

This report is part of the NOAA Mesophotic and Deep Benthic Communities (MDBC) Series of publications that share the results of work conducted by the *Deepwater Horizon* MDBC restoration projects.

The 2010 *Deepwater Horizon* oil spill was an unprecedented event. Approximately 3.2 million barrels of oil were released into the deep ocean over nearly three months. The plume of oil moved throughout the water column, formed surface slicks that cumulatively covered an area the size of Virginia, and washed oil onto at least 1,300 miles of shoreline habitats. More than 770 square miles (2,000 square kilometers) of deep benthic habitat were injured by the oil spill, including areas surrounding the Deepwater Horizon wellhead and parts of the Pinnacles mesophotic reef complex, located at the edge of the continental shelf.

Under the Oil Pollution Act, state and federal natural resource trustees conducted a Natural Resource Damage Assessment (NRDA). The Trustees assessed damages, quantifying the unprecedented injuries to natural resources and lost services. They also developed a programmatic restoration plan to restore injured resources and compensate the public for lost services.

In April 2016, a settlement was finalized that included up to $8.8 billion in funding for the Deepwater Horizon Trustees to restore the natural resource injuries caused by the oil spill as described in their programmatic restoration plan, Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement. The Deepwater Horizon Open Ocean Trustee Implementation Group is responsible for restoring natural resources and their services within the Open Ocean Restoration Area that were injured by the oil spill. The Open Ocean Trustees include NOAA, U.S. Department of the Interior, U.S. Environmental Protection Agency, and U.S. Department of Agriculture.

In 2019, the Open Ocean Trustee Implementation Group committed more than $126 million to implement four restoration projects to address the injury to MDBC. The MDBC projects are: Mapping, Ground-truthing, and Predictive Habitat Modeling; Habitat Assessment and Evaluation; Coral Propagation Technique Development; and Active Management and Protection. NOAA and the Department of the Interior are implementing the projects, in cooperation with a range of partners, over eight years.

Together, the projects take a phased approach to meet the challenges involved in restoring deep-sea habitats. Challenges to restoration include a limited scientific understanding of these communities, limited experience with restoration at the depths at which these communities occur, and remote locations that limit accessibility.

More information about *Deepwater Horizon* restoration and the MDBC restoration projects is available at: www.gulfspillrestoration.noaa.gov.

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Executive Summary

This environmental data summary report provides visualization and interpretation of all shipboard CTD data collected during the SALT 2 expedition (PS-22-22) in May and June of 2022. The results of this assessment will be used to inform laboratory-based husbandry of gorgonian octocorals in the northern Gulf of Mexico mesophotic zone. This assessment will also be applied to in situ and ex situ coral propagation trials for benthic habitat restoration in the Gulf of Mexico. Parameters of interest for these applications include temperature, salinity, oxygen levels, and light levels. CTD sensor data will also be used to calculate in situ water column properties (mixed layer depth [MLD] and the 10% and 1% surface irradiance) of the mesophotic zone in areas such as the Pinnacles Trend and the head of DeSoto Canyon. The CTD data presented here are a preliminary set from a single expedition and a more comprehensive dataset will be generated as more MDBC cruises are conducted.

1. Introduction to SALT 2 Environmental Data

The Submerged Acquisition of Living Tissue (SALT) 2 expedition collected environmental data in the 50- to 100-m depth range of the north-northeast Gulf of Mexico in May and June of 2022 in support of the coral propagation and habitat assessment goals of the Mesophotic and Deep Benthic Communities (MDBC) restoration type under the Open Ocean Restoration Plan. The work was performed aboard the R/V *Point Sur*, as were other SALT cruises since October 2021. This cruise was identified as PS-22-22 or "SALT 2" expedition of the MDBC 2022 field season.

Scientists used several tools at sea that were deployed over the side of the vessel, including a conductivity, temperature, and depth (CTD) rosette, HOBO temperature loggers, and tilt current meters (TCMs). Data were recovered from the CTD rosette. The HOBO loggers and TCMs were retrieved in May 2023 and will be reported separately. Data loggers were moved into position using the remotely operated vehicle (ROV) *Mohawk* from the University of North Carolina at Wilmington (UNCW). The ROV also had its own CTD sensor, which will also be archived and reported separately. This first report focuses on the data collected from the CTD rosette.

The purpose of this report is to visualize and interpret the environmental data from the CTD casts, as part of a quality assessment/quality control process that results in reliable and accessible information. The report will accompany the raw and processed data files in data archives maintained by NOAA's National Centers for Environmental Information (SALT 2 Collection – http://doi.org/10.25921/z4jm-q780) and the SALT 2 Cruise Report (Etnoyer et al., 2023), published in the NOAA Institutional Repository.

2. SALT 2 CTD Data

2.1. Methods

The CTD rosette was a Sea-Bird 32 carousel equipped with an SBE 19plus v2 SeaCat Profiler. Casts were performed across the northern Gulf of Mexico at 12 different locations from the R/V *Point Sur* to characterize the water column structure, water chemistry, and light levels. The work was conducted from May 31–June 11, 2022 in areas of the head of DeSoto Canyon and the Pinnacles Trend, consistent with other SALT expeditions since October 2021.

At each location, the CTD rosette was deployed to the maximum depth, typically < 100 m, and within 5 m of the bottom. Temperature, conductivity (from which salinity and density were derived), oxygen concentration, and pressure data were collected from each cast. Additionally, photosynthetically available radiation (PAR) and beam transmission were collected for casts 10–19. The data were collected using the sensors indicated in Table 1.

The data collected from the CTD were initially uploaded as .hex files into SeaSaveV7 software from Sea-Bird Scientific. One or two display plots were generated per CTD cast. Plot one included the temperature, salinity, oxygen, and density of the water column. Plot two displayed the optical properties of the water column using PAR and beam transmission when data were collected. Ranges for each parameter were selected to include all the values of the dataset and provide a clear visualization, or depiction, of change (See Appendix).

Table 1. Parameters and units reported by the CTD software. CTD = conductivity, temperature, and depth; PAR = photosynthetically available radiation.

Parameter	Units
Temperature	degrees in Celsius (ITS-90)
Salinity	PSU (PSS 1978)
Oxygen Concentration	mg/L
Density	kg/m^3
PAR	$\mu mol\ photons/cm^2/sec$
Beam Transmission	%

The .hex files were converted into .cnv files using SeaSoft V2 SBE data processing software from Sea-Bird Scientific. These files were uploaded into Ocean Data View software, where station data could be exported to Microsoft Excel. These data were analyzed to determine the mixed layer depth (MLD) and the 1% light level. The MLD was calculated using the sigma-theta density. The density at the surface was defined as the first density measurement before depth began increasing. MLD was defined as the depth in which surface density had increased by 0.125 kg/m^3 (Hosoda et al., 2010).

The 1% light level (z_{eu}, the bottom of the euphotic zone) and the 10% light level (z_m, the midpoint of the euphotic zone) were calculated using PAR data from CTD casts performed midday on clear days with minimal wave action (Kirk, 2011; Hinderstein et al., 2010). PAR was measured using a calibrated QSP200L PAR sensor (Biospherical Instruments Inc.). The spectral response of the optical collector is used to measure scalar irradiance (E_0) at a given depth. Assuming uniformity throughout the water column, vertical attenuation coefficients for scalar irradiance (K_d) were calculated from the downcasts of the optimal CTD profiles using the following formulation of the Bouguer–Lambert Law, where z represents depth, E_z represents the irradiance at depth z, and E_0 is the irradiance at the surface (Kirk, 2011):

$$E_z = E_0 \times e^{-K_d z}$$

This equation was used to calculate attenuation coefficients using irradiance measurements from the four best CTD downcasts across four different sites within the Pinnacles Trend region, all with maximum depths between 68 and 75 m. The casts were averaged to create a single preliminary model of PAR attenuation with depth for the survey area following the methods in Padilla-Gamiño et al. (2019).

2.2: CTD Cast Locations

A total of 19 CTD casts were performed at 12 different locations in 10 days, as shown in Table 2. The general trend of the survey was from the northeast to the southwest, moving from sites near the head of DeSoto Canyon ("Pensacola Edge" and "Dragon's Teeth") on the first two days, to Far Tortuga and other sites in the Pinnacles Trend, and then closer to the Mississippi River at Mountain Top Reef, the site located furthest to the west. DeSoto Rim was not surveyed on SALT 2 (see Figure 1).

Table 2. Location and depth information for CTD casts on the SALT 2 expedition. CTD = conductivity, temperature, and depth.

Cast	Site	Date	Latitude	Longitude	Depth (m)
CTD01	Pensacola Edge 1 (PE1)	6/1/2022	29.85175	−87.28688	66
CTD02	Dragon's Teeth (DRG)	6/2/2022	29.78945	−87.30455	96
CTD03	Dragon's Teeth (DRG)	6/2/2022	29.79366	−87.32203	68
CTD04	Far Tortuga (FAR)	6/3/2022	29.55473	−87.46358	67
CTD05	SALT Ridge 3 (SR3)	6/3/2022	29.50307	−87.50847	69
CTD06	SALT Ridge 2 (SR2)	6/4/2022	29.46100	−87.65996	68
CTD07	SALT Ridge 2 (SR2)	6/4/2022	29.45778	−87.66881	68
CTD08	Boulder Field 4 (BF4)	6/5/2022	29.46694	−87.73890	63
CTD09	Mountain Top Reef (MTR)	6/6/2022	29.23821	−88.43739	103
CTD10	Mountain Top Reef (MTR)	6/6/2022	29.23026	−88.43751	66
CTD11	Boulder Field 1 (BF1)	6/7/2022	29.30296	−88.21475	92
CTD12	Shoreline Ridge (SHR)	6/7/2022	29.39515	−88.00304	66
CTD13	SALT Ridge 1 (SR1)	6/8/2022	29.41592	−87.96420	73
CTD14	SALT Ridge 1 (SR1)	6/8/2022	29.42273	−87.86196	70
CTD15	Boulder Field 4 (BF4)	6/8/2022	29.45865	−87.73906	66
CTD16	Boulder Field 3 (BF3)	6/9/2022	29.42054	−87.73185	75
CTD17	Boulder Field 2 (BF2)	6/9/2022	29.45328	−87.78086	62
CTD18	SALT Ridge 2 (SR2)	6/10/2022	29.46333	−87.66917	66
CTD19	SALT Ridge 2 (SR2)	6/10/2022	29.45517	−87.66700	68

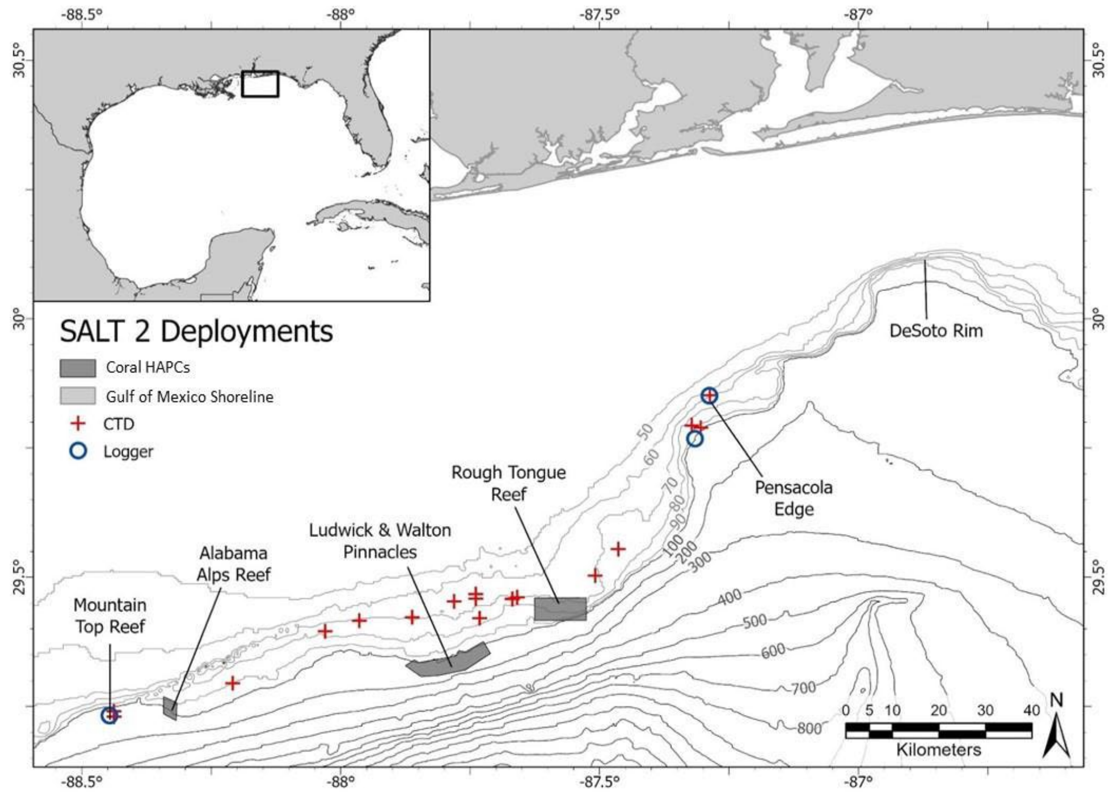

Figure 1. Locations of CTD deployments from R/V *Point Sur* for SALT 2. CTD casts are indicated by red crosses. Logger deployments are indicated by blue circles (Courtesy of Morgan Will).

3. Results

The depth range of sampling was 63–103 m, with an average depth of 72 m, over a linear distance of approximately 120 km along the continental shelf south of Mississippi and Alabama. Of the 19 CTD rosette deployments, 14 yielded MLD. Conductivity sensor errors occurred on five deployments, making MLD impossible to calculate. Only 10 of the 19 CTD rosette deployments yielded PAR data due to a delay in calibrating the PAR sensor. Unfavorable weather conditions (cloud coverage, precipitation, increased wave height, etc.) limited the casts that could be used to calculate z_{eu} and z_m, such that only four were used to calculate a general model of PAR attenuation with depth for the survey area.

The average (± SD) MLD was found to be 10.45 ± 3.50 m (Table 3). The shallow depth of the MLD was consistent across sites. A comparison of MLD across seasons is necessary to understand how this may vary.

The general PAR attenuation model for the survey area was calculated as:

$$E_z = 1305.6 \times e^{-0.064z}$$

This model found a K_d of −0.064 m^{-1}, a 10% surface irradiance (z_m) of 35.93 m, and a 1% surface irradiance (z_{eu}) of 71.8 m. At the z_{eu} depth, the average PAR level was 13.97 ± 10.07 µmol photons/m^2/sec (Table 3). The bottom of the euphotic zone in this area of the northern Gulf of Mexico was therefore approximately 72 m in May 2022. Above this depth, light levels are sufficient to support photosynthetic organisms (Kirk, 2011). One example of a photosynthetic organism observed via ROV footage was crustose coralline algae. The 1% light level is used here as a proxy for the "compensation point" where photosynthesis equals respiration. There is a net photosynthesis and production of organic matter above this depth. Below this depth, respiration exceeds photosynthesis, and there is net consumption of organic material (Lesser et al., 2009). Corals growing deeper than the 1% light level cannot rely on a trophic subsidy from photosynthetic symbionts and must rely on other trophic processes (e.g., heterotrophy) to meet their nutritional needs (Lesser et al., 2009). This result is consistent with ONMS (2020), which reported that light levels less than 1% of surface levels generally occur below 90 m but can be as shallow as 50 m in turbid conditions in the northern Gulf of Mexico.

Table 3. The calculated 1% light level (z_{eu}) and mixed layer depth (MLD) for each CTD Cast from SALT 2. An asterisk indicates data not collected or an error in sensor making parameter incomputable. Two asterisks indicate that environmental conditions caused the PAR reading to be invalid.

Cast Number	Date	Site	z_{eu} (m)	MLD (m)
1	6/1/2022	PE1	*	13.4
2	6/2/2022	DRG	*	12.7
3	6/2/2022	DRG	*	15.0
4	6/3/2022	FAR	*	10.5
5	6/3/2022	SR3	*	7.7
6	6/4/2022	SR2	*	12.6
7	6/4/2022	SR2	*	8.4
8	6/5/2022	BF4	*	5.0
9	6/6/2022	MTR	*	*
10	6/6/2022	MTR	**	*
11	6/7/2022	BF1	**	*
12	6/7/2022	SHR	*	*
13	6/8/2022	SR1	64–65	*
14	6/8/2022	SR1	70–71	7.0
15	6/8/2022	BF4	*	7.2
16	6/9/2022	BF3	70–71	17.7
17	6/9/2022	BF2	**	8.6
18	6/10/2022	SR2	**	9.9
19	6/10/2022	SR2	76–77	10.6

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Appendix: CTD Plots

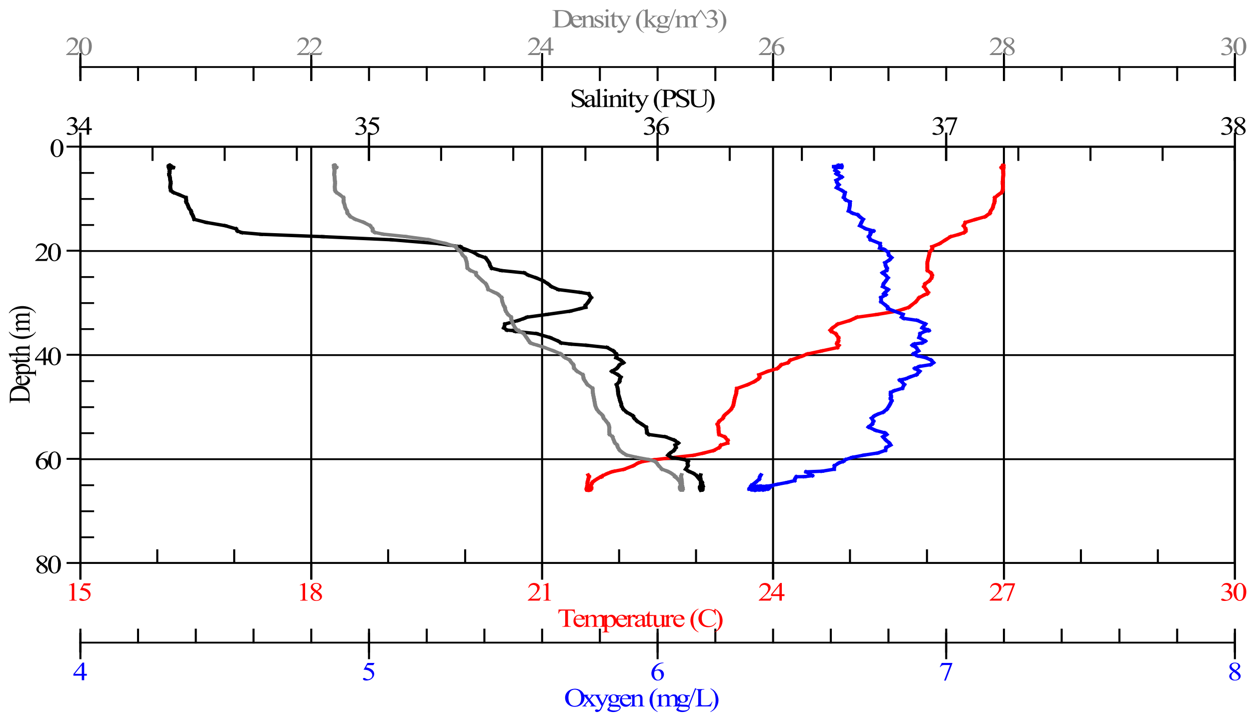

Figure 2. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 1 on 06/01/2022 at PE1.

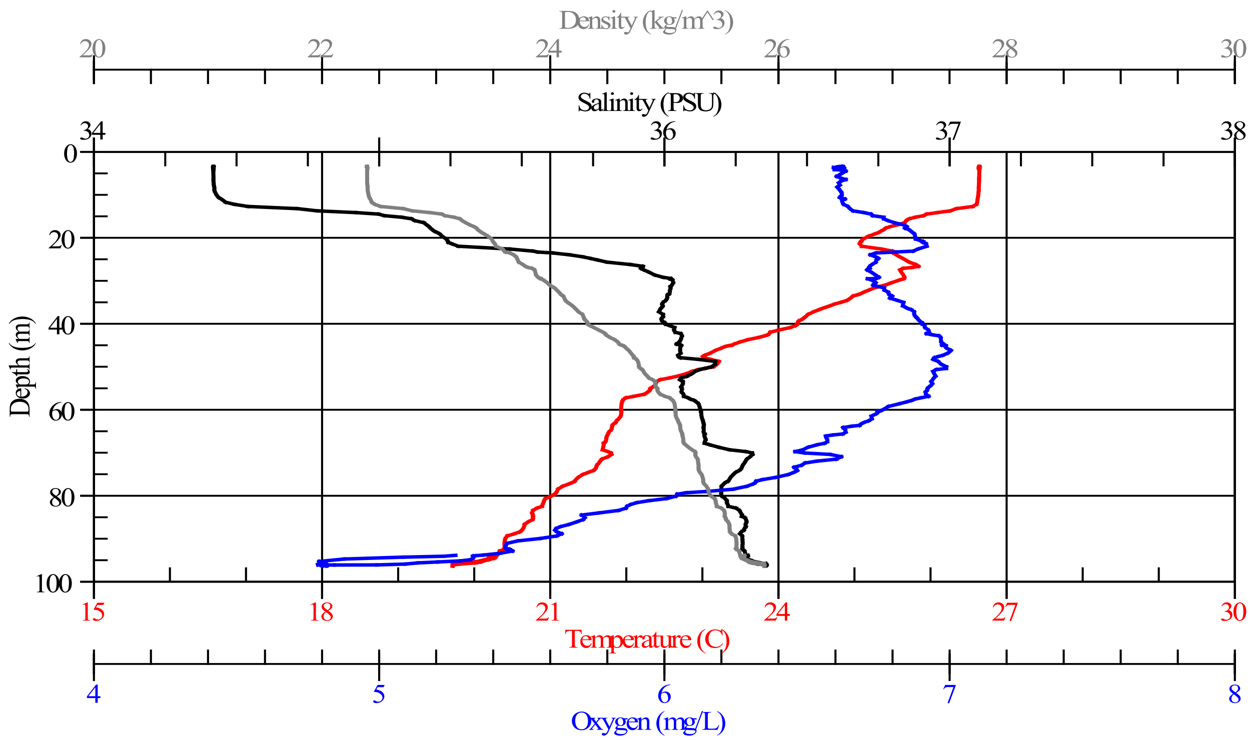

Figure 3. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 2 on 06/02/2022 at DRG.

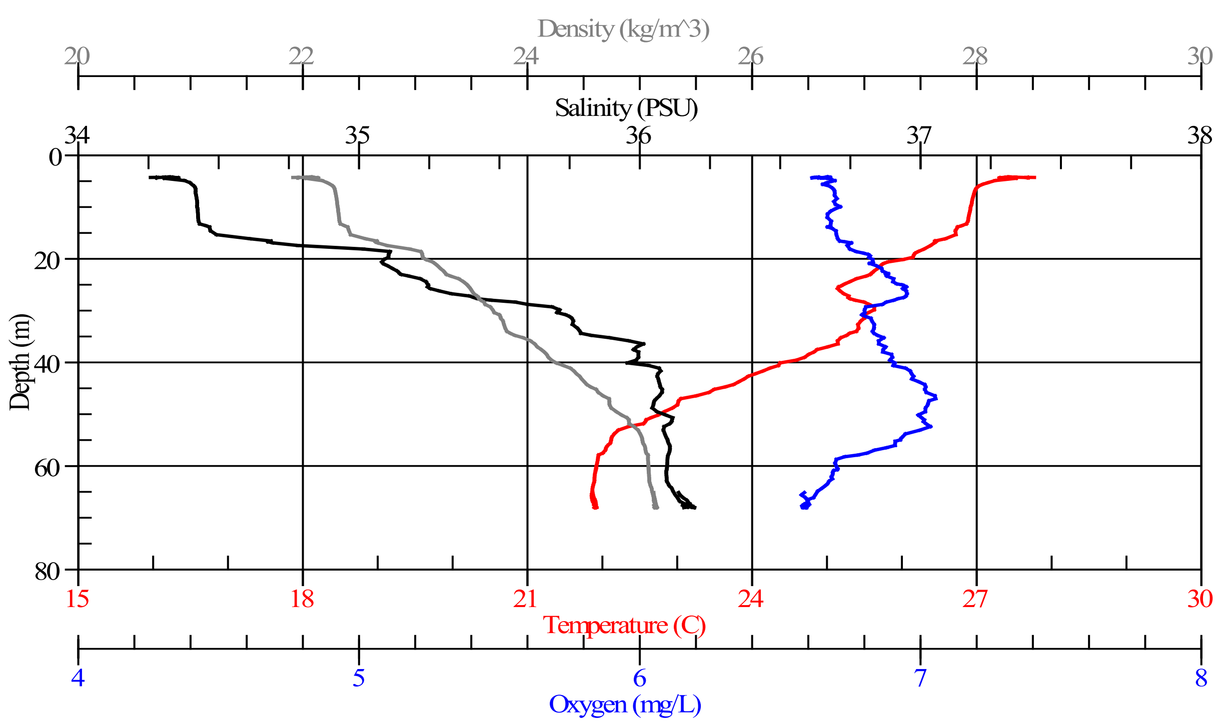

Figure 4. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 3 on 06/02/2022 at DRG.

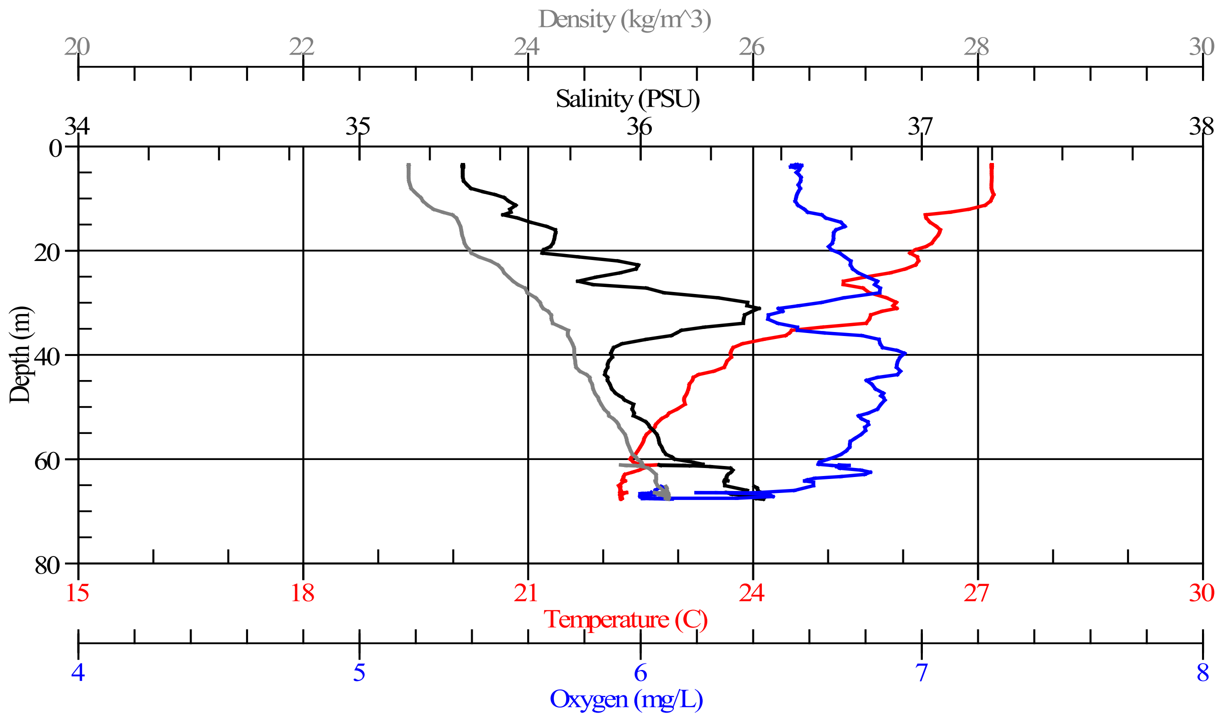

Figure 5. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 4 on 06/03/2022 at FAR.

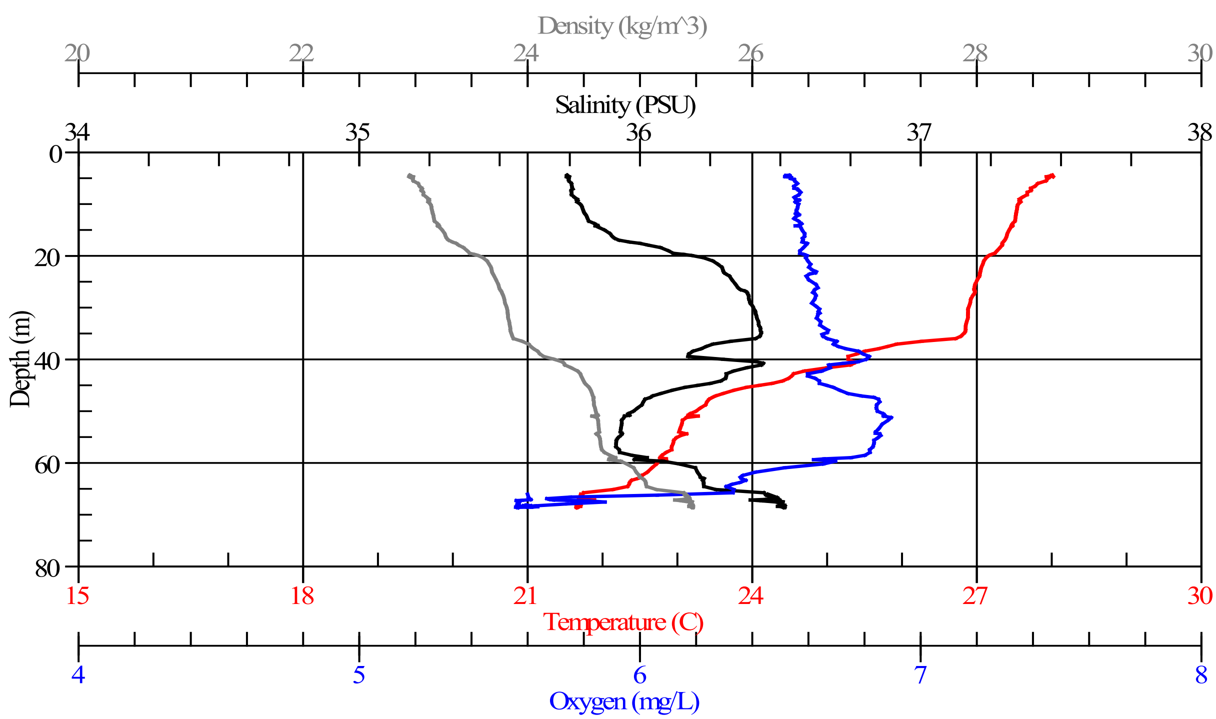

Figure 6. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 5 on 06/03/2022 at SR3.

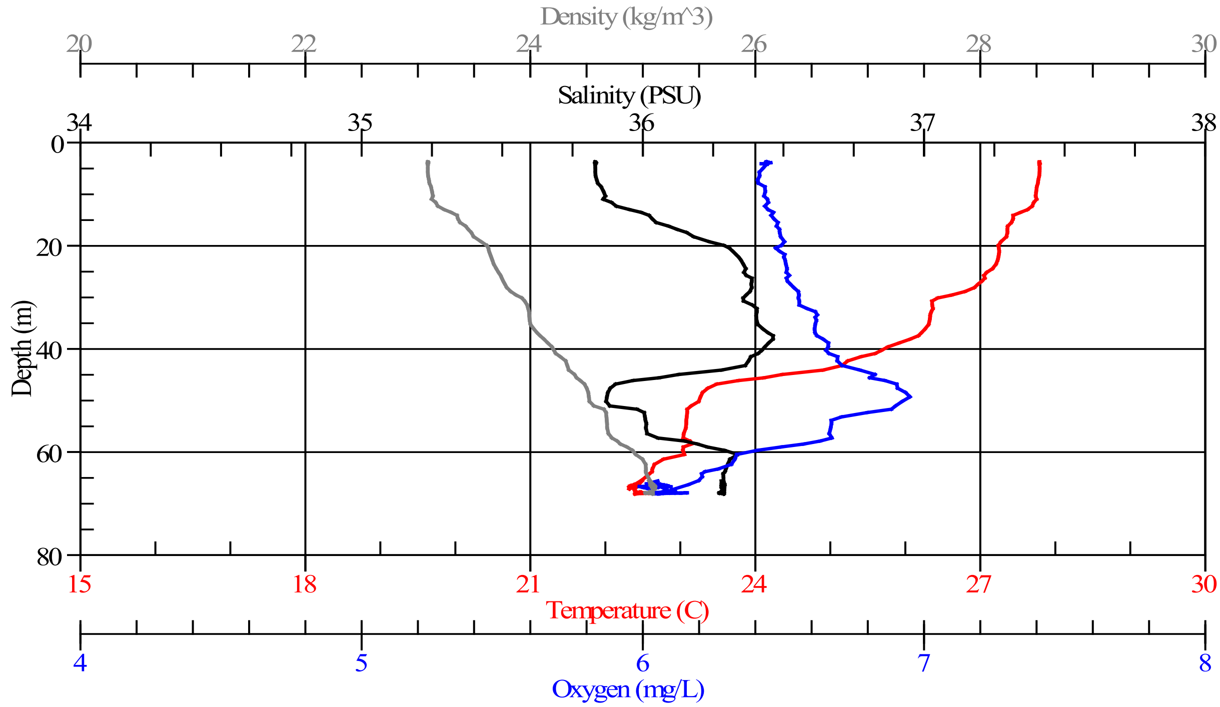

Figure 7. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 6 on 06/04/2022 at SR2.

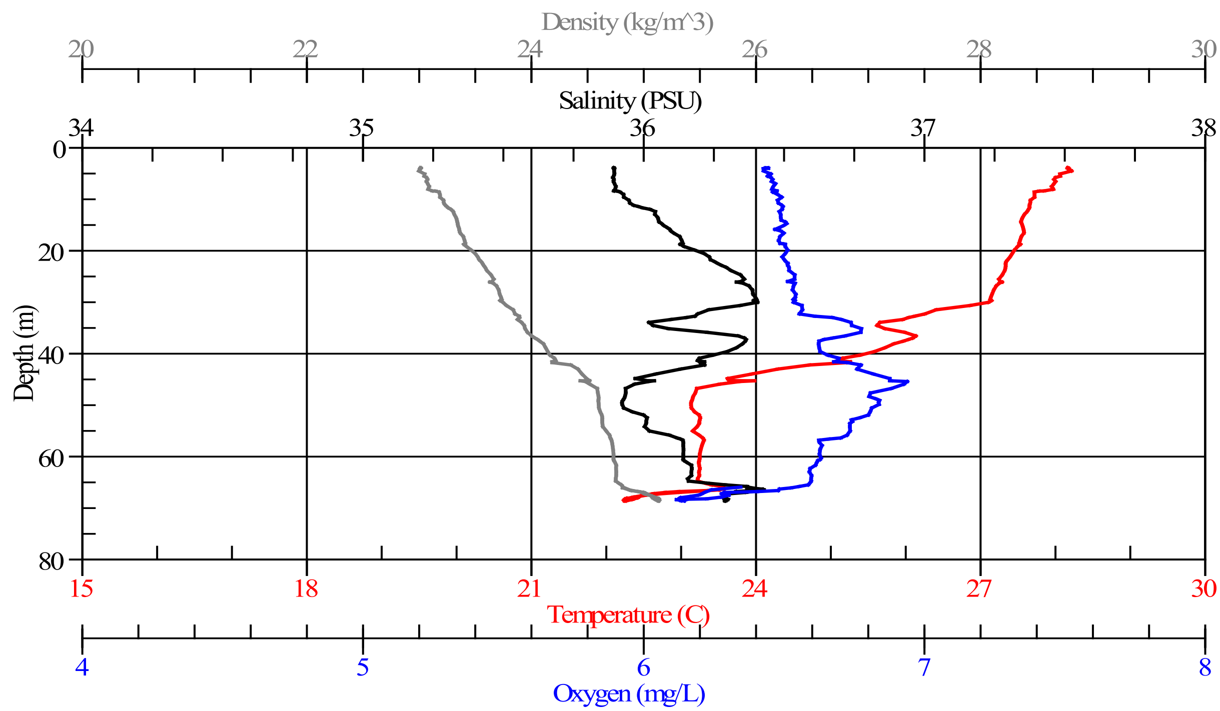

Figure 8. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 7 on 06/04/2022 at SR2.

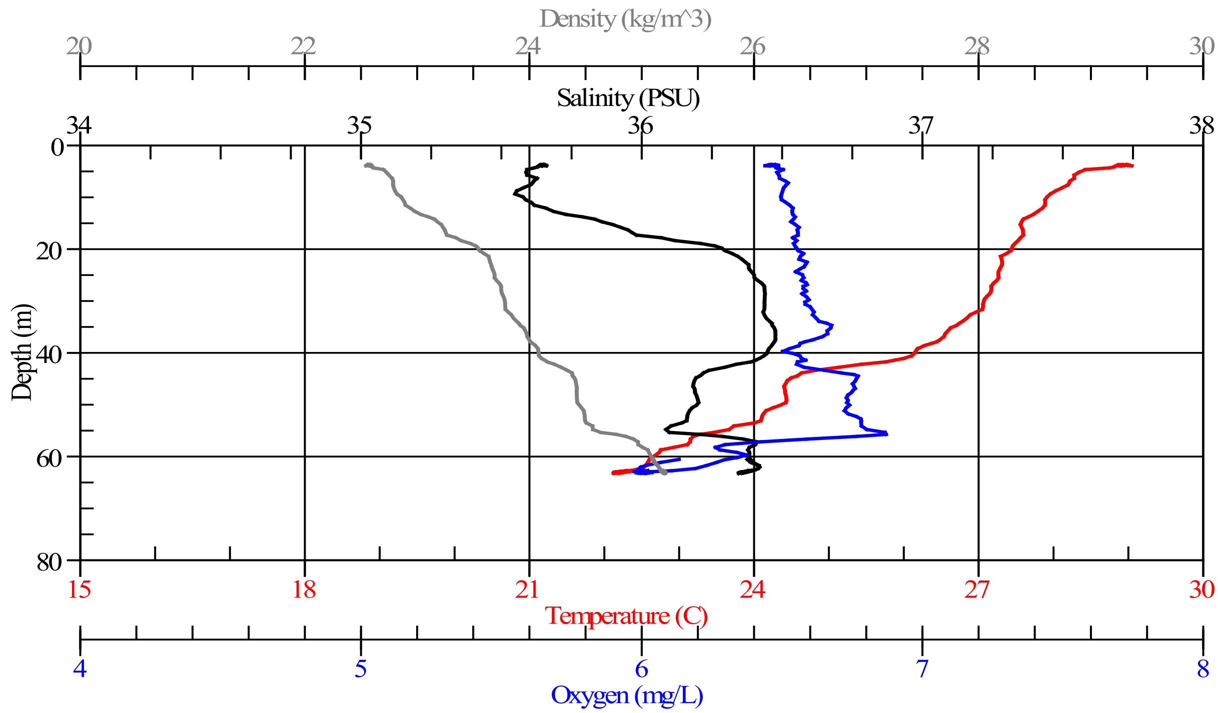

Figure 9. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 8 on 06/05/2022 at BF4.

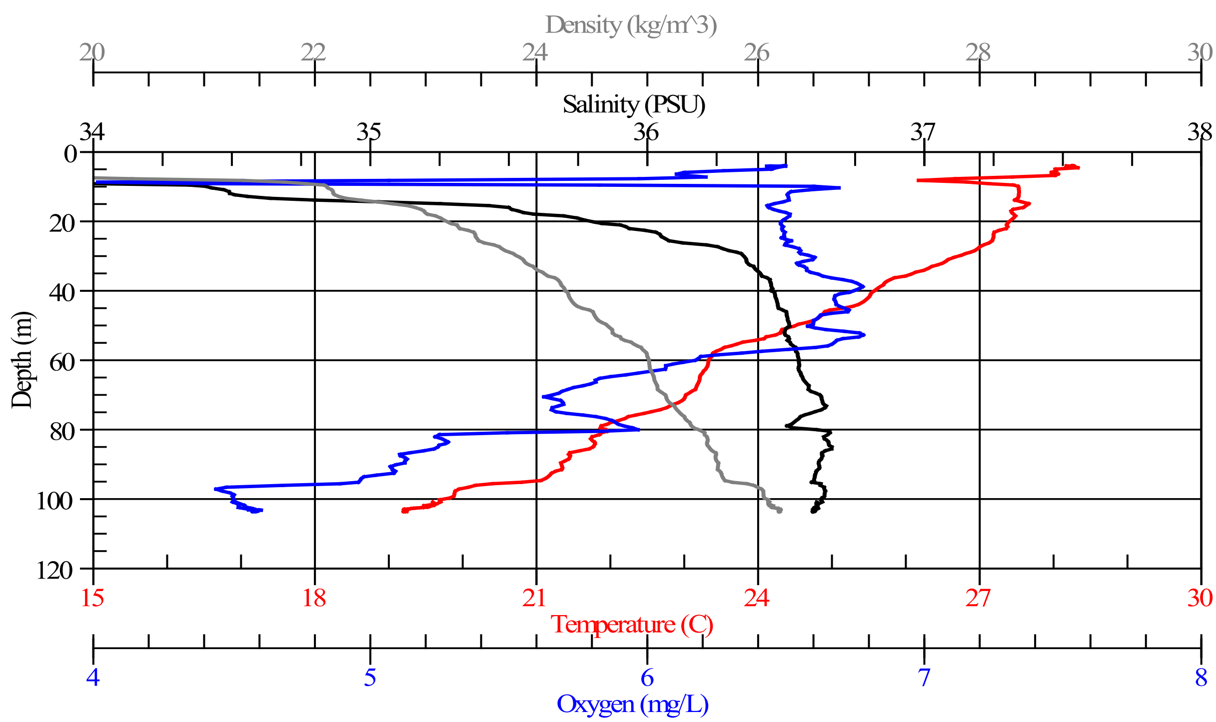

Figure 10. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 9 on 06/06/2022 at MTR.

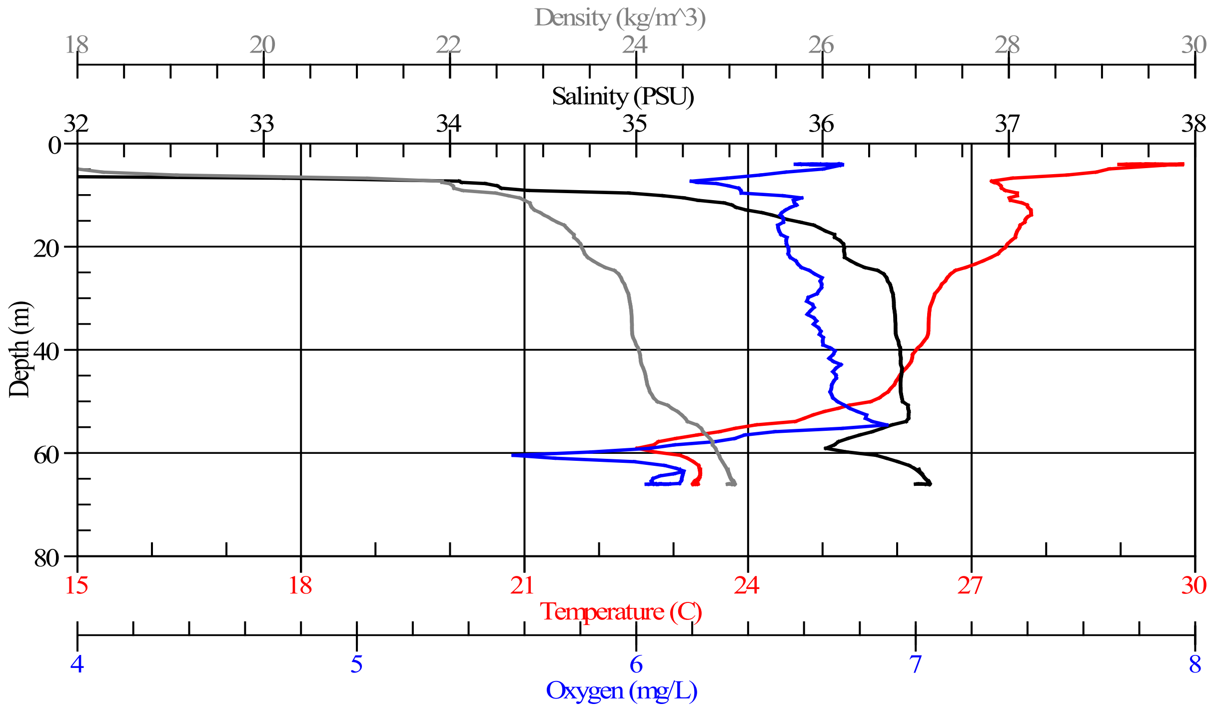

Figure 11.1. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 10 on 06/06/2022 at MTR.

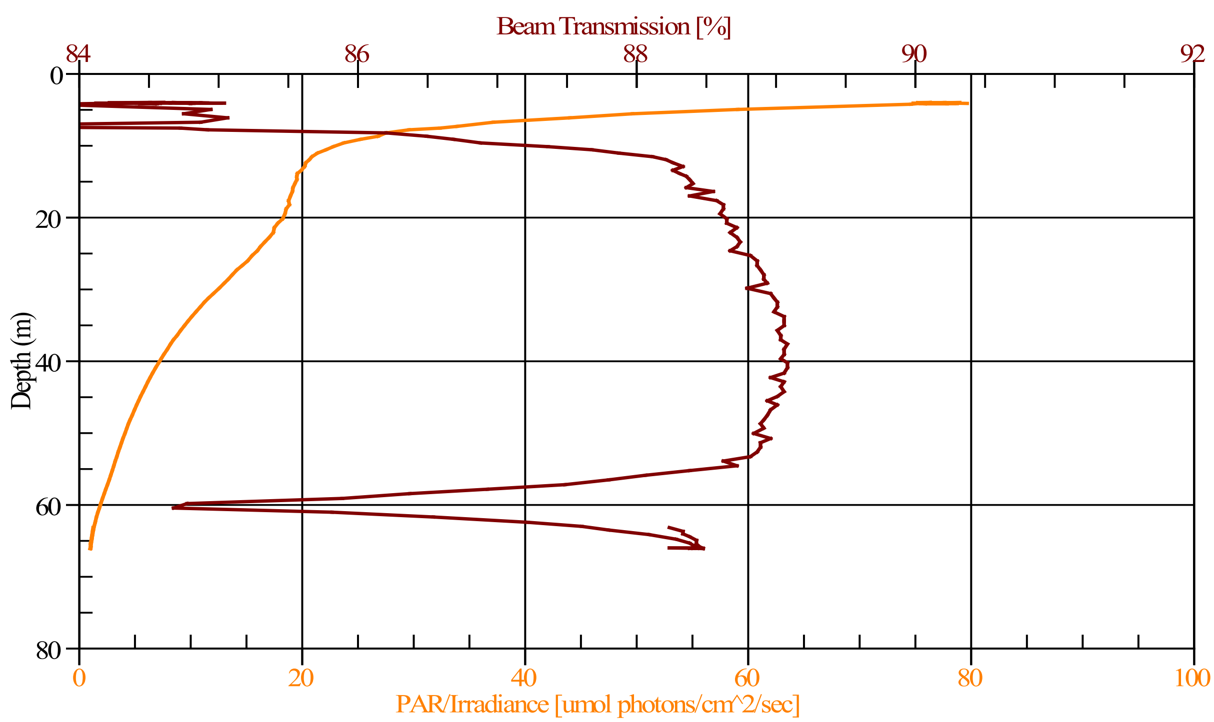

Figure 11.2. Plot showing PAR and beam transmission from CTD Cast 10 on 06/06/2022 at MTR.

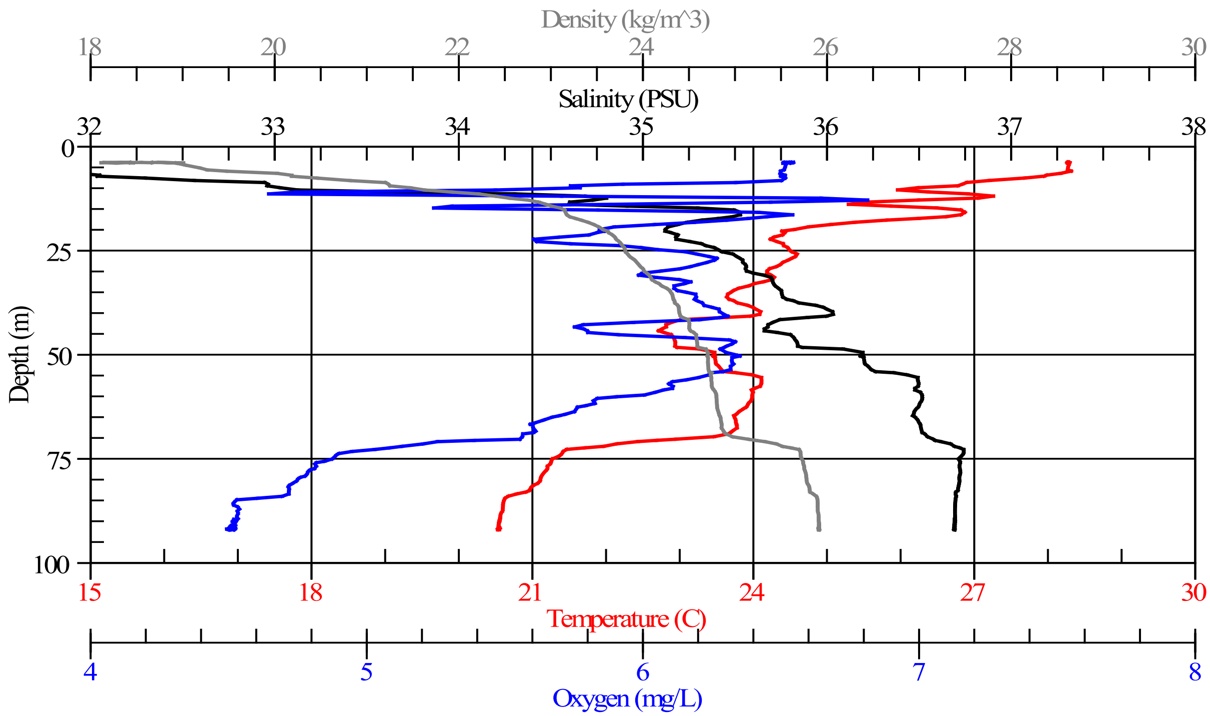

Figure 12.1. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 11 on 06/07/2022 at BF1.

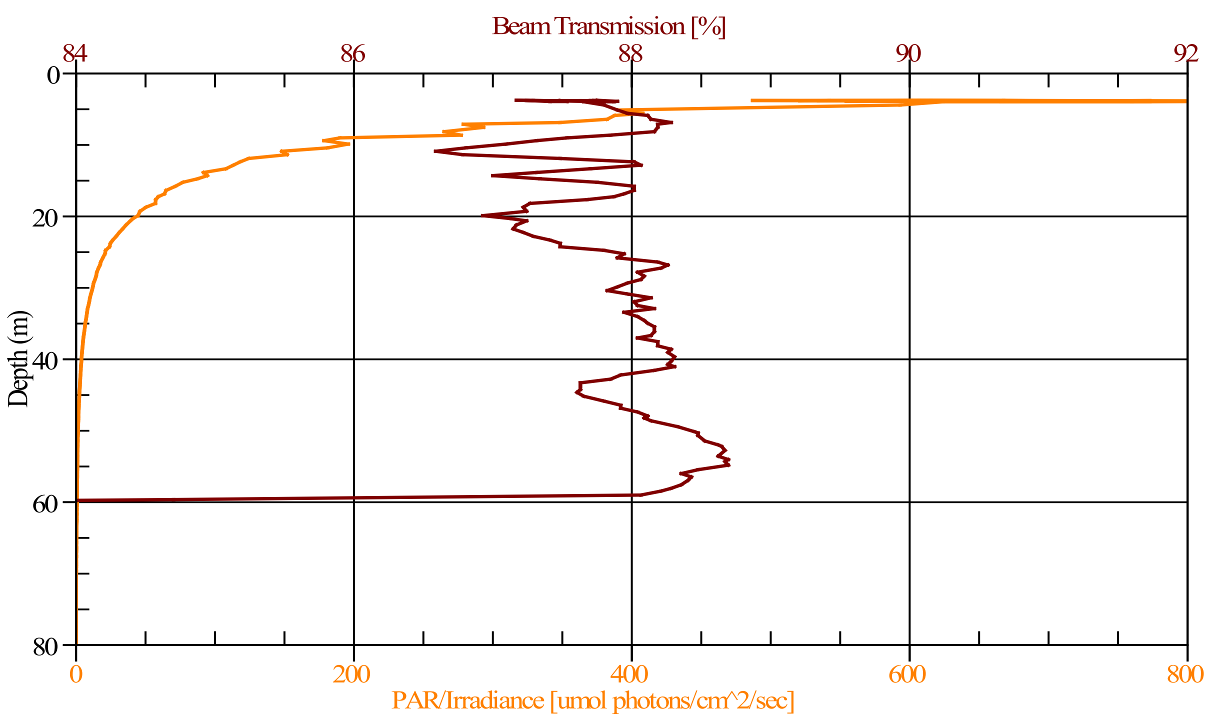

Figure 12.2. Plot showing PAR and beam transmission from CTD Cast 11 on 06/07/2022 at BF1.

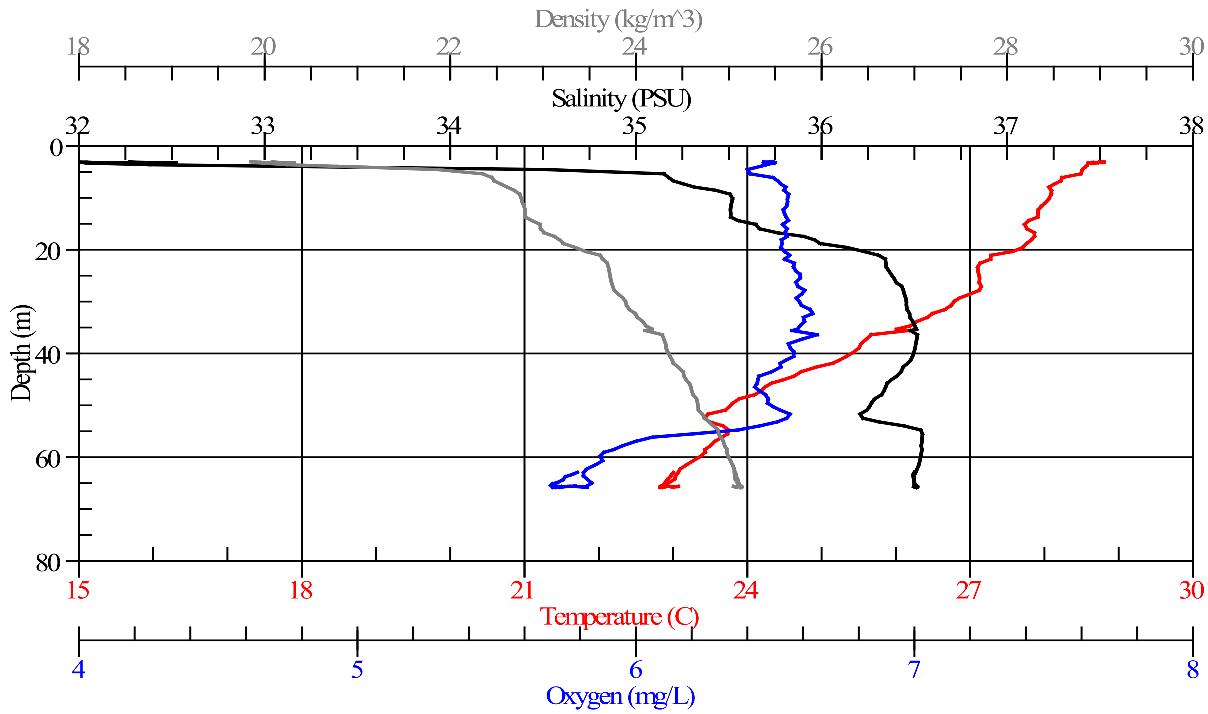

Figure 13.1. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 12 on 06/07/2022 at SHR.

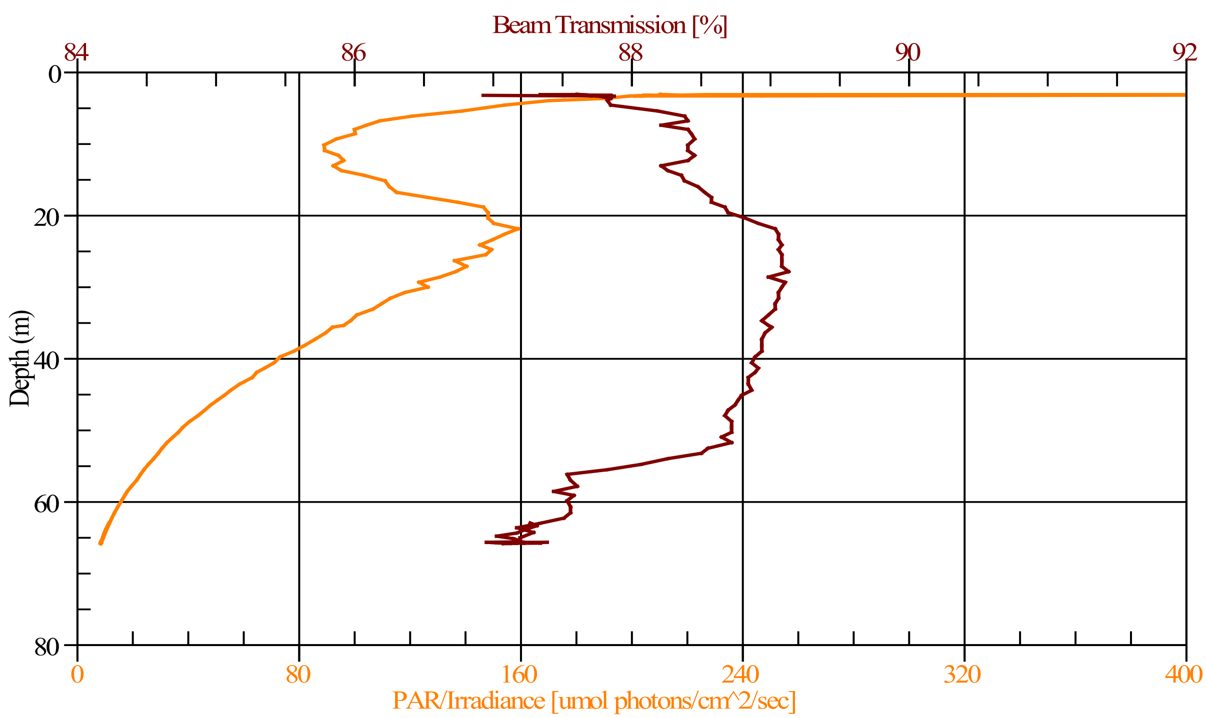

Figure 13.2. Plot showing PAR and beam transmission from CTD Cast 12 on 06/07/2022 at SHR.

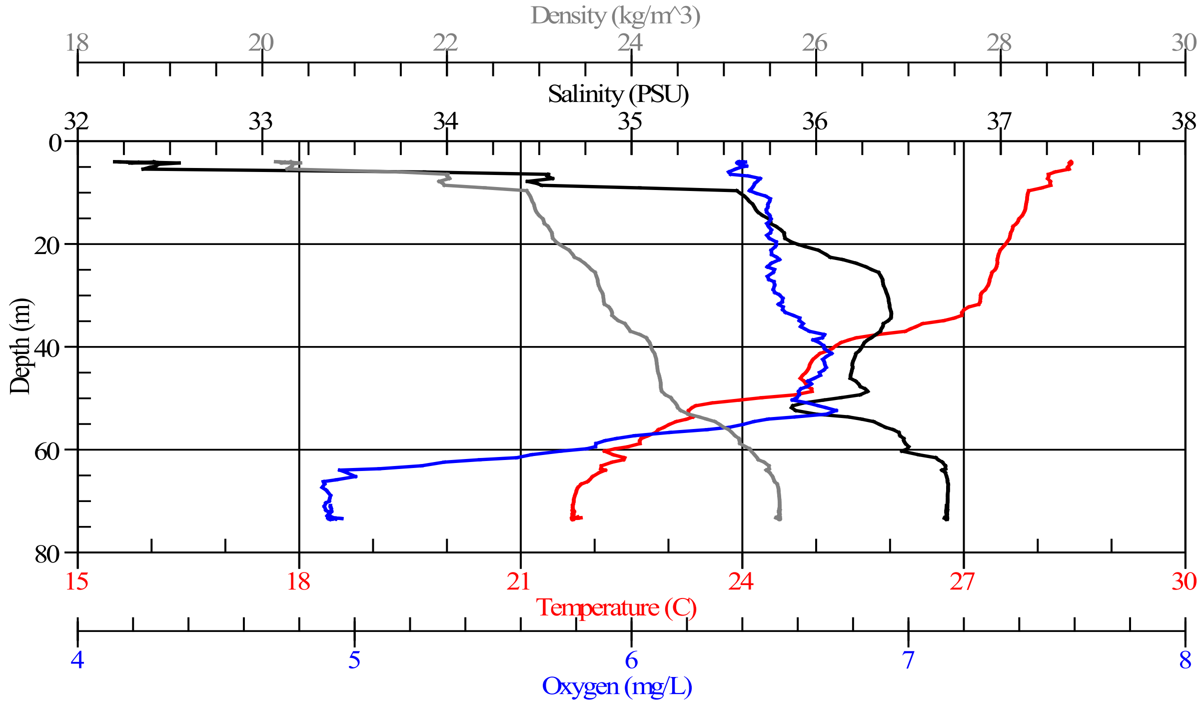

Figure 14.1. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 13 on 06/08/2022 at SR1.

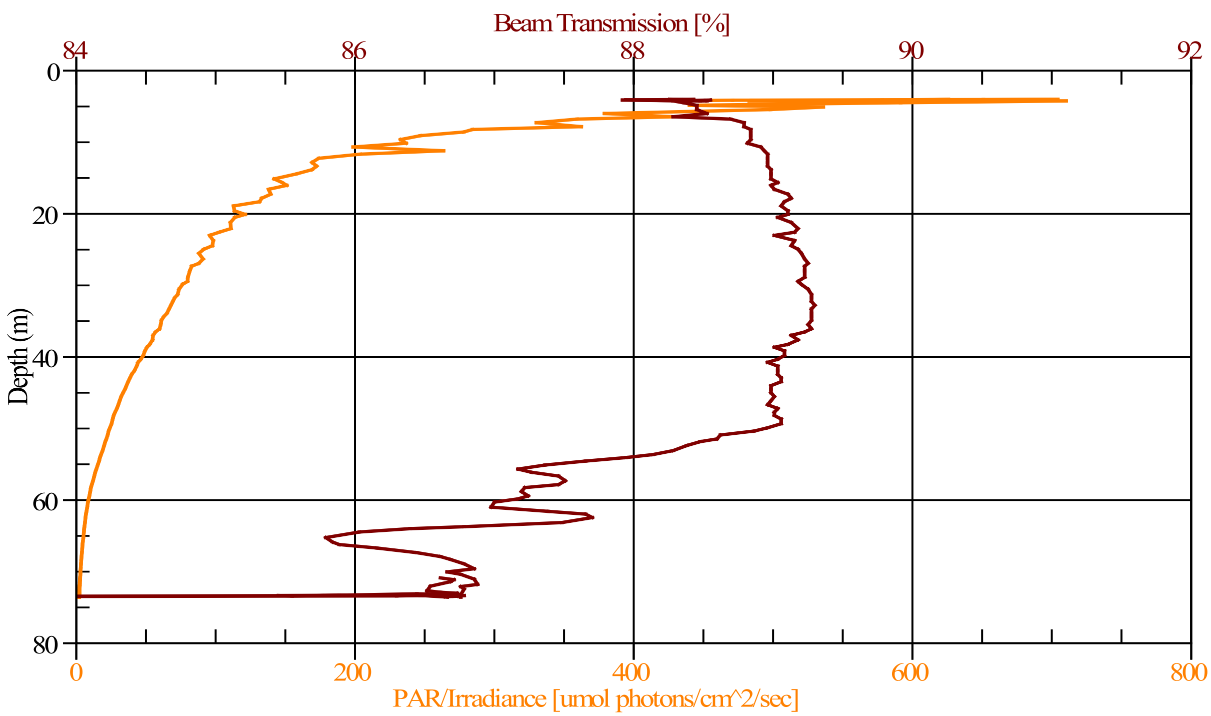

Figure 14.2. Plot showing PAR and beam transmission from CTD Cast 13 on 06/08/2022 at SR1.

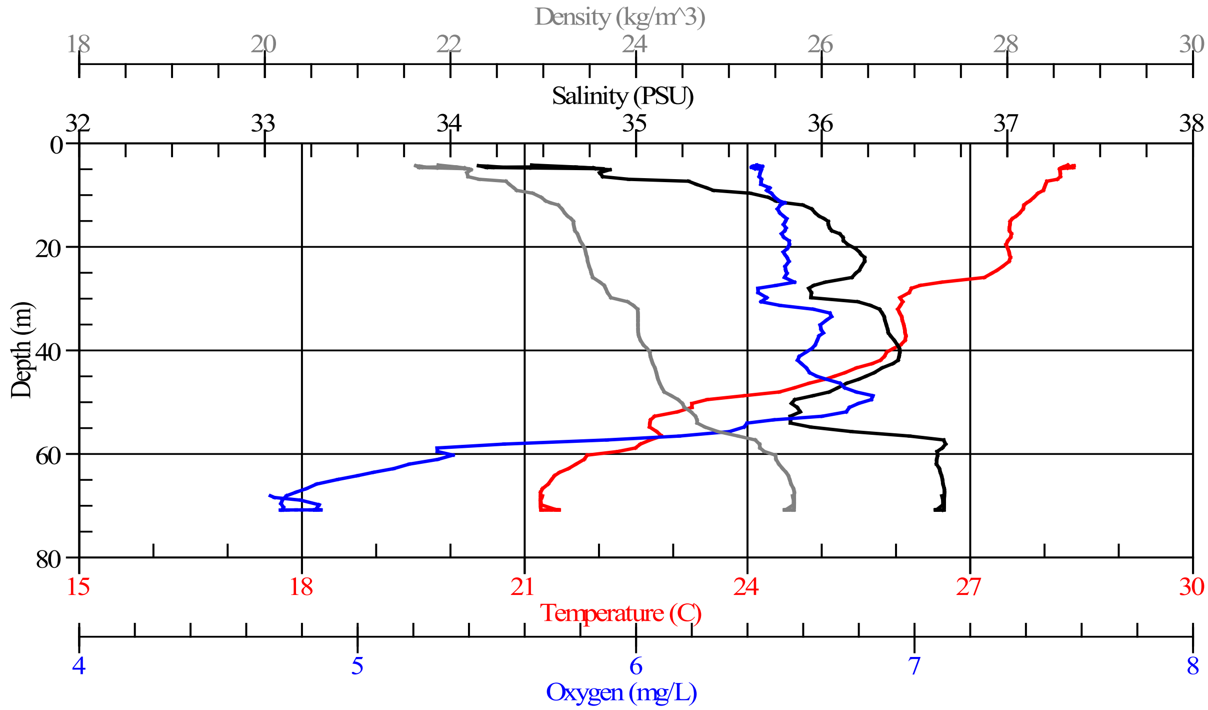

Figure 15.1. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 14 on 06/08/2022 at SR1.

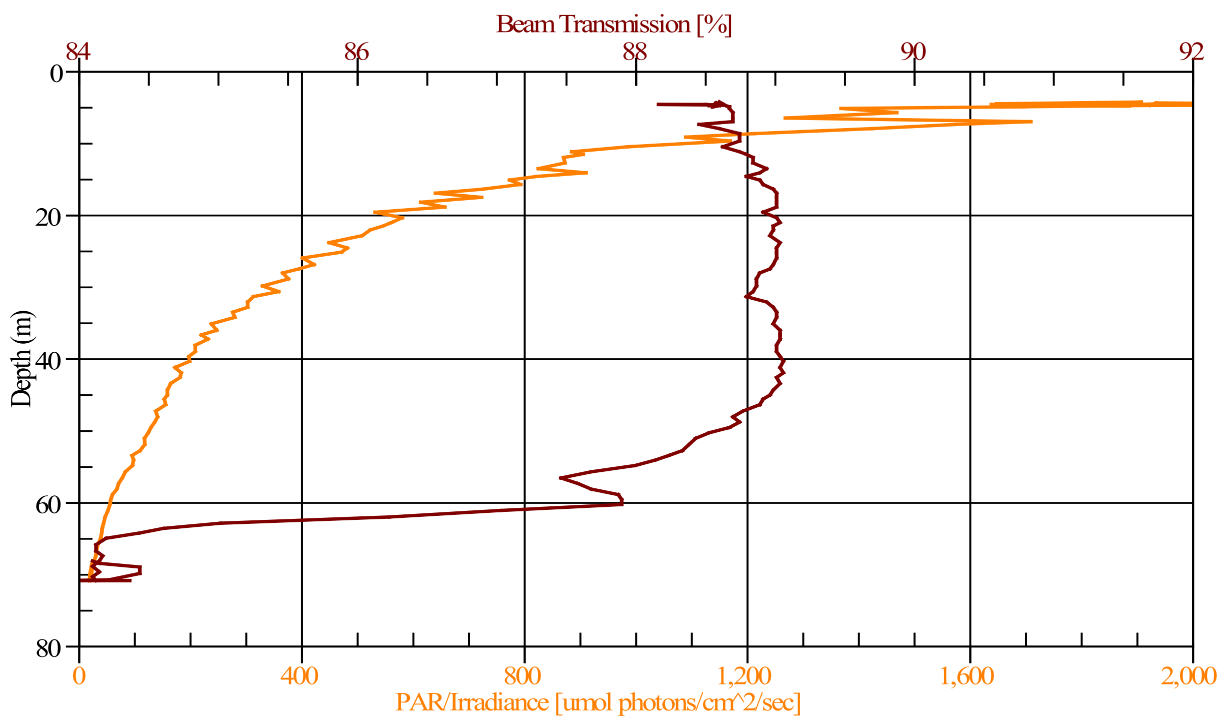

Figure 15.2. Plot showing PAR and beam transmission from CTD Cast 14 on 06/08/2022 at SR1.

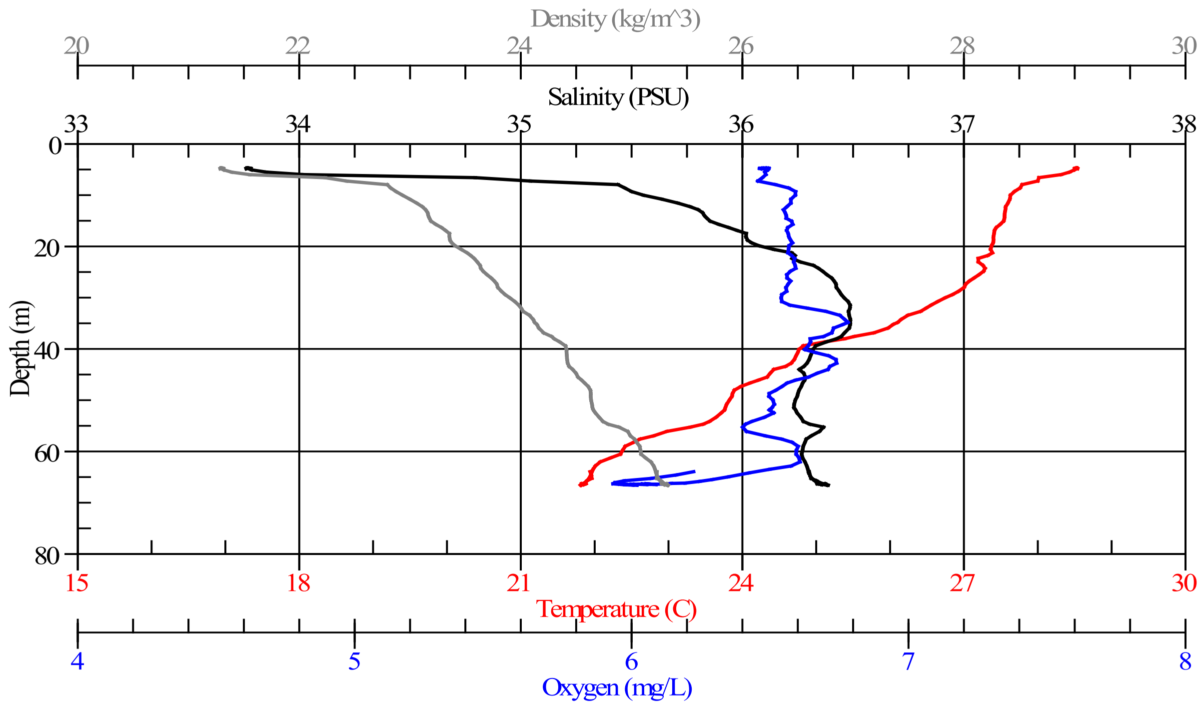

Figure 16.1. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 15 on 06/08/2022 at BF4.

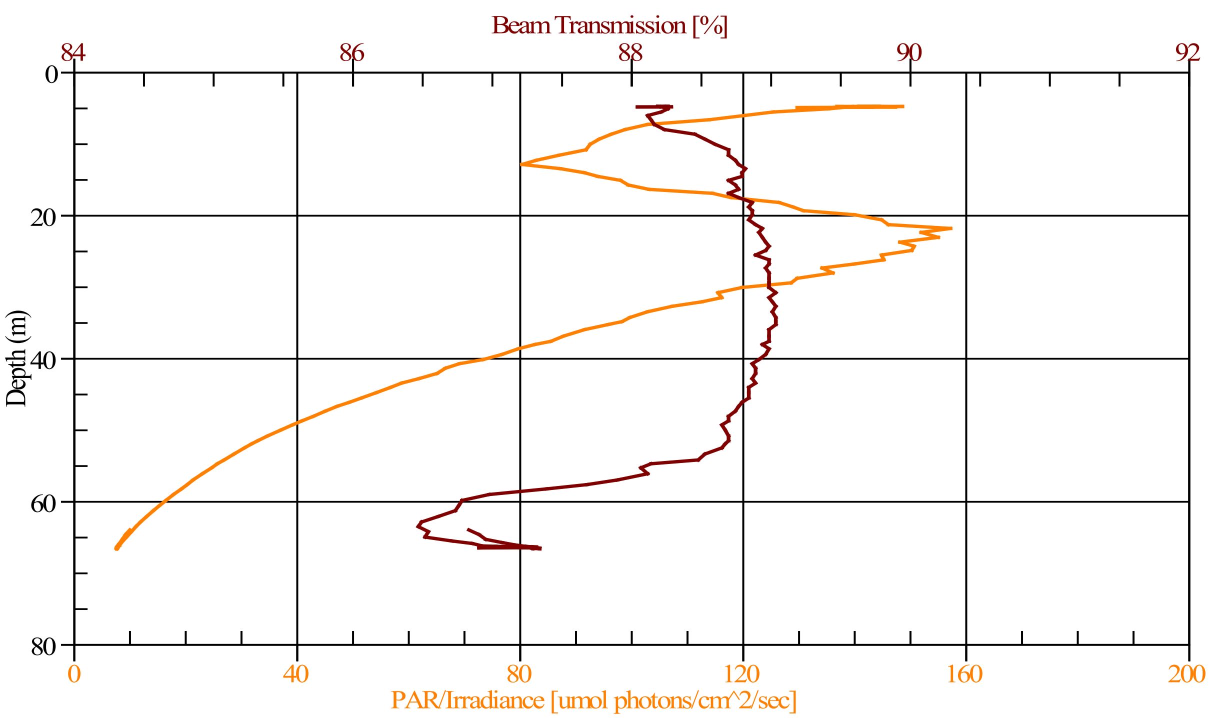

Figure 16.2. Plot showing PAR and beam transmission from CTD Cast 15 on 06/08/2022 at BF4.

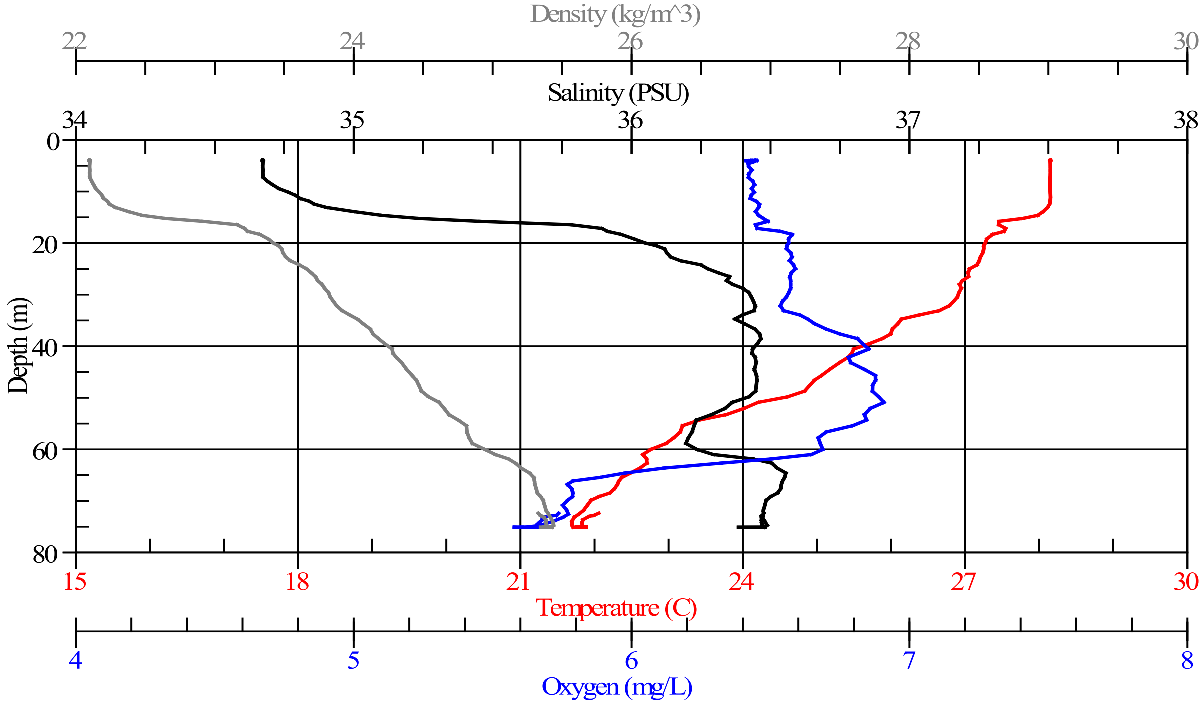

Figure 17.1. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 16 on 06/09/2022 at BF3.

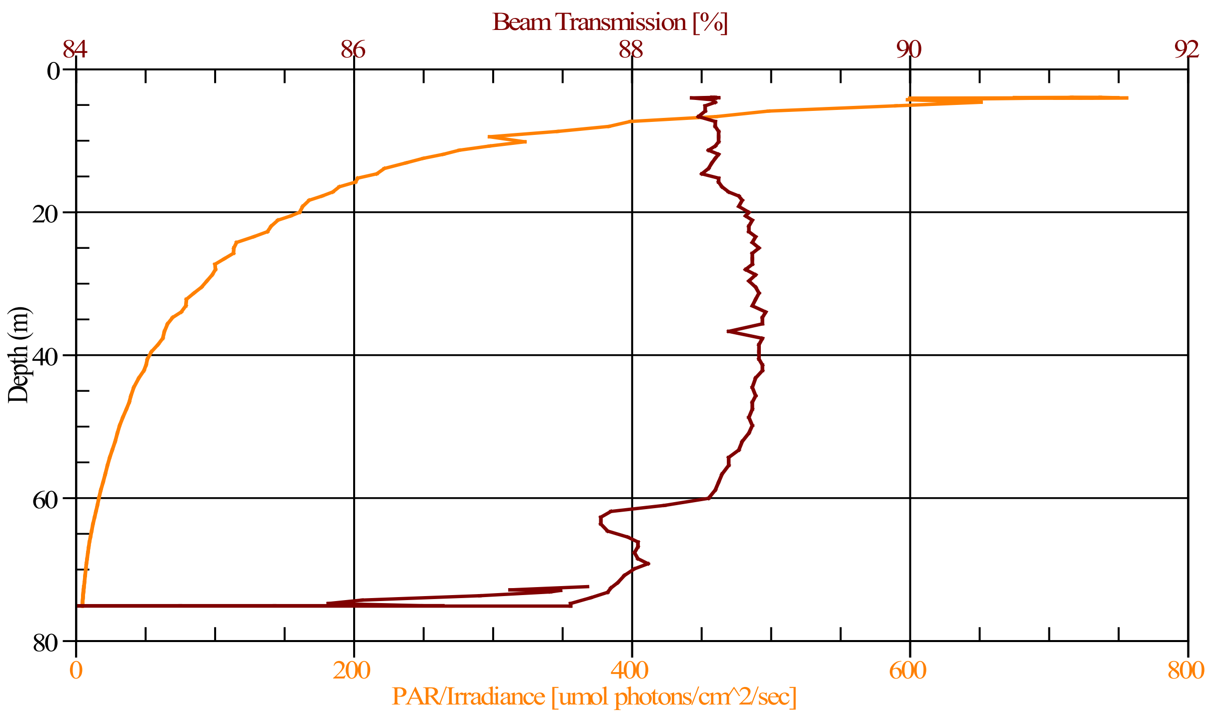

Figure 17.2. Plot showing PAR and beam transmission from CTD Cast 16 on 06/09/2022 at BF3.

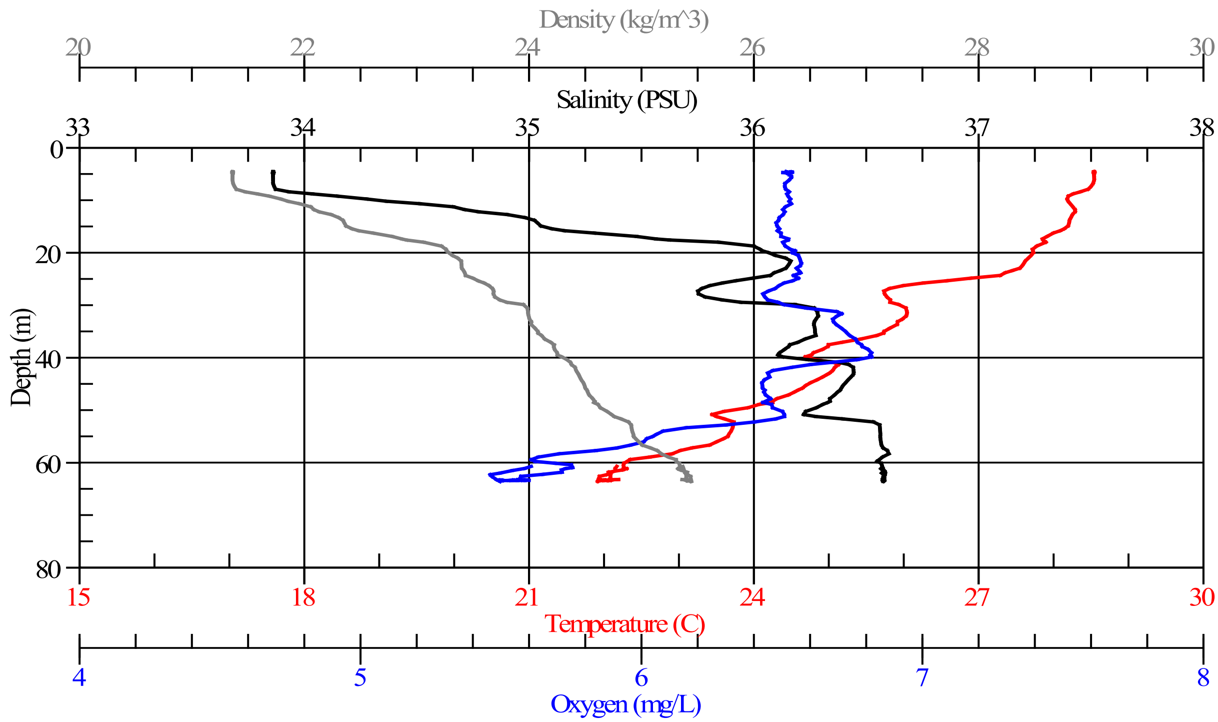

Figure 18.1. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 17 on 06/09/2022 at BF2.

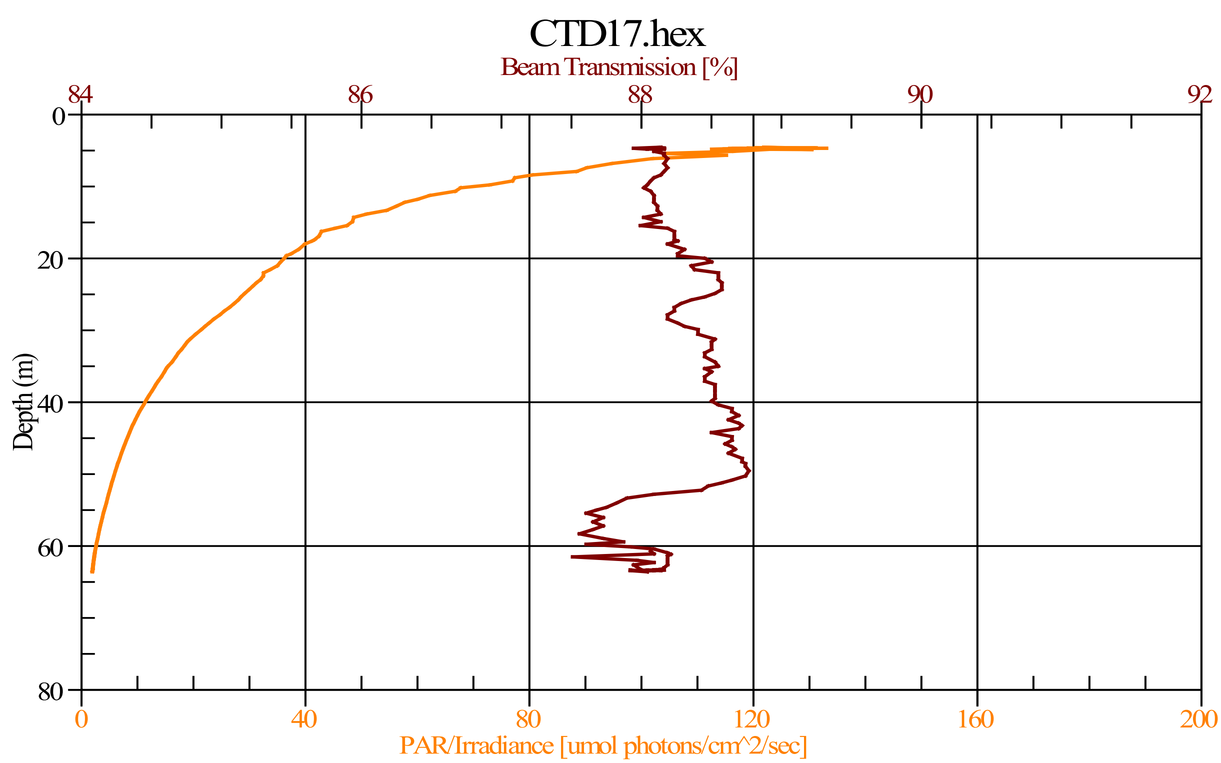

Figure 18.2. Plot showing PAR and beam transmission from CTD Cast 17 on 06/09/2022 at BF2.

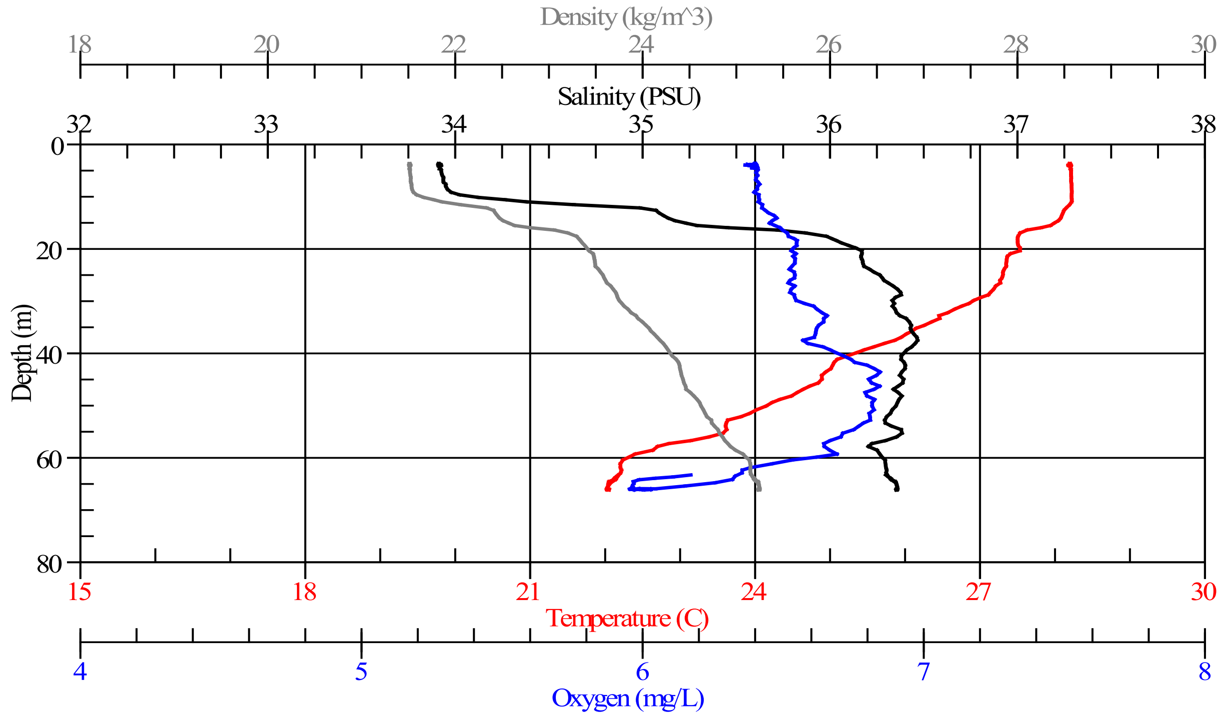

Figure 19.1. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 18 on 06/10/2022 at SR2.

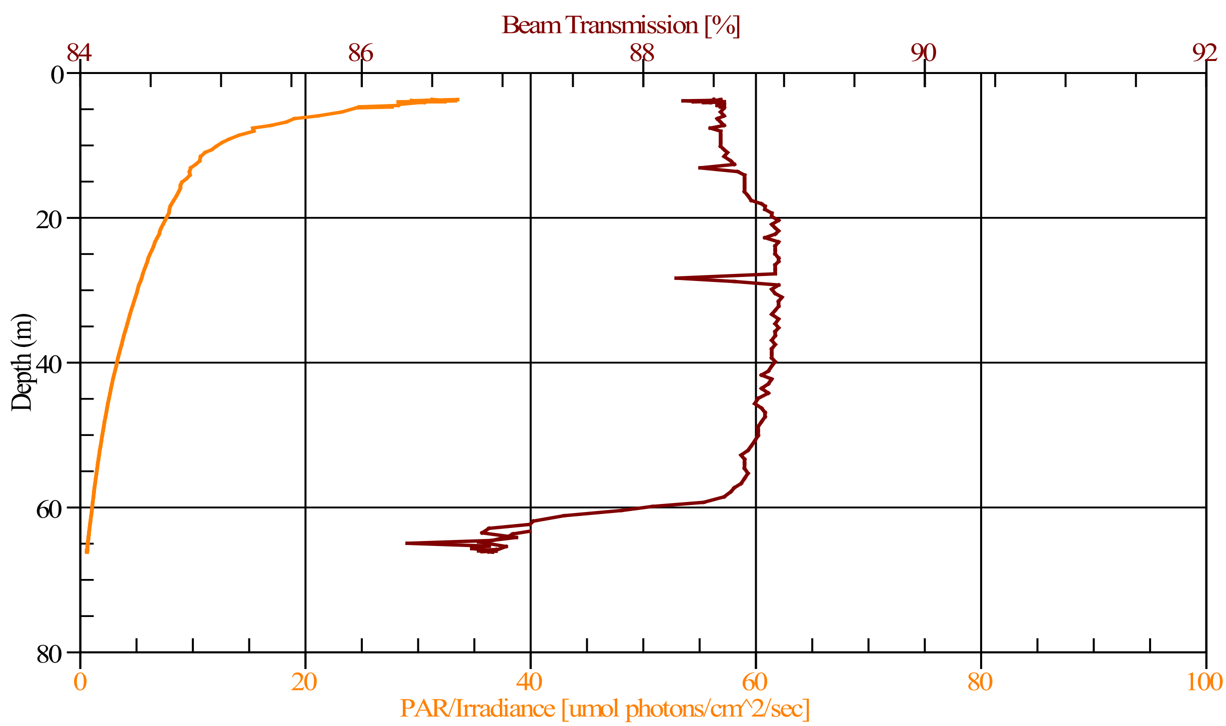

Figure 19.2. Plot showing PAR and beam transmission from CTD Cast 18 on 06/10/2022 at SR2.

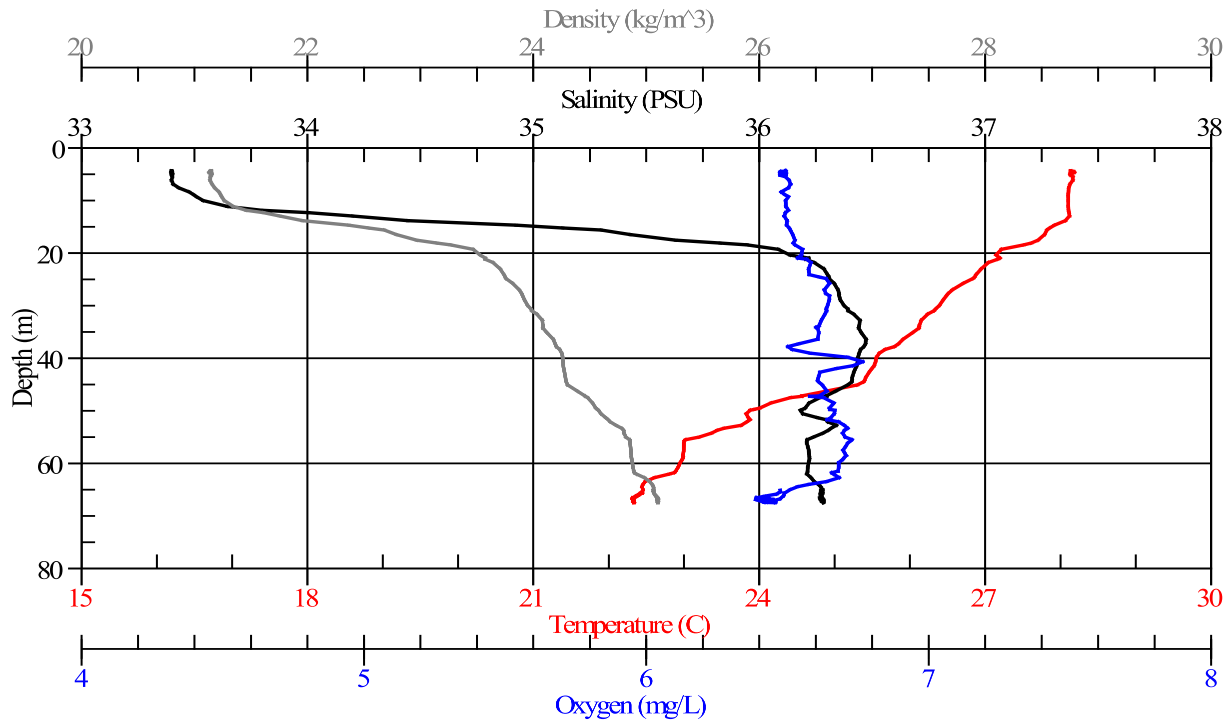

Figure 20.1. Water column profile for salinity, temperature, oxygen, and density from CTD Cast 19 on 06/10/2022 at SR2.

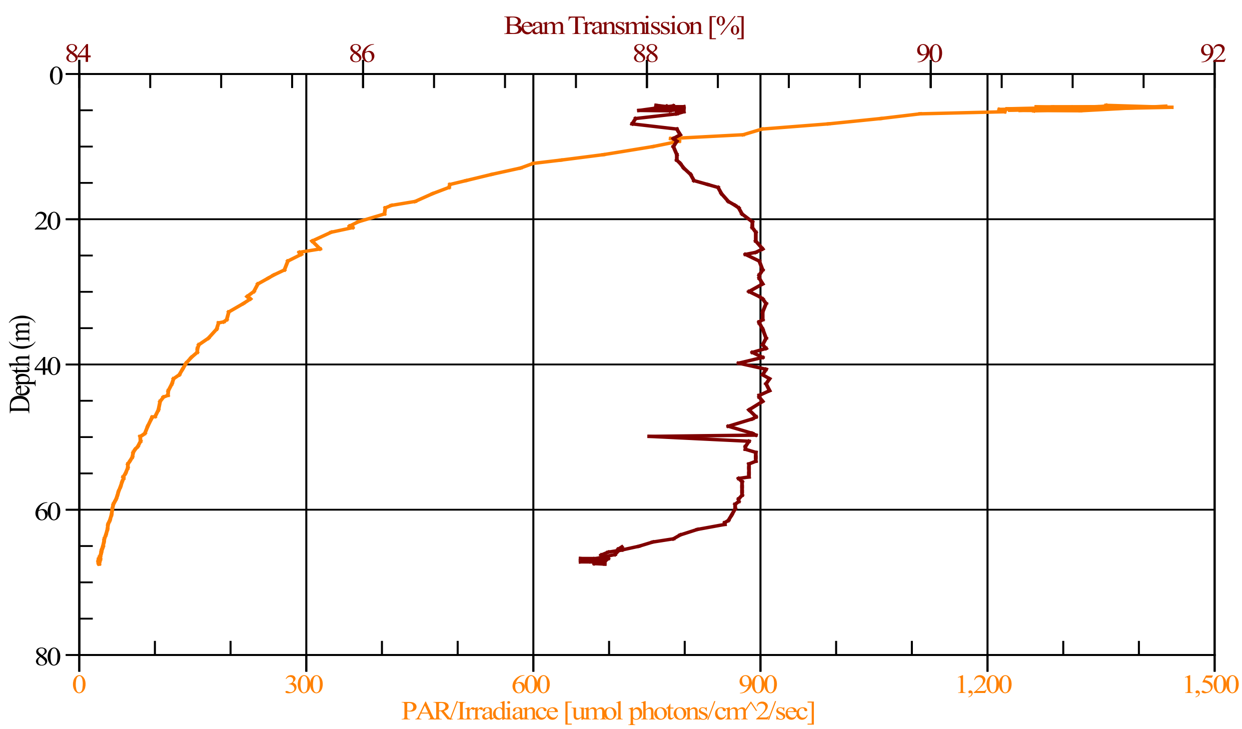

Figure 20.2. Plot showing PAR and beam transmission from CTD Cast 19 on 06/10/2022 at SR2.

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