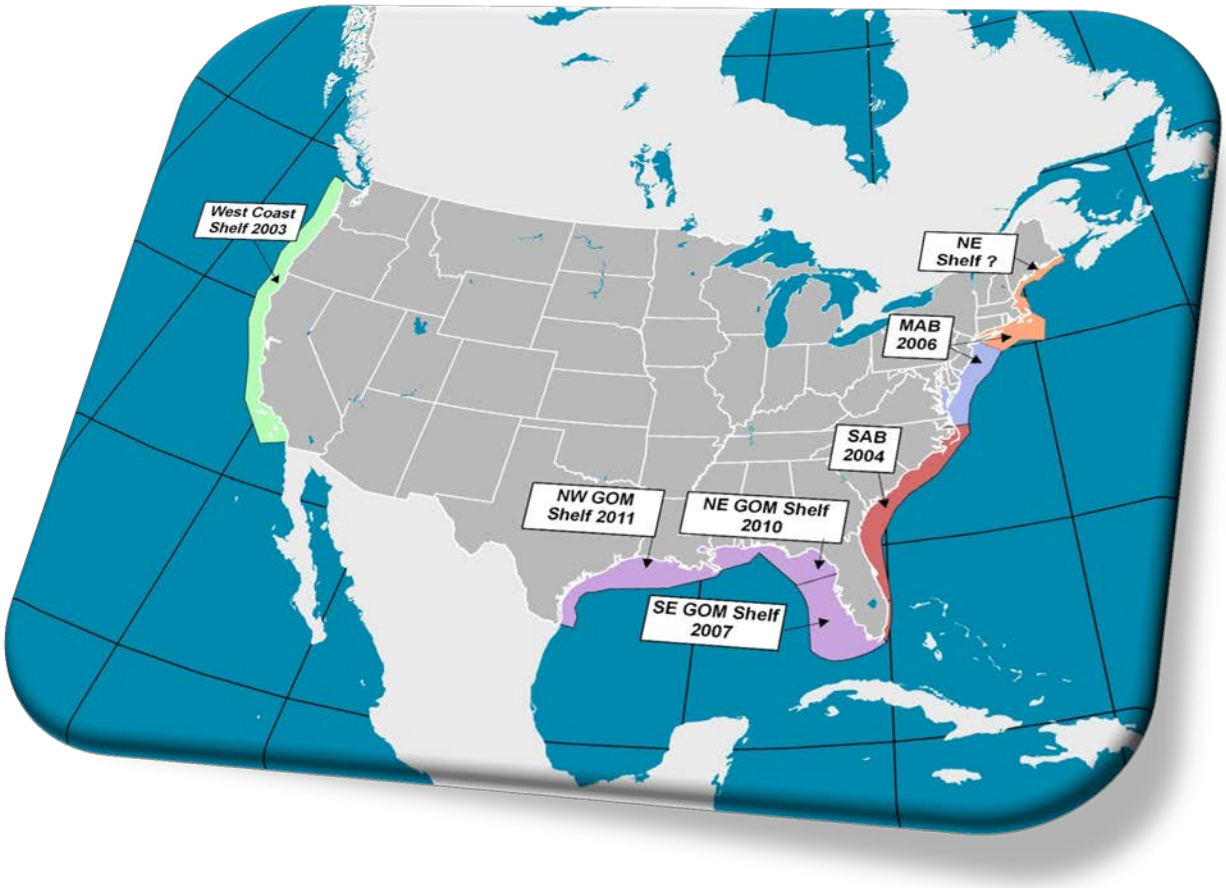
Cruise Report: Regional Assessment of Ecosystem Condition and Stressor Impacts along the Northwestern Gulf of Mexico Shelf

NOAA Ship Nancy Foster NF-11-07-RACOW
(August 8-16, 2011)



NOAA Technical Memorandum NOS NCCOS 140

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NOAA Ship Nancy Foster NF-11-07-RACOW
(August 8-16, 2011)

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Summary

This cruise report is a summary of a field survey conducted along a portion of the U.S. continental shelf in northwestern Gulf of Mexico (GOM), at navigable depths along the coastline seaward to the shelf break (~100m) from about 89°30' W to 95°28' W longitude, August 8 – 16, 2011 on NOAA Ship *Nancy Foster* Cruise NF-11-07-RACOW. Synoptic sampling of multiple ecological indicators was conducted at each of 34 stations throughout these waters using a random probabilistic sampling design. The original study design consisted of 50 stations extending from the Mississippi delta all the way to the U.S./Mexican border, but vessel failures precluded sampling at 16 stations within the western-most portion of the study area. At each station samples were collected for the analysis of benthic community structure and composition; concentrations of chemical contaminants in sediments and target demersal biota; sediment toxicity; nutrient and chlorophyll levels in the water column; and other basic habitat characteristics such as salinity, temperature, dissolved oxygen, turbidity, pH, sediment grain size, and organic carbon content. Other indicators, from a human-dimension perspective, were also recorded, including presence of vessels, oil rigs, surface trash, visual oil sheens in sediments or water, marine mammals, or noxious/oily sediment odors.

The overall purpose of the survey was to collect data to assess the status of ecosystem condition and potential stressor impacts throughout the region, based on these various indicators and corresponding management thresholds, and to provide this information as a baseline for determining how such conditions may be changing with time. While sample analysis is still ongoing, some preliminary results and observations are reported here. A final report will be completed once all data have been processed.

This was a multi-disciplinary partnership effort made possible by scientists from the following organizations:

- NOAA, National Ocean Service (NOS), National Centers for Coastal Ocean Science (NCCOS), Center for Coastal Environmental Health and Biomolecular Research (CCEHBR), Charleston, SC.
- U.S. Environmental Protection Agency (EPA), National Health and Environmental Effects Research Laboratory (NHEERL), Gulf Ecology Division (GED), Gulf Breeze, FL.
- U.S. Geological Survey (USGS), National Wetlands Research Center, Gulf Breeze Project Office, Gulf Breeze, FL.
- NOAA, Office of Marine and Aviation Operations, NOAA ship Nancy Foster
- NOAA National Coastal Data Development Center
- Texas A&M University, Department of Oceanography
- University of Maryland, Chesapeake Biological Laboratory (CBL)
- Barry A. Vittor & Associates, Inc.

Additional copies of this cruise report can be obtained by contacting:
NOAA, CCEHBR, 219 Fort Johnson Road, Charleston, South Carolina, 29412,
Telephone: 843/762-8511. Attention: Cynthia Cooksey.

1.0 Introduction

This survey is part of a continuum of studies being conducted by the National Oceanic and Atmospheric Administration (NOAA), U.S. Environmental Protection Agency (EPA), and partnering states to assess condition of aquatic resources throughout coastal-ocean waters of the U.S., inclusive of several National Marine Sanctuaries, using multiple indicators of ecological condition (Figure 1). The scope and design of these studies are similar to those used in the coastal component of EPA's Environmental Monitoring and Assessment Program (EMAP) and more recent National Coastal Assessment Program, which have focused mostly on estuaries and inland waters. The present work extends these prior efforts to coastal-ocean waters, from navigable depths along the coastline seaward to the shelf break (100 m). Surveys of benthic fauna and other multiple indicators of ecological condition and stressor impacts — including basic habitat characteristics such as depth, salinity, temperature, dissolved oxygen, pH, sediment grain size and organic content; nutrient and chlorophyll levels in the water column; chemical contaminants in sediments and biota — are conducted in these waters at a series of randomly selected stations using a probabilistic sampling design. Accordingly, the resulting data can be used to make estimates of the spatial extent of condition with respect to the various measured indicators, and to provide a baseline to determine future changes in environmental conditions. Thus far such efforts have included a survey of shelf waters along the U.S. west coast, from the Straits of Juan de Fuca, WA to Channel Islands, CA (summer 2003, NOAA Ship *McArthur II* Cruise AR-03-01-NC); a survey of shelf waters of the South Atlantic Bight from Cape Hatteras, NC to West Palm Beach, FL (summer 2004, NOAA Ship *Nancy Foster* Cruise NF-04-08-CL); a survey of shelf waters of the mid-Atlantic Bight (MAB) from Cape Hatteras to Cape Cod, MA (spring 2006, NOAA Ship *Nancy Foster* Cruise NF-06-06-NCCOS); a survey of shelf waters of the West Indian zoogeographic province from Tampa Bay to West Palm Beach, Florida (spring 2007, NOAA Ship *Nancy Foster* Cruise NF-07-08-NCCOS) ; and a survey of shelf waters of the northeastern Gulf of Mexico from the Mississippi Delta to Tampa Bay, Florida (summer 2010, NOAA Ship *Nancy Foster* Cruise NF-10-09-RACOW).

The present survey was conducted along a portion of the U.S. continental shelf in northwestern Gulf of Mexico (GOM) from 89°30' W longitude near the Mississippi River Delta to 95°28' W off San Bernard River, Texas (Figure 2). The original sampling frame consisted of 50 stations extending from the Mississippi River Delta all the way to the U.S./Mexican border, representing a total of 111,162 square kilometers, but vessel failures precluded sampling at 16 stations within the western-most portion of the study area. Results of this survey, covering a completed sampling area of 81,034 square kilometers, will be valuable in providing new information on ecological characteristics and conditions over a broad expanse of northwestern GOM coastal-ocean waters. The consistent and systematic sampling of the different biological and environmental variables across the region provides an opportunity for learning more about the spatial patterns of these resources and processes controlling their distributions. In addition, the synoptic sampling of the variety of different indicators is important in providing a means to support an integrative "weight-of-evidence" assessment of condition across these sites, and to allow the examination of potential associations between the presence of stressors and biological responses. This is the first such baseline of its kind (i.e., probability based) for offshore waters of the northwestern Gulf of Mexico shelf. The following report provides a brief summary of the scope and preliminary results of the supporting field work conducted August 8 – 16, 2011 on

NOAA Ship *Nancy Foster* Cruise NF-11-07-RACOW.

2.0 Scientific Approach

Samples were collected on NOAA Ship Nancy Foster Cruise NF-11-07-RACOW, August 8 - 16, 2011, at 34 random stations along the continental shelf of the northwestern GOM, from the Mississippi River Delta to about 95°28' W longitude off the Texas coast (Figure 2, Table 1). As mentioned above, the original study design consisted of 50 stations extending from the Mississippi River Delta to the U.S./Mexican border, but vessel failures precluded sampling at 16 stations within the western-most portion of the study area. At each station, samples were obtained for characterization of the following core indicators: (1) community structure and composition of benthic macroinfauna (> 0.5 mm); (2) concentration of chemical contaminants in sediments (metals, pesticides, TEHs, PCBs, PAHs, PBDEs); (3) sediment toxicity (Microtox); (4) general habitat conditions (water depth, dissolved oxygen, conductivity, temperature, pH, chlorophyll a, total suspended solids, water-column nutrients, % silt-clay versus sand content of sediment, organic-carbon content of sediment); and (5) condition of selected demersal fish species caught by hook-and-line (contaminant body burdens and visual evidence of pathological disorders). Several human-dimension indicators were recorded as well including presence of any vessels, oil rigs, surface trash, visual oil sheens in sediments or water, marine mammals, or noxious/oily sediment odors. Table 2 provides a list of samples collected during the cruise.

Sediment sampling was conducted using a 0.04 m^2 Young-modified Van Veen grab. Samples for benthic macro-infaunal analysis were collected in duplicate, live-sieved onboard through a 0.5 mm screen, and preserved separately in 10% buffered formalin with Rose Bengal stain. Samples for the analysis of sediment toxicity, sediment contaminants, % silt-clay, % water, and % TOC were sub-sampled from composited surface sediment (upper 2-3 cm) taken from additional grabs (typically two) independent of the macro-infaunal grabs.

A Seabird SBE 9 CTD was used to acquire continuous profiles of conductivity, temperature, pH, dissolved oxygen, depth, and turbidity (in Formazin Turbidity Units, FTU) as it was lowered and raised through the water column. The unit also was equipped with 12 Nisken bottles to acquire discrete water samples at two designated water depths (near surface and near-bottom) for analysis of dissolved oxygen, nutrients, total suspended solids, turbidity (in Nephelometric Turbidity Units, NTU), and chlorophyll. Discrete water samples for DO analysis were fixed onboard with manganous chloride and sodium iodide-sodium hydroxide, then transported to Texas A&M University for analysis.

3.0 Preliminary Results

A total of 34 stations were sampled for all indicators throughout the study region (Figure 2, Table 1). Presented here are preliminary results and observations from the cruise. A final report will be completed once all data have been processed.

Water depths at the 34 stations averaged 33.1 m and ranged from 13.0 – 83.0 m. Bottom-water salinity levels (PSU) were slightly varied across the region with values falling within a range of 31.1 to 36.4 and averaging 35.6. Other bottom-water physical characteristics were more variable, including bottom-water temperature which ranged from 19.4ºC to 31.0 ºC with warmer temperatures generally occurring at the shallower stations across the region. Turbidity ranged from 0.1 FTU to 8.2 FTU and averaged 2.2 across the region. Turbidity measurements were highest in proximity to the Mississippi River Delta. Bottom-water dissolved oxygen (DO) ranged from 0.0 mg/L to 6.65 mg/L and averaged 4.94 mg/L. Five stations (Figure 3) had DO values in a range (< 2 mg/L) often associated with adverse conditions for benthic fauna (USEPA 2004, Diaz and Rosenberg 1995) and 2 of those 5 stations were completely anoxic (0.0 mg/L). These hypoxic and anoxic stations were spatially limited to waters offshore of Louisiana in the region which routinely experiences low DO events (Rabalais et al. 2002). Values of pH ranged from 7.6 to 8.1 and were strongly correlated with DO (r^2=0.93, Figure 4). Bottom water-quality measurements for depth, temperature, salinity, pH, turbidity, and DO at each station are presented in Table 1.

Discrete water-column samples were collected from near-surface and near-bottom waters at every station for a variety of analyses (see Table 2) including DO as measured by Winkler titration and turbidity as measured with a HACH 2100P portable turbidimeter. These two parameters, DO and turbidity, were also measured continuously with the Seabird SBE 9 CTD using a SBE 43 probe and a Seapoint Turbidity probe, respectively. Near-surface and near-bottom values are provided in Table 3 for both DO and turbidity as measured with the CTD and discrete water samples (for turbidity, FTU and NTU are considered comparable to each other). There was generally good agreement between the two methods (Figure 5). Following the manufacturer's recommendations, the Winkler titration data were used to calculate a calibration adjustment for the SBE43 DO measurements (Application Note #64-2 available from www.seabird.com). All water-column profiles presented in Appendix A reflect corrected SBE43 DO probe data.

Observations of several human-dimension indicators (e.g., presence or absence of vessels, surface trash, surface oil, marine mammals, oily sediment, and noxious sediment odors) also were made at each station (Table 4). Surface oil slicks or oily sediment sheens were not observed at any of the stations. Surface trash was observed at one station (07). At 97% (n=33) of the stations, at least one indicator of human use (presence of vessels or oil rigs) was observed. Caution is advised however when interpreting these latter observations, as sampling occurred day and night and nighttime observations were limited.

A total of 51 fish from 6 species were collected with hook-and-line fishing gear and kept frozen during the cruise as candidates for subsequent tissue contaminant analysis (Table 5). These fish were collected from stations distributed across the entire study region (Figure 6). At this time, the following subset of fish has been targeted for further chemical analysis, based on their commercial/recreational value and/or broad spatial distribution across stations: *Centropristis philadelphica* (Rock Sea Bass, n=6), Cynoscion nothus (Silver Seatrout, n=2), *Micropogonias undulatus* (Atlantic Croaker, n=27).

Data for other biological and abiotic environmental variables listed in Table 2 will be available once the processing of these samples has been completed. A final report, inclusive of all results, is expected in FY13.

NF-11-07-RACOW was plagued with vessel problems over the 10 days-at-sea (DAS) of allocated ship time. The most serious problem had to do with the Integrated Vessel Monitoring and Control (IVMC) system, but other mechanical problems occurred as well. Combined, these problems caused the loss of 3 DAS, leading to a reduction in the size of the sampling area by over one-third and completion of only 34 out of a planned 50 stations. A follow-up cruise to complete sampling at the remaining 16 stations is being considered.

4.0 Acknowledgements

Support for this project has been provided through NOAA/NOS/NCCOS/CCEHBR FY11 base funds (field sampling personnel, supplies and equipment; sample processing) and NOAA/OMAO (NOAA Ship *Nancy Foster* support). All members of the field crew (Figure 4, Table 6) are commended for their high level of technical expertise, teamwork and dedication to getting the required sampling completed. Appreciation also is extended to the officers and crew of the NOAA ship NANCY FOSTER for the superb job performed on NF-11-07-RACOW. Special appreciation is given to Drs. Matt Howard and Steven DiMarco, and Mr. Erik Quiroz of Texas A&M University, Department of Oceanography for providing sampling materials and analysis of discrete water samples for dissolved oxygen concentrations.

5.0 References

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Rabalais, N.N, R.Eugene Turner, and W.J. Wiseman, Jr. 2002. Gulf of Mexico Hypoxia, A.K.A. "The Dead Zone." Annu. Rev. Ecol. Syst.33: 235-263.

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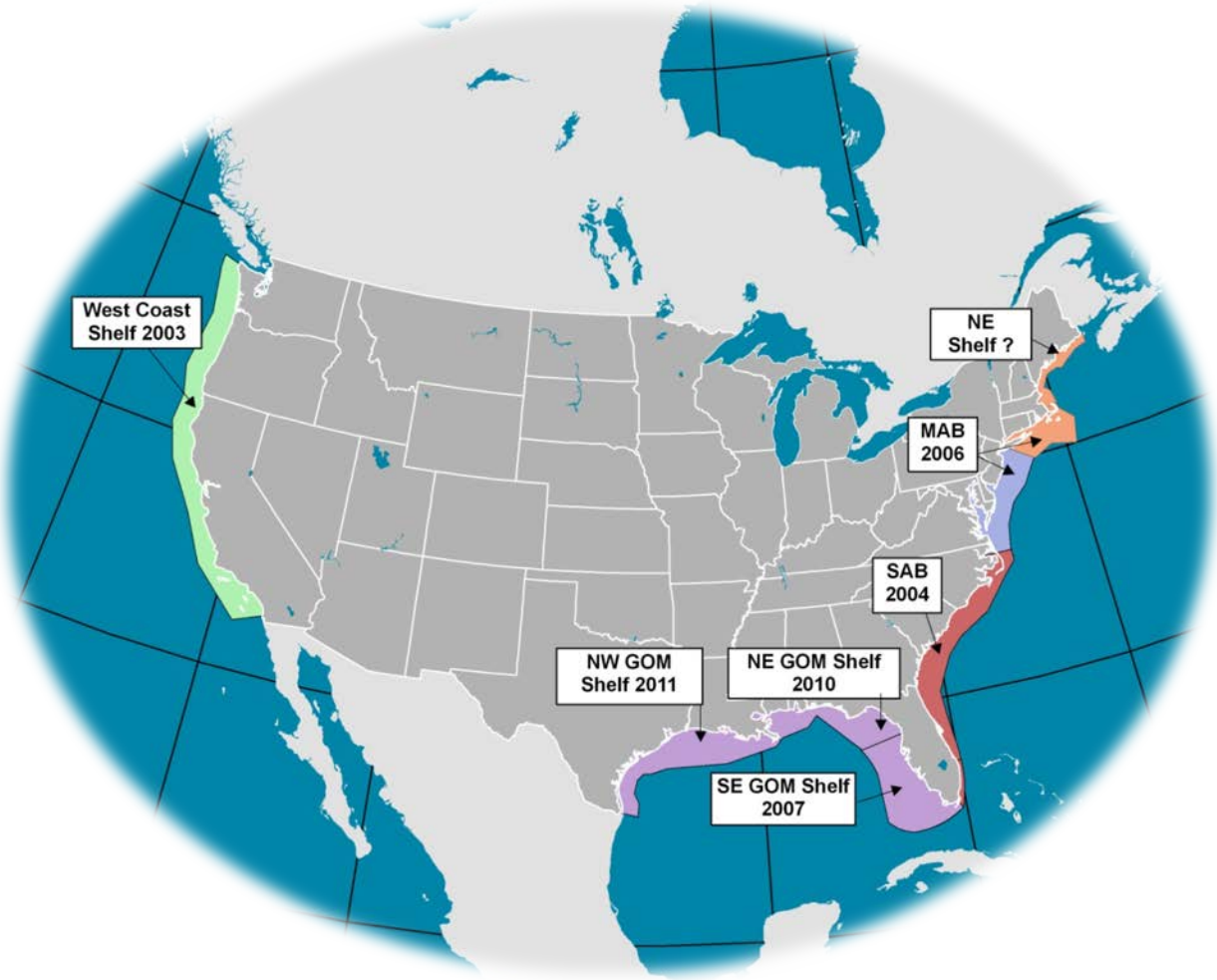

Figure 1. Overview of related series of offshore regional surveys to assess status of ecological condition and stressor impacts throughout various continental shelf planning areas of the United States.

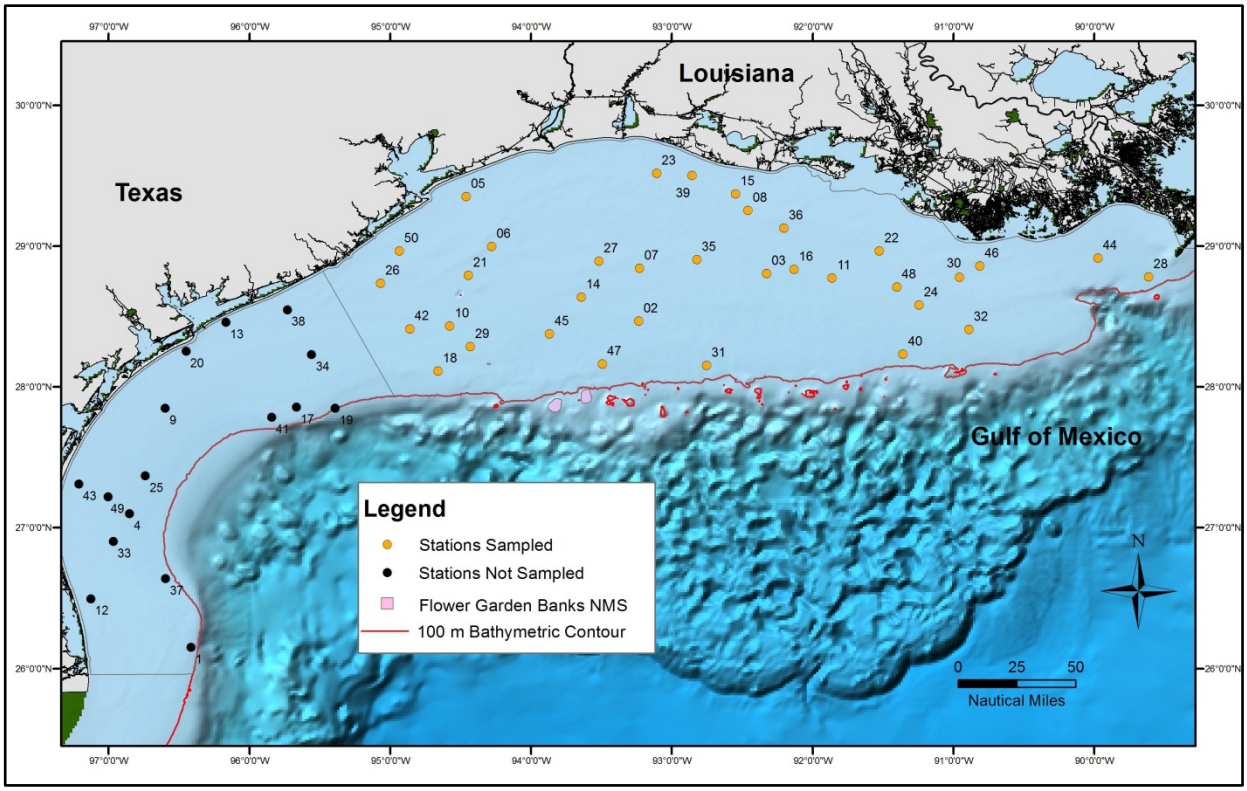

Figure 2. NF-11-07-RACOW station locations. The orange circles represent stations which were successfully sampled while black circles represent stations which were not.

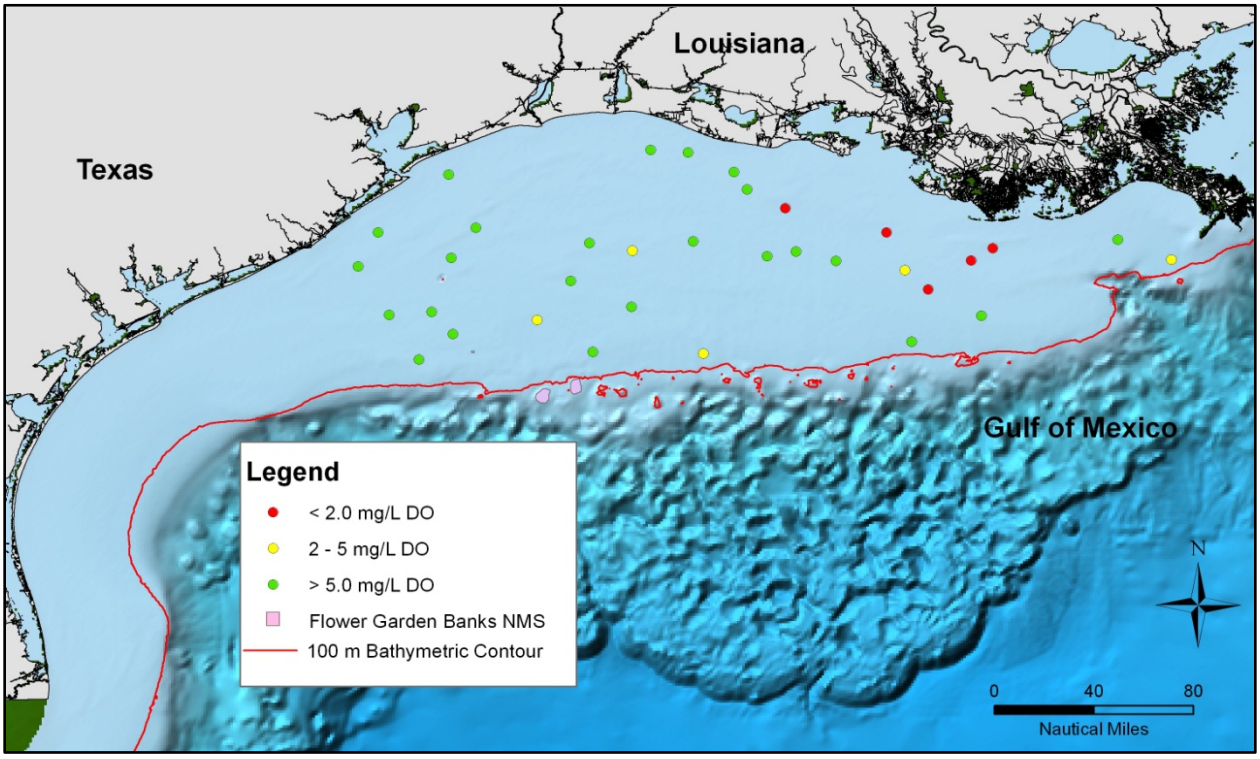

Figure 3. Ranges of dissolved oxygen (DO) concentrations in bottom waters for NF-11-07-RACOW.

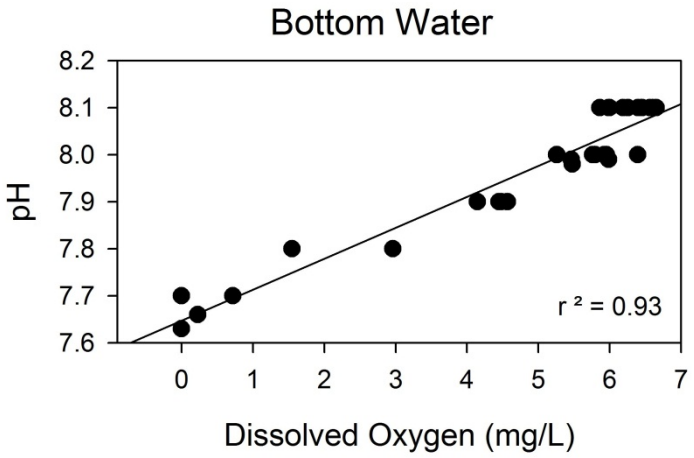

Figure 4. Linear regression of pH and dissolved oxygen, as measured by Winkler titration, for bottom waters.

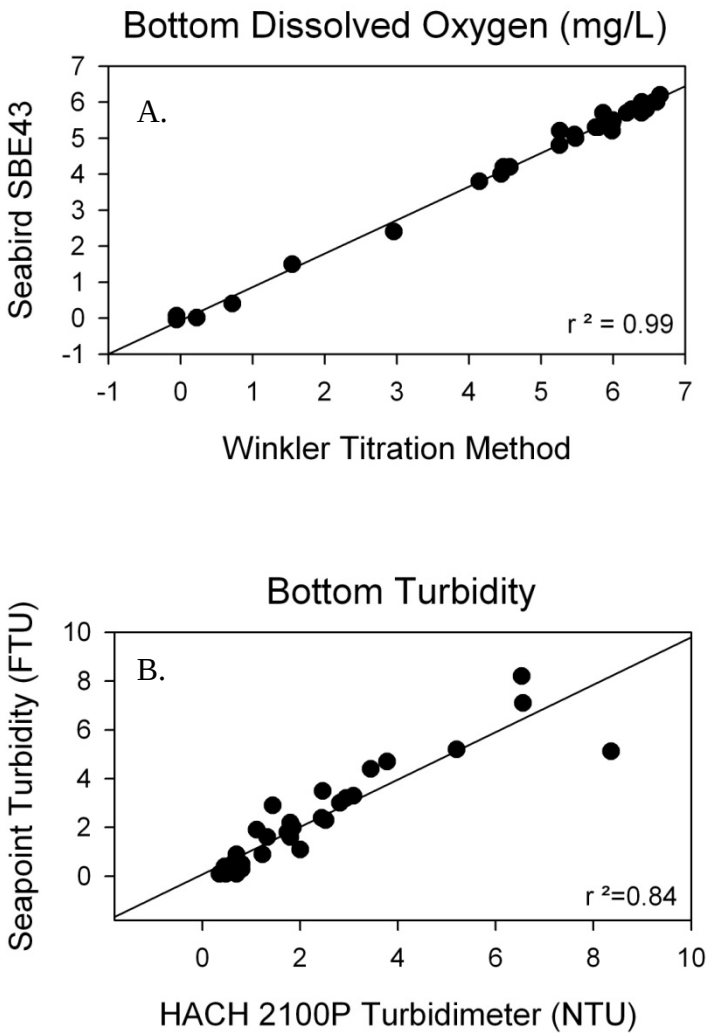

Figure 5. Linear regressions for near-bottom waters of (a.) dissolved oxygen, as measured by Winkler titration and Seabird SBE 43 probe, and (b.) turbidity, as measured by Seapoint Turbidity probe and HACH 2100P turbidimeter.

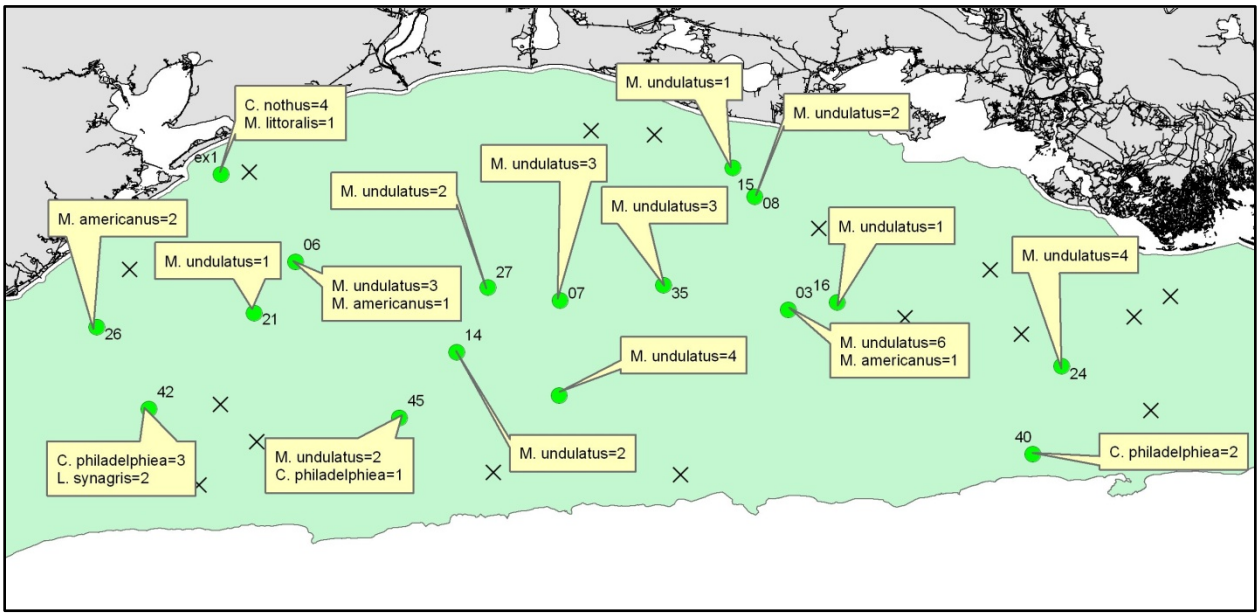

Figure 6. NF-11-07-RACOW station locations (green circles) where fish samples were collected for tissue contaminant analysis. Black Xs indicate stations where no fish were collected.

Table 1. Locations, depths, and bottom water characteristics for 34 stations sampled across the northwestern Gulf of Mexico continental shelf, August 8 – 16, 2011. Near-bottom water data are from the Seabird CTD except for DO which is from Winkler titrations.

Station	Date Sampled	Latitude (DD)	Longitude (DD)	Depth (m)	Near-Bottom Water Temp. (C)	DO (mg/L*)	pH	Salinty (PSU)	Turbidity (FTU)
02	8/14/2011	28.46568	-93.23498	44.9	21.8	5.25	8.0	36.3	2.2
03	8/10/2011	28.80551	-92.32641	33.2	26.4	5.95	8.0	36.0	3.7
05	8/13/2011	29.35128	-94.46214	13.4	30.5	5.80	8.0	36.2	5.2
06	8/15/2011	28.99617	-94.27983	17.5	30.6	6.19	8.1	35.8	0.4
07	8/14/2011	28.84163	-93.23053	26.0	26.4	4.48	7.9	35.6	0.2
08	8/11/2011	29.25348	-92.45907	13.0	30.5	5.86	8.1	31.1	0.6
10	8/16/2011	28.43109	-94.57719	40.7	24.2	6.60	8.1	36.4	0.9
11	8/10/2011	28.77335	-91.86272	28.7	26.7	5.95	8.0	36.0	4.7
14	8/14/2011	28.63782	-93.64192	34.0	28.8	6.39	8.0	36.0	1.6
15	8/11/2011	29.36910	-92.54710	13.0	30.5	5.98	8.1	32.0	1.1
16	8/10/2011	28.83473	-92.13220	29.3	27.8	6.56	8.1	36.2	2.9
18	8/16/2011	28.11170	-94.66162	56.0	24.7	6.65	8.1	36.4	0.1
21	8/15/2011	28.79222	-94.44418	25.1	30.0	6.45	8.1	36.3	0.6
22	8/10/2011	28.96346	-91.52482	13.5	26.2	0.22	7.7	35.1	2.4
23	8/11/2011	29.51665	-93.10694	13.2	31.0	5.76	8.0	34.4	7.4
24	8/10/2011	28.58138	-91.24372	31.0	24.5	1.55	7.8	35.8	3.7
26	8/15/2011	28.73637	-95.06802	22.0	29.6	6.40	8.1	36.4	0.1
27	8/14/2011	28.89327	-93.51757	22.0	30.2	6.00	8.1	35.7	0.2
28	8/9/2011	28.78113	-89.61170	83.0	19.4	4.45	7.9	36.4	2.4
29	8/16/2011	28.28362	-94.43266	48.3	23.4	5.79	8.0	36.4	2.3
30	8/9/2011	28.77697	-90.95576	15.3	26.4	0.00	7.6	35.2	2.9
31	8/14/2011	28.15103	-92.75326	77.3	19.5	4.57	7.9	35.9	3.4
32	8/9/2011	28.40644	-90.88850	42.1	22.7	5.98	8.0	36.2	0.9
35	8/14/2011	28.90307	-92.82142	25.8	30.3	6.26	8.1	33.9	0.1
36	8/11/2011	29.12817	-92.20402	13.5	26.8	0.71	7.7	34.9	4.4
39	8/11/2011	29.49957	-92.85714	13.4	31.0	5.92	8.0	33.8	8.2

Station	Date Sampled	Latitude (DD)	Longitude (DD)	Depth (m)	Near-Bottom Water Temp. (C)	DO (mg/L*)	pH	Salinty (PSU)	Turbidity (FTU)
40	8/10/2011	28.23202	-91.35672	82.0	20.3	5.46	8.0	36.4	2.0
42	8/16/2011	28.41152	-94.86200	38.5	25.6	6.44	8.1	36.4	0.3
44	8/9/2011	28.91518	-89.97200	34.0	23.7	5.48	8.0	36.4	0.4
45	8/15/2011	28.37622	-93.86803	54.5	21.0	4.14	7.9	36.3	3.0
46	8/9/2011	28.85815	-90.81122	13.5	26.1	0.00	7.7	35.3	3.8
47	8/15/2011	28.16147	-93.49432	64.8	23.1	6.40	8.1	36.2	0.6
48	8/10/2011	28.70927	-91.40098	24.0	26.4	2.96	7.8	35.3	1.6
50	8/15/2011	28.96487	-94.93657	18.7	28.1	5.26	8.0	36.4	2.0
			Mean	33.1	26.3	4.94	8.0	35.6	2.2
			Min	13.0	19.4	0.0	7.6	31.1	0.1
			Max	83.0	31.0	6.65	8.1	36.4	8.2

Table 2. Summary of field samples collected at each NF-11-07-RACOW station.

Parameters	# of Replicates	Container	Sample Size	Preservation
Infauna	2	1000 ml Polypropylene jar	All material retained on 0.5mm sieve	10% Buffered Formalin in the field
Metal Contaminants	1 (composited sediment)	250 ml (8 oz) polypropylene jar	2/3 full	frozen
Organic Contaminants	2 (composited sediment)	250 ml (4 oz) glass jar	2/3 full	frozen
TOC	1 (composited sediment)	125 ml (4 oz) Polypropylene jar	2/3 full	frozen
% Silt/Clay & % Moisture	1 (composited sediment)	500 ml (16 oz) HDPE jar	2/3 full	frozen
Microtox	1 (composited sediment)	125 ml (4 oz) Glass jar	2/3 Full	**Refrigerate**
Water Column (Temp., D.O., pH, Sal., Turb.)	1	N/A	Profile	N/A
Total Suspended Solids	2 (water column - surface, bottom)	47 mm preweighed filter pads	TSS retained on filter pad	frozen
Nutrients	2 (water column - surface, bottom)	60 ml HDPE containers	2/3 full	frozen
Chlorophyll a	2 (water column - surface, bottom)	25 mm filter pads	cells retained on pad	frozen
Turbidity	2 (water column - surface, bottom)	60 ml vial	Full	N/A
Fish Tissue	--	ziplock bag	5-6 specimens from up to 3 species	frozen

Table 3. Summary by station of dissolved oxygen and turbidity measurements in near-surface and near-bottom waters for NF-11-07-RACOW.

Station	Surface				Bottom			
	Dissolved Oxygen		Turbidity		Dissolved Oxygen		Turbidity	
	Winkler (mg/L)	CTD (mg/L)	HACH (NTU)	CTD (FTU)	Winkler (mg/L)	CTD (mg/L)	HACH (NTU)	CTD (FTU)
02	6.28	6.41	0.52	0.11	5.25	5.28	1.74	2.21
03	6.31	6.41	0.27	0.16	5.95	6.08	2.46	3.68
05	6.68	6.79	2.82	3.48	5.80	5.89	5.2	5.2
06	6.20	6.3	0.52	0.31	6.19	6.28	0.8	0.36
07	6.23	6.34	0.79	0.23	4.48	4.64	0.41	0.21
08	5.96	6.26	0.94	0.67	5.86	6.22	0.8	0.55
10	6.32	6.4	0.31	0.1	6.60	6.65	0.7	0.9
11	6.39	6.55	0.36	0.18	5.95	6.08	3.78	4.72
14	6.26	6.37	0.6	0.09	6.39	6.24	1.8	1.62
15	6.09	6.23	0.94	0.71	5.98	5.82	2	1.08
16	6.35	6.48	0.62	0.18	6.56	6.64	1.44	2.9
18	6.56	6.38	0.43	0.08	6.65	6.84	0.48	0.09
21	6.55	6.43	0.46	0.31	6.45	6.4	0.62	0.56
22	5.87	5.73	1.38	1.19	0.22	0.05	2.44	2.36
23	6.15	6.36	4.21	5.12	5.76	5.89	6.56	7.4
24	6.07	6.42	0.56	0.32	1.55	1.73	3.09	3.65
26	6.29	6.4	0.34	0.11	6.40	6.57	0.35	0.13
27	6.18	6.26	0.42	0.13	6.00	6.07	0.68	0.17
28	6.36	6.59	1.07	0.89	4.45	4.45	2.52	2.35
29	6.29	6.4	0.23	0.11	5.79	5.96	1.8	2.3
30	5.85	5.69	4.09	1.9	0.00	-0.06	.	2.87
31	6.36	6.4	0.55	0.08	4.57	4.61	2.94	3.4
32	6.71	6.83	1.05	0.59	5.98	6.47	1.23	0.88
35	6.32	6.44	0.61	0.12	6.26	6.41	0.7	0.14
36	6.36	6.73	1.07	0.83	0.71	0.41	3.44	4.41
39	5.95	6.05	6.11	8.29	5.92	6.06	6.53	8.19
40	6.30	6.46	0.68	0.25	5.46	5.63	1.85	2.03
42	6.30	6.4	0.38	0.19	6.44	6.26	0.45	0.34
44	6.59	6.85	1.12	1.08	5.48	5.47	0.73	0.4
45	6.27	6.38	0.32	0.08	4.14	4.16	2.81	3.02
46	8.80	7.11	2.56	2.4	0.00	0.12	8.36	3.77
47	6.25	6.37	0.35	0.07	6.40	6.57	0.63	0.6
48	6.42	6.62	0.53	0.35	2.96	2.67	1.33	1.56
50	6.46	6.56	0.95	0.95	5.26	5.27	1.11	1.96

Table 4. Summary by station of human-dimension indicators at 34 stations sampled as part of the NF-11-07-RACOW research cruise. Cautionary Note: The visual range was highly variable – daytime observations were limited to a range of 2-5 nm while nighttime observations were limited to what was immediately adjacent to the vessel or the object being observed had lights that could be seen from a distance.

Station	Surface Trash Present (Y/N)	Surface Oil Present (Y/N)	Other Vessels Present (Y/N)	Oil Rigs Present (Y/N)	Marine Mammals Present (Y/N)	Sediment Oily (Y/N)	Sediment Odor?
02	N	N	N	Y	N	N	None
03	N	N	N	Y	N	N	None
05	N	N	Y	Y	N	N	None
06	N	N	Y	Y	N	N	None
07	Y	N	Y	Y	N	N	None
08	N	N	N	Y	N	N	None
10	N	N	Y	N	N	N	None
11	N	N	N	Y	N	N	None
14	N	N	N	Y	N	N	None
15	N	N	N	Y	N	N	None
16	N	N	N	Y	N	N	None
18	N	N	N	Y	N	N	None
21	N	N	Y	N	N	N	None
22	N	N	Y	Y	N	N	None
23	N	N	Y	Y	N	N	None
24	N	N	N	Y	N	N	None
26	N	N	N	N	N	N	None
27	N	N	N	Y	N	N	None
28	N	N	N	Y	N	N	None
29	N	N	Y	N	N	N	Sulfur
30	N	N	Y	Y	N	N	Sulfur
31	N	N	Y	Y	N	N	None
32	N	N	N	Y	N	N	None
35	N	N	N	Y	N	N	None
36	N	N	N	Y	N	N	None
39	N	N	N	Y	N	N	None
40	N	N	N	Y	N	N	None
42	N	N	N	Y	N	N	None
44	N	N	Y	Y	N	N	None
45	N	N	N	Y	N	N	None
46	N	N	Y	Y	N	N	Sulfur
47	N	N	N	Y	N	N	None
48	N	N	Y	Y	N	N	None
50	N	N	N	Y	N	N	Sulfur

Table 5. Summary of fish collections for cruise NF-11-07-RACOW.

Common Name	Scientific Name	Number of Fish Collected	Number of Stations
Croaker	*Micropogonias undulatus*	34	13
Rock Sea Bass	*Centropristis philadelphica*	6	3
Silver Seatrout	*Cynoscion nothus*	4	1
Southern Kingfish	*Menticirrhus americanus*	4	3
Lane Snapper	*Lutjanus synagris*	2	1
Gulf Kingfish	*Menticirrhus littoralis*	1	1
	Total	51	17

Table 6. NF-11-07-RACOW cruise participants.

Name	Affiliation
Len Balthis	NOAA/NOS/CCEHBR
Mike Barajas	JHT, INC. @ NOAA/NOS/CCEHBR
Cynthia Cooksey	NOAA/NOS/CCEHBR
Scott Cross	NOAA/NESDIS/NCDDC
Jim Campbell	JHT, INC.
JD Dubick	JHT, INC. @ NOAA/NOS/CCEHBR
Mike Fulton	NOAA/NOS/CCEHBR
Jeff Hyland	NOAA/NOS/CCEHBR
Todd Neison	NOAA/NOS/CCEHBR
Steve Roth	JHT, INC. @ NOAA/NOS/CCEHBR
Blaine West	JHT, INC. @ NOAA/NOS/CCEHBR

Appendix A

NF-11-07-RACOW CTD profiles
Notes: (1) y-axis (depth) varies by station
(2) all DO has been corrected using Winkler titrations

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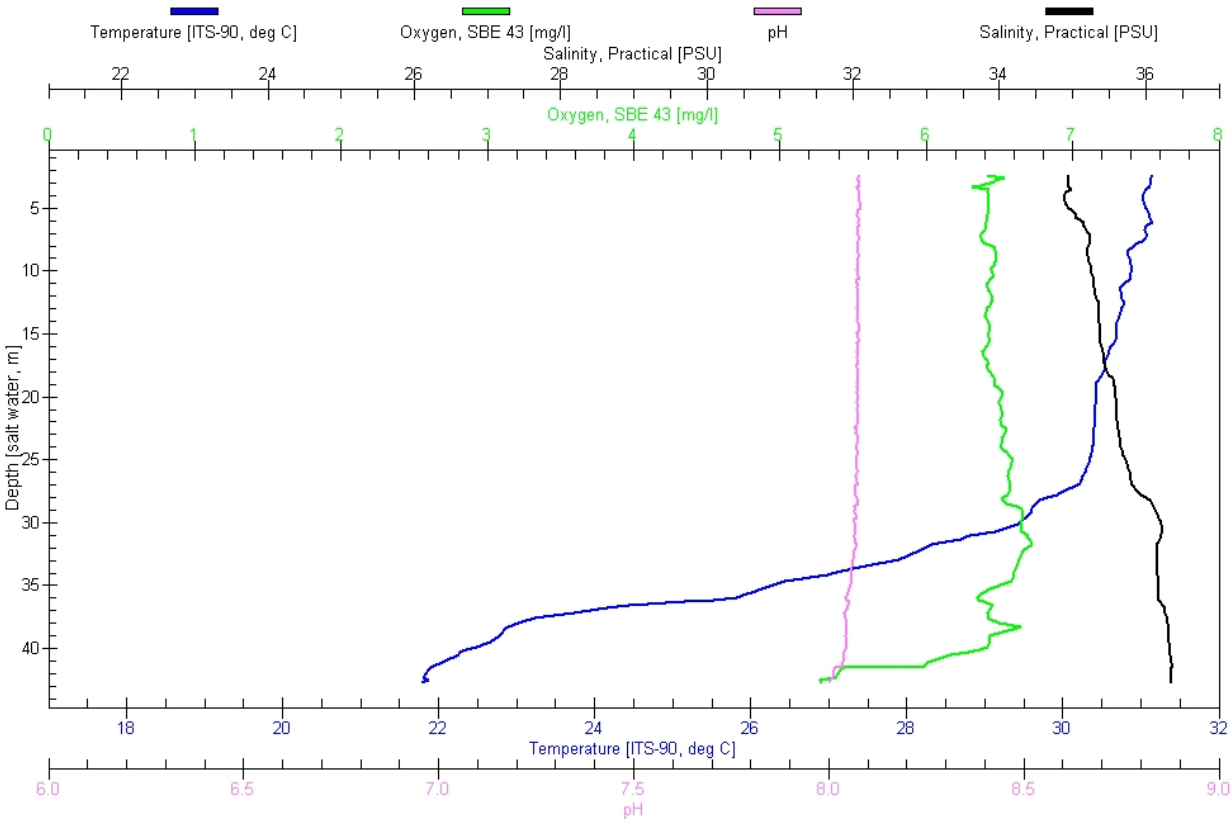
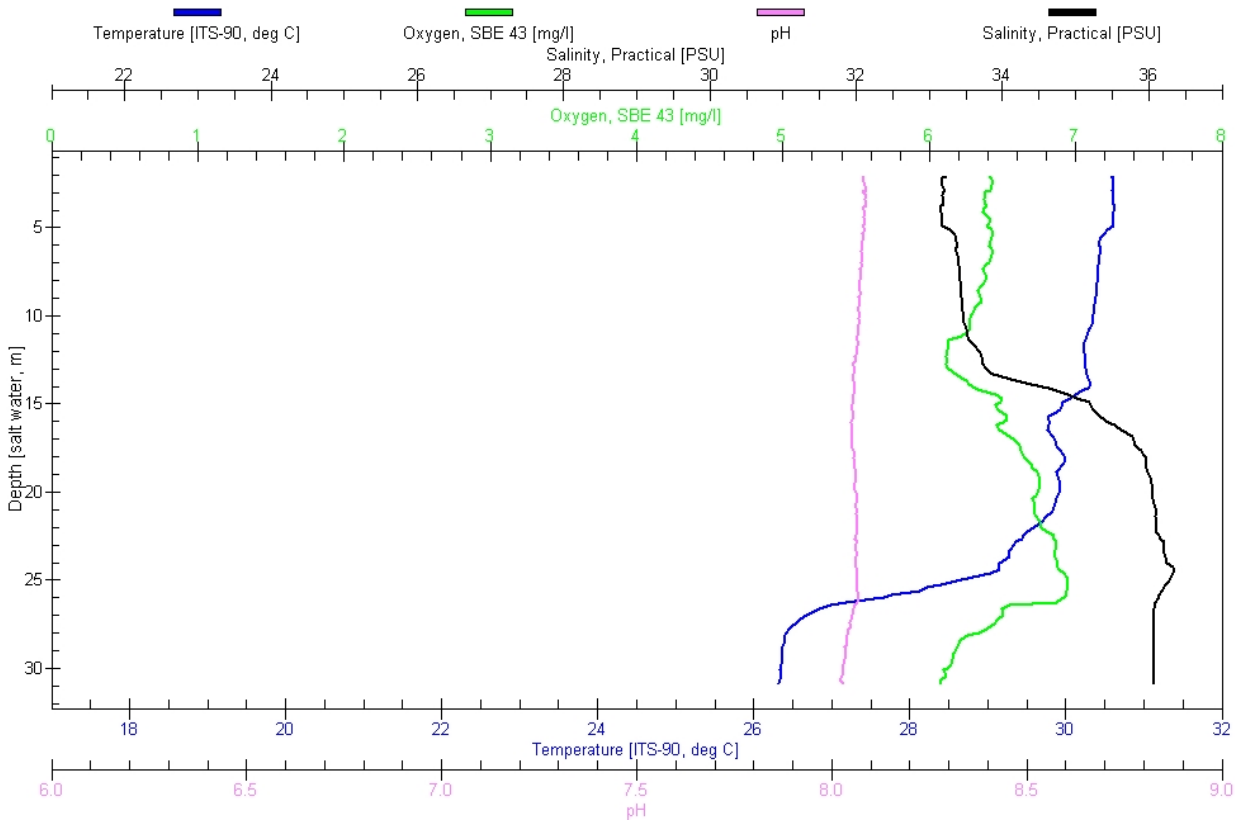
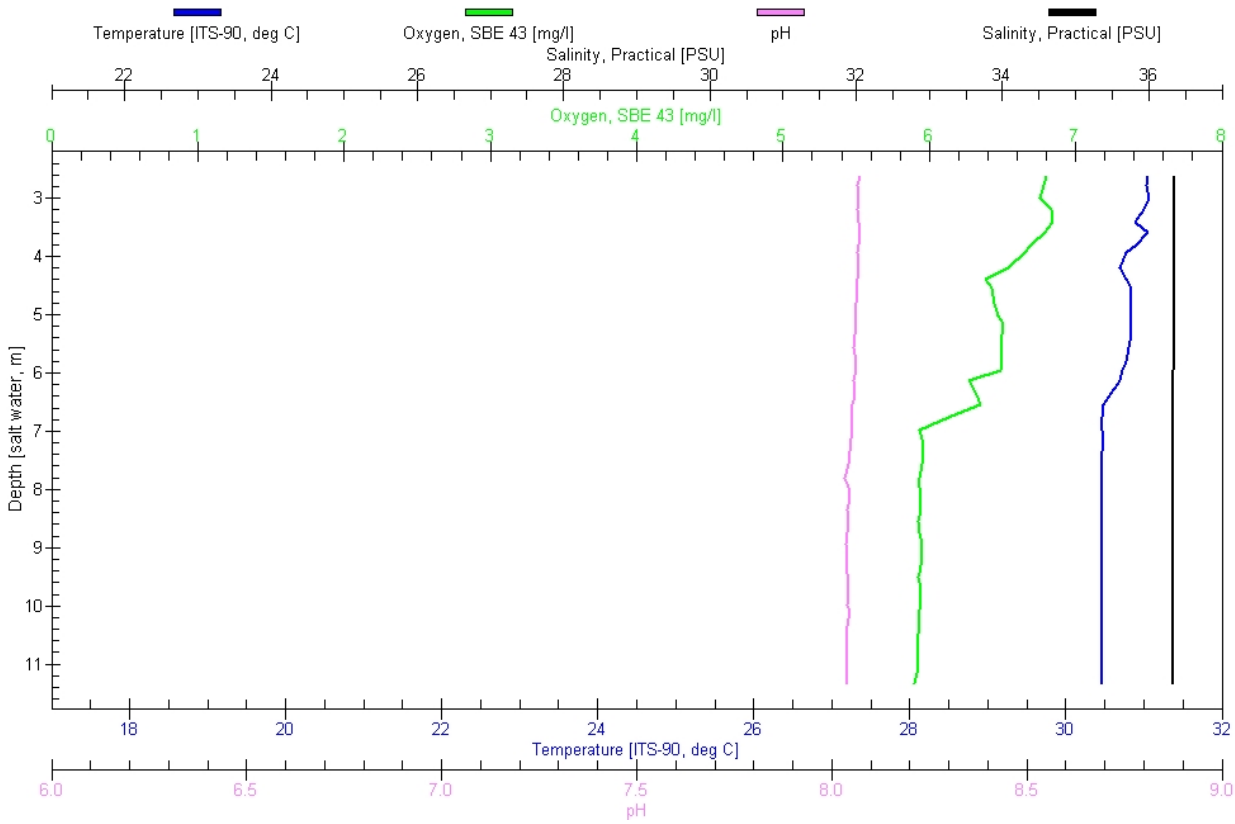
Station 02


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
5 10 15 20 25 30 35 40
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

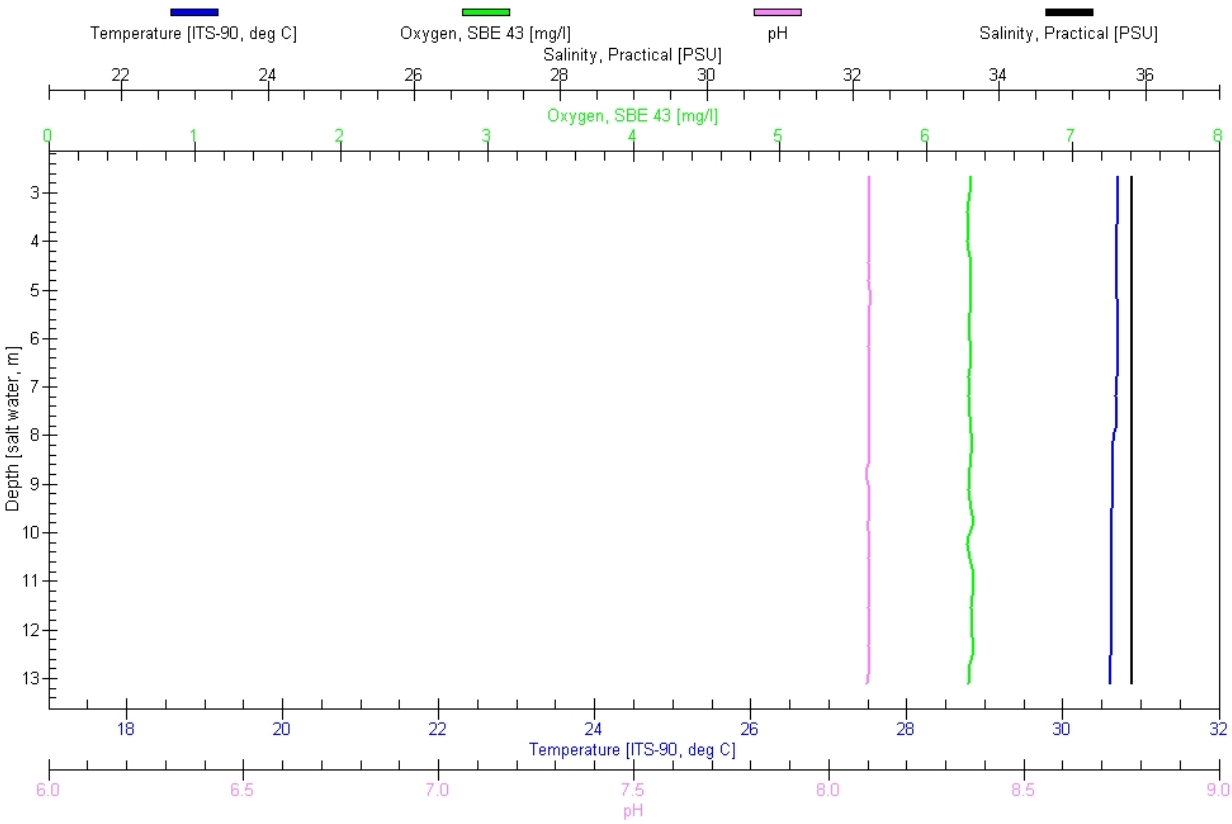
Station 03


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
5 10 15 20 25 30
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

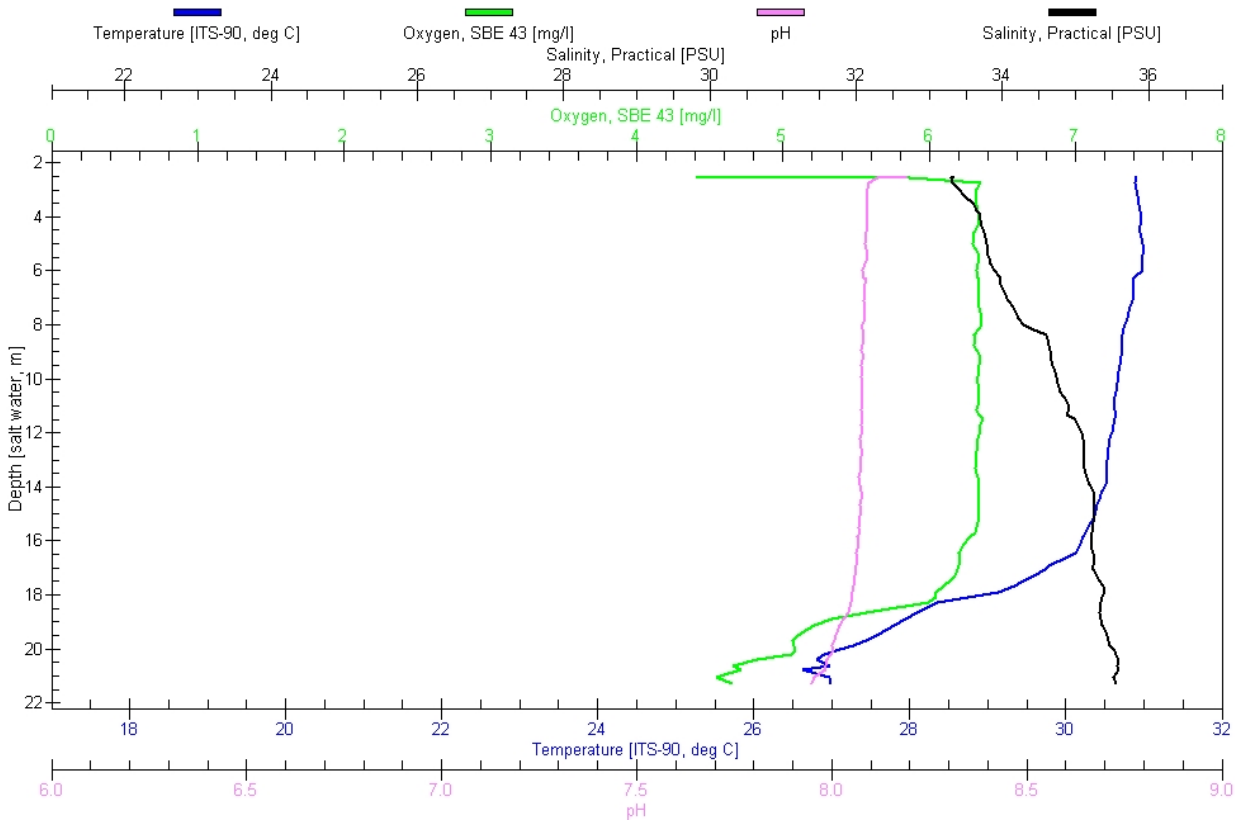
Station 05


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
3 4 5 6 7 8 9 10 11
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

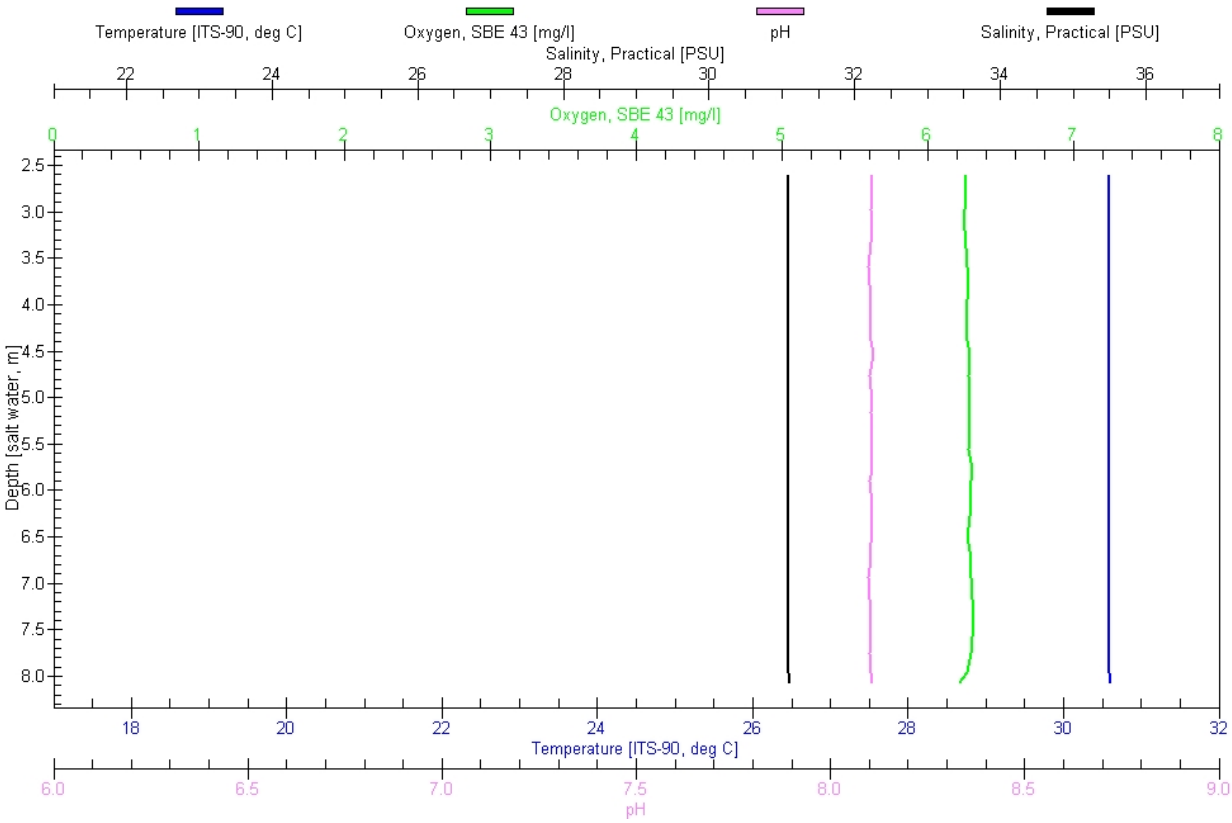
Station 06


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
3 4 5 6 7 8 9 10 11 12 13
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

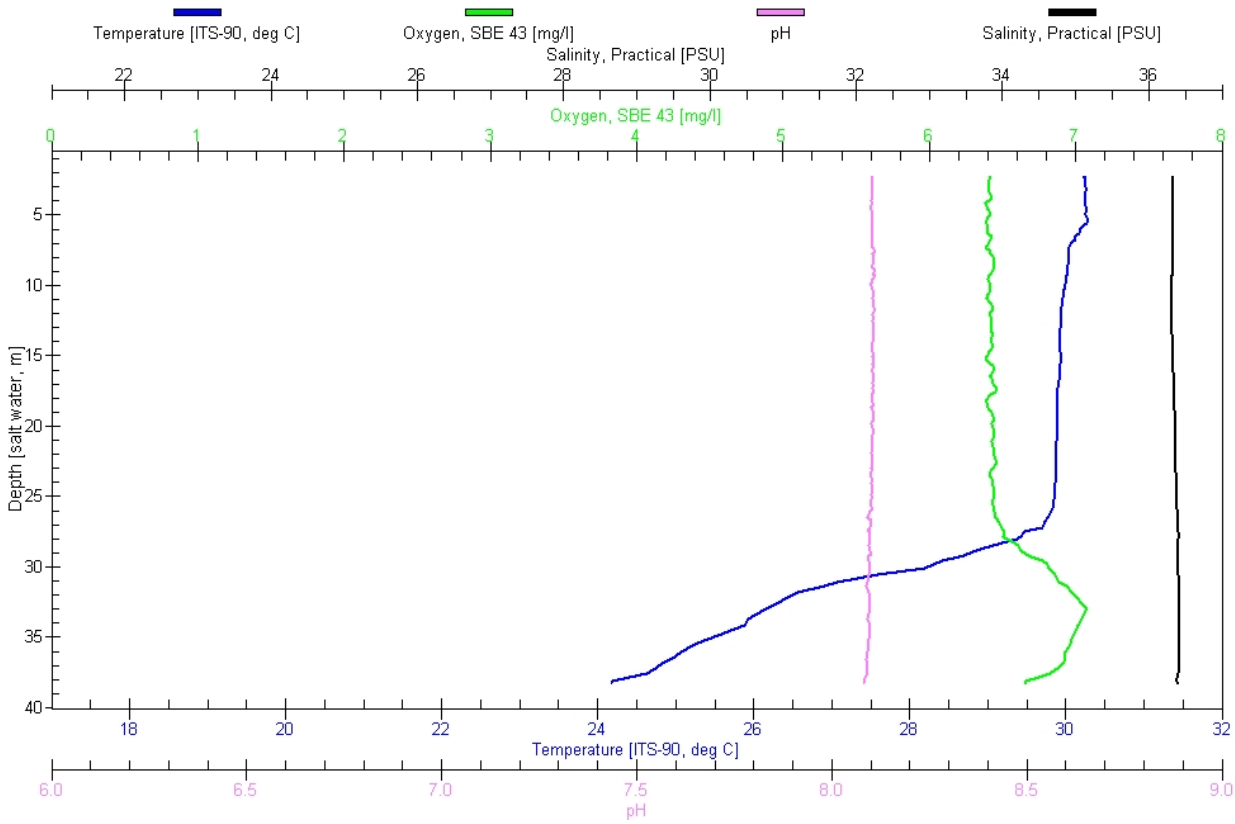
Station 07


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
2 4 6 8 10 12 14 16 18 20 22
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

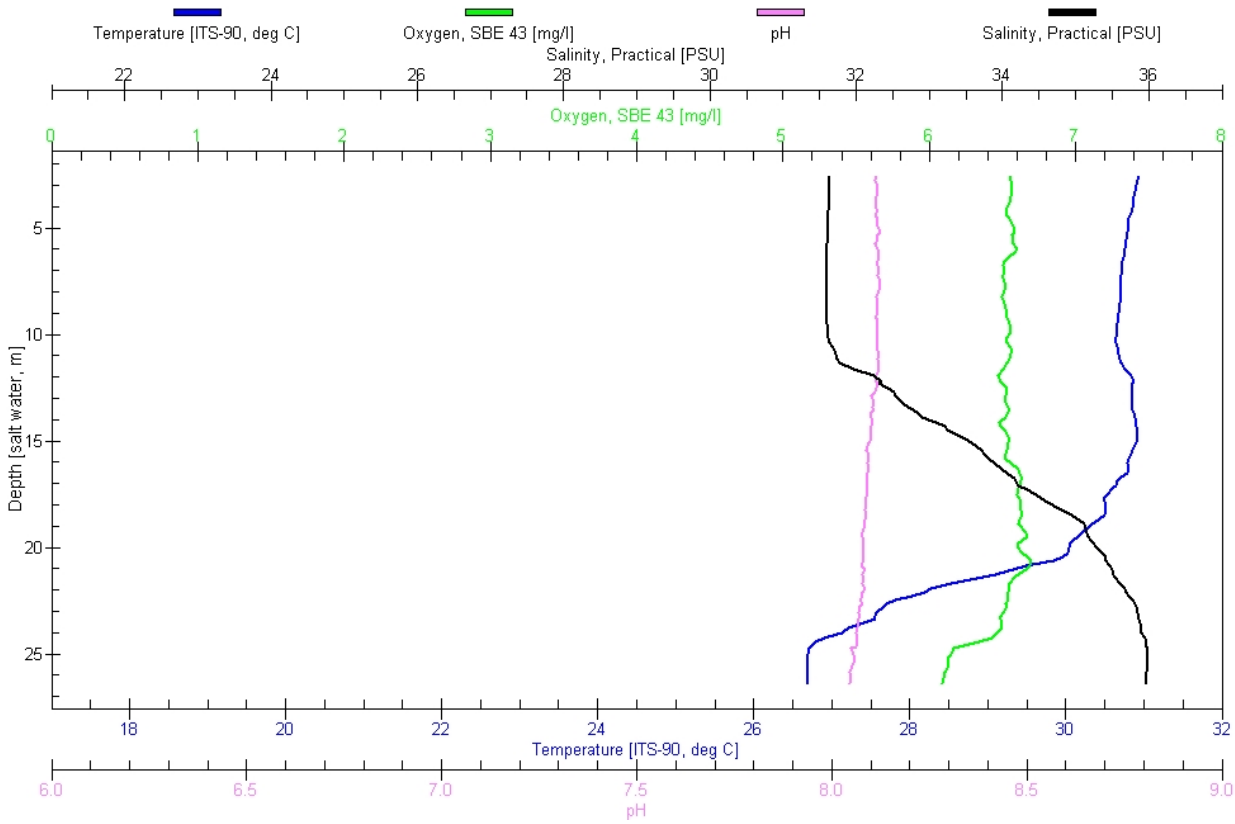
Station 08


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

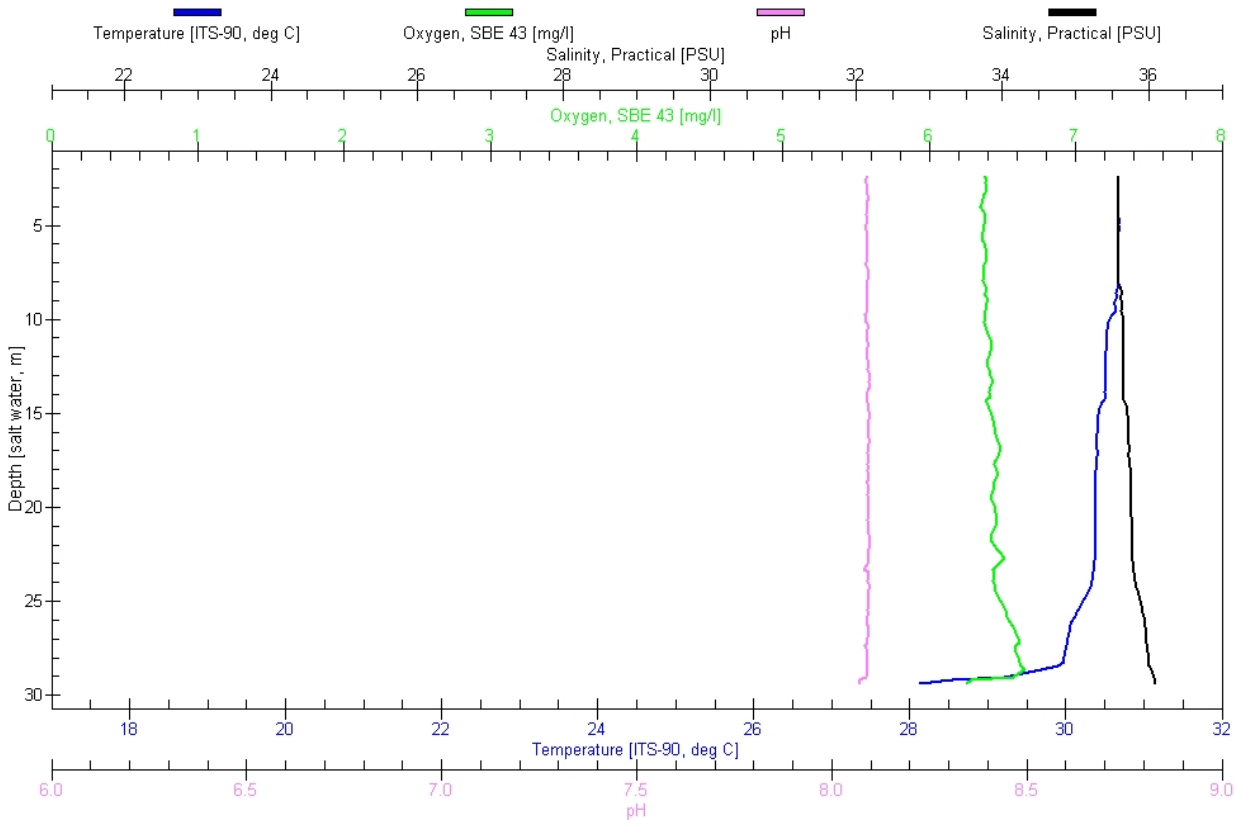
Station 10


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
5 10 15 20 25 30 35 40
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

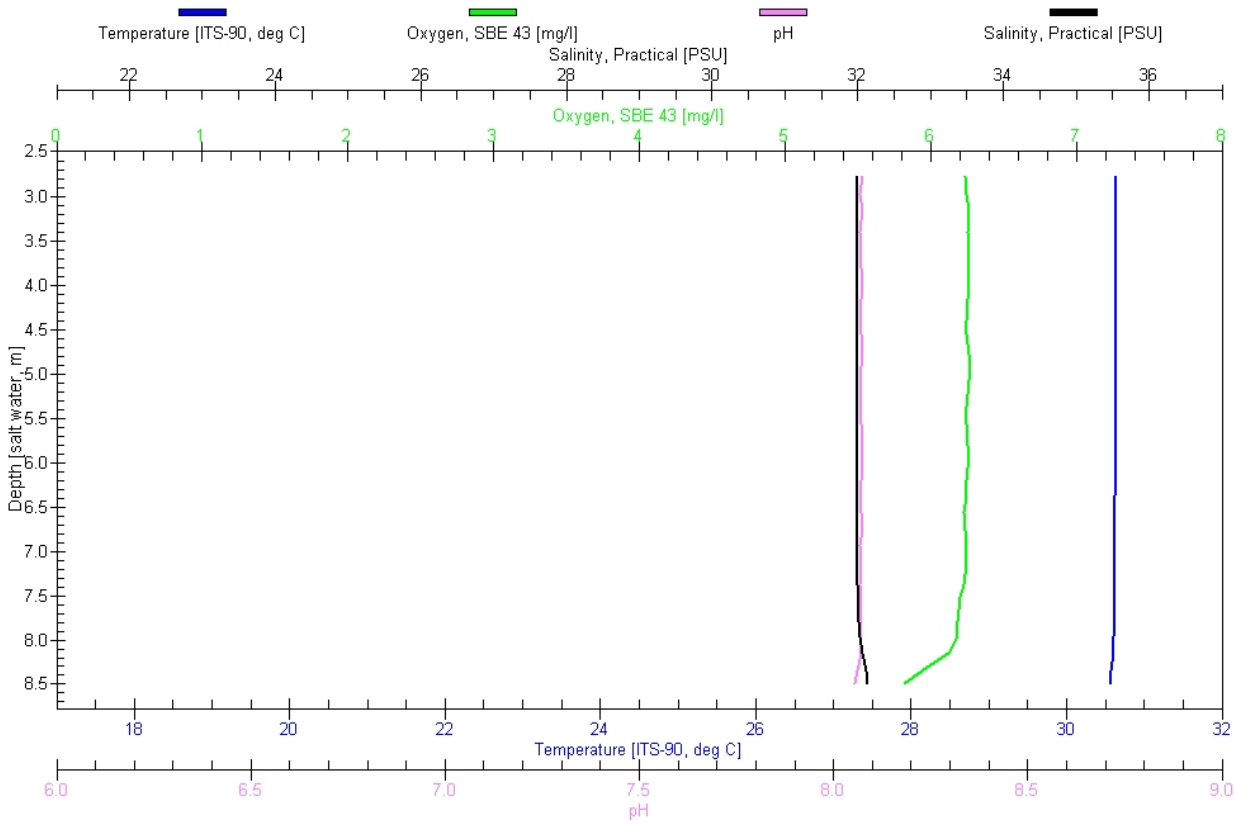
Station 11


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
5 10 15 20 25
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

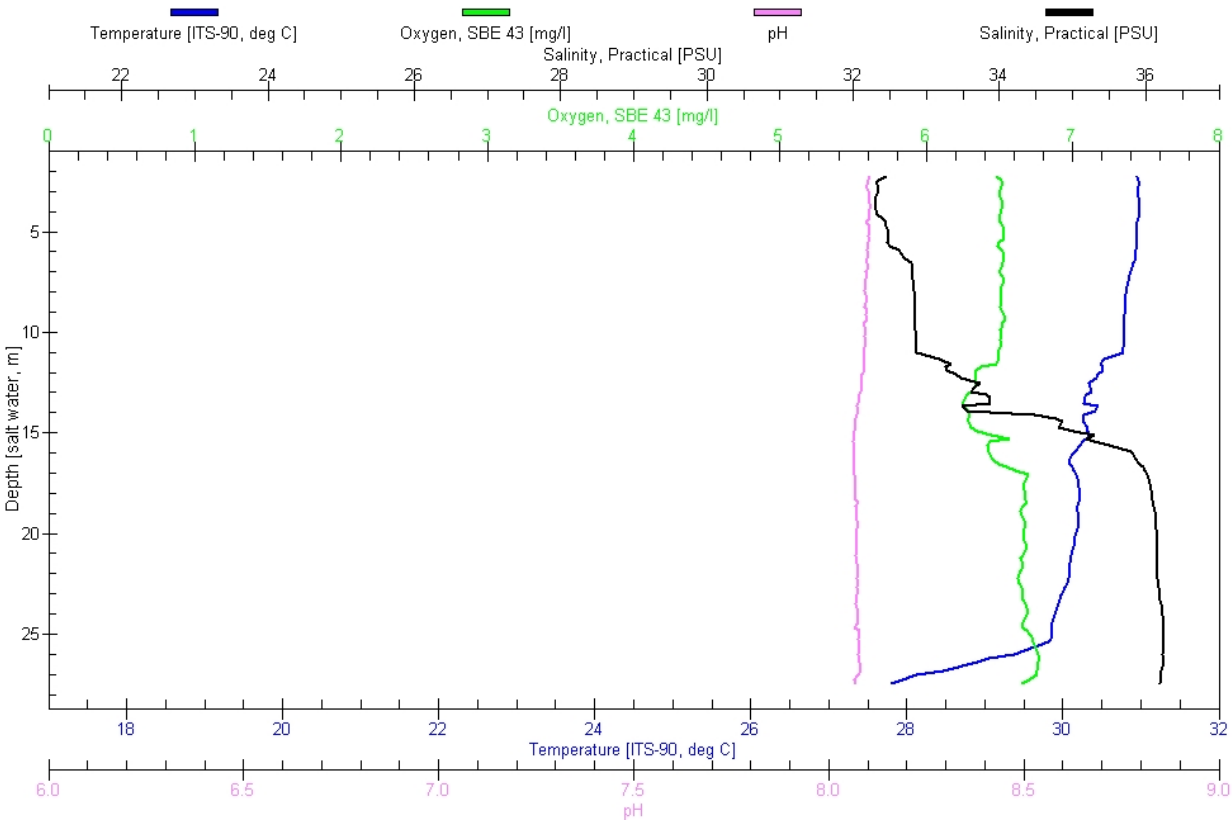
Station 14


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
5 10 15 20 25 30
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

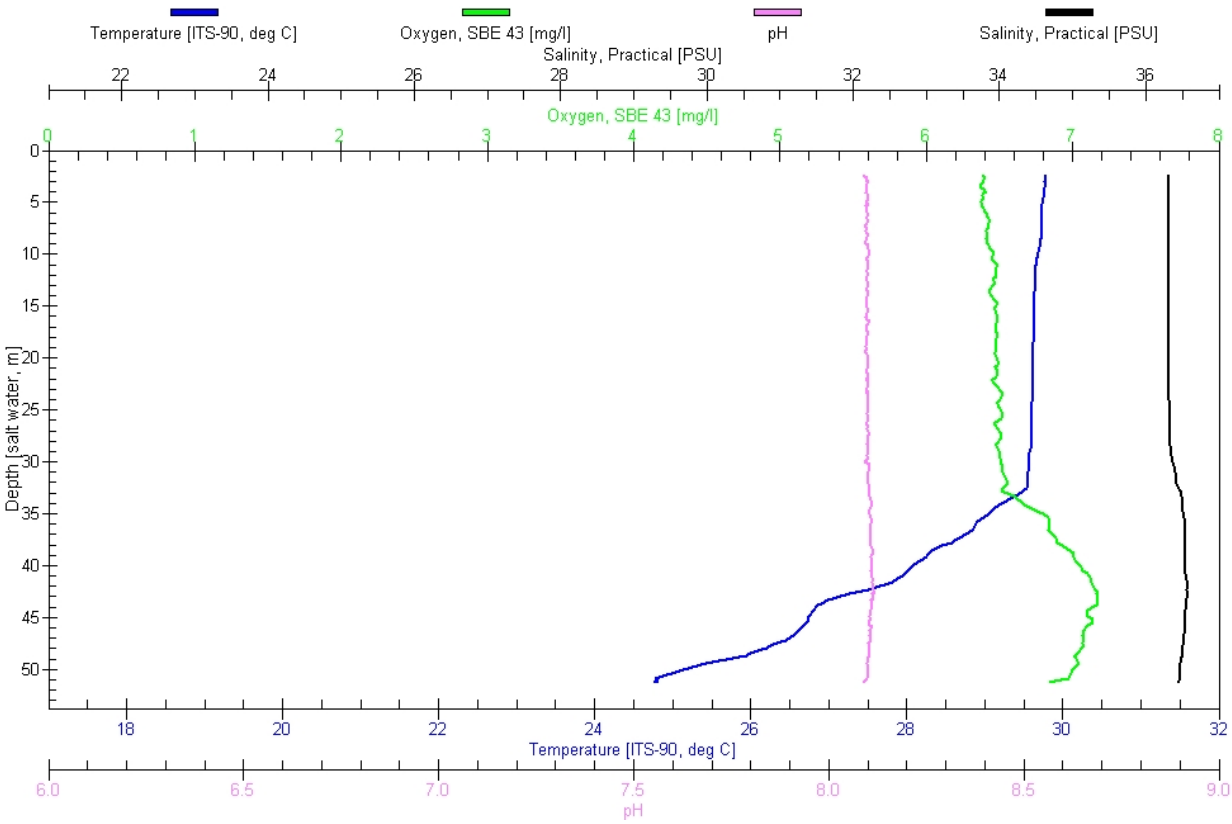
Station 15


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

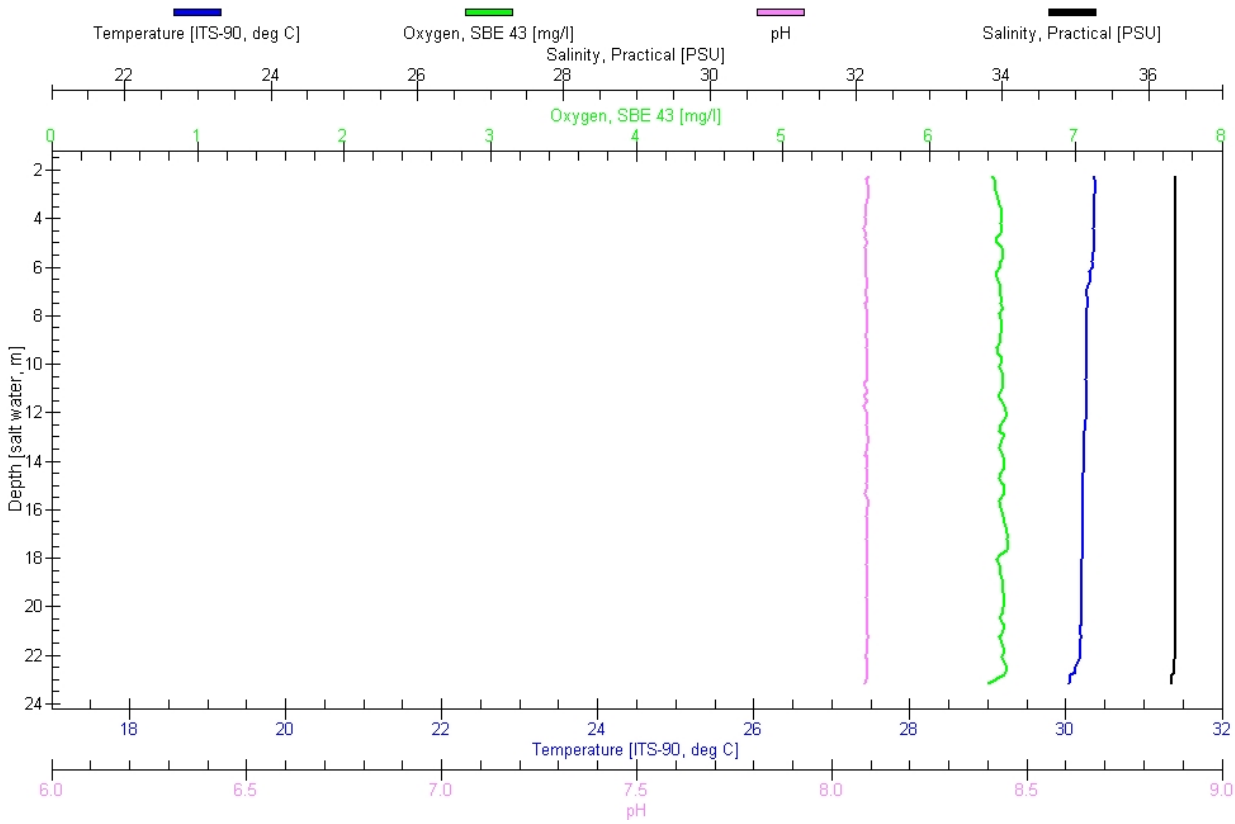
Station 16


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
5 10 15 20 25
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

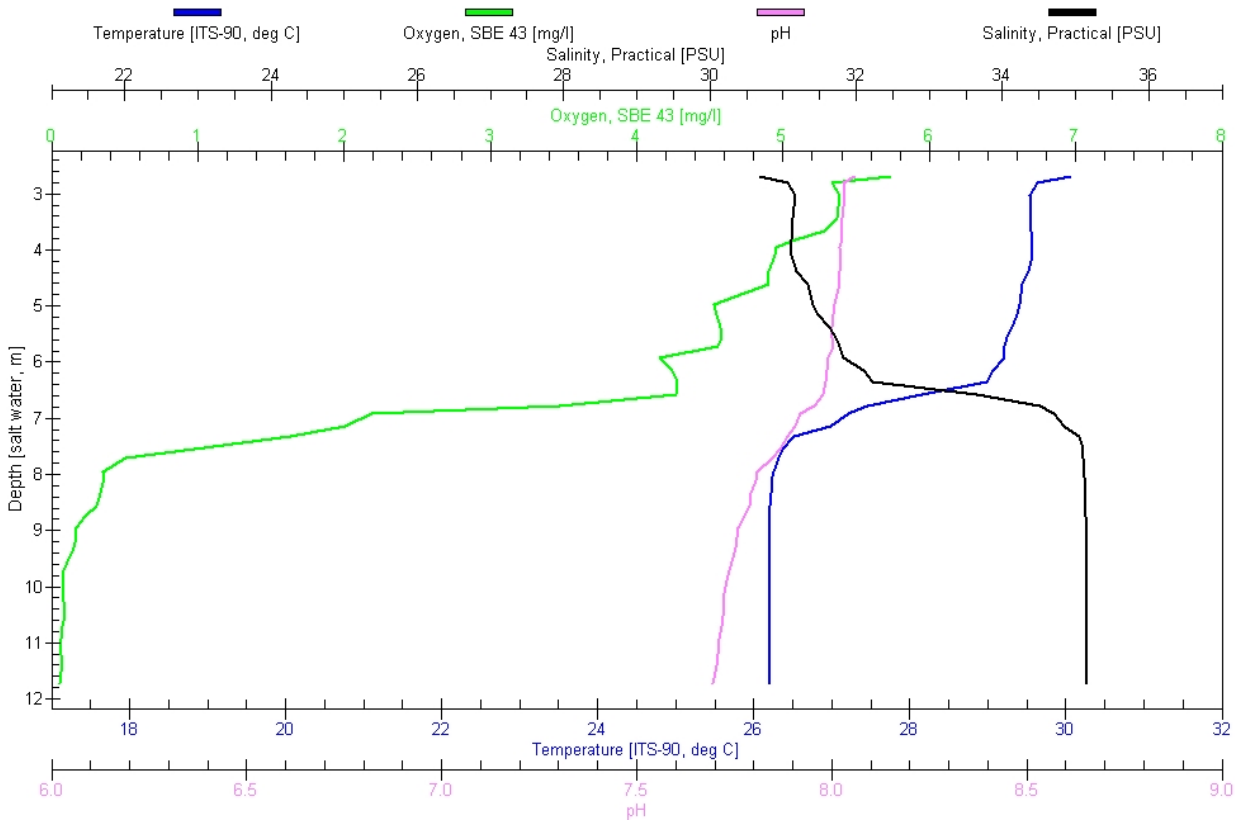
Station 18


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
0 5 10 15 20 25 30 35 40 45 50
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

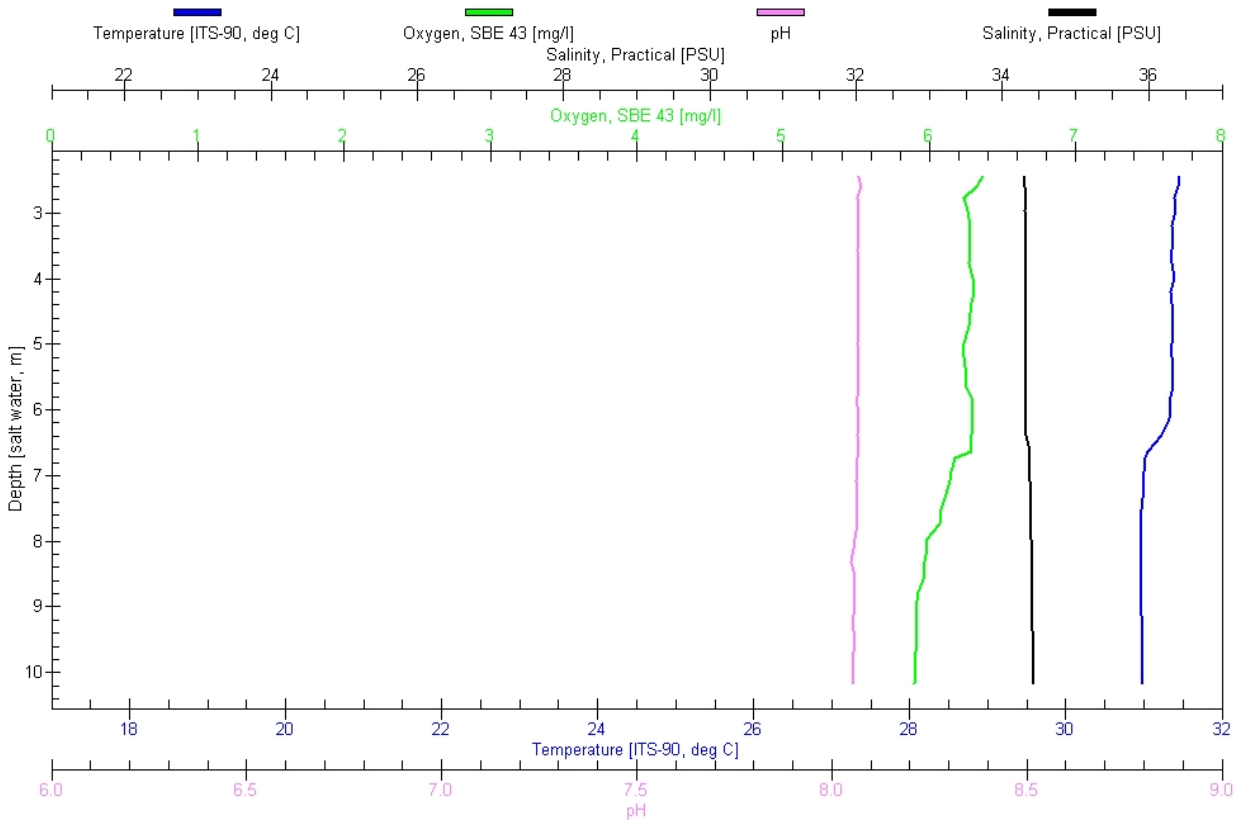
Station 21


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
2 4 6 8 10 12 14 16 18 20 22 24
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

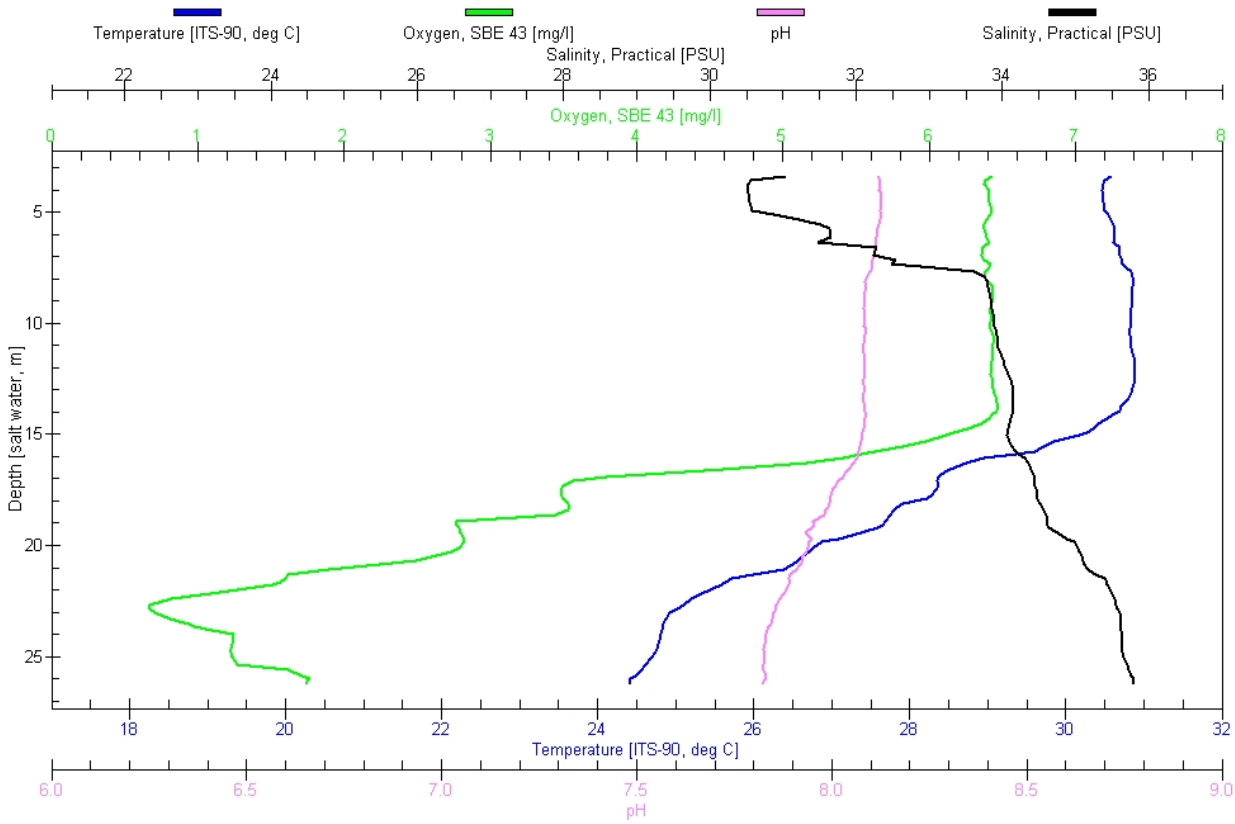
Station 22


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
3 4 5 6 7 8 9 10 11 12
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

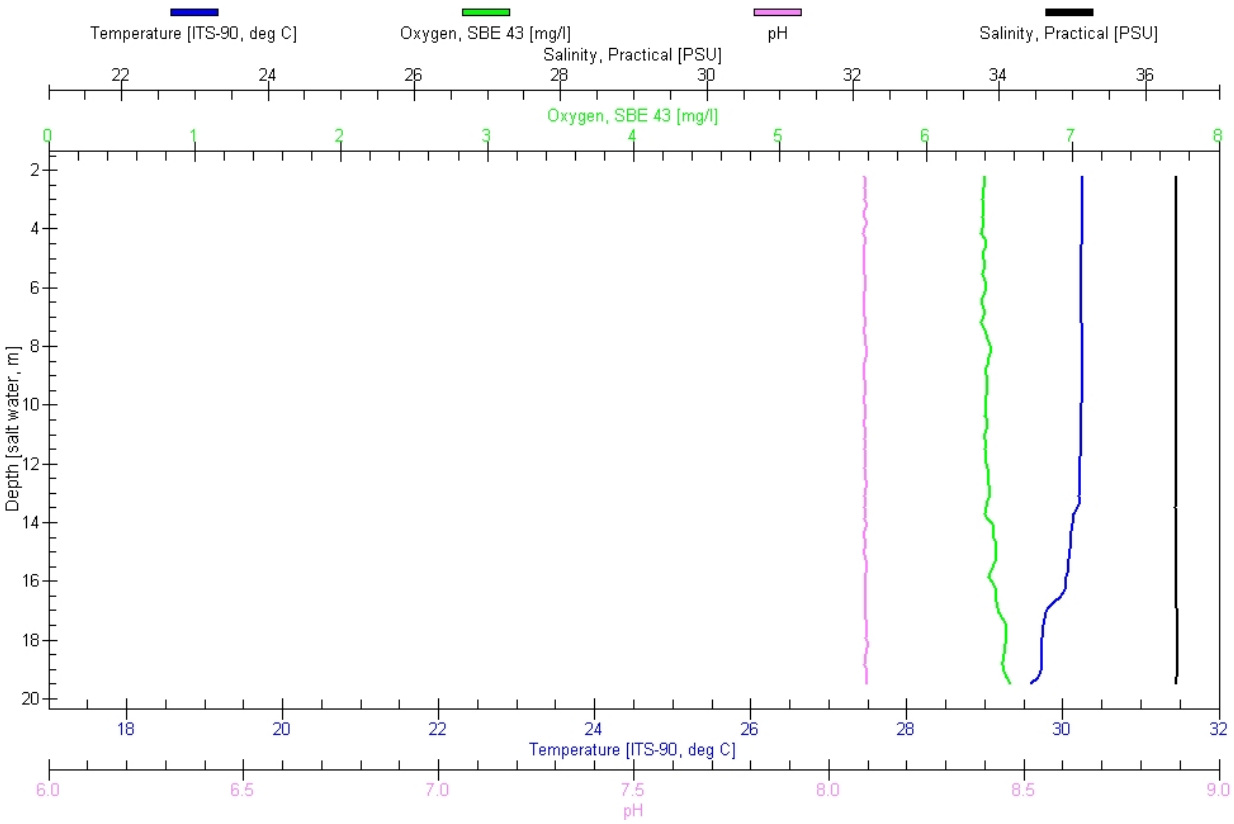
Station 23


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
3 4 5 6 7 8 9 10
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

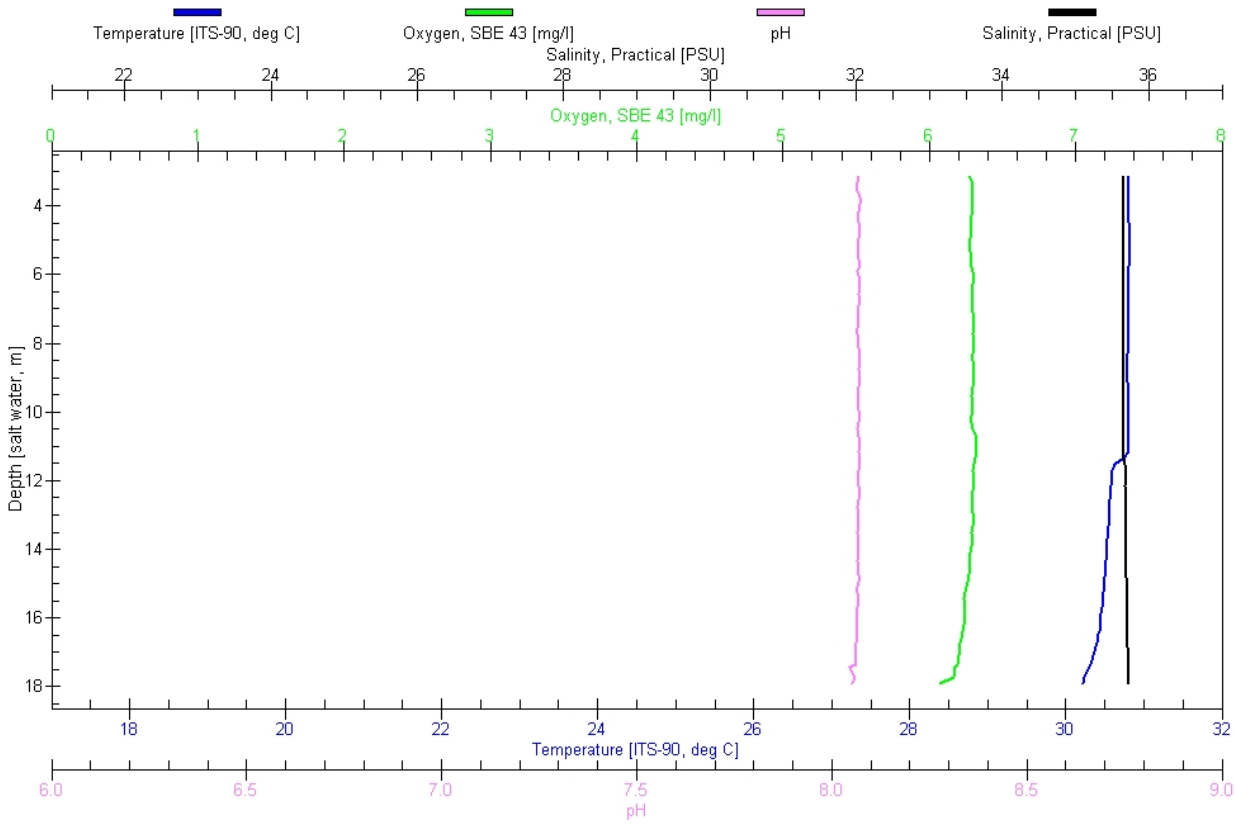
Station 24


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
5 10 15 20 25
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

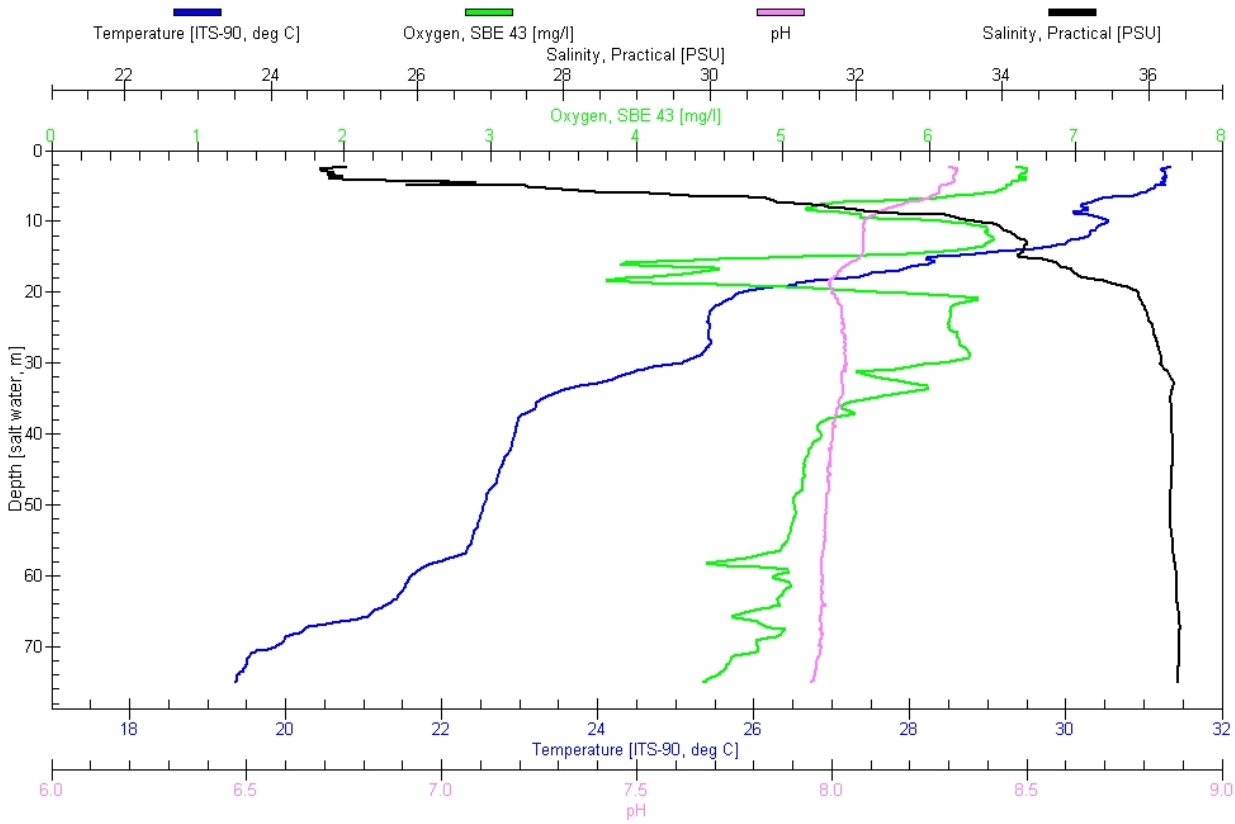
Station 26


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
2 4 6 8 10 12 14 16 18 20
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

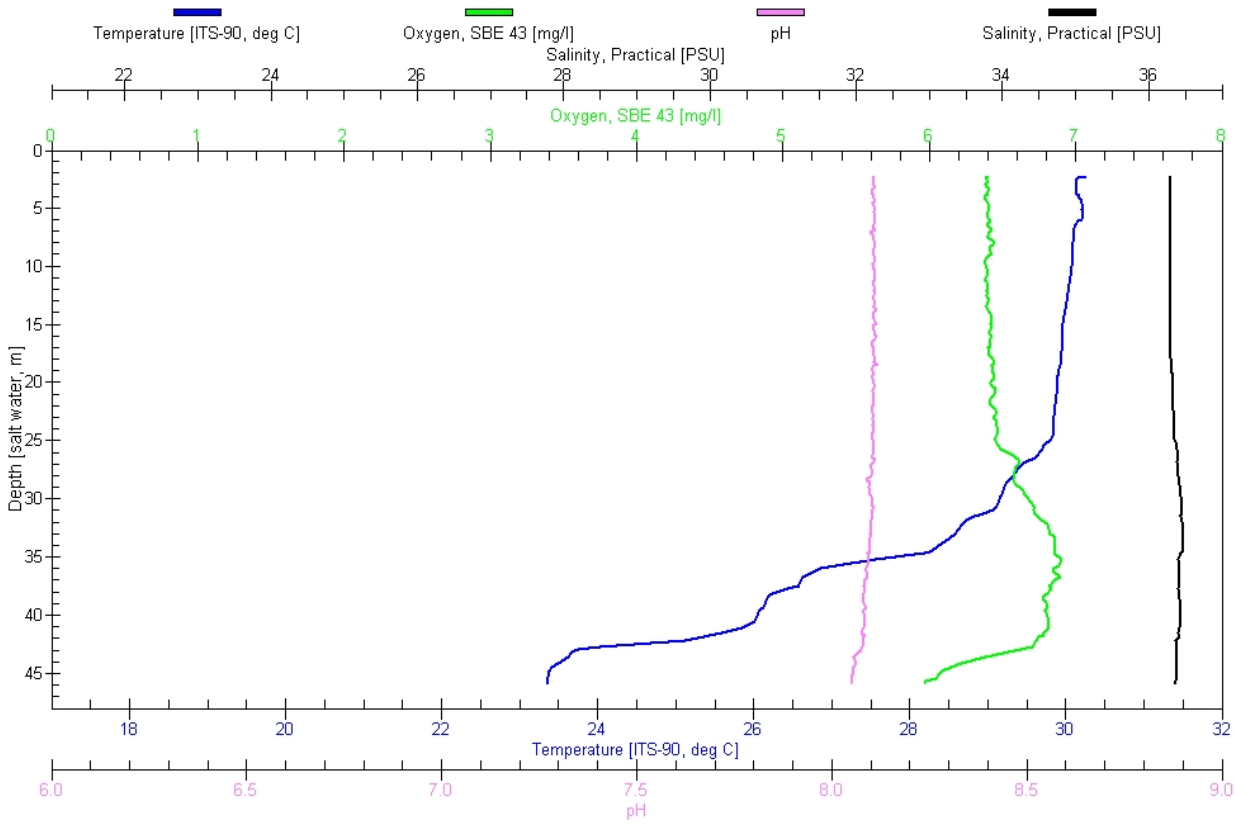
Station 27


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
4 6 8 10 12 14 16 18
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

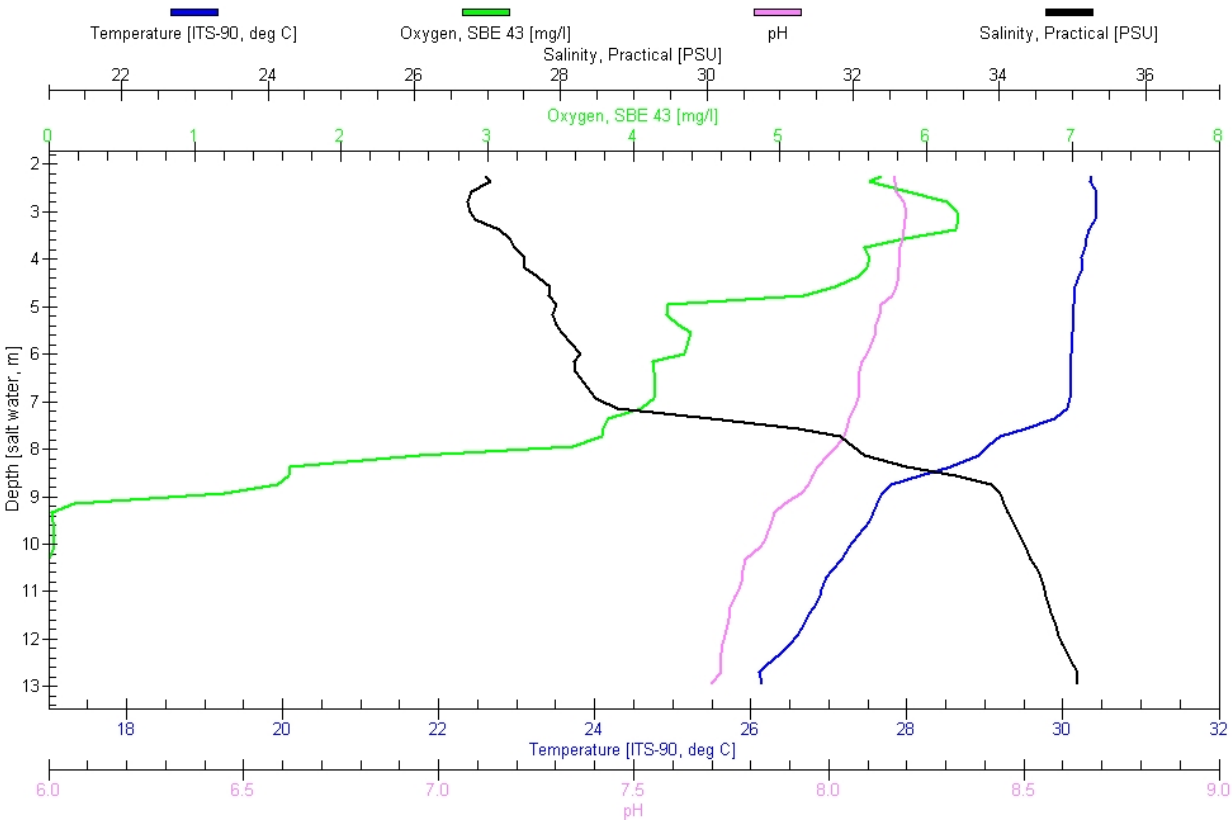
Station 28


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
0 10 20 30 40 50 60 70
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

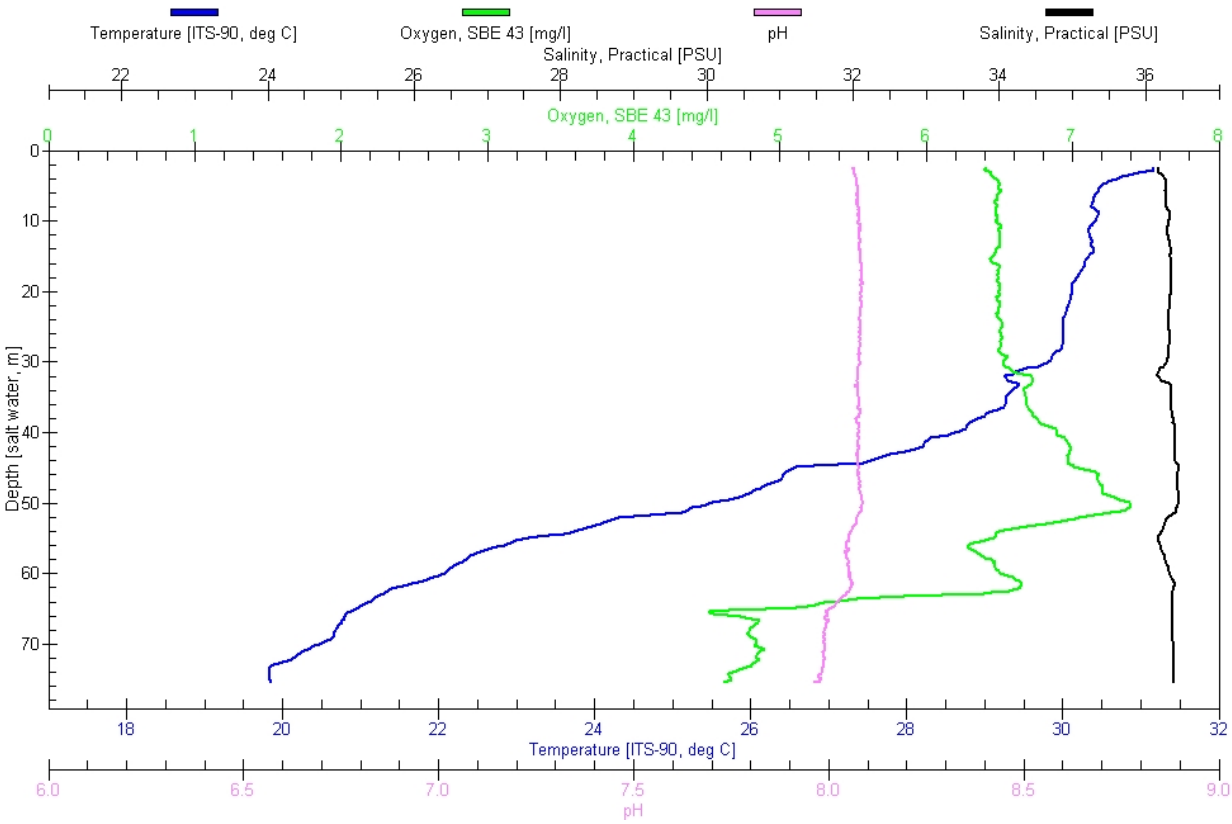
Station 29


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
0 5 10 15 20 25 30 35 40 45
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

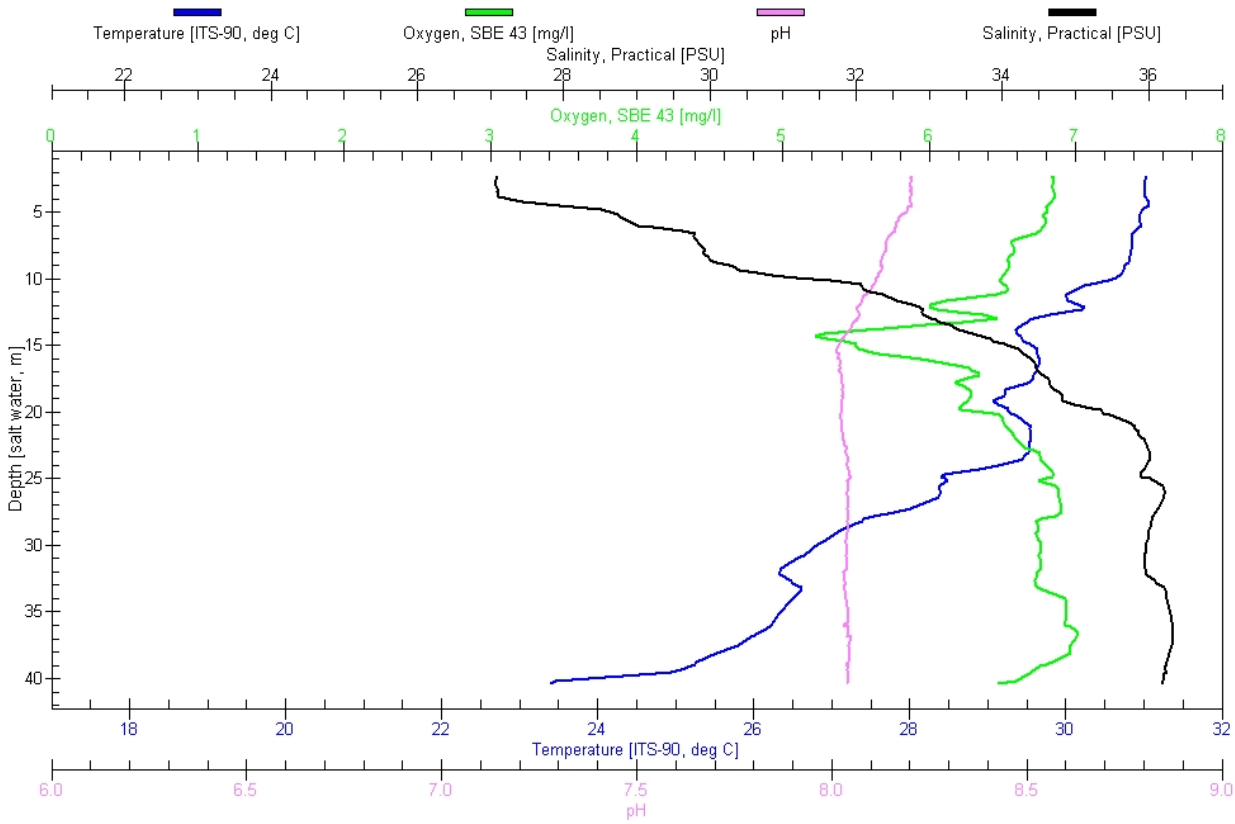
Station 30


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
2 3 4 5 6 7 8 9 10 11 12 13
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

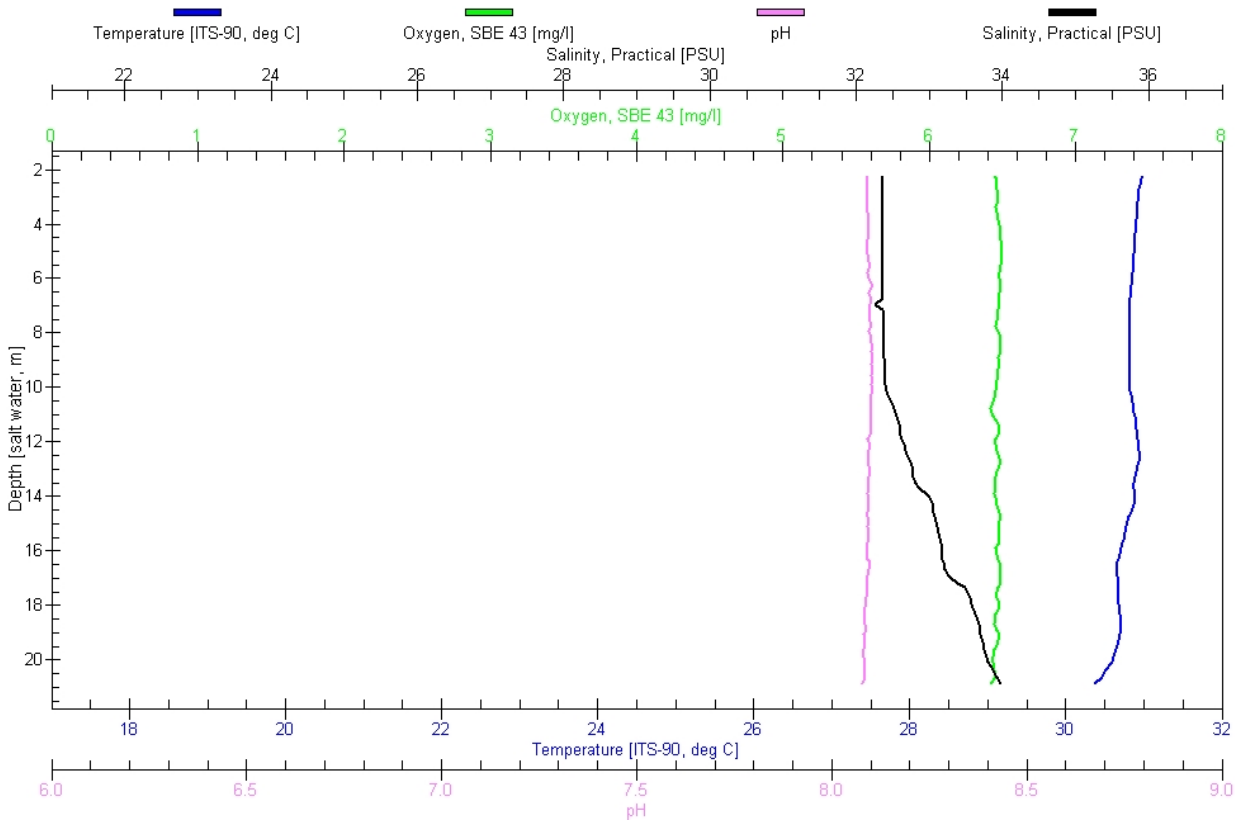
Station 31


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
0 10 20 30 40 50 60 70
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

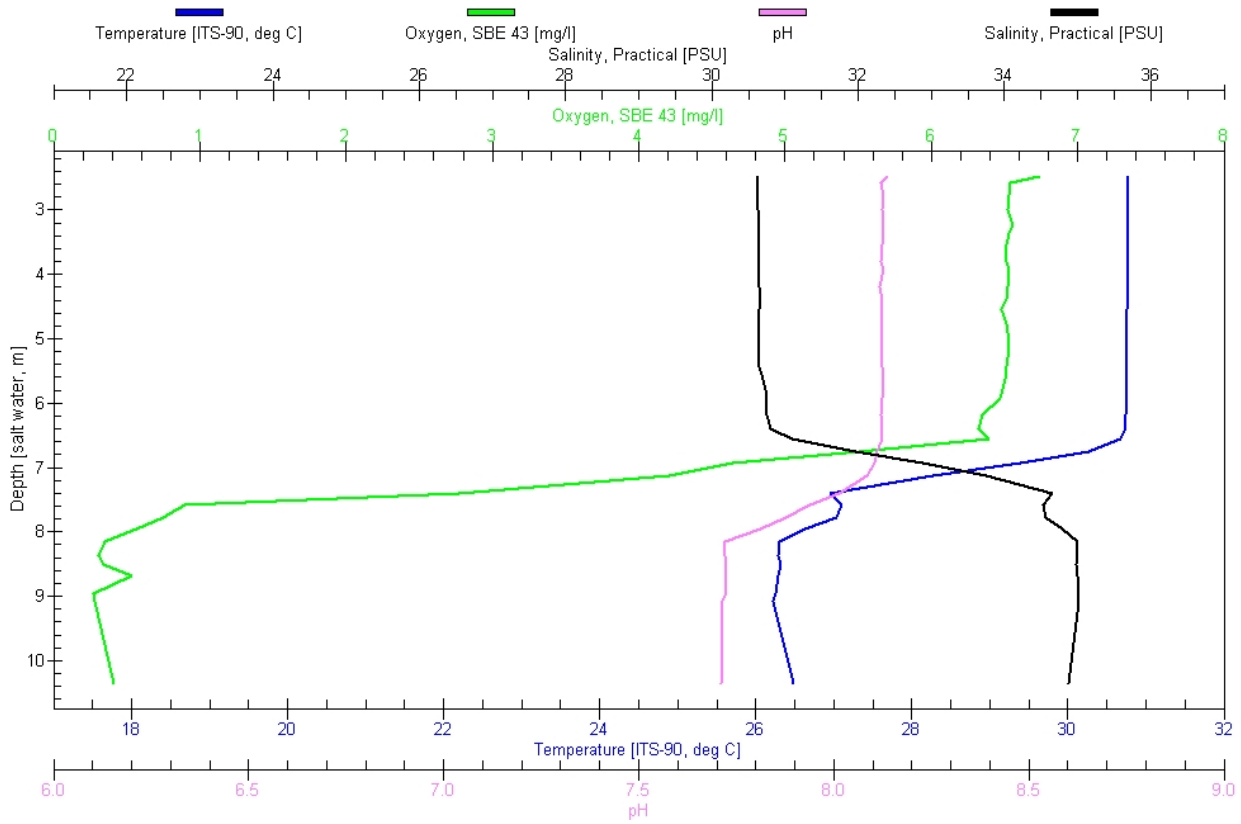
Station 32


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
5 10 15 20 25 30 35 40
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

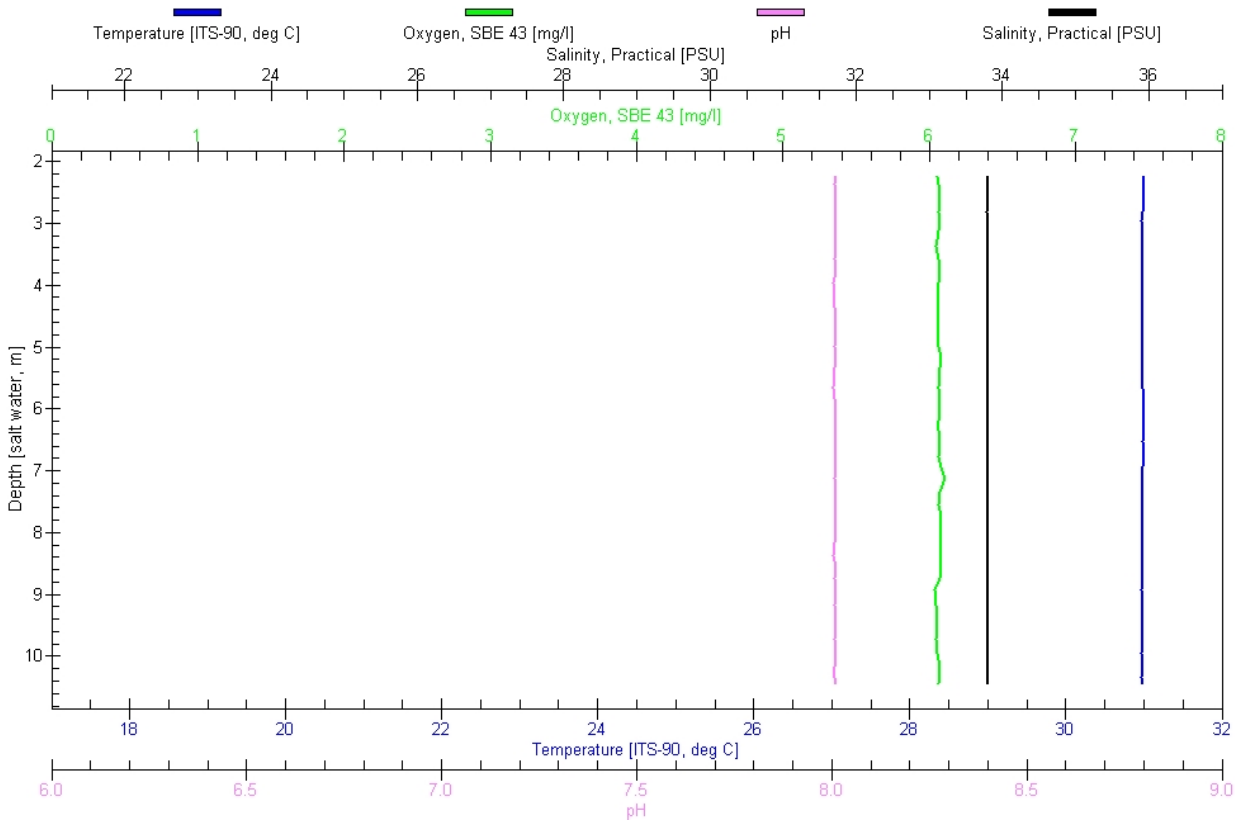
Station 35


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
2 4 6 8 10 12 14 16 18 20
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

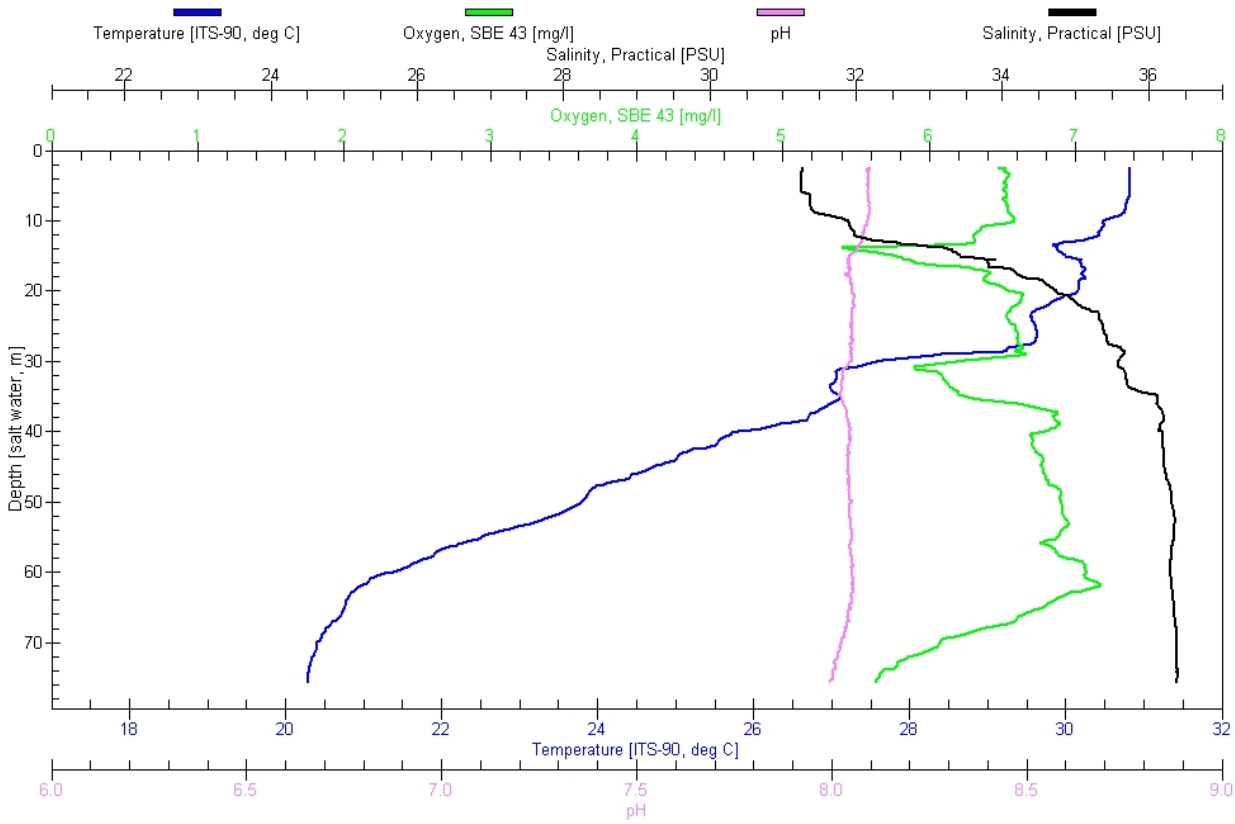
Station 36


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
3 4 5 6 7 8 9 10
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

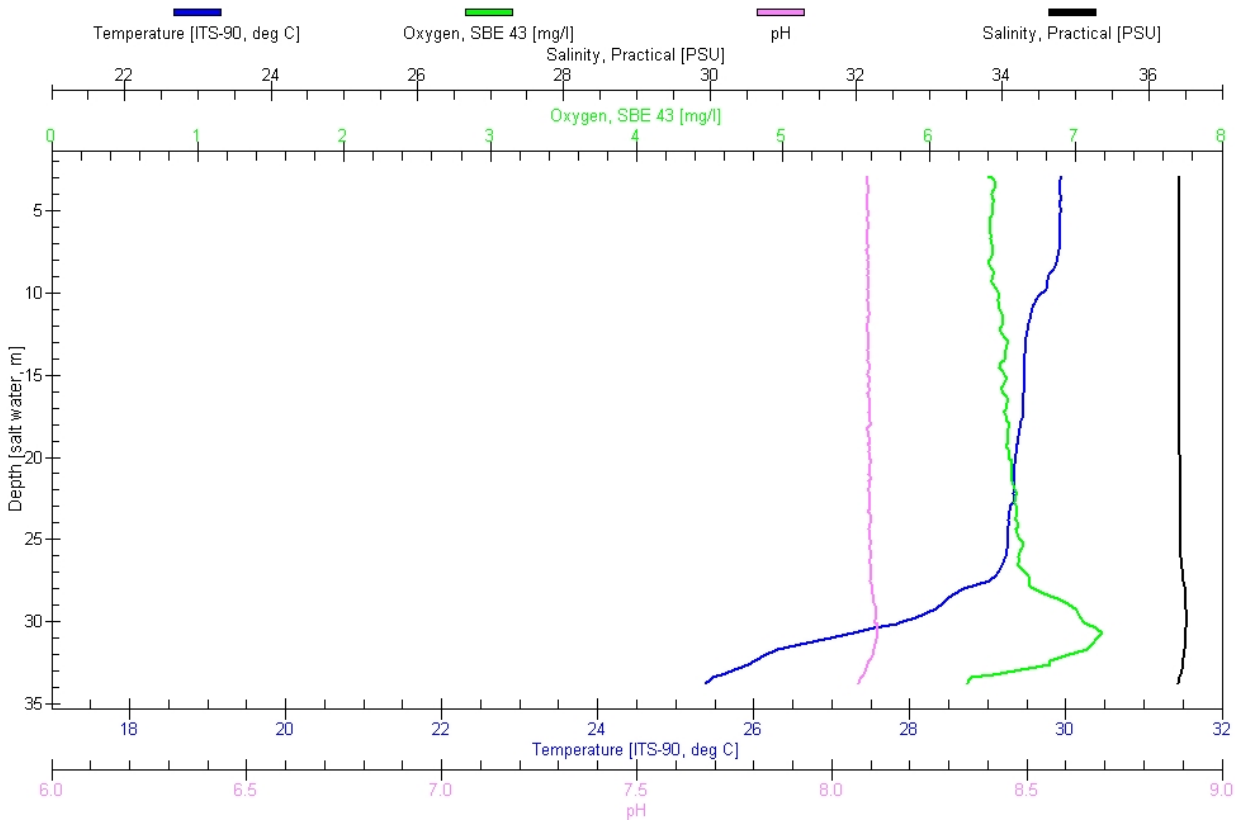
Station 39


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
2 3 4 5 6 7 8 9 10
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

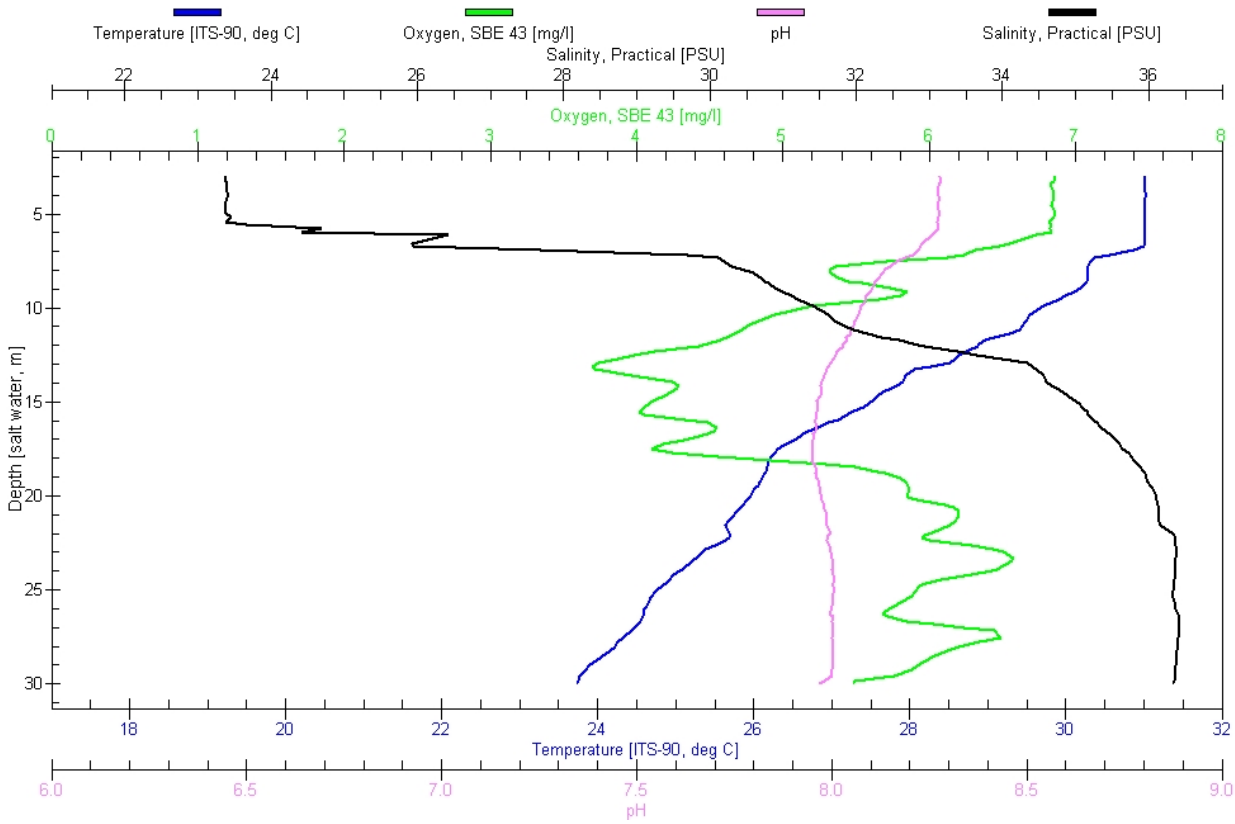
Station 40


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
0 10 20 30 40 50 60 70
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

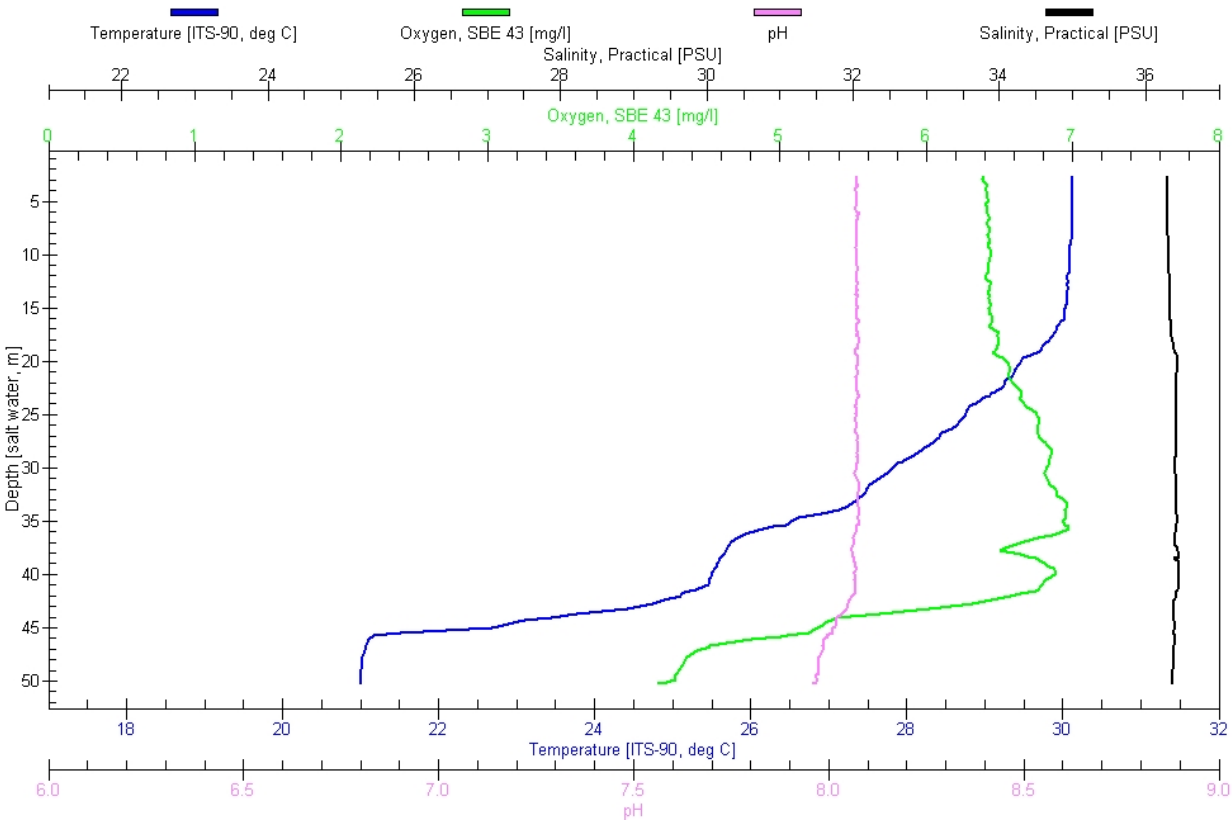
Station 42


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
5 10 15 20 25 30 35
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

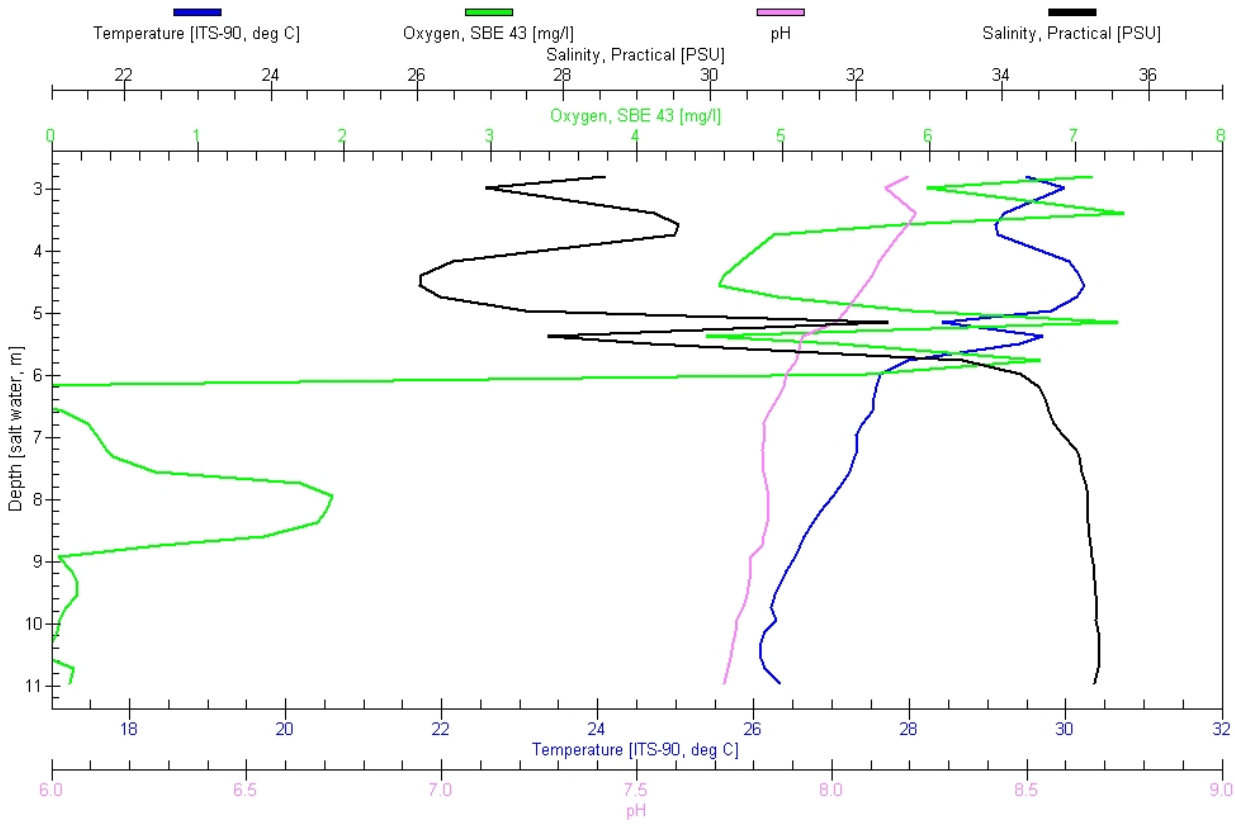
Station 44


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
5 10 15 20 25 30
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

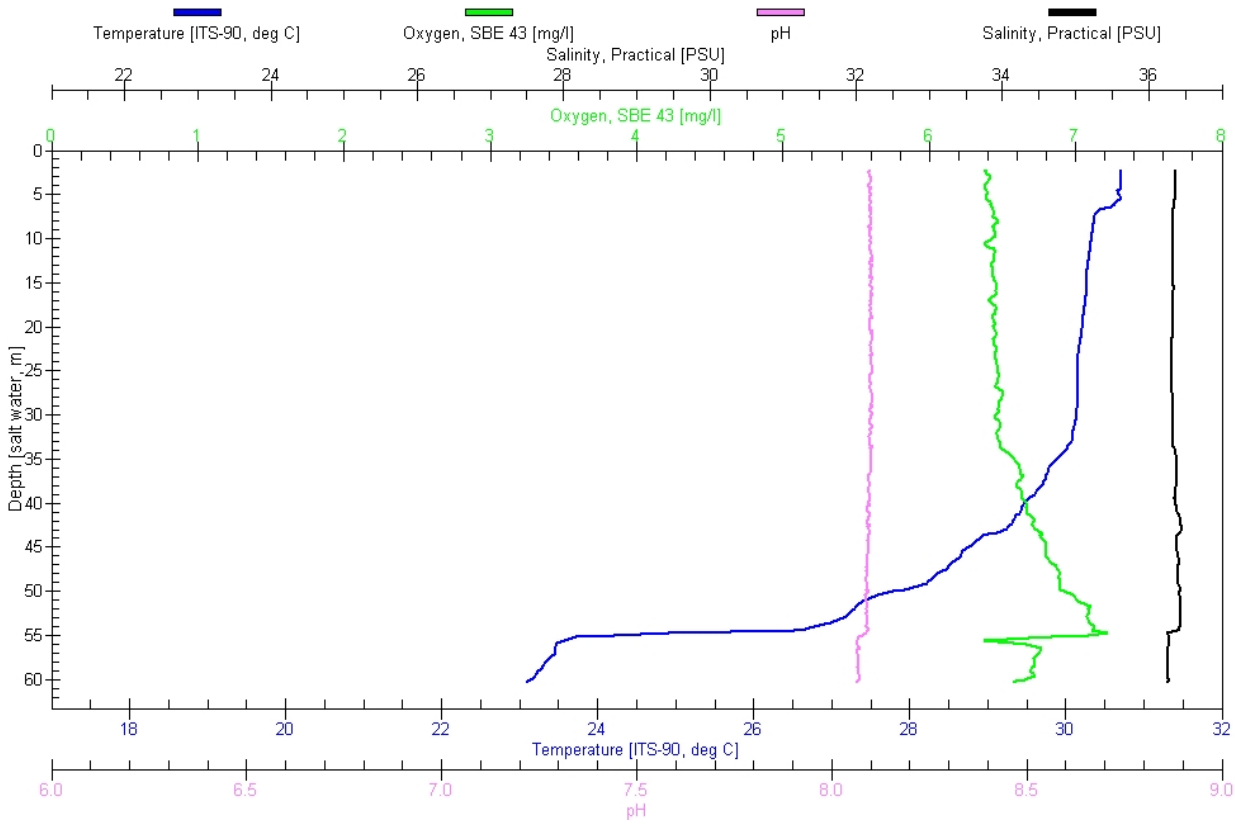
Station 45


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
5 10 15 20 25 30 35 40 45 50
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

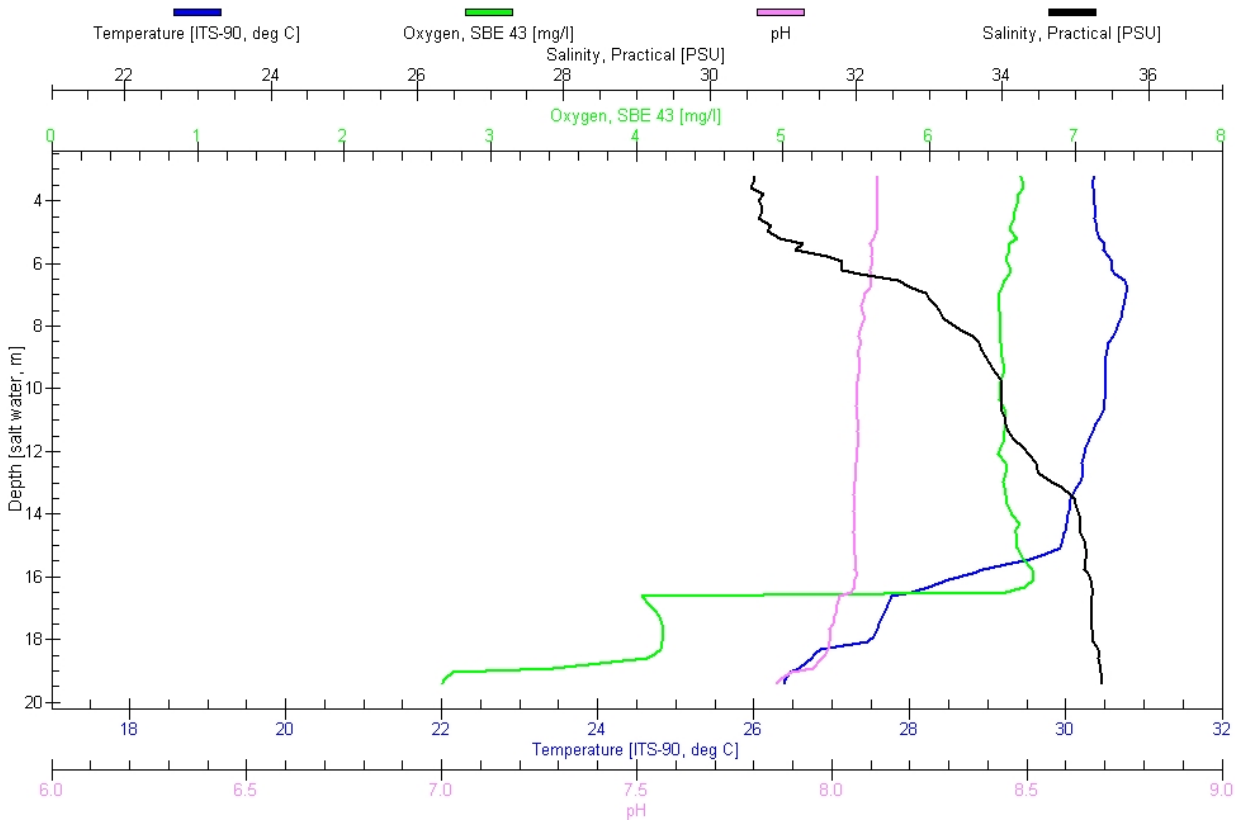
Station 46


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
3 4 5 6 7 8 9 10 11
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

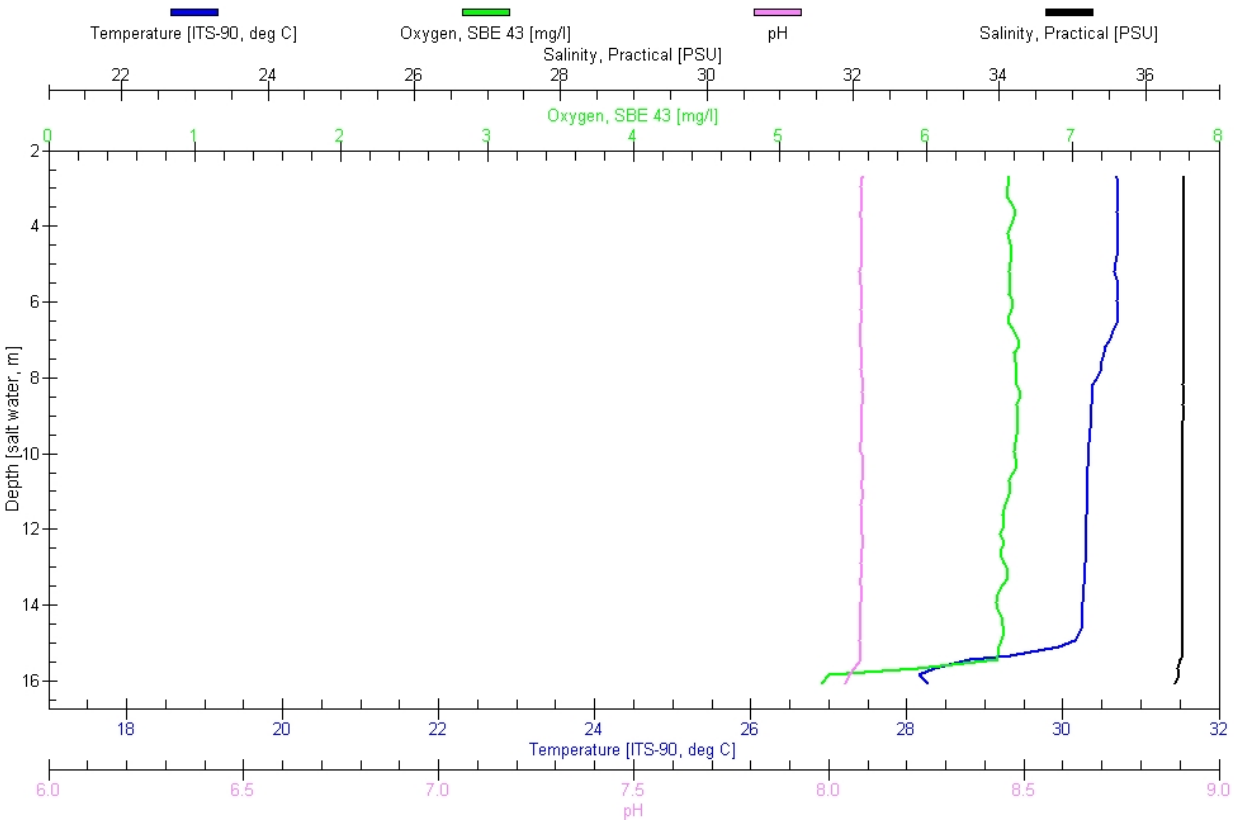
Station 47


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
0 5 10 15 20 25 30 35 40 45 50 55 60
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

Station 48


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
4 6 8 10 12 14 16 18 20
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

Station 50


Temperature [ITS-90, deg C]
Oxygen, SBE 43 [mg/l]
pH
Salinity, Practical [PSU]
Salinity, Practical [PSU]
22 24 26 28 30 32 34 36
Oxygen, SBE 43 [mg/l]
0 1 2 3 4 5 6 7 8
Depth [salt water, m]
2 4 6 8 10 12 14 16
18 20 22 24 26 28 30 32
Temperature [ITS-90, deg C]
6.0 6.5 7.0 7.5 8.0 8.5 9.0
pH

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