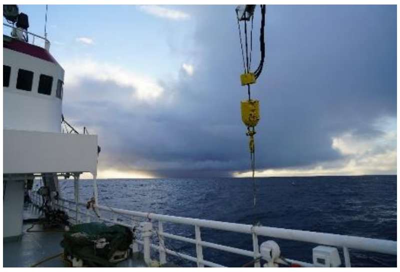 

Cruise report of the 2018 Sino-Norway Arctic Research Expedition

(no. CNNE-2018)

October 2-15, 2018

Location: Greenland Sea and Norwegian Sea

(05.09.2018, 20.09.-15.10.2018, Jnr. 18/12788)

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1 Scientific background

In the past decades, the Arctic environment has changed remarkably, e, g., the rising of temperature being about two times or even more faster than the global average, the obvious decreasing trend in sea ice extent and volume, a weakening of deep convection within the Nordic seas. As the most important cold source in the northern hemisphere, such changes can make a great difference in the global climate and further affect human activities. For example, more and more extreme weather disasters, faster rising of sea level are all thought to partly be related with the rapid Arctic changing.

The Nordic seas are the only abyssal passage that connects the Arctic Ocean and the Atlantic Ocean, through which warm Atlantic waters flow into the Arctic Ocean and polar fresh waters flow out. Unique geographical conditions make it possible for the Greenland Sea to generate dense waters in the upper layer during winter. These dense waters are transported southward by the inner circulation of the Nordic seas and eventually contribute to the formation of the North Atlantic Deep Water in the form of overflow. Due to the continuous warming since 1970s, nowadays the Nordic seas are turning to a warmer and more stratified ocean which may impede the production of dense water during winter. So far although it has been researched a lot, there still exist some uncertainties and doubts about how and to what extent the Nordic seas would response and feedback to the current climate change. Particularly after the year 2007, the Arctic sea ice extent in summer has maintained on a level of record low. Additionally, extreme weather events (hot wave and snowstorm) around mid- and high latitudes are reported more frequently. All these processes and events are more or less related with the adjustment of atmosphere and ocean circulation in the arctic region. As the core region of Arctic Oscillation and a source of deep ocean dense waters, it is imperative to organize a specific oceanography cruise aiming to investigate the oceanic processes and changes in the Nordic seas.

The key region is the Greenland Sea because that it is the main source of the densest overflow waters in the Nordic seas. Variations of water properties and dynamic conditions within the Greenland Sea can influence the lower limb of the Atlantic Meridional Overturning Circulation (AMOC). The meaning and effect of the AMOC on the global climate is well-known. In addition, oceanic relations between Arctic warming and flux variation of overflow water are not fully understand yet. To understand this question, it is need to reveal how the overflow water being transported to the Norwegian Sea through the mid-ocean ridges.

2 Cruise objective

The main scientific objectives of this international-joint cruise are listed as below:

1) Key modification and transport progresses of Greenland Sea dense waters and its relationship with the recirculated Atlantic Water from north;

2) Influences of frequency warm events (storms) during polar night on dense water generation and modification in the Greenland basin;

3) Geostrophic current structure in the Greenland Sea and upper ocean circulation scheme;

3 Cruise description

The research expedition was conducted by the Norwegian oceanographic vessel "STALBAS" (Figure 1) from October 02, 2018 to October 15, 2018. A total 51 physical oceanography stations were carried out during the cruise using the instruction of SBE-25 plus CTD (made by the US). Figure 2 shows the distributions of final stations. The CTD instruction contains pressure, temperature, conductivity, and dissolved oxygen sensors which have the characteristics of high accuracy and sampling frequency. The detailed technical parameters are shown in the following table:

Figure 3.1 Norwegian vessel "STALBAS" rented for the 2018 joint cruise.

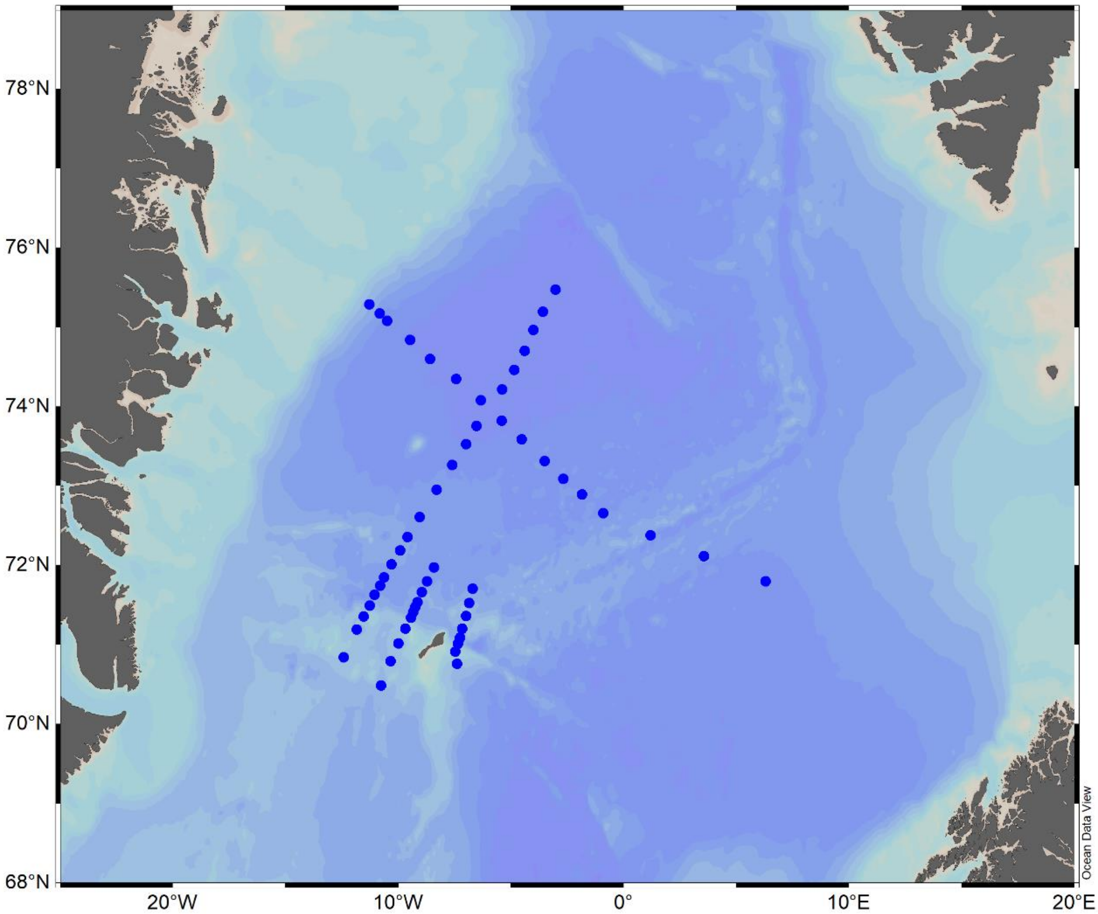

Figure 3.2 Stations locations (blue dots) of the 2018 cruise Sino-Norway Arctic Research Expedition

Table 1 technical parameter of SEB-25 plus CTD

Observation parameter	range	accuracy	Resolution of measurement using 16 Hz
temperature/°C	-5~ +35	0.001	0.0003
conductivity /S·m^{-1}	0 ~7	0.0003	0.00004
dissolved oxygen /ml·l^{-1}	120% surface saturation	±2% saturability	—
depth/m	0~7000	0.01% full range	0.002% full range


Figure 3.3 SBE-25 plus CTD used during the cruise

The details of oceanography stations, e.g., station number, date of measurement, location, water depth, ship speed, and ocean condition, are shown in the Table of Station Information (see in Table 2). In addition to collecting the temperature, salinity, dissolved oxygen profiles by SEB-25 CTD, waters at three standard depths (surface, 50 m and 100m) are also sampled to acquire the water temperature, dissolved oxygen, and tracers to calibrate the CTD profiles and track variations of water masses.

Oceanographic data was collected by Xiaoyu Wang, Kun Wang,Xin Wang, Shumeng Zhang

Data processing and figures were provided by Xiaoyu Wang

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Address: Ocean University of China, 238 Songling Road, Laoshan District, Qingdao, China

Table 2 Station Information

Region: Nordic seas Ship: STALBAS Date: 2018.10

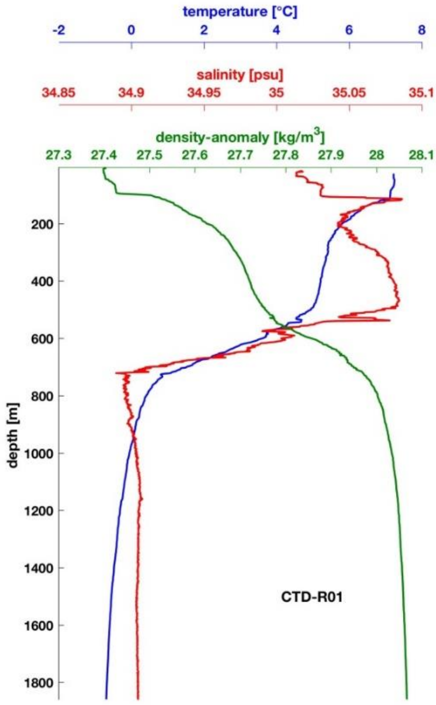
count	Station number	Date (mm.dd)	Instrument Deploy			speed (knot)	Water depth (m)	wind (m/s)	Dir. (deg.)	Air Tem. (°C)	pressure (hPa)	Notes
			Hh:mm	latitude	longitude							
1	R01	10.03	7:40	6.3017	71.7992	0.6	3069	-	-	-	-	
2	R02	10.03	17.05	3.5701	72.118	0.5	2756	-	169	1.8	1011	
3	R03	10.04	0:55	1.1986	72.3761	0.4	2056	3.3	202	2.6	1011.1	
4	R04	10.04	13:02	-0.9063	72.6588	0.6	>3000	5.2	336	3	1007.2	
5	R05	10.04	19:45	-1.8403	72.893	0.9	>3000	1.7	82	0.9	1005	Snowy weather
6	R06	10.04	22:57	-2.6731	73.0887	0.6	3244	2.8	164	2.2	1004.7	Strong wind
7	R07	10.05	6:54	-3.5078	73.3128	0.9	3083	6.7	323	0.6	1004.6	calm sea
8	R08	10.05	11:03	-4.5226	73.5897	0.5	3172	9.2	264	-0.3	1003.5	
9	R09	10.05	15:33	-5.4149	73.8242	0.3	>3000	1.9	334	-0.5	1001.1	Strong wind
10	R10	10.05	20:10	-6.3393	74.0773	2.4	1900	10.2	315	-0.6	1000.1	Snowy weather
11	R11	10.06	7:11	-7.4358	74.3478	0.3	>3000	6.1	319	-0.3	997.6	Snowy weather
12	R12	10.06	11:01	-8.5817	74.6008	0.6	3100	3.7	13	0.8	997.2	replace battery
13	R13	10.06	16:58	-10.4833	75.0783	0.6	3067	1.9	139	-1.8	998.1	
14	R14	10.06	19:14	-10.8125	75.1724	0.5	2613	1.8	107	-1.4	999.8	
15	R15	10.06	21:09	-11.287	75.2869	1.1	1644	5.3	318	-3.3	1001	
16	R16	10.07	6:26	-9.4624	74.8409	0.4	3274	1.6	75	-1.7	1001.4	
17	R17	10.08	2:27	-3.0153	75.4737	0.8	>3000	3.6	77	-0.7	996.1	
18	R18	10.08	6:48	-3.585	75.1932	0.4	3200	3.7	345	-0.3	994.5	
19	R19	10.08	10:04	-4.0097	74.9668	0.1	3250	8.9	303	-0.4	993.4	Winch

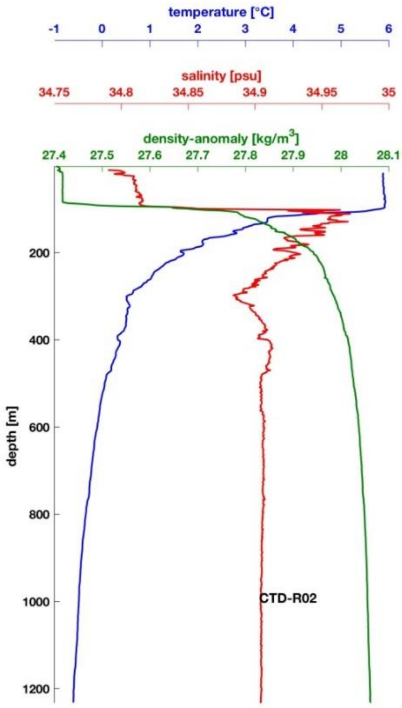
												broken
20	R20	10.08	13:18	-4.3936	74.7023	0.6	>3000	5.1	72	-0.7	992.6	
21	R21	10.08	17:33	-4.8479	74.4621	1.2	>3000	4.8	12	0.1	992.3	Snowy
22	R22	10.08	21:05	-5.3825	74.2163	0.9	>3000	5	18	0.2	992.8	Snowy
23	R23	10.09	3:25	-6.5202	73.7559	0.3	>3000	4.9	214	-0.6	994.5	
24	R24	10.09	6:28	-6.9911	73.526	0.3	2900?	4.5	318	-0.7	995	
25	R25	10.09	10:23	-7.6024	73.2649	0.5	2939	3.2	16	-0.4	997	replace battery
26	R26	10.09	14:37	-8.2933	72.9514	0.2	2539	1.2	286	0.2	997.1	
27	R27	10.09	18:22	-9.0518	72.608	0.4	2506	3.3	318	0.5	998.4	communication failure with the instrument
28	R28	10.09	21:56	-9.5902	72.3561	0.8	2306	1.6	306	-0.5	999.3	Strong water current
29	R29	10.1	0:48	-9.918	72.1877	0.4	2261	0.6	298	-0.2	1000	snowy
30	R30	10.1	5:02	-10.3009	72.0107	0.3	2478	1.1	96	-0.4	1000.2	snowy
31	R31	10.1	7:49	-10.6208	71.8459	0.6	2394	1.2	314	1.3	1000.2	communication failure
32	R32	10.1	9:58	-10.8056	71.7418	0.2	2394	3.4	267	1.7	1000.2	communication failure
33	R33	10.1	12:04	-11.0435	71.6266	0.1	2306	1.5	102	2.6	999.9	rainy
34	R34	10.1	14:00	-11.2573	71.4933	0.6	2022	4.8	293	2.8	1000.1	
35	R35	10.1	16:12	-11.5265	71.3549	0.3	940	3.2	283	3.5	999.7	
36	R36	10.1	18:17	-11.8455	71.192	0.6	1407	3.2	40	4.1	999.4	rainy
37	R37	10.1	22:16	-12.4255	70.844	0.8	863	3.5	342	4.7	1000.5	
38	R38	10.11	5:04	-10.77	70.4848	0.4	1648	1.4	159	3.8	1005.1	
39	R39	10.11	8:09	-10.3348	70.7918	0.5	1309	1.1	124	4.1	1006.8	
40	R40	10.11	10:47	-9.9941	71.0162	0.5	1085	2.5	113	3.9	1007.6	

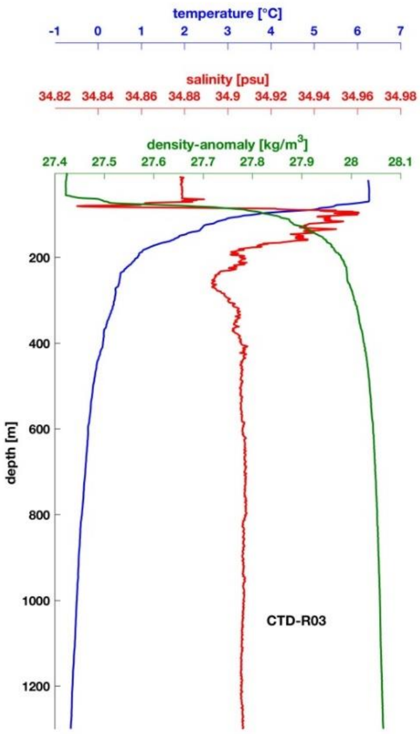
41	R41	10.11	13:00	-9.6792	71.2009	0.3	430	1.1	100	4.7	1008.2	
42	R42	10.11	14:52	-9.4345	71.3375	0.3	1426	1.8	107	4.2	1007.5	
43	R43	10.11	16:18	-9.3381	71.41	0.2	2342	3.8	17	4.2	1006.6	
44	R44	10.11	17:47	-9.2456	71.4736	1.4	2339	2.4	106	4.7	1006	rainy
45	R45	10.11	19:41	-9.1358	71.5373	0.4	1571	6.4	36	4.8	1004.5	
46	R46	10.11	21:35	-8.9535	71.663	0.6	2294	6.8	278	4.9	1004.1	rainy
47	R47	10.12	0:01	-8.7122	71.7977	0.7	2578	2.4	124	4.8	1001.8	foggy, rainy, Strong wave
48	R48	10.12	2:37	-8.4191	71.9735	1.1	2467	4	5	5.2	1001.1	foggy, rainy, Strong wave
49	R49	10.12	8:57	-6.6904	71.7071	0.2	2657	7.5	271	6.2	998	Strong wave
50	R50	10.12	11:42	-6.8515	71.5244	0.6	1711	6.8	320	5.9	995.8	Strong wave
51	R51	10.12	13:59	-6.9937	71.3618	0.7	1090	2.2	127	6.3	993.7	Strong wave
52	R52	10.12	15:49	-7.1556	71.2034	0.6	1111	3	77	5.9	992.5	Strong wave
53	R53	10.12	17:28	-7.2596	71.0872	0.6	2393	4.5	307	5.8	991.8	Strong wave
54	R54	10.12	19:16	-7.3546	71.0095	0.9	1266	2	83	5.7	990.4	Strong wave
55	R55	10.12	20:45	-7.4647	70.9136	1.1	332	5.3	236	6.5	987.1	Strong wave
56	R56	10.12	22:39	-7.3919	70.7606	0.3	1089	6.2	311	8.1	983.8	Strong wave

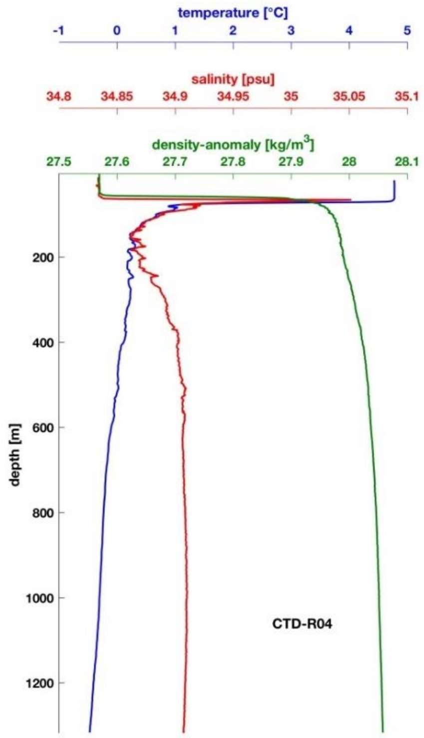
4 Data illustration

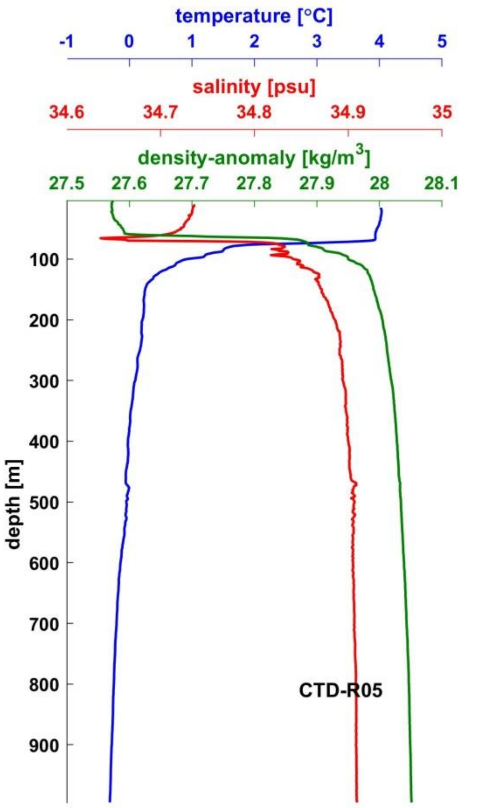
4.1 Temperature, salinity, dissolved oxygen profiles at each station







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salinity [psu]
34.6 34.7 34.8 34.9 35
density-anomaly [kg/m^3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
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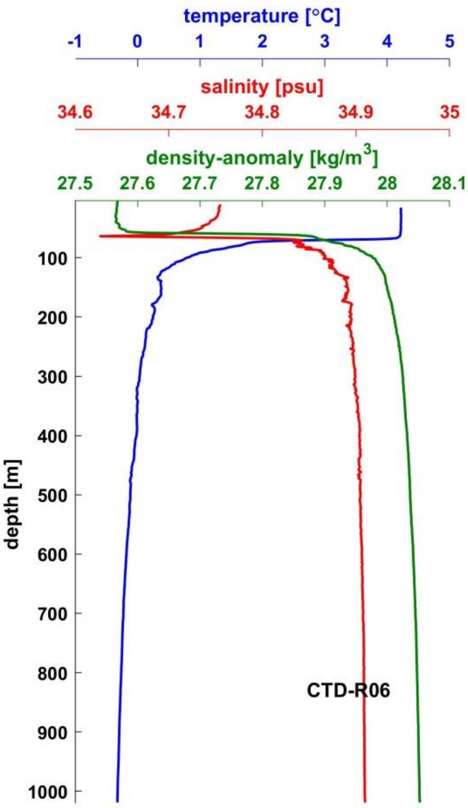
CTD-R05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salinity [psu]
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density-anomaly [kg/m^3]
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depth [m]
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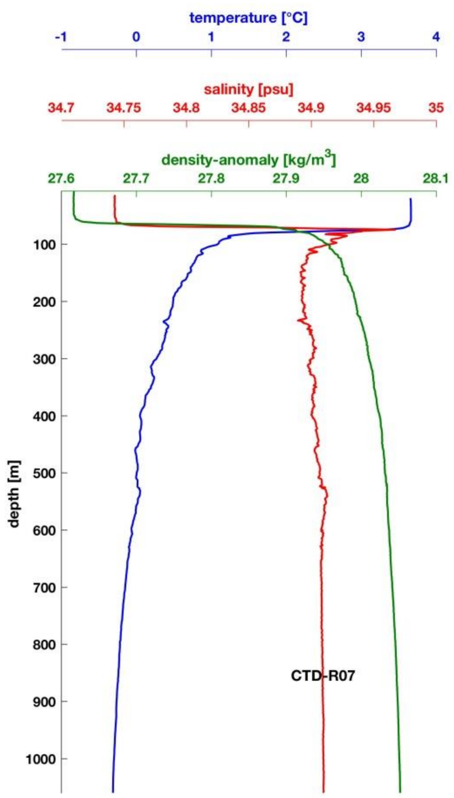
CTD-R06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salinity [psu]
34.7 34.75 34.8 34.85 34.9 34.95 35
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depth [m]
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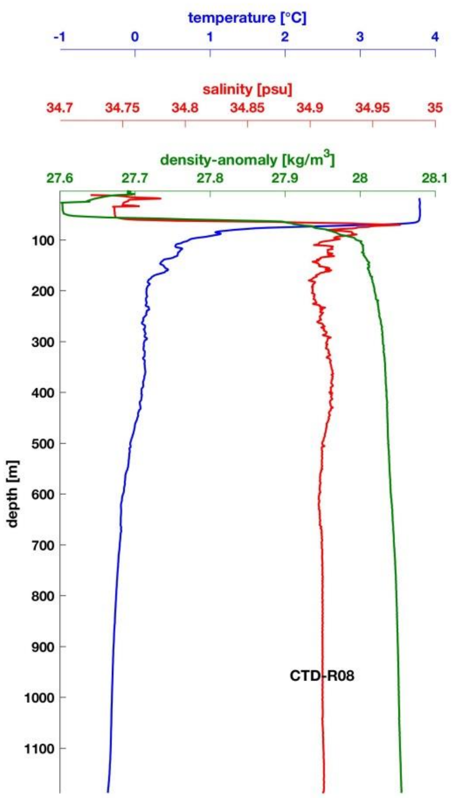
CTD-R07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salinity [psu]
34.7 34.75 34.8 34.85 34.9 34.95 35
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depth [m]
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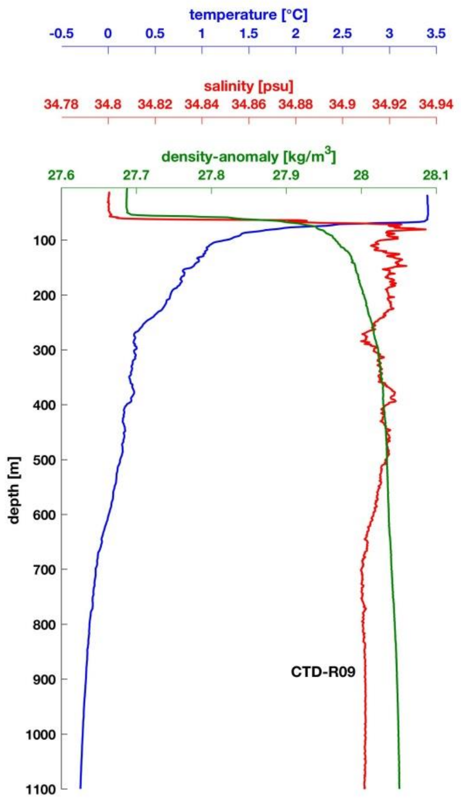
CTD-R08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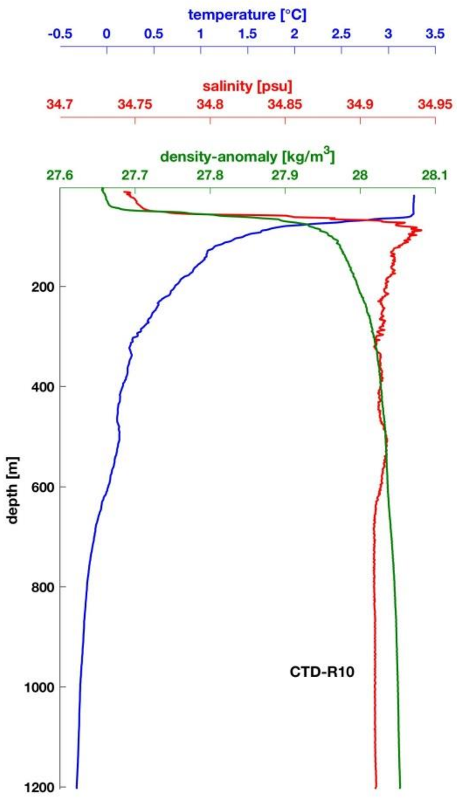
CTD-R09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salinity [psu]
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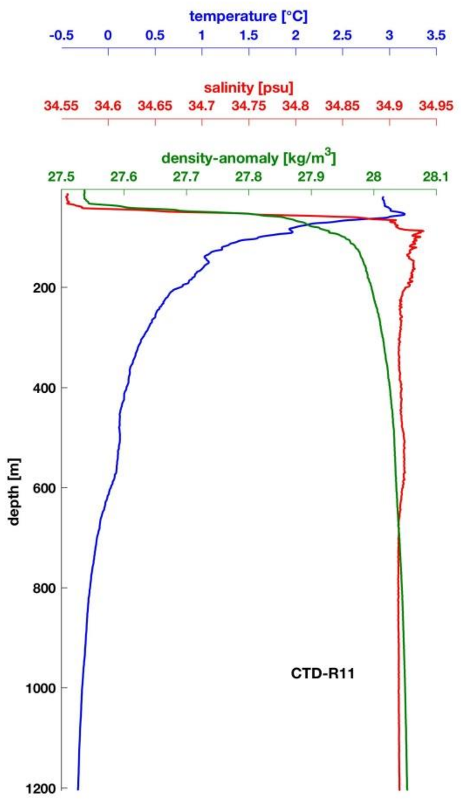
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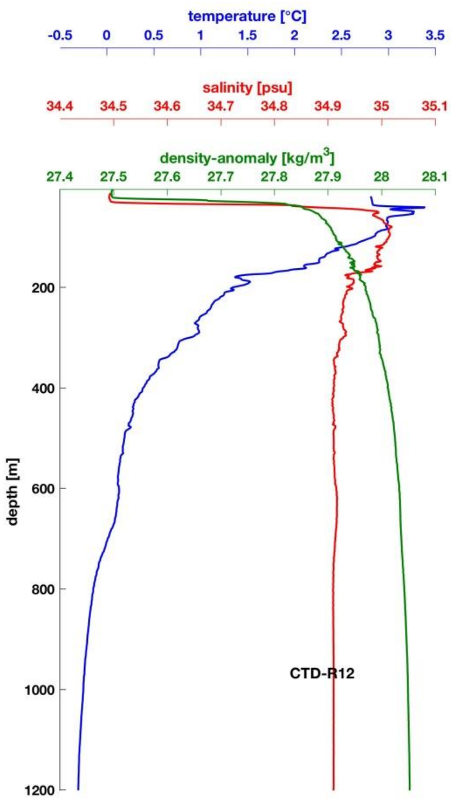
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salinity [psu]
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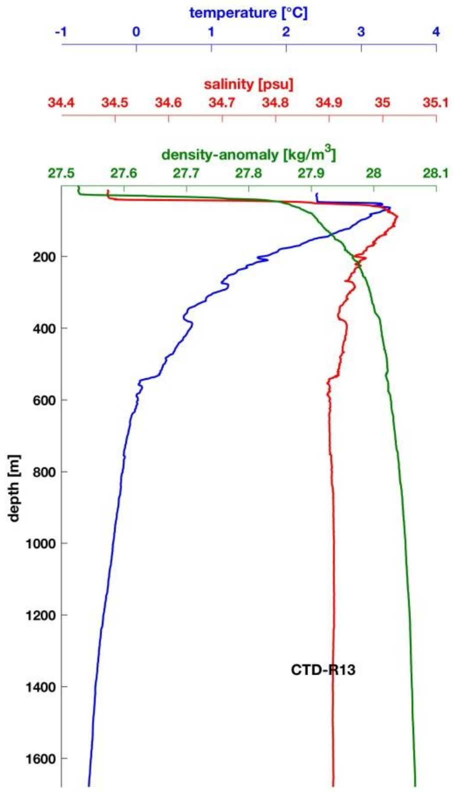
CTD-R12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salinity [psu]
34.4 34.5 34.6 34.7 34.8 34.9 35 35.1
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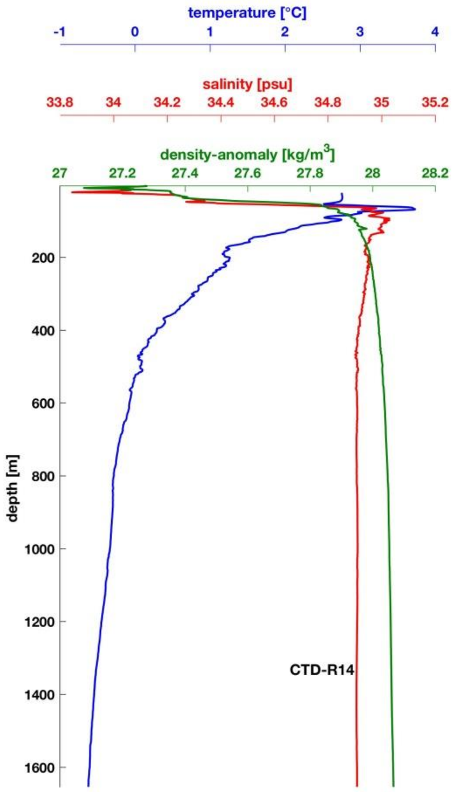
CTD-R13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33.8 34 34.2 34.4 34.6 34.8 35 35.2
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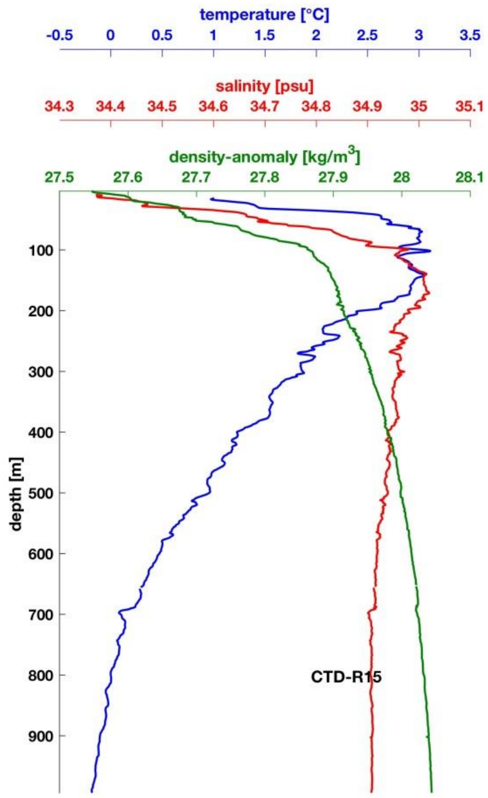
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depth [m]
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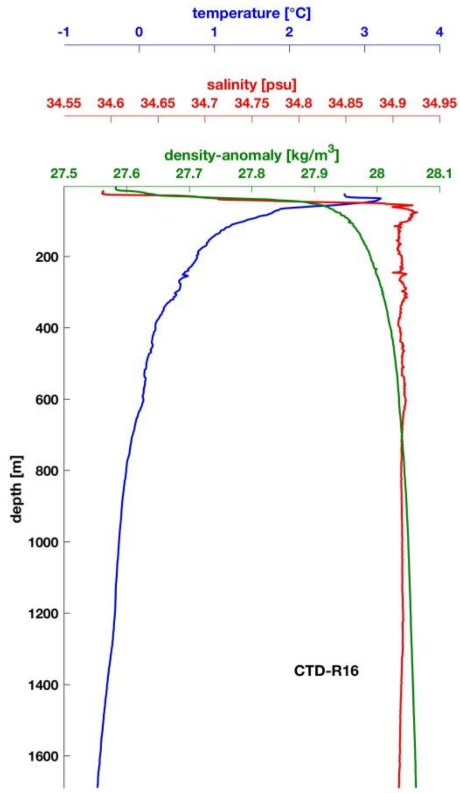
CTD-R15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depth [m]
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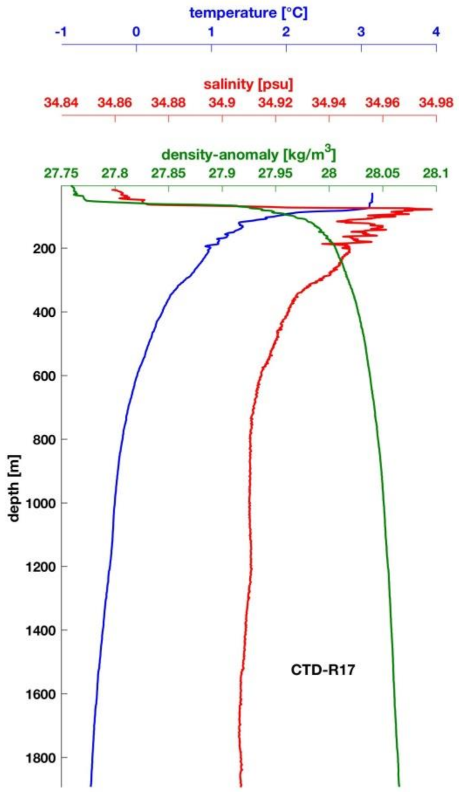
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depth [m]
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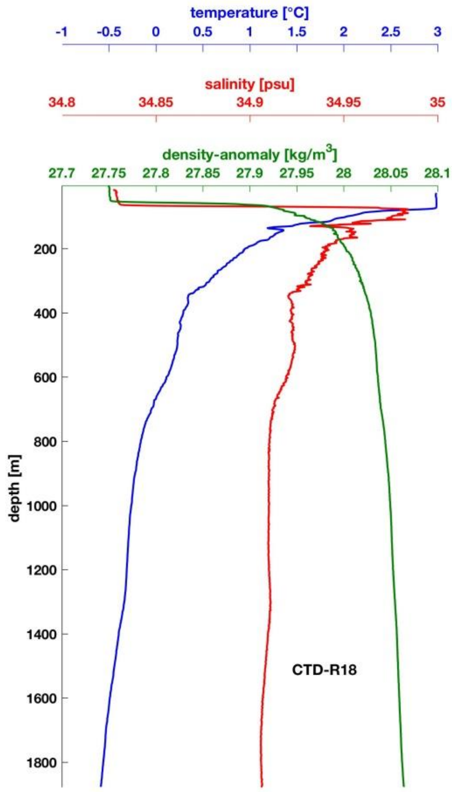
CTD-R17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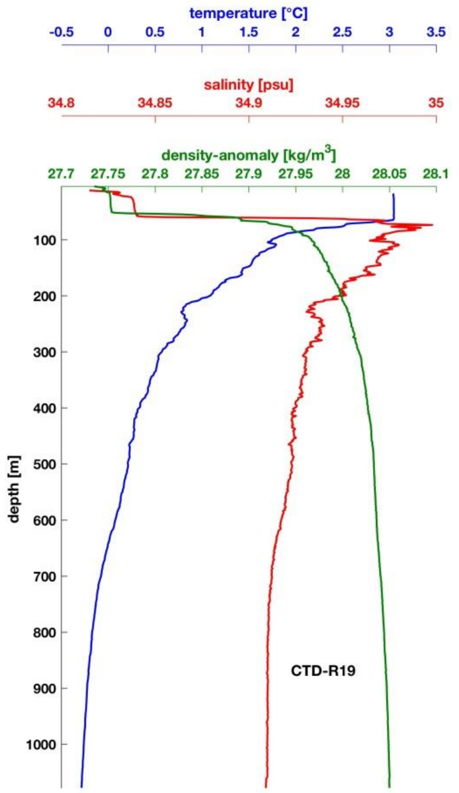
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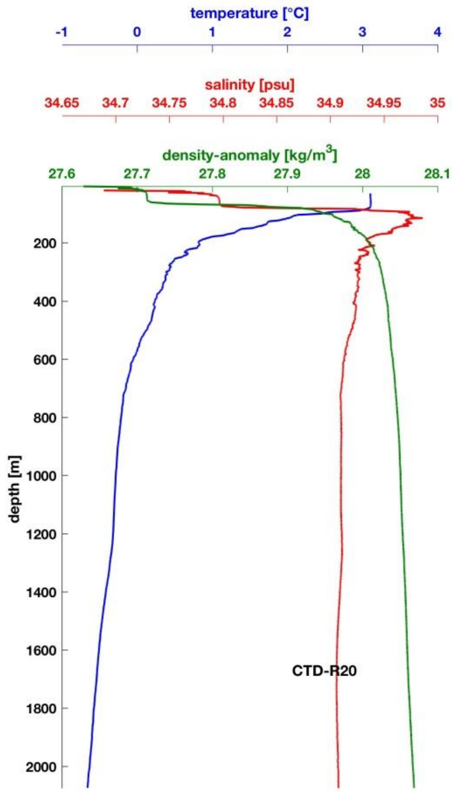
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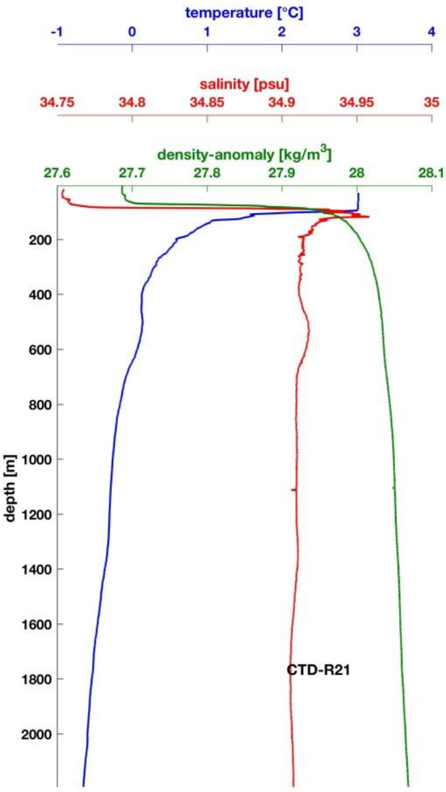
CTD-R20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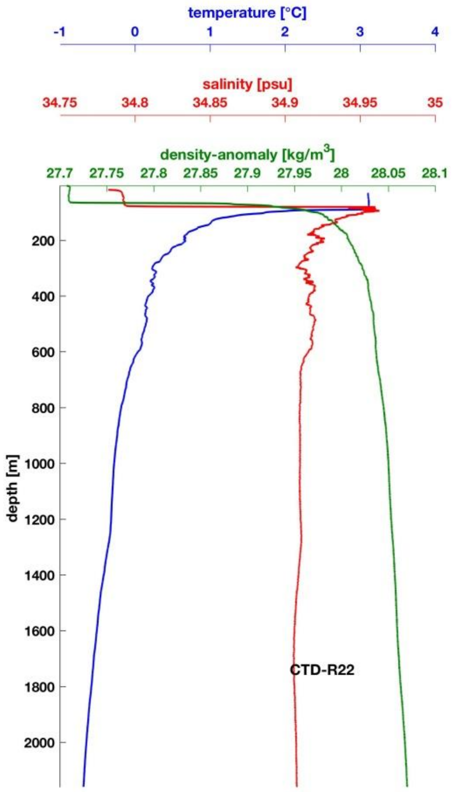
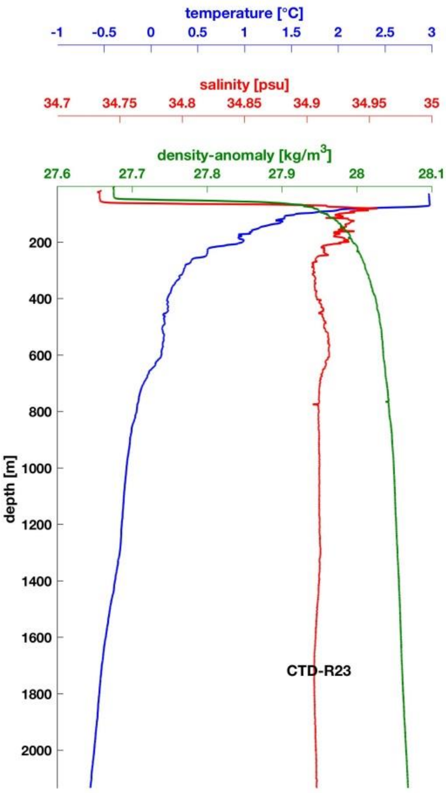
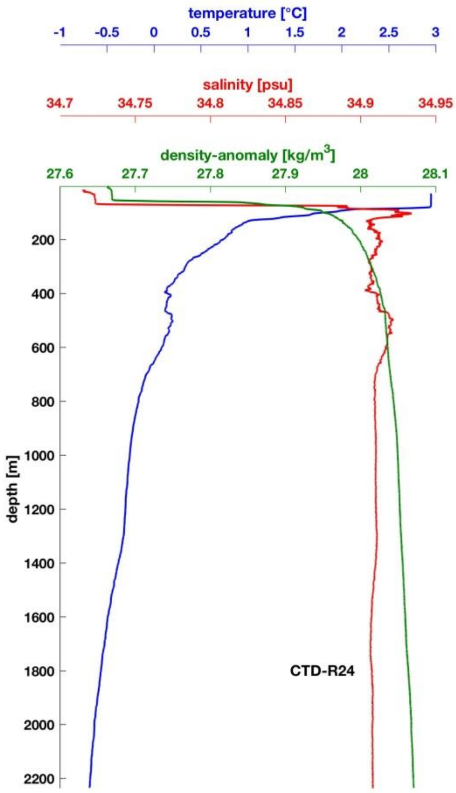
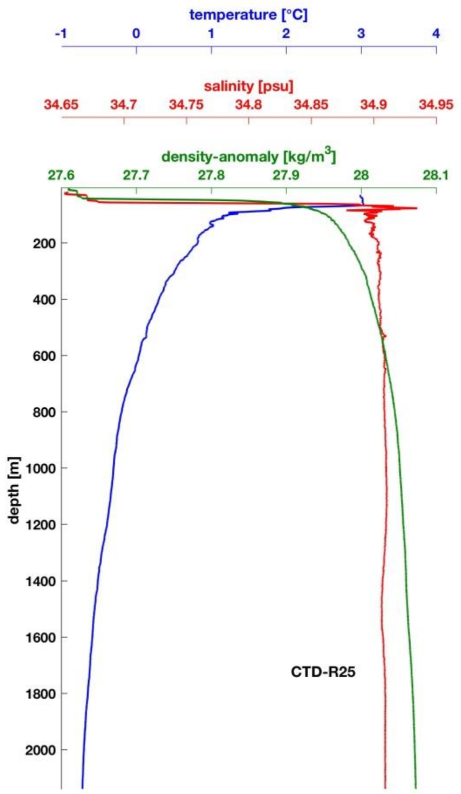
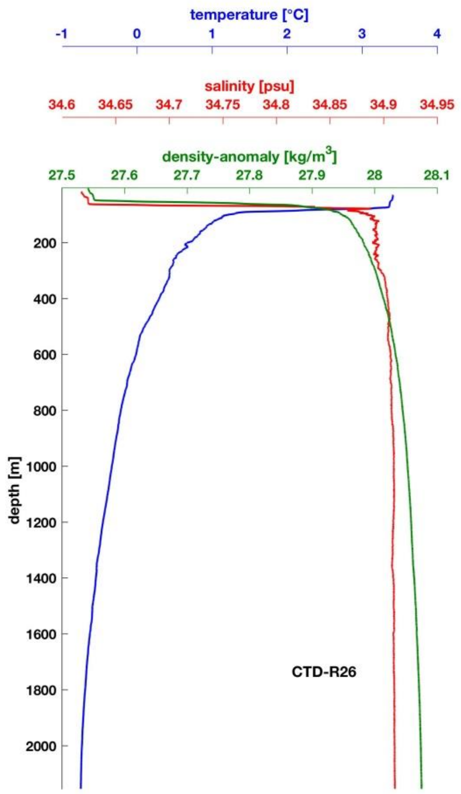
-1 0 1 2 3 4
salinity [psu]
34.75 34.8 34.85 34.9 34.95 35
density-anomaly [kg/m3]
27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000
CTD-R21

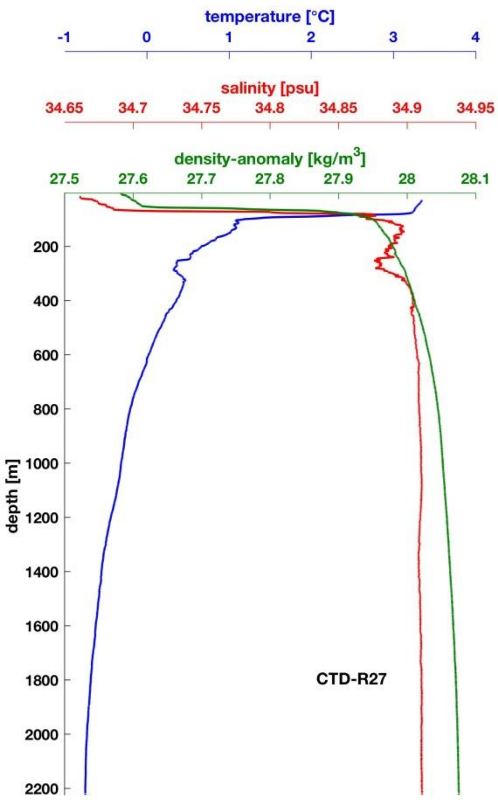

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.75 34.8 34.85 34.9 34.95 35
density-anomaly [kg/m3]
27.7 27.75 27.8 27.85 27.9 27.95 28 28.05 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000
CTD-R22

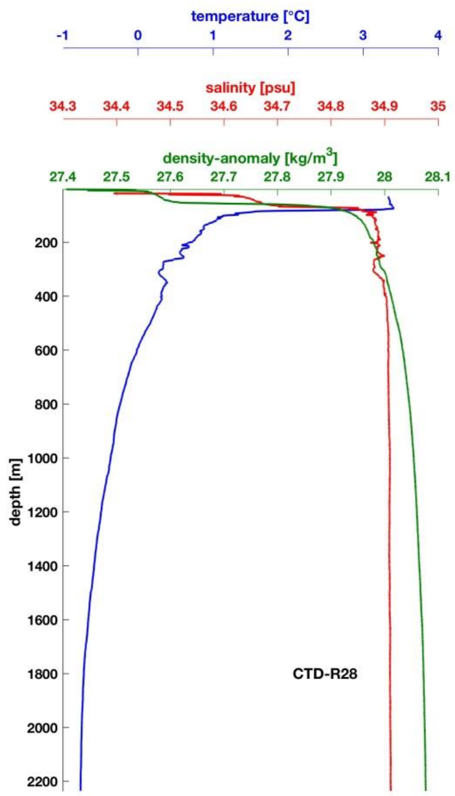

temperature [°C]
-1 -0.5 0 0.5 1 1.5 2 2.5 3
salinity [psu]
34.7 34.75 34.8 34.85 34.9 34.95 35
density-anomaly [kg/m3]
27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000
CTD-R23

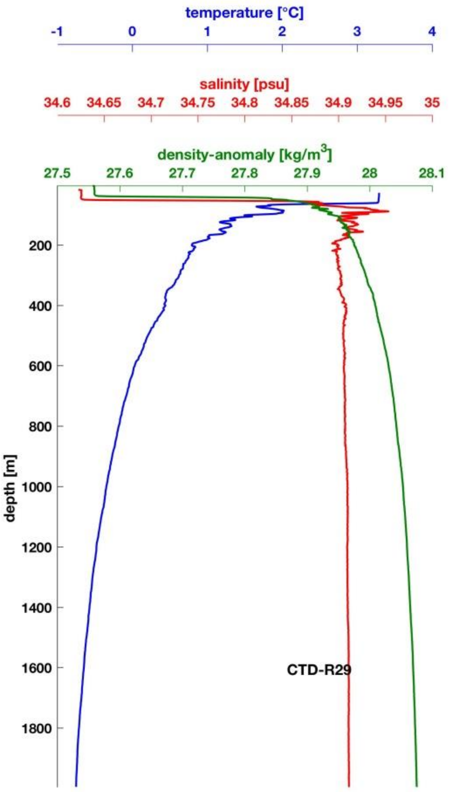

temperature [°C]
-1 -0.5 0 0.5 1 1.5 2 2.5 3
salinity [psu]
34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000 2200
CTD-R24

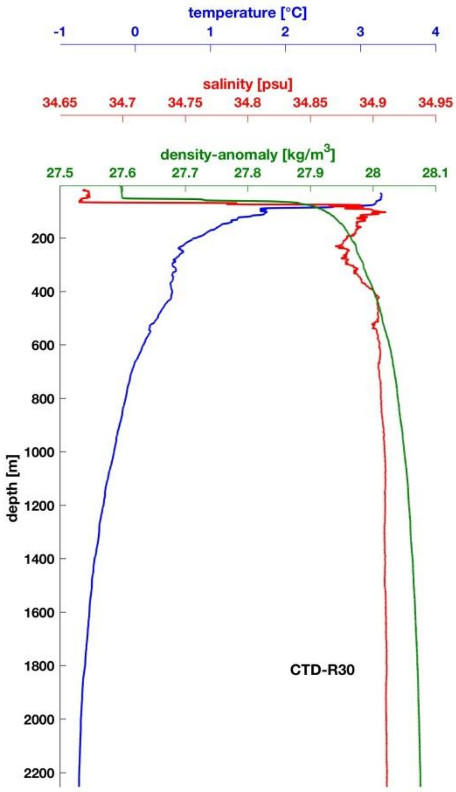

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.65 34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000
CTD-R25

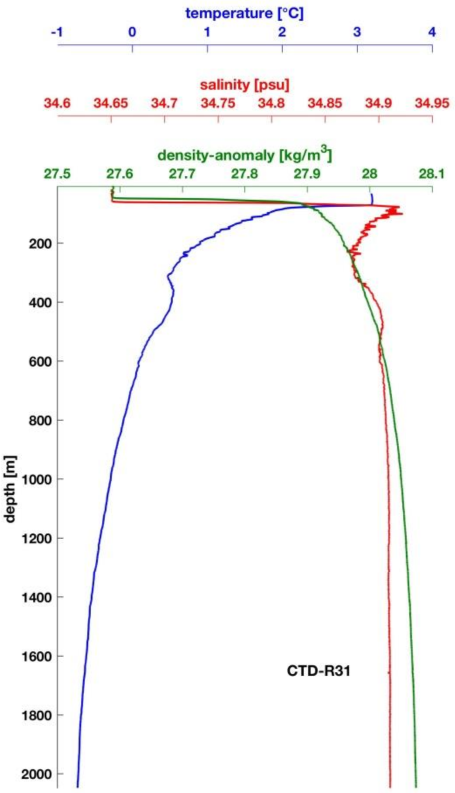

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.6 34.65 34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000
CTD-R26

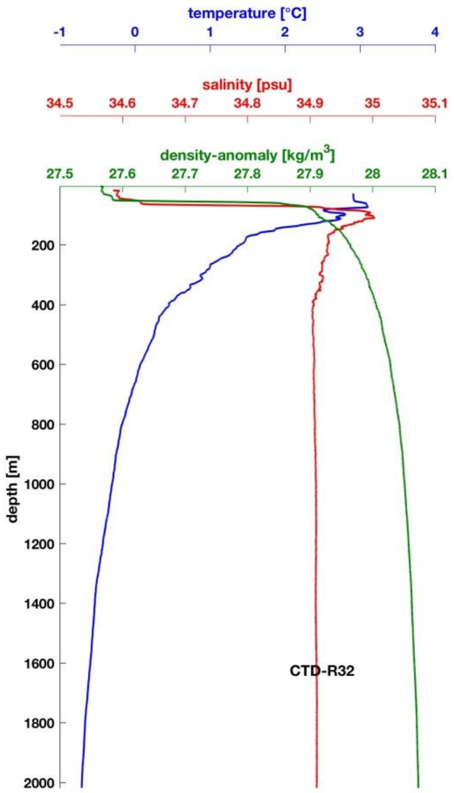

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.65 34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000 2200
CTD-R27

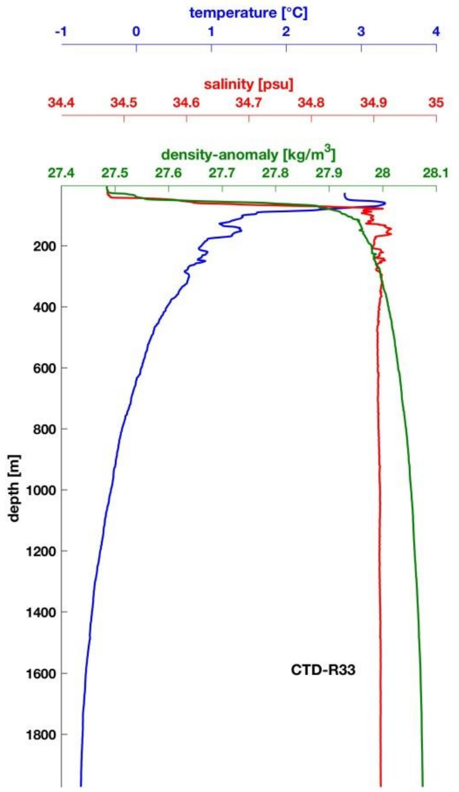

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.3 34.4 34.5 34.6 34.7 34.8 34.9 35
density-anomaly [kg/m3]
27.4 27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000 2200
CTD-R28

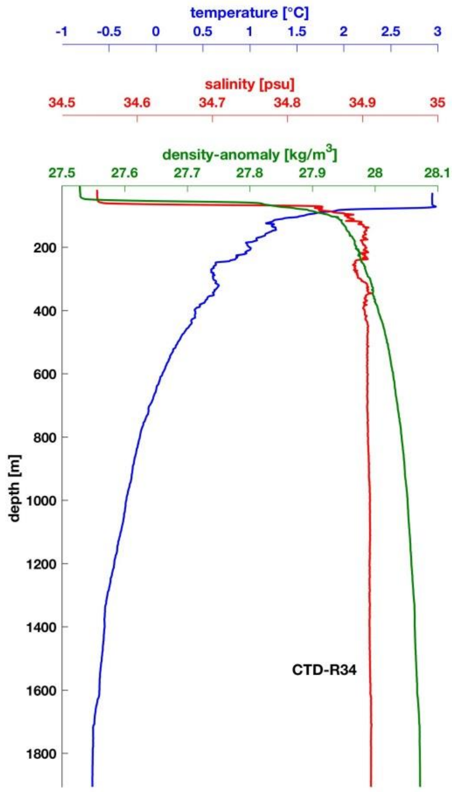

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.6 34.65 34.7 34.75 34.8 34.85 34.9 34.95 35
density-anomaly [kg/m³]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800
CTD-R29

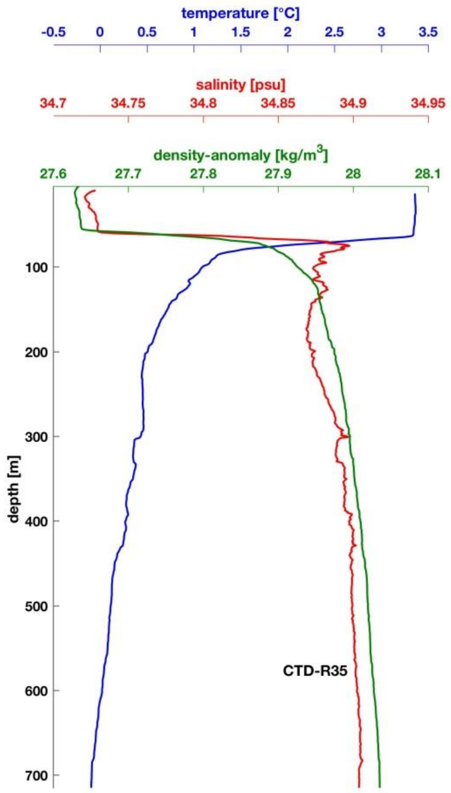

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.65 34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m³]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000 2200
CTD-R30

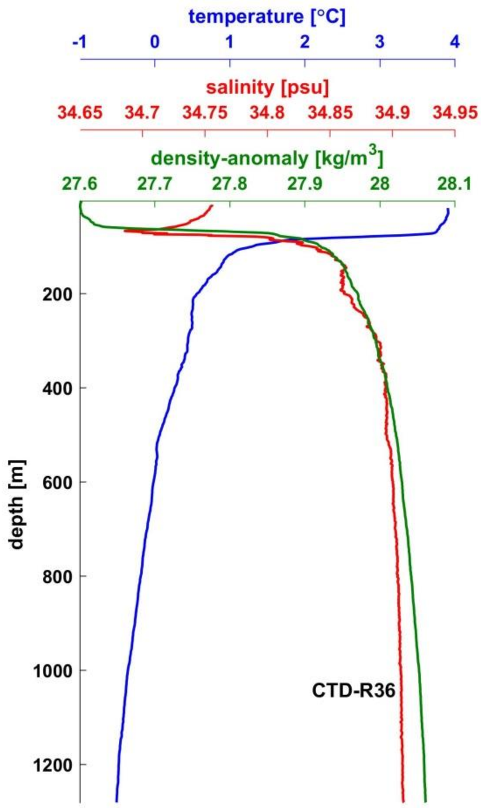

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.6 34.65 34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m³]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000
CTD-R31

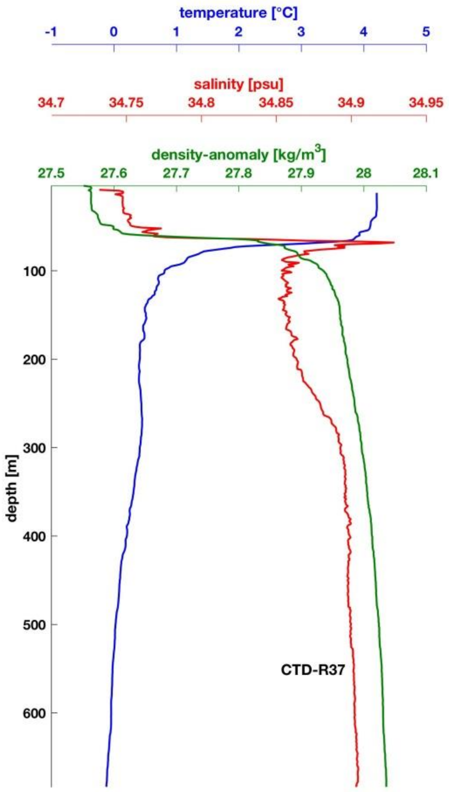

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.5 34.6 34.7 34.8 34.9 35 35.1
density-anomaly [kg/m³]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000
CTD-R32


temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.4 34.5 34.6 34.7 34.8 34.9 35
density-anomaly [kg/m3]
27.4 27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800
CTD-R33

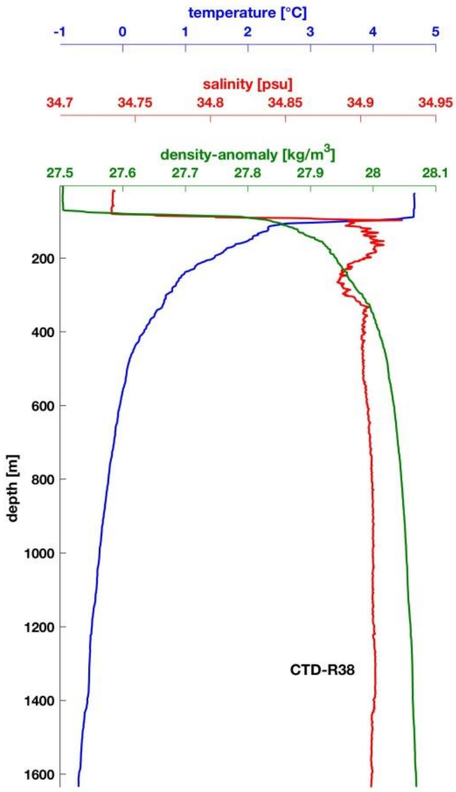

temperature [°C]
-1 -0.5 0 0.5 1 1.5 2 2.5 3
salinity [psu]
34.5 34.6 34.7 34.8 34.9 35
density-anomaly [kg/m3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800
CTD-R34


temperature [°C]
-0.5 0 0.5 1 1.5 2 2.5 3 3.5
salinity [psu]
34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.6 27.7 27.8 27.9 28 28.1
depth [m]
100 200 300 400 500 600 700
CTD-R35

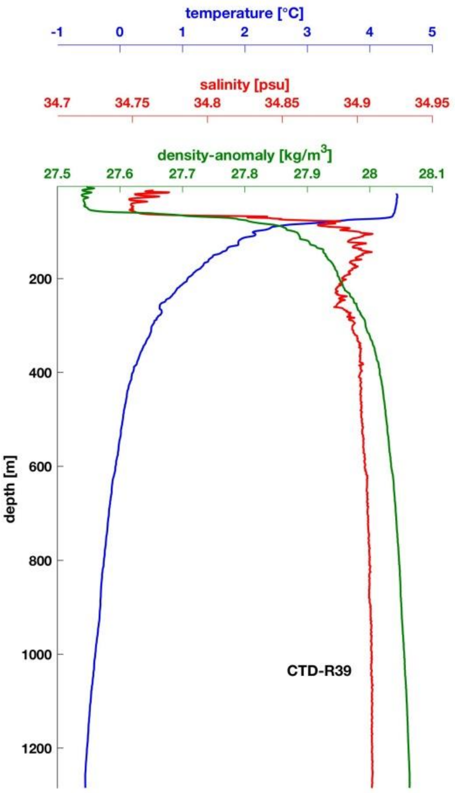

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.65 34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200
CTD-R36



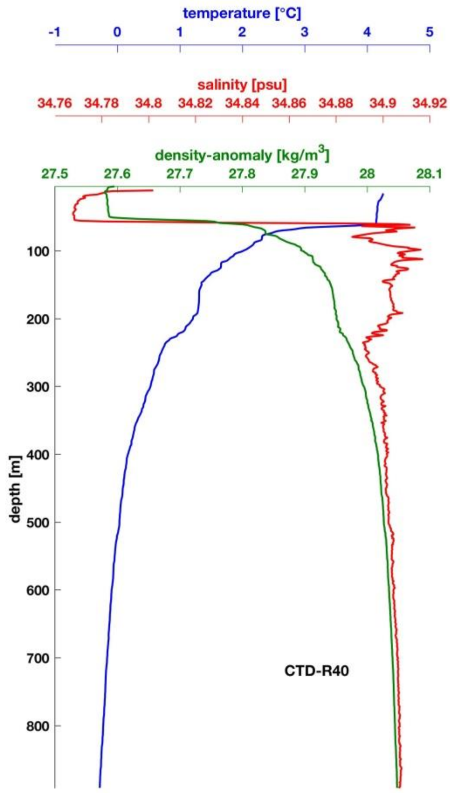
temperature [°C]
-1 0 1 2 3 4 5
salinity [psu]
34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m^3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
100 200 300 400 500 600
CTD-R37



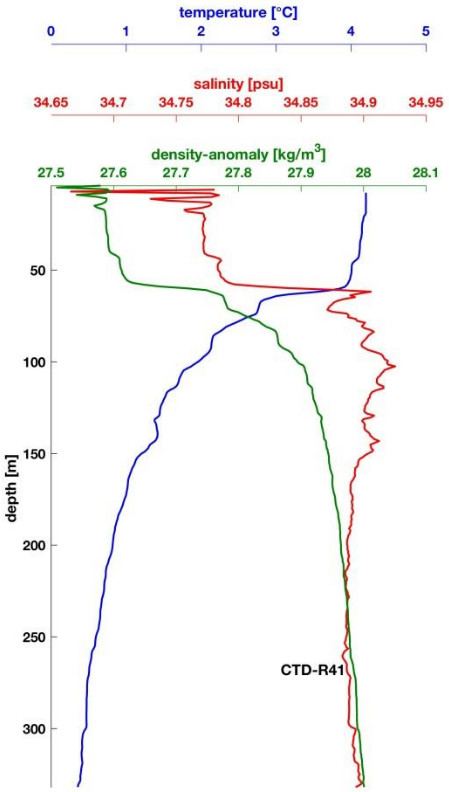
temperature [°C]
-1 0 1 2 3 4 5
salinity [psu]
34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m^3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600
CTD-R38

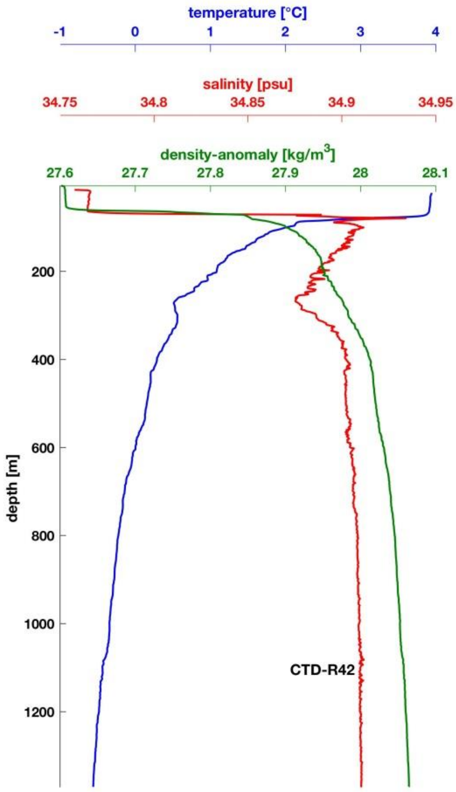


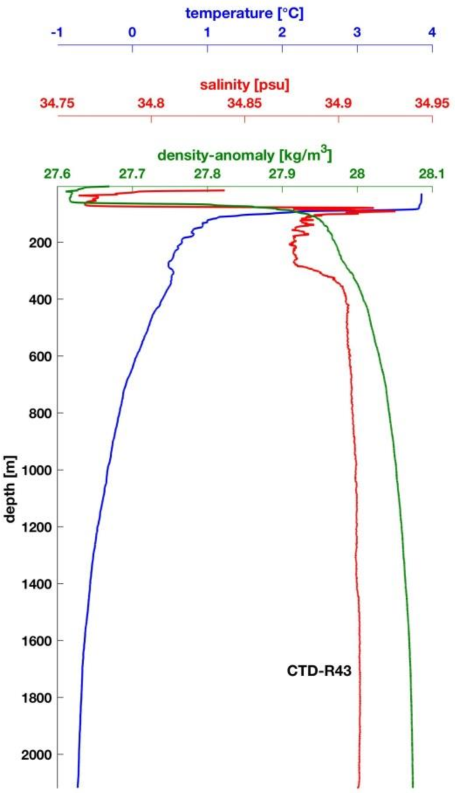
temperature [°C]
-1 0 1 2 3 4 5
salinity [psu]
34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m^3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200
CTD-R39

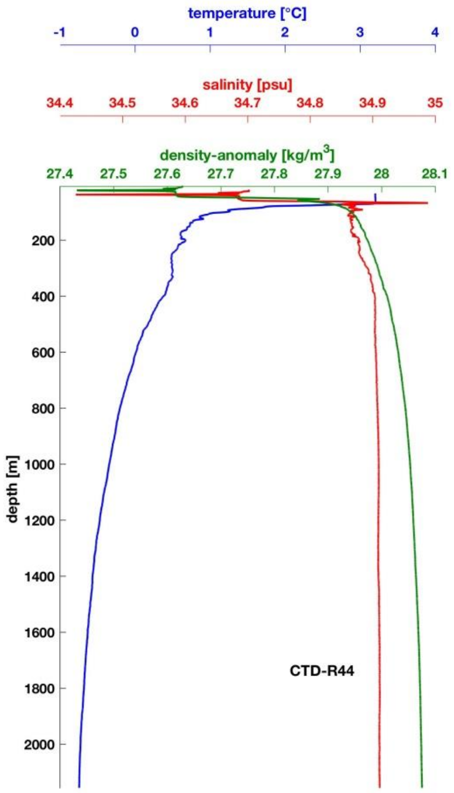


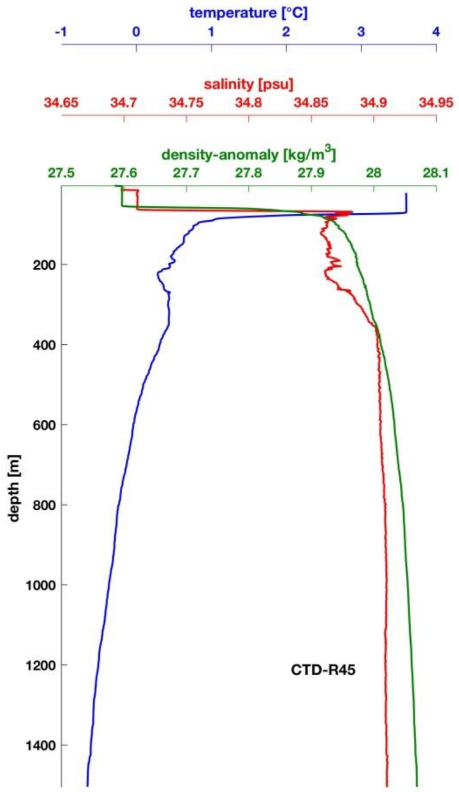
temperature [°C]
-1 0 1 2 3 4 5
salinity [psu]
34.76 34.78 34.8 34.82 34.84 34.86 34.88 34.9 34.92
density-anomaly [kg/m^3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
100 200 300 400 500 600 700 800
CTD-R40

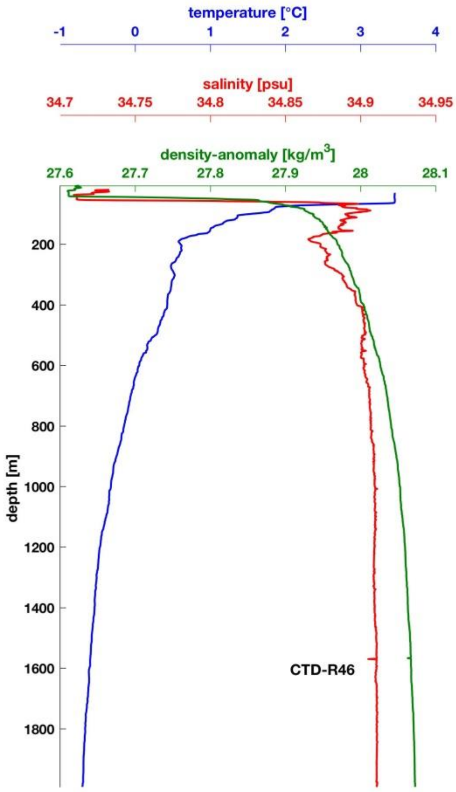

temperature [°C]
0 1 2 3 4 5
salinity [psu]
34.65 34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
50 100 150 200 250 300
CTD-R41

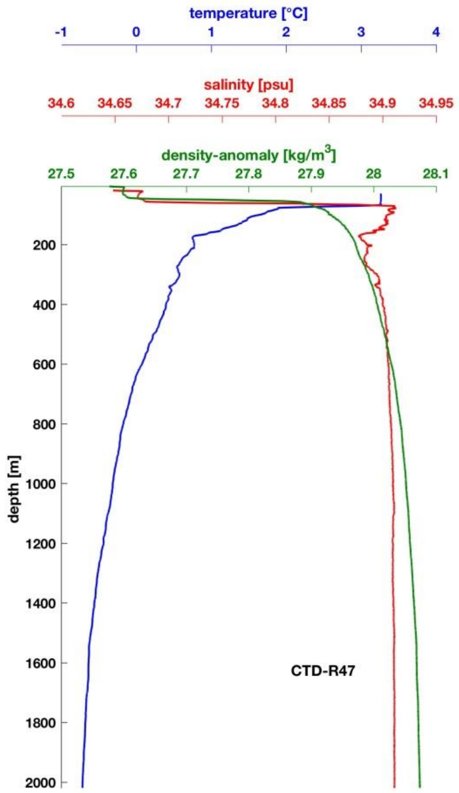

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200
CTD-R42

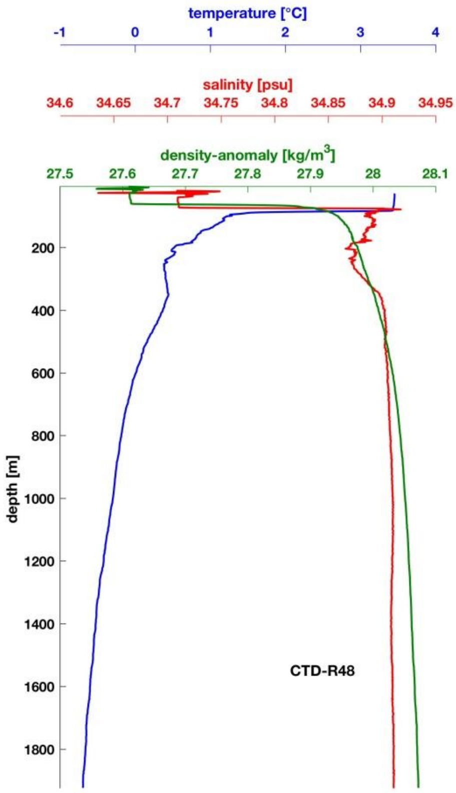

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000
CTD-R43

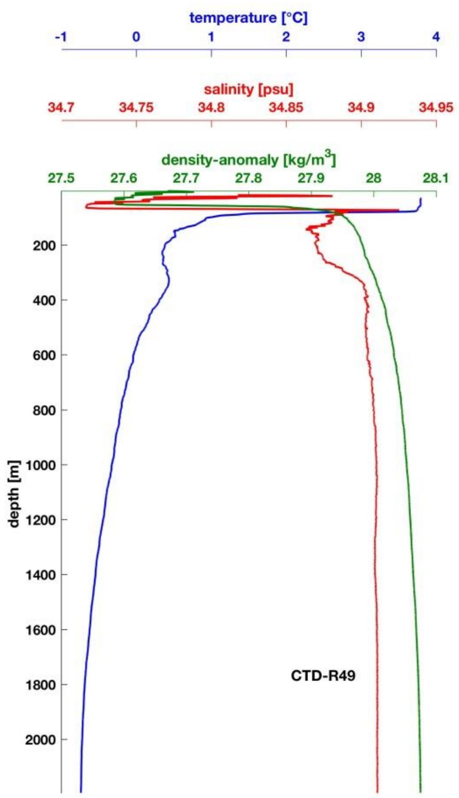

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.4 34.5 34.6 34.7 34.8 34.9 35
density-anomaly [kg/m3]
27.4 27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000
CTD-R44

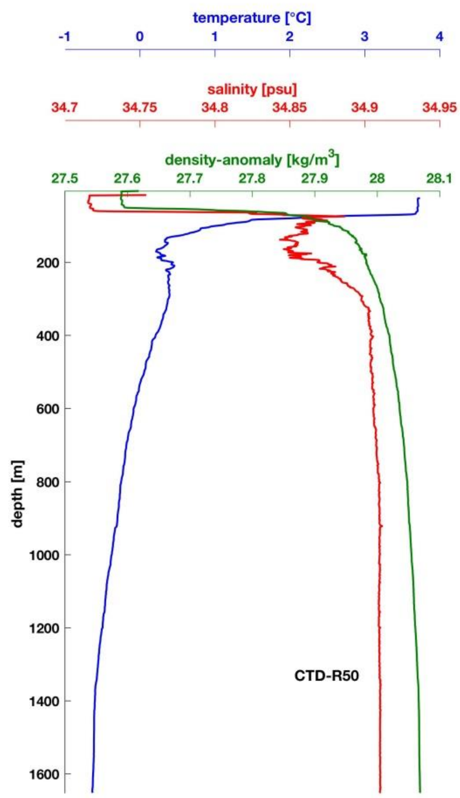

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.65 34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400
CTD-R45

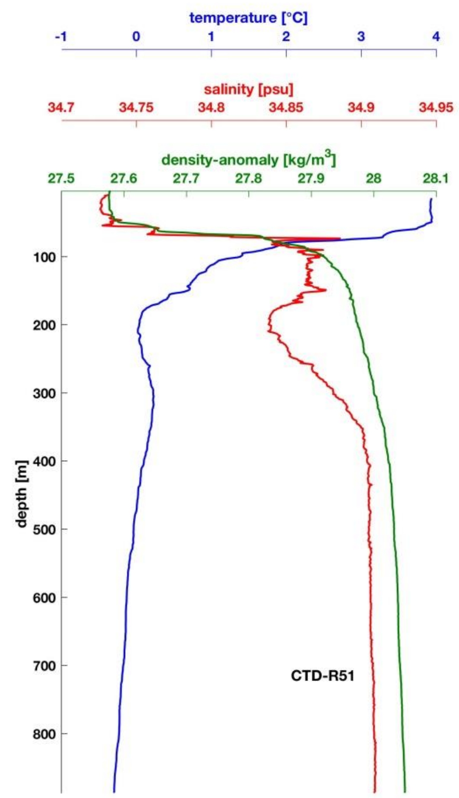

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800
CTD-R46

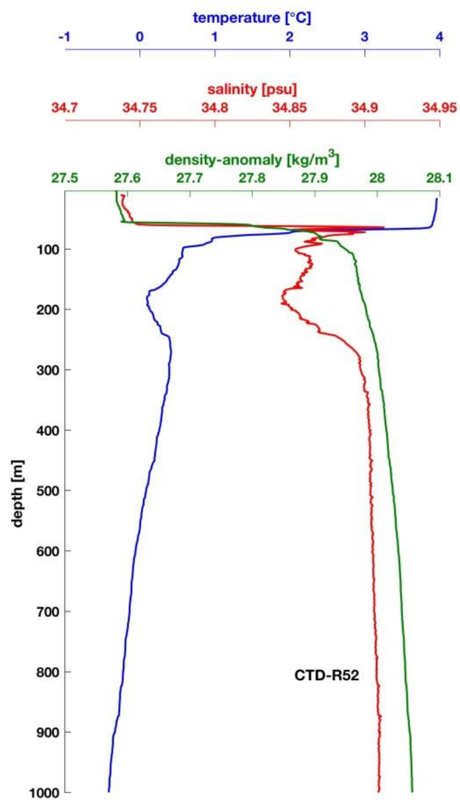

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.6 34.65 34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000
CTD-R47

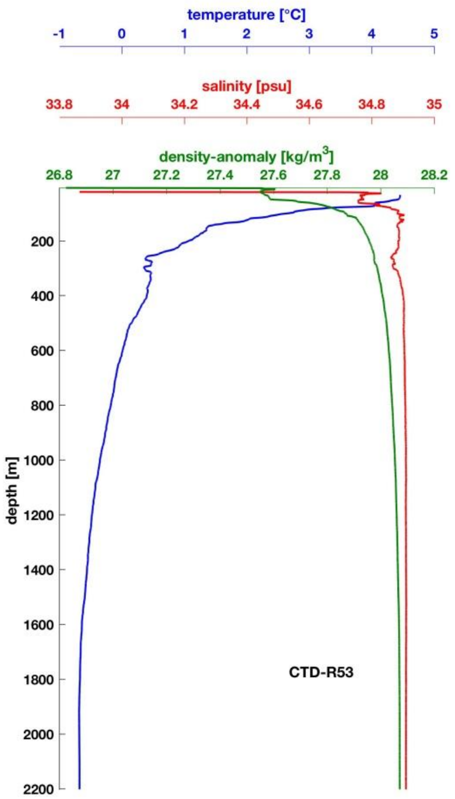

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.6 34.65 34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800
CTD-R48

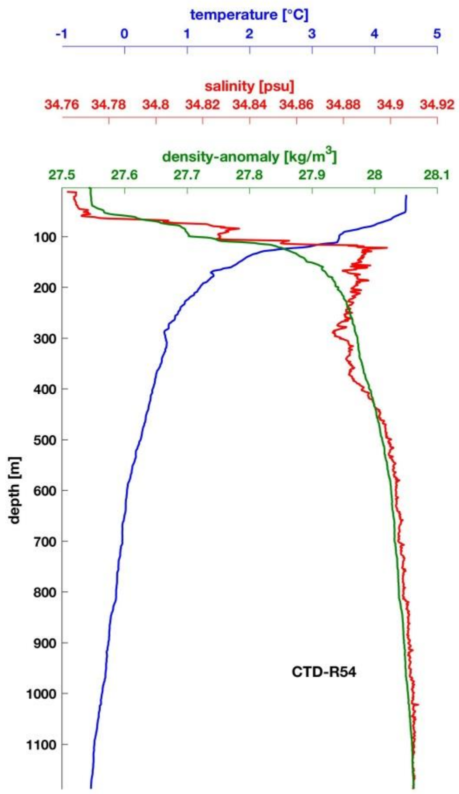

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000
CTD-R49

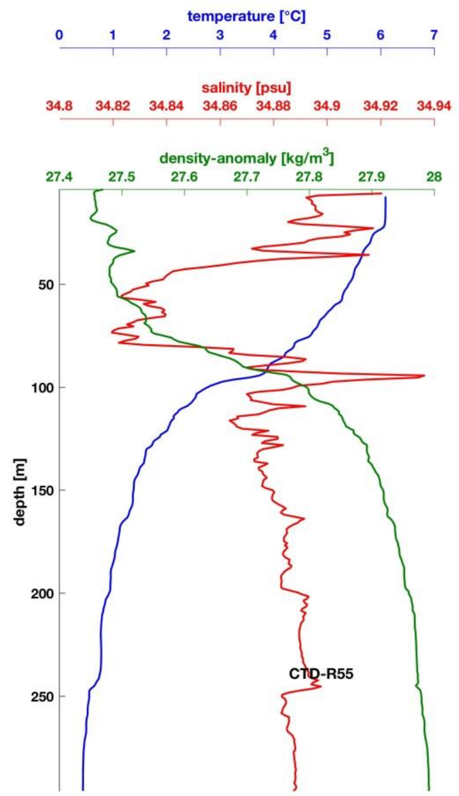

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
200 400 600 800 1000 1200 1400 1600
CTD-R50

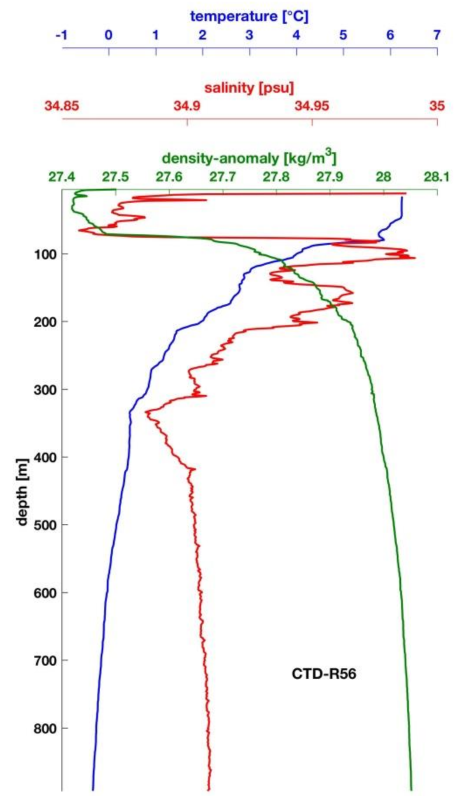

temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
100 200 300 400 500 600 700 800
CTD-R51


temperature [°C]
-1 0 1 2 3 4
salinity [psu]
34.7 34.75 34.8 34.85 34.9 34.95
density-anomaly [kg/m3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
100 200 300 400 500 600 700 800 900 1000
CTD-R52


temperature [°C]
-1 0 1 2 3 4 5
salinity [psu]
33.8 34 34.2 34.4 34.6 34.8 35
density-anomaly [kg/m3]
26.8 27 27.2 27.4 27.6 27.8 28 28.2
depth [m]
200 400 600 800 1000 1200 1400 1600 1800 2000 2200
CTD-R53


temperature [°C]
-1 0 1 2 3 4 5
salinity [psu]
34.76 34.78 34.8 34.82 34.84 34.86 34.88 34.9 34.92
density-anomaly [kg/m3]
27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
100 200 300 400 500 600 700 800 900 1000 1100
CTD-R54


temperature [°C]
0 1 2 3 4 5 6 7
salinity [psu]
34.8 34.82 34.84 34.86 34.88 34.9 34.92 34.94
density-anomaly [kg/m3]
27.4 27.5 27.6 27.7 27.8 27.9 28
depth [m]
50 100 150 200 250
CTD-R55


temperature [°C]
-1 0 1 2 3 4 5 6 7
salinity [psu]
34.85 34.9 34.95 35
density-anomaly [kg/m3]
27.4 27.5 27.6 27.7 27.8 27.9 28 28.1
depth [m]
100 200 300 400 500 600 700 800
CTD-R56

4.2 Temperature, salinity, dissolved oxygen sections

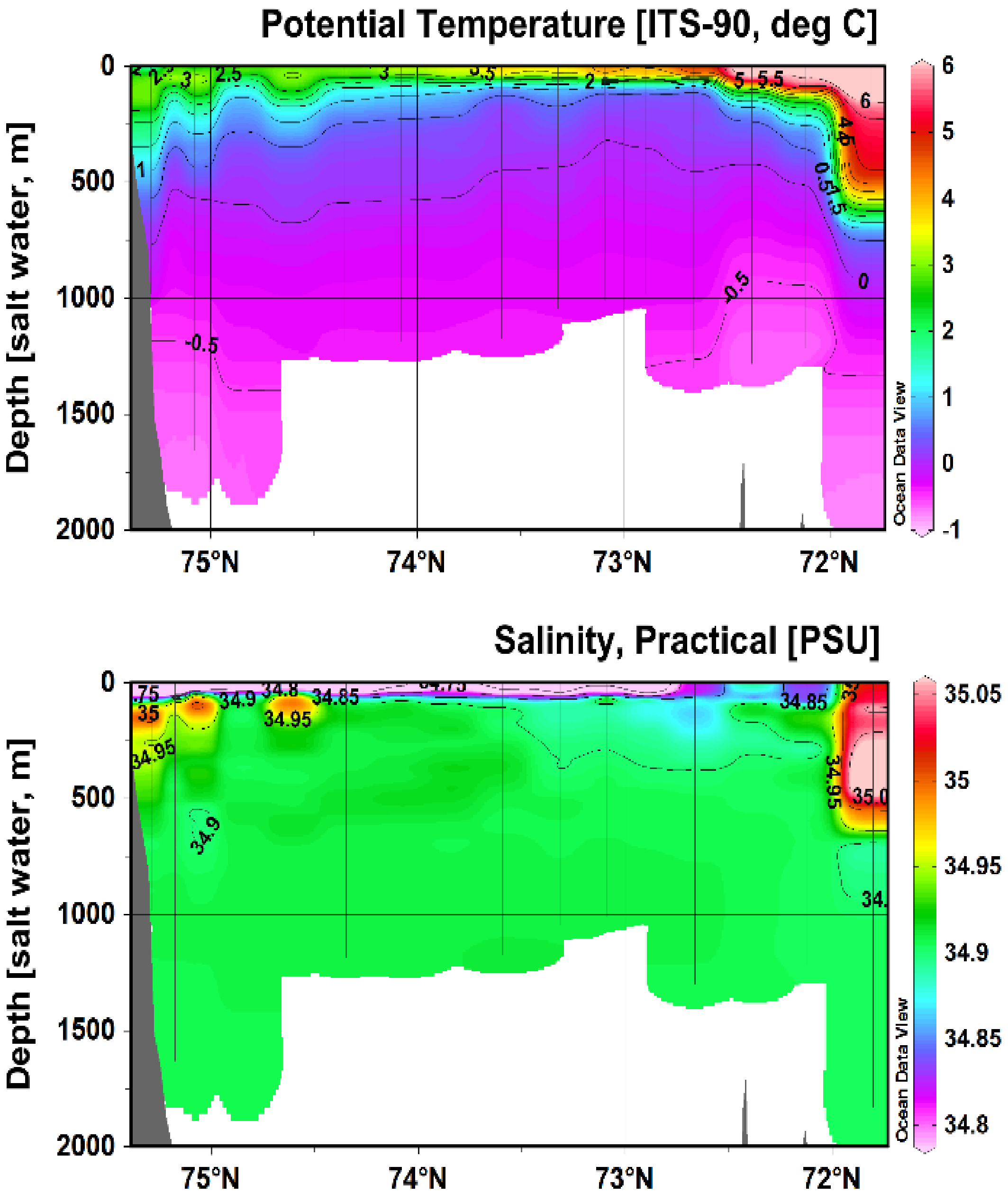


Figure 4.2.1 Distrubition of potential temperature and salinity along the section from the Greenland slope to the western Norwegian Sea.

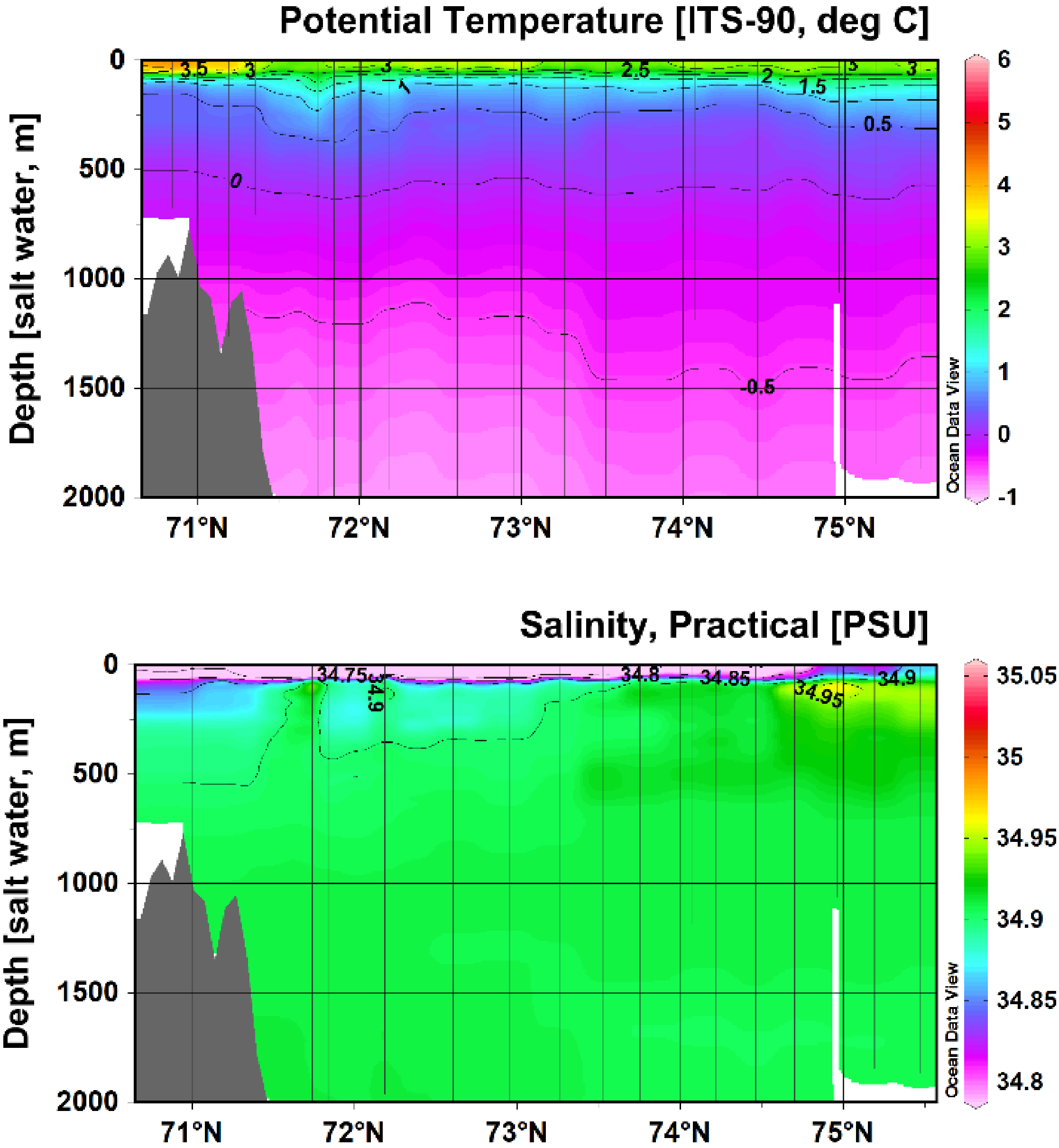


Figure 4.2.1 Distrubition of potential temperature and salinity along the section from the northern Greenland Sea to the west Jan Mayen Fracture Zone.

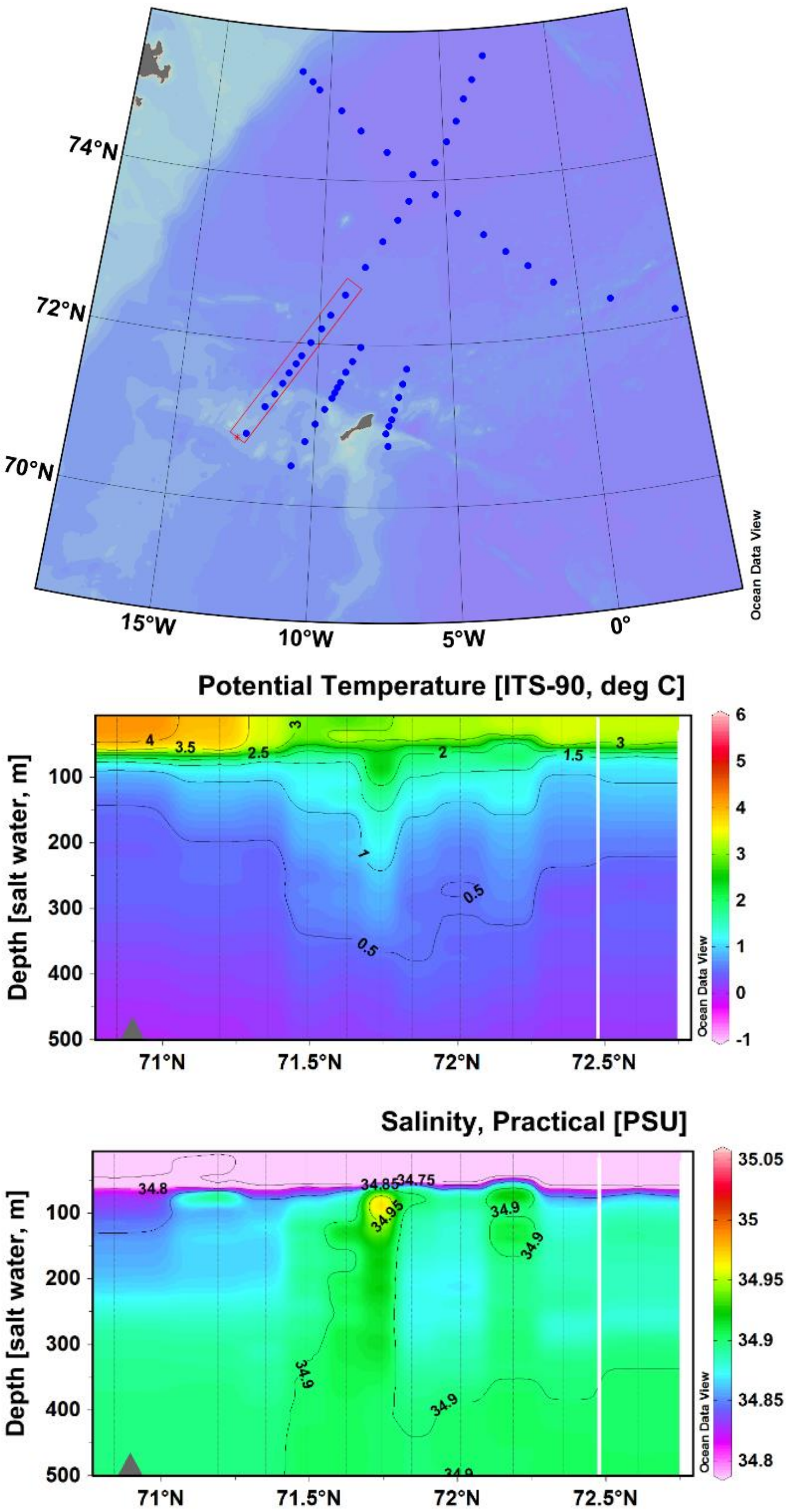


Figure 4.2.3 Distrubition of potential temperature and salinity along the short section at the upstream of the Jan Mayen Channel.

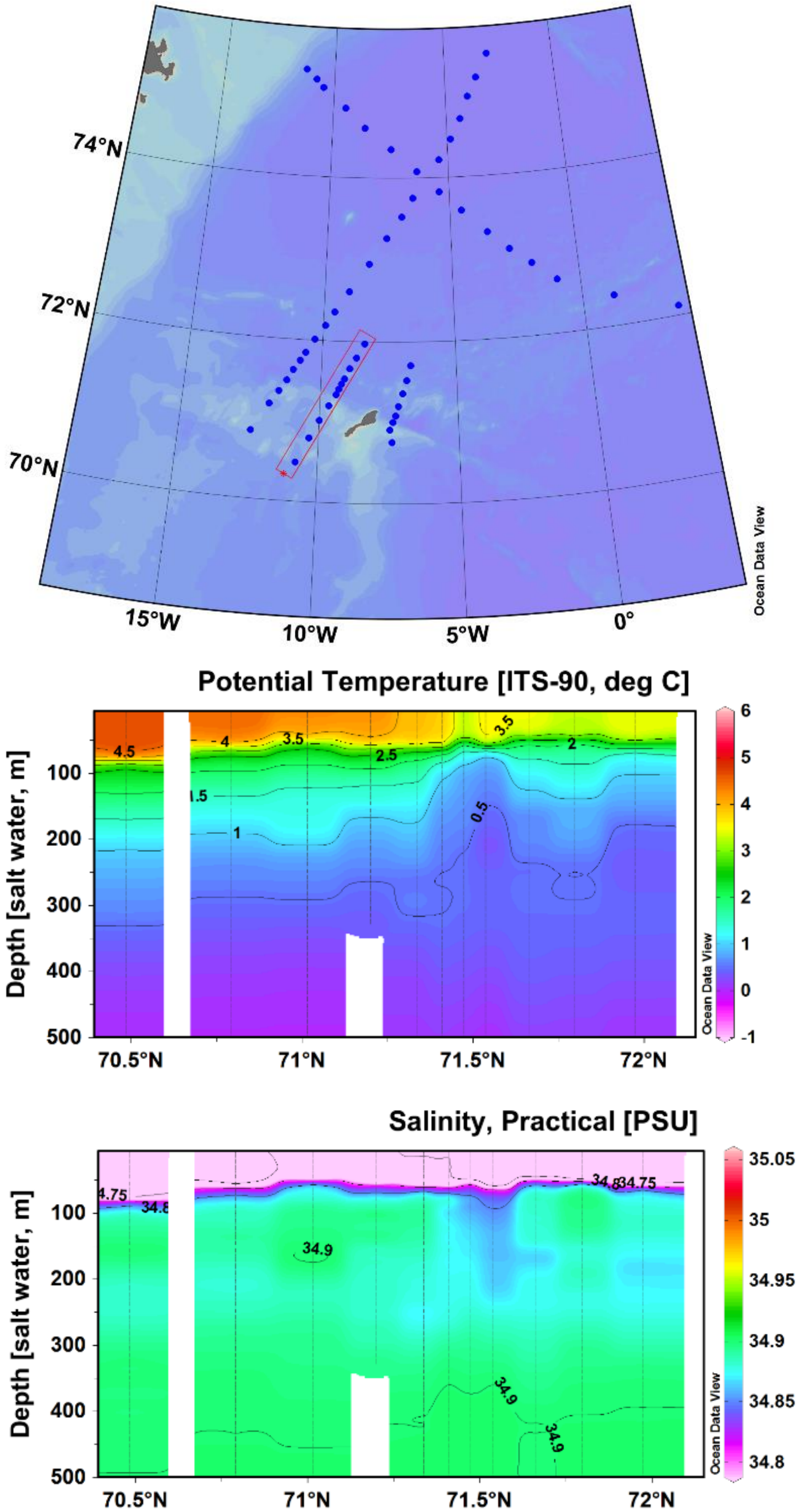


Figure 4.2.4 Distrubition of potential temperature and salinity along the short section ta the mid-stream of the Jan Mayen Channel.

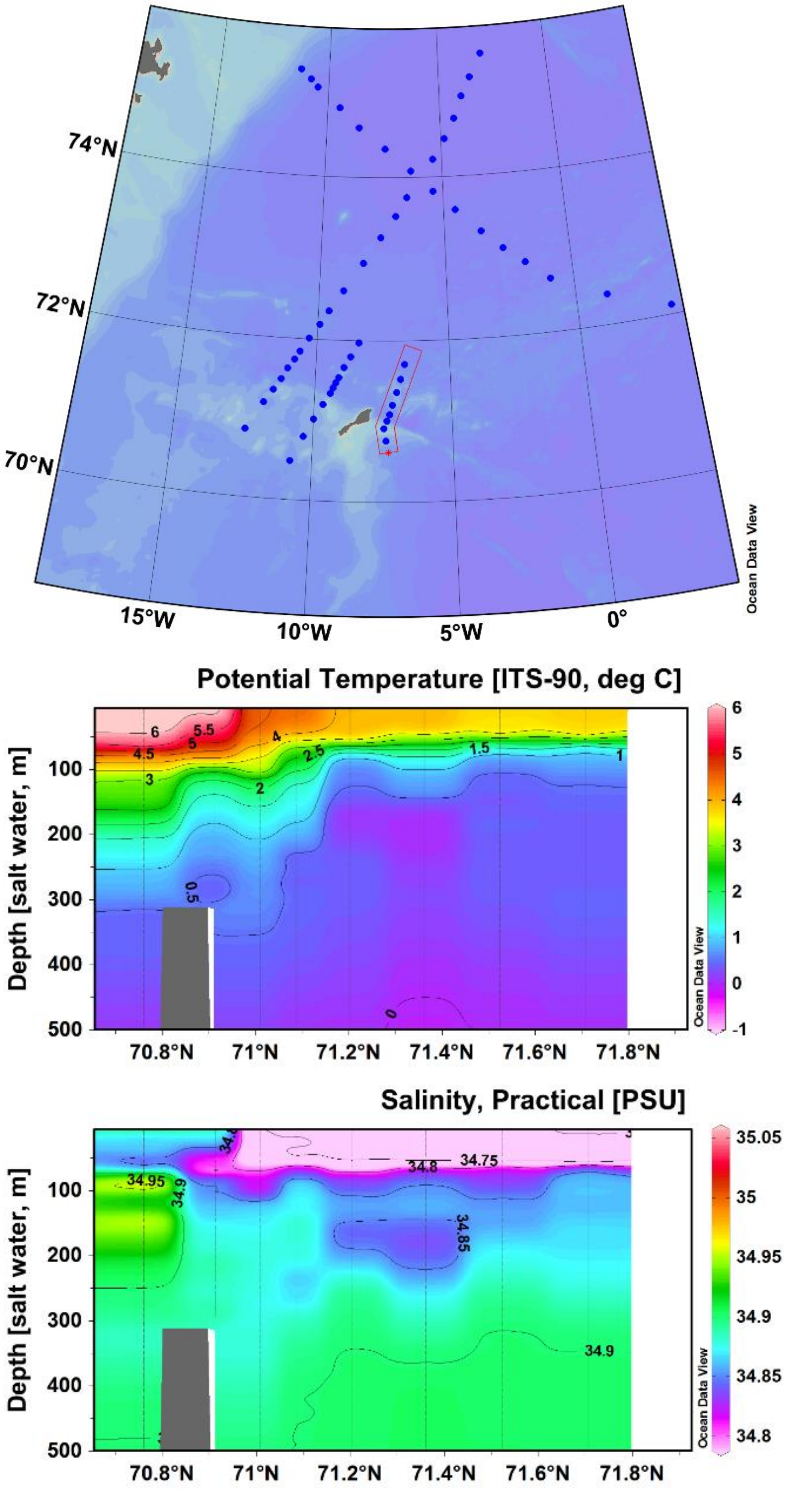


Figure 4.2.5 Distrubition of potential temperature and salinity along the short section ta the downstream of the Jan Mayen Channel.

4.3 Three-dimensional structures of temperature, salinity, and dissolved oxygen

In the winter of February 2018, observations showed that air temperature at the North Pole was higher than 0 ºC, which reached a record high in the past 100 years. The warm air was transported northward to the pole through the Nordic seas. As a result of the warming winter in the Greenland Sea during winter of 2018, temperature of the newly ventilated water within the Greenland Sea Gyre (>74 ºN) was even above 0ºC, which also reached its record high. Note that the newly ventilated water means intermediate waters which formed by cooling convection during the last winter (from January to April, 2018). These waters are characterized as a minimum of temperature in the intermediate layer with a higher dissolved oxygen (lower Apparent Oxygen Consumption). According to the distribution of Apparent Oxygen Consumption (AOU), we can clearly see that the Greenland Sea was divided into two regions: inside the Greenland Sea Gyre where waters there having lower AOU and higher salinity, and outside the Greenland Sea Gyre where waters having higher AOU and lower salinity. Obviously, waters inside the gyre were the newly ventilated waters, and their properties reflect a weak convection activity during winter. Higher salinity means their contains more Atlantic-origin water. The new produced intermediate waters could only fill up the interior of the gyre. As for waters in the southern Greenland Sea, their properties were similar with waters transported from the Arctic Ocean be the East Greenland Current. Unfortunately, we did not measure water chemical and isotopic properties, so we were unable to substantiate our speculation. All in all, we can conclude that the air temperature warming in early 2018 resulted in an extreme warming in the Greenland Sea intermediate layer, significantly weakening the convection activity in the Greenland Sea.

From Argos observation in the early 2018 (March and April), the maximum density of ventilated intermediate water was only about 28.04 kg/m^3. According to observations during the joint cruise, these ventilated waters were observed being transported from the gyre toward the Jan Maye channel through the intermediate layer between about 28.02 and 28.04 kg/m^3 (a depth range of 300–700m). The transport of ventilated waters formed an obvious "tongue" structure both in salinity and AOU. Our cruise gives a detail three-dimensional transport structure of the intermediate waters from the Greenland Sea to the Norwegian Sea.

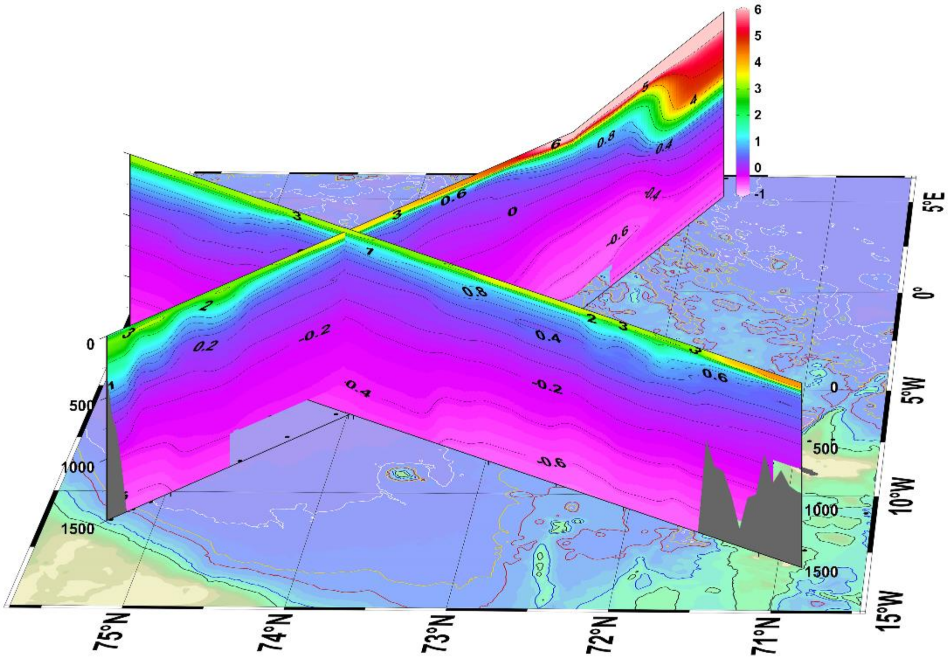


Figure 4.3.1 Distrubition of potential temperature in the Greenland Sea

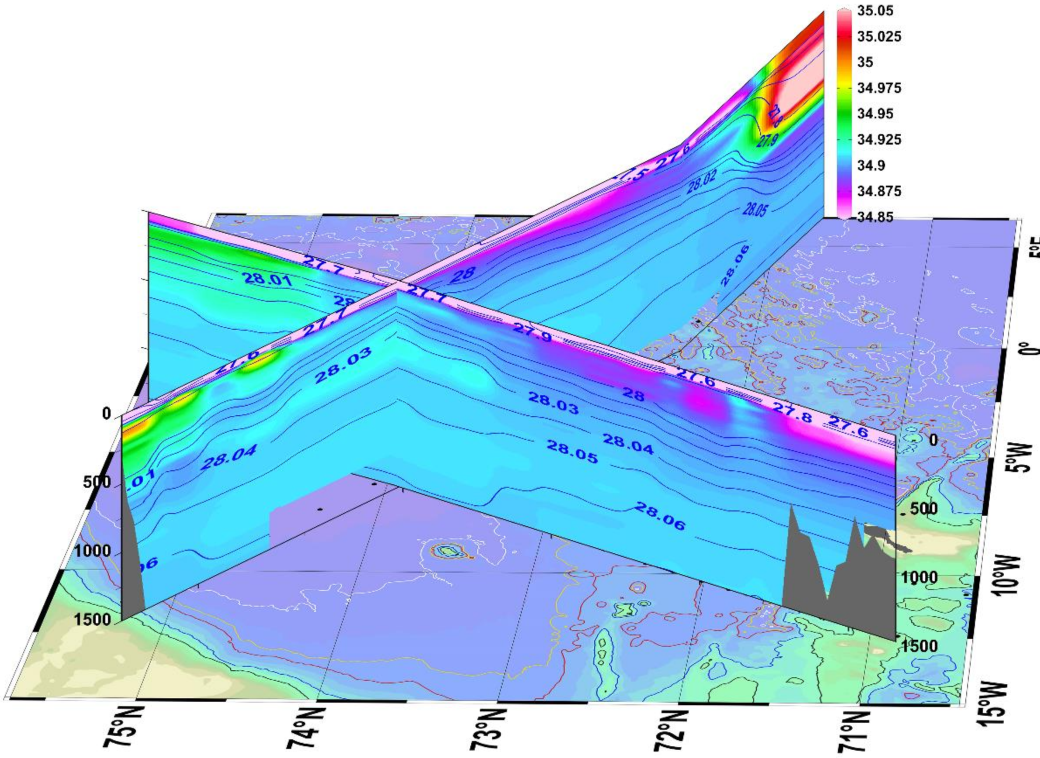


Figure 4.3.2 Distrubition of salinity in the Greenland Sea

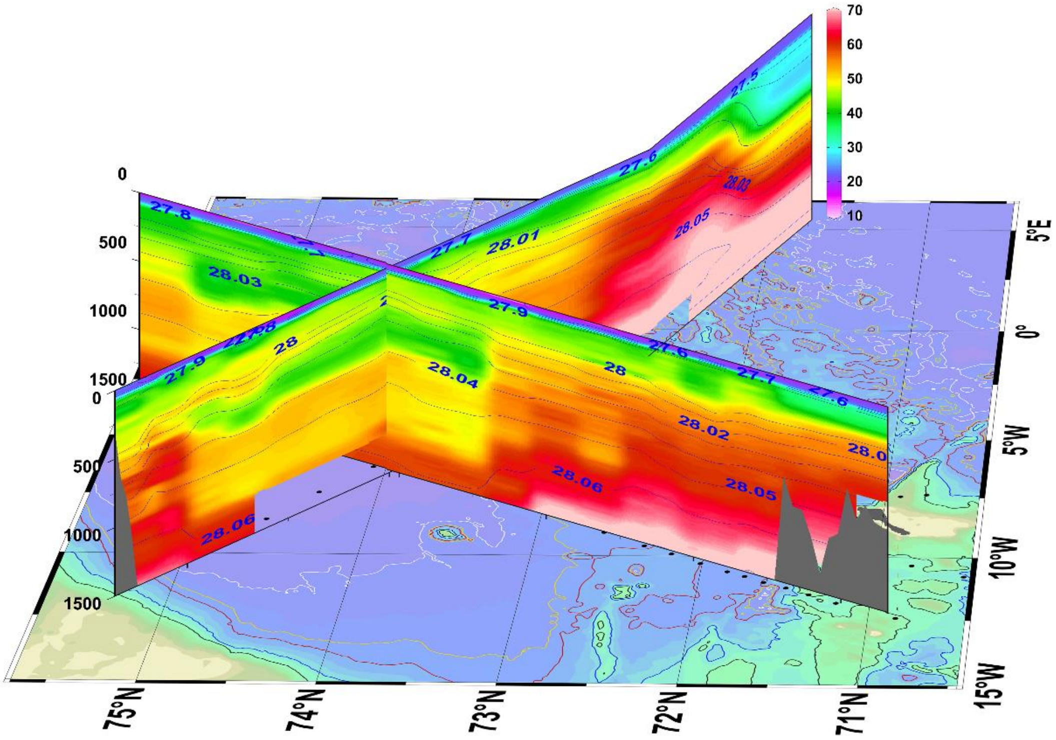


Figure 4.3.3 Distrubition of Apparent Oxygen Consumption (AOU) in the Greenland Sea. The AOU was derived from dissolved oxygen

4.4 Temperature-salinity diagrams

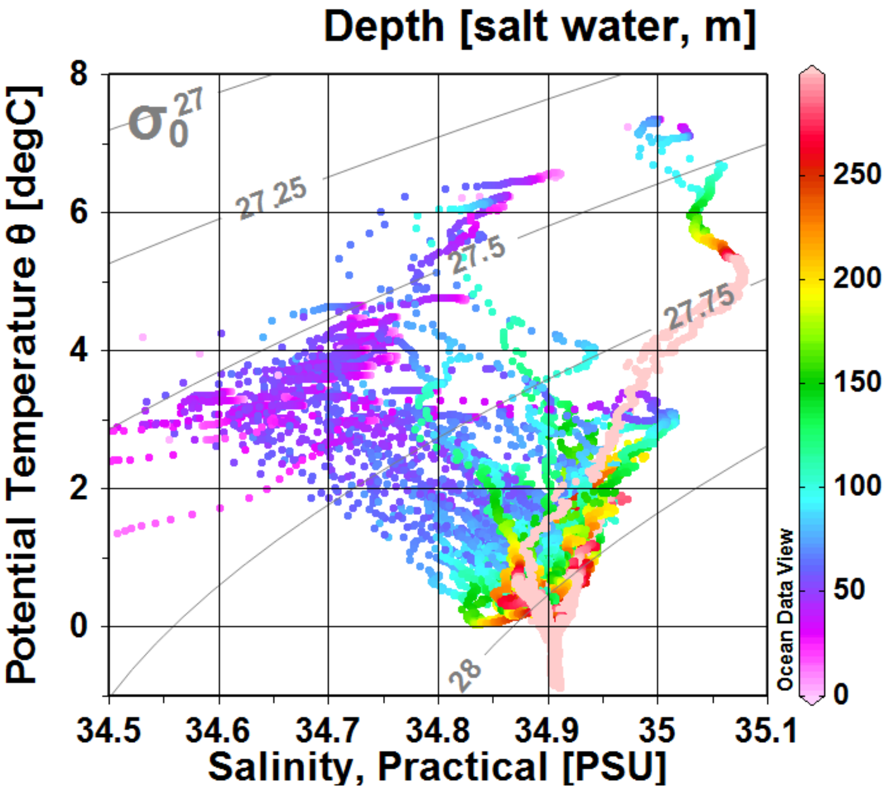


Figure 4.4.1 Temperature-salinity diagrams of all the stations.

There are almost no water bodies with temperatures below 0 ºC, which has never occurred in the Greenland Sea.

Appdedix A

Field work photos

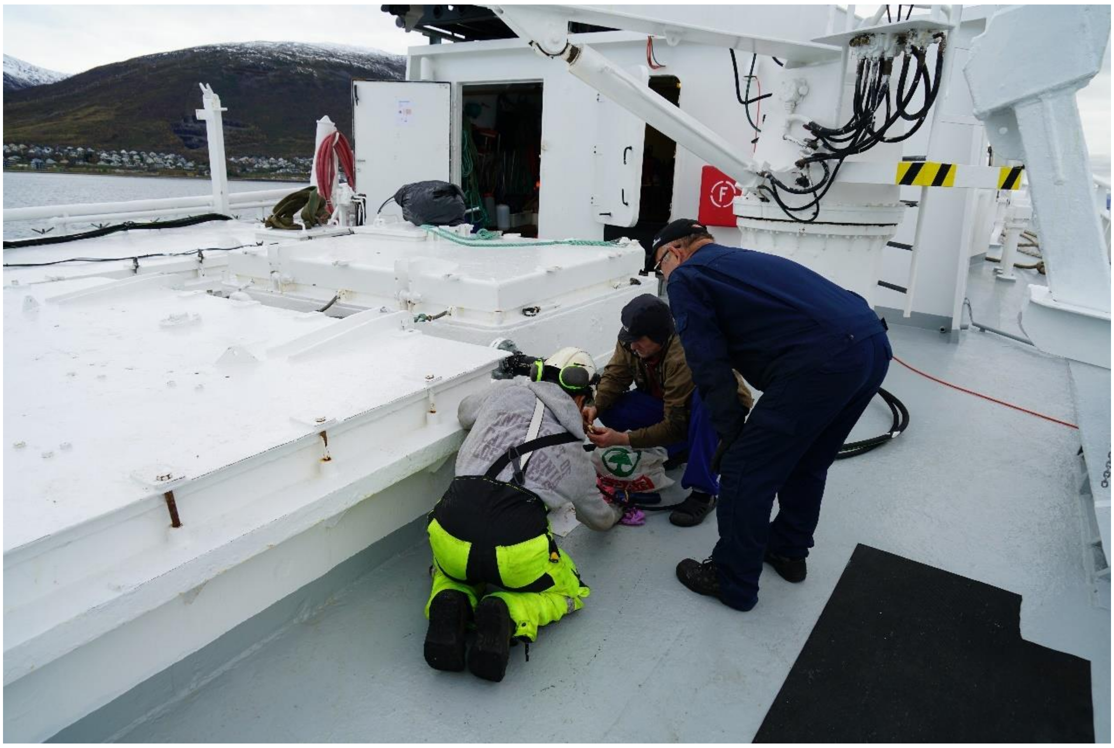


Figure 3.1.1 Preparatory work before the cruise (October 1st)

Figure 3.1.2 Data recovery from the CTD during work (October 4st)

Figure 3.1.3 Winch oprator (October 4st). we use a blue nylon rope as shown on this figure to replace the wirerope after when the wirerope was broke.

Figure 3.1.4 SBE-25 plus CTD Deployment in a sowny weather (October 8st)

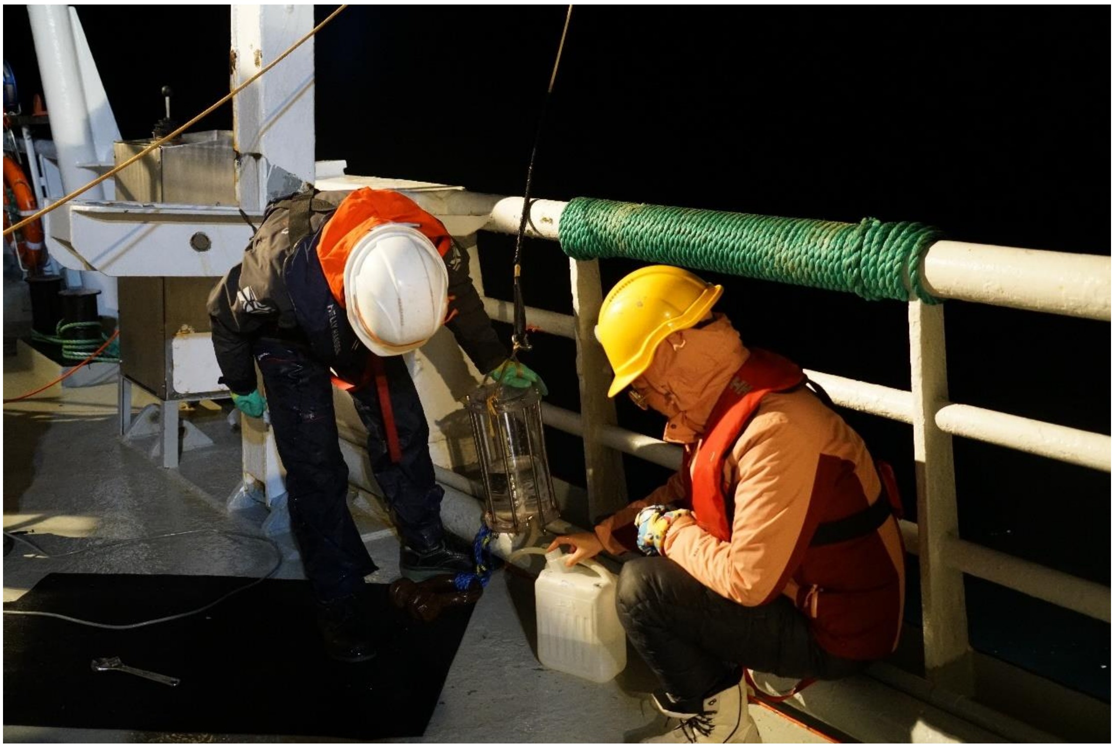


Figure 3.1.5 The plastic bottle used to sample waters at surface, 50m and 100m.