JR274 physical oceanographic analyses

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June 2014, **updated February 2015 to correct mean SST plot (Fig. 4.3)**

Contents

1 Introduction

This report gives a physical oceanographic context to the sampling carried out during RRS *James Clark Ross* cruise JR274, 09 Jan—12 Feb 2013, part of the UK Sea Surface Consortium Ocean Acidification research project. Data collected during the cruise, together with the cruise report, are available, from the British Oceanographic Data Centre; see https://www.bodc.ac.uk/data/information_and_inventories/cruise_inventory/report/11606/. The cruise report contains details on the equipment deployed during the cruise and sampling procedures. Note that there are some errors in the deployment information of some of the CTDs from JR274 in the cruise CTD log and cruise report: a corrected version is provided in Section 3 of this report.

For this report, data from physical oceanographic instruments used during the cruise together with remotely-sensed variables have been processed as required, plotted and analysed. Final datasets and plots (at higher resolution than presented in this report) generated from this project are stored in accompanying folders – see Appendix 1 for file listings. If you require any of the intermediate datasets, please contact Sally Thorpe (seth@bas.ac.uk).

2 Underway data

2.1 Oceanlogger and meteorological data

Surface ocean and meteorological data were logged continuously throughout JR274 using the ship's uncontaminated seawater supply and instruments on the ship's forward mast. Surface ocean data were recorded at five second intervals and meteorological data at two second intervals. The surface ocean data were processed after JR274 by Rachel Sanders and Matthew Palmer and are available from BODC. As part of the processing, the data were averaged into 1 minute intervals and the underway temperature and salinity data streams were calibrated against CTD data taken during the cruise. Further details can be found in the report by R. Sanders and M. Palmer, a copy of which is stored in the folders accompanying this report (see Appendix 1).   No further processing was undertaken as part of this project.

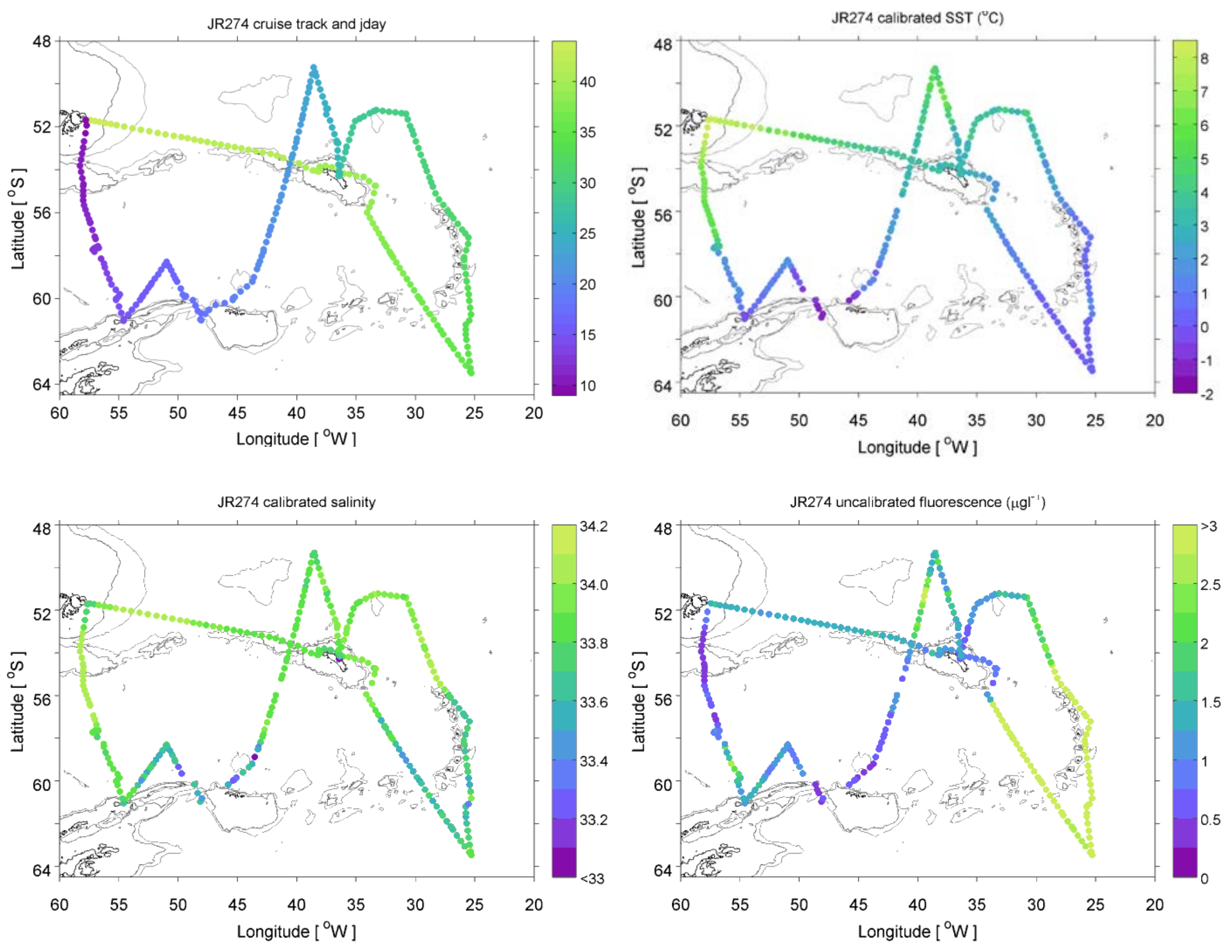

Fig. 2.1: Cruise track and underway data recorded during JR274: top left = cruise track coloured according to day of year (jday) occupied; top right = sea surface temperature; bottom left = salinity; bottom right = fluorescence. All data have been averaged onto one minute intervals; the temperature and salinity data have been calibrated but the fluorescence data remain uncalibrated. Unflagged data points every two hours are

plotted. The 1000 m and 2000 m isobaths are plotted in dark and light grey respectively. (Files = JR274/plots/underway/jr274_ocl_[jday/sst/salin/fluor/]_bodc.png)

Surface water temperatures encountered during JR274 increased with increasing latitude, ranging from <-1°C close to the South Orkney Islands to >8°C in the northeast of the study region near to the Falkland Islands. Salinity was lowest in the south of the study region with fresher water indicating the recent presence of sea ice. Surface salinity values were also low in Cumberland Bay, most likely due to glacial run-off.

A visual comparison of the underway fluorescence data with satellite-derived data for the cruise region (Section 4.4, Fig. 4.4) shows only moderate agreement between the two datasets, even taking into account that the underway data are uncalibrated. The area of greatest disagreement is east of South Georgia where the oceanlogger recorded high fluorescence (5—8 µg l^{-1}) on the easternmost transect towards and south of the South Sandwich Islands and on the subsequent northbound transect. The oceanlogger values remain high in comparison with the satellite data for the remaining cruise transit back to the Falkland Islands. Plots of the fluorescence data on the same colour axes as the satellite data (Fig. 4.4) are included in the plots folder for easier comparison between the datasets. The data suggest biofouling of the sensor (a concern that was raised by T. Tyrrell in the cruise report, p55) and it is recommended that the **underway fluorescence data should be treated with caution**.

2.2 Bathymetry data

Note that bathymetric data were collected with a hull-mounted Simrad EA600 single beam echosounder during JR274 but these data have not been processed as part of this project. The raw data are available on request from the British Antarctic Survey Polar Data Centre (polardatacentre@bas.ac.uk).

3 CTD data

A Conductivity-Temperature-Depth recorder (CTD) was deployed at all biological sampling stations during JR274 to characterise the hydrography and collect water samples (Fig. 3.1). The CTD data were processed and calibrated after the cruise by Matthew Palmer, National Oceanography Centre, and submitted to the British Oceanography Data Centre (BODC), from where the data on the downcast of each deployment are available at 1 m depth resolution and in a number of file formats: see https://www.bodc.ac.uk/data/information_and_inventories/cruise_inventory/report/11606/

Appendix 2 gives further details of the CTD deployments including location, depth and CTD frame which determined sensor configuration (further detail in the cruise report). Note that the event log from the cruise, including the copy in the cruise report, has **incorrect information (location and water depth) for several CTDs** – the correct information is given in Appendix 2. Location was corrected by comparing the time of the CTD with the underway navigation data. Water depth was corrected by referring back to the CTD log sheets from the cruise.

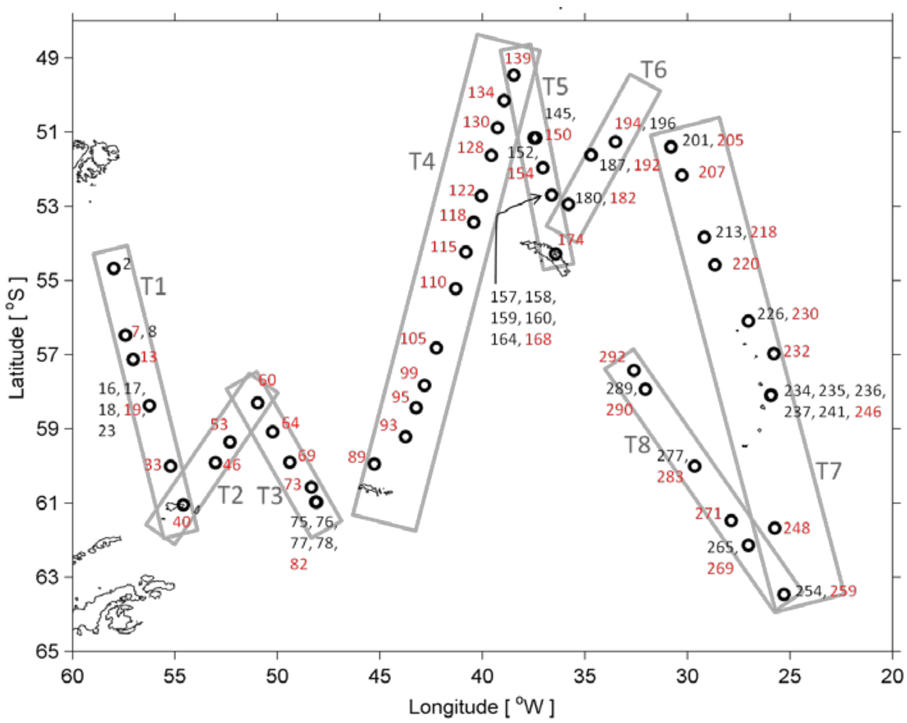

Fig. 3.1: Locations of JR274 CTDs (from corrected event information). Event numbers are given alongside CTD positions; red text indicates the deepest cast at each station. Corresponding station numbers are given in Fig. 3.2, and details on each CTD cast are given in Appendix 2. Transects used in subsequent figures are marked with grey rectangles (T1—T8).

Details of the minimal subsequent processing carried out to the CTD data as part of this project are given in Appendix 3.

Vertical profiles of potential temperature, salinity, potential density, PAR, fluorescence, dissolved oxygen, and beam attenuation/transmittance have been plotted per cast (see Fig. A4.1 in Appendix 6). A blank profile plotted for a cast indicates that that variable was not measured on that particular cast.

3.1 Hydrography: fronts and water masses

Stations occupied during JR274 spanned the Antarctic Circumpolar Current (ACC) and sampled the Weddell Sea. Based on the potential temperature-salinity properties of each CTD and using the nomenclature of Orsi et al (1995) for the zones of the ACC, the JR274 stations can be divided into the following water mass zones (Table 3.1, Fig 3.2). Note that two stations were located very close to the southern ACC front (SACCF) making it difficult to assign them north or south of the front (stations 17 and 31); as such, these stations are denoted 'SACCF'. The CTD station occupied in Cumberland Bay (station 30) has its own distinct water mass properties and is labelled 'South Georgia Shelf'. Any stations south of the southern boundary of the ACC have been classified as 'Weddell Sea'; most are likely to lie in the Weddell-Scotia Confluence. The water mass zones are separated by the fronts of the ACC. The transects crossed, from north to south, the Polar Front, SACCF and the southern boundary of the ACC (SB). The positions of the fronts across the region, beyond the CTD transects, can be approximated from dynamic height data – see Section 4.1 and Fig. 4.1.

Table 3.1: Classification of the JR274 stations according to sampled water masses

Water mass zone	Southern front	Northern front	Stations
Polar Frontal Zone (PFZ)	PF	SAF	1, 2, 19, 20, 25, 26
Southern Zone (SZ)	SACCF	PF	21—24, 27—29, 32, 34
SACCF	N/A	N/A	17, 31
Antarctic Zone (AZ)	SB	SACCF	3, 4, 6—8, 14—16, 33, 35, 36, 48, 49
Weddell Sea (WS)	SB	N/A	5, 9—13, 37—40, 42—46
South Georgia shelf (SG)	N/A	N/A	30

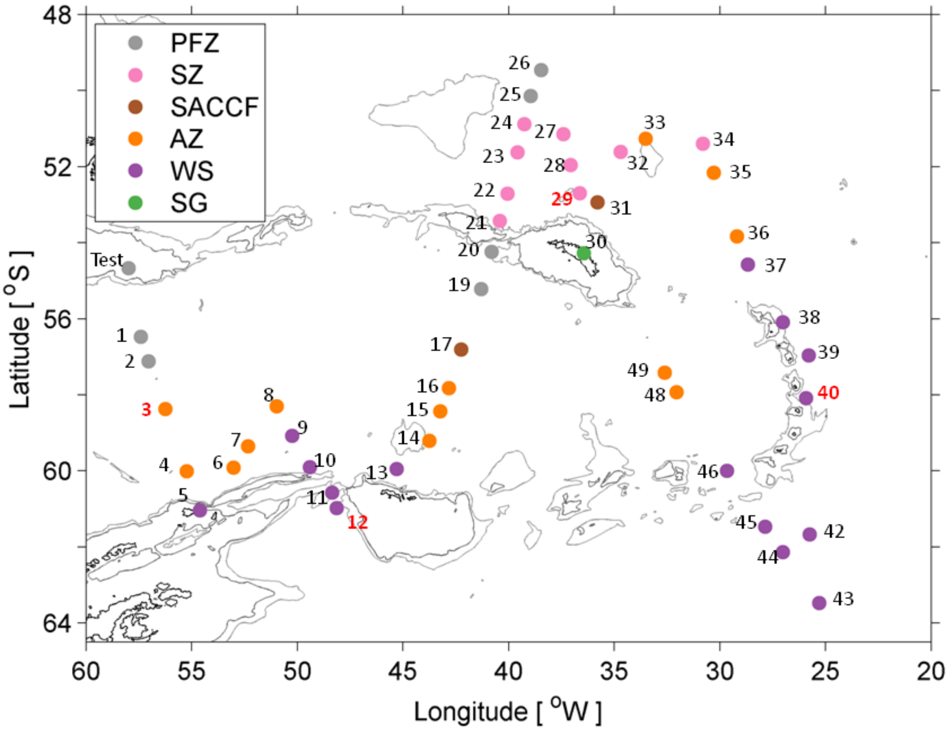

Fig. 3.2: JR274 CTD stations coloured according to water mass zone. Station numbers are marked, those in red denote locations of bioassay stations. Abbreviations used in the legend, together with the fronts that separate the water mass zones, are defined in Table 3.1. The 1000 m and 2000 m isobaths are plotted in dark and light grey respectively. (File = JR274/plots/jr274_ctdgroups_map_stns.png)

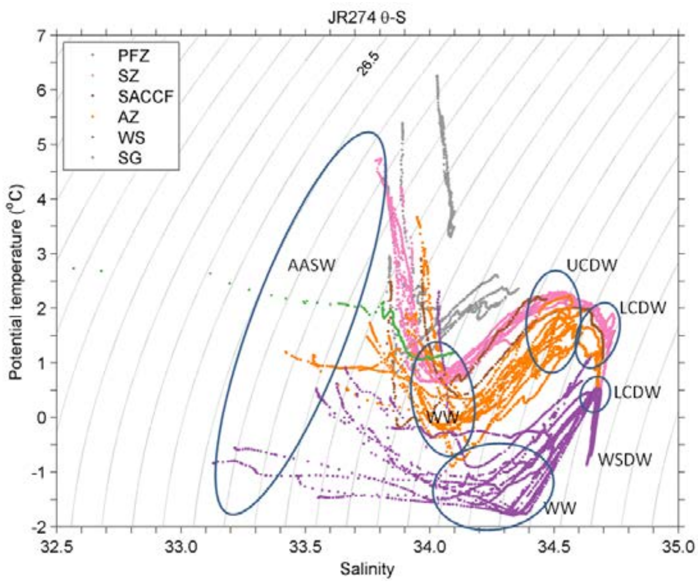

Fig. 3.3: Potential temperature-salinity profiles from CTDs taken during JR274. Profiles are coloured according to water mass zone (see Table 3.1 for abbreviations). Dotted lines mark contours of potential density anomaly (intervals of 0.1 kg m^{-3}). Water masses are marked (see text for abbreviations). Note that the order the profiles were plotted in mean that some of the data from the northern groupings are obscured. (File = JR274/plots/CTD/jr274ts_groups.png)

Potential temperature-salinity properties in each of the water mass zones can be determined from Fig. 3.3. Data plotted at the left side of the profiles mark surface waters, with depth increasing towards the right of the plot. Antarctic Surface Water (AASW) is only found south of the PF. Its temperature ranges from <-1°C to 5°C with salinity varying from <33 to ~34. The temperature minimum layer beneath AASW is Winter Water (WW) which retains the properties of the surface layer from the previous winter. The southern boundary of the ACC can be seen in the WW properties: WW south of the SB is colder and generally more saline, demonstrating the presence of sea ice the previous winter at these JR274 stations. Beneath the WW lies Circumpolar Deep Water which can be divided into Upper Circumpolar Deep Water (UCDW) and Lower Circumpolar Deep Water (LCDW). UCDW is warmer and less saline, and therefore less dense, than LCDW. A decrease in the temperature maximum of the UCDW marks the SACCF with stations north of the SACCF generally having a subsurface temperature maximum >2°C. The southern limit of UCDW marks the SB of the ACC. The properties of LCDW change across the SB becoming colder and less saline in the Weddell Sea. North of the SB, the core of LCDW is generally >1.5°C with salinity >34.7. South of the SB, maximum potential temperature of the LCDW is ~0.5°C with salinity >34.65. Beneath the LCDW lies WSDW, sampled only by the deepest CTDs, with potential temperature <0°C and salinity <~34.65.

Depth ranges of the water masses can be seen in the vertical property sections along the north-south transects of the cruise (accompanying plots, example in Appendix 4). AASW and WW typically occupy the top 100—150 m although stations 9—11 along transect 3 show evidence of mixing to > 200 m. UCDW shoals southwards across the ACC; its temperature-maximum core is around 400 m at the northern end of transect 7, decreasing to <300 m where sampled in the southern stations of the cruise. The core of LCDW also shoals southward from depths of ~1000 m in the northern stations to <500 m in the south.

4 Satellite data

4.1 Absolute dynamic topography/sea surface height

Maps of absolute dynamic topography/sea surface height can be used to provide a Scotia Sea-wide view of the positions of the ACC fronts (Venables et al, 2011). The ACC fronts can be approximated by fixed ranges of dynamic height across the Scotia Sea; the exact values depend on the constant of integration that is applied when calculating dynamic height. Here near real time maps of absolute dynamic topography were downloaded from Aviso (Rio and Hernandez, 2004) and used to calculate a composite dynamic height field for the duration of the cruise. The mean field was mapped using the frontal definitions of Venables et al (2011; Table 4.1) to produce mean positions of the fronts during JR274 (Fig 4.1).

Table 4.1: Values of absolute dynamic height used to map the ACC fronts encountered during JR274. Note that to ease visualisation, one value rather than a range was used for the SACCF and SB. Values were derived by Venables et al (2011).

Front	Absolute dynamic height value (dyn cm)
Polar Front	-71 to -45
SACCF	-99
SB	-116

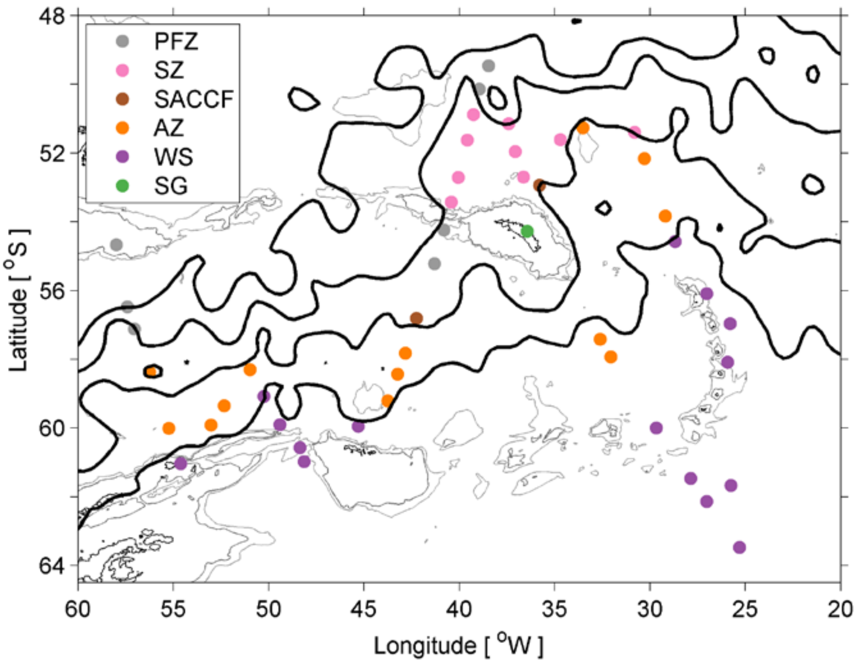

Fig. 4.1: Mean positions of the ACC fronts (thick black lines) during JR274 superimposed on the water mass zone classification of the CTDs. From north to south the fronts are: northern limit of the Polar Front, southern limit of the Polar Front, SACCF and SB as derived from absolute dynamic topography data provided by Aviso. The 1000 m and 2000 m isobaths are plotted in dark and light grey respectively. (File = JR274/plots/CTD/jr274_ctdgroups_map_dhtfronts.png)

The mean dynamic height-derived estimates of the fronts are in good agreement with the positions of the fronts determined from the CTD data. The main discrepancy occurs on transect 8 where the position of the SB as delineated by dynamic height data, both in the mean field and in the daily fields from the cruise period, lies two stations north of the water mass boundary (between stations 46 and 48). This suggests that in this region surface processes make the dynamic-height derived estimate of the position of the SB less reliable for this time period.

Drake Passage is a particularly dynamic region (Fig. 4.2). Daily positions of the fronts over the cruise period show north-south movements of the fronts in this region together with eddy-shedding. The dynamic height data suggest that at the time of sampling, station 3 was located in a cyclonic eddy recently shed from the SACCF. Plots for the whole cruise region for the same dates are available in the plot folder (see Appendix 1 for file listings).

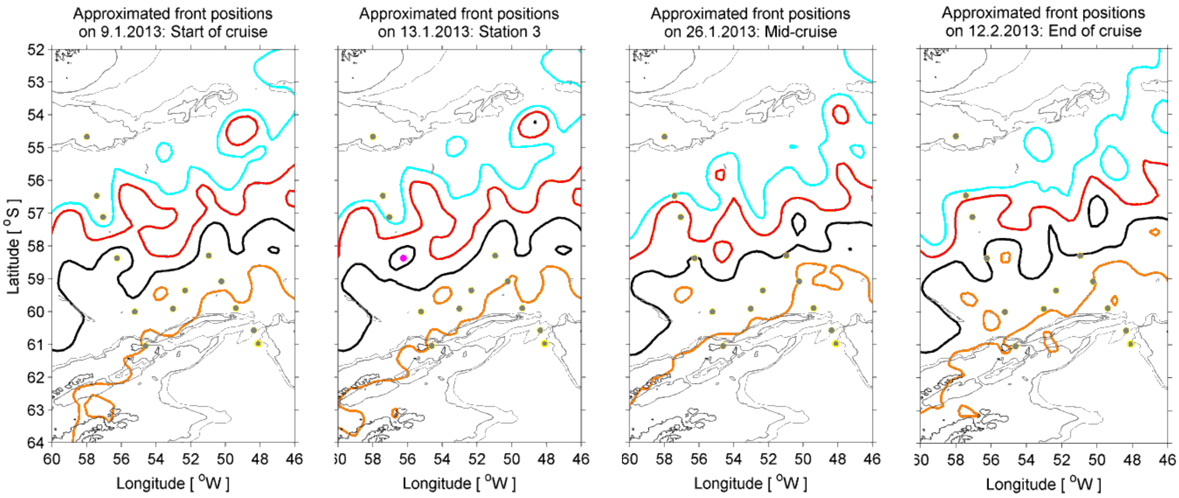

Fig. 4.2: Time-varying positions of the ACC fronts over the period of JR274 derived from absolute dynamic topography fields provided by Aviso. Fronts are colour coded: northern limit of the PF—cyan, southern limit of the Polar Front—red, SACCF—black, SB—orange. JR274 CTD stations are plotted in grey circles, the magenta circle in panel 2 marks station 3 on the day that the station was sampled (13 Jan 2013). The 1000 m and 2000 m isobaths are plotted in dark and light grey respectively. (Files = JR274/plots/dynht-fronts/jr274fronts_[date]_sub.png)

4.2 Sea ice concentration

High resolution (1/20 °), daily fields of sea ice fraction (concentration) provided by the UK Met Office Operational Sea Surface Temperature and Sea Ice analysis (OSTIA; Stark et al, 2007; Martin et al, 2007; Donlon et al, 2011) were downloaded from the MyOcean Data Access Portal (www.myocean.eu) for the cruise duration and for several weeks prior to the cruise to allow examination of the sea ice field and how it may have impacted the stations occupied during JR274. A sea ice fraction of 0.15 is commonly used to mark the sea ice edge; in the OSTIA dataset all values < 0.15 are set to 0.

Sea ice conditions were unusual in the Weddell Sea/southern Scotia Sea in the 2012/2013 summer season, with sea ice extending further northwards than average for the period December 2012—April 2013 (Fig. 4.2, top left). One month before the cruise, sea ice extended to approximately 60°S east of the Antarctic Peninsula across the cruise region. From then, the sea ice retreated southwards and westwards so that by the start of JR274 only the southwestern stations were impacted by sea ice. Sea ice remained dense in the northwestern Weddell Sea throughout the cruise.

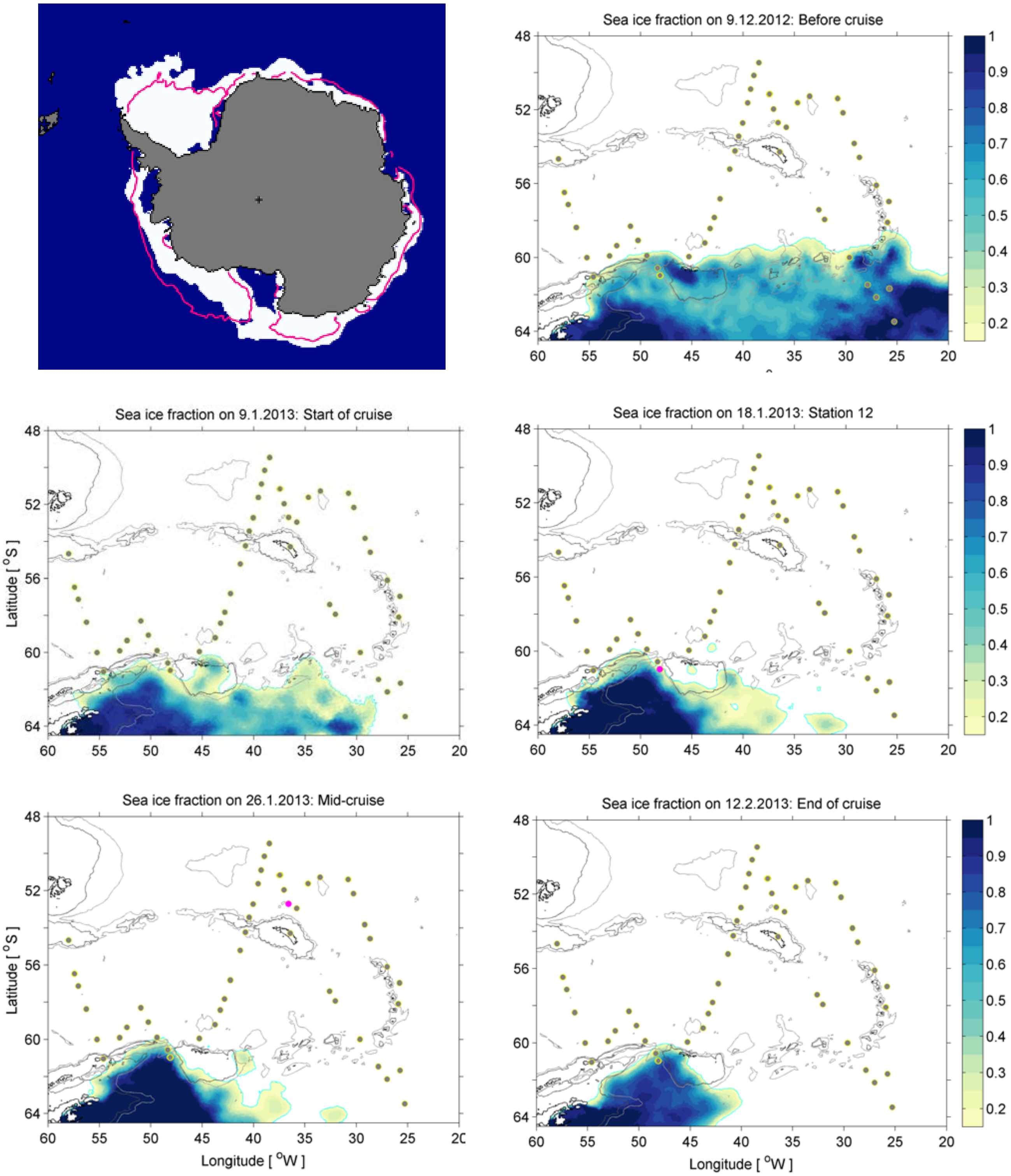

Fig 4.2: Sea ice conditions during JR274. Top left plot shows mean sea ice extent for January 2013 (white) overlaid by the median January ice edge for the period 1981—2010 (magenta line). Image provided by National Snow and Ice Data Center, Boulder, Colorado from http://nsidc.org/data/seaice_index/archives/image_select.html (accessed May 2014; Fetterer et al, 2002). Remaining panels show sea ice fraction from daily OSTIA fields one month before the cruise, at the cruise start,

at the time station 12 was sampled, at the mid-point of the cruise and at the end of the cruise. Station positions are plotted. The pink circle in the 18.01.2013 and 26.01.2013 plots marks the progress of the cruise up to that date. (Files = JR274/plots/sea-ice/ jr274seaiceedges_[date].png)

4.3 Sea surface temperature

High resolution (1/20 °), daily fields of sea surface temperature (SST) provided by the UK Met Office Operational Sea Surface Temperature and Sea Ice analysis (OSTIA; Stark et al, 2007; Martin et al, 2007; Donlon et al, 2011) were downloaded from the MyOcean Data Access Portal (www.myocean.eu) and averaged to create a composite SST field for the cruise duration (Fig. 4.3). Temperatures <-1°C in the northwestern Weddell Sea mark the presence of sea ice.

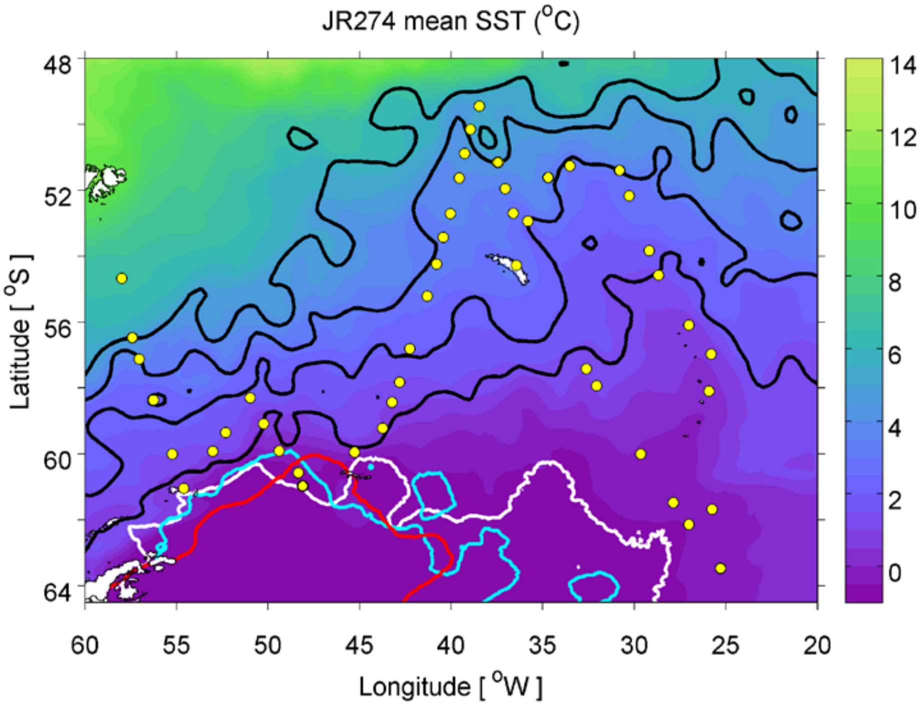

Fig. 4.3: Mean SST during JR274 averaged from daily, 1/20° resolution OSTIA fields for 09 Jan—12 Feb 2013. Superimposed is the sea ice edge at the start (white line), middle (cyan line) and end (red line) of the cruise as determined by the limit of 15% sea ice concentration (see Section 4.2 for data information). Black lines mark the positions of the ACC fronts during the cruise as determined from dynamic height data provided by Aviso; from north to south the fronts are: northern limit of the Polar Front, southern limit of the Polar Front, SACCF and SB. Further details are given in Section 4.1 above. (File = JR274/plots/sst/jr274_meansst.png)

4.4 Ocean colour (provided by Hugh Venables)

Fig. 4.4 shows the composite chlorophyll *a* field over the duration of JR274, constructed from MODIS satellite data (8 day, 9 km Level 3 mapped images; available from http://oceancolor.gsfc.nasa.gov/) by Hugh Venables, BAS. Blooms are evident to the northwest of South Georgia and east of the South Sandwich Islands.

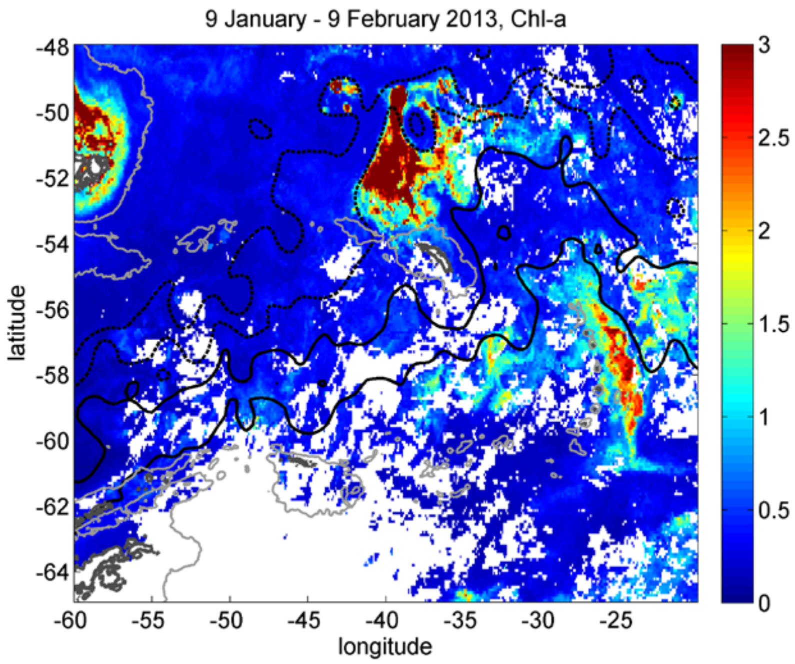

Fig 4.4: Mean chlorophyll a (μg m^{-3}) for the cruise period calculated from MODIS ocean colour products by Hugh Venables, BAS. Grey line shows 1000 m isobaths, black lines mark the position of the ACC fronts determined from sea surface height data as before. From north to south the fronts are: northern limit of the Polar Front, southern limit of the Polar Front, SACCF and SB. White grid cells mark missing data due to sea ice and cloud cover. (File = JR274/plots/chla-satellite/modisCHL_chlor_a90402013c3nsfronts.png)

5 Mixed layer depth

Local surface processes including wind mixing and density-driven convection influence the depth of the surface mixed layer in the ocean. There are a number of methods to automatically determine the surface mixed layer depth (MLD). This analysis used the criterion of Venables et al (2013) from the Western Antarctic Peninsula that MLD is defined as the depth where potential density differs from that at the surface by 0.05 kg m^{-3}. For JR274 this was a reasonable approximation for almost all stations (see accompanying vertical profile plots; an example is given in Appendix 4, Fig. A4.3). Note that tracer experiments carried out in the Southern Ocean suggest that mixed layer depth may be shallower than the deepest depths derived by this method (P. Nightingale, pers. comm.). MLD for each station, together with mean properties for the mixed layer, is given in Table 5.1, and a map of MLD along the cruise transect in Fig. 5.1. Data for all CTD casts are given in accompanying file JR274_mld.xls.

Table 5.1: Properties of the mixed layer at each station using data from the stainless steel frame casts. Grey shading indicates where the criterion used to select the base of the mixed layer may not be appropriate – refer to the accompanying CTD profile plots, an example of which is given in Appendix 4. ML—mixed layer, B—Bioassay.

Station	Event No.	CTD No.	Date	Mixed layer depth (m)	Shallowest data point (dbar)	Mean ML *in situ* temperature (°C)	Mean ML salinity	Mean ML potential density (kg m^{-3})	Mean ML dissolved oxygen (µmol L^{-1})
1	7	2	11/01/2013	54.49	3	5.40	34.05	26.88	317.19
2	13	4	11/01/2013	56.47	4	5.36	34.04	26.88	318.79
3 (B1)	23	9	13/01/2013	73.30	17	1.84	33.92	27.12	350.97
4	33	10	14/01/2013	51.50	16	0.73	33.92	27.19	352.80
5	40	11	14/01/2013	13.87	4	-0.20	33.87	27.21	353.11
6	46	12	15/01/2013	21.79	5	0.90	33.75	27.04	357.71
7	53	13	15/01/2013	26.75	2	1.11	33.85	27.12	353.87
8	60	14	16/01/2013	53.49	5	1.61	33.77	27.01	349.61
9	64	15	16/01/2013	18.82	4	-0.31	33.78	27.13	357.67
10	69	16	17/01/2013	17.83	4	-0.81	33.18	26.67	367.70
11	73	17	17/01/2013	14.86	4	-1.13	33.48	26.93	365.34
12 (B2)	82	22	18/01/2013	21.79	4	-1.46	33.57	27.01	360.48
13	89	23	19/01/2013	29.72	3	-0.57	33.23	26.70	366.97
14	93	24	19/01/2013	21.79	4	1.07	33.54	26.87	355.76
15	95	25	20/01/2013	18.82	5	1.16	33.44	26.78	355.39
16	99	26	20/01/2013	33.68	6	1.57	33.92	27.14	346.46
17	105	27	20/01/2013	55.48	6	2.42	33.84	27.01	346.05
19	110	28	21/01/2013	56.48	17	2.83	33.84	26.97	342.65
20	115	29	21/01/2013	69.36	10	2.86	33.84	26.97	341.64
21	118	30	22/01/2013	103.05	6	2.56	33.89	27.04	346.20
22	122	31	22/01/2013	74.33	4	3.27	33.89	26.97	359.52
23	128	32	22/01/2013	63.43	5	3.90	33.85	26.88	365.47
24	130	33	23/01/2013	39.65	5	4.40	33.82	26.81	348.18
25	134	34	23/01/2013	67.41	4	5.24	33.89	26.77	320.97
26	139	35	23/01/2013	56.51	6	4.25	33.83	26.83	337.11
27	145	36	24/01/2013	36.68	3	4.67	33.80	26.76	346.31
28	152	38	24/01/2013	52.53	3	3.56	33.87	26.93	348.75
29 (B3)	164	44	25/01/2013	75.32	2	2.23	33.93	27.10	342.28
30	174	46	27/01/2013	6.94	5	2.71	32.79	26.24	338.77
31	180	47	27/01/2013	30.72	15	2.69	33.97	27.09	341.37
32	187	49	28/01/2013	48.57	7	3.51	33.86	26.93	340.45
33	194	51	28/01/2013	50.55	5	2.81	33.98	27.09	342.53
33	196	52	28/01/2013	54.52	6	2.84	33.98	27.08	342.24
34	201	53	29/01/2013	34.69	3	4.19	33.88	26.88	345.08
35	207	55	29/01/2013	26.76	4	3.56	33.96	27.00	340.40
36	213	56	30/01/2013	39.64	5	1.48	33.93	27.15	353.17

37	220	58	30/01/2013	39.64	5	1.95	34.04	27.20	376.30
38	226	59	31/01/2013	37.65	9	0.91	33.69	27.00	391.93
39	232	61	31/01/2013	28.73	7	0.52	33.63	26.97	382.51
40 (B4)	241	66	01/02/2013	43.59	9	0.37	33.71	27.04	375.49
42	248	68	02/02/2013	30.70	5	0.35	33.56	26.93	353.48
43	254	69	03/02/2013	43.57	6	0.28	33.85	27.16	350.46
44	265	71	04/02/2013	29.71	8	0.07	33.63	27.00	357.32
45	271	73	04/02/2013	29.71	3	0.22	33.65	27.01	360.96
46	277	74	05/02/2013	25.75	6	0.40	33.55	26.92	351.94
48	289	76	06/02/2013	50.52	12	1.41	33.84	27.08	347.42
49	292	78	06/02/2013	43.59	8	1.44	33.76	27.02	351.19

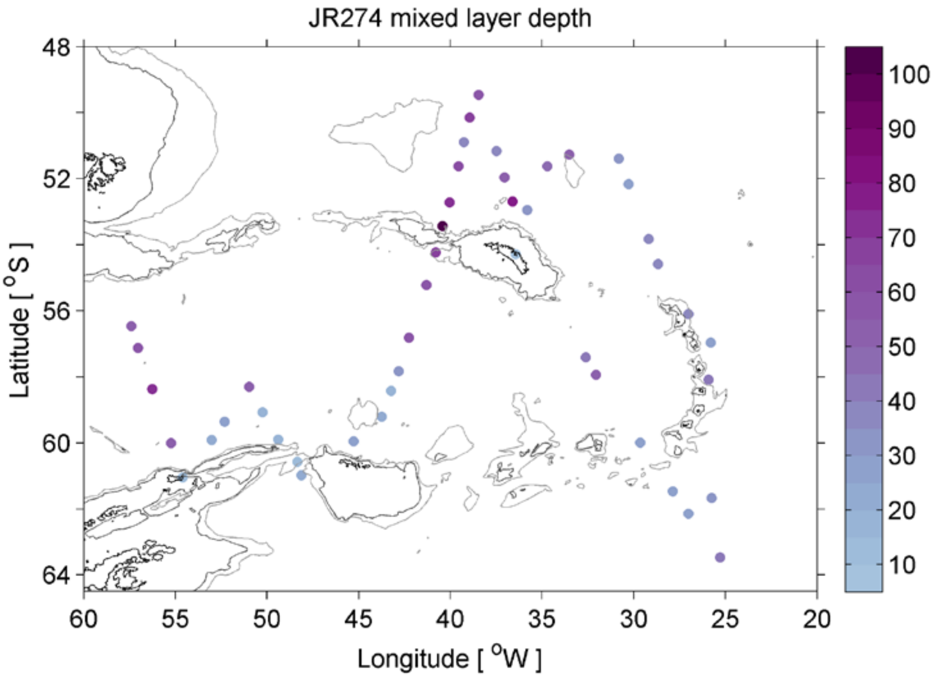

Fig 5.1: Mixed layer depth (m) derived from density profile at each CTD station, defined as the depth where potential density has changed by 0.05 kg m^{-3} from the surface value (Venables et al., 2013).

6 Acknowledgements

This project to analyse the physical oceanographic data from JR274 was carried out with funding from the Natural Environment Research Council (NERC). JR274 was one component of the Sea Surface Consortium Ocean Acidification research project that is jointly funded by NERC, the Department for Environment, Food and Rural Affairs, and the Department of Energy and Climate Change. The datasets and analyses presented in this report owe their existence to the scientists, officers and crew onboard JR274. Matthew Palmer and Rachel Sanders processed and calibrated the underway and CTD data. Processing of the physical oceanographic data made extensive use of Unix and Matlab scripts developed over time by various oceanographers onboard the RRS *James Clark Ross*, including, but not limited to, H Venables, J Screen, M Meredith, M Brandon and B King. The altimeter products were produced by Ssalto/Duacs and distributed by Aviso with support from Cnes.

The OSTIA high resolution sea surface temperature and sea ice data were provided through www.myocean.eu. MODIS chlorophyll data were provided by the NASA Ocean Biology Processing Group.

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Appendix 1: Accompanying files

The following identifiers are used in file naming:

C = CTD number; **DD** = day of month; **EEE** = 3 digit event number; **MM** = month; **N** = transect number; **SS** = station number. Details of CTDs are given in Table A2.1, and Fig. 3.1 shows station to transect allocations. Examples of the accompanying plots are given in Appendix 4.

JR274/data/MLD

- JR274_mld.xlsx Information on mixed layer for each CTD cast. Data in Table 5.1 were extracted from this file.

JR274/data/oceanlogger

- JR274 Underway Data Processing Report.pdf Provided by Rachel Sanders & Matthew Palmer.

JR274/plots/chla-satellite

- modisCHL_chlor_a90402013c3nsfronts[LOG].png Mean chl-*a* over cruise duration on standard and log colour scale.

JR274/plots/CTD

- **t-s-along-transects/**jr274transect**N**ts.png Potential temperature-salinity plots for stations along designated transects of JR274 (see Fig. 3.1 for transect information).

- **vertical-profiles/**jr274ctd**EEE**_stn**SS**_ctd**C**.png Plots of potential temperature, salinity and potential density vs pressure (0—300 db) for each CTD cast on JR274.

- **vertical-profiles/**jr274ctd**EEE**_stn**SS**_ctd**C**_pfo.png As above but for PAR, fluorescence and dissolved oxygen.

- **vertical-profiles/**jr274ctd**EEE**_stn**SS**_ctd**C**_att.png As above but for beam attenuation; only present for CTD casts where attenuation was measured.

- **vertical-sections/**jr274transect**N**_[chloxyatt/ptmpsalsig0].png Vertical sections (latitude v pressure) of CTD data: fluorescence, dissolved oxygen and beam attenuation (*_chloxyatt.png) or potential temperature, salinity and potential density (*_ptmpsalsig0.png).

- **vertical-sections/**jr274transect**N**_deep.png Transects 5—8 included some deep CTDs. These plots show data (potential temperature, salinity and potential density) to the full depth range.

JR274/plots/dynht-fronts

- jr274fronts_2013**MMDD**[_sub].png Maps of daily front positions derived from dynamic topography (sea surface height) data. Files with _sub suffix are for Drake Passage subregion.

JR274/plots/MLD

- jr274ctd**EEE**_stn**SS**_ctd**C**_mld.png Vertical profiles of potential temperature, salinity and potential density for upper 200 m of each cast, with automatically-detected base of mixed layer marked on. See Section 5 for further details.

JR274/plots/sea-ice

- jr274seaice_2013**MMDD**.png Maps of daily sea ice fraction for before and during the cruise.

JR274/plots/sst

- jr274_meansst.png Mean sea surface temperature over cruise duration

JR274/plots/underway

- jr274_ocl_*_bodc.png Maps of underway data collected with the oceanlogger during the cruise: sea surface temperature, salinity and fluorescence. Also map of position v time (jr274_ocl_jday.png).

- jr274_ocl_fluor_[comp/complog].png Maps of underway fluorescence on same colour axes as the satellite chl-*a* field images for comparison of the datasets.

Appendix 2: CTD deployments during JR274

Table A4.1: Details of the CTD deployments made during JR274. Most information is from the cruise report but several corrections have been made (yellow highlighting). BODC CTD ID gives the reference number assigned to each CTD cast by BODC. Note that CTD event 260 was not processed as it was deployed to respool the wire. B—bioassay.

CTD no.	Station	Event no.	BODC CTD ID	Date	Jday	Time at bottom	Latitude	Longitude	Water depth (m)	Wire out (m)	CTD type
1		2	1147294	10/01/2013	10	14:25	-54.66707	-57.99904	164.65	150	Ti
2	1	7	1147301	11/01/2013	11	10:04	-56.46616	-57.41651	3691.63	300	SS
3	1	8	1147313	11/01/2013	11	11:12	-56.46652	-57.4262	3736.5	80	Ti
4	2	13	1147325	11/01/2013	11	20:23	-57.11791	-57.05145	4177.8	300	SS
5	3 (B1)	16	1147337	13/01/2013	13	05:46	-58.3668	-56.2518	3922	100	Ti
6	3 (B1)	17	1147349	13/01/2013	13	07:10	-58.36677	-56.25203	3923.13	100	Ti
7	3 (B1)	18	1147350	13/01/2013	13	08:29	-58.36676	-56.25207	3923.39	100	Ti
8	3 (B1)	19	1147362	13/01/2013	13	10:22	-58.36676	-56.25207	3923.39	300	Ti
9	3 (B1)	23	1147374	13/01/2013	13	12:17	-58.36672	-56.25203	3922.85	300	SS
10	4	33	1147386	14/01/2013	14	09:37	-60.00289	-55.22979	3541.97	300	SS
11	5	40	1147398	14/01/2013	14	20:23	-61.0397	-54.6065	469	300	SS
12	6	46	1147405	15/01/2013	15	09:38	-59.90964	-53.02372	3425.27	300	SS
13	7	53	1147417	15/01/2013	15	20:17	-59.34893	-52.32418	3554.33	300	SS
14	8	60	1147429	16/01/2013	16	09:52	-58.29467	-50.96993	3969.03	300	SS
15	9	64	1147430	16/01/2013	16	20:17	-59.07664	-50.24104	3658.78	300	SS
16	10	69	1147442	17/01/2013	17	09:25	-59.89697	-49.40004	3643.38	300	SS

17	11	73	1147454	17/01/2013	17	20:17	-60.56888	-48.35974	2033.71	300	SS
18	12 (B2)	75	1147466	18/01/2013	18	05:31	-60.97562	-48.08661	2672.65	100	Ti
19	12 (B2)	76	1147478	18/01/2013	18	06:46	-60.96537	-48.11142	2681.84	100	Ti
20	12 (B2)	77	1147491	18/01/2013	18	07:55	-60.96249	-48.12895	2687.99	100	Ti
21	12 (B2)	78	1147509	18/01/2013	18	09:28	-60.97377	-48.13854	2697.2	100	Ti
22	12 (B2)	82	1147510	18/01/2013	18	11:15	-60.97153	-48.13172	2694.14	300	SS
23	13	89	1147522	19/01/2013	19	09:15	-59.94594	-45.29096	4945.93	300	SS
24	14	93	1147534	19/01/2013	19	20:12	-59.21035	-43.75769	3529.81	300	SS
25	15	95	1147546	20/01/2013	20	02:32	-58.42487	-43.24598	3065.72	300	SS
26	16	99	1147558	20/01/2013	20	09:12	-57.82134	-42.83111	2878.71	300	SS
27	17	105	1147571	20/01/2013	20	20:12	-56.80874	-42.25444	4058.02	300	SS
28	19	110	1147583	21/01/2013	21	11:07	-55.21271	-41.31037	3317.66	300	SS
29	20	115	1147595	21/01/2013	21	20:12	-54.23129	-40.81069	2107.51	300	SS
30	21	118	1147602	22/01/2013	22	02:56	-53.42679	-40.42895	2257.77	300	SS
31	22	122	1147614	22/01/2013	22	09:11	-52.71253	-40.05703	3784.51	300	SS
32	23	128	1147626	22/01/2013	22	20:10	-51.61916	-39.57362	3753.9	300	SS
33	24	130	1147638	23/01/2013	23	02:42	-50.88208	-39.26671	4205.76	300	SS
34	25	134	1147651	23/01/2013	23	09:13	-50.1441	-38.95718	4730.71	300	SS
35	26	139	1147663	23/01/2013	23	20:08	-49.45312	-38.468	1744.81	300	SS
36	27	145	1147675	24/01/2013	24	09:11	-51.15393	-37.49	1846.52	300	SS
37	27	150	1147687	24/01/2013	24	13:40	-51.1452	-37.4112	1831	1400	Ti
38	28	152	1147699	24/01/2013	24	20:06	-51.95159	-37.0574	835.17	300	SS
39	28	154	1147706	24/01/2013	24	21:17	-51.95205	-37.05743	838.05	800	Ti
40	29 (B3)	157	1147718	25/01/2013	25	05:32	-52.68937	-36.62316	2444.75	100	Ti
41	29 (B3)	158	1147731	25/01/2013	25	06:53	-52.68934	-36.62309	2444.72	100	Ti
42	29 (B3)	159	1147743	25/01/2013	25	08:19	-52.6893	-36.62303	2445.19	100	Ti
43	29 (B3)	160	1147755	25/01/2013	25	10:01	-52.68935	-36.62298	2444.37	100	Ti
44	29 (B3)	164	1147767	25/01/2013	25	11:39	-52.69266	-36.6257	2436.42	300	SS
45	29 (B3)	168	1147779	25/01/2013	25	14:50	-52.69329	-36.62613	2434.31	1400	Ti
46	30	174	1147780	27/01/2013	27	09:09	-54.27859	-36.43797	253.1	240	SS
47	31	180	1147792	27/01/2013	27	20:10	-52.94	-35.80365	3584.58	300	SS
48	31	182	1147811	27/01/2013	27	21:29	-52.93895	-35.80361	3575.3	1400	Ti
49	32	187	1147823	28/01/2013	28	09:10	-51.61614	-34.71588	4773.97	300	SS
50	32	192	1147835	28/01/2013	28	14:13	-51.60738	-34.70032	4792.74	1400	Ti
51	33	194	1147847	28/01/2013	28	20:06	-51.25922	-33.51341	2168.81	300	SS
52	33	196	1147859	28/01/2013	28	20:58	-51.25922	-33.51341	2168.81	300	SS
53	34	201	1147860	29/01/2013	29	09:08	-51.38936	-30.8106	3925.99	300	SS
54	34	205	1147872	29/01/2013	29	13:06	-51.39285	-30.80584	3925.9	approx 3850	Ti
55	35	207	1147884	29/01/2013	29	20:13	-52.16261	-30.27999	2807.87	300	SS
56	36	213	1147896	30/01/2013	30	09:06	-53.82507	-29.18846	4644.71	300	SS
57	36	218	1147903	30/01/2013	30	14:17	-53.82504	-29.18898	4645.09	1400	Ti
58	37	220	1147915	30/01/2013	30	20:06	-54.57426	-28.67163	5803.04	300	SS
59	38	226	1147927	31/01/2013	31	09:09	-56.08998	-27.02802	1974.48	300	SS
60	38	230	1147939	31/01/2013	31	12:28	-56.08933	-27.0249	1990.56	1400	Ti

61	39	232	1147940	31/01/2013	31	20:07	-56.96529	-25.79537	3437.47	300	SS
62	40 (B4)	234	1147952	01/02/2013	32	05:25	-58.08568	-25.92582	2902.54	100	Ti
63	40 (B4)	235	1147964	01/02/2013	32	06:42	-58.08567	-25.92578	2903.13	100	Ti
64	40 (B4)	236	1147976	01/02/2013	32	07:51	-58.08563	-25.92582	2905.99	100	Ti
65	40 (B4)	237	1147988	01/02/2013	32	09:23	-58.08701	-25.92901	2899.38	100	Ti
66	40 (B4)	241	1148003	01/02/2013	32	10:55	-58.08791	-25.93085	2895.94	300	SS
67	40 (B4)	246	1148015	01/02/2013	32	15:03	-58.08994	-25.92779	2893.64	1400	Ti
68	42	248	1148027	02/02/2013	33	20:04	-61.67219	-25.75233	4543	300	SS
69	43	254	1148039	03/02/2013	34	09:05	-63.4658	-25.29852	4936.72	300	SS
70	43	259	1148040	03/02/2013	34	15:29	-63.46659	-25.29452	4942.37	4888	Ti
None	43	260	Not processed	03/02/2013	34	20:04	-62.13486	-27.02783	3975.37		Ti
71	44	265	1148052	04/02/2013	35	09:09	-62.13842	-27.02567	4147.03	300	SS
72	44	269	1148064	04/02/2013	35	13:21	-62.13825	-27.02291	4192.95	4290	Ti
73	45	271	1148076	04/02/2013	35	20:03	-61.47087	-27.86421	3735.58	300	SS
74	46	277	1148088	05/02/2013	36	09:07	-59.99655	-29.66046	2567.95	300	SS
75	46	283	1148107	05/02/2013	36	14:32	-59.9974	-29.65944	2559	2550	Ti
76	48	289	1148119	06/02/2013	37	12:57	-57.92899	-32.05382	2869.11	300	SS
77	48	290	1148120	06/02/2013	37	14:27	-57.92901	-32.05401	2869.57	2860	Ti
78	49	292	1148132	06/02/2013	37	20:07	-57.41319	-32.61576	3898.16	300	SS

Appendix 3: CTD processing

All CTD data from JR274 are stored by the British Oceanographic Data Centre (BODC). BODC holds a metadata report for each CTD station that details the sensors used and variables recorded, the post-processing carried out on the data and the calibration procedures. The metadata reports are provided at:
https://www.bodc.ac.uk/data/information_and_inventories/cruise_inventory/report/11606/

For this project, the data were retrieved from BODC and the following Matlab script was used to load in the data and remove flagged data points:

loadjr274ctd.m Loads in the downcast data for each CTD and stores as matrices. Data flagged as suspect by BODC are replaced with NaNs. A spike in potential temperature in CTD 72 (event 269), not picked up in the BODC processing, was also removed. Any gaps were filled with linear interpolation.

Appendix 4: Example plots

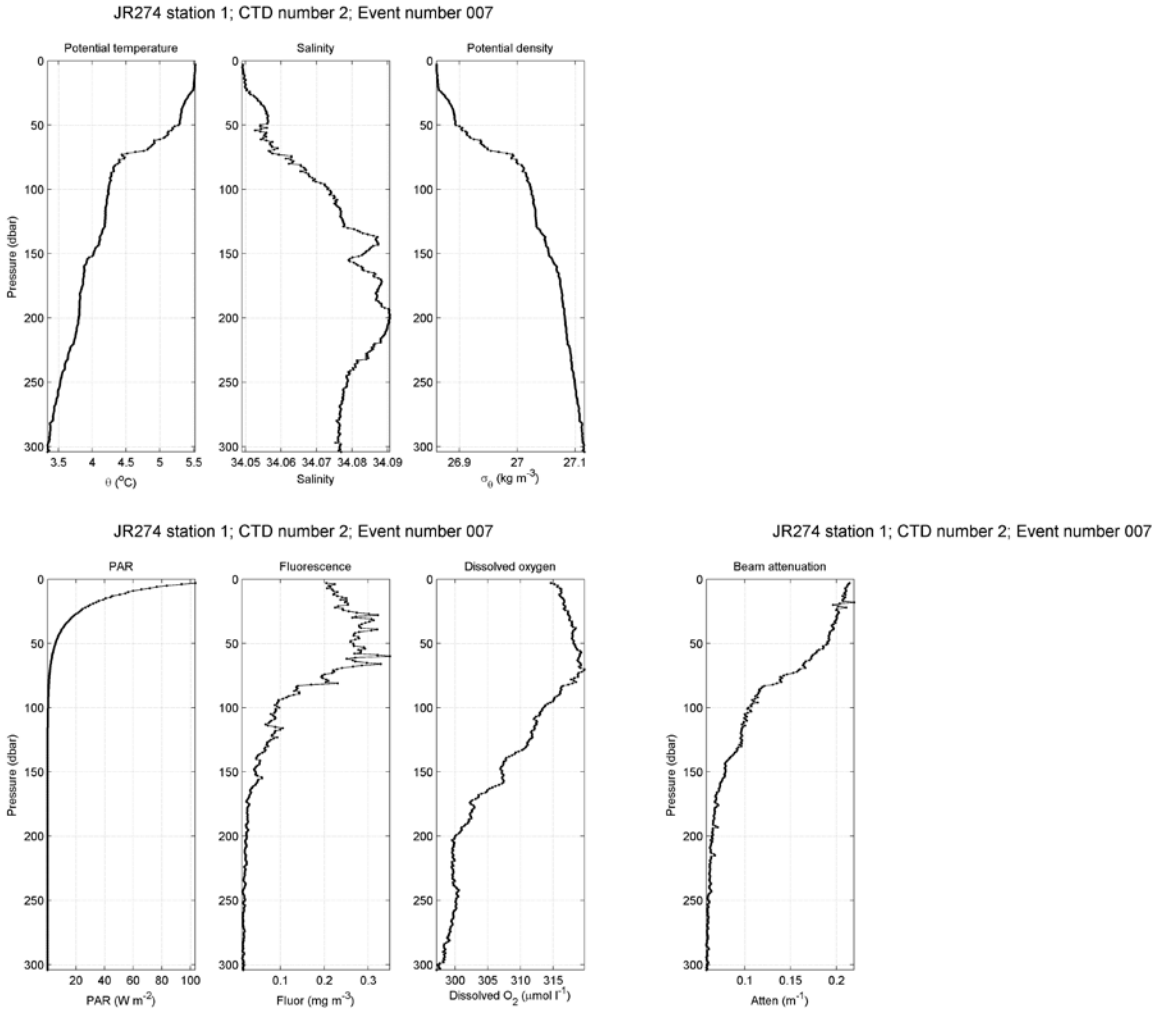

Fig. A4.1: Vertical property profiles from CTD data collected during JR274. Top: potential temperature, salinity and potential density; bottom: PAR, fluorescence, dissolved oxygen and beam attenuation. Profile plots are available for all casts; variables not measured during a particular CTD cast will show as blank. (Files = JR274/plots/CTD/vertical-profiles/jr274ctd007_stn1_ctd2[_pfo/_att].png)

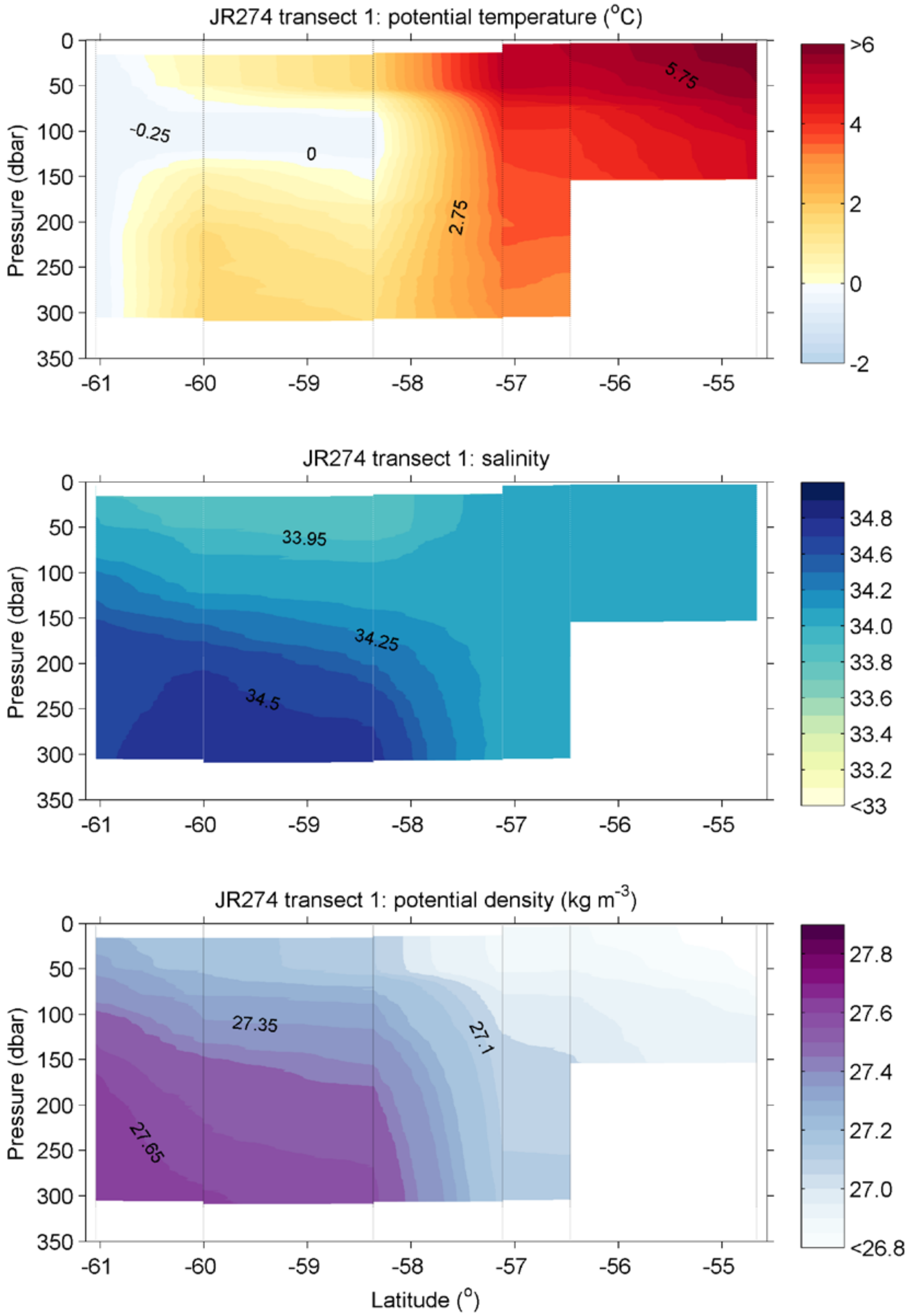

Fig. A4.2: Vertical property sections from CTD data collected during JR274: potential temperature, salinity and potential density. Vertical dashed lines mark location of CTDs. Contours have been arbitrarily labelled to aid interpretation. All transects have plots for the 0—300 db pressure range; transects 5—8 also have plots for the full recorded depth. Refer to Fig. 3.1 in main text for the CTDs assigned to each transect. (File = JR274/plots/CTD/vertical-sections/jr274transect1_ptmpsalsig0.png)

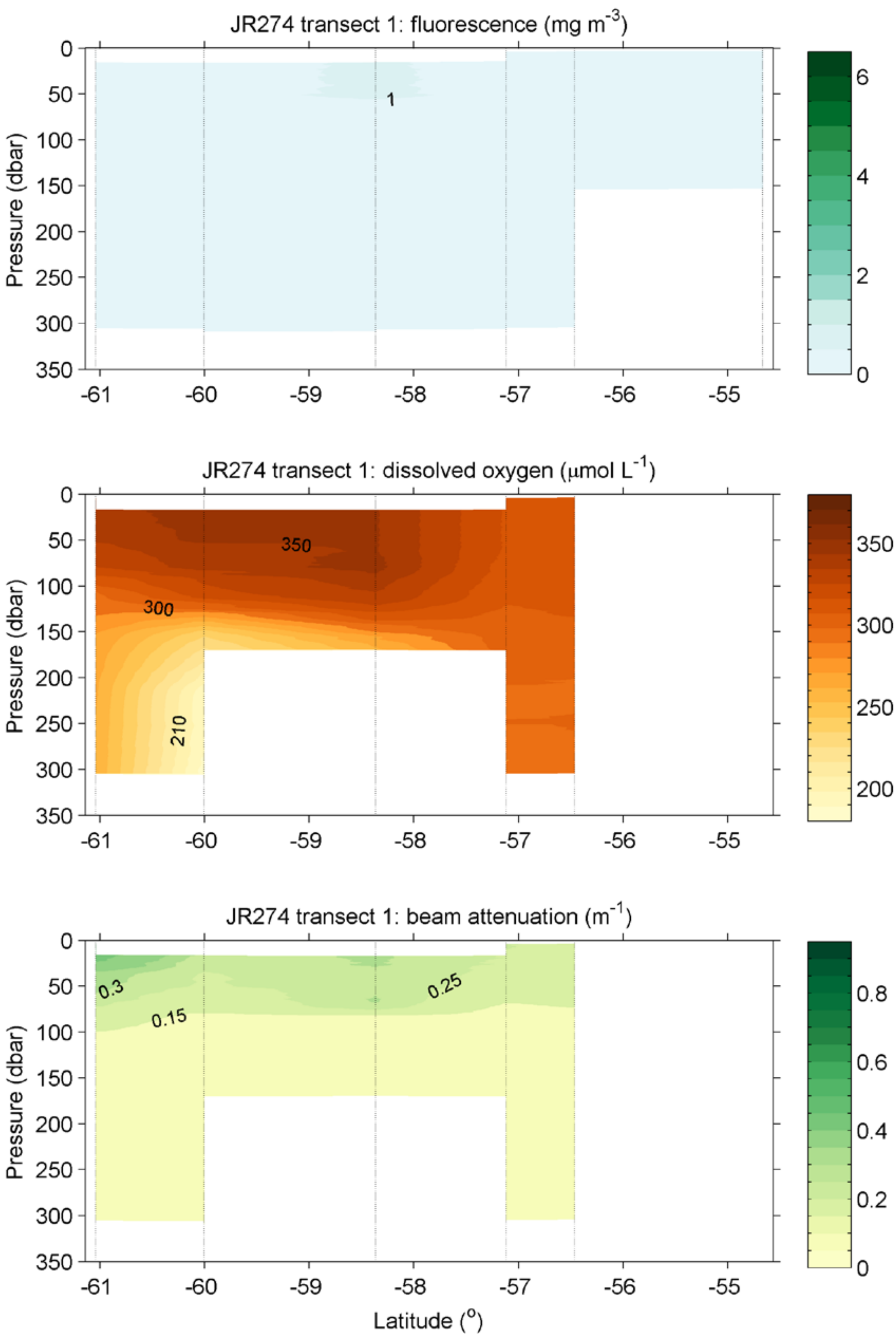

Fig. A4.3: Vertical property sections from CTD data collected during JR274: fluorescence, dissolved oxygen and beam attenuation. Vertical dashed lines mark location of CTDs. Contours have been arbitrarily labelled to aid interpretation. All transects have plots for the 0—300 db pressure range; transects 5—8 also have plots for the full recorded depth. Refer to Fig. 3.1 in main text for the CTDs assigned to each transect. (File = JR274/plots/CTD/vertical-sections/jr274transect1_chloxyatt.png)

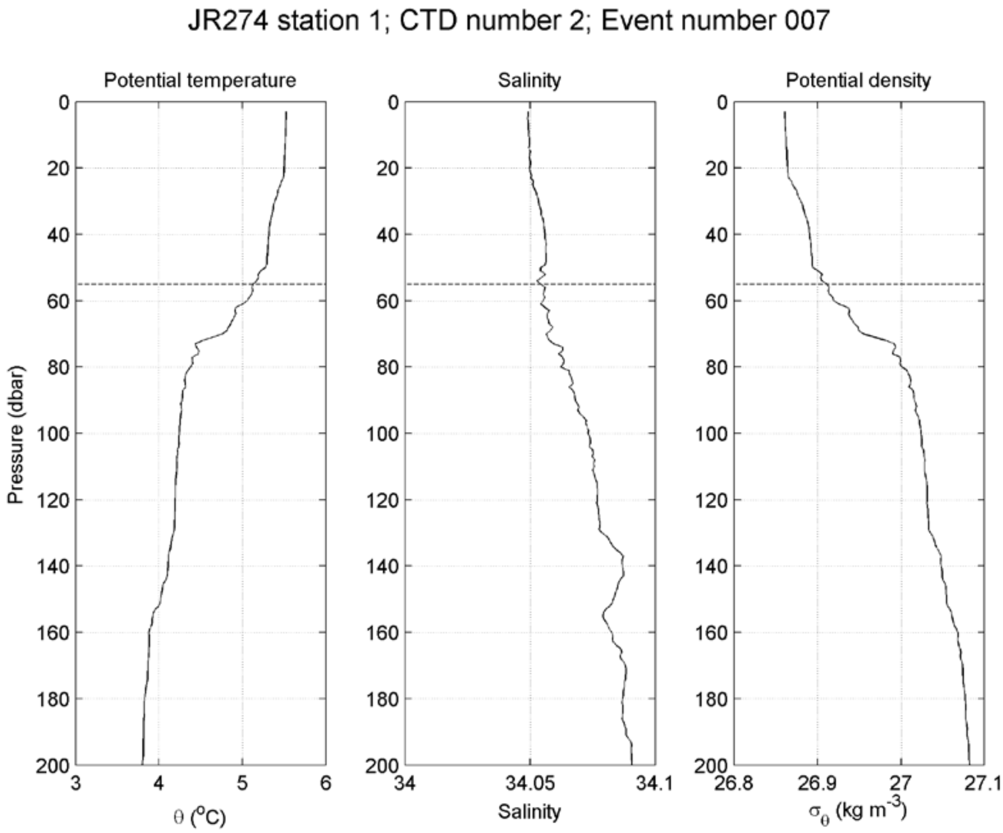

Fig. A4.4: Vertical profiles of CTD data with mixed layer depth added (dashed horizontal line; see Section 5 for details). Profiles for all CTD casts are available. (File = JR274/plots/MLD/jr274ctd007_stn1_ctd2_mld.png)